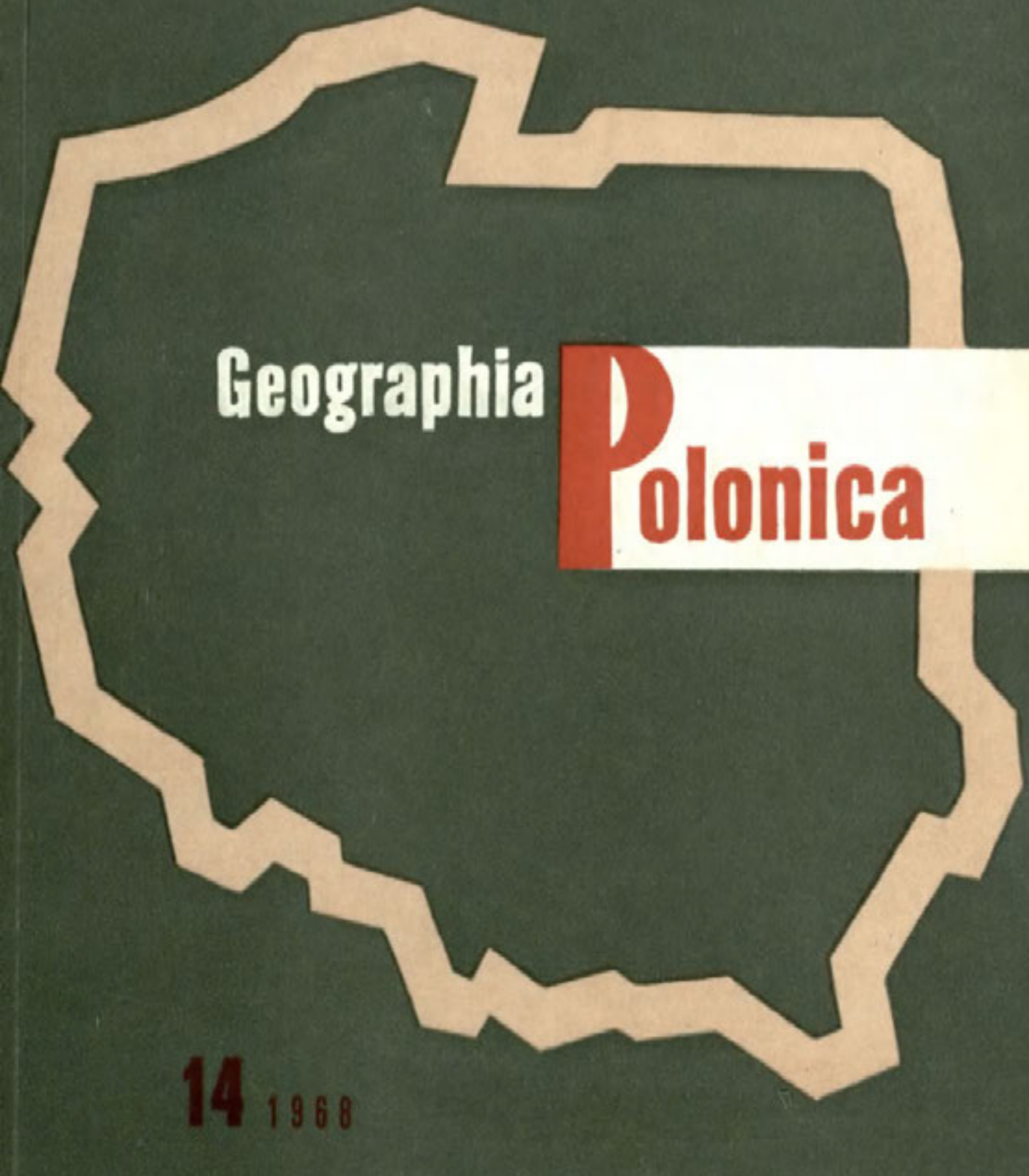

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I. GEOMORPHOLOGY

MORPHOLOGICAL SLOPE EVOLUTION BY LINEAR AND SURFACE DEGRADATION

ALFRED JAHN

THEORETICAL MODEL

It is common practice to illustrate the morphological features of a slope by drawing its longitudinal profile; profiles are also used for elucidating the mechanics of slope processes. The concept of what the author termed the balance of denudation [7], afterwards expanded by J. Tricart [19], R. Souchez [15], F. Ahnert (paper read at the Conference of the Commission of Slope Evolution IGU at Liège in 1966) also involves the slope profile. In much the same way a number of previous slope theories made use of the slope profile exclusively; among them were W. Penck's [8] classical analysis and the theories of P. Birot [3], J. P. Bakker and W. N. Le Heux [1]. In his mathematical calculations (linear, non-linear theory) A. E. Scheidegger [10] also employed the slope profile, although he envisaged the possibility of surface changes occurring when a slope is undercut by fluvial erosion. A. Young [20] reduced the results of his calculations exclusively to the slope, specifying what he calls his "models of slope evolution". In short, the main concepts of slope evolution involve theories referring to the slope profile — obviously a situation involving the risk of "overtheorizing" and of schematism. In reality a slope is a surface containing an indefinitely large number of profile lines. It therefore seems justified to analyze the entire slope surface with the processes which act upon it, and also to examine the balance of slope denudation in this context.

In this analysis let us split up a slope into horizontal bands marked by contour lines. According to the concept of denudation balance every kind of slope evolves from removal or building up of rocky material, that is, from degradation or aggradation. The effect of these processes is a gradual change in the contour lines shown on a map. The position of these contours with regard to the lines which represent the initial slope surface illustrates the intensity of the process acting upon the slope, or what is called its mechanics.

Processes of degradation operate in either of two ways: as surface or as linear degradation. When a slope is incised on its bottom part (linear erosion) and denuded and levelled all over the surface of its top part (surface degradation), the position of the slope and its morphological character will depend less on the type than on the intensity of the processes. This intensity is expressed by the quantity of rock mass which has been removed from successive altitude stages of the slope.

Let us imagine a slope of such a height that the upper part lies above the tree line and is exposed to surface degradation, while its lower part is within a forest zone and is dissected by gullies with flowing water.

In the upper section let a layer d be removed, say 10 m thick; this is, for example, the extent to which the upper part of the Karkonosze (Sudeten) slopes has been denuded as indicated by surviving „residual hills" or „tors". Thickness d is at the same time the depth of the gully incisions (w). The degradation of this upper slope part (of surface p) expressed as the volume of the layer removed, is:

$$V = p\,d\,(w).$$

In the lower slope part where the tree stand has prevented surface denudation, incision of the rock surface is taking place. For the sake of simplicity let us assume that the surface of the lower part of the slope is equal in area to that of the upper part. Let us assume further that the surface of the incisions accounts for $^1/_4$ of the entire slope surface. If degradation in the lower part, measured by the volume of the rock mass removed by incisions, is equal to the surface degradation in the upper part, the depth of the incisions would have to be four times that of d (w) if the incisions take the form of flat bottom valleys, or eight times this value if the incisions are V-shaped valleys (gullies). Thus:

$$V = 1/4\,p\,4\,w_1 = 1/4\,p\,8\,w_2.$$

In order to obtain the equivalent of the 10 m surface degradation of the upper slope part, the gullies in the lower part would have to attain a depth of 80 m. Only then would the balance of the slope be maintained and at the same time its general morphological character.

The disparity in slopes will depend on the quantity of material removed from their individual stages. The effect of surface degradation is more difficult to calculate than that of linear degradation. In the latter case the slope surface is indicated by the way in which the contour lines protrude on intervalley crests, while the retreat of the lines within valleys illustrates how much of the rock mass has been removed.

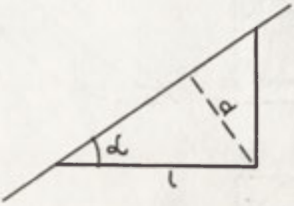

Fig 1. Diagram illustrating the ratio of horizontal slope retreat (l), to thickness of layer removed (*d*), for a slope inclination *α*

Reading changes like this on a map is a simple matter, because all one has to do is to select contour lines, preferably in the lower, the middle and the upper part of the slopes. Then the surface indicated by the deviation of the contour lines from the initial slope line is measured and this value is divided by the base of the form. In this way we obtain the mean value of the horizontal slope retreat [1]. For a slope inclination α this value can easily be converted into the thickness of the degraded layer (d), as shown by Fig. 1 and by the equation:

$$d = 1 \sin \alpha.$$

The erosive decrement in rock mass calculated in this manner can differ for particular stages of the slope. Let us examine several variants which are illustrated by the diagrams shown in Fig. 2. The value of mass decrement together with the modification of a slope can be transferred from map to profile, and in this way one can determine the general tendency of slope evolution.

The initial slope is rectilinear. With the gradual progress of dissection it is transformed not only by the erosive action of streams, but also — though to a much lesser degree — by denudation on the ridges between the incised gullies. For this reason we shall distinguish here three stages of evolution, the profiles of which are shown in Fig. 2: the initial slope (1), the slope reconstructed from surviving crest lines (2) and, finally, the actual slope as modified by the removal of rock mass mainly along the lines of erosive incisions (3).

When intense incision occurs on the lower part of the slope and decreases further up (Fig. 2 A) there are two ways in which the slope may develop: it may turn distinctly concave, or convex. In the latter

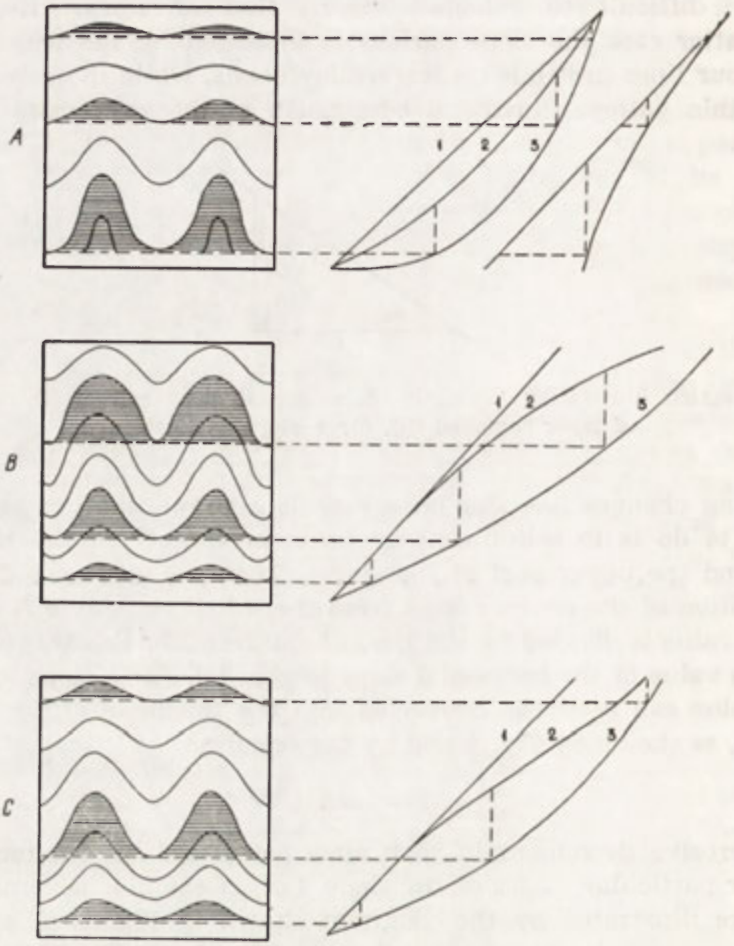

Fig. 2. Geometrical model of slope evolution effected by linear (erosive) incisions, when the maximum removal of rock mass occurs in the bottom part (A), in the top part (B) and in between (C). These profiles illustrate the general change in slope shape, starting from the initial profile (1) through the profile of degraded crest parts (2), to the profile showing total mass removal from the slope (3)

case the slope will grow steeper in its bottom part; the effect depends on the initial slope form, but in general it may be said that the angle of the slope will tend to increase.

Conversely, when the decrement in rock mass increases with height, the slope as a whole is bound to become more gentle (Fig. 2 B). This takes place when the depth of the incision gullies increases in the upslope direction. The galleys will then branch out and the removal of rock mass becomes particularly intensified at their spring basins. In consequence a convex slope changes into a concave one and in this way the whole slope assumes an inclination less steep than it was initially; this is called a flattening of the slope or a slope decline.

When denudation is most intensive in the middle part of the slope (Fig. 2 C), the general profile becomes rather concave and the slope declines.

The three types of slope evolution discussed above refer to erosive degradation. The predominant form of denudation is associated with incisions which determine the slope profile. The forms separating these incisions, called "slope ribs", are gradually worn down as the erosive gullies become wider.

As mentioned before, the second slope-sculpturing agency is surface degradation. Its effect cannot be identified from the run of the contour lines. This degradation operates on upper slope parts not reached by the erosion front. Climatic conditions here (a periglacial high-mountain climate) cause powerful surface denudation.

EXAMPLES

In his search for material to check the pattern of slope evolution described above, the author selected examples from three different areas: "inselbergs" in the Sudeten forefield, the Karkonosze range in the Sudetens, and the Beskid mountains in the Carpathian chain. In this way slopes were chosen with very different rock resistance and a variety of erosion effects. Slopes or slope fragments were taken into consideration (Figs. 4 to 7) only when they constituted whole morphological units terminated by crests (lines of watersheds).

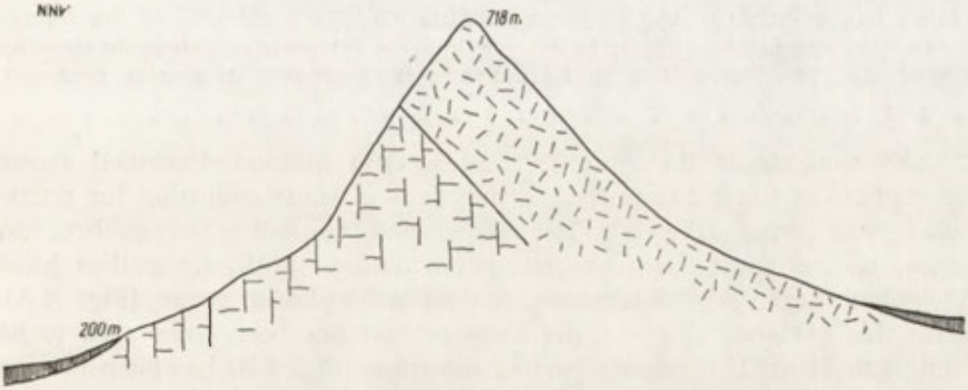

Fig. 3. Slope profile of the Ślęza inselberg

The slopes of Ślęza and Radunia were examined. These are two inselbergs in the Sudeten forefield, 718 m and 572 m high, set in a plain of 200 m altitude. The slopes of these mountains are identical as to their geological structure, being made up of granite, gabbro and serpentine schists. The age of the slopes is alike; they dip underneath Tertiary (Miocene) deposits and the development of both began in the Upper Tertiary. Their profile is concave, with an inclination of 15° at the base and 30° in the top parts (Fig. 3).

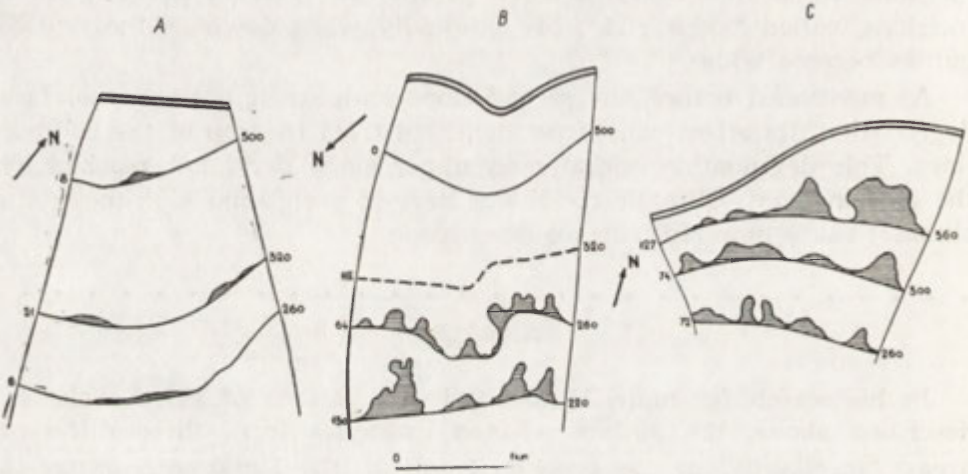

Fig. 4. Slope dissections of inselbergs in the Sudeten forefield as they occur in: gabbro (A), granite (B), and serpentine schists (C). The vight side of the figures shows altitudes (contour lines), the left side the slope retreat in m, as brought about by the erosion. The broken line (H. E.) indicates the boundary of erosive recession

The analysis of the contour lines by the method described above shows how considerable are the differences in slope evolution for particular rock types (Fig. 4). The slope part consisting of gabbro, an extremely resistant rock, has not been incised at all; no gullies have developed here. At most some denudation hollows occur (Fig. 4 A). With this evidence as basis, the slope retreat has been calculated to be from 8 to 21 m. The granite part of the slope (Fig. 4 B) has been incised only at the bottom; here the slope retreat amounts to 130 m at contour 220 m and 64 m at contour 260 m. Depending on the slope inclination the thickness of the denuded rock layer may be from 10 to 20 m. On this slope the boundary of head erosion can be distinguished, i. e. the level from which gully incision starts. It lies at an altitude of 320 m; higher up the section constituting the crest (600 m) is a smooth slope lacking incision. The slope retreat is greatest on the third slope formed by the serpentine schists (Fig. 4 C). The retreat extends further at the top (127 m) than at the bottom (72 m), and the thickness of the degraded layer increases from the bottom upwards, from 10 m to 40 m.

The principal phase of slope moulding, i e., the processes of incision, took place at the transition from the Tertiary to the Quaternary. During the Pleistocene it happened twice that the mountains were almost completely mantled by the inland ice and this protected them to some extent. The Last Glaciation brought again a period of intense periglacial activity, associated with surface degradation.

Generally speaking, since the Tertiary the degree of slope destruction has been relatively slight. Tertiary slope products (kaolin regolith) lie adjacent to the slope bases and sometimes on the slopes (S. Szczepankiewicz 1966). This would indicate that the first warmer period of slope incision brought the destruction of the kaolin regolith and that the slopes suffered some degree of degradation and recession, mostly due to the formation of gullies. In the hard gabbro rocks this destruction was insignificant and in the granites it affected barely one third of the slope, but in the schists it reached considerable proportions and gullies developed over the whole slope. The periglacial surface degradation, as studied in detail by the authors such as C. Schott [11] and S. Szczepankiewicz [18], caused the formation of rock debris and of klippen; their altitudes show that the periglacial period led to the denudation of a rock layer not exceeding 20 m in thickness. Since the dissection of the lower part of the granite slope failed to remove more than 20 m at the most, one may conclude that the Quaternary caused no changes in the slope profile of hard rocks in the inselbergs, so that its principal concave profile dates back to the Tertiary. The slope moulding was different in the soft serpentine schists. The degradation of the upper slope amounted to at least 40 m (compared with only 10 m in the lower part), so the slope inclination became more gentle. A process like this is illustrated by model B in Fig. 2; but even this slope retained its general Tertiary configuration, i.e. a concave profile.

The examples described from the Fore-Sudeten inselbergs show two typical features: 1) the slope profiles are of marked stability, and 2) the resculpturing of slopes is mainly contingent upon the degree of rock resistance.

The Karkonosze, composed of granites, are massive mountains. They consist of two parts: a slightly dissected main crest (1400—1600 m altitude) and what is called the Karkonosze Upland (600—700 m altitude) which is severely cut by valleys. Since these mountain sections are morphologically different, their slopes must be considered separately. Calculated from the evolution observed, the main slope retreat in the

Upland is 200 m; taking into account the slope inclinations this is equivalent to the denudation of a layer 50 m thick. The slope of the main crest part, where the inclination is double that of the foreland but it is much less broken up, has receded some 60 m. This corresponds to a degradation layer of 30 m thickness. However, this leaves out of consideration the powerful effect of surface denudation which played an important part during the phase of Pleistocene periglacial activity. J. Demek [4] and J. Sekyra [13] have explained that this kind of degradation proceeds mainly by a rearward evolution of altiplanation or cryoplanation terraces. The effectiveness of this degradation is shown by tors which rise almost on 30 m in height. Taking into consideration both degradation by incision and surface degradation, one may assert that these slopes have been lowered by not less than 60 m so that degradation here has been at least of the same order as the recession of the dissected Upland slopes.

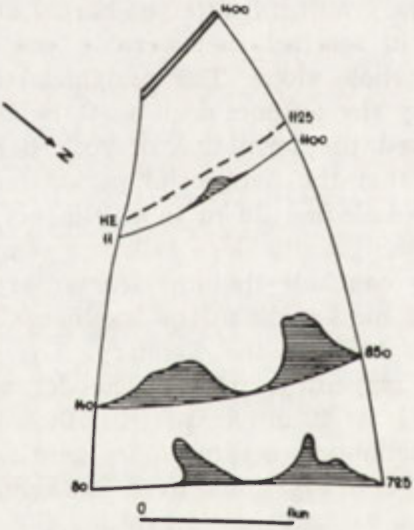

Fig. 5. Granite slope, main Karkonosze ridge. For explanation of symbols see Fig. 4

A further morphometric examination of the main mountain crest made in the region of Mała Kopa, 1400 m high (Fig. 5), shows that on this crest the slopes are dissected in their bottom part only. The front of upward erosion barely reaches to half the slope height. This is why on this slope the volume of degraded rock mass is much greater at the bottom than at the top, leading to the formation of a classical convex slope (model A in Fig. 2).

In the Carpathians the pattern of the mountain slopes differs very much from that described for the Sudeten and their forefield. This must probably be ascribed to differences both in rock material (flysch) and in the morphological evolution of the mountains. The author took several examples from the Beskid region, by random selection from "Atlas of Relief Forms and Types in Poland, 1960". Impressive slope dissections occur here as shown in an example from the Bieszczady Upland (Połonina Wetlińska) where the recession of slopes composed of shales and sandstones may be as much as 0·5 km (Fig. 6). In the lower part of this slope, a 90 m layer suffered degradation while in the upper part this thickness is only 40 m. The type of slope recession follows model A in Fig. 2, which means that concavity is maintained. It may also be deepened (model C in Fig. 2) as on a slope at Gorce in the Turbacz group (Fig. 7). Denudation is here most intensive in the middle part of the slope.

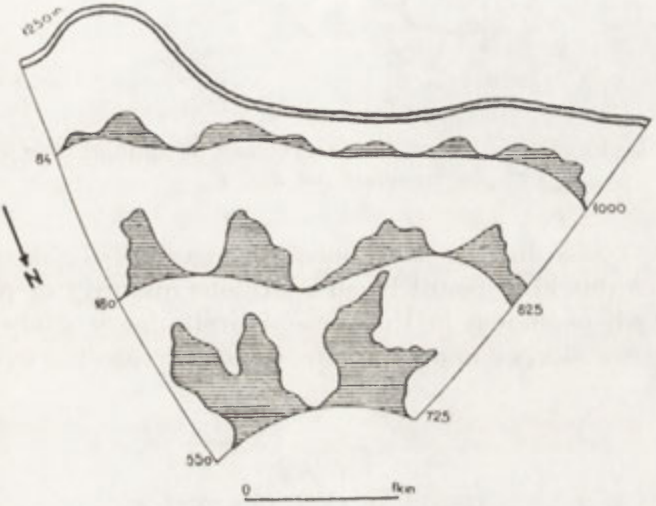

Fig. 6. Slope in the Carpathians: Bieszczady Mountains (Połonica Wetlińska). For explanation of symbols see Fig. 4

Carpathian slopes lack homogeneity, in contrast with the Karkonosze slopes described above. They are made up of rock material which varies very much in resistance and therefore reacts differently to the action of destructive forces, as has been stressed by L. Starkel [16]. No less characteristic of these mountains is their concave-convex slope profile (J. Dziewański, L. Starkel [5]). The concavity developed at the close of the Tertiary and evolved further in the Quaternary. This type of slope cannot always be regarded only as a place where surface processes such as solifluction have been operating, because deep erosional dissections are typical here. Such slopes differ in this respect from slopes of the massive rocks in the Karkonosze range or of Ślęza mountain. Dissections of this kind result in an enormous quantity of rock material being removed; as shown in the present preliminary study, this makes concavities grow deeper and rather tends to increase the overall surface inclination.

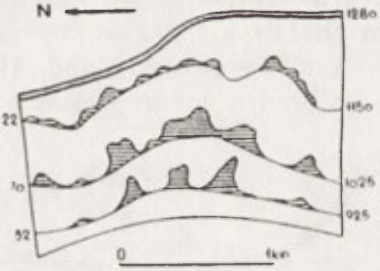

Fig. 7. Slope in the Carpathians: Gorce (Turbacz Mountain). For explanation of symbols see Fig. 4

GENERAL CONCLUSIONS

In geomorphology the concept of a slope lacks a precise definition, because no true criteria exist for this purpose. The same word may be used for the vast flanks of a high mountain range, the side of a wide valley, or of any small gully which is incised into the surface of a larger slope. When dealing with a slope we do not pay attention to its full length but only note its shape, which may at times be delusive when seen in field Analysis of a slope based exclusively on slope profile cannot be considered comprehensive and for this reason a slope should be examined over its entire surface, that is, by studying its successive altitude stages by contour (hypsometric) bands. In this way we take into account as forms produced by slope processes all slope incisions, both gullies and small valleys. Many scientists, like H. Baulig [2], deal with the concept of a slope in this manner, but the size of incision that can still be looked upon as a component part of the slope form remains an open question. To be exact, when does an incision become an independent form with its own slopes which in turn should be analyzed separately? Can one consider "badlands" in the sense used by American geomorphologists in their analyses (A. Strahler [17] or S. A. Schumm [12] to be slope forms or are they assemblages of erosively dissected slopes? So far these problems lack precise definition, and this explains why various authors look at them differently.

In the present analysis the slope has been treated "sensu lato" as a surface which undergoes degradation due to denuding agencies and the erosive incision of water channels. This concept explains the long history which slope evolution has had during the Tertiary and Quaternary; it admits the introduction of such notions as "head erosion" of the gullies destroying a slope, or "belts of no erosion", a term first used by R. E. Horton [6]. A slope consists of a lower erosive part and an upper denudational part; in·the former linear processes prevail, in the latter surface processes. Actually it is not the type of such processes which ultimately bears on the slope form, but the effect they bring about in the form of the rock layer removed, the magnitude of which can be determined. In this sense the concept of the "slope denudation balance" should be applied, involving the determination of mass removal from each altitude zone of a slope.

The decrements can be calculated by comparing the slope surface as it is today with visible forms deviating in plus (klippen under conditions of surface degradation) or in minus (dissection where linear degradation has taken place).

Linear dissection is an important factor in slope moulding, because it shapes the profile both directly and indirectly. A new slope develops along the line of the profile of incisions; moreover, further destructive processes ensue, tending to eliminate the crests separating the incisions. Examples can be cited from various climatic zones confirming that slopes develop in this manner. For instance, this is why in an arid climate "retreating (by rill wash) badland escarpments" are produced [14]. Reporting numerous examples from the humid tropics R.A.G. Savigear [9] asserts that "gullies... seem to be the most important factors determining parallel retreat and the perpetuation of slope forms". This same author corroborates that the slope profile depends on the profile of its incisions "the long profiles of the gullies may impose themselves on the hillsides".

Thus we see that linear erosion can lead to a radical change of the slope form, — as justly postulated by H. Baulig [2]. This refers to what should be called "large slopes" dissected by water gullies, not to "microslopes" which can always be reduced to the smallest elements subject to denuding agencies. The principal agency initiating the denuding processes is important, and in the lower slope parts flowing water provides this destructive force. The examples cited from the Sudeten and the Carpathians in which the slopes were treated in their totality, show that the removal of rock mass is primarily caused by the erosive action of water. In this respect the author disagrees with A. E. Scheidegger [10] who, in agreement with C. H. Crickmay, admits only one possibility: that “without any lateral river (or surf) action slopes do not recede but only become less steep”. The author prefers to believe that the action of water running off from a slope in small rills can gradually effect (especially in soft rock types) a complete modification of that slope, including its recession.

The surface degradation of a slope is a problem on its own. It may sculpture the slope either as an independent agency or together with linear degradation. In this action the initial slope profile can be maintained, with slope remaining parallel to its initial inclination as it retreats, when the rate of surface degradation of the upper part equals the rate of linear degradation in the lower part of the slope. Surface degradation operates mainly in the periglacial zone by its specific type of weathering, by solifluxion processes and, particularly, by rearward evolution of forms of cryoplanation.

It seems worth stressing that surface degradation affects all types of rocks without much variety in its way of acting. This does not apply to linear degradation, because here the lithology of a slope is of decisive importance. Often the susceptibility of the rock to erosive dissection determines the ultimate evolution of a slope. The morphological difference between a slope of soft (especially sedimentary) rocks and massive rocks resolves into the difference in resistance of the rock material to linear erosion, of course with weathering as an intermediate process. By such reasoning it is possible to explain the difference in slope forms between the Carpathians and the Sudeten, or the striking contrast apparent in the slopes of Ślęza and Radunia, the two mountains close to each other in the Sudeten forefield, as discussed above. Hence erosive dissection of rock material is an important process in slope degradation and recession, probably more important than surface degradation.

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NEO-PLEISTOCENE CHANGES IN A LARGE RIVER VALLEY WITH THE ODRA AS EXAMPLE

Stanisław Szczepankiewicz

As a rule the relief of the valleys of large European rivers shows the effect of the Ice Age especially the Neo-Pleistocene, when inland ice acted both directly and indirectly.

Several types of valley may be distinguished depending on the influence of the range of glaciation upon the pattern of the European river system and the course of the principal watershed lines (Fig. 1). They are: 1) river valleys which have lain completely, or almost completely, within the range of the inland ice; this class includes numerous European rivers situated proximately with regard to the movement of the ice, such as the Ems, Weser, Elbe, Odra, Vistula, and the rivers flowing northwards in European part of the Soviet Union; 2) the valleys of those large rivers which have been entirely outside the range of the inland ice, such as those of Western, Southern and and, in part Eastern Europe; 3) river valleys of which only the lower reaches were glaciated; 4) the valleys of those larger rivers which during the Pleistocene were glaciated merely in their spring sections; two large rivers of Eastern Europe, the Don and the Dniestr, may be regarded as classical examples of this type.

An analysis of how the maximum extent of the glaciation ran with regard to the European watershed lines — which during the Neo-Pleistocene remained practically unaltered — shows that in Europe there were three areas in which the ice masses extended particurarly far, passing the fiftieth degree of latitude. These were the catchment basins of the upper Don and the upper Dniestr rivers in Eastern Europe as well as those of the Vistula and the Odra rivers in Poland. The Don and Dniestr lobes were able to advance so far since the inland ice had only to pass a low watershed divide in order to penetrate into the upper parts of these distal river valleys. The third area where the ice transgressed a watershed line — in this case a high one — is the catchment bassin of the Upper Odra river in what is called the Moravian Gate. This latter river, being a proximal stream, has been within the range of the Scandinavian inland ice over practically all its legth. In this respect conditions for the Odra river were rather exceptional, because the valley became mantled by ice masses of both the Southern Polish (ApGl) and the Middle Polish (PGl) Glaciations. The boundary line of the maximum transgression which the Southern Polish Glaciation (ApGl) reached in Europe ran across the upper part of the Odra catchment basin. To the present author this area, representing the maximum extent of glaciation, seemed particularly suitable to be investigated as an example of the gradual evolution of a large river of a proximal character.

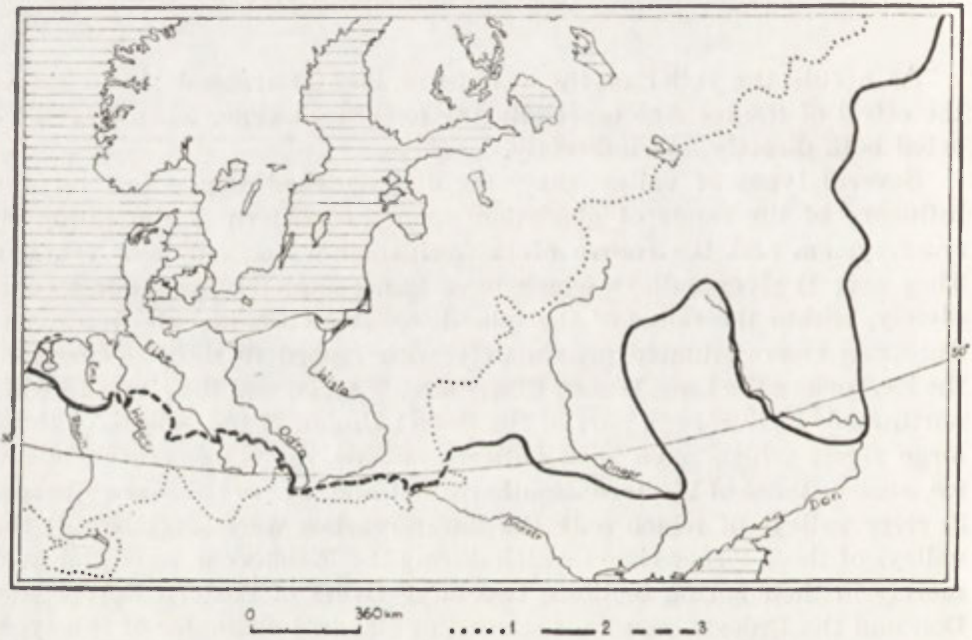

Fig. 1. Situation sketch of The Odra and some other European rivers as related to the maximum lowlands glaciation range. 1. principal European watershed, 2. maximum range of The Masovia—Podlasie Stage (PGl, Saale), 3. maximum range of The Southern Polish Glaciation (ApGl, Elster)

The author collected his basic material from the Odra valley, between the range of the maximum stage of the Middle Polish Glaciation (PGl) on the one hand and the Mazovia-Podlasie Stage of this glaciation on the other. For purposes of comparison he also investigated the zone between the maximum range of the Northern Polish Glaciation (LGl) and the fringe line of the Mazovia-Podlasie moraines. In this latter zone the Odra runs within what is called the Głogów—Barycz ice marginal valley (*pradolina*).

In the area under discussion the modern Odra valley can be divided, as far as the landscape is concerned, into a number of sections; they are specified here in upstream, that is southward, sequence: 1) An E-W section in the Głogów—Barycz ice marginal valley (*pradolina*). 2) A S-N section of the valley in the wide Ścinawa Depression [13], which splits the chain of upthrusted moraines of the Mazovia—Podlasie Stage (Warta Stage) into separate links. 3. A W-E section in what is called the Wroclaw—Bremen ice marginal valley (*pradolina*), west of Wrocław [10]. 4. A valley section within the extensive Wrocław Plain, with a surface composed of loose Tertiary and Quaternary sediments. 5. A valley section in the Opole neighbourhood with the landscape of an accumulation zone containing culminations of an older, Pre-Tertiary substratum. 6. An upper section, situated furthest to the south within Poland's boundaries, in the Racibórz Basin. This is made up of loose Tertiary and Quaternary sediments.

There are two features which link the individual sections into whole: one involves their relief elements, the other is of a fossil character. The Odra has three bottom terraces of Holocene age common to the whole of its middle and upper reaches. The second common feature is the existence — with the exception of certain gaps in section 5, of a deep fossil valley into which settled massive Quaternary deposits of assorted origin and age. The upper age boundary of this incision is marked by gravel beds of shallow Upper Pliocene cones dissected by the ancient valley form; this Pliocene horizon is important as a reference level. In order to obtain a logical picture of the whole, the author will present his analytical description of charecteristic features for the individual valley sections.

THE ODRA RIVER IN THE GŁOGÓW—BARYCZ ICE MARGINAL VALLEY (*PRADOLINA*)

This ice marginal valley section stretches between the moraines of the maximum range of the Last Glaciation (LGl) and the Mazovia-Podlasie thrust moraines (PGl). The Holocene accounts for three terraces the deposits of which are packed into the dissected accumulation of the Northern Polish Glaciation (LGl). A striking feature in this section is the asymmetry of the valley slopes. The steep slope of the left bank, composed of thrusted deposits of Tertiary and Quaternary moraines from the Mazovia—Podlasie Stage, stands in contrast with the right bank. Kames made up of sands and gravels lie on the slopes of the moraines, while a wide outwash plain is spread out on the right bank, associated with the maximum range of the Last Glaciation (LGl) (Fig. 2). The presence of fossil ground moraines has been detected in the valley substratum, indicating an ancient origin for this E-W depression. From the analysis of land forms and the examination of material from numerous recent bore holes it must be assumed that the glacifluvial waters from the maximum range of the Northern Polish Glaciation (LGl) and the Odra waters ran off to the lowermost depression of the inland ice of the Mazovia—Podlasie Stage, following the track of the ancient valley. No evidence is available to imply a definite runoff in a western (*pradolina*) direction.

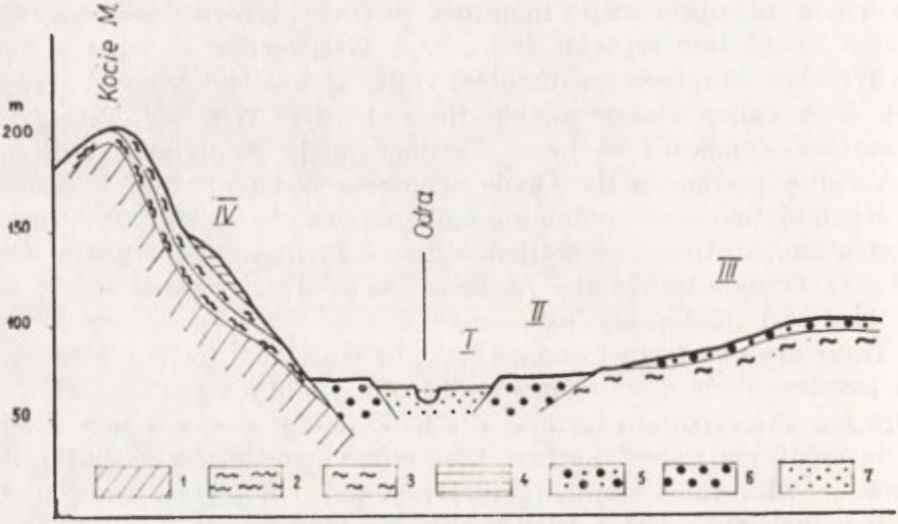

Fig. 2. Transversal section through Głogów—Barycz „pradolina" near Głogów. I. System of Holocene terraces, II. Northern Polish terraces (LGl, Weichsel), III. Outwash level, IV. Kame terrace; 1. Tertiary substratum, 2. Middle Polish moraine, maximum stage (Odra), 3. Middle Polish moraine, Warta Stage (Mazovia—Podlasie Stage, Warthe), 4. sands and gravels of the kame terrace, 5. sands and gravels outwash level, 6. sands and gravels of The Northern Polish terrace (LGl), 7. sands and muds of the Holocene terraces

THE ODRA VALLEY IN THE ŚCINAWA DEPRESSION

The S-N section of the Odra valley in the zone of the Mazovia—Podlasie moraines, formerly erroneously called the "Southern Odra gap" [13], connects the Głogów—Barycz ice marginal valley (*pradolina*) with the Wrocław—Bremen ice marginal valley. This depression is up to 20 km wide and contains groups of landscape and fossil forms derived from a variety of sedimentary enviroments. There are forms of fluvial accumulation, and of eolian, ice-dammed, glacial and glacifluvial origin. Among other phenomena two ground moraines were discovered in this depression. This fact in itself excludes a gap-caused origin for this S-N section of the Odra valley. On the contrary, this is a relict of an old valley depression. The chain of morainic hillocks which were upthrusted along the line of this depression has never had the nature of a continuous form. The origin of these hillocks should rather be linked with a two-stage thrust of fragments of ancient interfluves which were deposited on Tertiary sediments easily affected by pressure. The southern part of the section containes, apart from fluvial terraces, a level of an ice-dammed accumulation associated with the blocking of the outlet from an ancient land form by inland ice of the Mazovia—Podlasie Stage (Fig. 3).

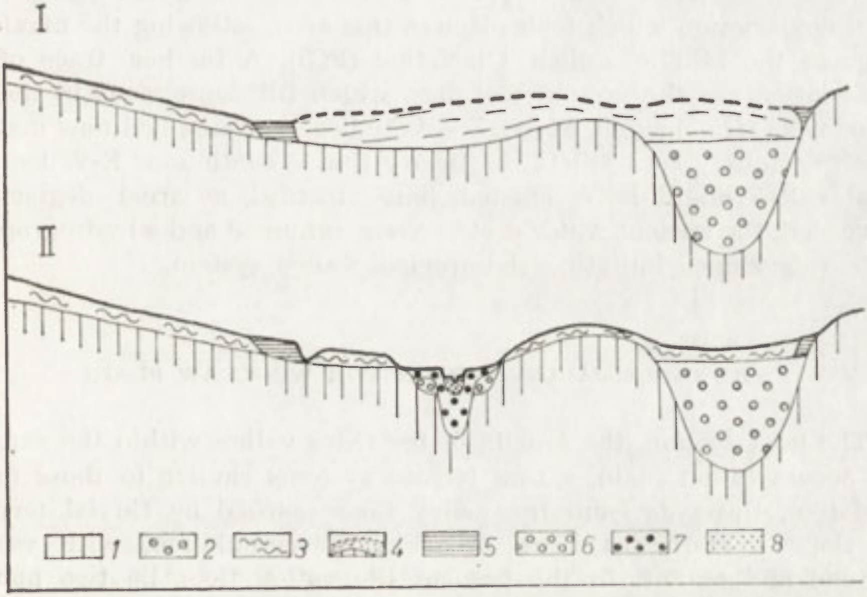

Fig. 3. The origin of a glaci-epigenesis gap. 1. older rock substratum, 2. filling-in of a section of ancient valley, 3. bottom moraine of the Middle Polish maximum glaciation stage (Odra, Drenthe), 4. dead ice in lower parts of the valley, 5. kame terrace sediments, 6. gravels of fossil terrace, Warta Stage, 7. gravels of Northern Polish filling-in (LGl), 8. sands and muds of Holocene terraces

THE ODRA VALLEY IN THE WROCŁAW—BREMEN ICE MARGINAL VALLEY (*PRADOLINA*)

This *pradolina* contains Holocene fluvial terraces and a terrace of Nouthern Polish Glaciation (LGl) formed similarily as in its further downstream sections. However, in this part of the pradolina the upper accumulation terraces connected with the filling-in of the Odra valley are lacking. A kame-type accumulation occurs locally on ledges built of morainic deposits and Tertiary loams. These are the direct result of the areal deglaciation which took place in this area, following the maximum stage of the Middle Polish Glaciation (PGl). A further trace of this deglaciation are the ground moraines which fill depressions in the line of today's Odra channel. More recent studies have supplied new material which definitely contradicts the theory that a continuous E-W ice marginal valley might have existed here. Instead, as areal deglaciation proceeded, the ancient water divides were exhumed and a hydrographical system developed imitating the oroginal valley system.

THE ODRA VALLEY WITHIN THE WROCŁAW PLAIN

The next section, the fourth, of the Odra valley within the range of the accumulation plain, shows terrace systems similar to those of the *pradolina*. Upwards from the valley floor marked by fluvial terraces, the slopes contain fragments of a kame accumulation, with varying altitude and extent. In the base of the valley floor lie two moraine horizons ascribed to the Southern Polish Glaciation (ApGl) and the maximum range of the "*pradolina*" section. This plain, lying only 140 m above sea level and rising locally a bare ten metres above the water level of the river, rules out any possibility that a high Neo-Pleistocene filling-in might have taken place in this section.

THE ODRA VALLEY WITHIN THE WATER GAPS ZONE

In this zone, where in the Opole neighbourhood the river has broken through rocks of the older substratum, marked differences appear in the evolution of the valley landscape compared with the lower reaches of the Odra. Numerous outcrops of Tertiary and Quaternary sendiments protrude in the Odra valley, and they are the cause of a number of rock

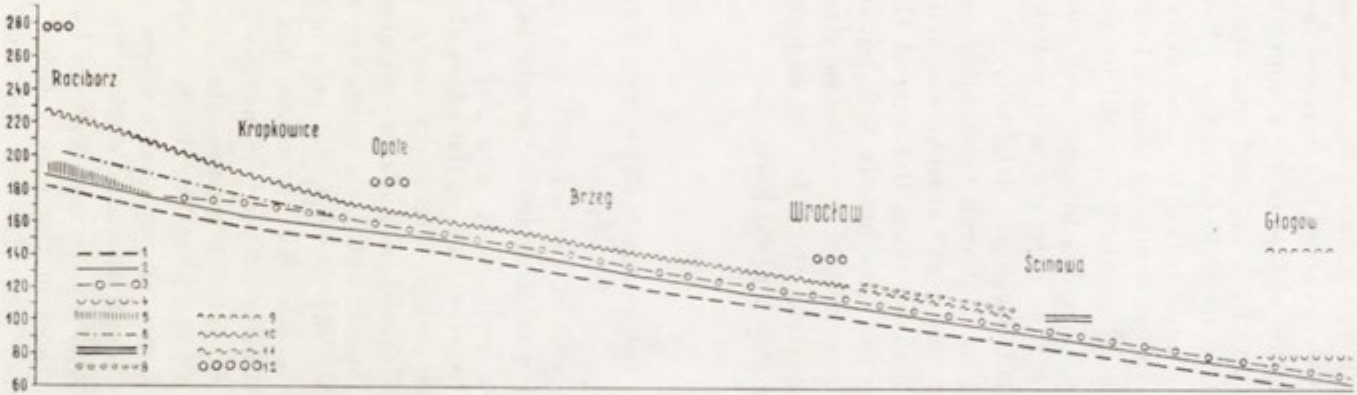

Fig. 4. Longitudinal section of The Odra valley between The Northern Polish Glaciation limit (LGl) and Middle Polish Glaciation limit (PGl). 1. river level, 2. bottom level, Holocene, 3. Northern Polish terrace (LGl), 4. Northern Polish outwash level (LGl), 5. bottom loess level, 6. cone-terrace Warta Stage, 7. ice-dammed level, Warta Stage, 8. outwash level Warta Stage, 9. kame terrace, Warta Stage, 10. kame terrace, maximum Middle Polish Glaciation Stage, 11. fossil kame terrace, maximum Middle Polish Glaciation Stage (PGl), 12. Pliocene cones

gaps, such as those near Opole and Krapkowice. Apart from more recent valley sections with young fluvial terraces, fossil sections are also found here. In this part of the Odra valley the terrace from the Northern Polish Glaciation takes on the character of a suprafloor terrace and maintains this character in the inter-gap sections; most probably this is the result of younger positive tectonic movements. Even so, the origin of the Odra gaps should not be ascribed to these movements of a relatively small amplitude, but rather to other agencies. In the light of recent research the origin of the gaps should be sought in a sui generis glaciepigenesis (Fig. 4). On this basis this phenomenon would be associated with areal deglaciation in a zone of permanent ablation, due to which the ancient river system had developed originally, in part at least, on the dead ice surface which then covered this valley zone. When deglaciation was proceeding and "thermal" erosion was active, the river did not always cut its chanel strictly along the axis of the former valley. At the sites of today's gaps the river mostly took advantage of low gap depressions amidst the chain of hills of the older substratum. The lack of traces a high valley accumulation precludes the assumption that a normal epigenesis might have taken place here.

THE VALLEY OF THE UPPER ODRA WITHIN THE RACIBÓRZ BASIN

The Racibórz Basin, the axis of which is followed by the upper Odra section, is a morphological unit with little variety in its landscape. It mainly consists of a wide basin floor and asymmetrical but little differentiated slopes. The western half of the basin shows gentle slopes covered by loess clays; the eastern slopes are steep, built of Tertiary loams with a thin cover of Quaternary sands and gravels. Closer examination of the left bank slope of this basin revealed several generations of typical landslides. This is clear evidence not only of the fluvial origin of this valley section, but also that slope processes like mass movements, induced by the type of substratum, have conspicuous tendency to widen this valley form. The specific relief form was also affected here by the fact that the region lies in a loess zone. For this reason it seems justified to consider the area of the basin floor as a zone where fluvial and eolian processes have been active simultaneously during the Northern Polish Glaciation (LGl), as is indicated by the occurence of loess deposits in the bottom plain of this basin and in the upper Odra valley. The top of the loess deposit, together with ice-dammed and fluvial deposits, forms a floor surface which is morphologically little differentiated

(Fig. 3). The deposits of the three Holocene terraces are packed into loess-like silt sediments in a partly swampy-aqueous facies. The Racibórz neighbourhood lacks a typical terrace level which in other valley sections dates from the Northern Polish Glaciation (LGl). The top layer of this latter age, composed of sands and gravels, lies some 8 to 10 m below the bottom of the basin. This gravel accumulation consists of facially little diversified sediments from the transition period between the Eemian Interglacial and the Northern Polish Glaciation. At the level of this accumulation, partly overlaped, lie the loess and silt deposits of a bottom facies. The ancient river, of periglacial age and therefore of meagre flow volume, was unable to carry of the silty material which covered the bottom banks. During the Northern Polish Glaciation (LGl) these loess deposits covered the adjoining upland, the slopes and two morphological levels of the Odra valley.

SOME EVOLUTIONARY STAGES OF THE ODRA VALLEY

The evolution of the Odra valley relief, as it proceeded within the extreme range of the two glaciations mentioned, shows a differentiation which goes back to the original relief, today constituting a deep-lying fossil form. The direction of the individual valley sections involved in these glaciations was of great importance in this evolution. Sections whose direction was parallel with the advance of the inland ice facilitated the penetration of ice lobes and glacier tongues. Other sections running at right angle to the ice advance, such as the section at Głogów [1], became temporary obstructions; at a latter stage these sections, changed into terminal depressions, led to the formation of glacitectonically upthrusted, distally situated interfluves.

In this way they partially predisposed the course of the thrust moraines, in this case the course of the moraines which were piled up during the second stage of the Middle Polish Glaciation (PGl). The Wrocław—Bremen *pradolina,* trough which passes the second E-W section of the Odra as mentioned above, consisted of sections with a variety of directions by which the Odra waters were carried off northwards through the Ścinawa Depression. The valley section within the Wroclaw Plain has no high fluvial terraces; after deglaciation following the Southern Polish Glaciation (ApGl) and the Middle Polish Glaciation (PGl), ground moraines mantled the flat Wroclaw Plain as well as all the ancient valley hollows, and in spite of being much eroded large portions of these ground moraines continue to be found in the base of the valley floor. The occurrence of two ground moraines, which were discovered in the ancient valley section where they form gaps, date these gaps from the deglaciation period of the Middle Polish Glaciation. In the two older glaciations which had a similar range in the investigated region the evolution of the Odra valley was much the same. A difference in this evolution did not set in until the younger stage of the Middle Polish and the Northern Polish Glaciations, by reason of their different ranges. During the Mazovia—Podlasie Stage ice-dammed silts were deposited in the lower part of the valley, and a terrace in the form of a sand-gravel cone in the upper part (Fig. 3). Later on, the accumulated deposits dating back to the decline of the Eemian Interglacial and the beginning of the Northern Polish Glaciation were covered, in part simultaneously, by fluvial deposits and eolian loesses. A similar evolution of all the valley sections distinguished took place with the decline of the Pleistocene. After a period of postglacial erosion, accumulation began to prevail, indicated by a 6 m bank of gravels and sands forming Terrace III, of post-Atlantic age, and by deposits on the lower Holocene terraces.

CONCLUSIONS

In the Neo-Pleistocene relief of the proximal valleys several sections can be distinguished, which differ in the evolution of their forms of accumulation and erosion. In the zone extending beyond the fringe of the Last Glaciation but within the farthest range of the glaciations, no ice marginal valley (*pradolina*) of a continuous character existed; water runoff in a variety of directions was the rule, dictated by the ancient valley network.

In the range of the glaciations a number of gaps developed in consequence of glaci-epigenesis; the decisive agency was here the affect of what is called “thermal erosion” upon dead ice covers surviving in valley depressions.

Where flat valley floors lie in loess zones, a coincidence of fluvial and eolian processes can be observed, this also refers to valley sections containing dunes.

The results of the author’s examinations show in many instances a lack of evidence for uniformity between right-bank and left-bank relief forms. The same, to an even greater degree, applies to the longitudinal profiles of river valleys (Fig. 3). The range of the Neo-Pleistocene glaciations shows clearly the phenomenon of their non-continuity. Apart from climatic and tectonic agencies, the evolution of the transversal and longitudinal valley profiles in the regions depended on further agencies also, such as conditions of local sedimentation.

The Odra valley, adopted as an example by the author, can probably be looked upon as a sui generis model for river valleys, whose floors are directed proximally with regard to the movement of the inland ice, and which are situated within the range of the two Pleistocene glaciations. It seems necessary to prepare further suitable schemes applying to those types of valleys which have been included in the author's introductory classification, and to undertake comparative examinations.

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PECULIARITIES OF THE CONDITIONS OF LOESS ACCUMULATION IN CENTRAL EUROPE IN THE LIGHT OF RESULTS OF HEAVY MINERALS ANALYSES

HENRYK MARUSZCZAK, ROMAN RACINOWSKI

Results of analyses of heavy minerals have long been employed, inter alia to determine the source and direction of the transport of loessy dust. They are thus of considerable significance for studies of the genesis and conditions of loess accumulation (A. Vendl et al., 1935, J. Tokarski 1936, V. Ambrož 1947, A. Malicki 1950, A. Jahn 1950, P. Krivań 1953, M. Mišik 1956, B. Grabowska 1961, J. Šajgalik 1965, R. Gwóźdź and R. Racinowski 1968). Such analyses were usually undertaken sporadically, chiefly with a few samples and employing various methods. As a result, these analyses have been very differently interpreted (e. g. A. Vendl et al. 1935 and P. Krivań 1953). The authors therefore decided to base their studies of the conditions of loess accumulation on the results of a larger number of analyses performed by a single method. Samples of loesses for these analyses were taken in the years 1957—1966 in Poland, Czechoslovakia, Hungary, Rumania and Bulgaria. Thus the present paper refers to the eastern part of Central Europe.

METHOD OF INVESTIGATING THE HEAVY MINERALS

Grains of all fractions of less than 0·25 mm were examined, i. e. practically all the samples of loess deposits, since only in exceptional cases were there any significant quantities of grains bigger than 0·25 mm. The examination of all fractions occuring in the loesses enables a comparison of these deposits to be made with sands. All the analyses were performed by one of the co-authors, R. Racinowski. The heavy minerals were separated from fractions of less than 0·25 mm, from samples weighing 100 g, using bromoform of specific weight

TABLE 1. Variability of heavy mineral content depending on: a) size of the analyzed fraction of aeolian loesses (A,B) and b) differentiation in grain caliber of deposits of varying origin deriving from one petrographic province (C,C_1)

Place where sample was taken (country)	Determination of deposit investigated (depth of taking the sample in metres)	Investigated grain fraction – in mm	Content of heavy minerals in % weight	Opaque minerals in %	Content of transparent minerals in percentages (Σ = 100%)														
					Amphibole	Apatite	Biotite	Chlorite	Disthene	Epidote	Glaukonite	Garnet	Pyroxene	Rutile	Staurolite	Sillimanite	Tourmaline	Zircon
A Puławy — Włostowice (Poland)	aeolian loess (4·8—4·9)	0·25—0·1	0·41	52	10	1	13	5	1	8	2	40	1	3	4	1	7	4
		0·1 —0·06	0·82	24	13	1	9	7	2	6	—	34	1	10	4	1	2	10
		0·06 >	0·18	38	5	—	8	4	2	7	—	13	1	16	5	—	3	36
B Kozar Belene (Bulgaria)	aeolian loess (ca 5·0)	0·25—0·1	2·70	32	3	1	78	5	1	2	—	8	1	+	1	—	—	+
		0·1 —0·06	7·10	32	11	—	36	4	3	6	—	23	5	3	3	—	1	5
		0·06 >	0·50	31	3	2	8	5	2	5	—	24	3	14	1	—	3	30
C Lublin — Rury 2 (Poland)	aeolian loess in terrace (3·75—4·25)	0·25 >	0·10	22·0	6·8	—	1·3	—	1·3	0·6	0·6	20·5	1·3	3·8	5·8	—	16·0	42·0
	alluvial loess — inundation facies (7·75—8·25)	0·25 >	0·12	23·8	7·5	—	4·4	—	4·6	2·2	—	28·5	—	11·4	4·0	—	10·0	27·4
	fluvial sands — bed facies (10·6)	0·25 >	0·20	29·5	2·7	—	0·6	—	1·4	4·3	—	54·8	—	0·6	19·6	—	8·7	7·3
C_1* Puławy – Włostowice (Poland)	dune sands	0·25—0·1	0·24	21·7	2·3	—	0·4	—	5·7	0·9	—	75·1	0·4	1·8	5·7	—	3·6	4·1
Zemborzyce near Lublin (Poland)	dune sands	0·25—0·1	0·16	20·2	3·0	—	—	—	7·3	3·5	—	67·0	—	1·8	6·5	—	6·6	4·2

* Data for dune sands from Puławy and Zemborzyce composed according to J. Morawski [„Osady piaszczyste Wyżyny Lubelskiej" (Sandy deposits in the Lublin Upland), Univ. MCS, Lublin, 1965].

2 • 88 g. In each sample the following were determined: a) the amount of heavy minerals in relation to the weight of the whole sample, b) the mineral components, based on analysis of 300—500 grains, c) the size of the grains: measurement of their longest axis. When establishing the composition, opaque and transparent minerals were dealt with separately. The amount of the former was established in quantitative percentages of all the grains analysed. The amount of the various kinds of transparent minerals was established in relation to the sum of grains of this group only.

The results obtained by this method should not be directly compared with results obtained by other methods. In particular it is not possible to compare the results of investigations of heavy minerals in various fractions of grain size. The amount of these oscillates greatly in the various fractions. This can be clearly seen in Table 1. The data were obtained by the method described, but the analyses were made separately for the 3 different fractions.

INTERPRETATION OF THE RESULTS OF HEAVY MINERALS ANALYSES IN THE LOESSES OF THE EASTERN PART OF CENTRAL EUROPE

By the method described, 120 samples of loess deposits from various regions of the eastern part of Central Europe were analysed; 103 of the samples were taken in 14 profiles of deep loess covers containing fossil soils. One hundred samples were taken from loesses from the last Glacial and 20 of the remainder from older loesses and soils. Non-weathered (carbonate) loesses account for 78 samples, and 42 are from soil levels. For comparison, simultaneously 30 samples of other Quaternary deposits occuring near the loess profiles examined, or subjacent, were also investigated. Since differentiation in the composition of the minerals investigated is considerable in the various levels of the same profile, mean values were widely used in the editing of the data. It appears that the number of samples investigated allows the authors to treat these mean values as being representative to some extent. Thus they have been employed in the setting out of Table 2.

The loess deposits investigated — especially their typically aeolian facies — can be clearly distinguished from the Quaternary deposits. Thus, for example, they differ from aeolian sands in smaller weight and different mineral composition. This is conditioned by: a) difference in the grain caliber of the deposits compared, b) the differing grain size of the various minerals. Among the investigated fractions of grain size

TABLE 2. Content of heavy minerals in fractions of less than 0·25 mm

No.	Country and place of taking sample	Determination of deposit investigated and its age	Determination of analysed samples (depth of taking the sample in metres)	Content of heavy minerals in %% weight	Opaque minerals in %%
	POLAND				
1	Kazimierz on the Vistula	Loess (Würm)	1 sample (4·0)	0·12	36·0
2	Lublin — Rury 1	Loess (Würm)	1 sample (10·75—11·25)	0·06	20·0
3	Hulcze to E of Tomaszów Lubelski	Loesses (Würm-Riss)	mean of 5 samples	0·05	34·8
4	Hulcze to E of Tomaszów Lubelski	Loess soils (Holoc.-Eem)	mean of 9 samples	0·06	39·4
5	South-eastern Poland	Loesses (Würm-Riss)	mean of 47 samples	0·10	28·6
6	South-eastern Poland	Loesses and soils	mean of 56 samples	0·10	30·4
	BOHEMIA				
7	Sedlec near Prague	Loesses (Würm-Preriss)	mean of 7 samples	0·20	39·4
8	Sedlec near Prague	Loess soils (Würm-Preriss)	mean of 10 samples	0·18	40·4
9	Sedlec near Prague	Loesses and soils (Würm--Preriss)	mean of 17 samples	0·19	40·0
	HUNGARY				
10	Tapiószentmarton to E of Budapest	Loess (Würm)	1 sample (2·0)	0·35	30·1
11	Tapiószentmarton to E of Budapest	Loesses and soils (Würm)	mean of 7 samples	0·55	28·6
	RUMANIA				
12	Slatina on the Olt	Loess (Würm)	1 sample (6·0)	0·14	26·6
13	Bucuresti	Loess (Würm)	1 sample (2·0)	0·08	32·5
14	Boujoru on the Danube to the SW of Giurgiu	Loess (Würm)	1 sample (10·0)	0·12	31·1

in samples of loess deposits from the eastern part of Central Europe

Content of transparent minerals in percentages (Σ = 100%)															Weathering coefficient*
Amphibole	Andalusite	Apatite	Biotite	Chlorite	Disthene	Epidote	Glaukonite	Garnet	Pyroxene	Rutile	Staurolite	Sillimanite	Tourmaline	Zircon	
10·0	—	1·0	3·0	1·0	1·0	—	+	14·0	—	18·0	1·0	—	11·0	40·0	2·54
5·3	—	0·7	2·7	—	1·3	1·3	1·0	25·9	—	9·3	2·0	—	10·0	40·5	1·76
2·8	—	0·4	4·4	0·2	2·4	1·0	0·4	26·2	0·2	17·0	2·0	—	4·0	39·0	1·84
4·0	+	0·7	3·8	0·3	2·0	0·7	0·9	21·7	0·1	17·1	1·2	+	4·2	43·3	2·19
6·0	+	0·3	3·8	0·6	2·6	0·9	1·9	19·8	0·2	13·6	2·2	+	9·8	38·2	2·14
5·7	+	0·4	3·8	0·6	2·5	0·9	1·8	20·1	0·2	14·2	2·0	+	8·9	39·0	2·14
12·5	—	0·2	5·9	—	2·7	3·1	—	18·5	7·4	12·3	1·6	—	7·0	28·7	1·10
10·4	—	0·2	4·0	—	3·0	2·5	—	17·0	4·7	15·0	1·1	—	6·8	35·2	1·57
11·3	—	0·2	4·8	0·1	2·8	2·7	—	17·7	5·8	13·9	1·3	—	6·9	32·5	1·35
5·6	—	1·0	2·0	—	5·1	5·5	—	24·2	1·6	22·8	1·0	—	6·2	25·0	1·50
3·9	—	0·9	2·2	0·1	3·8	4·1	0·2	33·2	1·0	13·6	1·9	0·1	5·5	29·6	1·20
9·2	—	0·5	10·4	4·3	1·9	1·9	—	30·5	1·9	8·1	0·5	0·5	3·3	27·0	0·72
8·8	0·7	1·5	4·4	1·5	2·7	7·3	—	41·0	2·3	6·0	11·7	0·7	4·1	7·3	0·49
9·1	—	0·6	5·9	1·1	1·0	6·5	—	37·5	3·7	11·9	1·6	0·6	3·1	17·4	0·55

No	Country and place of taking sample	Determination of deposit investigated and its age	Determination of analysed samples (depth of taking the sample in metres)	Content of heavy minerals in %% weight	Opaque minerals in %%
15	Galati on the Danube	Loess (Würm)	1 sample (15·5)	0·08	32·5
16	Southern Rumania (Cîmpia Romîna)	Loess (Würm)	mean of 11 samples	0·11	30·6
17	Southern Rumania (Cîmpia Romîna)	Loess soils (Würm-Eem)	mean of 9 samples	0·22	32·4
18	Southern Rumania (Cîmpia Romîna)	Loesses and soils (Würm--Eem)	mean of 20 samples	0·16	31·4
	BULGARIA				
19	Gomotarcy on the Danube to the N of Vidin	Loess (Würm)	1 sample (3·0)	1·09	22·1
20	Kozloduy on the Danube to the E of Lom	Loess (Würm)	1 sample	2·98	18·6
21	Kozar Belene on the Osym to the E of Pleven	Loess (Würm)	1 sample	1·42	29·0
22	North-western Bulgaria	Loesses (Würm-Riss)	mean of 9 samples	1·78	27·3
23	North-western Bulgaria	Loess soils (Würm-Riss)	mean of 11 samples	0·89	31·2
24	North-western Bulgaria	Loesses and soils (Würm--Riss)	mean of 20 samples	1·29	29·4

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* Weathering coefficient was calculated as the quotient of the number of resistant minerals biotite, epidote, garnet, pyroxene and syllimanite). When this coefficient was calculated, chlorite

distribution, the richest in heavy minerals were the largest in grain size: the sandy fraction 0·25 — 0·1 mm. The smallest — less than 0·06 mm (Table 1, A and B). Thus, the content of minerals investigated in dune sands is usually greater than in loesses. The average size of the various kinds of grains is also extremely varied. Biotite and amphibole usually

Content of transparent minerals in percentages (Σ = 100%)															Weathering coefficient*
Amphibole	Andalusite	Apatite	Biotite	Chlorite	Disthene	Epidote	Glaukonite	Garnet	Pyroxene	Rutile	Staurolite	Sillimanite	Tourmaline	Zircon	
8·7	—	3·1	5·4	2·4	1·2	7·5	0·6	38·0	1·8	11·2	1·2	—	2·6	16·3	0·50
7·8	0·1	2·5	6·7	2·3	1·9	5·4	0·1	35·8	3·2	9·5	2·9	0·2	2·8	18·8	0·58
7·9	0·1	1·9	5·3	2·7	2·0	4·9	0·1	32·9	3·1	11·4	4·2	+	2·3	21·1	0·73
7·8	0·1	2·2	6·1	2·5	2·0	5·1	0·1	34·5	3·2	10·4	3·5	0·1	2·6	19·8	0·65
9·1	—	—	4·7	2·4	5·9	4·1	—	34·5	3·4	9·0	5·3	—	3·1	18·5	0·75
5·7	—	2·0	27·2	4·3	1·9	2·1	—	28·7	2·8	8·1	2·8	—	3·3	11·1	0·40
8·7	—	2·8	31·7	7·0	2·7	2·7	—	19·3	4·0	7·3	0·9	—	2·1	10·8	0·34
7·4	—	1·6	23·7	3·7	3·0	3·8	—	27·8	4·1	7·6	2·1	0·1	2·8	12·4	0·41
7·7	—	2·1	15·7	3·2	3·1	5·4	—	32·3	4·4	9·3	2·9	—	2·6	11·3	0·43
7·6	—	1·9	19·3	3·4	3·1	4·7	—	30·2	4·3	8·5	2·5	+	2·7	11·8	0·42

(andalusite, disthene, rutile, staurolite, tourmaline, zircon) and less resistant (amphibole, apatite, and glauconite were omitted as difficult to classify from the standpoint of resistance.

occur in larger grains than zircon and rutile. Garnet in certain regions occurs chiefly in the larger grains (Poland), and in others in medium — size or even smaller grains (Bulgaria). The proportions of garnet and zircon are worthy of special attention. The former occurs in eastern Poland in far larger grains than the latter. Thus, in fractions of

0 • 25 — 0 • 1 mm garnet clearly dominates over zircon, and in the fraction of less than 0 • 06 mm the reverse is true (Table 1, A). If then, from the loess we isolate the untypical sandy fraction, the mineral composition will be similar to that of dune sand, for which this fraction is most typical (Table 1, C_1). Similar relations are also found when comparing aeolian loess and fluvial sand (Table 1, C). It should be emphasized that in addition to zircon and garnet, more distinct norms in the proportions of various grain size groups are shown by biotite, amphibole and rutile. The proportions of other minerals are not clearly differentiated according to the size of the fraction.

The peculiarity of the content of heavy minerals in loesses is thus conditioned to a considerable extent by their particular granulation. This strictly corresponds to the sedimentation milieu in which these deposits were formed. Thanks to this, we have a basis for using the results of our analyses for drawing conclusions on the conditions of loess accumulation.

The results obtained indicate the considerable spatial differentiation of the content of heavy minerals in loesses (Table 2). In these deposits in south-east Poland the most important are: 1 — zircon (38 • 2)[1], 2 — garnet (19 • 8), 3 — rutile (13 • 6) and 4 — tourmaline (9 • 8). Other authors of the more detailed, current investigations of heavy minerals in the loesses of other regions of Poland obtained similar results (J. Tokarski et al. 1961, B. Grabowska-Olszewska 1963, J. Malinowski 1964). The group of minerals in Bulgarian loesses was found to be quite different: 1 — garnet (27 • 8), 2 — biotite (23 • 7), 3 — zircon (12 • 4), and 4 — rutile (7 • 6). In Rumania they were: 1 — garnet (35 • 8), 2 — zircon (18 • 8), 3 — rutile (9 • 5), and 4 — amphibole (7 • 8). From Hungary we have only one profile from the northern area of the interfluves of the Danube and Cisa. In it the most important are: garnet, zircon and rutile. These modest data can be supplemented from the work of B. Molnar (Földt, Közlöny, 91, 1961). He stated that in the southern area of these interfluves, in the 0 • 125 — 0 • 1 mm fraction, garnet and amphibole dominate and zircon plays a minimum role. Taking into consideration corrections due to the size of the fraction investigated, the following order can be assumed to be the most likely for southern Hungary: garnet, amphibole, zircon. A similar order can be assumed for the loesses of south-west Slovakia, based on the results of the investigations of J. Šajgalik (Acta Univ. Comenianae, Geol. 9, 1965) and M. Mišik

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[1] The percentages of the mean contents of various minerals in non-weathered loesses according to Table 2 are given in brackets.

(Geol. Prace SAV, 43, 1956)[2]. In the Czech loesses according to the present authors' investigations, we have the same minerals in a different order: zircon, garnet and amphibole.

Such great regional differentiation clearly indicates the local origin of the loess material. We shall discuss the consequences of such a statement in our conclusions. At present we should like to draw attention to certain norms of the differentiation of the heavy minerals composition in the area. These norms can be defined as follows. In Polish loesses the resistant components decidedly dominate (zircon, rutile and tourmaline), while in Bulgarian loesses the fairly and weakly resistant minerals dominate (garnet, biotite and amphibole). The loesses of the remaining areas — from the point of view of resistance represent central positions between two extremes. We may thus state: in the direction from north to south, the degree of „freshness" of the group of heavy minerals in loesses clearly rises. This is obvious in the size of the weathering coefficients given in the last column of Table 2.

The differences in the degree of freshness of the group of heavy minerals can be conditioned by: 1) the difference in distance of the loess areas from the alimentation basins with numerous outcrops of igneous rock and 2) the difference in the geographic conditions of weathering and production of pulverulent materials.

It appears that the role of the first factor can most easily be defined by the example of the Bulgarian loesses. They are distinct because of the markedly large content of the minerals investigated in the great percentage of easily weathering biotite[3]. The investigated fraction contains 13 times more heavy minerals than the Polish loesses and 8 times more than the Rumanian ones (Table 2). The difference between them and the neighbouring Rumanian loesses is particularly striking. It seems that this peculiar feature — which compels us to treat the Bulgarian loesses separately — can be connected with the relatively slight distance

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[2] J. Šajgalik stated that in the loesses of the central area of the Vag basin, in fractions of 0·25—0·05 mm, the chief role is played by amphibole, garnet and epidote. In the loesses of southern Slovakia, as M. Mišik states, in this same fraction garnet clearly dominates over amphibole. A correction due to the size of the fraction allows us to put forward zircon for the third or second place in addition to garnet and amphibole.

[3] A large proportion of biotite among heavy minerals corresponds to a large proportion of muscovite in the light components of Bulgarian loesses. According to M. Minkov (Travaux Géol. Bulg., serie strat. tect., 1, 1960) in these loesses muscovite (7—20%) occupies second place after quartz (63—70%) and before feldspars (up to 10%).

from the numerous outcrops of igneous rock, which can be found in the western and central part of the Balkan mountains. The investigated Rumanian loesses are situated, however, at a great distance from the mountains, and what is more, adjacent to that section of the Carpathians in which the role of igneous rocks is slight.

The significance of the second factor, namely the difference in geographical conditions, can be seen from the regularity of changes in the meridian direction. The increase in the degree of freshness of the mineral content towards the south can be associated with the decrease in the humidity of the climate in the same direction. In the south, drier and less frosty, both at present and in the Pleistocene, chemical and mechanical weathering was slighter than in the north. A comparison of the results of the analyses of non-weathered loesses and soil horizons, shows how greatly the weathering process affects the formation of the heavy minerals content. This can be seen best in the results of the investigations of the profile at Sedlec near Prague (Table 2). In one loess profile in which fossil soils were investigated in Poland, the differences in the degree of weathering are far slighter. This could probably be explained by the fact that the material of the Polish loesses has already reached a high level of weathering selection. It is however difficult to observe the effects of weathering in the soils of the loesses peculiar to Bulgaria. It may be supposed that this is one of the consequences of the considerable biotite content. In non-weathered loesses this mineral dominates in the large fraction (Table 1, B), and in soil horizons the maximum proportion is clearly seen to be in the smaller fractions. This is the result of the swift breaking-up of grains of this mineral. This fact seriously complicates the system of the proportion of the content of the various minerals in soil horizons. It can most obviously be seen on the example of very resistant zircon. In soil horizons its proportion in percentages is on average slightly less than in non-weathered loesses (Table 2).

The results of microscopic measurements of the lenght of grains of heavy minerals are interesting. The present report would, however, be distorted out of all proportion if it undertook a full interpretation of them. Thus, we draw attention only to one aspect. It appears, from the authors' measurements that the median of grain caliber distribution is clearly enough connected with the content of heavy minerals. In loess profiles in which "large-grained" garnet decidely predominates over "small-grained" zircon, the mean size of grains is greater than when the proportions of these two minerals are reversed. Thus, for example, in Polish loesses the median for all grains of transparent minerals is usually 0·04 — 0·5 mm, and in Rumanian loesses 0·06 — 0·07 mm.

It should be emphasized here that this is probably not an effect of the general grain size distribution. The loesses compared do not differ seriously in their granulation.

CONCLUSIONS ON THE CONDITIONS OF LOESS ACCUMULATION

1) The considerable regional differentiation in the proportions of the heavy minerals found, indicates the chiefly local origin of loess silt. This theory was previously put forward in rather a sporadic manner (e. g. A. Vendl et al. 1935). For 20 years, however, it has been more frequently advanced in opposition to the previously accepted theory that the silt was transported from great distances (V. Ambroz 1947, A. Ma- 1964, J. Sajgalik 1965). In Polish literature it was particularly strongly licki 1950, A. Jahn 1956, M. Misik 1956, M. Minkov 1960, H. Maruszczak supported by A. Malicki (1950), and this affected the views of other authors (e. g. A. Jahn 1950 and 1956). In many publications, however, the view of transport from a considerable distance still predominates. Thus, for example, P. Krivań (1953) made the charge that the results of analyses of heavy minerals in the loesses near Budapest cannot be the basis of determination of the origin of the basic silt fraction of these deposits. He considered that these minerals play a more important role only in larger fractions. He also assumed that these fractions only represent local elements, transported by west winds. He associated the typical silt with transport from a considerable distance to the east. This view was accepted and is supported by L. Moldvay (1963) inter alia. Thus, it would be useful to compare all the arguments pro and contra. The following arguments are against the theory of the deciding role of transport of the silt from a considerable distance:

a) The considerable content — observed by us — of heavy minerals and the regional nature of their grouping in fractions typical for loesses.

b) The marked differentiation in the composition of light minerals (M. Minkov 1960, H. Maruszczak 1964, J. Sajgalik 1965).

c) The fact that the material now settling (transported as a suspension in the atmosphere at great heights and from a great distance) is composed of clay fractions with mean measurements of 0·005—0·003 mm (J. Tokarski 1936, A. Malicki 1950, J. Wojtanowicz and A. Zinkiewicz 1966).

d) Considerable differentiation and certain regional regularities in the distribution of loess covers, which do not form a uniform sheet (A. Malicki 1950, A. Jahn 1956, H. Maruszczak 1964).

A consequence of the theory of the local origin of the greater part of loess silt is the association of its accumulation with low winds. This gives a basis for the definition of the dynamic conditions of this accumulation and thus indirectly of the reconstruction of the directions and velocity of the winds (A. Jahn 1956, H. Maruszczak 1964).

2) A distinct effect of weathering-soil-forming processes on the formation of the complex of heavy minerals was observed. This finds expression in the proportion of more resistant components to the less resistant ones. It was found that the weathering coefficient of heavy minerals decreases from the north (Poland) to the south (Rumania, Bulgaria). This is the result not only of the geological-petrographical peculiarities of the various regions, but also the difference in geographical conditions. In the north, in the Pleistocene and Holocene, the climate was generally more humid and frosty than in the south. This decided the considerable difference in the force of the effects of physical and chemical weathering. Therefore the material from which loess accumulated in a periglacial zone derives (Poland, Czechoslovakia) shows signs of much greater destruction than that of loesses accumulated in the temperate zone (Rumania, Bulgaria). A similar theory was put forward by H. Maruszczak (1964) on the basis of the results of investigations on the wear of quartz grain in loesses. Destruction of heavy minerals should probably, however, be associated not so much with physical forces — as in the case of wear of quartz grains — as with chemical ones.

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L'ACTIVITÉ ÉOLIENNE EN TANT QU'UN DES PLUS IMPORTANTS PROCESSUS MORPHOGÉNÉTIQUES ACTUELS DANS LE CLIMAT TEMPÉRÉ HUMIDE

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Dans la zone des climats tempérés, à humidité modérée et humides, dans les régions de montagnes moyennes et basses et de plateaux, on considère que les principaux processus morphogénétiques sont les suivants: l'érosion fluviale, le ruissellement, l'accumulation, les mouvements en masse et la dissolution. En général dans cette zone on n'attribue pas de grande importance à l'activité du vent dans le modelage du relief [8] excepté dans les terrains couverts de sables mouvants où se forment des dunes. En Europe on ne souligne une activité destructive du vent connue sous le nom de "tempêtes noires", que dans les régions de steppes en URSS [7]. On a enregistré également dans quelques travaux concernant le territoire de la Pologne des manifestations relativement récentes, de déflation et d'accumulation des poussières éoliennes. Dans quelques uns d'entre eux [10, 11, 13] il est question de la sédimentation des poussières amenées de loin et la possibilité de formation de loess qui en découle; dans d'autres [5, 9, 12], la déflation et l'accumulation éoliennes de provenance proche. Ces derniers travaux concernent le territoire de la Pologne centrale et septentrionale et contiennent pour la première fois des données quantitatives. Dans la Pologne méridionale, sur les territoires fortement dégradés de la partie externe des Carpathes nommés *Pogórze* Carpathique, l'étude des couvertures de poussières rencontrées ici communément, a ammené à la conclusion que les principaux agents ayant apporté la formation de ces couvertures, ont été la solifluction et le ruissellement des produits d'altération formés dans la phase anaglaciale de la glaciation baltique (Würm) de roches schisto-marneuses du flysch carpathique [1].

De nombreuses observations effectuées par les auteurs de cet article dans différents points du Pogórze, durant ces dernières 15 années, démontrent que le processus de déflation et d'accumulation éolienne des matériaux provenant du sol (surtout sur la neige) doit être considéré comme un des principaux processus morphogénétiques actuels sur ce territoire (voir aussi [14, 15]).

Cette constation a été appuyée sur des mesures quantitatives détaillées faites par les auteurs de cet article en hiver et au printemps de 1965 aux environs de Krosno.

Le Pogórze Carpathique — terrain de nos observations et de nos mesures — représente une des plus importantes régions de la Pologne méridionale. Au Sud de ce territoire s'élève une chaîne de montagnes de hauteur moyenne, les Beskides — la principale chaîne des Carpathes. Au Nord le plateau du Pogórze Carpathique descend en seuil vers la région de la dépression précarpathique.

La région du Pogórze Carpathique d'une largeur de 30—60 km représente la partie extérieure des Carpathes polonaises. Elle est fortement dégradée, formée de couches du flysch crétacé-paléogène fortement plissées d'une hauteur absolue de 300—500 m, avec des fragments de petite étendue de restes d'une surface d'aplanissement pontique se présentant sous forme de bosses doucement arrondies, orientées O—E, ONO——ESE et NO—SE. Ces bosses sont séparées par de nombreuses vallées (le plus généralement d'une profondeur de 20 à 100 m) en berceau, à fond plat, ou en V. Leurs pentes ont le plus souvent de 10° à 30° d'inclinaison.

Ce territoire, pendant la glaciation Cracovienne (Mindel) était couvert dans sa partie septentrionale par un glacier continental et pendant les glaciations posterieures (Riss, Würm) il se trouvait dans la zone périglaciale on périnivale. Au début de l'Holocène il était couvert par une forêt ininterrompue d'arbres d'espèces caduques et peristantes et ensuite il était graduellement déboisé en résultat de l'activité de l'Homme. Au cours du dernier millénaire il est devenu un terrain de culture intense. Actuellement les surfaces cultivées occupent 90% de la superficie totale dont la plus grande partie est soumise à des labours réguliers. Les fonds de vallées sont en grande partie couverts de prairies et de pâturages. Les forêts comprennent 5—20% de la superficie totale, et elles se trouvent d'ordinaire sur les pentes abruptes des vallées et sur les plus importantes crêtes.

Le climat de la région en question est pluvio-nival, tempéré chaud, transitoire entre le climat océanique et continental. Il peut être caractérisé par les données moyennes de la période 1951—1962 [3]: température le l'année — +8,0° C, janvier — —2,0° C, juillet — +18,5° C, minimum absolu — —25,0° C, maximum absolu — +37,0° C, journées de gel permanent — 55, journées de gelée matinale — 85, hauteur totale de la précipitation atmosphérique — 800 mm, nombre de journées à couverture de neige — 65, durée de la végetation — environ 200 jours,

jours à vent $\geqslant$ 5 m/sec. — 90, direction dominante des vents — du S et SO.

On a effectué les mesures détaillées en hiver et au printemps 1965 dans plusieurs localités situées au Sud — Est de Krosno. Ce terrain est constitué par des couches de Krosno inférieures (flysch oligocène) plissées, représentées par des schistes marneux siltitiques intercalés de bancs minces et moyens de grès à grain fin et par des grès friables en bancs épais.

On a spécialement étudié la surface des bosses arrondies d'une hauteur absolue d'environ 350 m, séparées par des vallées à fond plat d'une profondeur d'environ 50 m, dont les pentes avaient des inclinaisons atteignant 15°. Les bosses ainsi que les vallées étaient utilisées par l'agriculture. Dans leur voisinage immédiat il n'y avait aucun obstacle (bâtiments, bosquets, clôtures) offert aux vents du Sud qui soufflent avec la plus grande force à la fin de l'automne, en hiver et au début du printemps [4], quand les champs sont labourés et qu'il n'y a aucune végétation. Ce terrain se trouve à environ 25 km au Nord du col de Dukla (503 m d'altitude) dans la chaîne principale des Carpathes. Dans cette zone aussi bien la déflation que l'accumulation éolienne sont actuellement fortement accentuées.

Sur les bosses on a observé des zones de déflation et d'accumulation éolienne, semblables à celles observées par Rockie [6] aux Etats Unis, avec cette différence qu'ici on distingue dans la zone d'accumulation plusieurs sous-zones se différenciant entre elles sous le rapport de la quantité de matériaux organo-minéraux apportés par le vent sur la neige sous-jacente, de leur granulométrie et des microformes formées par ces materiaux (Fig. 1).

Sur les versants au vent ainsi que sur les sommets arrondis des bosses on a constaté les traces d'une forte déflation (balayage de la neige, de chaume, des particules de terre). Sur la surface même du terrain on

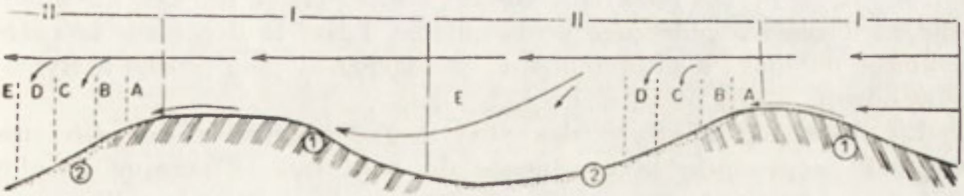

Fig. 1. Activité éolienne sur le profil transversal de deux collines au Sud-Est de Krosno

I zone de déflation. II zones d'accumulation éolienne: A. faible supérieure, B. modérée supérieure, C. maximum, D. modéré inférieure, E. faible inférieure, 1. flysch oligocène, 2. couverture de limons. La flêche indique la direction du vent

Fig. 2. Neige couverte d'une couche de 2 cm de matériaux éoliens provenant du sol avec une linéation nette de débris végétaux — zone B

a observé des produits d'altération riches en débris des roches flyscheuses sous-jacentes.

Sur les versants sous le vent on a constaté la présence de plusieurs zones d'accumulation dans lesquelles les matériaux grossiers consistaient en petites mottes (agrégats) de sol, débris de schistes (jusqu'à 30 mg) et de résidus de plantes. On pouvait remarquer que les débris de plantes, dans le dépôt accumulé, étaient régulièrement orientés dans la direction de leurs axes longitudinaux (Fig. 2).

Les mesures de cette orientation, selon l'endroit où elles avaient été faites ont donné des directions variant entre 345° et 15°. Ces directions sont conformes à celles des vents qui ont laissé le dépôt sur la neige (données obtenues à la station météorologique la plus proche à Rymanów Zdrój).

La dispersion observée des directions d'orientation des éléments végétaux dépend de la confluence du vent qui se marque le plus fortement aux bords opposés du versant sous le vent de la colline dans le cas où celle-ci se rapproche par sa forme d'un cône tronqué ou arrondi. Ces observations indiquent la méthode à suivre pour mesurer les direction de transport des materiaux éoliens quand on ne peut pas identifier immédiatement la direction du vent.

Fig. 3. Fragment de la zone C avec des formes „barkhanoïdales" — à droite on voit des fragments de formes en cordes, passage à la zone B

Sur le profil transversal du versant sous le vent, on a distingué en allant du sommet à la base les zones suivantes d'accumulation éolienne sur la neige (Fig. 1):

A. Zone supérieure d'accumulation faible de matériaux à gros grain (prédominance >2 mm) amassés dans les concavités du microrelief comme rigoles, sillons; la répartition et la disposition de ces matériaux vers le bas indiquent une traction superficielle et une saltation comme mécanisme de transport des matériaux grossiers.

B. Zone supérieure d'accumulation modérée des matériaux grossiers sur une largeur de 10 à 30 m, sous forme de structures en corde à torsions réitérées mais généralement toujours orientées conformément à la direction du vent. L'épaisseur du dépôt change le long de son parcours de 1 à 10 cm et entre les différentes cordes de 0 à 1 cm, donnant en moyenne environ 0,5 cm ce qui fait 5000 m^3 au km^2.

C. Zone d'accumulation maximum (Fig. 3) de matériaux grossiers et moyens ($77\% > 1$ mm) sur une largeur de 50 à 150 m sous forme de structures „barkhanoïdales" (Fig. 4) à noyau de neige et une couverture épaisse, presque continue, de dépôt de particules du sol (2—5 cm, en moyenne 3,5 cm $=$ 35 000 m^3 au km^2). La hauteur de ces structures est

Fig. 4. Coupe d'une forme „barkhanoïdale" montrant le noyau de neige avec de minces couches à stratification oblique de neige mêlée de matériaux de sol ainsi que couverture de 3 à 10 cm d'épaisseur de d'épôt éolien provenant du sol, plus recente et sus-jacente

d'environ 0,5 m, leur longueur d'ordinaire de 3 m et leur largeur atteint 2 m. Le plus souvent elles se groupent en rangs serrés.

D. Zone inférieure d'accumulation modérée de matériaux à grain moyen ($17\% > 1$ mm) d'une largeur de 10 à 50 m sous forme de lambeaux linguiformes allongés sur une longueur d'environ 40 m (Fig. 5) ainsi que de structures en cordes semblables à celles rencontrées dans la zone B. L'épaisseur moyenne du dépôt de terre est ici d'environ 1 cm = 10 000 m^3 au km^2.

E. Zone inférieure d'une faible accumulation de materiaux fins s'étendant sous forme d'une couverture mince et plutôt régulière, disparaissant à la base de la colline suivante.

En plus de zones décrites plus haut d'accumulation éolienne intense et différenciée sur les versants sous le vent, une sédimentation éolienne importante se produit également dans les congères de différentes sortes liées à des obstacles et que l'on rencontre aussi bien sur les versants que sur les terrasses et très souvent derrière les ruptures convexes des versants où l'inclinaison des pentes augmente tout à coup, ou bien derrière celles qui se trouvent entre les versants plus anciens et les

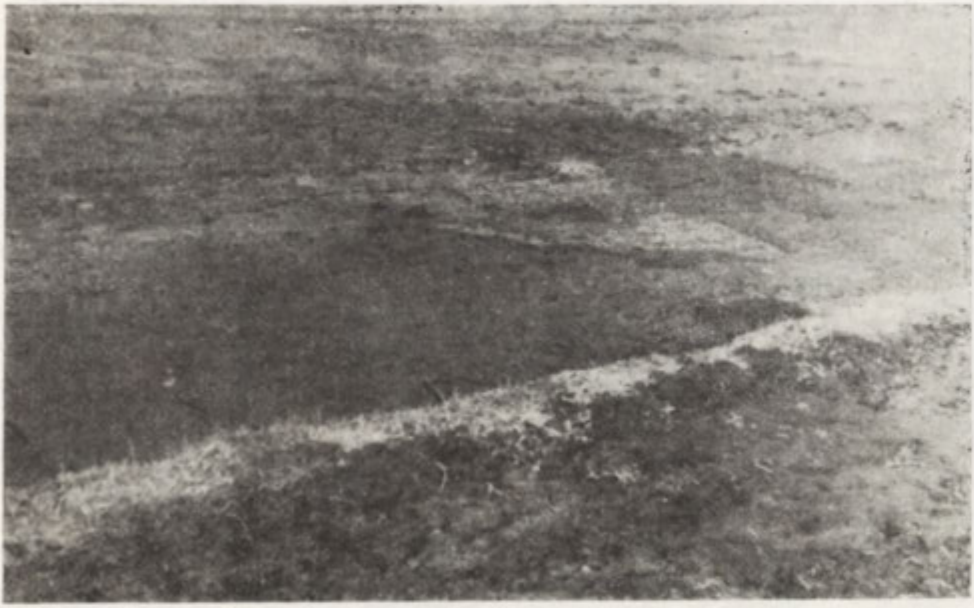

Fig. 5. Fragment de la zone D avec accumulation de matériaux éoliens provenant du sol sous forme de larges langues

pentes abruptes des vallées plus jeunes d'érosion et de dénudation (Fig. 6). Dans des congères de ce genre on a observé une alternance de couches de neige pure et de neige mélangée à une quantité plus ou moins grande de dépôt provenant de la déflation du sol. Les mesures faites dans quelques unes de ces congères à Łężany, près de Krosno ont dénoté une épaisseur d'environ 2 cm de dépôt — consistant pour la plupart en poussières — ce qui donnerait 20 000 m³ au km².

Après la fonte de la neige les matériaux éoliens se déposent sur la surface du terrain et forment une sorte de croûte qui, à mesure qu'elle s'assèche craque en un réseau de crevasses de disseccation et s'unit

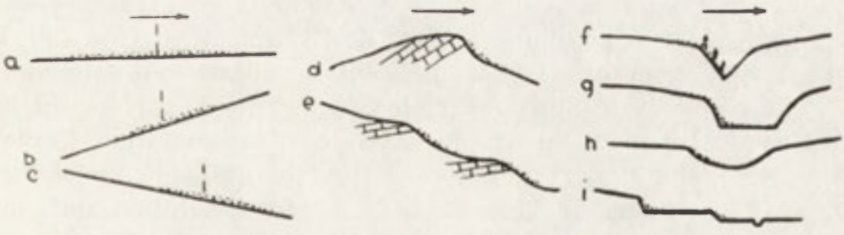

Fig. 6. Exemples de l'accumulation éolienne liée aux obstacles et aux ruptures

a — c obstacles sur des surfaces plattes et sur des versants, d — e ruptures structurales des versants, f — h ruptures convexes des jeunes vallées i — ruptures convexes des terasses ensuite à la terre arable sous l'action de la végétation printanière. Cependent, les matériaux ne restent pas en place en entier: une grande partie en est emportée par l'ablation causée par les eaux de fonte des neiges. Une partie de ces derniers matériaux s'accumule sur les basses parties du versant et à son pied, le reste s'en va avec les eaux dans les rivières où il devient une des principales sources des matériaux transportés et déposés par elles à cette époque. De plus, les produits de l'accumulation éolienne sur les parties supérieures des pentes à mesure qu'elles augmentent en épaisseur deviennent l'objet d'une lente action de la gravitation. Il faut donc prendre en considération non seulement la sédimentation éolienne directe qui apparaît sur une grande échelle, mais aussi son influence indirecte sur l'accumulation causée par d'autres processus.

Les observations faites en différents points du Pogórze Carpathique ainsi que les mesures détaillées des convertures d'accumulation éolienne sur la neige dans les environs de Krosno, unis à la fréquence des phénomènes décrits qui se répètent tous les ans avec une intensité plus ou moins grande, montrent le rôle énorme de la déflation et de l'accumulation éolienne dans le climat tempéré-humide. Ce processus se développe surtout à la fin de l'automne, pendant l'hiver et au début du printemps, tandis que pendant les autres saisons, par suite du développement d'une végétation abondante et aussi d'une plus grande rareté et d'une moindre intensité des vents violents, ce processus est beaucoup plus faible et seules les surfaces des routes, et de différentes sortes de remblais artificiels restent sujets à la déflation.

Pour illustrer l'importance des processus éoliens actuels dont l'échelle est exprimée ici par les accroissements des dépôts en m^3 au km^2 par an (0—35 000) nous citons les données quantitatives touchant d'autres processus [2] en m^3 au km^2 par an. Erosion fluviale = sont emportés du bassin: matériaux en suspension — 50, matériaux entraînés et emportés par saltation — 15, matériaux en dissolution — 26. Ruissellement sur les pentes de 5° à 30°: terres labourées — 2500, pâturages — 3, prairies — 0,4, forêts avec sous-bois — 0,3. Mouvements en masse — selon les calculs préliminaires pour une surface de 23 km^2 — environ 300. Il faut cependant souligner que la déflation et l'accumulation éolienne ne se développent seulement que sur certains secteurs de la surface du terrain, de même que les mouvements en masse et l'accumulation fluviale, et, en opposition, d'une part à l'érosion fluviale qui agit linéalement de l'autre aux processus de ruissellement et de dissolution qui ont lieu sur toutes les surfaces possédant une inclinaison quelconque.

L'influence défavorable des processus éoliens sur l'agriculture est évidente. Sur les surfaces qui sont l'objet de son action, la déflation agissant directement et mécaniquement sur la végétation provoque non seulement sa destruction mais aussi l'élimination successive des couches fertiles du sol. Dans la zone d'une accumulation éolienne particulièrement intensive la végétation est détruite par ensevelissement sous une couche trop épaisse de matériaux éoliens et aussi par ce que la couche de neige protégée par les matériaux amenés par le vent, s'y maintient plus longtemps.

Dans de telles conditions un microclimat désavantageux, un haut degré de saturation du sol avec de l'eau ainsi que l'arrêt de la circulation de l'air amènent la destruction des emblavures d'automne sur d'importantes surfaces. Cela oblige les cultivateurs à répéter les semailles au printemps ou à passer de la culture des céréales à celle des plantes sarclées. D'une façon générale ce processus fait subir à l'agriculture des pertes importantes.

Tandis que les versants au vent sont dénudés, souvent jusqu'au sous-sol, sur les versants sous le vent, où on observe une accumulation éolienne intensive, apparaissent d'épaisses couvertures de limons auxquelles on attribuait jusqu'à présent différentes sortes de genèses et l'âge pleistocène. Il semble que ces couvertures se sont formées pour une grande part en résultat d'une accumulation éolienne dans l'Holocène le plus récent, par suite du déboisement du terrain par l'Homme. Les mesures des différentes valeurs donnent en effet dans les points de la plus grande accumulation une valeur moyenne de 3,5 m d'épaisseur du dépôt seulement durant les 100 dernières années, ce qui, si l'on considère la réduction liée à l'ablation et à la compaction du dépôt, donne des grandeurs d'un ordre imposant, montrant la grande importance des processus éoliens actuels dans la transformation du relief des montagnes basses fortement dégradées ainsi que celui des plateaux dans la zone du climat tempéré du type de l'Europe centrale.

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THE ANNUAL RHYTHM OF MORPHOGENETIC PROCESSES IN SPITSBERGEN

ZDZISŁAW CZEPPE

In 1957/58, 1959 and 1960 the author carried out investigations in the Hornsund region and along the Sörkappland shores in Spitsbergen on how the morphogenetic processes vary, in space and in different seasons. These studies concerned: 1. rock weathering due to frost and chemical action; 2. gravity processes, like debris fall and solifluxion; 3. thermal processes in the ground, such as the formation of fibrous ice, frost swelling, the formation of hydrolaccoliths, and frost cracks in the ground; 4. aquatic processes: erosion and accumulation caused by flowing water; 5. eolian processes: eolian deflation and accumulation. The author supplemented his observations and measurements with laboratory examinations and by correlating the results with his own observations of the course of meteorological phenomena and of the thermal and humidity conditions of the ground.

CLIMATE

The climate of the region under discussion is marked by a mean annual temperature of —7·61° C, a mean temperature of the warmest month (July) of +5·4° C, a mean temperature of the coldest month (February) of —18·6° C (Knothe [3]), and by abrupt temperature changes in winter. In the profile of the active soil layer the maximum depth of which is more than 1·5 m, the author distinguished 4 thermal zones: 1. the superficial zone, a few centimeters thick, which on the whole reflects the thermal conditions of the ground surface; here the transition periods between winter (permanently frozen) and summer (permanently thawed) extend over a total of 5 months, showing temperature oscillations crossing zero. The soil humidity also changes within wide limits; 2. the transition zone which is up to 30—40 cm in depth. At the top of this zone, the spring oscillations vanish when the temperature passes zero and multigelation occurs only in autumn. Both the summer period (permanently thawed) and the winter period (permanently frozen) are of longer duration; 3. the lower zone in which no periods of multigelation occur, there is only one period of thawed ground (in summer) and one of frozen ground (in winter). The transition from one condition to the other takes place without fluctuations but with growing delay. The lower limit of this zone marks the depth to which ground thaws annually; 4. the zone of sporadical thawing; it constitutes the transition zone to the permafrost base. The above differentiation of the active ground layer is of essential significance for the course of frost-upheaving of rock blocks and for sorting grain fractions.

The annual precipitation was: 309 • 8 mm (in 1912—1921) at Green Harbour (Knothe [3]), only 300 mm (in 1947—1954) at Isfiord Radio, and 346 • 8 mm (in 1957/58) at Hornsund. The author is fully aware of the inaccuracy of the precipitation measurements made under arctic conditions and attaches weight to Kuziemski's [4] calculations, according to which the surface run-off in the Revelva drainage basin was 320—410 mm; on this basis he estimated the annual sum of precipitation to be about 500 mm. The winter maximum is particularly noticeable. Approximately $^2/_3$ of the annual precipitation is stored in the form of ice and snow in winter and runs off during meltwater flow. The thickness of the snow cover is very uneven.

Wind action is most intensive in autumn (July to October) and least intensive in spring (March to June). Observations at Hornsund revealed for every month of the year at least 3 days with winds reaching velocities up to 20 m/sec., and for every winter month (October to March) from 8 to 16 days with winds of 10 to 20 m/sec. velocities. Sudden gusts cause velocities up to 30 m/sec. or more. In February 1958 the mean wind velocity was 7 m/sec., with maxima during squalls reaching as much as 49 m/sec. According to Makarewicz [5], on the average, strong winds from NE blow during 12 days per month.

FROST WEATHERING

It is commonly believed to be one of the processes predominating in the Arctic. Only a few scientists question what they consider the overrating of the role which frost weathering is supposed to play today on Spitsbergen (Troll [7], Rapp [6]). This process sets in when the rock temperature passes through zero and when the rock is sufficiently water-soaked. The water content depends on rock porosity or jointing, on water being available, and on the land relief. In Hornsund the period in which the ground temperature oscillates above and below zero, lasts about 5 months on the surface and about 3 months at 20 cm depth; temperature oscillations of this type occur much more often on the ground surface than in the meteorological screen. An important part in thermal changes is played by strong winds which cause an abrupt cooling of the rock surface. The maximum values of cooling are 59 • 5 mcal/cm^{-2}/sec^{-1} in July, and as much as 172 • 4 mcal/cm^{-2}/sec^{-1} in January (Wójcik [8]).

The rock formations in the vicinity of Hornsund are greatly differentiated as to jointing and porosity. The most jointed are schists, and the least — the coarse-grained quartzites. However, all the rock types have in common either fracturing or interlaminar fissures into which water penetrates easily. The density of such fissures determines the regolith fractions. Autumn, in which the thermal conditions are most favourable for intensive frost weathering, brings some 30% of the annual precipitation, spring only about 10%. This shows that in the Hornsund region the water supply is ample and that underneath flat surfaces the ground is water-soaked. However, on rock walls and steep slopes the water quickly runs off, and fissures exceeding capillary size will easily run dry. Moreover, since the temperature drops first on the upper slope sections, the water flow from higher up stops while the downslope flow is still possible; in this way water escapes from fissures before it can freeze. Penetration of thermal oscillations into the fissures also facilitates the escape of water temporarily frozen. Thus it is seen, that the reason why frost weathering on steep slopes is at present insignificant, is the lack of water in the rock fissures. An exception to this rule are shore cliffs which from September to November are continuously drenched by stormy wave action. In spring, until the middle of June, frozen remnants of the ice cover cling to the rock, and in pockets firn patches survive. Underneath these forms, the existing microclimatic conditions further processes of frost weathering. Frost weathering is therefore very intensive at the coast.

On coastal plains, between the shore line and mountain slopes, rainfall saturates the active ground layer more or less uniformly, while the thickness of the snow cover differs very much. From winward slopes snow is continuously carried off, whereas on the lee side deep snowdrifts accumulate. In the spring these drifts keep for a long time in the form of firn patches, intensifying frost weathering in their vicinity. The result of these yearly repeated processes is an asymmetry in ridges and hillocks which on their lee sides usually show rock-built undercut slopes.

Thus processes of frost weathering are distinctly differentiated in space, from a high intensity along the coast to a very feeble intensity on mountain slopes — caused by differences in the amount of water retained in rock fissures during the multigelation period. Frost weathering is most intensive in autumn.

CHEMICAL WEATHERING

In spite of low temperatures, chemical weathering commonly takes place in the Arctic and many of its features are observed, such as salt crusts, weathering aureoles on boulders, or mineral glazings resembling desert varnish. An evolution of soil processes is also noticed. In the Hornsund region intensive corrosion features can be seen on the surfaces of larger pebbles of crystalline and sandstone rock which had been buried in finegrained regolith; this causes quartz grains to protrude from such pebbles.

The moraines of the Sofiebreen glacier are strewn with a large number of ankerite blocks containing galenite. Where these blocks are derived from modern moraines, they show fresh surfaces; taken from a moraine laid down shortly after 1936 they show dulled surfaces with quartz veinlets clearly marked. The surface of boulders from a moraine developed earlier than 1936 is rough, and quartz veinlets and galenite crystals protrude up to 2 mm from the surface. This shows, that during a 15-year period chemical weathering is apt to lower the surface of ankerite boulders about 1 mm.

On the Sörkappland coast, near the neck of the Palffyodden peninsula, Carboniferous sandstones, which built up a 7 m terrace here, are weathering by the rock face "peeling off" in the form of shells. Mineralogical examinations disclosed that the cause of this type of weathering is the passage of iron and silica solutions towards the boulder surface, and due to this the iron emerges onto the surface while the silica recrystallizes near the surface forming a hard crust which later falls off (Czeppe [1]).

The surfaces of quartz grains in the metamorphic schists containing pyrite, chalcopyrite and pyritine, are covered by a rust-coloured or dark-brown coating, sometimes turning into a shiny enamel-like surface.

All this, as well as an intensive development of karst features, are evidence of a high activity of chemical processes not only in the regolith but in the base rock as well. As far as temperature is concerned, the discussed processes are most active during the arctic summer.

GRAVITATIONAL PROCESSES

Rock fall from steep rock walls is the result of earlier rock weathering followed by an infringement upon the equilibrium of the weathered surface layer. In the examined area intensive rockfall was only observed from shore cliffs. The rock waste, dropped in spring, accumulates on the firn patches which are piled up in rock corners. From measurements of the volume of such material Jahn [2] calculated, that the rate at which strongly weathered calcareous rock faces retreat is from 2.5 to 5.0 cm per year. Obviously this presupposes a continuous penetration of water into the rock interstices. As the distance from the coast line increases traces of contemporaneous fall of rock waste decrease; these processes only proceed intensively near patches of firn while elsewhere surprisingly little weathered material drops from rock walls, notwithstanding clear evidence of weathering. The reason for the minor quantity of rock waste dropping from steep walls is the lack of water in the interstices; and therefore the loosening of the outer weathered part of a rock wall proceeds very slowly. Deeper in the rock interstices water is permanently frozen and acts as some kind of binder. Waste fall from rock walls is greatest during spring while mountain slopes are thawing.

The large debris masses covering mountain slopes, the enormous rock slumps and the nival moraines must be associated with the transition period from a cooler to a warmer climate during the Holocene, in which thawing to increasing depths led to mass movements of the large accumulation of rock waste. The long solifluxion tongues, dead today, with their marginal debris ridges should be dated from this same period. Today an intensive downward flow of regolith in greater masses is observed only on ice-cored ridges, while this process is more limited and more shallow on slopes built of argillaceous shales or on other rocks forming a finegrained debris. Modern solifluxion processes attain their highest intensity at the beginning of the warm season (June to middle of July).

THERMAL GROUND PROCESSES

Fibrous ice develops both in spring (May to beginning of June) and in autumn (end of August to beginning of September). Due to this the cohesion of the soil layer near the surface is weakened, minor rock fragments are raised and turf is loosened from its soil bed. An important part in solifluxion processes is attributed to these changes.

Frost heaving of the ground proceeds in 5 stages: stage one involves repeated heaving and settling of the ground, associated with autumn multigelation, which penetrates gradually deeper to 30 or even 50 cm; stage two brings a definite freezing of the ground combined with inertion of its active zone; stage three stabilizes frost conditions; stage four causes, in advance of spring, a settling of the still frozen ground, probably connected with a decrease of the ice volume at the same rate at which the temperature rises toward zero; stage five is the period of a rapid and continuous settling of the ground during spring and summer, with the thawing of its active zone. The result of ground heaving is the thawing of boulders, which takes place at different rates within the successive thermal zones of the active ground layer: in the lower layer a boulder rises only once a year, because here only one thermal phase occurs: a single freezing and a single unfreezing of the ground. In the intermediate and the upper layers the number of multigelation cycles increases at a rate depending on how near the layer is to the surface; the effect is that the boulder moves towards the surface as many times as it is affected by the multigelation cycles. Due to this the boulder emerges rapidly onto the ground surface. The difference in the rate of rising, between the lower and the two upper layers, effects the sorting of the rock fractions. The supply of boulders from the lower layer goes much slower than their extrusion onto the surface from the upper layers; this causes the top layer to be emptied of coarser rock fragments much earlier, so that it soon contains only finegrained rock waste, while the rock surface becomes cloaked almost exclusively with coarser debris. In the lower layer the fractions are intermixed. Relief irregularities, unequal thickness of the debris cover, uneven swelling of the finegrained layer and microsolifluxion in spring effect the development of sorted ring-like or net-shaped forms on the surface. The main period of ground swelling and the fraction sorting associated with it is autumn (middle of August to end of October).

The formation of hydrolaccolites is associated with the increase of ice lenticles hidden underneath the turf and soil in places, where for some reason or other the vegetation cover which isolates the active ground layer from external thermal changes is of exceptional thickness. Such ice lenticles grow in size, because at their bottom successive layers of ice crystals accrue developed due to free access of water. Hydrolaccolites are only encountered near lakes or streams. The growth of an ice lenticle stops when, due to expansion, the turf or soil layer covering the hydrolaccolite is fractured and atmospheric water or warm air penetrates into it. Melting of the ice along such fractures causes these forms to decay and disappear. The period during which hydrolaccolites develop and vanish is several years, their growth taking place in spring and autumn.

Cracks in the soil appear in regions built of loose rocks which in winter lack a snow cover; the cause are abrupt thermal changes. The author observed the formation of cracks twice, in February and March 1958. In both cases the soil temperature 20 cm below the surface dropped to —9° and —11° C (Czeppe [1]). Similar thermal conditions are apt to occur in any winter month.

AQUATIC PROCESSES

These are mostly associated with the flow of meltwater over a still frozen substratum. For this reason surface denudation prevails, and the relatively insignificant linear erosion is limited to frost fissures, to rocky parts of structural soils, and to other forms predisposing the linear flow. Fluvial erosion is less intensive too, because usually meltwater flows in frozen and ice- or snow-lined channels, and at river mouths this flow impinges upon barriers built of high storm ridges. In this way flooded areas develop, which are not drained until the water succeeds in overflowing the barrier and cutting a gap through it. After meltwater has receded in spring, the water level oscillates but little in streams; the most effective action of flowing water is limited to spring and summer.

EOLIAN PROCESSES

They are confined to deflation and accumulation without any formation of separate relief forms. The content of eolian material in melted snow varies, from 0·2 to 2·0 g/litre. Assuming a mean value of 1 g/litre and calculating this in proportion to surface covered, we obtain a volume of 100 g eolian deposit per 1 sq m surface, accumulated during the four winter months. Taking for granted, that the surface of deflation is one fifth of the surface on which accumulation takes place, we find that during one winter approximately 0·5 kg of fine rock waste is carried off by winds from 1 sq. m ground surface. However, this is certainly too modest a figure, because in winter wind-swept bare surfaces constitute a minor percentage of the ice- and snow-covered ground surface, and only larger fractions are deposited on the snow, while finer material is carried off into the sea, and because deflation of finer debris parts from dry elevations takes place during the warmer season also. All the same, the approximate estimate given above indicates, that eolian processes transfer considerable quantities of rock waste. Moreover, strong winds indirectly affect the course of a number of other morphological processes by blowing the snow cover away and by forming snowdrifts — a topic discussed before.

All the morphogenetic processes mentioned can be divided into groups, according to the seasons in which they attain their highest intensity (Fig. 1).

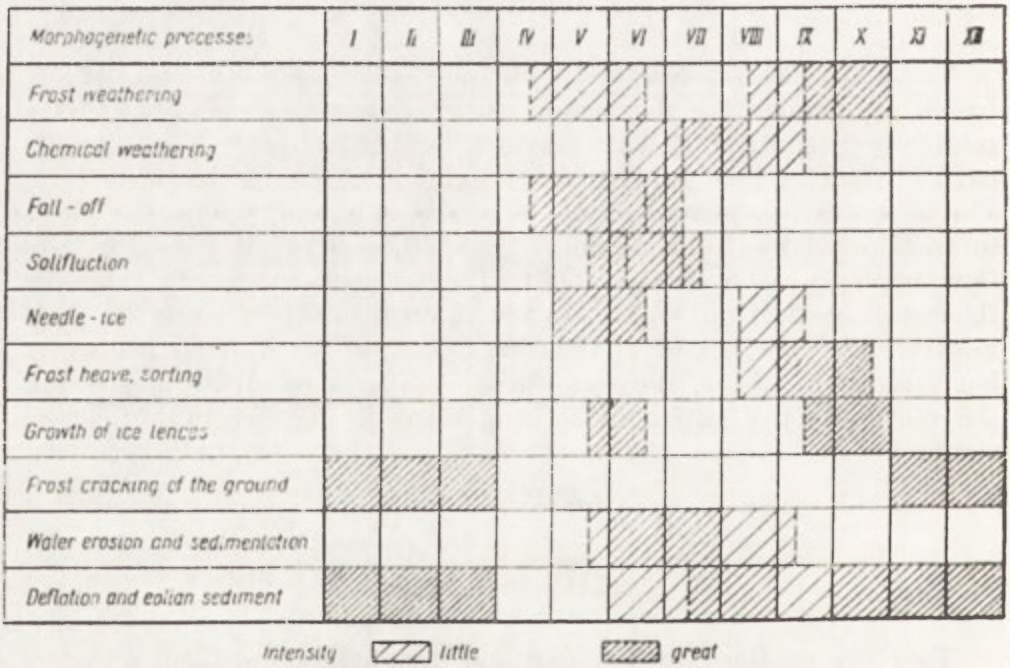

Fig. 1. Annual rhythm of morphogenetic processes in Spitsbergen

1. Spring and early summer: debris fall, solifuxion, formation of fibrous ice,
2. Summer season: chemical weathering, erosion and accumulation by flowing water,
3. Autumn: frost weathering, frost swelling of ground, growth of ice lenticles in the ground,
4. Winter: frost fracturing of the ground,
5. Yearlong: eolian deflation and accumulation.

All the above processes act superficially, by denudation, without creating outstanding land forms of erosion or accumulation. This is the reason, why their effect is difficult to notice and to define quantitatively.

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ON THE MORPHOGENESIS OF EUROPEAN HIGHLANDS BASED ON THE FIELD STUDIES IN THE HOLY CROSS MOUNTAINS

Cecylia Radłowska

The present paper deals with the pre-Pleistocene relief of selected parts of the European Highlands: the Massif Central, the Sudety Mountains, the Ardennes and the Holy Cross Mountains. Areas in which tectonic processes are not revolutionary offer much better conditions for the solution of Palaeomorphological problems than areas essentially changed as a result of the above processes. The Holy Cross Mountains provide a good example in this respect; the studies the author carried out in that region have provided a basis for comparison and for drawing more general conclusions.

The Palaeozoic massif of the Holy Cross Mountains and its Mesosoic peripheries constitute a still elevated part of an orogenic formation which was once much more wide-spread. Its northern and southern peripheries lay deeply buried under younger formations. In the south-east a strongly dislocated massif is covered by the sediments of Tertiary seas and loess. In the Holy Cross Mountains denudated rocky formations are visible beginning with the Precambrian era (Rifeicum) and ending with the lower Sarmatian. This petrographic wealth is the reason for granting them the rank of a mountain range, although their absolute height only slightly exceeds 600 m.a.s.l. (the Łysica Peak 612 m.a.s.l.) and the maximum altitude difference is less than 300 m. The influence of older orogenic trends on the younger ones has resulted in the formation of a complex tectonic pattern which is the reason why in the Palaeozoic centre of the range the direction WNW-ESE prevails, and in the Mesosoic peripheries the NW-SE direction [8, 9, 15].

The relief of the Holy Cross Mts only indirectly reflects the previous tectonics through the direction of the zones of elevation and the elongated depressions. On the other hand, it depicts kind of rocks quite faithfully, up to morphological inversion. Despite outstanding lithological features, the planation surfaces have been preserved on various levels.

In the development of the Holy Cross Mts relief and of the whole European Highlands, not so much cycles as morpho-tectonic stages can be distinguished. The above formulation allows to take into account the fact of complex morphological evolutions during which periods of intense orogenic activity occurred at intervals with periods of marine transgression and subaerial sculpturing during which, Hercynian massifs revealed a lasting trend towards elevation and their peripheries a trend towards depression [8, 24, 31].

The planation surfaces of different age seen on the ridges and slopes of mountain ranges as planation surfaces bordered by edges are the result of gradation combined with tectonic processes. These planation surfaces are arranged in step-like succession: the younger the lower, and having the smaller spatial range.

Nevertheless on mountain slopes there occur cases of a scissorlike arrangement of planation surfaces resulting from tectonic processes, e.g. in the Holy Cross Mts and Ardennes [22, 24]. In this situation, depending on local conditions, the younger planation cutting the older one, can find itself on a lower or higher step (Fig. 1, 2).

The differences in the number of destruction levels distinguished result from a somewhat different geological past, the number and length of periods of the formation of relief in subaerial conditions and also the advancement of detailed exploration so far. Despite the application of different correlation criteria, the post-Hercynian surface, the low Tertiary surface (also known as Palaeogene, Palaeocene, Eocene, Eogene) and the Neogene levels have been identified everywhere.

In the Holy Cross Mts the Tertiary planations dominate. The older post-Hercynian planation does not play any particular morphological role today. It may be reconstructed from correlation sediments, the Zechstin conglomerates in which remnants of Cambrian quartzites are found [7, 15]. This proves that the post-Hercynian gradation had reached the innermost anticline layers of the massif. In earlier works discussing morphological processes in Central Europe the hypothesis was put forward that the "middle quartzite crest was not affected by the post-Hercynian planation" [31]. The denudated Devon limestones were already exposed to karst phenomena at that time. The karst pits near Kielce have been filled with kaolin clays, terra rossa and quartz sands in which low-Trias fauna was found. The discordant superposition of the lower Trias on the eroded Palaeozoic base provides another example of the scope of degradation and planation of surface at that time [13, 15].

The post-Hercynian planation in the Holy Cross Mts does not give rise to any doubts, as in Ardennes where its age has also been identified on the basis of the characteristic features of Perm conglomerate and in the Massif Central, although in the latter it was deformed and sheared by faults so that it now occurs at different altitudes [2, 5, 8, 17, 19].

In Ardennes, Massif Central and the eastern peripheries of the Paris Basin the existence of low Cretaceous or pre-Mastrichtian planation was discovered [5, 19, 22, 30].

According to the most recent geological data the Palaeozoic massif of the Holy Cross Mts was not covered by sea in the low and middle Cretaceous period, and later it was again encompassed by upper Cretaceous transgression which lasted until the Turonian. This stage of the formation of the relief has not been taken into consideration as yet and continues to be an unsolved problem [8, 15].

The lower Tertiary planation generally known as Palaeogenic is most representative of the whole European Highlands. In the Holy Cross Mts it was already formed in the Palaeocene [14]. Accurate dating was made possible owing to the existence of the de-calcified top of Danian gaizes under the cover of marine sediments from the lower Oligocene [23]. During that period of time the Mesosoic structures were cut and also the Palaeozoic structure that had again been denudated, and later their chemical composition was transformed. The beginning of subaerial destruction and the time it takes varies depending on the moment when a given part of the mountains emerged from the upper Cretaceous seas. The decalcification indicates that the climate was warm and humid. The course and results of chemical alteration depended on the petrographic features and internal rock structure. In the subtropical climate of the Eocene chemical processes occurred on the Palaeocene surface which caused decalcification, karst phenomena, silicification and separation of ferro-manganese concretions [14, 23, 26]. A similar type of weathering allows of establishing the age of the older Eocene surface in the SE part of the Massif Central (excursion in 1964 led by Professor J. Tricart). In Ardennes the Eocene age of the surface was established in the ground of Bruxelien marine transgression (middle Eocene) [19].

The Palaeogenic planation have almost everywhere been dislocated from their original position. In certain areas, e.g. in Ardennes, they were only inclined, in other places, sheared into single parts, occurring at different altitudes, e.g. in the Massif Central and the Sudety Mts [2, 5, 11, 12, 13, 19, 20, 21].

The Palaeogenic planation in the Holy Cross Mts occurs at different altitudes ranging from 400 m to 145 m a. s. l. in the norhtern peripheries where it has a fossil character. In the centre of the mountains it is bipartite: on the levels of 400 m and 360 m, inclined south-east [17, 18, 24]. The importance of Palaeogenic gradation here is particularly great.

A system of transversal valleys was formed and the Palaeozoic massif appeared from under the cover of Mesosoic formations. This massif was consistently only subaerially sculptured up to the Pleistocene.

The Palaeogene planation surface, because of its large size, was called a peneplain, although many researchers unanimously recognized the climate of that period as subtropical. So the notion "peneplain" appears again, but having a different meaning than that used by Davis [19].

The Palaeogene (Palaeocene) surface in the Holy Cross Mts "was not a peneplain: it linked areas that were at different stages of advanced development" [13]. On the outcrops of carbonate rocks it assumes to some extent the character of a "bipartite planation" as Büdel understands it [6]. The problem of the origins of older planations remains unsolved for the whole of the Highlands [3, 4, 10].

The next younger degradation surface is that formed by the planation which is defined in Ardennes as "de base de l'Oligocène", preceding the upper Oligocene transgression [19]. This planation has no counterpart in time either in the Holy Cross Mts or the Sudety, because on the area of Poland the Oligocene was a period of tectonic processes linked with volcanic eruptions (the Sudety Mts) during which the Palaeogenic surface was disturbed and dissected by river valleys [13, 24].

The Neogene dissected surfaces are much less developed than the older ones. Their number and more thorough division into age levels reveal certain regional peculiarities. The Miocene surface is the common feature of many areas; it was formed either in the early Miocene (the Sudety Mts) or during the Miocene (the Holy Cross Mts), or at the end of Miocene (Massif Central, Massif Morvan), in the latter case it has been called Mio-Pliocene [5, 13, 18, 20, 21].

In the Holy Cross Mountains the Miocene level 330—300 m mostly occurs in the peripheries of the mountains. Its age has been established on the basis of the following features: (1) in the peripherial zone of the mountains the surface partly passes into the abrasive platform of the Miocene sea, (2) on that surface are karst pits filled with weathering and fluvial material, (3) in one of the karst pits, pieces of timber were found belonging to the Glyptostroboxylon tenerum, a characteristic plant of the Miocene [13, 18].

The warm Miocene climate with its dry and humid variants, enhanced further chemical and mechanical weathering [29]. This resulted in developing the cuesta relief on Mezozoic rocks and in the molding of monadnocks in the central part of the mountains (13, 24). Chemical weathering resulted in the formation of variegated ceramic clays which filled the erosive furrows and old karst pits; at the same time new karst forms were developed. Most of the weathering sediments are of chemical origin, but not all. Dust, sands and quartz gravel indicate the action of running water. At that time the Miocene sea was the erosion base for the southern slopes of the Holy Cross Mts: all the rivers flowed into that sea. Today we find there river deposits of the miocene. Some river valleys of that time have become dry or completely buried. The Miocene rivers formed valleys running in a new direction WSW — ESE, almost perpendicular to the Palaeogene ones [14, 24].

The Miocene relief was shaped under the influence of climate and tectonic as well. The correlating deposits with the coarse grained fraction date from the lower Sarmatian and are discordantly laying over the Tortonian. It was the period in which the Holy Cross Mountains had been elevated to the maximum [13].

Particularly lively tectonic activity in the Miocene connected with volcanic eruptions is well known from the Sudety Mts [13] and the Massif Central. It dislocated the Miocene horizon from its original position and sheared it by faults. Nevertheless both the character of correlating sediments and the weathering covers in situ allow of defining the age of the degradation surface, generally speaking, Miocene, or Mio-Pliocene, as in the Massif Morvan [5] and Massif Central (the excursion with Professor Dr J. Tricart already mentioned earlier). In the Sudety Mts gravels and sands from the degraded mountains are found in the peripheries in the depressions among the upper-Miocene lignite deposits [13].

In Ardennes the higher grade planation surfaces called peneplains, ended with the Oligocene. According to opinions proclaimed up to now, they form a system of steps: the lower the younger [19]. Pissart ques-

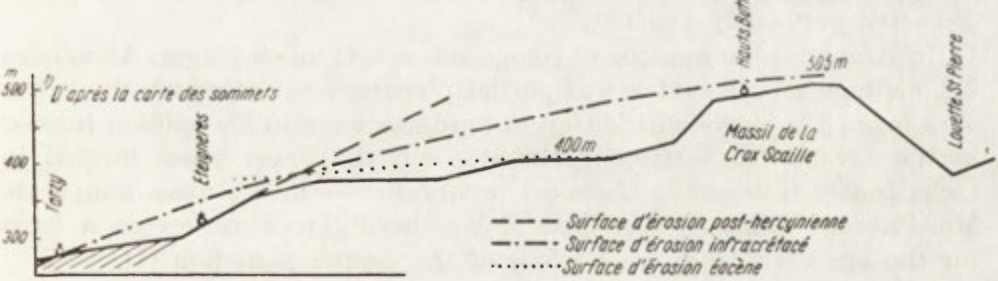

Fig. 1. Profile of Tarzy, Éteignères, Hauts Buttés, showing the possible course of erosion surfaces of Plateau de Rocroi (Pissart)

tioned the correctness of the above opinion and to support his own thesis he drew the profile of a planation pattern in Plateau de Rocroi [22].

The older the surface the more it is inclined. Pisart's opinion has not won general support. Macar considers that the age indices given by Pissart should be revised, because they are only hypothetical [19]. The problem of scissor-like arrangement of planation surfaces will be discussed again on the example of the Holy Cross Mountains.

In the whole area of the Highlands the younger the surface, the smaller its size. The less developed erosive levels are called partial planation surfaces [1, 19].

In the Holy Cross Mts this stage of sculpturing the relief took place in conditions of land stability. The wasting planation processes lasting for quite a long time during the Sarmatian, resulted in the formation of peripheral planations in less resistant rocks. They were finally sculptured in the period of the dry or half-dry climate of the lower Pliocene [33]. The lower Pliocene (Pontian) level occur on the sheared Tortonian formations and the lower Sarmatian clays and sandstones [13, 25].

On the NE side of the Holy Cross Mts the Pontian planation 180—160 m. a.s.l. encompassed areas earlier covered by sediments of the lower Oligocene sea and penetrated into the zone of relief following its Palaeogene mould. The margin line of the Palaeogene planation is winding with numerous spurs and monadnock-type elevations. This is the result of the receding evolution of the Pontian planations. Despite the seemingly step-like arrangement of the two planations they actually form a scissor-like pattern [24]. Fig. 2.

In the extreme northern periphery both planations are fossil, the Palaeogene planation occurring below that of the lower Pliocene.

The level of the lower Pliocene planation has also been identified in the Sudety Foothills as a surface on the sheared Miocene rocks and basalt cones [13]. The Mio-Pliocene level in the Massif Central was included in time limits corresponding to the degradation surface discussed previously and now.

In Ardennes the number of Neogene levels is much bigger. Alexandre e.g. distinguished 9 surfaces of partial planation out of which the upper ones formed in rocks with different hardness were in his opinion formed in the savana Oligo-Miocene climate, and the lower ones, formed in rocks poorly resistant to chemical weathering — in the more temperate Mio-Pliocene climate. The type of weathering rock serves as a basis for the age division of the surface of the partial planation [1].

The final stage of the development of Tertiary relief took place in the upper Pliocene. In the Holy Cross Mts, in conditions of savana-like upper-Pliocene climate [16, 27, 28], valleys gained considerable width as

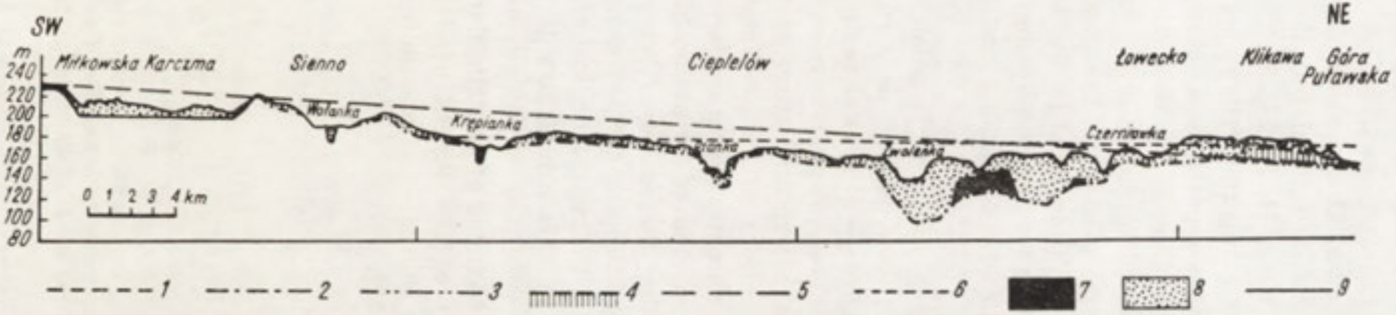

Fig. 2. Levels of Tertiary planations on the NE peripheries of the Holy Cross Mountains

1 -- top of jura rocks, 2 — top of Cretaceous rocks, 3 — top of Cretaceous rocks (Danian), 4 — top of Oligocene rocks, 5 — line linking the points of Paleogene planation, 6 — line linking the points of lower Pliocene planations, 7 — pre-glacial formations, 8 — glacial formations, 9 — supposed top of the base

a result of valley side retreat and with the contribution of lateral erosion of seasonal waters. This is how the rock ledges came into being-flat surfaces along the valley forms. The climate was favourable for the further development of pediments (glacis) but they did not have time enough to spread over large areas [4, 13, 24].

The upper Pliocene levels along the valleys occur in many parts of the Highlands. In Ardennes two partial planation levels were distinguished, formed under the influence of the sub-arid climate of the upper Pliocene. They are related to the valley system [1].

The less developed Neogene planations are mostly examined on the basis of the type and scope of alterations in the bedrock, that is, with the help of more and more exact correlative methods. This allows of a closer definition of the climatic conditions and the directions of the development of relief.

All over the Highlands each younger planation was developed at the expense of the older one, situated higher, as a rule. This is a kind of a common feature — as it were — of spatial reduction of the mountain area. It may indicate a more general phenomenon of a wide concept of slope retreat. This is the characteristic feature of the younger Tertiary and it gives ground to suggestions of Palaeoclimatic nature. More and more precise descriptions of climatic conditions on the basis of the type of weathering covers and the system of formation of planations, allows of drawing conclusions concerning the action of types of climate in which dry and rainy seasons occur. Despite certain nuances in the interpretation of the Neogene climate, the morphological effects of processes are to a great extent similar. In this connection it is assumed that the Neogene planations are the result of slopewash and soil creep.

In the study of the development of the Highland relief the problem has not been solved as yet of the length of various morphotectonic periods and the polygeneous character of weathered rock on the surface of older planations [19, 22, 32].

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THE MORPHOGENETIC ROLE PLAYED BY THE HOLOCENE IN DIFFERENT CLIMATIC ZONES OF THE WORLD

LESZEK STARKEL

The past 10,000 years brought a world-wide warming of the climate. In the northern hemisphere this caused the melting of inland ice and a northward migration of climatic and vegetal zones. The Holocene includes only part of the warming of the climate which started a few thousand years earlier.

The peculiarity of the Holocene is particularly noticeable in the temperate zone of the northern hemisphere [16], and it was here that it was first distinguished. In place of the ice sheet, arctic tundra and steppe it has been covered by before, most of Europe became dominated by forests. The whole assemblage of morphogenetic processes underwent a fundamental change. Under the impression of this contrast one is tempted to compare the period of maximum glaciation with today's conditions, disregarding the successive changes in which not only the intensity of the processes changed but the acting processes as well. The changeover from the Glacial to the Holocene was not everywhere as strikingly marked as in Europe. For this reason the necessity of distinguishing the Postglacial as a separate period has often been questioned [31].

STUDIES OF CHANGES IN MORPHOGENETIC PROCESSES IN PARTICULAR ZONES OF CLIMATE AND VEGETATION AT THE CHANGE FROM THE LAST GLACIAL TO THE HOLOCENE AND DURING THE HOLOCENE

a) The arctic ("scree") zone is an area of frost processes, weathering and solifluxion [17]; ice caps occur in this region. During the Ice Age the extent of the ice caps was wider and the snow line was at a lower altitude, but in exposed areas the processes under way were of the same kind as are found today, though of lesser intensity. Thus the Holocene did not introduce any new groups of processes into these areas, with the exception of regions from which the glaciers have retreated. On the other hand, the oscillations of glaciers in the arctic zone distinctly reflect climatic changes during the Holocene [18, 42], and only the short period of climatic optimum brought a different group of processes into play.

b) The tundra and forest-tundra zones, covering the northern marginal parts of Europe and Asia, show severe frost weathering and an abundance of solifluxion and other processes associated with permafrost conditions. During the Ice Age, sheets of inland ice covered the land, or the arctic zone climate prevailed. In the postglacial climatic optimum, forests advanced some 100 to 200 km northwards [10, 33]. Afterwards, distinct traces of laterization [26] and decayed pingo-type forms [1] survived in the tundra zone. The retreat of the forests led to an increase in surface denudation and fluvial accumulation, as in the lower Yenisey [22] and the Pur [25] drainage basins.

c) The wide forest belt of the moderate zone is much differentiated. In Europe the area of taiga and of mixed forests and deciduous forests was covered successively from north to south by an inland ice sheet, a periglacial zone, a tundra and a steppe zone. This is the picture that existed at the time of the recession of the inland ice, some 15,000 years ago [10, 13, 30]. In the place of mechanical weathering, solifluxion, deflation and slopewash, the Holocene brought chemical weathering, a decrease in surface denudation, and a concentration of the action of flowing water. Forests invaded areas of loesses, dunes, scree and block fields. The intensity of natural processes in the Holocene depended on the amount of precipitation. The humid periods (Atlantic, Subatlantic) caused increased laterization [28], salt solution [27], fluvial processes [34, 38] and landslides [39], while less intensified processes operated during drier periods. In the Subboreal, steppes replaced for a time the wide zone of forests covering the South-Eastern parts of Europe [33].

In Southern Siberia the Ice Age did not cause an universal recession of the forests [11, 35]. In this period, the warmer summer seasons of the continental climate made the permafrost in the ground melt to a fair depth. In the mountains, forests gradually covered the cryo-planational (treeless) terraces during the Holocene. After the climatic optimum, however, a new permafrost invasion set in.

d) The Mediterranean zone is distinguished by its periodicity of precipitation and its high intensity of linear erosion, slopewash and mass movements. Now deforested by man, this area was during the Last Glacial an important region of forest refugiums [7, 10]. Traces of frost weathering (block fields, solifluxion covers) commonly seen at altitudes from 700—1000 m indicate how low the tree line used to run [10, 19].

Recent studies in Greece [13] and Southern Spain [30] reveal that these lands were covered by steppes during the Late Ice Age. Thus forests survived only in minor spaces, more humid and isolated, above the lower humidity boundary of the forests. An expansion of forest growth started with the decline of the Ice Age, but in regions like Dalmatia a Mediterranean vegetation did not penetrate until the Boreal and the Atlantic [4]; beginning with these periods one may speak of processes typical of this zone.

e) The arid zone is the most complex as to climate, vegetation and morphogenetic processes. It consists of steppe areas, semi-deserts, deserts and savannahs, as well as areas where seasonal water flow and wind action predominated. The individual regions will be discussed in turn:

1. The deserts and the cool steppes in Asia (those of China, Turkestan, Kazakhstan) were more humid during the Last Glacial if only by reason of reduced evaporation. Evidence for this is provided by traces of higher water levels in the lakes and the presence of finegrained alluvia, covered by coarsegrained Holocene deposits piled up by torrential floods [29]. Even so, the central parts of depressions far removed from rivers like Amu Daria, and from the southward vanishing forests, retained their desert character [29]. On the other hand, very distinct changes in humidity occurred during the Holocene proper in the area of Turan, coinciding with similar changes in the forest area. During the Atlantic period, the Uzboj channel carried the Amu Daria waters to the Caspian Sea [21]. The Subboreal brought a high intensity of eolian processes in the vicinity of the Aral Sea [21] and on the western shore of the Caspian Sea [41]. The more humid Subatlantic heralded an increase in river flow and the encroachment of the steppes even forest-steppes (fossil soils on dunes — [41]). The later destruction of the vegetation must be ascribed, in part at least, to man's activities.

2. It used to be believed that the desert areas of the Near East were covered by forests during the Ice Age [11]. Research in Iran [43] and Iraq [2] has revealed that during the Older Würm forests grew here at altitudes from 500 to 1500 m above sea level, while by the Late Ice Age these areas had become arid. Forests penetrated the Iranian Plateaus at about 9000 B. C. [43]. The climatic optimum brought a rise in the level of lakes, and gradually chemical weathering and the action of flowing water began to outweigh the effects of mechanical weathering and wind. Butzer reports that precipitation in Israel increased some 30% at that time [5]. After the Atlantic period aridity set in again.

3. The Sahara. Geological and archeological evidence indicates that the Sahara was arid throughout the Quaternary and only the degree

of aridity varied [5]. In the Younger Würm the local climate was cool and pluvial. Afterwards, towards the decline of the Ice Age, it was replaced by an arid climate. This was the time when dunes developed in Egypt and probably in the Haussa territory also [6]. The Atlantic period again brought a pluvial type of climate; according to Butzer [6] the annual percipitation was 50—200 mm [at present it is 5—75 mm]. A savannah landscape covered large parts of the Sahara desert (neolithic findings). An intensified activity of the Nile at about 3000 B.C. corresponds with the erosion of soil covers from the valleys of the Libyan desert [6]. The period from 2350 to 870 B.C. was dry again; dunes invaded the Nile alluvia, the savannah retreated southwards. However, the earlier part of the Subatlantic brought again some slight increase in humidity.

4. The deserts and prairies of North America. During the Last Glacial, the desert area of what are called the Great Basins in the Rocky Mountains had a humid climate; examinations at Searles Lake show that from 23,000 to 11,000 B.C. the water level was high [9]. With the decline of the Ice Age, marked fluctuations in water levels set in, combined with a drying out of the lakes. Here the Holocene was a period with a specific morphogenetic character [37]; forests penetrated the prairies (Dakota) some 11,000 years ago [43]. The climatic optimum (6000—2000 B.C.) was dry as in the intermountain basins, and the area of prairie land increased.

5. The scanty data available from South Africa indicate that during the decline of the Glacial the steppe-desert character of the Kalahari region covered a wider range. Dunes from this period (in NE Angola they have been dated from 9240 ± 490 years B.C. [6]) reached as far as Leopoldville. During the climatic optimum a vegetation cover took firm root; black soil areas are evidence of this increase in humidity [6].

f) The tropical zone used to be considered climatically as the most stable one [7]. However, peat examinations in Columbia at 2500 m altitude [12] have provided evidence that even here fluctuations in humidity and temperature must have occurred in the Holocene, and that in the Younger Würm the mean annual temperature must have been 6° to 8° lower than it is today (+13°). The presence of illite and epidote underneath a thin laterite layer, determined by Bakker [2] in Surinam, is an indication that the uplands covered today by forests were once an area of a less humid savannah. Galon [14] also observed in Venezuela's tropical forests an assemblage of forms typical of a drier climate. Thus in the tropical zone, vertical climatic zones have been subject to fluctuations, as it has also been found in Africa [31]. For all this it remains an open question, whether the dry period in America coincided with the Late Glacial desiccation that took place in Europe and Africa, since a divergent rhythm in humidity changes has been discovered in the Columbian mountains.

g) Changes in climatic and floral zones, as well as in morphogeny, are seen most distinctly in high-mountain areas, where from Glacial times to the Holocene both the tree and the snow lines have moved some 1500 to 2000 m. Evidence of a lowering of the vertical zones following the Holocene optimum is afforded by the penetration of solifluxion covers onto peat bogs (the Caucasus [33]) and the vanishing of karst lapies in the forest zone [23], even their cutting by advancing glaciers [3]. Phases of glacier formation and decay in the mountains [15] were accompanied by stages of a lowering or raising of scree formation. In the Pyrenees, corrosional ravines which dissected the slopes of glacier troughs active during the climatic optimum, were later smothed [40].

CONSEQUENCES OF CHANGES OCCURRING AT THE DECLINE OF THE ICE AGE AND IN THE HOLOCENE

If we study the climatic and morphogenetic changes that took place in the individual zones, we obtain a much more detailed picture than that which Büdel [6] has given. The period of the Last Glaciation was by no means merely a cold and arid period in temperate latitudes, and a pluvial period in the lower latitudes. All zones moved towards the equator [8, 14]. The boundary lines between deserts and savannahs and between savannahs and tropical forests also shifted; however, in Central Asia with its continental climate these changes were less marked [10]. The climax period of the Würm was cool and humid in the arid zone, but in the Late Ice Age the climate turned drier practically everywhere, while tundra and steppe vegetation predominated in the northern hemisphere.

Nor was the "forest" Holocene uniform in nature. In Eurasia and Africa the Atlantic and the older Subatlantic were more humid, the Boreal and Subboreal less humid in all climatic zones. However, the rhythm of these changes was different in the southwestern part of North America and all over the southern hemisphere [20, 24]. In consequence one cannot speak of an universal stability of morphogenetic zones in the Holocene, nor of an all-round morphogenetic difference of the Holocene from conditions as they were during the Last Glacial.

THE VARIED PART PLAYED BY THE HOLOCENE MORPHOGENY

In the period from the Last Glacial to the Holocene, paleogeographical changes set in, in all climatic zones. Still, areas can readily be distinguished where these changes were very intense and others which remained more stable.

A) Areas where fundamental changes occurred in the morphogenetic environments on the Pleistocene-Holocene borderline. Here the Holocene assumed distinctly different features. Even so, due to the insignificant fluctuations in humidity, the changes observed in the Holocene involve only the intensity of processes.

Amongst areas of this type the author includes the belt of temperate zone forests in Europe and North America which had previously been covered by inland ice, tundras and steppes. The deserts — arid today — in the western part of the United States also belong here. The mountains of this moderate zone also show the greatest differences in the course of tree and snow line between the Glacial and the Holocene [8].

B) Areas of relative stability of processes, even on the scale of the Quaternary as a whole. Changes in thermal conditions and precipitation from the Glacial to the Postglacial were rather insignificant here, so that the same group of processes continued to predominate.

These areas comprise: a) today's arctic zone where constantly low temperatures prevail, b) the zone of tropical lowland forests with their generally high temperature and humidity; and, to a rather lesser degree, c) the zone of continental deserts in Asia (like the Gobi), which show a continual deficiency in humidity. To these areas should also be assigned the southern part of Siberia, which retains the features of a forest zone. Forests survived here in the extremely continental climate of the Ice Age, on a base of permafrost.

C) A separate group includes areas where the consequences of morphogenetic changes followed one another with a high frequency. During the successive stages of the Glacial and the Holocene the areas of this group showed a humidity alternating between scarcity and relative plenty; in consequence, these areas continuously oscillated between climates of a semidesert or steppe and a forest steppe or savannah. Every period of increased humidity or of a warmer and drier climate left its imprint in the form of changes in physico-chemical and biological processes. The boundaries between forest steppe, steppe and semidesert are now difficult to be detected, because plant assemblages merge into one another.

The present steppes and semideserts of South-Eastern Europe, Kazakhstan, a considerable part of North Africa, and the Plateaus of the Near East should be assigned to this latter type of area.

The study of the paleogeography of the Holocene should lay stress on different aspects for each of these three groups of areas. The Holocene constitutes a separate morphogenetic period in the temperate latitudes of Europe and North America, while it represents an extension of preceding morphogenetic periods in some arctic regions and in the lowlands of the tropical zone. In what is called the semiarid zone, on the other hand, the Holocene is a period of continuous fluctuations the more worth emphasizing, since here these fluctuations constitute features of both the warm Holocene and the cooler Glacial.

Extensive research is currently directed towards an understanding of the morphogenetic part played by the Holocene [6, 10, 14, 15, 16, 18, 19, 21, 28, 37, 38, 39, 42, 43] with the aim of determining the successive changes in both type and intensity of the processes involved. It is important that the individual features being characteristic of different zones should be distinguished. In this way many problems existing up till now will gradually be solved. If this research is particularly concentrated upon those areas where the boundaries of climatic and morphogenetic zones (for mountains vertical zones) are marked by oscillations, this is bound to disclose the mechanics of such changes, and to throw light on the origin of the different types of landscapes. The advance of research will be accompanied by a diminution of regions containing what are called typical landscapes, because in the majority of cases they bear traces of repeated changes of morphogenetic environments.

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THE DYNAMICS OF SEDIMENTARY ENVIRONMENTS IN THE LIGHT OF HISTOGRAM TYPES OF GRAIN ABRASION

LUDWIKA KRYGOWSKA and BOGUMIŁ KRYGOWSKI

Numerous attempts have been made to determine the dynamics of sedimentary environments from studies of the deposits left by them. These attempts have mostly been based on the structure of the deposit (Ławruszyn 1963, 1965, 1966, Łazarenko 1963, Davis 1938, Mellon 1955, Szancer 1961), its mechanical composition and, less often, its grain abrasion [2, 1, 5, 12, 10, 11, etc.]. This was largely the result of the scarcity of accumulated analytical data which were usually attained at an exceptionally slow rate with the definition hitherto applied to grain abrasion. Obviously this made it impossible to apply comprehensive statistics, and it therefore prevented an evaluation of the suitability of grain abrasion parameters for determining the dynamics of sedimentary environments.

By applying mechanical graniformametry [6, 7, 9] a relatively rapid determination of grain abrasion from a great number of samples became possible. The authors of the present paper were thus able to base their conclusions on the examination of more than 1500 samples collected from 8 different sedimentary environments, and on several thousand analyses (abrasion tests) by means of their graniformameter. This considerable source material confirmed the opinion — by no means original — that a sedimentary environment of deposition and its dynamics are characterized not by one but by at least several parameters. In this instance the following parameters were taken into account:

1) the coefficient of grain abrasion — Wo
2) the coefficient of irregularity of abrasion — Nm
3) the histogram type of grain abrasion.

The last-mentioned "parameter" has been picked out since it provides the most comprehensive definition of the deposit as far as the dynamic conditions of its origin are concerned [3]. The scrutiny of a few thousand histograms, of which an example is shown in Fig. 1, made it possible to arrange a classification for them [4] as in Fig. 2. Here four

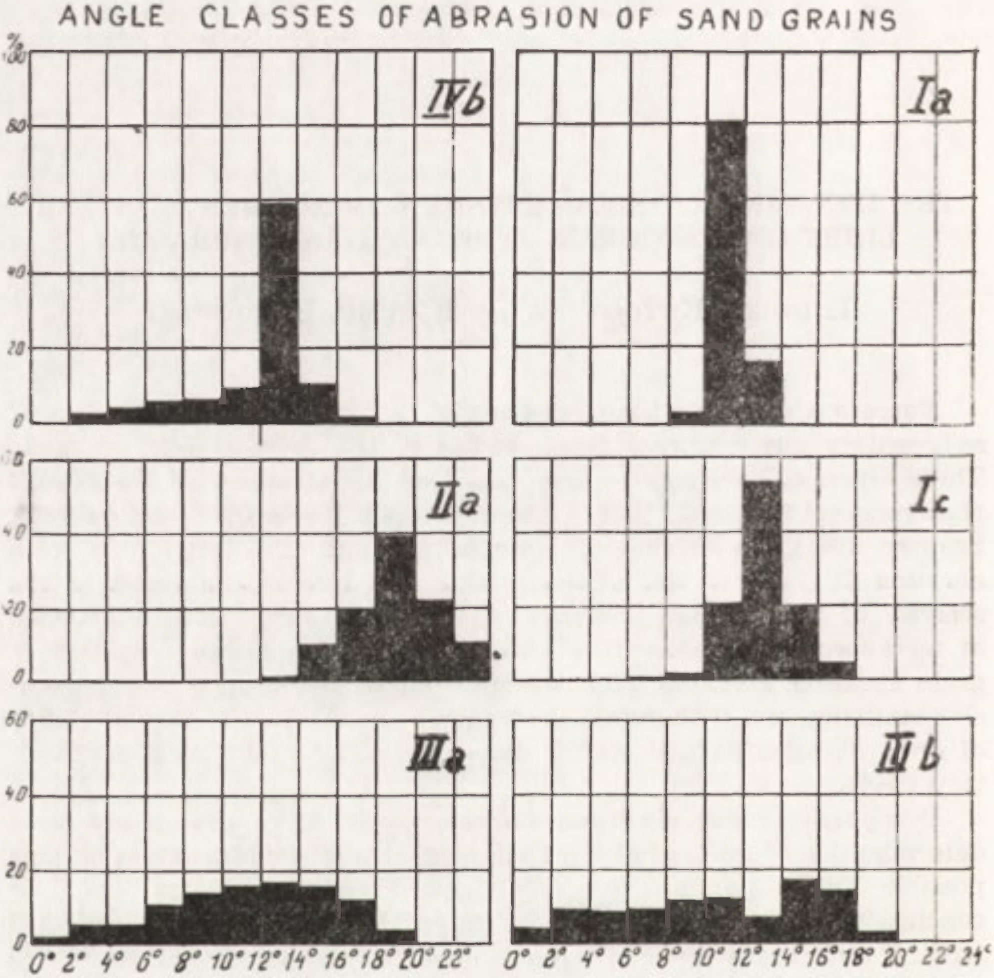

Fig. 1. Examples of some histogram types of abrasion of sand grains

IVb — sea beach sand from Mielno (Baltic Sea), Ia — sea beach sand from Mielno, IIa — granite weathering product, in situ, from Michałowice (Sudetens), Ic — sea beach sand from Grodno (Wolin Island, Baltic Sea), IIIa — dune sand from Toruń Basin, IIIb — dune sand from Toruń Basin

principal types of histograms are shown: I — a markedly slender type, illustrating a strong tendency for shape selection within a give environment, II — a less slender type, III — flattened histograms corresponding to a negligible tendency towards shape selection or a total lack of this tendency. Type II is intermediate, between types I and III. Finally, Type IV comprises combinations produced by the superposition of two different histograms. This latter type illustrates some sort of

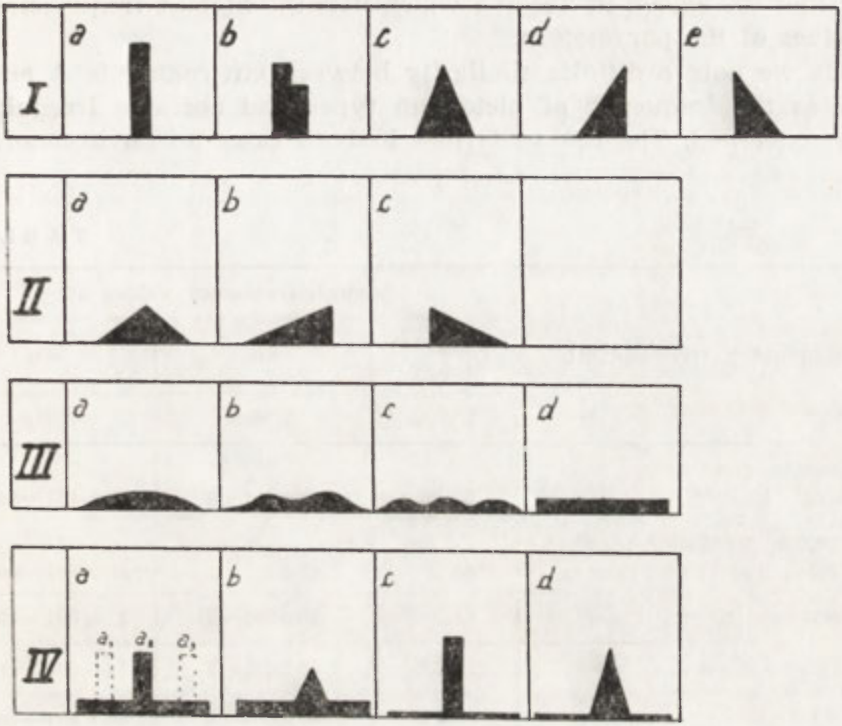

Fig. 2. Classification of histograms of sand grain abrasion expressed by means of symbols (abbreviations of abrasion silhouettes)

Type I — elongated: Subtype Ia with 66% of grain in main fraction: symbol — column. Subtype Ib with 80% of grain in two predominant fractions taken together: symbol — double column, the whole distributed over 4 classes. Subtypes Ic, Id and Ie, acute angled triangels (symmetrical, with left and with right slopes), with 45—66% of grain in the main fraction, the whole distributed over 6 fractions. Type II — short: symbol – obtuse angled triangel. Subtypes IIa, IIb, and IIc are symmetrical, with left and with right slopes. These denote 33—45% of grain in the main fraction, the whole distributed over 8 fractions. Type III — flattened: symbols — convex (IIIa), bimodal (IIId), polymodal (IIIc), 33% of grain in main fraction. Subtype IIId, symbol — rectangle; no main fraction, 20% of grain in individual fractions, the whole distributed over more than 8 fractions. Type IV — compound type: subtypes IVa and IVb are combinations of Subtype IIId with various Subtypes I.

pulsation of two tendencies within the environment, one towards shape selection, the other to "aselection".

It is readily seen that an environment is not determined from one sample, but from the frequency with which samples occur showing definite parameters and coefficients — a statistic principle of long standing which the authors applied to the material they collected.

The graph (Fig. 3) refers to eight different environments in the light of the parameters distinguished above. It indicates both similarities and differences occurring between individual environments. These characteristics are shown in Table 1 which lists the highest frequencies for the values of the parameters.

Thus we note a difinite similarity between environments A and B, as far as the frequency of histogram types and abrasion irregularity Nm is concerned. The reason is that in both cases an environment of granite weathering products is involved, either is situ (A) or in slope covers (B). The considerably higher abrasion coefficient Wo (701—800) in the cover material compared with the one in situ (401—500) would seem to indicate that, in the slope granite, the relatively short slope transport, and particularly frost disintegration and chemical processes (wearing down the sharp edges) led to a distinct increase of grain abrasion.

TABLE 1.

Sedimentary environment	highest frequency values of:		
	histogram types	Nm	Wo
	%/type	%/Nm	%/Wo
A — granite weathering products, in situ	65/II	56·9/2·1—3	20·8/401—500
B — granite weathering products, from slope covers	64/II	47·5/2·1—3	38·3/701—800
C — mountain river	61/I	59·9/2·1—3	32·5/901—1000
D — lowland river	51/IV	56·2/2·1—3	34·0/1001—1100
E — glacial till	64/IV	49·2/2·1—3	46·4/901—1000
F — dune	82/III	38·1/6·1—7	46·0/1201—1300
G — Baltic beach sand	54/I	47·7/2·1—3	45·2/1001—1200
H — fluvioglacial sand	63/IV	35·8/2·1—3	30·9/901—1000

In the mountain river (C) which carried off the weathered material for a distance of a score or several scores of kilometers, a further and fairly considerable increase of value Wo (901—1000) can be observed, — clearly the effect of water transport. This process is also illustrated by the high frequency of histogram type I (61 • 1%), — evidence of strong selective tendencies; in the material found in situ this type plays a secondary role.

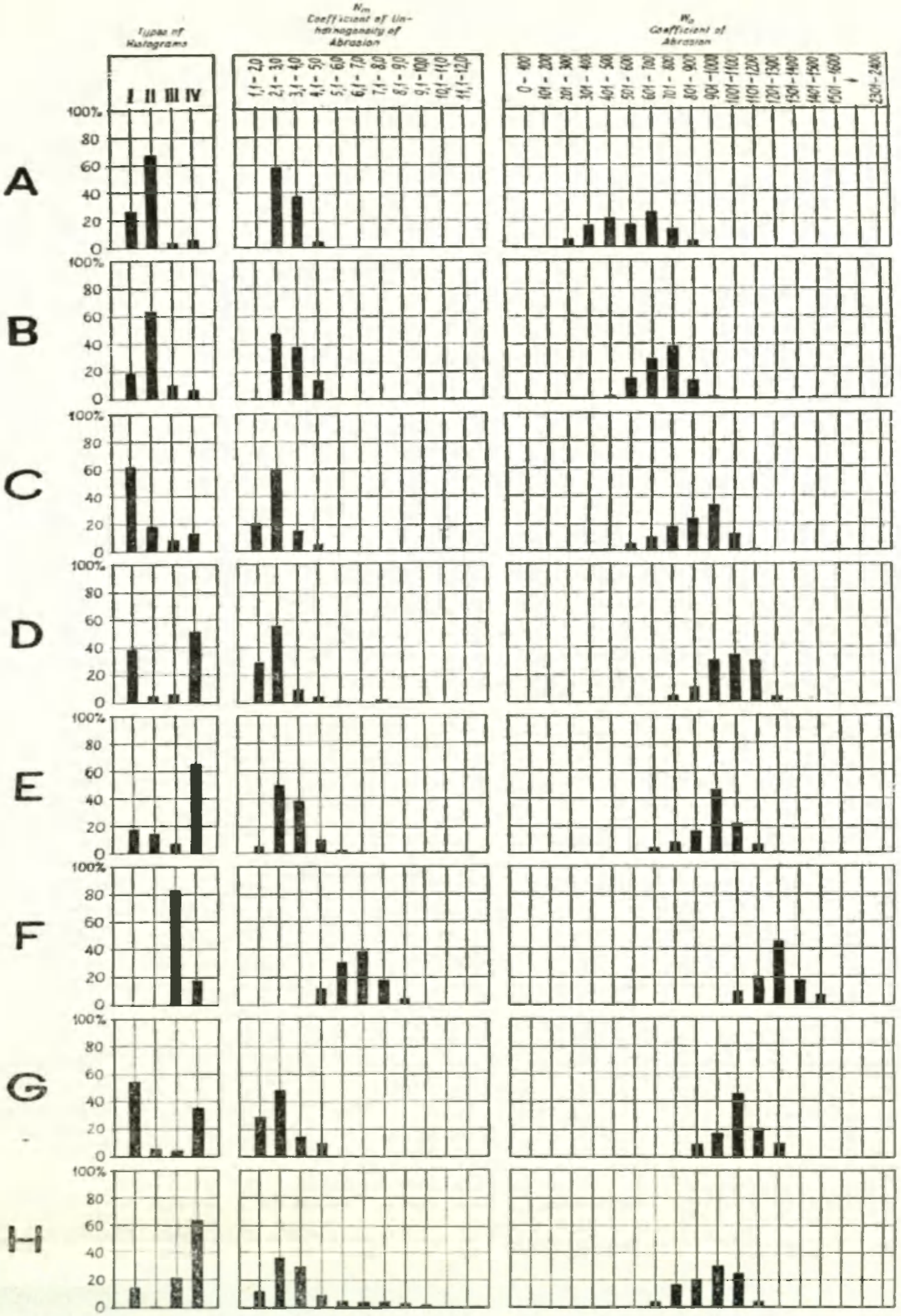

Fig. 3. Size frequency distribution (in %) of histogram types of quartz grain abrasion (four fractions: 0·5—0·8; 0·8—1·0; 1·0—1·25; 1·25—1·6 mm) and of abrasion coefficient Wo and its irregularity coefficient Nm, determined in a number of sedimentary environments

A — granite weathering products, in situ (Michałowice, Sudetens), B — granite weathering products, in slope cover (Karkonosze massif, Sudetens), C — sands and gravels of a mountain river (River Kamienna, Karkonosze massif), D — sands and gravels of a lowland river (River Dunajec, Sub-Carpathian Basin), E — glacial till from Baltic Glaciation (sea cliff at Rewal, Baltic coast), F — dune sands from Toruń Basin (from Professor R. Galon's material), G — sea beach sands (Międzyzdroje, Wolin Island, Baltic Sea), H — outwash sands from near Poznań (Krzyżowniki). Marked differences can be seen between sedimentary environments especially in histogram types and in the abrasion coefficient Wo. This indicates very distinctly an increase in abrasion in the following sequence: granite weathering product in situ (A), — ditto in slope covers (B), — mountain stream in granite bed (C), — lowland river (D). — dune (F). This differentiation is not only brought about by processes of selection

A lowland river (D) is strikingly unlike the mountain river. Here the combined type histogram accounts for 51% in frequency — clearly proof of pulsations between the two tendencies mentioned above. The abrasion coefficient Wo is also markedly higher (1001—1100) compared with that in the mountain stream.

The beach environment (G) comes nearer to the mountain stream environment as far as the histogram type is concerned (G — 54/I, C — 61/1), but it differs considerably as regards the frequency Nm, and particularly the value of Wo.

A separate group constitute: glacial till (E) and, resulting from its denudation, beach sands (G) and fluvioglacial sands (H). For all their common origin (a glacial environment) these products came to differ considerably. The reason is that the motion of water along the beach and that of meltwater flow tend to some degree to alter the original environment glacial till, although certain common features have survived in the parameters under discussion. The correlation:

environment	histogram type	coefficient Nm
glacial till	64/IV	3·5/1—2
fluvioglacial deposit	63/IV	11/1—2
beach sands	54/I	28/1—2

shows, that for both glacial till and fluvioglacial deposits the basic histogram is of type IV.

A different picture is shown by the beach sands for which type I shows the highest frequency. Generally speaking, in these three environments an increase in shape selection may be observed, in the order: till — fluvioglacial — beach. Apart from the histogram types, this relation is also illustrated by the increase in Nm frequency in division 1—2.

A dune environment (F) is characterized by the very high frequency of histogram type III, and in this respect differs very much from all remaining sedimentary environments. Here the tendency towards vanishing of selection is paramount; an important part is also played by processes of grain abrasion. It suffices to point out that, in division 1201—1300, the frequency of the abrasive coefficient Wo, i. e. of a far-advanced abrasion, is 46%, and in division 1301—1400 it is 17·4%.

The above description of a number of sedimentary environments has been compiled for deposits of known (modern) sites. We now know the features of these deposits that have been quantitatively determined much more accurately than at any time before. Hence, reversing the process we can now draw conclusions as to the type of sedimentary environment in which samples from exposed deposits or from bore holes must have been deposited. Conclusions of this kind must obviously be based on a statistically satisfactory number of samples.

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INFLUENCE OF PETROGRAPHICAL DIFFERENTIATION OF GRANITOIDS ON LAND FORMS

BOLESŁAW DUMANOWSKI

Granites make up a large proportion of the rocks in the earth's crust. Characteristic forms are frequently observed, such as convex elevations or domes, klippen forms, bowl-shaped depressions, etc. In many areas the granites are covered by mantles of considerable thicknesses, chemically changed to a greater or lesser degree. For a long time these facts have been of interest to scientists, who in determining their origin have mainly paid attention to the part played by climate and geological structure. The present author has studied granite forms in a variety of climatic zones and found that they reveal many common features independent of climatic conditions. This seems to indicate a definite dependence of relief forms on geological structure.

In 1896 J. C. Branner [3] established by observations in Brazil that crystalline rocks, in particular granites, have thick regolith covers, often more than 30 m thick. He noticed an interrelation between regolith distribution and thickness, and fractures and grain size of the rock, with weathering proceeding along the fractures and more readily attacking granite rock of a coarser grain. However, J. C. Branner admits that his opinion conflicts with the fact that in various places he also observed high peaks built of coarsegrained rock. In the same year another scientist, J. P. Merrill, concluded on the basis of comparisons between the chemical composition of bad rock and its regolith cover, that among igneous rocks plagioclases weather much more rapidly than potassium feldspars. T. L. Watson [19] reports that the source material so far available fails to elucidate the part played by grain size in weathering. H. Lautensach [8] mentions observations resembling those made by many other scientists, which seem to indicate that grain size and the density of rock fractures have a strong influence on the evolution of weathering processes and relief forms; in his opinion the mineral composition is of secondary importance in the evolution of forms. In contradistinction to this P. Birot and E. Jeremine [2] believed that apart from grain size, a biotite content in the granite furthers a more rapid weathering. Taking observations made at Corsica as a basis, W. Klaer [7] reached conclusions similar to those of P. Birot and E. Jérémine, adding that in his opinion rock fractures are of minor importance in weathering processes.

The author has mentioned only a few scientists, in order to point out those features of granite rocks which have been considered essential for the evolution of regolith and granite forms, and in order to stress how different these opinions are. As to the influence which the type of granite exerts upon the development of regolith covers and land forms, the majority of scientists assign first place to fractures; next they put grain size, and only a few point to the role played by the kind of minerals in the granite composition; in this respect biotite is often mentioned as supposedly most important. Statements on this subject are frequently rather vague. Granite is spoken of as more resistant when appearing in what is called "positive" forms and resistant to weathering, or as more subject to weathering and giving rise to "negative" forms.

Near Canton in China there are granite elevations several of which rise to some 50 m high, built of porphyritic and a finegrained granite. Macroscopic examinations show that the finegrained granite elevations have steep walls and lack regolith covers almost completely; and it is remarkable that locally this granite is intensely fractured. The ridges of porphyritic granites are gently rounded and the rock is weathered to considerable depth.

Similar interrelations prevail in the region of Soochow, it seems that the porphyritic granite is generally less fractured. Observations seem to indicate that for porphyritic granites a more rapid weathering depends on grain size, — incidentally a feature mentioned by a great number of authors. Hence in this instance the density of fractures seems to be of secondary importance or of no importance at all. This opinion, however, is refuted by observations made in a variety of regions by other authors. In what is called the Eastern Desert in Egypt, the present author studied granite hills rising to relative heights of several hundreds metres; they consist of porphyritic or of finegrained granite. Where the grain size is differentiated, the ridges are usually more rounded and the slopes less steep than for granite of a fine and uniform grain. A striking feature is that the inclination of some slope sections is closely related to the dip of the fracture planes. No regolith covers are seen on either granite type mentioned, and since not even the gently inclined rock surfaces have covers of regolith accumulation, it is everywhere relatively easy to examine the differences in grain size, fracture density, and even mineral composition. The author was therefore able to determine that, in depressions surrounding higher elevations, the granite contains much less quartz than is found in the elevations, and usually the grain is coarser. Thus in the granite of these regions the "negative" forms appear to be mostly associated with quantitative differences in mineral composition, as well as with a coarser grain. The author has described all the forms observed in Egypt in an earlier paper, published in 1960 [4].

Examinations of the granite of the Karkonosze massif have shown that regolith covers are mostly found on porphyritic granite. Locally the orthoclase crystals are more than 7 cm long, while in a granite of uniform grain size they are usually of the order of 1 to 3 mm. Here, as a rule, the rock shows no chemical weathering. The most intensive chemical changes are observed along fractures where they decrease with increasing depth. The average distance between fractures is from 0•5 to 1 m, but locally fractures occur in bundle-like accumulations with distances reduced to about 1 cm, less often to a few centimeters. Mineral cataclasis is sometimes observed at such densely grouped fractures, and in such cases layers of regolith appear, as it were, in the compact rock. This shows that a close interrelation exists between fracturing on the one hand and the degree of chemical change and thickness of the regolith cover on the other. Even so, outcrops are also found where for all the density of fracturing no chemical change can be found, or where a porphyritic granite lacks features of weathering altogether; this may have been caused by a differentiation in mineral composition. The author collected samples from places with a regolith cover and from other places where bedrock appears on the surface in order to determine the quantitative mineral composition of this granite. Micrometric examinations made for 30 selected places disclosed the following proportions (in volume percent) of individual minerals: plagioclases 21 to 45•66%, potassium feldspar 17•49 to 43•42%, quartz 25•82 to 42•86%, biotite 0•12 to 9•70%. Further minerals such as zircon, apatite, muscovite, epidote, chlorite and iron oxide occur only in tenths or hundredths of one percent. Thus feldspars and quartz are the basic minerals, and in accordance with the terminology used by K. Smulikowski [16] the rock forming the Karkonosze massif should be called a granitoid, with varieties like granite and granodiorite predominating in the granitoid. The differentiation in the quantitative mineral composition is seen to affect the thickness and the distribution of the regolith covers very much. The latter occur clearly and almost exclusively on granodiorites where plagioclases prevail over potassium feldspars, while they are usually lacking on granites. It has been known for a long time that plagioclases undergo weathering much more rapidly than potassium feldspar (G. P. Merrill [13]). This means that a considerable predominance of plagioclases renders a rock much more predisposed to chemical weathering. The Karkonosze examinations show that a granitoid rock is particularly subject to chemical weathering when its plagioclase content is more than 40% of the rock volume and when anorthites predominate in this component. On the other hand the author does not consider biotite as important as is believed by P. Birot and E. Jeremine [2] mainly because there is usually little biotite in the granitoid, and because S. S. Goldich [6] has demonstrated that biotite weathers less rapidly than plagioclases. Thus the observations mentioned seem to indicate that, within granitoid rocks, the rate of chemical weathering depends on features like quantitative mineral composition, differentiation in grain size, and density of fractures. At individual places the degree of weathering is contingent on a combination of these features and on their respective intensity. The quantitative mineral composition is probably the decisive factor here. For all this it is possible for regolith covers to develop in spite of a less favourable quantitative mineral composition where fractures are numerous and the grain size uniform. At places where the above features change sharply over a short distance, a sharp boundary may be seen between regolith and bare rock. The author therefore believes this to be the cause of what D. Linton [9] calls a "basal platform" and B. P. Ruxton and L. Berry [14] a "basal surface". Where no such sharp difference exists, a regolith cover passes gradually into a bedrock surface.

The differences that have been discussed in the features of granitoid rocks affect relief forms as well as regolith covers. In the Karkonosze massif all the sharply sculptured peaks (Szrenica, Łabski Szczyt, Mały Szyszak) are made up of granite with fine- or mediumsized grain containing a predominance of quartz, whereas the amount of sodium-calcium feldspars is about equal to that of potassium feldspar. As a rule, fractures are more common here than the average for the whole granitoid. A porphyritic granite containing approximately equal amounts of both feldspars and quartz gives rise to rounded ridges; a number of granite hills rising above more or less flat surfaces owe their survival to the differentiation in their mineral composition. The origin of the mountains described by J. C. Branner [3], H. Lautensach [8], A. Mabbutt [11], W. Klaer [7], J. P. Bakker [1], H. Louis [10], and many other authors can perhaps be explained in this way. Nor can it be disputed that the "dome" forms described by many scientists (G. K. Gilbert [5], F. E. Matthes [12], B. P. Ruxton and L. Berry [15], C. R. Twidale [17]) may be the result not only of the characteristic pattern of their fractures but also of a differentiation in their quantitative mineral composition. Apart from fractures, small grain sizes and an appropriate mineral composition have also played a part in forming the slope terraces and knick contours observed on the Karkonosze slopes. It is a remarkable fact that what are called "klippen" are mostly found at the contact between a porphyritic and an equigranular granite, and that they contain much less sodium-calcium feldspar in their rock structure, than potassium feldspar or quartz. The mean values determined from 5 micrometric analyses of klippen rock revealed: 25% sodium-calcium feldspar, 34% potassium feldspar, and 33% quartz. The relatively high biotite content (3·3 to 9·4%) is surprising. The Karkonosze passes and valleys are also closely associated with the mineral composition of the granitoid, and this dependence is clearly noticeable in the shape of small valley forms. On surfaces of granite with a smaller amount of plagioclases and a fine grain, minor streams fail to erode distinct valley forms: as a rule such streams flow over the rock surface incising only the slope covers. At the contact between granite and granodiorite however a distinct step is seen in the longitudinal profile, and within the granodiorites the valley forms stand out clearly. When it comes to larger valleys, they became distinctly widened in the granodiorite rock and they develop slopes which are more gently inclined. The widened valleys in the Dartmoor region in England, described by R. S. Waters [18], are probably also associated with an increased density of fractures and, especially, with a differentiation in the quantitative mineral composition of the rock. In the Karkonosze it was found in one instance, that rock outcrops on the crest of the massif contain more than 40% plagioclases. The strong resistance of this rock to chemical weathering, in spite of its high plagioclase content, must probably be ascribed to the differentiation of these rock constituents. S. S. Goldich [6] found that basic plagioclases are the first to undergo weathering; their disintegration is more rapid than that of hornblende, even of augite, while acid plagioclases are much more resistant. For this reason more detailed examinations will be necessary to determine accurately the kind of plagioclase encountered.

As shown above, the quantitative mineral composition is a very important feature which, together with grain size and fracture density, affects the development of regolith covers and the shape of mountain forms. In the author's opinion the ambiguities which have hitherto existed in determining the effect of the type of rock upon the evolution of granite forms, have mainly been occasioned by the fact that granites were considered to be homogeneous as to their quantitative mineral composition. Rocks commonly called granites differ very much, and this has an important influence on the forms they assume.

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THE ORIGIN OF THE FORMS KNOWN AS KARST POLJES

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A new concept has recently emerged with regard to the formation and further development of what are known as karst poljes, based on investigations in the Dinarian karst region of Yugoslavia. The author has carried out detailed geomorphological and geological studies in cooperation with Dr. J. B. Petrovic at a number of places including Dabarsko, Fatničko and Plansko Poljes in Eastern Herzegovina [5, 8]. Hitherto students of these poljes have been of the opinion that they must have originated due to tectonic phenomena and been resculptured afterwards by karsting processes. This is in agreement with the commonly held belief that "the principal agent in the formation of poljes are karsting processes of dissolution, due to which sinks and potholes develop, joining each other and forming widespread depressions — poljes. These processes are facilitated by the karst tectonics, that is, folded and faulted structures" [6].

The poljes investigated by the author extend in a straight line from NW to SE, that is, parallel to the Dinarian foldings. An identical pattern is seen in the Nevesinjsko and Gatacko Poljes which adjoin them to the north and at Ljubisko, Ljubomirsko, and the big Popovo Polje (Fig. 1) to the south. To some extent this characteristic situation of the poljes throws light on their origin, implying the possibility that their formation may have been associated with the sculpturing of the non-karsted land relief.

Dabarsko, Fatničko and Plansko Poljes are situated in the central part of the extensive Rudine karst surface at a height of 600 m above sea level. They are bordered on the NW by the Snježnica (1262 m), Trušine (1149 m) and Panik mountain ridges, to the SE by the Sitnica (1149 m), Oblo Brdo (1114 m) and Kubas (1021 m) ridges. The relative height of these chains above the bottom level of the poljes is about 500 m.

Of the three poljes under discussion, Dabarsko Polje is the largest; its length is 21 km, its width varies from 0·7 to 3·5 km. The polje bottom occupies an area of some 30 sq. km and lies at 490 m above sea level. The much smaller Fatnicko Polje extends SE of Dabarsko Polje, separated from Dabarsko Polje by a calcareous ridge called Prevlaka, 2·5 km wide and 5·5 km long; its relative height is about 150 m, its absolute altitude 600 m. The long axis of Fatnicko Polje is 5·3 km, its bottom measures some 10 sq. km, its altitude is 470 m. Fatničko Polje is particularly interesting on account of an isolated calcareous hump called Humac, of 510 m altitude, which protrudes from amongst flysch sediments. The smallest of the three objects discussed is Plansko Polje, situated furthest southeastward. Its length from NW to SE is some 4·0 km, its width 1·4 km. The bottom area of this polje is about 5·5 sq. km and its altitude 480 m above sea level.

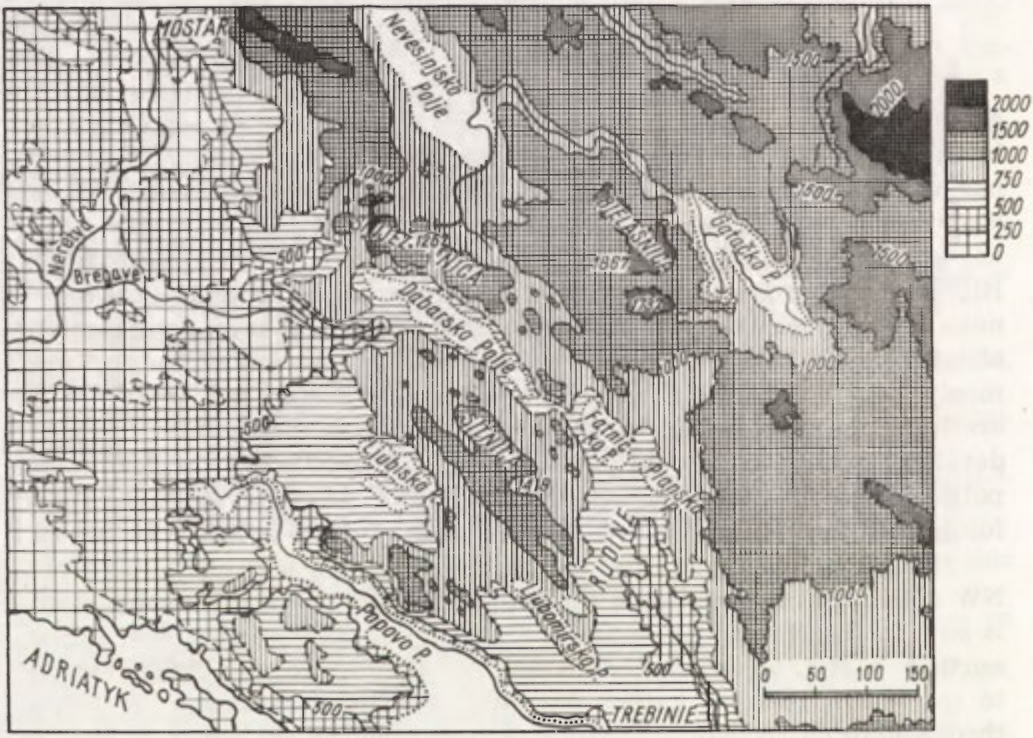

Fig. 1. Map showing the position of major karst poljes in Eastern Hercegovina (heights in metres)

The present hydrographical conditions at Dabarsko, Fatničko and Plansko Polje are distinguished by three independent hydrographical systems, where each polje represents a drainage basin of its own. Dabarsko Polje is the basin most amply supplied with water. The principal stream is the Opačica river. One tributary, arriving from Trusinsko Polje, is Trusinski Potok, water is also received from the Ljeljesničkie Springs and from Bileji Potok. At moderate water levels the Opačica vanishes into a cavern (ponori) in the SW part of the polje, while at high water it joins the Vrijeka creek which issues from an enormous cave at the northern edge of the polje. At low water the Opačica vanishes in the Ponikve sink [7]. From November until May, when the polje is flooded, the water is carried off through the Kuti sink in the SE part of the polje (Fig. 2). Fatničko Polje shows very little variety

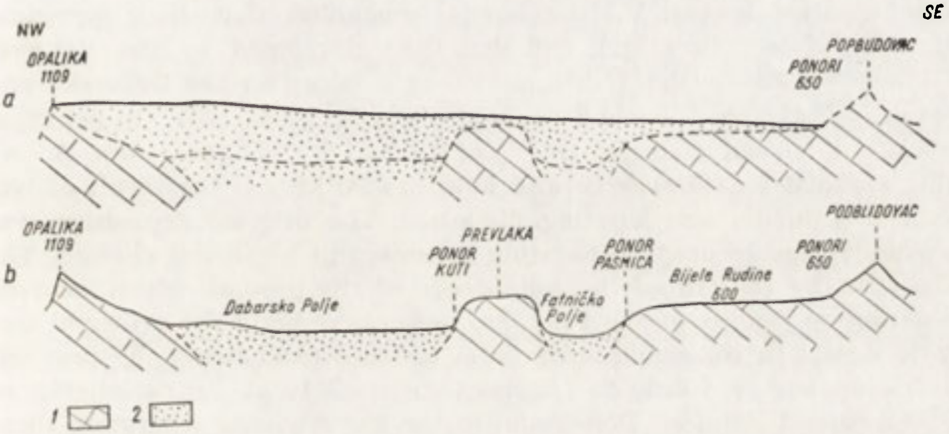

Fig. 2. Diagram of a longitudinal profile across Dabarsko and Fatničko Poljes
1 -- Cretaceous limestones, 2 — Eocene flysch: a original stage, of evolution, b — today's stage.

hydrographically and is lacking in perennial surface streams. In summer, only a few low-capacity springs in the northern periphery of the polje supply water, while in winter — the rainy period of the year — the largest seasonal source, Obod spring, yields an abundant flow. In the rainy period the Fatnička Rijeka flows in its shallow bed and causes slight flooding on the adjoining land. All the water from Fatničko Polje runs off into a group of sinks situated in the SE part of the polje, of which the most important is the Pasmica ponori (Fig. 2). Plansko Polje has no constant-flow streams nor springs. Seasonal springs yield water only in the autumn, flooding the central part of this polje; all the water disappears into sink holes in the southern periphery.

The problem of the origin of these poljes has received much attention from scientists such as J. Cvijić [2], A. Lazić [7], B. Hawelka [4] and more recently O. Zubčević [11].

In the opinion of J. Cvijic [2] their origin was due to tectonics, and he dates the principal tectonic movements from Pre-Neogene time. He believes that "the Neogene deposits found mainly in the polje margin are proof that a lake existed here in the Neogene period. This lake has been drained by the deeply incised Prijevojac and Predolje depression, which resembles a river valley". A Lazic [7] holds that "the principal lines of these poljes originated due to tectonic movements which took place towards the end of the Tertiary Period. These movements caused renewed folding and an upheaval of calcareous rock masses, in consequence of which karsting developed here...". On the basis of the position of the Eocene conglomerates at a relative height of some 400 m above today's poljes bottom V. Hawelka [4] concluded that their principal lines are of tectonic origin, and that they developed in the Younger Tertiary. O. Zubcevic [11] has published a paper on the Dabarsko and Fatnicko Poljes in Fascicle 2 of Geografsko Pregleda 1957. On principal points this author endorses the opinions held by his precessors. According to Zubcevic, "Dabarsko and Fatnicko Poljes are the result of tectonic movements and karsting processes. The original depression was gradually resculptured by karsting processes in a diluvial climate. The dissection by faults and the subsidence of the ground which ocurred towards the decline of the Pliocene, took place along the principal tectonic lines... In consequence of these tectonic movements the previous flat levels survived only in fragments, noticeably at the peripheries of Dabarsko and Fatnicko Poljes and in the karst humps separating these two poljes". In O. Zubcevic's opinion the subsidence of these poljes did not take place all at the same time.

The above survey shows full agreement between the authors quoted, that Dabarsko and Fatnicko Poljes must have originated principally due to tectonic phenomena, and that they were subsequently resculptured by karsting processes. However, the observations and opinions cited have been founded on insufficient investigation and evaluation of the geological facts.

Dabarsko, Fatnicko and Plansko Poljes all resemble each other in geology and tectonics. Only rock formations of the Upper Cretaceous and Upper Eocene age [3] are found in the structure of these poljes and of the adjacent terrain. The Upper Cretaceous is represented by Cenomanian and Senonian limestones. The dip angle of the Upper Cretaceous rocks is highly important in all further deliberations. Along the SW margin of the poljes they are tilted northward at some 30°, while in the NE periphery they show an opposite dip, inclined southward also at some 30°. This shows that the Upper Cretaceous strata form a wide syncline here (Fig. 3). The Upper Eocene sediments have mainly developed as limestones and flysch rocks. A limestone series appears only at the periphery of Dabarsko Polje, maintaining its Dinarian direction, that is from NW to SE. The flysch series, consisting of sandstones, marls and clays, appears to have been laid down within the Pre-Eocene synclines.

The essential feature of the geological structure to throw light on the origin of the poljes, is the fact that the flysch rocks are nowadays confined to the bottom of the poljes and to the lowermost part of the ridges surrounding them. The Eocene flysch zone at Dabarsko and Fatnicko Poljes is interrupted by Upper Cretaceous rock banks, which make up the hump separating Dabarsko Polje from Fatnički Polje (Fig. 2).

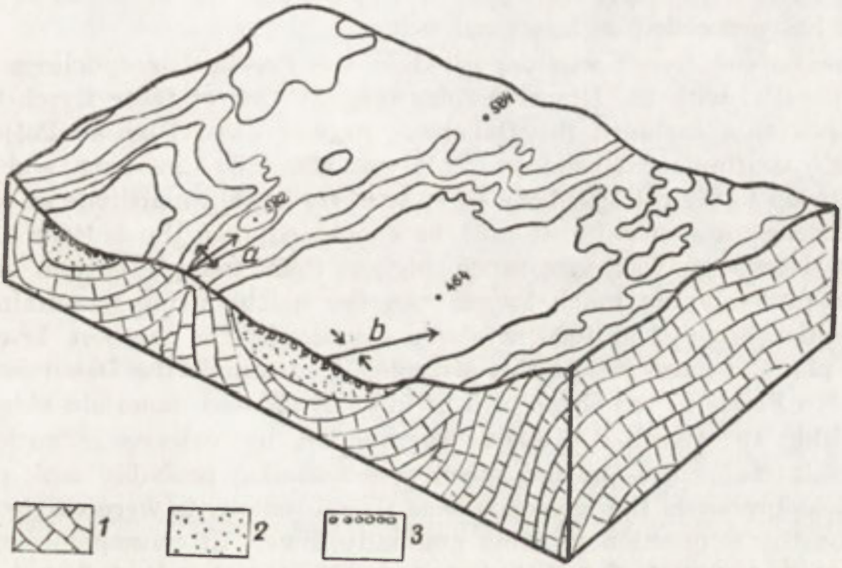

Fig. 3. Blockdiagram of Fatničko Polje

1 — Cretaceous limestones, 2 — Eocene flysch, 3 — diluvial-eluvial deposits. a — anticlinal axis, b — synclinal axis. According to J. B. Petrovic.

A similar, although much smaller, calcareous barrier rises between Fatničko and Plansko Poljes. From geophysical examinations and drillings made here in 1958 and 1959 it has been determined that no lacustrine deposits nor limestones lie underneath the Quaternary cover; instead, the Eocene flysch was found to be of considerable thickness [1, 10]. At Fatničko Polje, for instance, the thickness of the flysch is more than 180 m, and it is not until this depth that the Upper Cretaceous limestones are encountered. This recent information is of particular significance for the problems of karst morphology, and throws an entirely new light on the origin of the poljes.

The tectonic features here are relatively uncomplicated. Recent geological studies have disclosed the existence of only one line of dislocation extending along the NE margin of the Dabarsko, Fatničko and Plansko Poljes [1]. The results of these investigations conflict with the opinion that the poljes themselves are areas of subsidence along certain tectonic lines. Nor can the assertion of earlier workers be endorsed that two tectonic faults exist, one at either side of the 2 km calcareous hump separating Dabarsko Polje from Fatnicko Polje.

In view of these new determinations, the theories hitherto held as to the origin of Dabarsko, Fatničko and Plansko Poljes must be regarded as fully or partly disproved. Instead, it seems that the evolution of these forms has proceeded as is set out below.

The Eocene flysch was deposited in the Pre-Eocene synclines running parallel with the Dinarian folds (Fig. 3). One of these flysch-filled synclines once included the Dabarsko, Fatničko and Plansko Poljes in a single continuous depression. This was about 80 km long and had a width up to 5 km (Figs. 1, 2). In view of the absolute altitude at which the Eocene sediments lie, it may be concluded that the bottom of the flysch depression was once much higher than today's bottom of the poljes, probably not much lower than the neighbouring mountain passes which are 900 to 1000 m above sea level. The highest level of karst planation also lies at this altitude. It surrounds the Dabarsko and Fatničko Poljes in the shape of a band of denudated mountain ridges.

Within the flysch depression surrounded by calcareous anticlinal ranges intensive erosion and selective denudation probably took place. By these processes the low-resistance flysch sediments were carried off, causing this depression to grow gradually lower. In consequence of this continuous removal of the flysch, probably associated with powerful Pliocene tectonic movements, the existing fluvial system was put out of order. The surface rivers turned into karst streams, that is rivers flowing partly underground. One of these new rivers developed in the depression containing what are now Dabarsko, Fatničko and Plansko Poljes. This is indicated by enormous sinks (ponori), today inactive and apparently hanging, found in the east part of the Bijele Rudine plain, south of Bileje Rudine village, at the foot of Podbudovac Mountain, at an elevation of about 650 m above sea level (Fig. 2). The karst stream of Dabarsko, Fatničko and Plansko Poljes, flowing through flysch sediments, carried away this relatively low-resistant material and deposited it in the caves mentioned above. With the further lowering of the flysch surface calcareous humps emerged from the uneven substratum of the paleorelief. From the time that such calcareous rocks began to appear on the surface, a discontinuous change in the evolution of the poljes set in: the previous hydrographical network was broken up within the Dabarsko, Fatnicko and Plansko Polje depression, and new conditions arose for the evolution of three isolated flysch depressions — the origin of the three separate poljes each with a hydrographical system of its own.

First the continuity of the flysch sediments was interrupted. This happened when the calcareous hump became exposed which today separates Fatnicko Polje from Dabarsko Polje. Thus Plansko Polje developed as the first independent one of the three discussed. As soon as the limestones underlying the flysch sediments had been uncovered, the karst stream failed to reach the above mentioned cave; instead it vanished in lower karst sink in the Padjene depression not far above Fatnicko Polje, some 5 km from the caves mentioned previously. With this Plansko Polje started its existence as a separate basin — the first to be isolated in the formerly common depression.

Within the flysch depression, both Fatnicko and Dabarsko Poljes began to develop as independent basins at 650 m above sea level, and the limestones of the barrier ridge separating them were laid bare at this altitude. Running up against impermeable limestones the Dabarsko and Fatnicko Polje river again shortened its course and gradually vanished within these rocks. Evidence for this is provided by the Kuti sinks, situated in the SE margin of the Dabarsko flysch basin (Fig. 2). As the Kuti caves developed, the NW part of the flysch depression turned into a separate unit, and from then on the two basins developed independently of each other, each with its own fluvial system. The further evolution of these two basins was influenced by local conditions: the most important was the pattern of the flysch sediments, since it largely determined the size of each polje. The position and growth of the sink holes and caves also had some influence as did the amount of water supplied by springs and by precipitation.

Selective erosionand denudation continued within the poljes which from now on were separate units. While the polje floor was gradually lowered and calcareous rock groups were uncovered in increasing number, new sink holes were developing into which the underground streams vanished with their load of flysch.

Flat levels can be seen above the poljes. Among them there is a very well preserved karst surface at 600—700 m extending above the SW periphery of the Dabarsko and Fatnicko Poljes. Towards the southeast this surface passes into the Bijele Rudine surface already mentioned. The formation of this flat surface is closely associated with the evolution of the flysch depression, because it lies at the same altitude in which the sink holes of the Dabarsko-Fatnicko river existed:

the river which ran through the flysch depression prior to the formation of the separated basins, today's poljes.

According to J. Roglic [9] and O. Zubcevic [11] these surfaces were formed by corrosive processes during a relatively calm period in tectonic movements, while J. Cvijic [2] and A. Lazic [7] believe they developed during a lacustrine phase. The evolution of the Bijele Rudine level may be taken as an example. After the river running through today's poljes had undergone karsting and had changed into an underground stream, vanishing in a cave at the foot of Podbudovac Mountain and sweeping out the material from the flysch depression, an extensive accumulation plain developed around this cave, made up of material brought in by the river. Very intensive chemical processes set in on this level, particularly in the warm Tertiary climate. This led to a rapid destruction, or rather solution, of the underlying limestones. The rate at which this new surface grew was dependent on agencies such as the amount of water flow, the size of the flooded area, the petrographic purity of the limestone, the composition of the rocks involved in forming the accumulation plain, climatic conditions, etc. Similar corrosive processes can also be observed today. At the altitude of the Fatnicko Polje plain, near the Pasmica cave, a corrosive plain is developing which steadily increases the area of this polje.

The origin of the poljes under discussion cannot be ascribed to traditional karsting processes because non-karsting material lies at the bottom of the poljes: flysch up to 180 m thick. Nor can a tectonic origin be assumed. Instead, studies of the Fatnicko, Dabarsko and Plansko Poljes seem to indicate that a fairly important part was played in their evolution by denudation and selective erosion, causing destruction and removal of the flysch material which had filled the ancient synclines in their calcareous rock bed. The importance of selective erosion for the formation of poljes in karst regions is also brought out by the existence of Humac, the isolated calcareous hump in the floor of Fatnicko Polje; this structure is well preserved, while the flysch sediments, less resistant to destructive processes, have been swept out from this region by erosion and denudation. The existence of this hump amidst flysch sediments of considerable thicknesses conflicts with the theory of a karst origin for the poljes; it rather indicates that the karsting processes which were dissolving the calcareous surfaces must have been proceeding at a much slower rate than the erosive processes which denuded and lowered the flysch surfaces. Evidence similar to the Humac hump in support of the significance of selective erosion, is provided by the calcareous ridges up to 180 m high which separate the three poljes from each other. Further proof of the same sort is provided by the fact that

Dabarsko Polje with its permanent fluvial system is the best developed of the three poljes; while Plansko Polje, although the first to develop, is the smallest and shallowest due to the small surface occupied by flysch and the lack of a perennial fluvial system.

Arguing from the investigations at Dabarsko, Fatnicko and Plansko Poljes it may be asserted that, in the evolution of some of the forms known as karst poljes, true karsting and tectonic processes played only secondary roles: tectonics only in the deposition of the flysch sediments or in the paleorelief, karsting only insofar as it opened the way for water runoff from the flysch areas by underground flow. Since in the development of the poljes the share of karsting processes has been or, putting it more guardedly, may have been insignificant compared with the effect of selective erosion and denudation, it seems appropriate that the term "kraska polja" ("karst poljes") commonly used so far should be replaced by a more appropriate term which would not beg the question of a karst origin, — a term like "polja u krsi", that is a polje on a karst bed or a polje in a karst region.

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THE EASTERN SIBERIAN KARST

Marian Pulina

Thanks to the kind assistance granted him by the Institute of the Earth's Crust of the Soviet Academy of Sciences at Irkutsk in 1964, the author was able to investigate karst phenomena in two geographical regions of Eastern Siberia. These regions were the Siberian Platform, and the mountain regions of the Eastern Sayan Ridge and Chamar-Daban on the Baykal shore. Both constitute part of what is called the "Irkutsk Amphitheatre" (Fig. 1). The two regions differ in their geological structure and in the features of their respective geographical environments. The Platform is covered by horizontally spread sedimentary rocks of the Older Paleozoic and the Younger Mesozoic (mainly the Jurassic)

Fig. 1. The Eastern Siberian karst.

A — areas covered with carbonate and sulphate rocks, mostly of Lower Cambrian age, B — karst areas in which examinations of chemical denudation were made. Vallies: 1 — Wielka Biała and Wielka Iret, 2 — Unga and Zalari, 3 — Osa, 4 — Kyngarga, and 5 — Slyudyanka and Pochabich which overlie the older crystalline substratum. Carbonate and sulphate rocks of the Lower and Middle Cambrian predominate here, with a total thickness of some 350 m [5, 11]; these rock formations appear mostly on the surface, or are covered by a thin mantle of younger deposits. The mountains on the other hand, made up of Precambrian crystalline rocks, contain marbles and dolomites in the shape of relatively small bands up to a few kilometres wide.

The areas covered by soluble rocks occupy some 30% of the surface of the Irkutsk Amphitheatre. equivalent to a total of more than 300,000 sq. km.

A typical continental climate, mitigated by the "oceanic" influence of Lake Baykal, rules in the Irkutsk Amphitheatre. It is characterized by extremely severe winters (the Siberian anticyclone) and a scanty precipitation; the winter lasts fully 6 months. The mean annual air temperatures vary from —1° C in the Baykal region to —3° C on the Platform and to —6° C in the high-mountain regions [2, 3]. Precipitation is lowest (less than 300 mm/annually) on the Platform and in the sheltered mountain valleys, and highest (more than 1000 mm) on the southern Baykal slopes. These exceptionally severe climatic conditions explain why the Irkutsk Amphitheatre is part of a zone of long-term permafrost [15].

The wide extent of karst rocks in Eastern Siberia is of great interest to scientists who study them from both a theoretical and a practical point of view. Since the 19th century when Polish deportees were the first to study this karst [7, 8], much research has been undertaken, published in more than 100 original papers. At present, Irkutsk is the centre concentrating all research covering this region. In connection with hydraulic construction work under way on the Angara river, a score of new papers have recently been published on such topics as: karst regionalization [18], karst hydrography [1, 2, 12, 13], hydrochemistry [4, 17, 19], — as well as reports with results of geological and engineering investigations [5, 11], among them an interesting study dealing with landslides due to suffosion and karsting processes [10].

The karst regions of the southern part of the Siberian Platform are grouped in its centre (the Angara valley and its large tributaries) and along its periphery. They form separate karst regions each with its own distinctive hydrographical and morphological features. The group of surface forms developed in the karst relief is particularly interesting. Among the macroforms to be mentioned are dry valleys ("*suchodol*" in Russian) up to 50 km long. Within these valleys lie separate widened regions, karst hollows measuring a few square kilometres each; most of these hollows are drained periodically, but at times water is retained

Fig. 2. Karst waters (Great Iret River)

forming lakes (such as Augon lake in the Osa valley). Each hollow contains a system of springs and caverns ("ponore"), connected by a directional outflow of subterranean water from beneath the *suchodol* bottom (Fig. 2). Caverns are found here constituting the remains of underground tunnels by which the water was once carried from the karst hollow (such as the Balagansk Cave, some 1200 m long, in the Melchituj *suchodol*). Mesoforms should include the numerous sinkholes encountered in both bottom and slopes of a *suchodol* frequently above caverns formed by collapsed tunnels), and partly on the flat surfaces extending between suchodols. The sinkholes are from a few to a dozen meters deep, but there are also deeper holes, such as for instance a water-filled sinkhole 56 m deep in the Osa valley [9]. An interesting feature is the system of small sinkholes which have developed in the Angara terraces where the chemically active Angara waters have penetrated the ground intensively; they are so numerous that a relief has developed resembling what is called a "bugrova" area. Recently the formation of new sinkholes has increased, in consequence of the construction of a storage basin in the Angara valley associated with the new Bratsk hydroelectric plant.

In contrast with the Platform, the karst relief in the mountain areas is poorly developed. Here meso- and microforms prevail, with a subterranean karst hydrography.

The author's principal aim was to determine quantitatively the extent of modern chemical degradation in the karst regions of Eastern Siberia. This problem has been of interest to several scientists from Irkutsk [4, 17, 19] who, as a side-issue in their hydrochemical research, attempted to determine the quantity of ions carried off from several topographical catchment basins. The author is indebted to these scientists for supplying him with chemical analyses of waters and with certain hydrometric data.

To determine the extent of chemical denudation the author applied his hydrometric method $D = 12{\cdot}6\ TQ/P$, or $D = 0{\cdot}0126\ TV$ where $V = 1000\ Q/P$. For purposes of comparison, calculations were made in several areas, based on Corbel's climatic method [6] $D = 4\ ET/100$, where D = chemical denudation in cu.m/sq.km/year, or mm/1000 years, Q = flow in cu.m/sec, P = surface in sq.km, V = unit flow in litres/sec/sq.km, E = precipitation, and where the content of dissolved salts is given in mg/litre and evaporation in decimeters. The author's hydrometric method was evolved theoretically and checked in the Polish karst region. It was subsequently used for comparative determinations in other karst regions [14]. The method can also be presented graphically (Fig. 3).

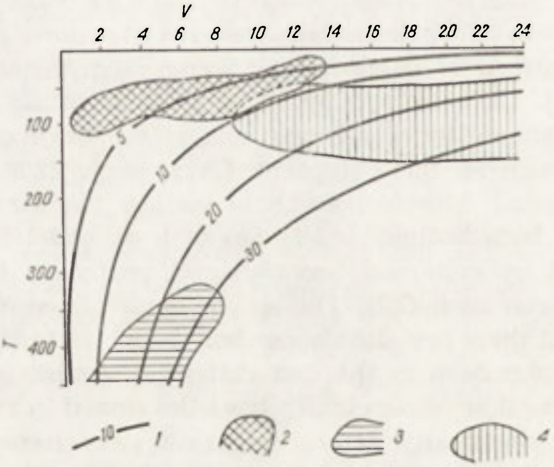

Fig. 3. Chemical karst denudation in Eastern Siberia plotted from the relation $D = 0{\cdot}0126\ TV$.

1 — isolines of denudation, in cu.m/sq.km/year or mm/1 000 years; 2 — karst of the Siberian Platform — carbonate, 3 — karst of the Siberian Platform — sulphate/carbonate; 4 — karst of Eastern Sayan and Chamar-Daban — carbonate.

The investigations made in the Irkutsk Amphitheatre took two directions. The chemical degradation was determined: 1) for the Angara catchment basin and the basins of 22 Angara and Lake Baykal tributaries, 2) for 5 typical karst areas on the Siberian Platform (in the valleys of the Wielka Biała, the Unga and the Osa rivers), in Eastern Sayan (the Kyngarga valley in the Tunkin Alps), and in Chamar-Daban (the Slyudyanka and the Pochabich valleys). The sample material from observations enabled the author to determine the denudation not only of carbonates and sulphates (the chemical karst denudation), but that of all ions in the water as well (overall chemical denudation). In his calculations he took into consideration the infiltration of water from one catchment basin into others, and the volume of salts derived from atmospheric precipitation. Fig. 4, illustrates the annual fluctuations of salt concentration in the karst waters.

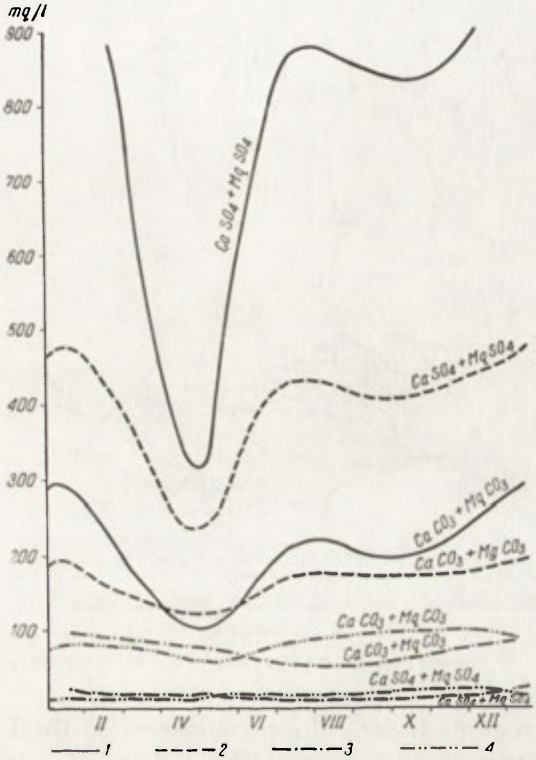

Fig. 4. Annual variations in salt concentration in karst waters in Eastern Siberia, from the valleys of:
1 — Unga, 2 — Osa, 3 — Slyudyanka, 4 — Kyngarga.

The overall chemical denudation for karsted and non-karsted areas comprising the Angara and the Baykal drainage basins amounts to more than 3 cu.m/sq.km/year. With regard to the mineral material carried by the Angara (of which the long-term mean is about 100 kg/sec), chemical degradation accounts for 10—20%. The pattern of chemical denudation in the Irkutsk Amphitheatre is shown in Fig. 5. The highest values appear on the Siberian Platform in karst areas, at places where infiltration of chemically active transitory waters is taking place (as in the Osa valley — 20 cu.m) and in the mountain regions (40 to 60 cu.m).

Fig. 5. Overall chemical denudation (mean annual value) in Angara and Baykal basins.
1 — denudation in cu.m/sq.km/year, or mm/1000 years

In non-karsted regions these values are lowest on the Platform and in the Selenga basin (less than 6 cu.m). The values of karst denudation for the three Eastern Siberian areas mentioned are shown in Table 1 and in Fig. 5.

Apart from chemical denudation the author also determined on the basis of the Trombe-Tillmans [16] chart, the present-day chemical activity of the water. This is shown in Fig. 6, from which it can be seen that the greater part of the karst waters of Eastern Siberia is non-saturated and shows a high chemical activity.

The results obtained from studies of the Eastern Siberian karst led the author to the following general conclusions:

I. The best developed karst relief of the Siberian Platform lies in the Irkutsk Amphitheatre. Here a group of macro- and mesoforms predominates, shaped differently from the forms hitherto known in other

TABLE 1. Chemical denudation in the karst of Eastern Siberia (taking into account salts derived from atmospheric precipitation)

Karst area	Chemical denudation in cu.m/sq.km/year, or mm/1000 years		
	Karst denudation		Overall denudation
	carbonates	carbonates + sulphates	sum of salts
Tunkin Alps			
Kyngarga valley	32·3	40·1	42·6
Western Chamar-Daban:			
Slyudyanka and Pochabich valleys		43·8	61·4
South-Western Scarp of the Siberian Platform			
Wielka Biała valley	5·8	6·5	8·3
Siberian Platform:			
Unga valley	1·1	6·7	8·1
Osa valley	4·6	15·9	19·7

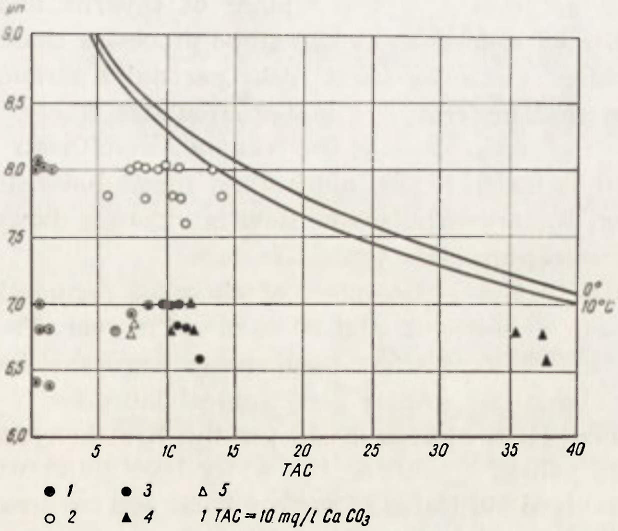

Fig. 6. Chemical aggressiveness of waters of Eastern Siberia plotted on Trombe-Tillmans' chart. Slyudyanka and Pochabich valleys (Chamar-Daban): 1 — water from crystalline rocks; 2 — waters from karst areas; Kyngarga valley (Tunkin Alps): 3 — karst waters; Southern part of Siberian Platform: 4 — karst waters: 5 — waters of transitory rivers.

karst regions. Many arguments support the proposition that this karst should be referred to as "Siberian karst". Its characteristic features are: 1. It is polygenic and originated during the long periods of the middle Cambrian and the Upper Paleozoic; it has been developing since the Cretaceous and continues to do so. 2. The development of the karst relief was directly dependent on the subterranean hydrography, and proceeded independently for each of the regions in their own underground catchment basins. They differed in their rate of degradation, and this explains the marked variety in which these karst forms have developed. 3. The base of denudation for the evolution of karsting processes has been formed by the floors of the Angara valley and of its larger tributaries. The level of the karst waters is associated with these forms, which accounts for the frequent occurrence of dry voids in the rocks below the floors of higher valleys. 4. As soon as the waters issuing from mountain areas penetrate the karst formations of the Platform, they lose part of their volume to the underground water horizons. These waters emerge on the ground surface at the contact with non-karsted deposits lying above carbonate rocks a score or so kilometers from the ponores, or in the valley floors of the Angara and its larger tributaries. 5. At present the majority of macroforms and the caverns connected with them are being sculptured only to a minor degree, and they are often bypassed by the normal circulation of the karst waters. On the other hand, intensive evolution is currently taking place of caverns underneath these forms, together with karst sinks and slope processes caused by chemical karst denudation. 6. In the karst rocks perennial permafrost is poorly developed, so that underground water circulates freely.

II. In the mountain areas of the Irkutsk Amphitheatre the evolution of karst relief is insignificant; older karst forms have survived merely in relict form. Underground water flow is vigorous, however, and subterranean river capture is a typical feature.

III. In modern times the effect of chemical denudation in Eastern Siberia fluctuates between 2 and 60 cu.m/sq.km/year. These values are, at the most, one half of what they are in European karst regions in a temperate climate at similar geographical latitudes.

IV. The new large storage basin for the Bratsk hydroelectric plant in the Angara valley, by raising the water level 60 m within the karst regions, has revived old forms of surface karst and caverns. The chemical infiltration of active transitory waters of the Angara is leading to the transformation of older and the creation of new karst mesoforms.

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II. CLIMATOLOGY, HYDROLOGY, GLACIOLOGY AND OCEANOGRAPHY

CLIMATE CLASSIFICATION AND REGIONALIZATION

WINCENTY OKOŁOWICZ

INTRODUCTION

Regionalization is one of the tasks which geographical science is expected to solve; and criteria must be applied suitable for the ultimate purpose which is to be served. However, the choice of appropriate criteria is the more difficult, the more complex is the group of features to be considered in distinguishing between regions. Considerable difficulties are likely to arise not only in attempts to regionalize some area generally, say physico-geographically, but also when efforts of this kind are limited to some separate constituents of the natural environment or of geographical space, — one of which is the climate.

Climatological research is made difficult by the fact that climate is essentially contingent upon all the physical properties and processes of the atmospheric environment. On the one hand these properties are the result of what is taking place in the atmosphere over wide areas, and on the other, they are dependent on the strictly local effect exerted by factors such as the substratum which itself depends on structure, relief forms, and ground covering in the immediate vicinity of a given place. Further, atmospheric conditions are subject to diurnal and annual changes brought about by the rotation of the Globe and to the much less regular fluctuations and disturbances which occur over longer periods of time with different frequencies. All in all, the result is that the features of regions may be seen to differ with time, and that the regional boundaries may shift. Hence the necessity of using only homogeneous observations from identical long periods. The use of source material for individual climatic stages derived from different periods would lead to results that are unsuitable for comparison.

These complications are involved in most climatological studies, and are due to the very nature of the processes forming the climate. They must be considered typical of climatology. Other geographical sciences are not hampered by difficulties of this kind, or only to a lesser degree.

Climate may be defined as the sum of types of weather, of atmospheric conditions, and of processes and phenomena associated with them, which recur over long periods in patterns characteristic of given areas. The weather, on the other hand, is the pattern of an extensive group of meteorological elements, in other words the physical condition of the atmosphere, as it is maintained without essential change during relatively short periods of time like quarters of an hour, several hours, a day or a number of days, — unless normal diurnal changes of processes and phenomena are taken into account.

If weather can reasonably be considered as a complex pattern, climate is even more so. For this reason all attempts so far made to classify or regionalize the climate have met with difficulties the same and other than those mentioned above. The summary of the present paper refers briefly to the methods hitherto used in climatological regionalization. In principle, by reason of the difficulties mentioned, none of these methods takes into account a greater number of climatic features, or meteorological elements as they are called.

For a long time now, practical and theoretical requirements have demanded that climatologists should take fully into consideration all characteristic features of weather and climate in matters of regionalization. This is readily understood, because the full assemblage of atmospheric conditions, and not merely single meteorological elements, are always involved when it comes to evaluate processes of life, inanimate nature and a variety of technological processes. To avoid this long-lasting dilemma the author has presented a method of his own, published in Polish under the heading: “An attempt at a complex regionalization of Poland’s climate” in: “Proceedings of the Third Polish-Czechoslovakian Geographical Seminary”.

BASIC ASSUMPTIONS AND METHOD FOR COMPREHENSIVE CLIMATIC REGIONALIZATION

The author assumed that the climatic properties of any specific region may be expressed by mean long-range values for individual meteorological elements which may respectively be defined as more or as less favourable. For instance, for Poland the summer cannot be considered excessively warm in view of the normal long-term mean air temperatures recorded. No complaints are raised in any economic domain about losses suffered due to these temperatures; it would even be better, if it were warmer in those regions of Poland where lower mean temperatures are the rule. This means that when summer temperatures do not reach normal mean long-term values losses are experienced, especially in agriculture, people complain about spoiled vacations, etc. Abnormally cool summers in Poland are mostly associated with excessive and too frequent precipitation, — a serious encumbrance at harvest time.

Ample precipitation in January, usually in the form of snow, is rather favourable to agriculture in Poland, mainly because a snow cover protects winter crops. However, in April when much water is stored in the soil after the winter and ground humidity delays work in the fields, heavy rains must rather be considered an unfavourable feature of the climate; conditions are better when it rains less in April. More intensive rainfall in July than the mean value is unfavourable in some regions in view of the effect on harvesting.

In a similar way the author evaluates other individual meteorological elements which can be expressed by non-dimensional whole numbers, or "points", with the + sign used for favourable, the — sign for unfavourable features. Climatic features "marked" in this manner lend themselves to mathematical procedures, such as addition. The final pattern of such a punctuation reflects the differentiation prevailing in climatic features.

The author made use of existing isarhythm maps of a number of meteorological elements. In order to determine the marking for a given region, the contour lines of the map were covered by a transparent rectangular grid sheet. For Poland (312 000 sq. km) the grid had more than 500 squares, giving the same number of sums which were used for plotting the isarhythm map (Fig. 1). In the working map the isarhythms were entered in greater density so as to obtain a more precise picture.

Since the geographical distribution of the mean long-term values is different for each individual feature, a highly diversified isarhythm picture was obtained.

Next the boundaries of regions and climatic provinces were plotted along zones of greater isarhythm density, in places across "passes" between isarhythms, and with some adjustments for altitude, morphology, surface waters and forests. Some of the boundaries were marked on the basis of other criteria; in the north of Poland, for example, the boundaries of the direct (thermal) influence of the Baltic were drawn in accordance with the diurnal amplitudes of the air temperatures. Fig. 2 shows an alternative climatic division of Poland. A further simplified variant intended for use in schools, has been published in the atlas "Poland" (PPWK, Warszawa 1966).

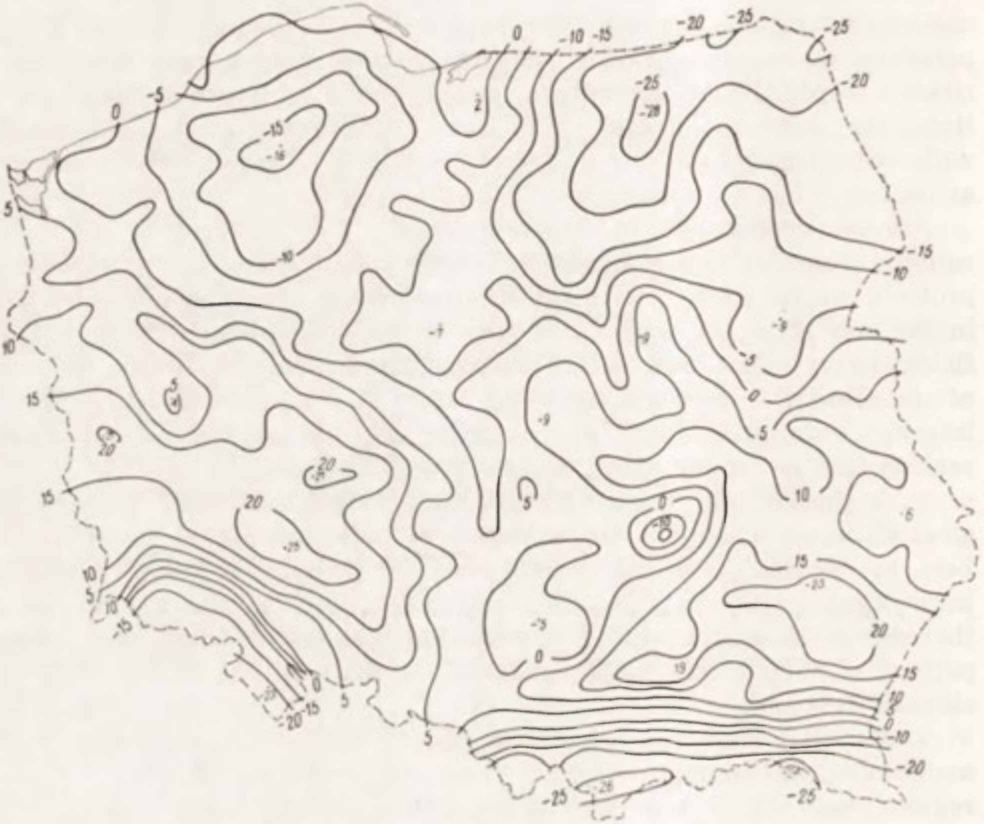

Fig. 1. Isarhythms of marking sums of different meteorological elements (evaluation of climate properties)

As an example of how to apply the author's method, a map was compiled showing the isarhythms of differences in atmospheric conditions in Poland for July. This map shows where it is usually warmest, with the least humidity (rainfall) and the greatest number of sunshine hours (Fig. 3). Further maps (Figs. 4 to 7) show how different meteorological elements have been evaluated.

A further example, this time referring to the Deccan Peninsula, is shown in Fig. 8. This is presented to show how the suggested method can be put to use, without regard to the correct criteria for marking. The author took advantage of maps Nos. 4, 5, 6, 11 and 12 attached to N. N. Ivanov's book written in Russian: "Atmospheric humidity conditions in tropical and adjoining parts of the Globe", edited by the Academy of Sciences of the Soviet Union, Moscow-Leningrad 1958.

In the monsoon climate of this peninsula the life and the economy

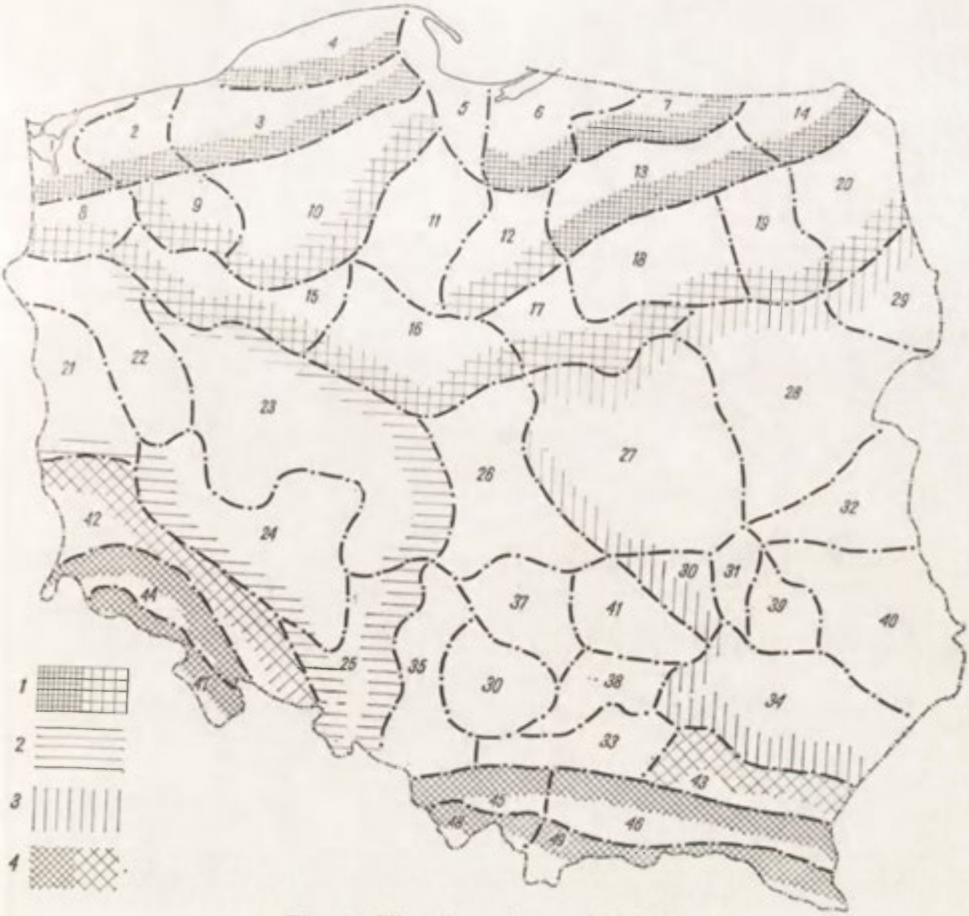

Fig. 2. Climatic regions of Poland.
1 — prevailing influence of the Baltic Sea, 2 — prevailing influence of the Atlantic Ocean, 3 — prevailing influence of the continent, 4 — prevailing influence of mountains

of the population have adjusted themselves to the alternating dry and humid seasons. The following are regarded optimum conditions:

a period of 100 to 150 days with predominance of rain over evaporation (Ivanov's criteria) and an equal duration for the dry period;

a negative humidity balance (rainfall-evaporation) has been marked by —, a positive balance by +;

the sum of rainfall in the driest quarter of the year (in percents of the annual sum) have been marked by + when this precipitation was more than 5%; the same marking applies to the most humid quarter of the year when rainfall was up to 60%.

In detail the marking on Ivanov's maps is as follows (the numbering of all maps agrees with that used by Ivanov):

Fig. 3. Isarhythms of marking sums for July according to the optimal number of sunshine hours and the thermal conditions in time when precipitation is least

Map No. 4: Annual humidity balance (rainfall minus potential evaporation), in mm:

—3000 to —2000	—2000 to —1500	—1500 to —1000	—1000 to —500
—8	—6	—4	—2

—500 to +500	+500 to +1000	+1000 to +1500	+1500 to +2000	>+2000
0	—1	—2	—3	—4

Map No. 5: Total rainfall in most humid quarter of the year (in percent of the annual total):

80	80 to 70	70 to 60	60 to 50	50 to 40	<40%
—6	—4	—2	+2	+4	+6

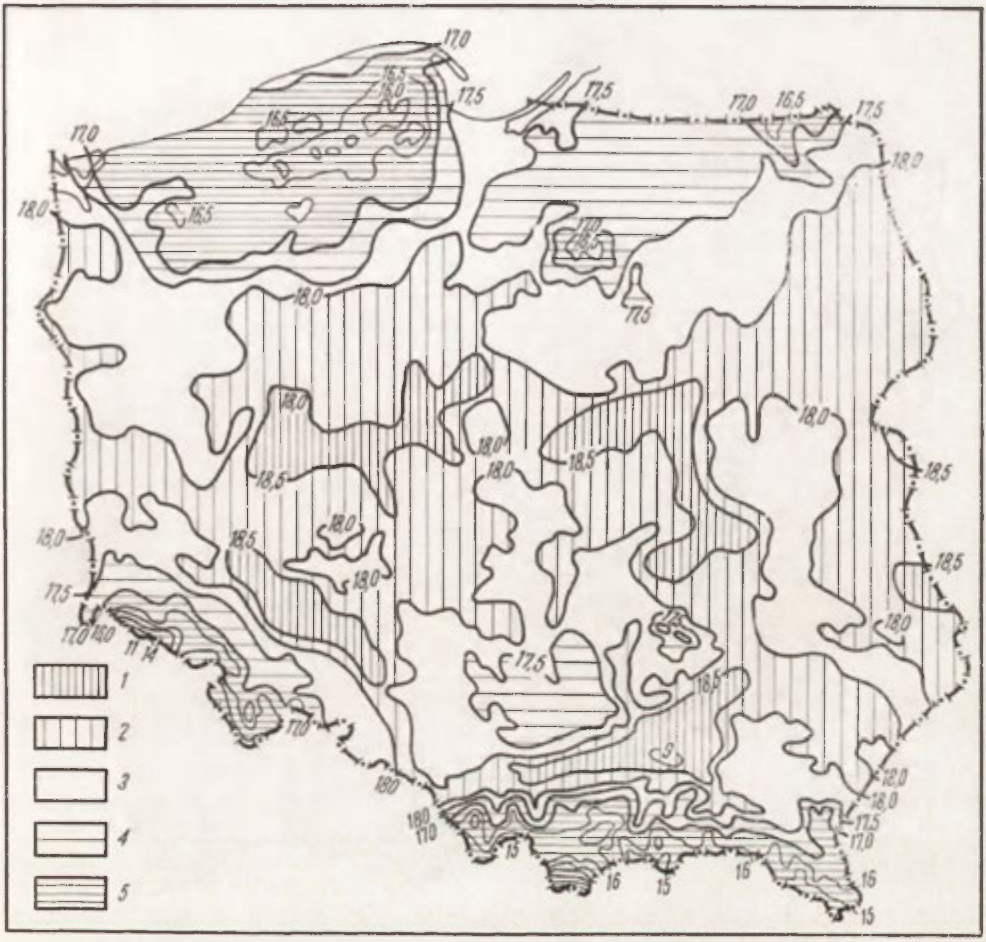

Fig. 4. July temperatures at actual altitudes. Marking: (1) > 18·5 = +2, (2) 18·5—18·0 = +1, (3) 18·0—17·5 = 0, (4) 17·5—17·0 = —1, (5) > 17·0 = —2

Map No. 6: Total rainfall in driest quarter of the year (in percent of the annual total):

0	0 to 2	2 to 5	5 to 10	> 10%
—4	—2	0	+2	+4

Map No. 11: Duration of dry season, in number of days:

up to 50	50 to 100	100 to 150	150 to 200	200 to 250	250 to 300	> 300
+2	+4	+8	+4	+2	+1	0

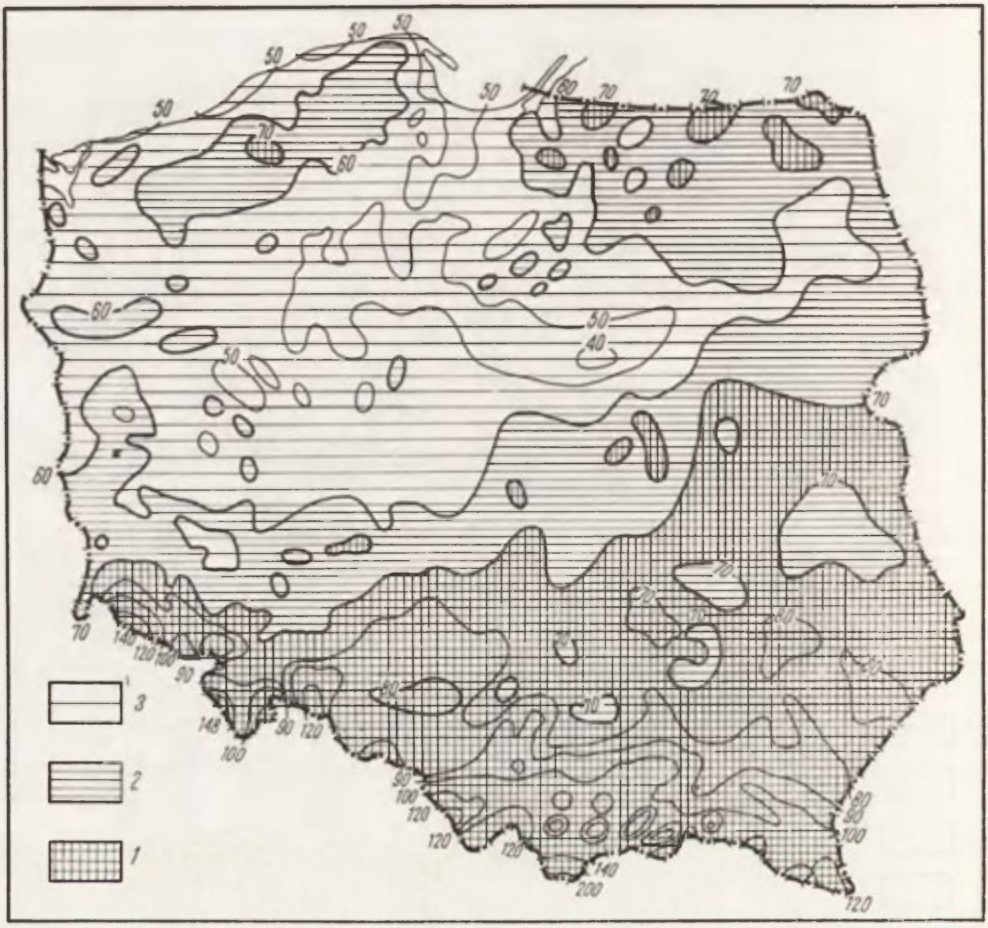

Fig. 5. Sum of precipitation in July. Marking: (1) < 60 mm = —1, (2) 60—70 mm = —2, (3) > 70 mm = —3

Map No. 12: Duration of rainy season, in number of days:

0	0 to 50	50 to 100	100 to 150	150 to 200	200 to 300	> 300
0	+ 2	+ 4	+ 8	+ 4	+ 2	+ 1

With the map shown in Fig. 8 as a basis, an attempt can be made to distinguish regions; the author forebore to do this, considering it superfluous to the explanation of his method.

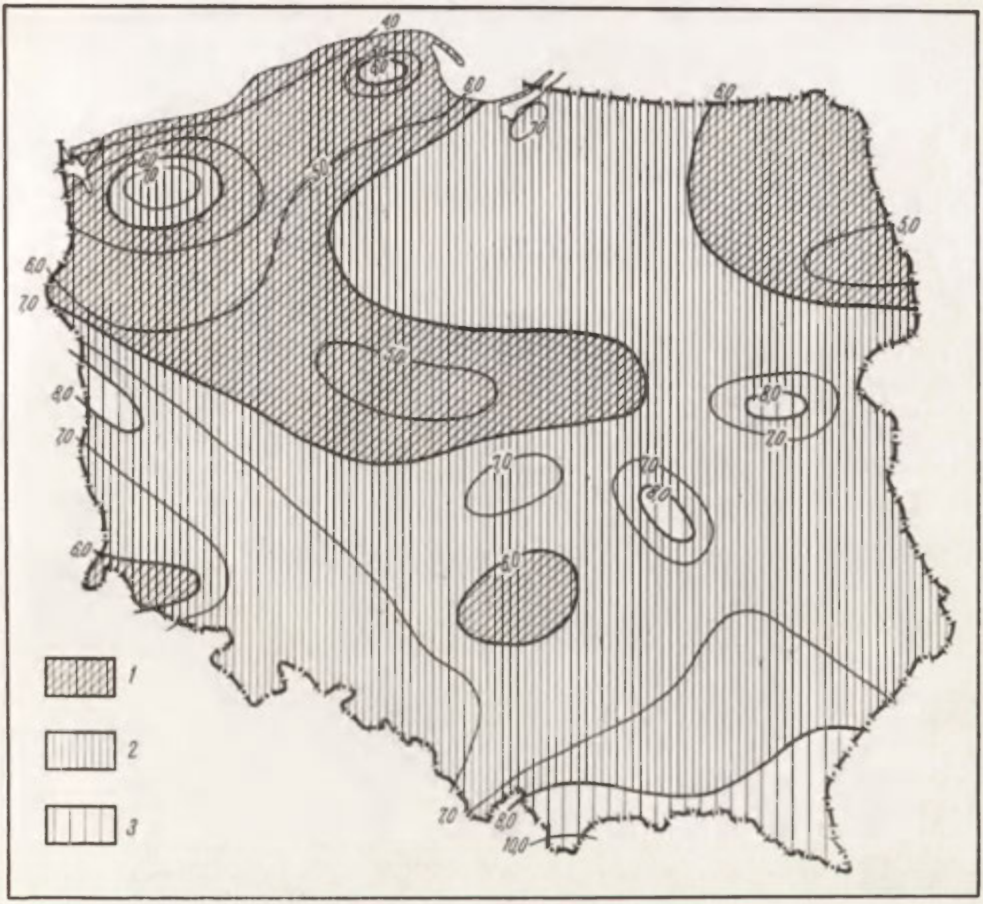

Fig. 6. Number of thunderstorms in July. Marking: (1) < 6 = 3, (2) 6—8 = 2, (3) > 8 = 1

RESULTS OBTAINED, AND COMMENT

1) In principle Figures 1, 3 and 8, compiled in the manner described in the preceding chapter, show the distribution of the climatic properties. Obviously this appraisal is relative, being to some extent adapted to conditions as they exist in given countries, and to definite needs. In principle this involves a further presupposition: that the inhabitants of a given region are adjusted with their habits and their economy, to the conditions existing in their countries. Even in climates with extreme conditions such as the Sahara, certain forms of life and economy have developed (a pastoral economy combined with a nomadic

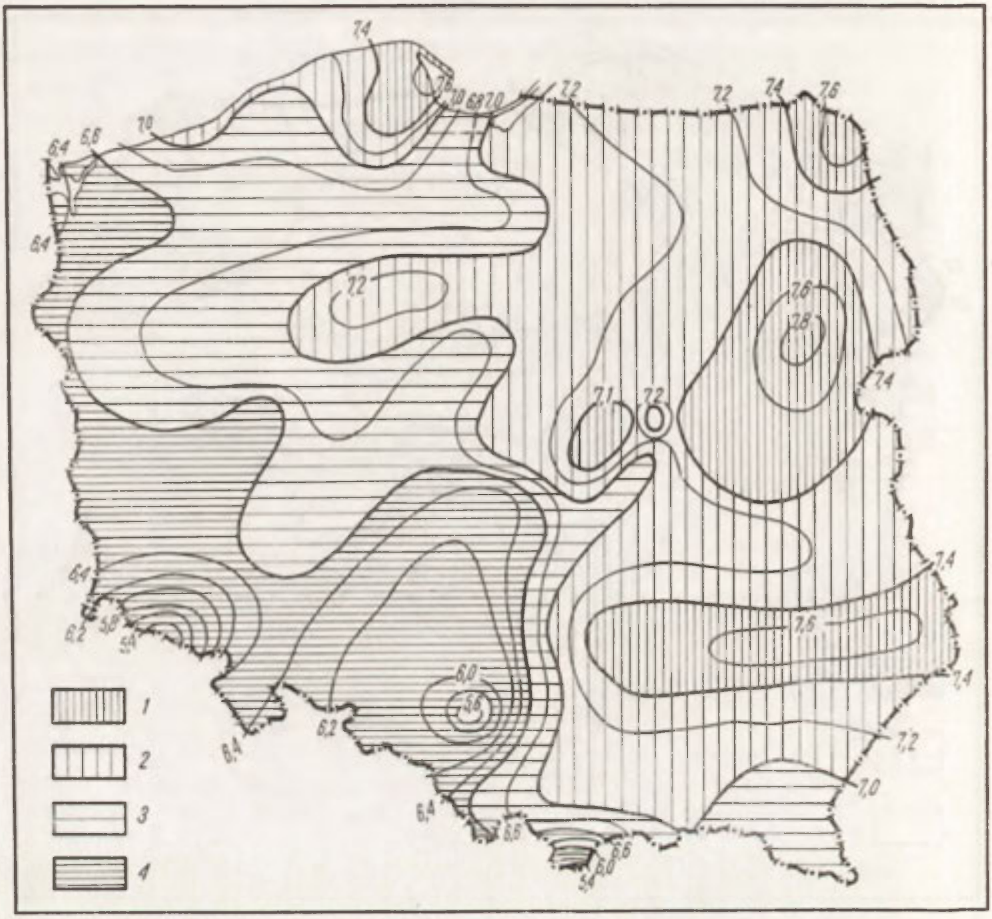

Fig. 7. Absolute insolation in July (mean hours per day). Marking: (1) > 7·4 h = +2, (2) 7·4—7·0h = +1, (3) 7·0—6·6h = —1, (4) < 6·6 h = —2

way of life), perfected by centuries of experience and adapted to the prevailing conditions. If we were to take into consideration more general presuppositions we could obtain criteria more universally applicable to the beneficial and detrimental properties of a climate and useful in the climatological classification of wider areas.

The method of appraising and marking climatic features can be applied to definite requirements, such as:

— water economy, taking into account such elements of the water balance as the total precipitation, the amount of evaporation, etc.;

— agriculture, for example conditions which are favourable (or unfavourable) to raising particular crops such as wheat, maize, rice, etc.;

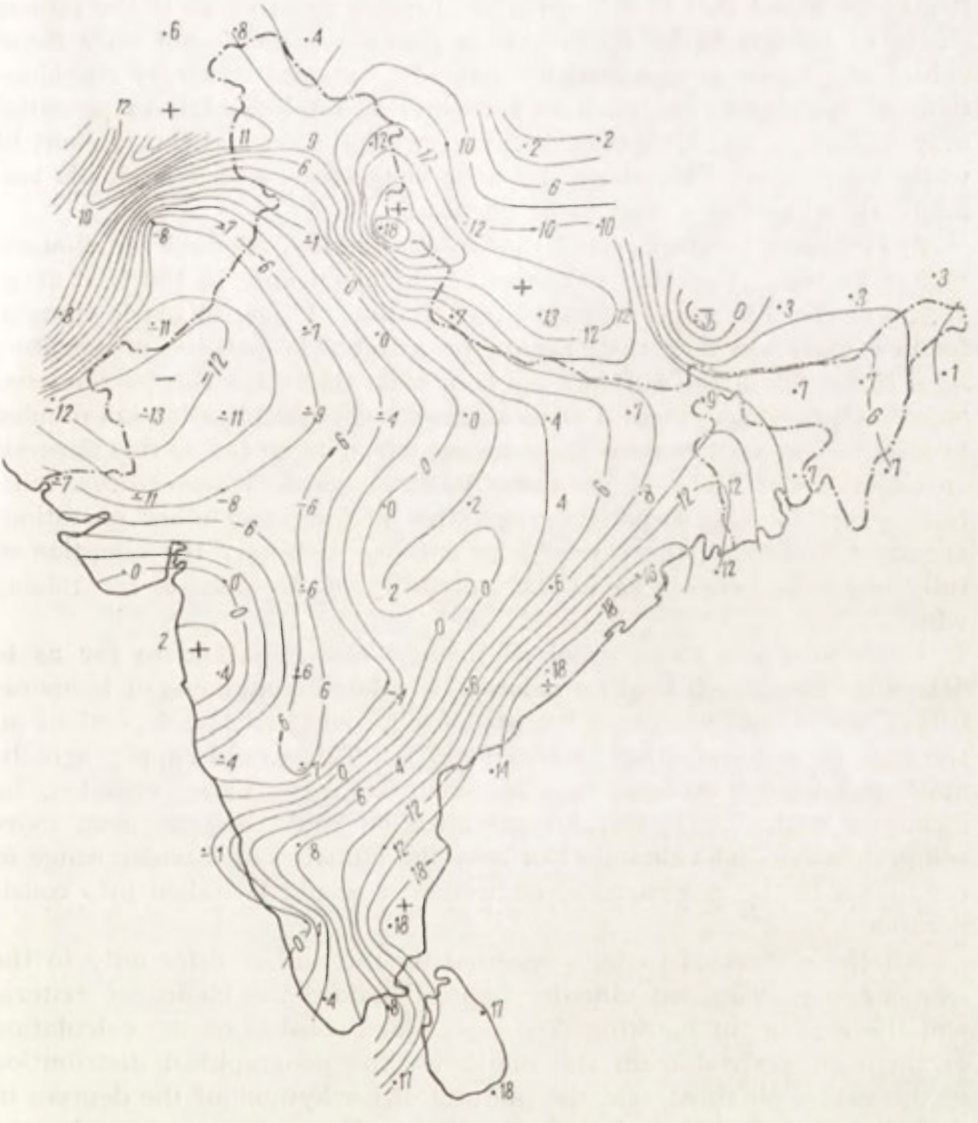

Fig. 8. The Deccan Peninsula. For marking see text

— transport, with reference to the occurrence of extreme temperatures, the frequency of snow storms, dust gales, strong winds, etc.;

— bioclimatology, indicating the extent to which a climate guarantee conditions of "comfort", or threatens the attack of certain diseases, etc.

The regionalization of Poland's climate, presented by the author as an example of the method he suggests, is the first attempt of its kind.

It may be hoped that it will stimulate further research as to the proper choice of criteria to be applied. It is possible to mark not only mean values of various meteorological elements, but also arbitrary combinations of such elements, such as the ratio of total rainfall to potential evaporation, or the difference between precipitation and the amount of water evaporated. This shows that the suggested method is elastic and might be applied to a variety of purposes.

2) It should be emphasized that in the method adopted for climatic regionalization, subjective judgement is involved only in the first stage of the work; this stage refers to the decision of how to mark climatic features, and whether they are to be assigned a positive or negative sign. However, in the author's opinion, even this stage can be rendered objective to a large extent. Let us assume that regionalization is intended to indicate the best regions for growing wheat in so far as this depends on climatic conditions. If we know what mean air temperatures, rainfall figures for the successive vegetative periods, and other conditions are most beneficial, there would be nothing to hinder the adoption of fully objective criteria as to the suitability of the climate for raising wheat.

Continuing the same trend of thought one might go so far as to determine how much heat (in calories calculated from sums of temperatures), water, etc. would be required for growing wheat, dependent on the type of soil and other factors involved. This would supply agroclimatic-pedological criteria, or other criteria even more complex, by means of which agricultural regionalization could become even more comprehensive and valuable. Not only the climate but a wider range of conditions in the geographical environment would be taken into consideration.

All the reflexions so far presented by the author refer only to the first stage of work on climatic regionalization: the choice of criteria and the manner of marking. The next stage consists of the calculation of the sum derived from the markings, the geographical distribution of the values obtained, and the plotting of isarhythms of the degrees of differentiation in given climatic conditions. None of these second stage operations is in any way dependent on any kind of a subjective concept of how the division into regions should be made.

The ultimate picture created in this way may come as a surprise even to its author, and this happened in the attempt to regionalize Poland's climate. In earlier divisions of this kind, made by Romer and Gumiński, the area of the Central Polish lowlands always used to be treated as a single climatic region, and nothing would have implied that some new attempt would reveal a different picture. But it came to light that

Poland's territory is not only split into latitudinal zones, but that it is crossed obliquely from north to south by a most remarkable groove-like zone which might indicate a distinct climatic boundary. Some geographers interpret this groove as a dividing line between an area where the influence of the Atlantic Ocean predominates in the west and another area to the east, more subject to continental conditions.

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A METHOD OF DISTINGUISHING AND SPECIFYING VERTICAL CLIMATIC ZONES IN TEMPERATE ZONE MOUNTAINS (WITH THE WESTERN CARPATHIANS AND THE EASTERN ALPS AS EXAMPLES)

Mieczysław Hess

The distribution of climatic conditions by zones in lowland and vertical zones in mountain regions, is one of the basic standards for the differentiation of climates on our Globe. Zonal differences of the climate were already known in ancient times, being expressed in what was called the "solar" system of climates. On the other hand, attention has been paid to the vertical distribution of climate only since the beginning of the 19th century.

Alexander von Humboldt initiated work in this domain and made a most valuable contribution to the investigation of mountain climates which still holds good to the present day. He determined the zonal and the multistage differences that occur in the vegetation cover of the Earth, correlating them with differences in climatic conditions from the equator towards the poles, and in altitude above sea level. He also found evidence that thermal conditions at every point of the Earth depend on both geographical latitude and longitude, and also on altitude above sea level [8].

Today these rules have become obvious to such a degree, that handbooks dealing with climatology and physical geography contain extensive chapters dealing with the influence of land relief on climate; a number of separate studies on mountain climates have also been published. Mostly these papers report values for individual climatic elements from what, by force of circumstances, can be only a few meteorological stations. With evidence as scanty as this, the differentiation of the climate can be related only to the altitude above sea level. In all papers dealing with vertical climatic zones the authors refer to zones of the natural vegetation, and there is virtually no classification based on climatological criteria (barring the author's own efforts to classify the climate of glaciated and non-glaciated mountains [2, 3], and his attempts to distinguish and specify climatic zones in the Carpathians [4, 7]. The reason is that too little interest is being taken in mountain climatology, which should be regarded as a marked deficiency in modern climatology. This fact was also mentioned at the 20th Geographical Congress in London.

Admittedly, in recent years much has been written on the vertical climatic zones of vegetation in different mountain regions; still, very little is actually known about their climate, because the climatic conditions are mainly evaluated by reference to floral indices. While it is true that the distribution of vegetation depends mostly on climate and that therefore the boundaries of climatic zones may be, generally speaking, identical with the boundaries of plant assemblages, this fact in no way reduces the need to specify the character of mountain climates on the basis of climatic criteria.

To distinguish and specify vertical climatic zones requires the application of a clearly defined method; that is, a classification. It is also known that the most difficult task in establishing a classification system is how to determine the boundaries between individual climatic types or groups. Without these boundaries individual types cannot be distinguished; however very rarely is it possible to point out definite boundary lines between them.

For distinguishing and specifying vertical climatic zones on the basis of climatological criteria, definite information must be available as to the changes in the climatic conditions along the vertical profile of given mountain areas. In the Western Carpathians and the Eastern Alps the author therefore applied a method by which he analyzed in detail the dependence on altitude above sea level of values of individual climatic elements within the vertical profile of these mountains; simultaneously he determined the quantitative interrelation between the different climatic elements. The author has presented these correlations in the form of simple equations of type $y = ax + b$ (Table 1), and this has enabled him to distinguish climatic stages by means of a comprehensive function closely associated with a whole series of climatic elements.

The author investigated how the individual climatic elements change with an increase in altitude, and this enabled him to obtain a reasonably full and accurate picture of the climate of the Western Carpathians and the Eastern Alps. His method of applying functional dependences proved very useful since it indicates values of the different climatic elements for any point of the vertical profile of the mountain areas under discussion. This method also revealed that the individual climatic elements as well as their groups undergo gradual changes with altitude and

TABLE 1. Interdependence of annual temperature (t) and certain climatic elements (y) in the Western Carpathians and the Eastern Alps

Climatic elements	Western Carpathians		Eastern Alps	
	equation	r	equation	r
Number of days with frost ($t_{max} < 0°$)	$y = 139{\cdot}3 - 13{\cdot}4\,t$	$-0{\cdot}98$	$y\,(t < 0°) = 117{\cdot}6 - 18{\cdot}4\,t$ $y\,(t > 0°) = 117{\cdot}3 - 10{\cdot}3\,t$	$-0{\cdot}99$ $-0{\cdot}99$
Number of days with frost or light frost ($t_{max} < 0°$ or $t_{min} < 0°$)	$y = 225{\cdot}7 - 15{\cdot}5\,t$	$-0{\cdot}99$	$y(t < -2°) = 181{\cdot}0 - 19{\cdot}5\,t$ $y(t > -2°) = 196{\cdot}9 - 11{\cdot}5\,t$	$-0{\cdot}99$ $-0{\cdot}99$
Number of hot days ($t_{max} > 25°$ C)	$y = 5{\cdot}71\,t - 16{\cdot}7$	$0{\cdot}95$	$y = 6{\cdot}04\,t - 10{\cdot}5$	$0{\cdot}96$
Mean January temperature	$y = 0{\cdot}824\,t - 8{\cdot}586$	$0{\cdot}99$	$y(t < +4°) = 0{\cdot}856\,t - 7{\cdot}521$	$0{\cdot}99$
Mean July temperature	$y = 1{\cdot}167\,t + 8{\cdot}632$	$0{\cdot}99$	$y = 1{\cdot}176\,t + 8{\cdot}242$	$0{\cdot}99$
Number of days with snow cover	$y = 215{\cdot}0 - 18{\cdot}75\,t$	$-0{\cdot}98$	$y = 233{\cdot}2 - 21{\cdot}20\,t$	$-0{\cdot}99$

that an increase in their gradient is encountered only in some parts of the vertical profile. As a result, after certain threshold values have been exceeded, the climatic elements give rise to qualitatively different conditions. To give example: starting at an altitude of 2200 m in the Eastern Alps and 2000 m in the Western Carpathians, the gradient corresponding to the decrease in the number of days with a mean annual temperature above $+5°$ C with increase in altitude is numerically greater. The result is that at 2400 m in the Alps and 2250 m in the Carpathians the vegetation disappears (Table 3). This shows that this kind of qualitative climatic change is distinctly reflected in the landscape, especially in its vegetation, because in the Eastern Alps and the Western Carpathians the last-mentioned altitudes coincide with the boundary lines between the (Alpine) pasture zone and the seminival zone.

In view of this the author chose a method of limit values in his differentiation of climatic zones. So as not to consider the climate in abstraction from other elements of the geographical environment, he selected such threshold values as would create qualitatively different climatic conditions. Values like this appear most distinctly at the boundary lines of plant zones. Thus, the author's classification is not based on floral criteria, since the climate of individual floral zones is not indicated by their vegetation cover. On the contrary, a detailed characterization of the climate in the vertical profile of mountain areas enabled the author to establish the climatic conditions governing individual floral zones in the mountain areas under discussion. The boundaries of the floral zones merely indicate altitudes at which the climatic changes are so explicit as to preclude the further distribution of given plant assemblages. This means that the boundaries between individual climatic zones are by no means fixed arbitrarily but that they are soundly based.

Climatic zones cannot be determined on the basis of all climatic elements. For every classification system there should be one function which emphasizes the most essential differences between the climatic zones distinguished; it should be unambiquous, simple and comprehensive, thus illustrating the effect of as many climatic elements as possible. The mean annual temperature is most suitable for this purpose because it is a true and complex climatic feature [4, 5] with a close, often linear, relationship with many climatic elements, among them the mean monthly temperatures (Table 1). A close association also exists between the mean monthly temperatures and the mean values of a number of climatic elements. The quantitative relationships determined between mean annual temperatures and other climatic elements therefore provide detailed characteristics of the climatic conditions for the whole year and for individual months.

With these relationships in mind the author distinguished vertical climatic zones on the basis of mean annual temperatures, and he drew the boundaries between them at the same altitudes as the boundary lines between the individual plant zones. In this manner the mean annual temperature became the backbone of the whole classification scheme, surrounded by a variety of other climatic elements and indices which are associated with the mean annual temperature by close functional dependences. Thus this is a genetic classification, because it gives a picture of the conditions under which climate is formed by heat balance, air circulation and land relief, and the boundaries between climatic zones are distinctly reflected by features of the landscape.

In the vertical profile of the Western Carpathians the mean annual temperature fluctuates between +8° C and —4° C, while for the Eastern Alps these figures are +9° C and —6° C [4, 11]. Very close linear relationships of type $y = ax + b$ exist also between altitude above sea level (h) and mean annual temperature (t), and for the two mountain areas under consideration their form is:

Western Carpathians: $t = 9{\cdot}231 - 0{\cdot}00498\,h$; $r = -0{\cdot}998$
Eastern Alps: from 200 to 1400 m: $t = 9{\cdot}838 - 0{\cdot}00417\,h$; $r = -0{\cdot}996$
above 1400 m: $t = 12{\cdot}480 - 0{\cdot}00606\,h$; $r = -0{\cdot}996$

A comparison of the altitudes of the boundaries between individual floral zones with the altitudes of the annual isotherms, reveals that the upper boundary of the semi-nival (subnival) zone coincides with the annual isotherm —4° C, the upper boundary of the mountain pasture (Alpine) stage with isotherm —2° C, the upper boundary of the dwarf-pine stage with 0° C, the tree line in general with isotherm +2° C, the tree line for fir-beech growth with +4° C and that for oak-elm with isotherm +6° C. This relation holds for both the Western Carpathians and the Eastern Alps. With these data a suitable number of climatic zones can be distinguished for the mountain areas that have been mentioned (Table 2).

TABLE 2. Vertical climatic zones in the Western Carpathians and the Eastern Alps

Vertical zones	Mean annual temperature (°C)	Altitude above sea level (m)	
		West. Carp.	Eastern Alps
Very cold	< —4	—	from peaks down to 2720 m
Cold climatic snow line	from —4 to —2	from peaks down to 2250 m	from 2720 m to 2400 m
Moderately cold	from —2 to 0	from 2250 m to 1850 m	from 2400 m to 2050 m
Very cool upper tree line	from 0 to 2	from 1850 m to 1450 m	from 2050 m to 1730 m
Cool	from 2 to 4	from 1450 m to 1050 m	from 1730 m to 1400 m
Moderately cool	from 4 to 6	from 1050 m to 650 m	from 1400 m to 920 m
Moderately warm	from 6 to 8	from 650 m to forefield level	from 920 m to 400 m
Warm	> 8	—	from 400 m to forefield level

The number of climatic zones depends on altitude, compactness and exposure of the given mountain area. Thus in the areas discussed the number of zones varies, the boundaries between identical climatic zones run at different altitudes, and on slopes with southern exposure the boundaries lie higher than on northern slopes. A smaller number of climatic zones has been found in the Western Carpathians than in the

TABLE 3. Characteristics of vertical climatic zones in Western Carpathians and Eastern Alps

Vertical climatic zones		Average altitude of boundaries in m above sea level	Mean temperature (in °C)				Number of days with mean diurnal temperature > + 5° C	Annual number of days					Relative air humidity (in percents)	Total annual precipitation (in mm)	Number of days		Relative frequency (in percent) of snow fall		Number of days with snow fall	Maximum thickness of snow cover
			annual	for January	for July	variation		with frost (max < 0°)	with frost and light frost (max and min < 0°)	with light frost (min < 0°)	without frost or light frost (min > 0°)	hot (max > 25°)			with dry land surface	with snow cover	in winter	in summer		
Western Carpathians		Peaks																		
	Cold (climatic snow line)	(2665)	—4	—11·9	4·0	15·9	·	193	286	93	79	·	80	1625	36	290	100	51	168	ca 600
	Moderately cold	2250	—2	—10·2	6·3	16·5	·	166	257	91	108	·	82	1750	57	252	100	34	145	460
	Very cool (upper tree line)	1850	0	—8·5	8·6	17·1	100	139	226	87	139	·	79	1800	78	215	99	19	122	290
	Cool	1450	2	—7·0	11·0	18·0	140	112	192	83	170	·	74	1600	100	178	97	8	98	215
	Moderately cool	1050	4	—5·3	13·3	18·6	170	86	164	78	201	6	76	1400	120	140	93	2	75	140
	Moderately warm	650	6	—3·6	15·6	19·2	200	59	133	74	232	18	78	1000	143	103	82	·	92	80
		230	8	—2·0	18·0	20·0	220	32	202	70	263	29	79	800	165	65	61	·	88	40
		Forefield																		
Eastern Alps		Peaks																		
	Very cold	(3050)	—6	—12·6	1·2	13·2	·	228	298	70	67	·	84	?	·	360	100	71	192	570
	Cold (climatic snow line)	2720	—4	—10·9	3·5	14·4	·	191	259	68	106	·	81	?	18	318	100	51	168	415
	Moderately cold	2400	—2	—9·2	5·9	15·1	·	154	220	66	145	·	78	?	40	276	100	34	145	296
	Very cool (upper tree line)	2050	0	—7·5	0·2	15·7	100	118	197	79	168	·	74	1870	63	233	99	19	122	210
	Cool	1730	2	—5·8	10·6	16·4	140	97	174	77	191	2	73	1653	84	191	97	8	98	160
	Moderately cool	1400	4	—4·1	12·9	17·0	170	76	151	75	214	14	73	1430	107	148	93	2	75	120
	Moderately warm	920	6	—3·9	15·3	19·2	200	56	128	72	237	26	77	1104	139	106	82	·	51	87
	Warm	400	8	—2·5	17·6	20·1	220	35	105	70	260	38	74	752	174	64	61	·	28	30
		200	9	—1·4	18·8	20·2	230	25	93	68	272	44	71	616	187	48	49	·	16	20
		Forefield																		

Eastern Alps. Since the former are situated further north, they are without a warm zone; nor do they have a very cold (nival) zone on account of their lower height.

A great number of annual and monthly values can be quoted for the individual climatic elements when describing the vertical climatic zones distinguished by the author in detail. In the present paper only annual values (together with the January and July temperatures) are given for a variety of climatic elements (Table 3). These are the values which are most frequently closely dependent on the mean annual temperature. The figures given refer to the boundaries of individual climatic zones. For any other point on the vertical profile of a mountain area between the boundaries, the value wanted can be calculated either by using the equations given in Table 1, or by means of the gradients of the respective climatic element (Table 3). All the same, many essential features of particular climatic zones can only be determined by detailed studies of their individual meso- and macroclimatic conditions.

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LE BILAN THERMIQUE DE LA SURFACE ACTIVE COMME PRINCIPE DE LA CLASSIFICATION CLIMATOLOGIQUE

JANUSZ PASZYŃSKI

L'une de principales tâches de la climatologie contemporaine est l'élaboration des principes d'une cartographie détaillée du climat. Le but d'une telle cartographie serait l'exécution d'une carte climatique à grande échelle, couvrant sinon la surface totale du pays, du moins certaines de ses régions. Une carte de ce genre aurait certainement une grande importance à la fois scientifique et pratique. D'une part elle conduirait à une connaissance approfondie du milieu naturel, donc à une explication des rapports mutuels des composants de ce milieu, et constituerait — à coté de cartes détaillées de type géomorphologique, hydrographique etc. — l'une des bases de la division du territoire en microrégions, ce qui est une des principales tâches de la géographie physique. D'autre part, dans de nombreux domaines de l'activité humaine et de la vie économique une connaissance exacte des conditions climatiques est nécessaire, surtout dans le cas de la planification à l'échelle locale et régionale. L'utilisation rationelle du milieu naturel et de ses ressources exige que la carte climatologique détaillée devienne pour les spécialistes de l'aménagement un instrument de travail au même titre que les cartes géologique et pédologique; celà permettrait d'éviter des erreurs de localisation aux conséquences souvant désastreuses et irréversibles, et favoriserait également la modification consciente des conditions naturelles dans une direction favorable.

C'est pour cette raison qu'au cours des dernières décennies ont été réalisés dans differents pays des essais de levés climatologiques détaillés. Quoiqu'une grande quantité de travaux cartographiques ait été publiée dans ce domaine, nulle part, jusqu'a ce jour, n'ont été réalisés des levés climatiques à l'échelle nationale, malgré certains efforts dans ce sens [4]. Ces travaux, en général, concernent de surfaces assez limitées de l'ordre de quelques dizaines, au maximum quelques centaines km². Au contraire des cartes climatiques à petite échelle fondées sur de longues series d'observations météorologiques, les levés de ce genre ne peuvent reposer que sur de recherches spécialement effectuées dans ce but et, quoique de courte durée, assez coûteuses.

Un trait caracteristique de ces travaux est qu'ils furent, en general, entrepris dans l'optique d'une application à des besoins concrets. Dans la plupart des cas ce sont des cartes destinées ou à l'agriculture et l'horticulture, ou à l'urbanisme. Les buts utilitaires décidèrent du sujet des cartes et du choix des phénomènes représentés. C'est pourquoi il est difficile ici de parler de cartes du climat dans la pleine extension de ce mot. Dans la distinction des unités climatiques il a été tenu compte de certains seulement des éléments ou des indices du climat selon l'importance que leur attribuait l'utilisateur de la carte. Ainsi par exemple les travaux effectués pour les exigences de l'agriculture tiennent compte avant tout des gelées locales qui constituent dans la zone temperée l'un des phénomènes climatiques les plus gènants pour l'agriculteur. Les cartes exécutées pour les besoins de l'urbanisme attirent l'attention sur d'autres traits du climat tels que la pollution atmosphérique dans le cas des grandes villes et des centres industriels, ou l'insolation dans le cas des stations de cure et de repos. Pour cette raison des cartes représentant des terrains de destinations différentes ne sont pas comparables.

La nécessité de satisfaction d'exigences concrètes impose aux travaux mentionés non seulement l'enregistrement des faits sous forme cartographique, mais souvent aussi leur évaluation sous différents points de vue. En exemple citons les essais de cartographie du climat selon les méthodes d'indices numériques, permettant l'estimation des risques de gelées [7] ou celle de la proprieté d'un terrain à la construction [1, 2]. Il est évident que les méthodes de cote ne peuvent être considerées comme suffisamment objectives, les moyens d'estimation y étant trop approximitafs et la marge d'arbitraire trop importante.

Il résulte de ces remarques que la cartographie du climat à grande échelle ne doit pas se limiter à quelques uns seulement de ses éléments ou de ses indices, mais embrasser tous les phénomènes et processus dont l'importance sur la formation du climat est fondamentale et qui permettent de le définir de façon exhaustive.

Dans la ligne de telles considérations furent entreprises par la Section Climatologique de l'Institut de Géographie de l'Academie Polonaise des Sciences des recherches sur le bilan thermique de la surface active, et ceci dans le but d'établir les principes d'une classification des climats locaux. Le bilan thermique exprime notamment les échanges d'énergie se produisant à la surface active, c'est à dire à la surface limite terre — atmosphère, et déterminant des régimes thermique et hydrique des basses couches d'atmosphère. Nous pouvons ainsi affirmer que la structure du bilan thermique définit précisémment le climat d'un lieu donné.

L'équation du bilan thermique de la surface active resultant de la loi de conservation de l'énergie se presente comme:

$$R + B + P + E = 0 \qquad (1)$$

ou R est le transfert de la chaleur par rayonnement (bilan radiatif), B — le transfert dans le sol par conduction, P — le transfert de la chaleur sensible par convection, E — le transfert de la chaleur latente de vaporisation de l'eau.

Chacun des termes d'équation (1) peut être positif ou négatif. Les valeurs positives designent un flux de chaleur dirigé vers la surface terrestre, les valeurs négatives un flux dirigé de cette surface.

Le but de nos recherches exigeait l'application des méthodes simples, permettant de mesurer les valeurs instantanées de chaque terme du bilan thermique sur le terrain, simultanement en plusieurs points de la surface étudiée. Celà nécessitait un équipement spécial, adapté aux exigences évoquées. Les travaux de construction et d'installation ont été réalisés dans le laboratoire technique de la Section Climatologique sous la direction de M. Kuczmarski.

Le terme R, soit le bilan radiatif, a été évalué comme la somme algébrique des flux de rayonnement descendant ($Q^{\downarrow}$) et ascendant ($Q^{\uparrow}$):

$$R = Q^{\downarrow} + Q^{\uparrow} \qquad (2)$$

Pour les mesures de ces deux flux on a construit un instrument portatif à pyranomètres thermoélectriques munis de coupelles en polyethylène transparentes au rayonnement compris dans le domaine spectral entre 0,3 et 60 μ (Fig. 1). Simultanement on a utilisé une seconde paire de pyranomètres dont les coupelles sont en verre et transparentes seulement au rayonnement de courtes longueurs d'onde. Ceci permet d'obtenir chaque composant du bilan radiatif d'après:

$$R = R_K + R_L = Q_K{}^{\downarrow} + Q_K{}^{\uparrow} + Q_L{}^{\downarrow} + Q_L{}^{\uparrow} \qquad (3)$$

ou l'indice K designe le rayonnement de courtes longueurs d'onde (d'origine solaire) et l'indice L celui de grandes longueurs d'onde (d'origine terrestre).

Quant à l'échange thermique avec le sol par conduction (terme B) on l'a déterminé sur la base de la variation de l'accumulation de chaleur dans la couche active du sol (z_0 — z_1) en fonction de temps:

$$B = \frac{1}{\tau} \int_{z_0}^{z_1} c\,\varrho\,\Delta t\,dz \qquad (4)$$

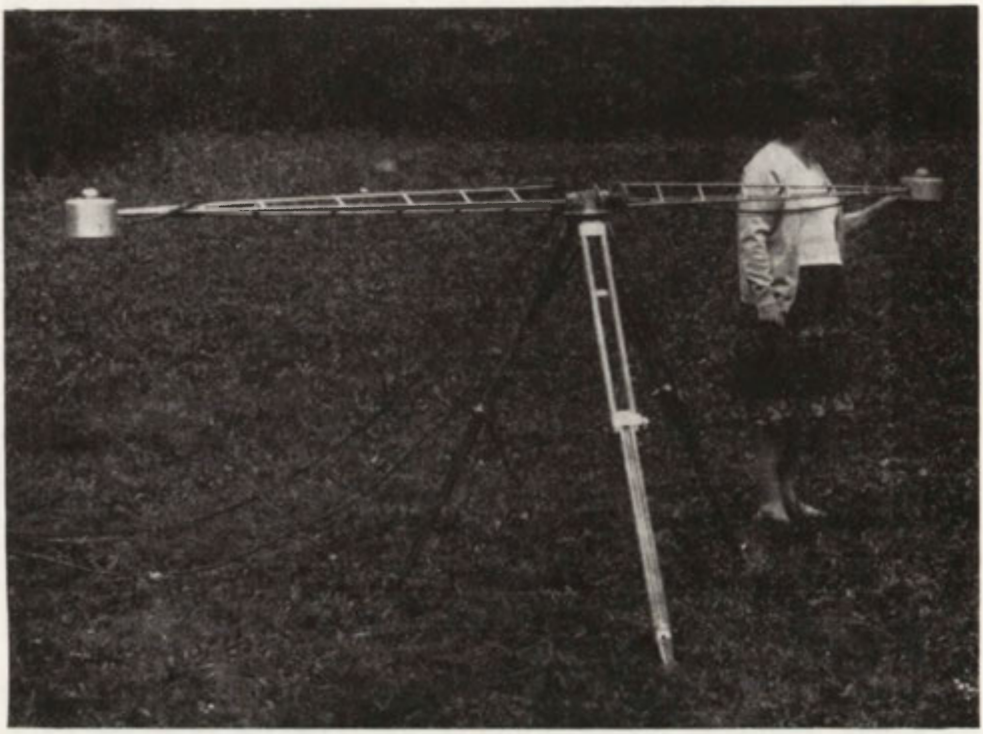

Fig. 1. Équipement portatif pour les mesures des flux radiatifs

ou c est la chaleur specifique du sol, ϱ sa densité, t sa temperature, et z la profondeur. Les changements de la temperature du sol (Δt) pendant la période τ ont été évalués à partir des mesures horaires effectués à plusieurs niveaux caracteristiques (entre $z_0 = 0$ cm et $z_1 = 50$ cm) à l'aide des thermomètres à résistance. Les valeurs c et ϱ ont été calculées sur la base des données expérimentales indiquant les proprietés thermophysiques du sol, tenant compte évidemment des variations de son humidité; l'humidité du sol a été déterminée en appliquant la methode gravimetrique à des échantillons prélevés deux fois par jour.

Enfin, les flux convectifs des chaleurs sensible et latente (les termes P et E) peuvent être determinés à partir des gradients verticaux de la temperature de l'air $\left(\frac{dt}{dh}\right)$ et de son humidité spécifique $\left(\frac{dq}{dh}\right)$. En exprimant par K le coefficient de transfert turbulent on peut écrire:

$$P = K c_p \varrho \frac{dt}{dh} \quad \text{et} \quad E = K L \varrho \frac{dq}{dh} \qquad (5, 6)$$

ou c_p est la chaleur spécifique de l'air, ϱ sa densité, L la chaleur latente de vaporisation. Pour obtenir le rapport $\frac{P}{E} = \beta$ (le rapport de Bowen) il est légitime de remplacer les gradients verticaux par les differences de temperature ($\Delta t = t_2 - t_1$) et d'humidité ($\Delta q = q_2 - q_1$) entre deux niveaux h_2 et h_1. On peut alors écrire:

$$\frac{P}{E} = \beta = \gamma \frac{\Delta t}{\Delta q} \tag{7}$$

ou γ désigne le coefficient de proportionnalité $\left(\gamma = \frac{c_p}{L}\right)$. On a donc à résoudre le système d'équations (1) et (7) pour trouver:

$$P = -\frac{R + B}{1 + \frac{1}{\gamma} \frac{\Delta q}{\Delta t}} \quad \text{et} \quad E = -\frac{R + B}{1 + \gamma \frac{\Delta t}{\Delta q}} \tag{8, 9}$$

Les mesures de la temperature et de l'humidité de l'air ont été exécutées aux deux niveaux suivants: $h_1 = 0{,}5$ m, $h_2 = 2{,}0$ m, en utilisant les psychromètres d'aspiration munis également de thermomètres à résistance (Fig. 2).

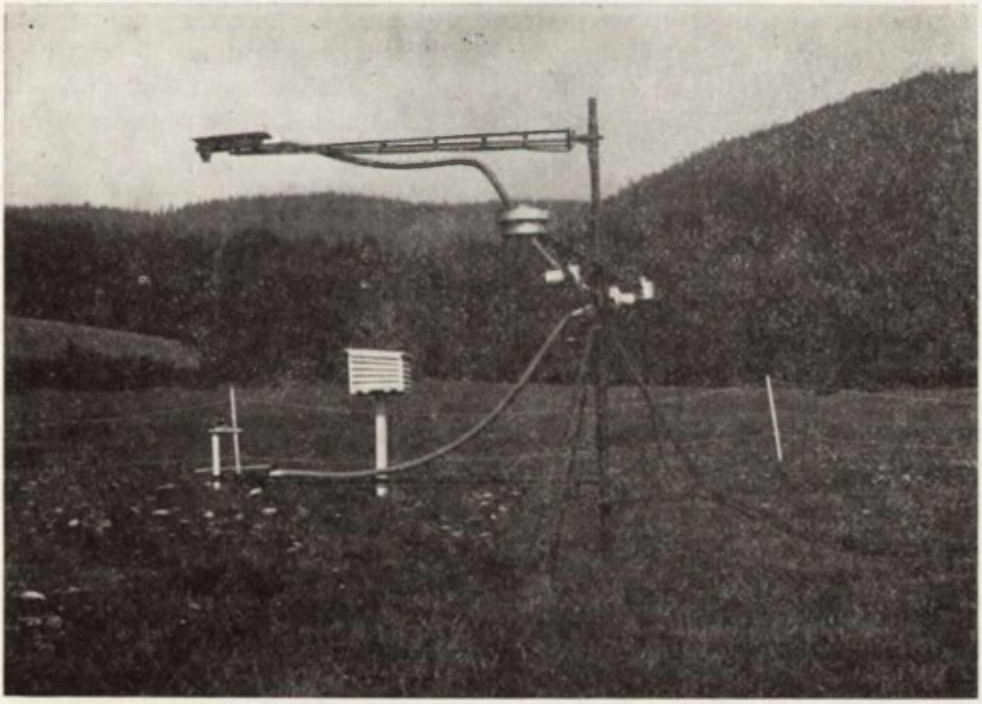

Fig. 2. Équipement pour les télémesures des gradients verticaux

Cependant, la méthode évoquée ne peut être appliquée dans les cas ou $\beta \to -1$, c'est à dire quand les flux P et E dirigés inversement (Δt et Δq de signes contraires) ont des valeurs absolues voisines. Dans ces cas particuliers le terme P a été évalué indépendemment, en fonction de la vitesse du vent et de la rugosité de la surface [3].

Les résultats de nos mesures permettaient de suivre la marche journalière de tous les composants du bilan thermique et alors de sa structure. Tenant compte les directions de chacun de quatre flux il a été possible de distinguer plusieurs types structuraux du bilan thermique. Pour l'étude du climat les plus importants sont les types qui dominent par temps clair ou peu nuageux, donc quand l'influence des facteurs locaux sur le bilan thermique est la plus accentuée.

Pour les heures diurnes d'une forte insolation le plus caracteristique est le type A: $R > 0$, $B < 0$, $P < 0$, $E < 0$. Pendant nuits claires on observe le plus souvent les deux types suivants: type B_1 avec $R < 0$, $B > 0$, $P > 0$, $E > 0$, qui indique l'apport de la chaleur latente lié à la formation de la rosée, ou type B_2 avec $R < 0$, $B > 0$, $P > 0$, $E < 0$, lié à l'evapotranspiration nocturne.

Les différences locales des valeurs numériques de chacun de quatre flux sont aussi les plus apparentes dans le cadre de types structuraux énumérés. Ces differences peuvent de leur côté servir comme base d'une classification du climat. En qualité d'exemple dans ce sens nous voulons présenter ici un essai de division en unités climatiques d'un petit territoire situé en Pologne méridionale, et comprenant la région centrale du bassin de la rivière Nida [5].

Les traits essentiels de la topographie de cette région d'une superficie d'environ 100 km^2 sont présentés sur la carte jointe (Fig. 3). Sur la carte on a aussi indiqué les localisations des points de mesure situés dans les endroits les plus caractéristiques du terrain.

A partir des résultats des mesures et d'une analyse de la distribution géographique de differents facteurs locaux (tels que le relief, les sols, les eaux superficielles et souterraines, la végétation etc) déterminant les proprietés physiques de la surface active et intervenant ainsi dans l'échange de l'énergie, on a pu distinguer sur le territoire étudié plusieurs unités climatiques. Nous appelons ces unités "les topoclimats" en accord avec la terminologie proposée par C. W. Thornthwaite [6]. Ce terme nous semble indiquer à la fois l'effet de l'influence de la topographie du terrain sur le climat local et l'échelle das phénomènes étudiés correspondant à l'échelle des cartes topographiques.

De cette façon furent distingués trois groupes avec trois topoclimats à l'interieur de chacun des groupes, soit neuf topoclimats différents. Les aires occupées par chacun des topoclimats sont représentées sur la carte. On y constate que les fôrets furent exclues de notre classification, compte tenu des difficultés liées à l'étude du bilan thermique des surfaces boisées.

Pour obtenir la division en trois groupes principaux de topoclimats on a tenu compte des variations locales de l'échange convectif entre la surface active at l'atmosphère (terme *P*), observées pendant les nuits claires, donc dans les types structuraux B. Cet échange est d'une importance décisive pour la formation des inversions thermiques nocturnes et des gelées d'origine locale.

Dans le premier groupe (I) on a classé des terrains ou les valeurs de *P* sont relativement élevées. Gràce à un échange convectif assez intense il n'y a pas formation d'une couche d'air froid au dessus de la surface terrestre. On compte dans ce groupe toutes les pentes ainsi que toutes les élevations desquelles le découlement de l'air froid vers les terrains situés plus bas n'est pas gêné.

Dans le groupe suivant (II) sont classés les aires de valeurs relatives du terme *P* intermediaires. Ces sont les plaines et les pentes à faible inclinaison qui s'élèvent au dessus des fonds des vallées. Les conditions de l'échange convectif pendant les nuits claires y sont moins favorables et le mélange de l'air froid du voisinage du sol avec l'air plus chaud des couches supérieures est ici moins fort que sur les terrains du groupe I. Le risque de gelées locales dépend ici surtout de la conduction de chaleur dans le sol; c'est elle qui compense les pertes de chaleur dues au rayonnement nocturne.

Le dernier groupe (III) englobe les terrains où par suite de l'advection locale de l'air froid l'échange nocturne de chaleur sensible par convection ne peut guère se produire; les valeurs relatives du terme *P* sont donc minimales. L'écoulement de l'air froid des terrains élevés cause une stratification stable qui rend difficile le mélange des couches d'air de différentes altitudes, donc de temperatures différentes. En particulier, dans ce groupe on compte toutes les formes concaves du terrain, et surtout les fonds de vallées larges, mais aussi les clairières entourées de fôrets, endroits typiques de la formation des inversions thermiques nocturnes. Ce groupe se caractèrise par un risque maximal de gelées d'origine locale.

Les divisions suivantes en topoclimats à l'interieur de chacun de trois groupes énumérés sont fondés sur les mèmes principes, c'est à dire sur les valeurs relatives d'un des composants du bilan thermique.

Les terrains appartenant au groupe I ont été divisés conformément aux variations locales du bilan radiatif (terme *R*) pendant les heures diurnes, donc dans le type structural A. Ces variations sont des conséquences de l'exposition des pentes, ce qui provoque des différences considérables de l'apport du rayonnement solaire global (Q_K), constituant alors le terme principal dans l'équation (3). De cette façon, on a distingué trois types topoclimatiques: le topoclimat Ia au rayonnement solaire le plus intense, ce qui est dû à l'exposition au sud; le topoclimat Ib au rayonnement solaire égal ou peu différent de celui qu'obtient une surface horizontale — les sommets, certaines parties douces des pentes ainsi que toutes les pentes à l'orientation neutre où l'importance de l'insolation est moyenne, y ont été classés; le topoclimat Ic au rayonnement sensiblement reduit à cause de l'exposition au nord.

Comme critère de distinction des terrains du groupe II on a admis la valeur relative de l'échange de chaleur entre la surface et le sol par conduction (terme B). Cet échange dépend des proprietés thermophysiques du sol et, en principe, de sa conductibilité thermique. On a donc distingué dans le groupe II trois types de topoclimats: le topoclimat IIa concerne en premier lieu la partie méridionale du territoire étudié, couverte de loess dont la conductibilité thermique est relativement grande; les autres terrains du groupe II, à l'exception des sables, caractérisés par la conductibilité thermique moyenne, ont été classés comme topoclimat IIb; les valeurs relativement faibles du transfert conductif observées sur les sols sableux nous autorisent à les distinguer dans un type topoclimatique IIc.

Enfin, comme composant du bilan thermique qui intervient décisivement à la formation des différences climatiques locales sur les terrains du groupe III on a adopté le terme E d'équation (1), c'est à dire les pertes de chaleur provoquées par l'évaporation. Ce groupe a été divisé, lui aussi, en trois topoclimats. Le type IIIa englobe les terrains où l'évapotranspiration est la plus intense, donc les vastes fonds de vallées couverts d'une dense végétation herbacée et formant des prairies humides. Une évapotranspiration plus faible a lieu sur les terrains situés également dans les vallées larges, mais plus sèches que les précédentes. Par conséquence l'eau disponible y est le seul facteur limitatif dans le processus de l'évapotranspiration. Ces terrains ont été classés dans le type topoclimatique IIIb. Le dernier topoclimat de ce groupe IIIc englobe des vallées étroites et des gorges, où par suite des faibles vitesses du vent, l'évapotranspiration potentielle est limitée par la facteur énergie et, par conséquent, l'évapotranspiration réelle y est aussi sensiblement réduite.

Il est évident que la carte présentée doit être considerée surtout comme un essai de cartographie du climat fondée sur le bilan thermique de la surface terrestre en tant que principe de classification en topoclimats. Ce principe n'est pas encore parfait car il est fondé sur des valeurs relatives. Il serait donc désirable de préciser les critères de division en introduisant une échelle de valeurs absolues. La délimitation

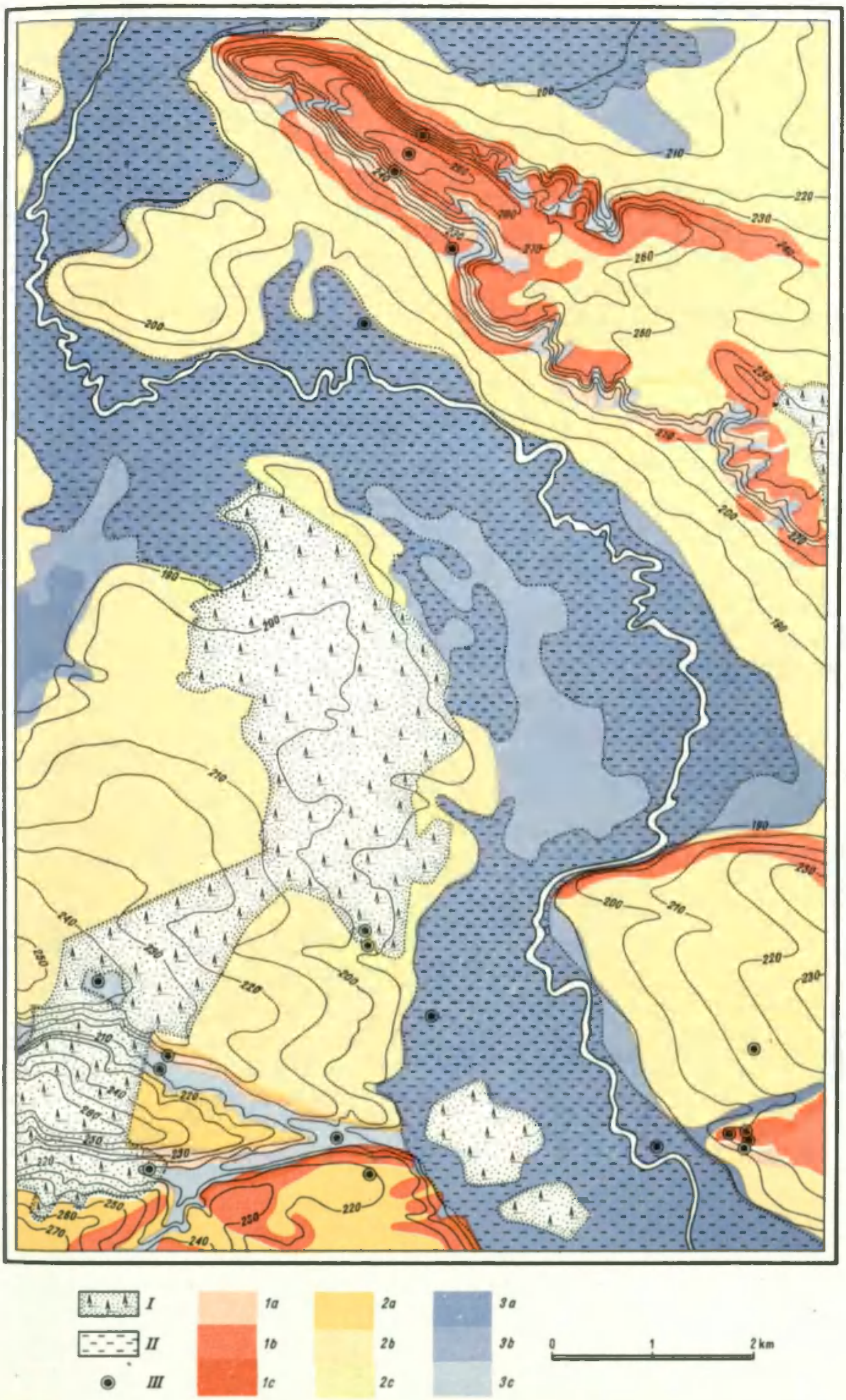

Fig. 3. Carte topoclimatique

I. Forêts, II. Prairies, III. Points de mesure.
Division en groupes et en types des topoclimats: Groupe 1 aux valeurs de P rélativement élevées. Type 1a aux valeurs de R rélativement élevées. Type 1b aux valeurs de R intermediaires. Type 1c aux valeurs de R rélativement basses.
Groupe 2 aux valeurs de P intermediaires: Type 2a aux valeurs de B rélativement élevées. Type 2b aux valeurs de B intermediaires. Type 2c aux valeurs de B rélativement basses.
Groupe 3 aux valeurs de P rélativement basses: Type 3a aux valeurs de E rélativement élevées. Type 3b aux valeurs de E intermediaires. Type 3c aux valeurs de E rélativement basses.

de chacun des topoclimats exige, hors des données numériques obtenues par les mesures, une étude sérieuse sur le terrain concernant la distribution géographique des différents facteurs naturels. Cette étude complexe ne peut être conduite que par un géographe specialisé dans les différentes branches de la géographie physique et ayant une bonne expérience de ce genre des travaux.

Les principes de classification adoptés permettent néanmoins d'analyser les effets du processus de l'échange de l'énergie à la surface terrestre sous la forme de ses régimes thermique et hydrique; ils permettent aussi d'expliquer les différences climatiques locales. Il n'est pas indifférent par exemple de connaître la cause des galées exceptionellement fréquentes et fortes dans un lieu donné: elles peuvent être des conséquences du manque de convection, ou d'un rayonnement nocturne intense, ou de la conduction réduite, ou enfin des pertes de chaleur dues à l'évaporation.

Les problèmes de ce genre sont d'une importance particulière en ce qui concerne l'application à des interventions actives dans le cadre de la lutte contre les phénomènes météorologiques nocifs comme, dans le cas des gelées, sont par exemple les nuages artificiels, le mélange forcé de l'air, son échauffement, l'aspersion etc. La connaissance approfondie des problèmes évoqués est indispensable aussi pour l'amélioration des conditions climatiques existantes, par l'intermédiaire de la modification de la surface active et de ses proprietés physiques.

La carte topoclimatique pourrait, enfin, être considerée comme point de dèpart des évaluations du climat. Il est pourtant clair que toute évaluation du climat ne peut être exécutée que sous un angle special, correspondant aux besoins pratiques précisement définis. Les cartes d'évaluation ayant le caractère de cartes "dérivées" da la carte topoclimatique initiale exigent une collaboration étroite avec les spécialistes du domaine correspondant, qui seuls peuvent préciser les critères de l'évaluation.

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THE COMPILATION OF A GENERAL HYDROGEOGRAPHICAL MAP WITH LUBLIN VOIVODSHIP AS AN EXAMPLE

Tadeusz Wilgat

INTRODUCTION

In every domain of natural science each stage of research is terminated by some sort of synthetic review. In geography this might be done by means of a cartographical survey. Maps of larger areas, usually medium or small scale, are also syntheses to some extent. Frequently, however, such maps refer only to a single phenomenon: in such cases they may be considered as geographical syntheses of the given phenomenon. Other types of syntheses also exist, intended to illustrate groups of phenomena which may be mutually associated in one way or anothor; these may be called complex syntheses. Examples of this kind include tectonic, geomorphological, and environmental maps. A further cartographical type of synthesis is provided by maps of regional divisions; they constitute supplements to complex syntheses.

Until recently hydrogeographical problems were rarely the principal topic of general maps, which usually showed only surface waters. watershed lines, and navigable waterways. In recent years, however, the number of problems illustrated cartographically has increased notably. General hydrogeological maps have appeared, as well as maps of runoff conditions, water balance maps, maps of fluvial systems, of chemical properties of water, etc. Some of these may be looked upon as approximations to complex syntheses in their approach [1]. Maps of hydrological economy also have this comprehensive character, because the topic itself requires this kind of synthesis. However, so far no complex hydrogeographical maps exist. In geographical atlases containing interesting syntheses of all domains of physical geography and a variety of complex economic maps, syntheses of hydrological features are for the most part absent. This shortcoming requires to be made good, the

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[1] An example is the map of world fluvial systems in Fiziko-Geograficheskij Atlas Mira, Moscow 1964.

more so since problems of water economy are gaining in importance and becoming more and more universal.

Compiling a complex hydrogeographical map for a large area is no easy matter; still, it seems worth an attempt, and the author decided to prepare a map for Lublin Voivodship, an area of 24 829 sq. km.

GENERAL ASSUMPTIONS

The general assumptions for this map had to be established, because no accepted clear-cut methods exist. The author assumed that a general hydrogeographical map should supply information on the circulation of water and generally illustrate existing hydrological conditions and their spatial differentiation within the area discussed.

This intention was put into effect by presenting on the map a variety of hydrological phenomena and indices, illustrating the features and circulation of water. The main difficulty lay in choosing the elements of the map, since to a large degree this decides the final effect.

The following guiding rules were adopted:

1. The information supplied should be exhaustive. As far as possible all successive phases of water circulation should therefore be taken into account.
2. The elements chosen should be illustrative in character, so as to emphasize the essential problems.
3. At the same time special consideration should be given to those quantities which vary distinctly with location, and are therefore best adapted for the requirements of regionalization.
4. The map should be easy to read. This depends on the number of elements illustrated and on their degree of generalization.
5. Obviously, subjective opinions enter into every choice of this kind. This may lead to the deformation of real conditions — a danger that cannot anyway be avoided entirely. Here safety may lie in an effort to keep the danger constantly in mind.

ELEMENTS OF THE MAP

1. Water courses

The rivers have been shown divided into classes according to mean annual flow. The lower part of this classification has been split into smaller units, so as to make meagre streams stand out. None of the

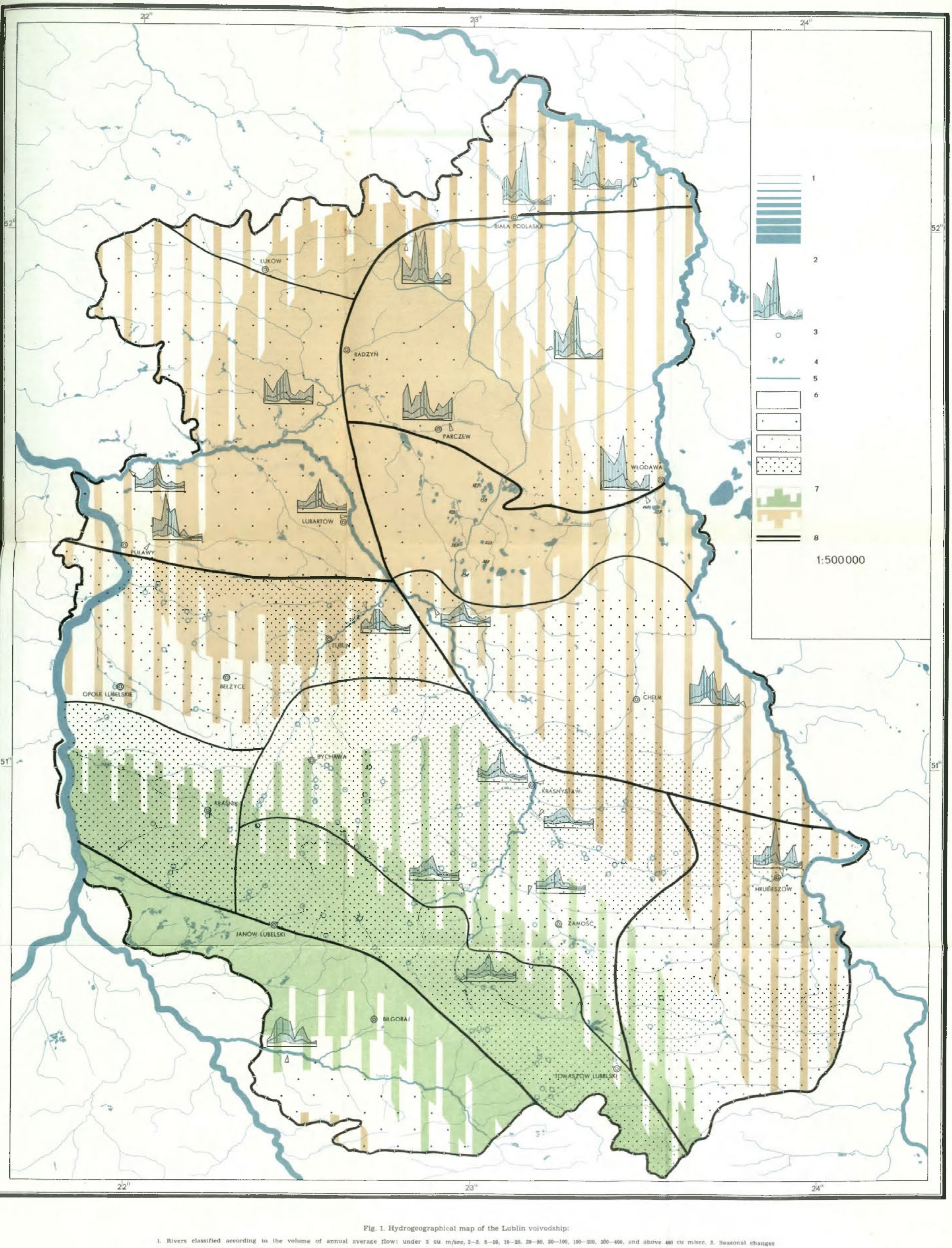

Fig. 1. Hydrogeographical map of the Lublin voivodship:

1. Rivers classified according to the volume of annual average flow: under 2 cu m/sec, 2—5, 5—10, 10—20, 20—50, 50—100, 100—200, 200—400, and above 400 cu m/sec. 2. Seasonal changes of flow. The graph in the middle shows the average monthly coefficient of flow expressed in the form of the result of the division of the average flow in a given month by the average annual flow. The graphs on the two sides show similar coefficients computed from maximum and minimum monthly averages during the observation period. The area marked with lines depicts changes of coefficients. 3. More important springs (no detailed maps were drawn for the south-eastern part of the voivodship). 4. Lakes and ponds. The number indicates the maximum depth. 5. The Wieprz-Krzna Canal. 6. Underground waters. Regions where shallow and very shallow waters prevail Regions with shallow waters prevailing. Regions with great differences in the depth of waters. Regions where deep and very deep waters prevail. 7 Water surpluses and deficits. Region of water surplus: small, considerable. Regions with absolute water deficit: big, small. 8. Limits of hydrogeographical regions and subregions. Drawn in the Hydrography Institute of the Maria Skłodowska-Curie University, Lublin, 1964, Executed by Jan Kasperek, M.A.

Zakł. Graf. PWN, Łódź, zam.412 n.1000

below 0 · 5, and even below 0 · 3. The differences in monthly flow between individual years are great, even for the short period that observations are available. The highest coefficients for the mean monthly flow exceed the values for the mean long-term annual flow by a factor of 7 to 8, while the lowest coefficients are less than 20%, sometimes only 10% of this flow. Cases of abundant flow occur not only in spring but also in summer. Exceptionally meagre flows are recorded in the summer months, as in autumn.

The marked differences in river regime indicated above follow from differences in the geological structure of the land and from the part consequently played in the runoff by underground water. In the lowland rivers to the north of the voivodship, the spring flow maxima are higher, because the waterlogged region resists infiltration into the soil. In June when the spring flood has subsided, the rivers reach their minima due to lack of alimentation from underground water resources. The small quantity of water that can be retained in the subsoil is also demonstrated by increases in flow during the precipitation maximum in July.

In the southern part of Lublin Voivodship with its upland character, the rivers owe their more balanced flow to the permeability of the substratum (loesses, cracked Cretaceous rocks). Even an abrupt snowmelt or torrential rains can only cause shortlived rises in the water level, without raising the mean monthly values to any marked extent. The River Huczwa which drains the eastern part of the upland shows intermediate features: it resembles the upland rivers in its late minimum in monthly flow, but differs from them by a greater variation in monthly flow from year to year, and by an outstanding July maximum in which it rather resembles the lowland rivers. A late flow minimum is proof of the existence of underground water resources, capable of maintaining flow although water losses are growing larger. The variableness of monthly flow is associated with the wide expanse of impermeable areas conducive to surface runoff.

As regards artificial water courses, the map shows only the Wieprz-Krzna Canal. When full, its carrying capacity is some 32 cu. m/sec. In the period from May to August the canal diverts some 50 million cubic metres of water from the River Wieprz, for irrigation purposes and for feeding storage basins. To a large extent this water is consumed in transpiration and evaporation, but part of it is passed on to the Bug drainage area. Thus the Wieprz-Krzna Canal introduces important changes into the runoff conditions in Lublin Voivodship. The remaining canals and irrigation ditches, for all the importance they may have locally, have been omitted in view of the scale of the map.

2. *Stagnant water*

Water storage basins are of great significance in Lublin Voivodship, where large areas have very sparse river systems, while in other areas the flow in the rivers is exceptionally meagre. The map therefore shows all lakes and groups of ponds which can be indicated in this scale. Deeper lakes are marked by figures of maximum depths. This does not give the capacity of the basins, but it does stress the peculiarity of those lakes of karst origin, the depth of which stands out by contrast with the flat land and its shallow underground water.

3. *Underground waters*

Underground waters are an element extremely difficult to show graphically, due to their great variety. To show them in an appropriate way a number of features would have to be taken into account, but this is obviously impossible in view of the character and scale of the map. The author therefore selected that feature which would best illustrate the type of water circulation and the resulting hydrographical conditions. This is the depth of the highest water level in the ground. In Lublin Voivodship the first underground water table may occur anywhere in a wide range of depths, from zero to 100 m below the surface. For wide areas of the voivodship a detailed map showing isohydrobaths presents a veritable mosaic. The 1 : 500 000 scale adopted could not possibly show a differentiation of this type, and the author has had to generalize.

The author uses four categories for classification, based on the predominance of a given depth range for the underground water table. Obviously, regions where shallow or extremely shallow water predominates will also contain places where the first water table lies at greater depths; but cases like this are exceptional. Mostly the highest water table is encountered near the topographical ground surface. In these shallow-water areas the depth varies during the year in accordance with the rhythm of alimentation, the level rising highest during times of snowmelt and heavy rainfall. When droughts set in, the water table drops, but mostly no deeper than to 2 m. This shallow occurrence of underground water affects its own nature as well as hydrographical conditions as a whole. Its physical, chemical and bacteriological properties do not comply with the standards established for drinking water. Numerous perennial or seasonal marches are associated with a shallow water table. Only minor reserves can be accumulated in the shallow water-bearing strata, and this is reflected in fluctuations of the river regimes. Shallow underground water is intensively involved in circulation, being readily renewed and depleted. Diminution takes place not only by runoff to rivers but simultaneously by evaporation from marshes and wet soil and by plant transpiration. In the water balance this results in losses at the expense of runoff.

The second category comprises areas where shallow underground water predominates. Here the first water table is commonly reached at depths of the order of a few to — more rarely — a dozen metres.

The third category takes into account areas where the depth from surface to water table varies. A typical example is provided by the Chelm hills in the eastern part of the voivodship, where wide and flat valley floors contain shallow, even very shallow water-bearing strata, while in the Cretaceous elevations water is only reached at considerable depths.

A deep-lying water table — the fourth category — is characteristic of the major part of the Lublin Upland. The hydroisobath picture for this area is highly diversified. In the floors of the river valleys the underground water table lies at a very shallow depth and the same applies to the lower slope sections. At times water levels at barely a few or a dozen metres depth are also encountered in upland regions; this is connected with the local occurrence of shallow water-bearing strata, small in storage capacity and limited in horizontal extent. However, the overall total of the shallow water areas does not account for a large area.

A deep-lying table is associated with a sparse network of surface waters and a runoff more uniform than in lowland regions. The properties of water derived from greater depths satisfy accepted drinking water standards.

4. *Springs*

The last among the hydrographical elements shown on the map are copious-flow springs. Undoubtedly it would improve the map if all existing springs could be indicated. This would bring out the difference between the upland part of the voivodship rich in springs, and the lowland practically devoid of springs. Those with ample flow occur only in the upland zone and they are mostly grouped along river valleys. Their concentration in the upland zone emphasizes the part played in runoff conditions by underground water.

5. *Water surpluses and deficits*

To illustrate the water balance within the voivodship, areas of absolute water surpluses and deficits have been marked on the map. For this purpose the author made use of a paper by K. Wojciechowski [2] who calculated the water balance for stations with rainfall gauges in Lublin Voivodship, applying the method of C. Thornthwaite and J. Mather. The author has modified K. Wojciechowski's picture slightly, but without altering the main concept.

Lublin Voivodship consists of two parts with different water balances. In the northern and eastern part the balance is negative, and — according to K. Wojciechowski — on the average the annual deficit exceeds water surpluses by more than 50 mm. The southern part (with the exception of a minor portion in the south) shows a prevalence of surpluses over deficits. Here the maximum values of absolute surpluses exceed 100 mm. The magnitudes of surplus and deficit are illustrated on the map by different intensities of surface marking. Highest values are indicated by uniform colouring while, surrounding them, areas with lower values are marked by two types of coloured stripes. The areas of surpluses and deficits are separated by colourless bands in which the balance is even; that is, annual deficits approximately equal annual surpluses.

It is characteristic that absolute water deficits occur mostly in areas where the coefficients of seasonal flow are highest, the underground water at highest level, and the hydrographical network densest. On the other hand, surpluses are associated with the relatively dry upland zone where the river system is sparsest and the water table at greatest depth. Still, this is not an absolute rule; high surpluses are also found in the southern part of the voivodship, in the Sandomierz Depression which resembles a lowland area with its shallow underground water table and its dense fluvial network. Water deficits also occur in the northern part of the upland which in many ways resembles the southern surplus-featured part of Lublin Voivodship.

6. *Hydrogeographical regions*

The last element shown on the map are the boundaries of hydrogeographical regions and subregions. This division into regions originated from the author's analysis of characteristic hydrographical conditions;

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[2] K. Wojciechowski, Water Deficits and Surpluses in the Lublin Voivodship. Annales UMCS, S. B., XVIII, 12, 1963 (Summary in English).

and of their variation with time and location[3]. Their association with the natural environment has also been taken into account. Thus this division constitutes a synthetic generalization, and on the general map it takes the place of all the elements which cannot be shown; it also emphasizes what are the differences and the similarities of hydrographical conditions in the area under investigation.

CONCLUSION

Hydrographical conditions are affected by a great number of agencies, and this explains why they differ so much, not only on a world scale but on a regional scale as well. The diversity of hydrographical phenomena and their interrelation creates features peculiar to individual regions and each region assumes a hydrogeographical individuality different from that of other regions. It is the goal of every kind of synthesis, and therefore of a cartographical synthesis also, to reveal this individuality without distorting actual conditions, without omitting essential features and without getting lost in minor details.

There are many different paths to a solution, some of them more auspicious than others. It is probably impossible to hit upon an ideal method, especially in view of the fact that the importance of individual elements of such syntheses depend on the scale of the map. So several different solutions should actually be looked for, and the author's map may be considered as an attempt at one of them. In assessing the value of this attempt it must be considered, whether the picture presented on the map actually reflects the hydrographical conditions as they exist in the area investigated[4]. The author's effort may be considered a step in the right direction if it helps to start a discussion on how to compile a truly general hydrogeographical map.

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EVAPORATION FROM WATER SURFACES BY DAY AND BY NIGHT

EDWARD MICHNA

INTRODUCTION

The quantitative determination of the share of evaporation by day and by night during the full 24-hour period is of great importance for hydrology and climatology. A quantitative treatment of this problem affords a better understanding of the essence of evaporation, which is one of the components of the water balance. At the same time it provides a chance to determine the variations which occur in this element and their relevance to both the micro- and the macro-climate of a region.

For many years the literature dealing with meteorology and hydrology has contained controversies on the question, how much evaporation occurs during the day and how much during the night. Figures for both daily and nightly evaporation have been determined by direct measurements and by theoretical calculations. However, estimates of evaporation vary widely.

Schmuck gives as an example that, according to Rethly, at some places in Hungary nightly evaporation is in winter 40 to 80%, and in summer 15 to 35% of 24-hour evaporation [9].

Kaczmarek asserts in his reflexions on the course of 24-hour evaporation from water surfaces, that “from a physical point of view the assumption of high values for nightly evaporation is fully justified” ([4] p. 272). In support of this opinion he cites results obtained by Fransilla, Kozłow, Ognievoj, Venkiteshvaran, and others, which indicate that nightly evaporation constitutes a considerable part of full-day evaporation, reaching in particular months of the year some 40 to 50% of total evaporation [4].

A different opinion is expressed by Demiańczuk. On the basis of calculations and theoretical considerations he believes that, except when influenced by the Sun, the intensity of evaporation is negligible [3].

Chyliński discusses the results of measurements on evaporation from water surfaces which he made before the war at the latitude of the Polish Lowland and reports that, on the annual average, the nightly evaporation accounted for 20 to 23% from a Wilde evaporometer and for 23% of the full-day evaporation from a Kadel evaporometer [2].

On the basis of measurements made at Wrocław in 1947 and 1948, Schmuck maintains that during the period from July to September nightly evaporation from the Wilde evaporometer averages from 9 to 12% of full-day evaporation.

These examples show that no uniform values have been found for the ratio of night-time and day-time evaporation to the 24-hour figure, whether by direct measurement or theoretical reasoning. The evaluations for nigthly evaporation by different authors vary by as much as 40% of full-day evaporation.

It is impossible to correlate the results obtained from a number of different geographical regions, due to differences in the methods applied and in the instruments used. Further, some of the authors consider "nightly evaporation" to involve the amount of water evaporated from 9 p.m. to 7 a.m., others from 5 p.m. to 8 a.m. or from 7 p.m. to 7 a.m.

The time limits of 9 p.m. to 7 a.m. or from 5 p.m. to 8 a.m. are artificial when applied to evaporation measurement, because they neither coincide with the true duration of the night, nor are they symmetrical with regard to the solar noon or midnight.

METHOD OF MEASURING

When investigating evaporation from a water surface with the hope of making progress in the problem, the most appropriate period for night-time evaporation must first be decided. The author picked the period between sunset and sunrise, in the belief that measurements made at the time the sun rises and sets would yield results which illustrate the true amount of evaporation during night-time and during day-time.

Following this rule the author measured evaporation from a free water surface at two different places: at the Research Station of the Physical Geography Laboratory of the Curie-Sklodowska University situated at Równia (Western Bieszczady), and at the Meteorological Station of the State Hydrological and Meteorological Institute at Przemyśl (marginal zone of the Przemyśl Carpathians).

At Równia the measurements were made in 1961 and 1962, from May to October. During winter, evaporation was not measured on account of heavy snowfall and frequent snow dritfs (the snow cover often exceeded 80 cm). The meteorological garden of the Research Station is situated on a low terrace in the valley of the Równia Stream. The altitude of the Station is 500 m above sea level, $\varphi = 49°24'$, $\lambda = 22°35'E$.

At Przemyśl evaporation was measured continuously from January 1, 1961 to December 31, 1963. The meteorological plot where the evaporometer was set up, is situated in the peak section of a gently inclined slope, with ESE exposure. The altitude is 235 m above sea level, $\varphi = 49°47'$, $\lambda = 22°46'E$.

A Wilde evaporometer was used, set in a screen 50 cm above ground level under a slatted roof. Readings were made twice daily, at sunrise and sunset. Every day the evaporometer was filled with an identical amount of water, immediately following the sunrise reading.

RESULTS OF MEASUREMENTS

The figures of Table 1 show that evaporation from a water surface is greater at Równia than at Przemyśl. This is influenced by the more intensive night-time evaporation at Równia.

TABLE 1. Mean monthly sums of evaporation (in mm) at Równia and at Przemyśl (1961—1962)

Month	Równia			Przemyśl		
	day	night	total	day	night	total
May	55·1	13·2	68·3	47·5	7·6	55·1
June	47·5	7·3	54·8	57·7	8·3	66·0
July	59·5	10·5	70·0	68·1	6·6	74·7
August	66·6	15·2	81·8	61·3	9·4	70·7
September	59·3	17·5	76·8	48·9	10·7	59·6
October	39·9	21·7	61·6	32·9	9·5	42·4
May — October	327·9	85·4	413·1	316·4	52·1	368·5

At Przemyśl, the day-time evaporation (from sunrise to sunset) during the warmer season (from May to October) averaged 86% of the full-day value; nightly evaporation was 14%. During the same months, nightly evaporation was much greater at Równia: on the average it was 21⁰/₀ of full-day evaporation, i.e. 7⁰/₀ more than at Przemyśl (Table 2). This more intensive nightly evaporation at Równia is presumably caused by local factors such as downslope winds.

TABLE 2. Ratio (in %) of daily and nightly evaporation to full-day evaporation af Równia and Przemyśl (1961—1962)

Month	Równia		Przemyśl	
	day	night	day	night
May	80·7	19·3	86·2	13·8
June	86·7	13·3	87·4	12·6
July	85·0	15·0	91·2	8·8
August	81·4	18·6	86·7	13·3
September	77·2	22·8	82·0	18·0
October	64·8	35·2	77·6	22·4
May — October	79·4	20·6	85·8	14·2

The percent ratio of daily and nightly evaporation to full-day evaporation varies over a wide range for the different months of the warm season. To give an example, at Równia night-time evaporation was 13⁰/₀ of full-day evaporation in June while for October the figure was as much as 35⁰/₀. These very marked differences in percent values of night-time to full-day evaporation are due, apart from other causes, to differences in the duration of day and night in the individual months of the year.

In order to eliminate this factor, the author calculated the hourly evaporation for the day and the night (Table 3).

It appears from Table 3 that at Przemyśl from May to October the hourly evaporation during the day-time was four times greater than during the night, while for Równia this proportion was 3 to 1. The differences in hourly evaporation between day-time and night-time were greatest for July, smallest for May and October.

As mentioned before, at Przemyśl evaporation has been measured for all months of the year throughout the period 1961 to 1963, and this supplied information as to how much water evaporated during the winter months. Thus, at Przemyśl where for the whole year night-time evaporation accounted for some 20⁰/₀ of full-day evaporation, it proved to average 53⁰/₀ in the winter months and only 12⁰/₀ in summer. The mean evaporation values for one night-hour during the cool season were at Przemyśl nearly half of what they were for one day-time hour [7].

TABLE 3. Mean hourly evaporation (in mm) at Równia and at Przemyśl (1961—1962)

Month	Równia		Przemyśl	
	day	night	day	night
May	0·11	0·03	0·10	0·02
June	0·10	0·03	0·13	0·04
July	0·12	0·04	0·14	0·02
August	0·15	0·05	0·13	0·03
September	0·15	0·05	0·13	0·03
October	0·12	0·05	0·10	0·02
May — October	0·13	0·045	0·12	0·03

CONCLUSIONS

The measurements discussed above covered only a short period and the results obtained can only be used to estimate approximately the ratio of night- and day-time evaporation to full-day evaporation in two geographical regions of SE Poland (the Western Bieszczady and the Carpathian Upland). Even so these results indicate that nightly evaporation constitutes a considerable part of full-day evaporation — particularly in the cooler season.

It is worth noting how closely the author's results agree with those of Chyliński [2]; this applies especially to the mean annual ratio of day-time and night-time evaporation to full-day evaporation.

In the author's opinion, measurements of evaporation from water surfaces made for the periods suggested yield true values of day-time and night-time evaporation; moreover, calculated per hour of day and night, they enable comparisons to be made between results obtained at places of different latitudes.

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EVALUATION OF THE WATER BALANCE OF AN INTERCONNECTED GROUP OF LAKES ON EXAMPLE OF THE GREAT MASURIAN LAKES *

Zdzisław Mikulski

The problems arising in assessment of lake water balances have not yet been adequately studied, the respective investigations being of recent date.

In the present study an attempt is made to work out the water balance of a group of interconnected lakes forming one hydrographic system. The Great Masurian Lakes located in the region of the Masurian Lake District of northwest of Poland were taken as an example.

FORMATION OF THE LAKE WATER BALANCE

Compared to the water balance of a river basin, the water balance of a lake is more complex since it comprises more elements the determination of which often presents considerable difficulties. In the water balance of a lake we have to consider the following factors: atmospheric precipitation in the catchment basin, evaporation from the water surface, runoff conditions in the basin, fluctuations in water stages and lake storage.

The water balance of a lake forms under the influence of the so called vertical water exchange and the horizontal exchange (inflow — outflow). The general water balance equation reads

$$P_j + H_d = S_j \pm \Delta R_j$$

where: P_j — atmospheric precipitation on the lake surface, H_d — inflow to the lake (surface and subterranous), S_j — evaporation from the lake surface, H_w — outflow from the lake (surface and underground), ΔR_j —

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* Material contained in the work: Zdzisław Mikulski — Bilans wodny Wielkich Jezior Mazurskich (Water Balance of Great Masurian Lakes), *Materiały PIHM*, Warszawa 1966, was used in the present paper.

difference in lake storage between the beginning and the end of the balance period.

The computation of such elements as atmospheric precipitation, variations in lake storage and often in surface runoff, does not commonly present major difficulties. There are greater difficulties encountered in determination of the surface inflow, therefore one has to assess its value on basis of the unit runoff in the catchment basin or that in adjacent basins with a similar hydrologic regime. In many cases the determination of ground water inflow and outflow is practically impossible, for which reason it is usually assumed that both these quantities balance. It is also believed that the part of groundwater inflow and outflow is relatively small as compared to other elements and does not exceed a few percent of the total water balance.

The subject of the present study was to define tentatively the formation of the water balance of a group of interconnected lakes forming one continuous waterway. Calculations are here greatly hampered by the difficulties arising in determination of their inflow and outflow. In the case of the Great Masurian Lakes a further difficulty was encountered, namely that of defining the location of the divide on the path of the chain of lakes, which is decisive for the magnitude of the particular lake catchment areas in different hydrologic seasons.

THE GREAT MASURIAN LAKES

The Great Masurian Lake group is located in the region of the Vistula — Pregolya divide, on which their affluents Pisa and Węgorapa originate. To this group, comprising 300 sq km of water surface, belong the two largest Polish lakes — Śniardwy with 110 sq km surface in the south part, and Mamry with 102 sq km in the north part of the region — and over 20 smaller lakes with a sum-total of 2745 cu km of water (Fig. 1). The whole catchment area between outflow from lakes to the north (Węgorapa river) and to the south (Pisa river) comprises 3645 sq km, of which the north part accounts for 615 sq km and the south part for 3030 sq km of the catchment area. The whole group represents almost 65% of the water surface and 79% of the storage capacity of all the lakes in the catchment area.

The first step in calculation of the water balance was to define the location of the water divide, which is decisive for the magnitude of the outflow index of the particular lakes situated on the path water runoff from the catchment area. In detailed field investigations it was found that the location of the water divide depends on the ratio of northward to

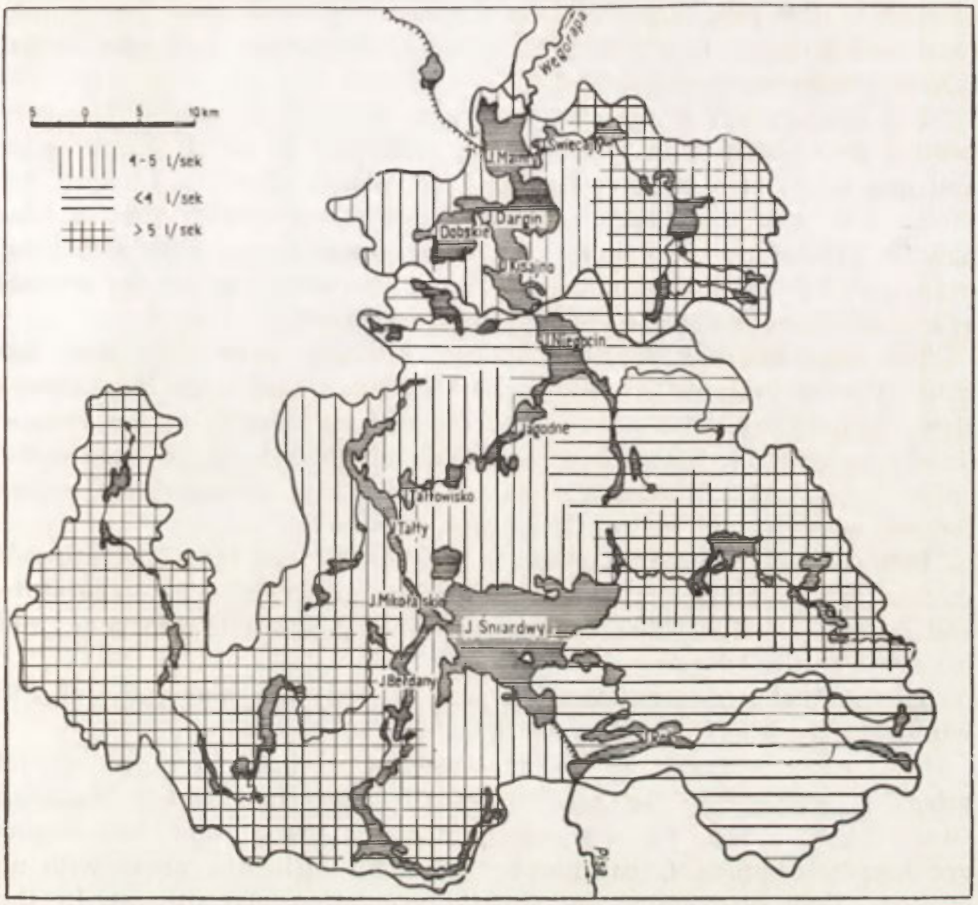

Fig. 1. Water runoff per unit in the Great Masurian Lakes basin

southward outflow from the lakes. The magnitude of those ratios was determined for particular months of the balance period 1951—1960, and the corresponding catchment areas of the north and the south parts were calculated from them, and subsequently the approximate position of the divide was determined. Along the water divide the points of bifurcation were defined, i.e. the places of varying flow direction.

ELEMENTS OF THE WATER BALANCE

Atmospheric precipitation is one of the better known elements of lake water balance owing to the general adequately dense network of measurement points in the catchment basins. The northern part of the Great Masurian Lake region shows a fairly distinct preponderance of precipitation (595 mm) over the southern part (568 mm). The annual mean precipitation is 572 mm, the ratio of the winter half-year to the summer half-year being 1/3 : 2/3.

The evaporation from lake surface is difficult to assess. The respective data obtained in recent years, primarily by USSR hydrologists and confirmed also by investigations in Poland, allow to advance the thesis that the magnitude of many year's evaporation from a lake may be defined by the volume of evaporation measured with a floating evaporometer, possible gaps in data being supplemented by the records of a shore evaporometer after appropriate correction.

The experimental results obtained hitherto show also that the magnitude of evaporation from a lake surface depends on local conditions, primarily on the size of the lake and its location in the terrane (insolation degree). Since, however, relevant measurements were made only on Lake Mikołajskie, we had to assume equal evaporation values for the whole group of the Great Masurian Lakes.

Evaporation in the winter season was determined by Konstantinov's method which allows to compute it from the mean air temperature and humidity values, due consideration being given to the snow and ice cover of the lake.

The annual mean evaporation sum is 682 mm, the ratio of the winter to the summer half-year being 22 : 78.

The runoff conditions in the catchment basin require special attention, notably in the case of transit lakes such as the Masurian Great Lakes group. The hydrographic conditions in such lake basins are mostly complex (great number of small affluents, areas with no outflow, flow obstruction by aquatic vegetation and others). In the case of the examined lake group, determination of runoff conditions was based on synoptic measurement series in the whole basin from which it results that the characteristic unit runoff for larger basins amounts to 5—7 l/sec/sq km (mean 6 l), and in smaller basins to 3—5 l/sec/sq km (mean 4 l).

Equally important was the determination of the magnitude of water discharge from the whole group of lakes: northward through the Węgorapa river, southward through the Pisa river. The water flow is partly regulated by hydrotechnical structures, so that the respective calculation could be verified in several profiles located downstream of the lake outlet. The total outflow in an average year is 20 · 2 cu m/sec, of which 3 · 5 cu m/sec (27%) flows in northerly direction and 16 · 7, cu m/sec (83%) in southerly direction. Attention should be drawn to the high degree of equalization in the monthly intervals, owing to which distribution in the two hydrologic half-years is almost equal.

The last element of the water budget is lake storage. In contrast with ground storage, its computation does not involve major difficulties if bathymetric curves of the lake and water stage records are available. If the lake surface is large and water stage fluctuations are relatively small, it is sufficient to know the area of the lake surface. This procedure was used in calculating storage in the Great Masurian Lakes.

In storage computation we have to consider water stage variations, in particular, whether they have the same level at the beginning and the end of the balance period. If this is not the case, the respective difference in water storage must be taken into account in the water balance equation. The balance period 1951—1960, for which the water

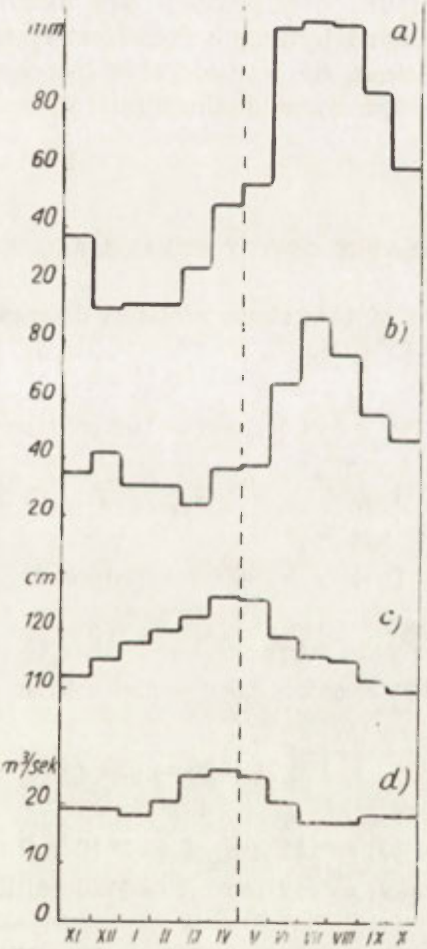

Fig. 2. Annual course of the balance elements:
a — evaporation from water surface; b — precipitation; c — height of water in Giżycko; d — total outflow

balance of the Masurian Great Lakes was calculated, included dry and wet years and was characterized by fairly equal water stage levels, the amplitude of mothly mean stage fluctuations in the examined decade was slightly over 1 meter, the difference in storage between the beginning and the end of the balance period amounting to approximately 30 million cu m.

Comparison of monthly evaporation from the water surface and atmospheric precipitation in the basins with the water stages and outflow of the lakes definitely indicates an approximate 9-month lag of maximum outflow (water stage) in respect to the maximum atmospheric precipitation, while the minimum outflow shows a 4-month lag in respect to the minimum precipitation. The occurrence of minimum outflow in July — August is largely the effect of the maximum evaporation noted at the time, the considerable increase of evaporation in June being accompanied by a distinct fall of water stages and lake outflow (Fig. 2).

WATER BALANCE OF THE GREAT MASURIAN LAKES

The water balance of this chain of lakes defines the annual amount of water circulating in them.

The gains include:

$$P_j = 331 \times 573 \times 1000 = 190 \text{ million cu m}$$

inflow to the lakes

$$H_d = S_j + H_w - \Delta R - P_j = 644 \text{ million cu m}$$

total gains

$$P_j + H_d = 834 \text{ million cu m}$$

The losses comprise:

evaporation from the lake surface

$$S_j = 331 \times 682 \times 1000 = 226 \text{ million cu m}$$

outflow from the lakes

$$H_w = 3645 \times 175 \times 1000 = 638 \text{ million cu m}$$

change in lake storage

$$\begin{array}{lll} 1.\text{XI}.1950 & H = 132 \text{ cm} & R = 2810 \text{ million cu m} \\ 30.\text{X}.1960 & H = 112 \text{ cm} & R = 2780 \text{ million cu m} \\ \hline & & \Delta R = 30 \text{ million cu m} \end{array}$$

total losses

$$S_j + H_w - \Delta R = 834 \text{ million cu m.}$$

From the balance sheet (Tab. 1) it results that the water balance of this group of lakes has been formed primarily under the influence of horizontal water exchange, i.e. inflow and outflow, these positions constituting almost 80% of the balance sum.

TABLE 1. Water balance of the Great Masurian Lakes group for the period 1951—1960

Gains			Losses		
Item	million cu m	%	Item	million cu m	%
precipitation on lake surface	190	22·8	evaporation from lake surface	226	27·1
inflow to lake	644	77·2	outflow from lake	638	76·5
total	834	100 0	total	864	103·6
			changes in water level (Nov. 1, 1950—Oct. 30, 1960)	—30	—3·6
Total	834	100·0	Total	834	100·0

The water balance of particular lakes can be established on the basis of previous determination of the seasonal location of the water divide. The whole group of lakes was divided into particular distinctly separate lake systems. For each system (lake) the following features were determined: on the side of gains — precipitation on the lake surface and inflow from the catchment area (including the inflow from systems of lakes situated at a higher level), and on the side of losses — evaporation from the water surface and outflow from the lake. Different precipitation values were determined for the two parts of the catchment area — the north and the south part, while evaporation was necessarily assumed to be uniform over the whole chain of lakes.

In calculating the water balance of lakes lying in the range of the divide zone the location of the latter, which varies every month and is decisive for the inflow volume to those lakes was taken into account. Runoff from the catchment areas was calculated on the basis of unit runoff (Fig. 1). The partitioning of flow volume according to month was made on the basis of the monthly distribution of the runoff in the

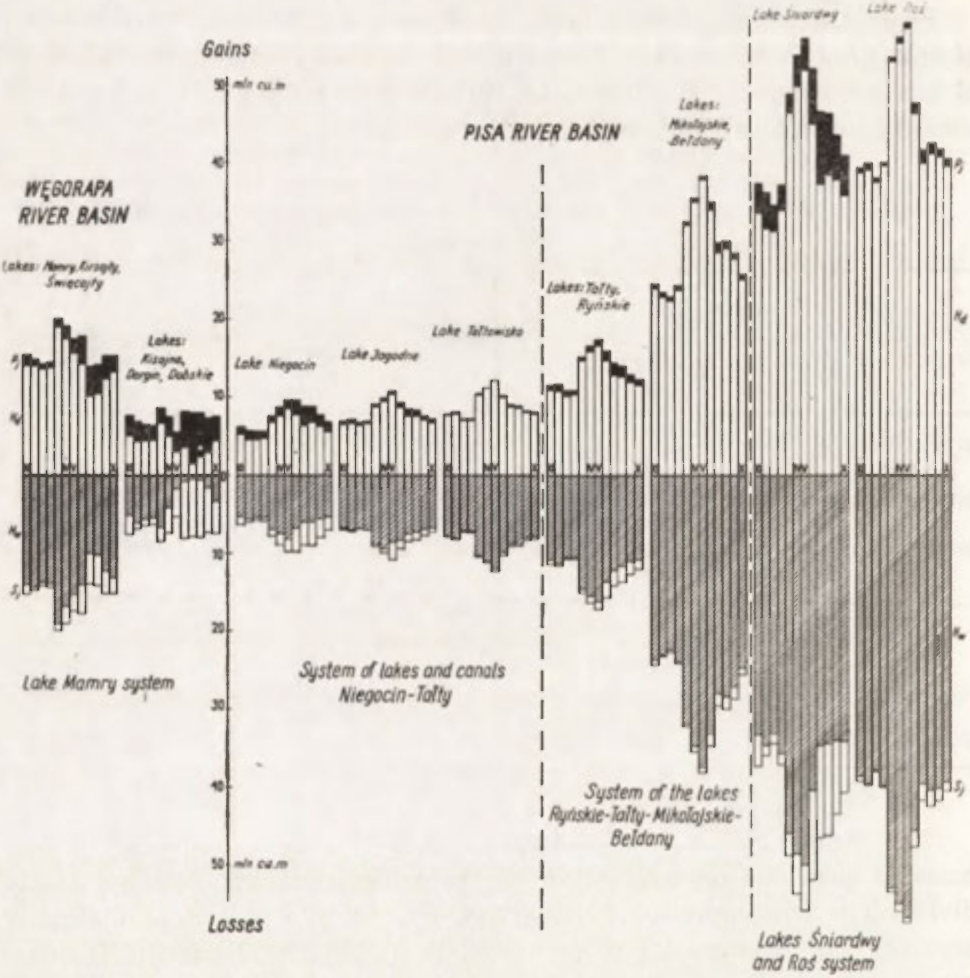

Fig. 3. Formation of water balance of separate lakes, 1951—1960

control profiles. The formation of the water balance of particular lakes is shown in Fig. 3.

In analysis of the findings, attention should be paid to the relative ratios of the magnitude of vertical and horizontal exchange. In lakes located in the zone of the water divide, vertical exchange in the summer half-year exceeds the horizontal exchange, often considerably, but maintains the same order of magnitude on an annual scale. The farther is the lake from the water divide, the greater the part of the horizontal exchange. Thus every lake has its specific water balance, resulting in considerable heterogeneity in the Masurian Great Lakes group.

WATER EXCHANGE IN THE LAKES

Knowing the water balance of lakes, we are able to define the pattern of the total water exchange between these lakes. As we know the amount of water circulation on one hand, and the storage capacity of the lake basins on the other hand, we are able to define the intensity of water exchange.

The lakes of the Masurian Great Lakes group that are located in the vicinity of the water divide show (as was previously mentioned) a relatively low water exchange, while the small transit lakes lying at some distance from the divide have intense water exchange. The range of fluctuations in the latter is enormous — from several percent to well over three-hundred. In the northern part of the lake group the annual water exchange amounts to 110 million cu m, so that with a lake storage capacity of over 1000 million cu m the exchange intensity is about 10%. The southern part of the lake group carries off almost five times more water than the northern part so that, with a storage capacity of approximately 1600 million cu m, nearly one third of the water is exchanged in the course of the year. The whole group of the Great Masurian Lakes exchanges annually about 40% of its waters, so that full exchange of the waters theoretically takes place within approximately 2½ years. A water layer of approximately 2 · 60 m thickness per year undergoes exchange.

The tentative evaluation of the water balance presented in this study may form an initial approach to developing water balancing methods for interconnected lake groups.

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GLACIATIONS IN THE SPITSBERGEN AREA

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Spitsbergen is the largest island of the Svalbard archipelago, which has a total area of 62 000 sq. km. Within this relatively small area rocks are found from practically all geological formations from the Precambrian to the Quaternary, together with a variety of tectonic structures. The oldest rocks are granites and gneisses which constitute fragments of an ancient crystalline platform; they occur in the NW part of Spitsbergen and in the northern part of Nordaustlandet. In a zone 20—30 m wide along the western shores of Spitsbergen, strongly metamorphosed rocks appear in what is called the Hekla-Hoek formation. These are crystalline limestones, dolomites, and a variety of schists derived from the Precambrian, Cambrian and Ordovician. During the Caledonian orogenesis these sediments became strongly folded and formed a mountain chain extending from Northern Ireland by way of Scotland, Norway, Bear Island and Spitsbergen as far as Greenland. The Caledonian zone contains the most spectacular land forms of Spitsbergen: soaring peaks and steep mountain crests reaching up to 1000 m and more above the water level of the fiords and the Greenland Sea. This chain is called Hornsundtind. Its highest peaks, 1431 m above sea level, are situated in the southern part of Spitsbergen.

Further east from the Caledonian chain rocks of younger geological formations, from the Devonian to the Tertiary, lie almost horizontally, or slightly tilted. They consist of sandstones, shales and limestones and have produced an altogether different type of landscape in these parts of Spitsbergen. The place of craggy pinnacles is taken by widespread planted uplands cut by deep and steep-sided valleys.

No evidence of folding movements of the Alpine orogeny since Tertiary times are recorded in the Spitsbergen area. However intrusions of granites, basalts and diabases did take place during this period, squeezing into the Mesozoic rocks. The highest Spitsbergen peak, Newtontoppen, 1712 m, emerges from one of the flat uplands built of intrusive red granites.

The author has presented this brief survey of the general geological structure and tectonic style in order to make it easier to follow the course of events in this area during the Quaternary era.

GLACIATIONS IN THE PLEISTOCENE

From copious geological and geomorphological data it can be seen that the old Pleistocene glaciations used to extend farther in the Spitsbergen area than they do today. In areas lying outside today's glaciation one may observe many U-shaped glacier valleys, glacial cirques, glacier-smoothed surfaces, ice striae and an abundance of erratics. A controversy began with investigations made in the second half of the 19th century by Swedish expeditions by O. Torell, A. S. Nordenskiöld, A. G. Nathorst and G. de Geer and has continued to this day on two problems:

1. the extent of the Pleistocene glaciation in the Svalbard archipelago, and
2. the direction in which the glaciers were moving during the Pleistocene and where centres of glaciations were located.

As to the maximum range of the glaciations, widely divergent opinions have been expressed. Some authors believe that each of the individual Arctic archipelagos developed its own centre of glaciations in the Pleistocene, while others suppose that an enormous cap of inland ice was spread out all over the Barents Sea area. In the second half of the 19th century A. G. Nordenskiöld introduced the idea that during the Pleistocene Spitsbergen was connected with Scandinavia to the south and Siberia to the east, and was not an island at all but part of an extensive land area in the northern part of Eurasia covered by a thick sheet of inland ice. In his comments on Nordenskiöld's theory A. G. Nathorst [13] asserted that, even if this concept must be considered too far-reaching, there can be no doubt that some time ago the area of Spitsbergen and the whole Svalbard archipelago must have been at a higher altitude and of a wider extent than today. It must have been the heavy ice cap which depressed this region in much the same way as the Scandinavian peninsula, to be followed by an emergence after the glaciations had passed. It was Nathorst's belief that the glaciations reached beyond the present outer land contours of the Svalbard archipelago. Similar opinions about a wider glaciation range on Spitsbergen were also expressed by O. Torell, E. de Geer, J. E. Andersson and B. Högbom.

Later years witnessed further research. A. Hoel and E. Drygalski [6] endorsed the opinions put forth by the Swedish scientists that the glaciers covered wider areas in the Pleistocene, and presented further arguments in favour of this belief. According to Hoel the spread of erratic boulders in the Isfiord region extends to the mountain crests, while around Krosfiorden and Kongsfiorden they are found not higher than to 350 m. Drygalski asserted that great differences in the degree of weathering may be observed between mountain crests and lower parts of mountain slopes and valleys. Steep mountain slopes and steep-sided valleys show glacier-smoothed surfaces and very little advance in weathering, while the mountain peaks are mantled by thick regolith covers. From this Drygalski concluded that during the Pleistocene the peaks protruded above the ice surface in the form of nunataks and suffered intensive mechanical weathering, while the mountain slopes and the valleys were protected against weathering by the overlying ice sheet.

Soviet students of the Arctic were likewise greatly interested in the extent to which glaciations have affected the shelf of the Barents Sea which embraces Spitsbergen as well as Bear Island, Franz-Josef Land, and Novaya Zemlya; they express divergent opinions on this subject. I. M. Ivanov [11] and W. H. Saks [16] assumed that separate centres of glaciation existed for Spitsbergen and for Franz-Josef Land in the Pleistocene. To W. D. Dibner [5] it seemed probable that the ice sheet covering the Svalbard archipelago was connected with that on Franz-Josef Land and Scandinavia, and perhaps also with the ice cap on North Land (Severnaya Zemlya) and the Taymyr Peninsula. Dibner based his theory on oceanographic studies, especially on results of analyses of ocean bottom deposits and on the relief on the Barents Sea floor. In the Barents Sea glacial deposits and an exerative glacial relief were discovered on the shelf surface, extending as far as the northern limits of Europe.

J. Corbel [3] went even further in his conjectures. He held that in the Late Pleistocene and the rise of the Holocene the Barents Sea shelf was covered by a compact mantle of inland ice, the outline and size of which almost corresponded to the area of Greenland, i.e. some 1.8 million sq. km. Corbel placed the centre of this glaciation somewhere in the Franz-Josef Islands.

Studies made by A. Jahn [12] and K. Birkenmajer [1] during the Polish Expedition of the International Geophysical Year in 1956—1960, supplied further evidence in favour of a wider spread of the ice sheet during the Pleistocene, and of its transgression in the Hornsund region beyond the present western coast line of Spitsbergen.

J. Büdel [2] discovered three generations of glacier fissures on Barents Island; with this as basis he considered the degree of glaciation on the Svalbard archipelago during the Würm peak and the Late Pleistocene. Büdel placed the Würm peak glaciation centre approximately on Kong Karls Land. He believed the glaciers to have progressed from this centre to the east, north and south, and to have covered all of the Svalbard Islands with a compact ice mantle.

In a paper dealing with the evolution of the coast line of Franz-Josef Land, M.G. Grosvald [9] presented convincing evidence that a compact ice cover connected Spitsbergen with Franz-Josef Land in the Pleistocene. According to him the centre of this ice cover lay in Victoria Island, approximately halfway between the Svalbard archipelago and Franz-Josef Land. Groswald based his conclusions about the probable thickness of the ancient ice cover on data of isostatic emergence. For the centre of this cover, above Victoria Island, he assumed a thickness of 2800 m, with 1300—1500 m for Spitsbergen and Franz-Josef Land. Obviously this thickness must have varied in accordance with orographic features. Groswald does not dispute that the entire shelf may have been covered by inland ice during the Pleistocene glaciations. It is an acknowledged fact that the ocean level was then depressed by about 300 m [8], so that to a large extent the shelf must have been land: glaciers and glacial relief may well have developed on this surface.

With the decline of the Pleistocene some ten thousand years ago, the ice sheet on Spitsbergen and in the whole Arctic shrunk considerably. Saks [16] and Feyling-Hanssen [7] supposed that the extent of the glaciations at the decline of the Pleistocene differed little from that it is today, while de Geer [4] believed the glacier recession at the end of the Pleistocene to have been more intensive than is shown by the range of the present-day glaciation. In A. Jahn's opinion [12] glaciers have survived only in the central part by the end of the Pleistocene, and the range of the glaciation was then narrower than it is today. In contrast with this, H. Philipp [15] argued that the decline of the Pleistocene witnessed a complete disappearance of the ice cover on Spitsbergen. The most extreme opinion in this matter was held by E. W. Gorbackij [8] who believed today's glaciers on Arctic archipelagos to be relicts of the Pleistocene glaciation.

So far we lack conclusive evidence that repeated glaciations have taken place on Spitsbergen, as was the case in Northern Europe where a threefold, and in some places even a fourfold, glaciation has been proved irrefutably.

In South Spitsbergen, in the forefield of terminal moraines of the present glaciation, A. Jahn [12] and K. Birkenmajer [1] discovered what they call moraines of an older generation. Birkenmajer considers these moraines to belong to the Würm glaciation; in other words, he agrees with some of the authors mentioned above that traces of two generations can be found on Spitsbergen: one of Pleistocene age, the other the contemporaneous glaciation. Jahn looks upon the older generation moraines as remnants of what he calls the "postglacial glaciation" and therefore distinguishes three glaciations on Spitsbergen: 1) the Pleistocene glaciation which left traces in the form of erratics, 2) the postglacial glaciation which he believes to have taken place 6000 to 5000 years B. C. and which left what he calls older generation moraines as traces, and 3) the Holocene glaciation, the range of which is marked by the terminal and lateral moraines of the contemporaneous glaciation.

A chronology for the Spitsbergen glaciations can be established by correlating the moraines with the isostatic rise of the marine terraces observed along the shores. In recent years the C^{14} method has been used for a number of absolute datings of mollusc shells, of whale bones, and of drift wood collected from different terrace levels [7, 9, 10], and these examinations have been used to determine the absolute ages of these terraces. In South Spitsbergen, terraces of this type occur at altitudes up to 340 m (W. Werenskiold [20], Jahn [12]). In Rev valley, on the northern shores of the Hornsund fiord, Jahn found that moraines of the older generation cover a 65 m terrace, while a younger level of 45 m shore terraces is incised into this moraine. The determination of the absolute age of these terrace surfaces also disclosed the relative age of the moraines. On the basis of an extrapolation made by Groswald [9, 10] the age of the 65 m terrace in the Hornsund region may be set at 10 500 years and that of the 45 m terrace at 9 500 years. Hence the age of the older generation moraines built on the 65 m terrace may be some 10 000 years. This would mean that they developed at the time when the Younger Dryas governed the climate of Northern Europe, so that they are of the same age as the moraines of the Saupaselli Stage and mark the final stage of the Würm deglaciation on Spitsbergen.

THE HOLOCENE GLACIATION

While investigating the Hornsund region in South Spitsbergen, the present author noticed that some of the forms constituting the older generation moraines lie below the 40 m terrace [18]. In 1963, while taking part in the work of an expedition from the Norwegian Polar Institute to North Spitsbergen, he observed on Amsterdam Island and on the shores of the Magdalene fiord moraines of the older generation on a terrace of only 5 m altitude (Fig. 1). Since these moraines must be younger than the terrace surfaces on which they have developed,

Fig. 1. A morainic ridge from the Holocene Glaciation Magdalenefiorden Stage, situated on Bockfiord in North Spitsbergen at 50 m above sea level and attaining a height of 28 m. Photo by Jan Szupryczyński, July 1963

it seems reasonable to conclude that a sharp cooling of the climate took place in the Holocene after the 5 m terrace had been built, and that this led to the development of ice covers, a transgression of valley glaciers, and a strong evolution of slope-névé glaciers.

Feyling-Hanssen and Olsson [7] have determined the age of a 5 · 8 m terrace in Central Spitsbergen as being 3958 ± 150 years; Soviet examinations gave the age of 2400 ± 120 years for a 5 · 5 m terrace on Barents Island. The moraines resting on the 5 · 0 m terrace are 2400 years old. For the same period G. Østrem (1961) mentions an extension of glaciation in Norway where terminal moraines have been dated from 2600 ± 100 years back. For Franz-Josef Land Grosvald [9] reports that marine terrace deposits on a 5 · 0 m terrace were piled up and associates this with what is called the Siedov Phase of glaciation. For this period A. Weidick [19] describes from SW Greenland features of a cooler period, known as the Nersaarsuaq Stage. A period of cooling and glacier transgression, known as the Larstig Stage [17], occurred in the Alps at the same time.

In what he calls moraines of an older generation on Spitsbergen,

Fig. 2. An ice-morainic ridge in front of the snout of Gåsbreen in South Spitsbergen. Photo by Jan Szupryczyński, 1959

the author distinguishes forms built by two glaciations: the Würm and the Holocene. The source material collected leads him to assume the following sequence of glaciations for Spitsbergen:

I. The Pleistocene Würm Glaciation: erratics and moraines found on higher terraces down to 45 m above sea level. This he calls the Hornsund Stage.

II. The Holocene Glaciation:

a) The Magdalenefiorden Stage whose traces are older generation moraines (Fig. 1) on terrace surfaces lying between 45 m and 5 m above sea level. This stage occurred after the 5 m terrace had been formed at about 500 B.C. and probably lasted to 1000 A.D.

b) The contemporaneous stage. Its transgression probably began during the 13th century and reached its peak in the middle of 19th century. This stage is marked by the ridges of terminal and lateral moraines and by the range of other glacial and glacifluvial forms (Fig. 2).

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III. BIOGEOGRAPHY

STRUCTURES OF BIOGEOGRAPHICAL COMPLEXES, WITH PALEARCTIC PAPILIONOIDEA AS AN EXAMPLE

ANDRZEJ SAMUEL KOSTROWICKI

One of the fields of interest of biogeographers is provided by spatial complexes of live organisms, in other words, of "faunas" and "floras". Because of the huge abundance and diversity of living organisms, examinations of the whole of the fauna and flora can be made only over very small areas. Any biogeographical research covering larger areas is therefore usually based on some single selected group of animals or plants. But while this kind of limitation of the source material is unavoidable, the investigation of only one feature of this material, usually its systematic arrangements, is by no means a condition sine qua non.

On the assumption that the basic element involved in the structure of any fauna or flora in the species (or, to be exact, the population of the species), the systematic position of this species is manifestly only one of its features. Other features, no less important for the given species, have usually been neglected completely in biogeographical studies, or else examined independently, without reference to other features. In most cases this has been due to the lack of a satisfactory amount of source data. However sufficient factual material is now available for at least some systematic groups of animals (such as vertebrates, or some orders of insects) and plants (such as vascular plants). So for such cases at least an attempt can be made at a more comprehensive approach.

Since from the biogeographical point of view a fauna is an assemblage of a strictly defined taxon (family, order etc.) collectively occupying a common sector of the biosphere, its structure obviously embraces the individual features of the different species. The greater the number of features taken into consideration, the fuller is bound to be the image of the given fauna, and the wider will be the possibilities of interpreting these features.

The present paper presents some of the results obtained from studies of faunas. The author's aim was to discover the structure of these faunas and their variation with space and time. As an example he chose the suprafamily of Papilionoidea (Lepidoptera), primarily because this group of animals has been thoroughly explored. No less important is the fact that this group is sufficiently numerous for statistic methods to be applied.

Altogether 1368 species belonging to this family have been reported from the Palearctic. Their distribution over the investigated area is irregular; they occur in greatest number, as many as 464 species, on the eastern Tibetan slopes, while the least — only 6 — are found in Iceland and Greenland.

With a study of degrees of relationship as basis, 66 faunas have been distinguished in the Palearctic, more or less homogeneous in their systematic arrangement. The boundaries of these faunas tally approximately with the boundaries of geobotanical (not phytogeographical) regions. Islands are an exception. Although geobotanically they belong to continental regions, they have faunas of their own. Each of the selected 66 faunas has been studied separately, and the following individual features of the species belonging to a given category were taken into consideration:

a) systematic membership,

b) relation of the species to the character (biomorph) of its food plants (whether they live exclusively on trees, shrubs, herbs, or on all these forms),

c) relation of the species to food plants as systematic units. In this instance the following categories have been distinguished: monophags — species whose food plants belong to one genus; oligophags — species living off plants of one family, and polyphags — feeding on plants of different families and orders,

d) association with a definite geographical element,

e) association with a definite historical element (the probable period in which the species settled in a given area).

A number of further features were taken into account, such as the relation of the population of the species to normal present-day natural conditions in a given region (zonality and intrazonality), the frequency of occurrence, the preference for certain plant formations, etc. Each of these individual features, considered separately for individual faunas and the Palearctic as a whole, supplied ample material for comparative studies, especially for studies of regionalization.

As a result of his analyses of the systematic composition of the investigated family as a whole, the author drew the following conclusions:

a. The Papilionoidea as a whole are a tropical group. Further north, they become less numerous and more homogeneous.

b. A feature of this family is its great systematic concentration. 6 · 5% of the palearctic genera comprise more than 47% of all species of this family which occur in the area examined.

c. Narrow-range species, indigenous to individual geobotanical regions, gather in those areas where the Pleistocene glaciations were least effective, especially mountainous areas. The one exception are the Alps, which are particularly rich in neoendemites.

d. The share of species from individual families found in the local faunas investigated, shows a distinct geographical regularity. In faunas met with in the Arctic and in the mountains of the temperate zone, species of the Satiridae family take first place, while in the Boreal zone and in the Far East the Nymphalidae family predominates, and in the temperate and meridional zones the Lycaenidae family.

From studies of edaphic conditions the author concludes that:

a. No direct correlation exists between the predilection for a definite biomorph of food plants, and the type of phagism shown (monophagism, oligophagism, polyphagism).

b. Both monophagism and oligophagism are statistically typical of species found over small or medium-size areas, whereas polyphagism is typical of species living throughout large, sometimes transcontinental, areas.

c. A close relationship exists between the age and character of plant formations, and the predominanat phagism type of the Papilionoidea species which populate these plant areas. In historically young forest formations polyphags predominate, in the old Tertiary forests monophags, and in forestless formations, whether young or old, oligophags are the most numerous.

d. Historically, polyphagism is younger than either oligophagism or monophagism among the palearctic Papilionoidea. The distribution of the polyphags shows that they originated from monophags within the boundaries of Tertiary floras of the Far East; it was only in the Pleistocene that they covered the whole of Eurasia.

As basis for an areographic analysis the author chose a classification of the species by size, form, and situation of their areas. He considered it important to create a system in which the individual areographic units (the zoogeographical elements, or their groups) would characterize not only the geographical situation of the areas, but also the ecological character of the species connected with these units.

Detailed studies revealed that the variety of the areas increases in southward direction. In the Arctic and the Boreal zones barely 6 ecologo-chorological types of ranges were determined, while in the temperate zone there were 14, and in the meridional zone 16. Whereas, in the Arctic, species covering wide transcontinental areas constitute 82·7% of the whole of the Papilionoidea fauna, in the taiga zone there are 55·2%, in the moderate zone 22·3%, and in the meridional zone only 2·5%.

A distinct discrepancy was also observed between zonal variations of vegetation cover and analogous differences in the fauna encountered. The faunal zone of the Arctic is limited to the North Atlantic islands, while in the tundra Boreal species predominate, and in the taiga, species of the temperate zone. To a large extent this state of affairs has been brought about by human activity, which facilitated the penetration of temperate zone species into both the Boreal and the meridional zone. Faunal analyses make it easy to reconstruct the boundaries of different agricultural systems, of the past as well as the present.

Studies of the age of contemporaneous faunas have shown that no distinct interdependence exists in the various areas between the history of the fauna and that of the flora. The Papilionoidea faunas are much younger; among the Tertiary vegetation Papilionoidea species which arrived in the Pleistocene predominate, and among the Pleistocene fauna those from the Holocene. An exception is formed only by the faunas of some islands (Kyushu, Shikoku, the Canary Islands, Madeira and the Azores) where the faunas are of the same age as the floras.

The comparison of different faunas with regard to the significance of all their determined structural features simultaneously is no easy matter, especially when these features are not correlated or when their interrelation is not readily apparent. The method called the "morphographical star" is probably the most suitable for a comprehensive picture of numerous features of a given fauna. Comparing the structures of different faunas by this method one is able to determine at sight not only their qualitative but also their quantitative differences.

Figs. 1 to 4 give a picture of the structures of a number of local Papilionoidea faunas, in a sense their morphographical models. On each of the rays the per cent value of a given feature has been marked. Connecting these points gives the morphographical star, which defines the character of the fauna in question.

Figs. 1 and 2 show the morphographical images of the structures of those Papilionoidea faunas which lie roughly on the same meridian across the central part of the Palearctic. Fig. 1 illustrates the structure of the fauna occuring in the tundras of the Ob and Yenisey estuaries and the taiga of Central Siberia. Fig. 2 shows the nature of the faunas

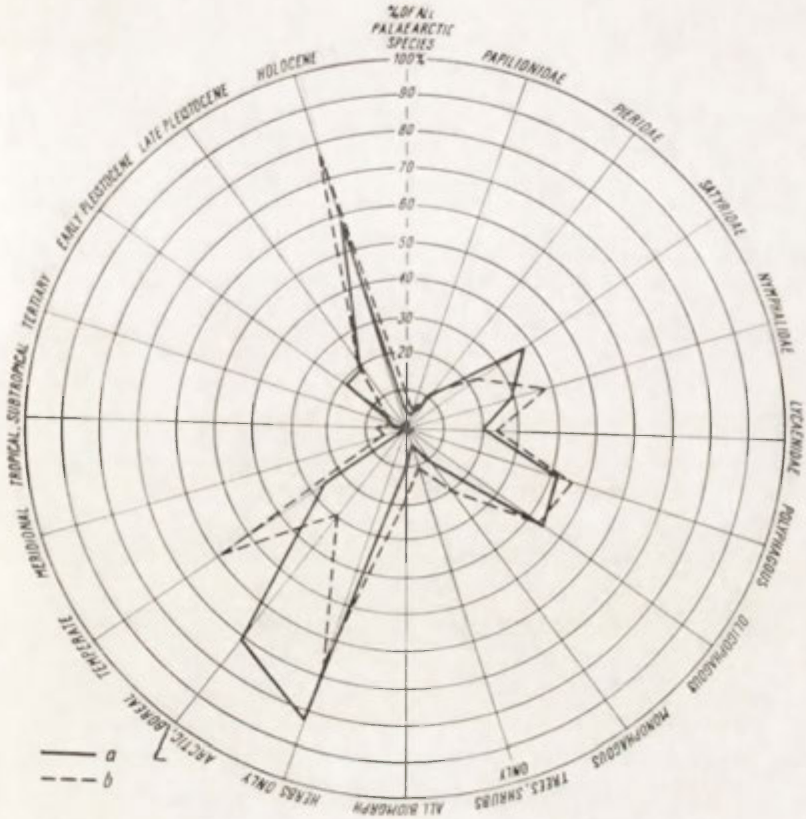

Fig. 1. Morphographical image of two Papilionoidea faunas from the central part of the Palearctic

a — fauna occurring in the tundra of the Ob and Yenisey estuaries; b — fauna occurring in the taiga of the Central Siberia

of the temperate-steppe zone of northern Kazakhstan and of the more meridional zone of Turkmenia.

Fig. 3 gives a morphographical picture of the structures of two faunas of the temperate zone remote from one another: in France (with the exception of the mediterranean coast) and in Central Mongolia, while Fig. 4 shows the structure of two faunas situated near each other, but of different age: the Tertiary Papilionoidea fauna of the Canary, Madeira and Azores Islands and the much younger Pleistocene fauna of the Maghreb.

It can be seen immediately that considerable differences exist between the structures of faunas of various climato — vegetal zones (Figs. 1 and 2) in spite of features in common (such as the predominance of

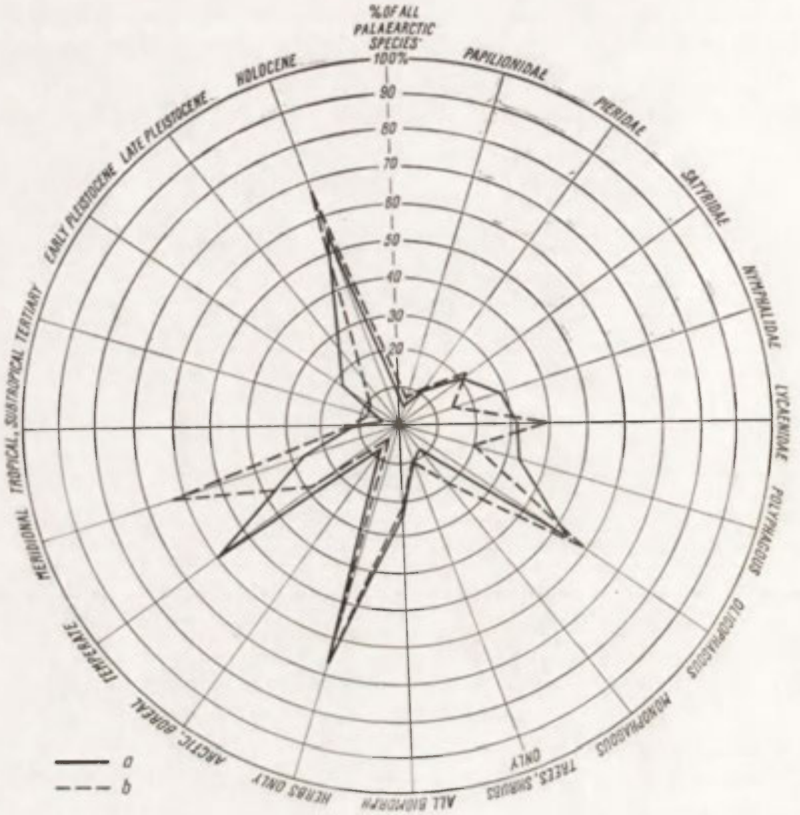

Fig. 2. Morphographical image of two Papilionoidea faunas from the central part of the Palearctic

a — fauna of the temperate zone (Northern Kazakhstan); b — fauna of the meridional zone (Turkmenia)

oligophages, or of species living exsclusively on herbal plants), which are characteristic of all local Papilionoidea in the Palearctic.

On the other hand, within a given zone the structure of faunas usually resemble each other. The morphographical pictures of the faunas found in the Alps, on the Black Sea steppes, in France and in Mongolia (Fig. 3) are much alike, although it is mostly entirely different species that form these pictures. Greater divergences occur only in the structure of the age of settling — which is quite understandable, since the history of each of the regions has run its own course.

The history of a fauna and its age is also an important structure-forming factor. This may be seen from Fig. 4 which illustrates the structures of two meridional faunas, interrelated but of different age.

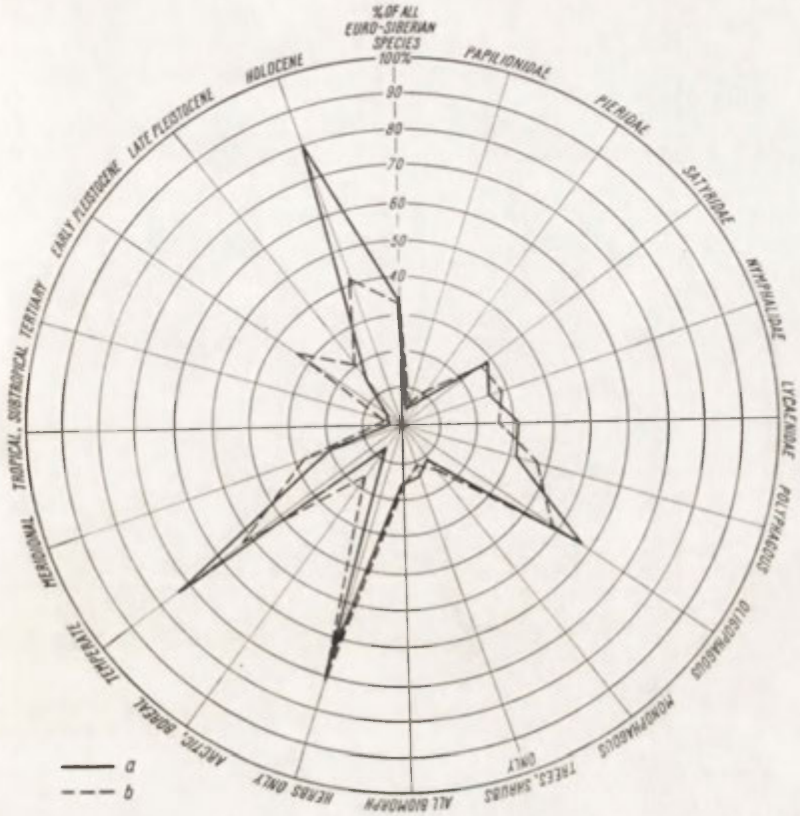

Fig. 3. Morphographical image of two Papilionoidea faunas from the temperate zone
a — fauna of France; b — fauna of the Central Mongolia

Apart from the features mentioned, there is no similarity between the two faunas, although they are fairly closely related in their systematic classification. A resemblance of the same kind exists, for instance, between the ancient desert fauna of Kashgaria and the much younger fauna of the Aralo-Caspian region, or between the Tertiary fauna of the Japanese Islands and the Pleistocene fauna of North China.

A comparative analysis of the structures of all 66 local faunas revealed a number of surprising regularities.

In general it might be asserted, that the frequency of the occurrence of a given feature in an assemblage depends merely on the size of this assemblage. The richer the fauna, the more species of it show a given feature. In other words: irrespective of the number of species occurring in the individual faunas, the proportion of the majority of features is

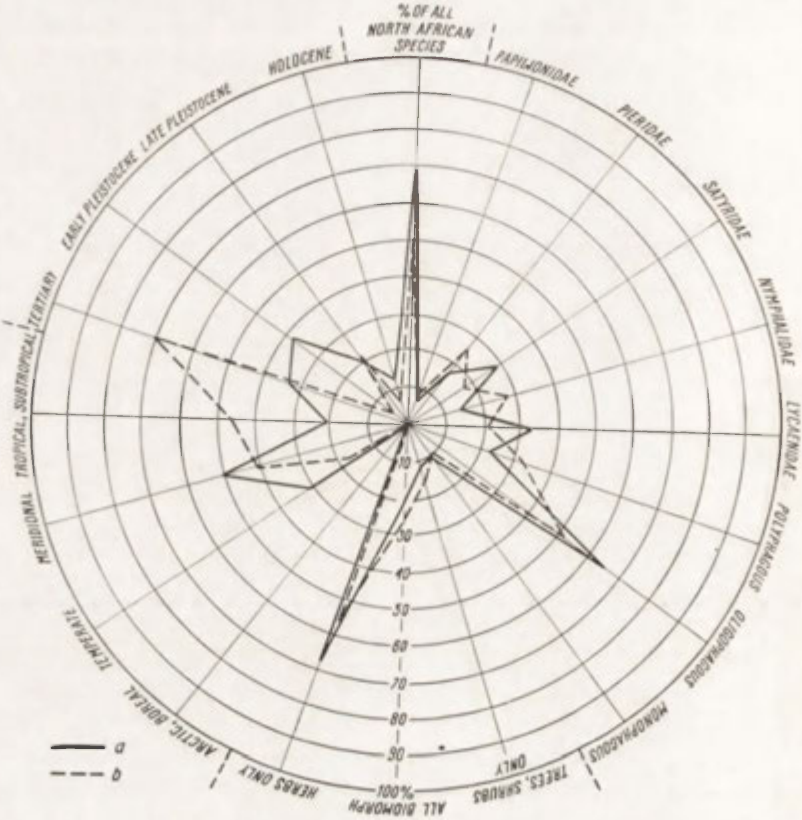

Fig. 4. Morphographical image of two meridional faunas
a — fauna of Maghreb; b — fauna of Canary Islands and the Azores

nearly constant over practically the whole area of the Palearctic. This applies mainly to ecological features and the system of classification. These interrelations are shown in Figs. 5 and 6.

The first of these two charts shows the ratio of the number of species living exclusively on trees and shrubs to the number of species of trees and shrubs growing within the boundaries of local faunas on the territory of the Soviet Union. It would seem that a direct corelation exists between these elements. However, irrespective of the fact that within the boundaries of a given fauna 80 or 500 species of trees or shrubs may be growing, the number of Papilionoidea species associated with these types of plants is everywhere almost the same. Only the more dendrophil faunas of the Far East (marked by crosses in both charts) are anomalous. Fig. 6 shows the ratio of these species to the total abundance of faunas. In this instance a direct relation may be

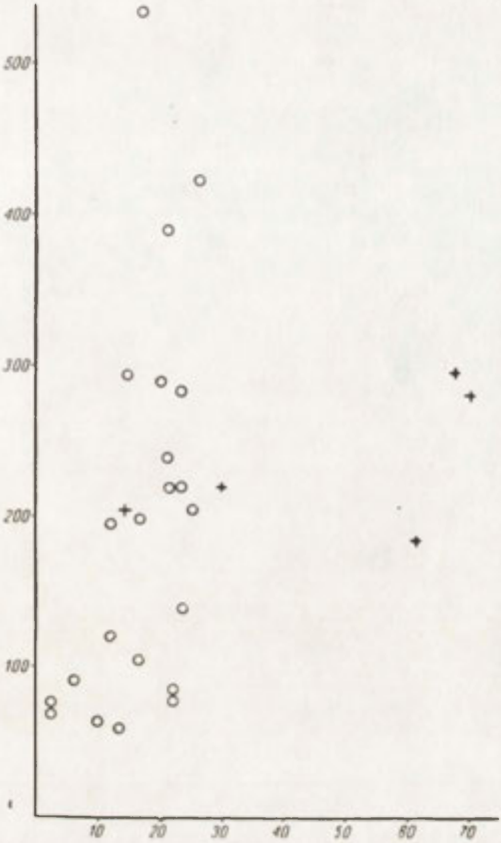

Fig. 5. Relation between the number of trees and shrubs species and the number of Papilionoidea species living exclusively on trees and shrubs in different faunas of the USSR. Vertical line shows the number of trees and shrubs species; horizontal line shows the number of Papilionoidea species living exclusively on trees and shrubs

+ — faunas of the Eastern Palearctic Province

observed between the number of dendrophagous species and the total number of species in the faunas. Even so, as in Fig. 5, the Far East faunas are represented by a separate curve.

A dependence of this kind can be observed for many features that have been analysed (such as the proportion of a definite type of phagism, the number of representatives from individual faunas, etc.).

On the basis of the facts presented above, obtained from the investigation of an enormous amount of source material, it may be maintained that a fauna is by no means an accidental collection of species, but a complicated spatial entity. It is a structural system, open, stable

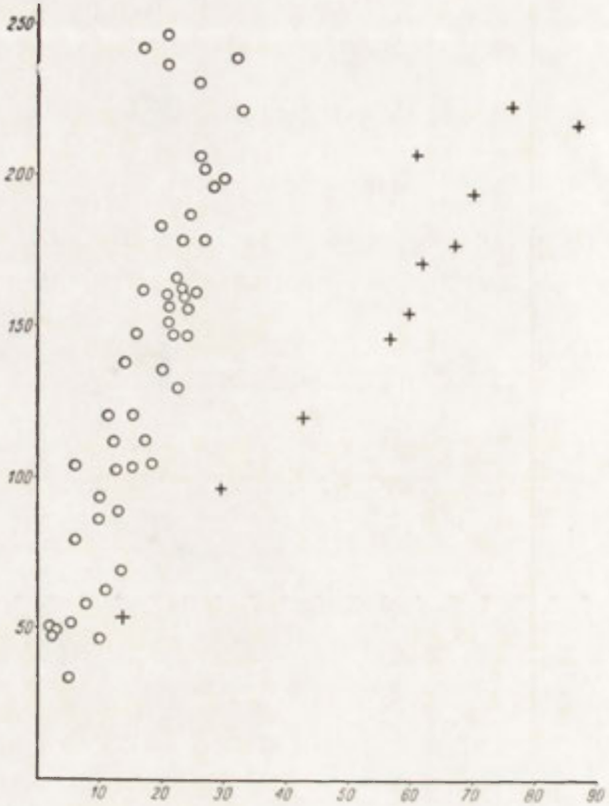

Fig. 6. Relation between the number of Papilionoidea species on faunas and the number of species living exclusively on trees and shrubs. Vertical line shows the number of Papilionoidea species on fauna; horizontal line shows the number of Papilionoidea species living exclusively on trees and shrubs

+ — faunas of the Eastern Palearctic Province

and harmonious. In the classification of systems it therefore occupies a similar stage to that of biocenosis, but in a different rank because biocenosis, although likewise a harmonious structural system, is rather confined and labile.

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IV. COMPLEX PHYSICAL GEOGRAPHY

THE PHYSICO-GEOGRAPHICAL REGIONALIZATION OF EUROPEAN COUNTRIES

JERZY KONDRACKI

Problems of physico-geographical regionalization were presented during the XX International Geographical Congress in London in the Section of Regional Geography. They were treated in a different way in the final report of the Commission of Classification of Geographical Books and Maps; and again at the cartographical exposition, on sheets of the Soviet-edited "Physico-Geographical Atlas of the World". The constrast of the different concepts at the London Congress led to a debate as a consequence of which symposia on physico-geographical regionalization were held in the German Democratic Republic (1965), in Poland (1966) and in Czechoslovakia (1967), where representatives of other countries also took part.

Generally speaking there is agreement that regional differentiation of the Earth's surface exists objectively, and that physico-geographical regional units are of a complex nature. In spite of this, the regional divisions so far adopted in European countries are not always suitable for combination into a whole and integration into general continental systems of division. The reason for this is that taxonomical systems and methods of procedure differ under the influence of subjective agencies which can be traced to differences in the evolution of geographical science in the various countries. The numerous symposia held in recent years have to some extent led to a convergence of opinions amongst geographers of the Soviet Union, Poland, both German states, Czechoslovakia and Hungary, while similar tendencies may also be observed among Roumanian and Bulgarian geographers.

It is remarkable that a complex division of the Earth's surface into spatial units of different rank is being introduced more and more often into national and regional atlases. This is done either with typological maps, i.e. maps showing types of the natural landscape, or as purely regionalizing maps where the physico-geographical space is subdivided into units of different rank (with emphasis given to the delimitation of such units). Sometimes both these conceptions are combined so that the landscape pattern is indicated within the boundaries of individual regional units. One of the first methodical attempts of this kind worth mentioning was made by J. G. Granö, first published in 1928 in the third edition of the "Atlas of Finland" and later, modified by L. Aario, in the fourth edition of 1960.

The topic has been introduced into a number of Soviet atlases in addition to the "Physico-Geographical Atlas of the World" (1964), which subdivides all continents into landscape zones and into larger physico-geographical areas and provinces. Thus maps of physico-geographical divisions form parts of the regional atlases of Armenia (1961), the Ukraine (1962), Azerbeidzhan (1963), Georgia (1964), the Kustanay district (1963), and other areas.

Maps of physico-geographical regionalization have been included in regional planning atlases published in Austria and Germany, in the national atlas of Czechoslovakia (1967), and in the national atlas of Poland (in press); such maps were also attached to a geographical monograph on Roumania (1960). A map with divisions showing the whole of Germany, prepared to a scale of 1 : 1 000 000, has been published by the Bundesanstalt für Landeskunde at Bad Godesberg. This institution has also published a series of maps of the natural spatial division of Germany to a scale of 1 : 200 000 with descriptive data, in the form of a 9-volume publication: "Handbuch der naturräumlichen Gliederung Deutschlands" (1953—1962). Outside Europe, maps showing physico-geographical divisions have been included in the Atlas of Israel (1956) and the Atlas of Canada (1967). So far no maps of this type exist in the national atlases of France, Italy, the Bielorussian Republic, and others.

The attention paid to problems of the classification and typology of natural geographical complexes is steadily increasing and the relevant literature is fairly ample. This follows not only from the necessity of expanding the theory of physico-geographical space, but also from the significance of this kind of study for spatial and urban planning, for the economic requirements of agriculture and forestry, and for water economy. However, these problems assume different aspects depending on the size of the territory under consideration. This was pointed out by E. Neef [4, 5] amongst others. He distinguishes three different "dimensions" in his spatial physico-geographical classification: topological, chorological, and geospherical. The topological range refers solely, to basic, homogeneous units which are called physiotopes or ecotopes by Neef and landscape facies by Soviet writers. These units are investigated quantitatively by studying the processes to which they are exposed; by combining them into larger units basic chorological (regional) units are formed which E. Neef calls microchors or ecochors. A new significance is given to regional units by a knowledge of their structure and their ecological sense which cannot be gained from the traditional though much quicker method whereby the surface of the Earth is subdivided into successively smaller units. The method of division ("Gliederung" in German) uses the normal regional divisions supplied by various natural-geographical disciplines, in which stress is laid on what is called index agencies for individual areas. These divisions take into account the differenciation caused by existing geographical zonal patterns as well as by azonal features whose origin is mainly based on endogenic processes.

The Symposium held in 1965 at Leipzig provided an opportunity to discuss the detailed methods of research applied by German geographers to topological problems as well as means of combining basic homogenic complexes into units of a chorological domain. A Symposium held a year later in Poland included in its agenda demonstrations of detailed field studies, and the study and classification of regional units of different rank with their boudaries. Alongside the Polish geographers, relatively large and representative groups of German and Soviet geographers participated in this Symposium. Representatives from Czechoslovakia, Hungary and Finland (altogether 24 foreign guests) also took part. The discussions, some of which were held in the field, led to a full agreement as to the methods of research and taxonomic systems to be applied. This was reflected in the conclusions arrived at in the resumé. The feasibility of using the decimal system in defining regional units of different orders was also discussed in connection with E. Meynen's [6] scheme, to which some corrections were suggested.

The map in Fig. 1 presents the general framework for a physico-geographical division of Europe in a decimal classification, in which E. Meynen's scheme has been slightly modified. In its corrected pattern this map follows the paper which the present author read at the London Congress on the taxonomy of natural units in regional geography [1], and a later polemic paper in Polish on a physico-geographical division of Europe in decimal classification [2]. In accordance with the latest instructions issued by the "Fédération Internationale de Documentation", the figure 0 (zero) has been omitted in this marking.

Appart from the numerical sign for the whole of Europe (in the decimal classification of physico-geographical units of the Earth), a single-figure marking has been applied not to the four great areas which the author had suggested in 1964, but to 9 sub-areas, corresponding to what is called "strana" (land) in the taxonomic system of the Soviet Union and has been introduced in their "Physico-Geographical Atlas of the World". Two-figure markings apply to landscape zones or larger provinces (mega-

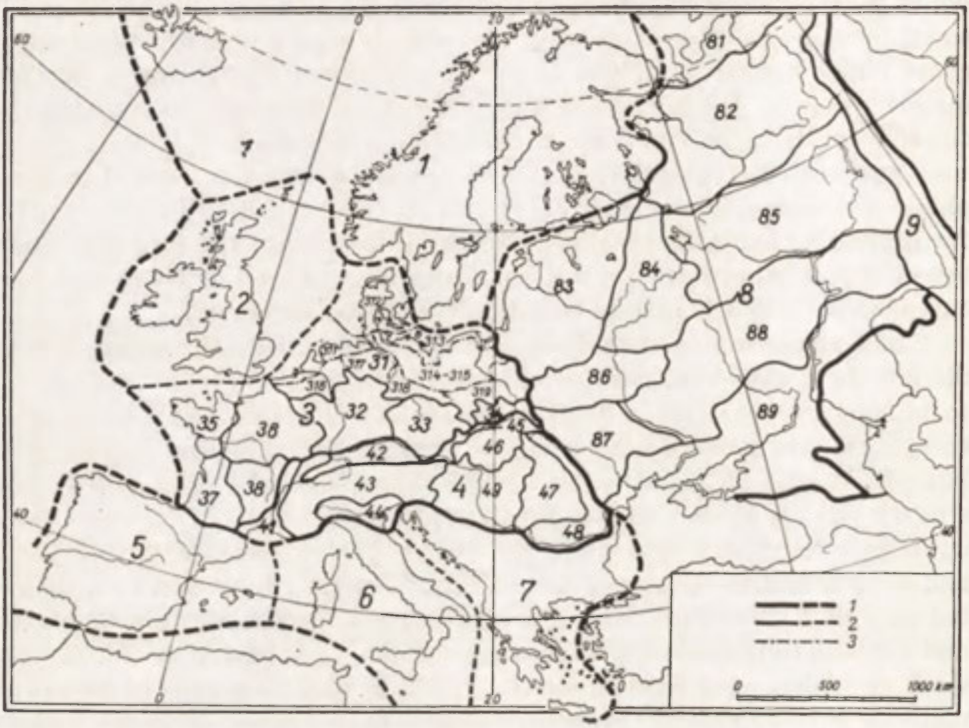

Fig. 1. Regional division of Europe in a decimal classification system
1 — boundaries of physico-geographical areas, 2 — boundaries of sub-areas, 3 — boundaries of zones and intrazonal provinces. For explanation of regional markings see below

chors), three-figure marking to sub-provinces, and so on. On the map (Fig. 1) two-figure markings are shown only for the central and eastern part of Europe, by way of example.

Thus the map carries markings for the following regional units:

Area of Northern Europe

1. Fennoscandia and Islands of the North Atlantic (Iceland, Faroe Islands, Jan Maynen Island.

Area of Western Europe

2. British Isles
3. Extra-Alpine Western Europe
    31. Central European Plain
    32. Middle-German Mountains
    33. Bohemian Massif
    34. Lesser Poland Plateau

    35. Armorican Massif
    36. Paris Basin
    37. Aquitanian Basin
    38. French Central Massif
  4. Alpine-Carpathian Lands
    41. Rhodan Basin
    42. Sub-Alpine Plateau
    43. Alps and Jura Mountains
    44. Po Basin
    45. Western and Northern Sub-Carpathia
    46. Western Carpathians
    47. Southeastern Carpathians
    48. Southern and Eastern Sub-Carpathia
    49. Pannonian Basin

Area of Southern Europe

  5. Iberian Peninsula and Balearic Islands
  6. Apennine Peninsula and Tyrrhenian Islands
  7. Balkan Peninsula

Area of Eastern Europe

  8. Eastern European Plain (with Crimea)
    81. North Russian Tundra Plain
    82. North Russian Taiga Plain
    83. Eastern Baltic Plain
    84. Central Russian Plain
    85. Eastern Russian Plain
    86. Polesie Plain
    87. Volhynian-Podolian Plateaus
    88. Dniepr—Don—Volga Forest-Steppe Plain
    89. Caspian-Black Sea Steppe and Semidesert Plain
  9. Urals

A detailed division of Polish lands was made within the framework of the units set out above. This division contains the provinces (or parts of them) with the numbers: 31, 33, 34, 35, 45, 46, 47, 83, 86, 87; in the Poland of today there more are than 300 units denoted by five-figure signs (mesoregions).

At the 1966 Symposium it was ascertained that the main provinces of Czechoslovakia (Nos. 34, 45, 46, 49) and of Hungary (Nos. 46 and 49) can easily be marked in an identical way. However, some controversy arose regarding the proposals submitted by E. Meynen who — according to his most recent suggestion submitted in a letter — denoted the Alps by "4", and assigned "5" to what he calls Southeastern Central Europe, in which he includes not only the Carphatian countries but also a considerable part of the Balkan Peninsula (without Greece and Dalmatia). He allotted "6" to all the Mediterranean countries. Further differences with regard to E. Meynen's proposals concern the division and the marking of Extra-Alpine Western Europe which E. Meynen divided into only three large provinces (Great Britain, Atlantic France, and Northern Central Europe), where he grouped plains and midland mountains together, while the present author distinguishes 8 provinces, rejecting the German concept of a "Central Europe".

Soviet geographers, who have their own well prepared taxonomic system and their own signs, were not particularly intersted in the decimal classification. In the Symposium debate they admitted, that the provinces distinguished by them have a somewhat different meaning and are units of a smaller size, so that there are as many as 62 units in their Eastern European Plain, combined into 9 landscape zones. Indeed, the two-figure numbers in the decimal system which the author suggests for the Eastern European Plain refer rather to zones, as to provinces, (allowing for certain deviations). All the same, while it must be admitted that the numerical markings for Western and Eastern Europe are to some extent inadequate, the decimal classification of the regional units is a convenient and useful system, suitable for application in an elastic manner.

In this brief survey the author has presented the tendencies in evolution of regional physical geography in a number of European countries. These tendencies show the theoretical and practical necessity for a complex apprehension of the properties of physico-geographical space. Topological studies are particularly important for this, but a more precise definition and coordination under international auspices of the methods to be applied in dividing geographical space into regional units is also indispensable. Most probably a methodological approach will soon be made to the spatial units which E. Neef calls microchors while the present author prefers the term microregion. These units are intermediate between the topological domain in which the basic types of geocomplexes and their quantitative features are examined, and the chorological (regional) domain in which the structure of complex units is studied. It seems the International Geographical Union should pay attention to problems of this character very soon, as the author suggested at the 20th International Geographical Congress in London.

In conclusion it should again be stressed that typology and physico-geographical regionalization, especially where basic units are concerned, are apt to facilitate the economic evaluation of regions and the planned exploitation of local resources. They also help to determine the way in which natural conditions should be changed, and therefore form link with applied physical geography and a base for cooperation with economic geographers and planners.

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MATHEMATICAL METHOD OF REGIONALIZATION AND ITS APPLICATION TO POLAND'S TERRITORY

LESZEK PERNAROWSKI

1. Regionalization signifies the process of dividing geographical space into certain spatial units which, when they intersect a topographical surface, form territorial units denoted as regional. The term "geographical space" signifies a zone situated on both sides of the earth's topographical surface in which phenomena occur or have occurred which influence man's active or passive activities either directly or indirectly. Any selected feature, element or part of geographical space which is the object of investigation by a geographical discipline, or else geographical space as a whole can be the subject of regionalization. This leads to the following conclusions: (1) the problem of regionalization occurs in all geographical disciplines, (2) the complexity of this problem depends upon the complexity of the subject of regionalization.

2. The survey of current methods of regionalization permits us to classify them into two groups, qualitative [4, 18, 5, 25, 6, 8, 19] and mathematical [3, 20]. Qualitative methods have been applied to cases with predominantly qualitative cartographical material, mathematical — to cases with predominantly rational cartographical material. The qualitative and rational methods which have been applied up to now are, however, imperfect as they are characterized by subjectivity in 1) the selection of features, 2) the choice of methods, 3) the determination of the significance of features when qualitative methods are applied, or 4) the determination of comparable measures when mathematical methods are applied, 5) the delineation of boundaries and determination of their rank. As a result, several, often basically differing regional divisions of one type are obtained for one and the same territory [10, 18, 25, 26].

3. In every type of regionalization the appropriate cartographical material provides the starting point. Such material includes maps not only with rational but also with qualitative contents. The rational content presents the surface distribution of the value of a feature: (1) in

a continuous form, by using isolines = rational mape of type "a", (2) in a non-continuous form, by using limited surfaces with equal values of a feature = rational maps of type "b". When qualitative methods of regionalization are applied, rational maps are turned into qualitative ones, and this is the source of many mistakes in their interpretation. When mathematical methods are applied, qualitative maps must be turned into rational ones and qualities must be expressed by values of a properly selected rational feature. The selection of the feature must fulfil the following conditions: (1) the feature must be appropriate to the qualities of one geographical discipline only, (2) it must exist for all qualities, (3) the distribution of the values of this feature must be even, i.e. no large group of qualities with identical or very close values can exist, (4) the oscillation of the selected rational feature existing within every quality must be relatively small. Only then can this rational feature give reliable information regarding the quality. A qualitative map can always be turned into a rational map of type "b". The substitution of qualities for values of the rational feature does not change the desing of the map.

4. A uniform set of rational maps of types "a" and "b" are not comparable. The values of the separate features "u_n" are represented by various symbols and are therefore not comparable. If, however, the marginal values of the features $u_{n\max}$ and $u_{n\min}$ on earth are known, they can be expressed by means of the following parametre:

$$t_n = 100 \frac{u_n - u_{n\min}}{u_{n\max} - u_{n\min}} \tag{1}$$

This new percentage measure, common to all rational features, makes them comparable over the whole area of the earth.

Rational maps can in turn be replaced by block diagrams or spatial models if the percentages of parametres are expressed by means of a uniform scale of height. Bearing in mind that hypsometry can also be expressed by means of parametres, and substituting symbols used in formula (1) $u_{n\max} = 8848$ m, $u_{n\min} = 0$ m and $u_n = z_n$ we obtain:

$$t_n = 100 \frac{z_n}{8848} \tag{2}$$

and therefore

$$z_n = 8848 \frac{t_n}{100} = 8848 \frac{u_n - u_{n\min}}{u_{n\max} - u_{n\min}} \tag{3}$$

On the basis of formula (3) we can express the intensity of each feature "u_n" with a second measure "z_n", in conventional metres. It is worth while noting that the introduction of value t_n or z_n in place of u_n

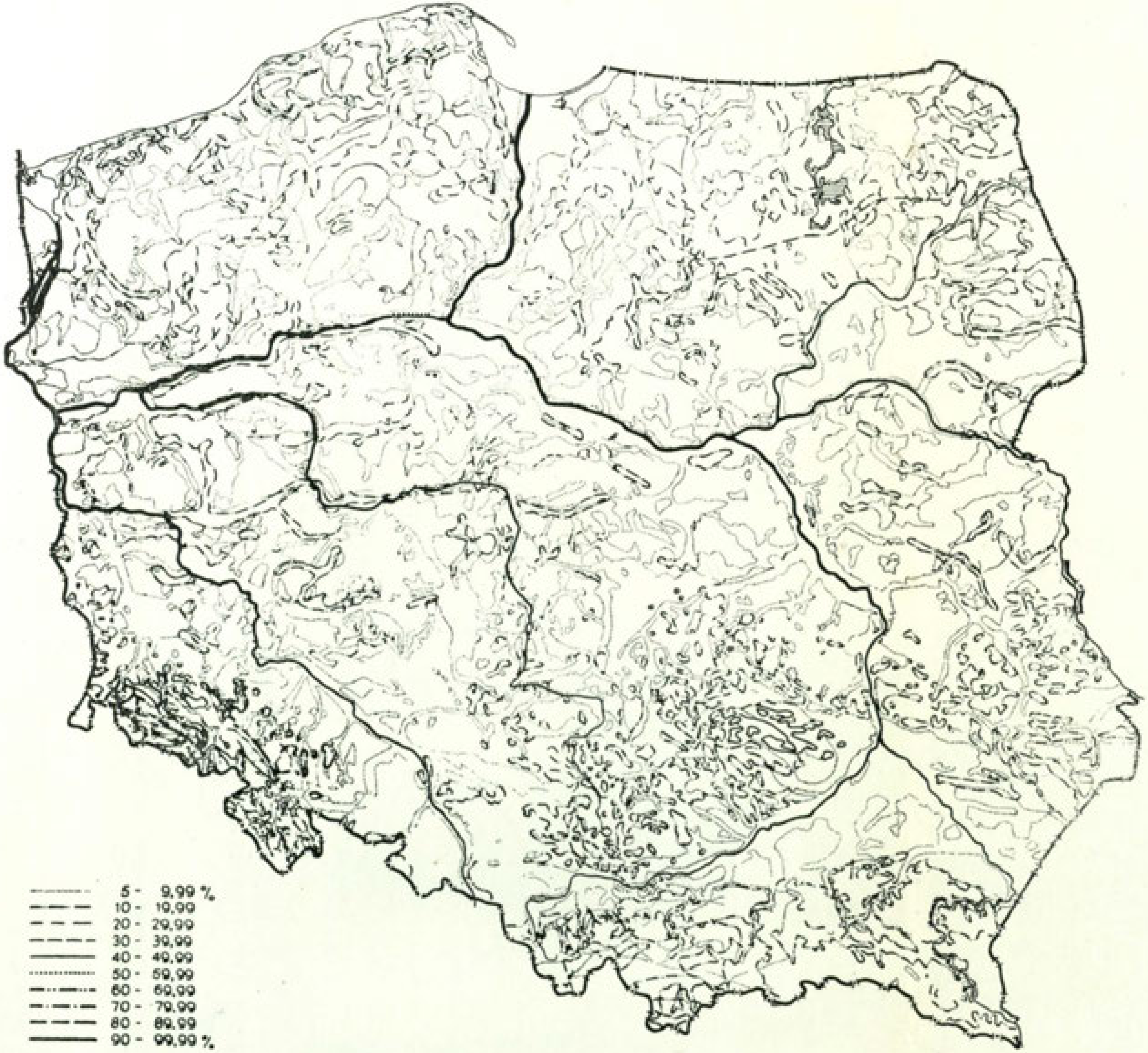

Fig. 1. Map of the values of boundaries and megigradients.

into the cartographical material does not necessitate any other change in the design of the maps apart from that of the description of the value of isolines and fields of area.

5. On maps with identical differences in the value of the nearest isolines certain zones can be differentiated with a denser grid of isolines. Transversal profiles drawn through such zones and their environment reveal that the points where the inclination of profiles attains its maximum, can be accepted as the boundary between their separate sectors. There is no difficulty in finding such a boundary on the map as it is characterized by the greatest varability of the value of the rational feature. It always runs between the two nearest isolines in the given territory, and is a set of points with the highest values of gradients of separate profiles. Consequently I have called it the line of megigradients, or in short a megigradient (from the Greek megitos = the greatest).

The value of a megigradient at every point equals that of a gradient at this point, expressed as a percentage:

$$s_m = 100\,\frac{\Delta z_n}{\Delta s} = 8848\,\frac{\Delta t_n}{\Delta s} = \frac{884800}{u_{n\max} - u_{n\min}} \cdot \frac{\Delta u_n}{\Delta s} \tag{4}$$

Boundaries between separate areas with various values of features are delineated on rational maps of type "b". On the basis of formula (4) we can conclude that the comparable value of this boundary with the value of megigradients equalling s_m can be found when we introduce $\Delta s = 8848$ metres. Hence:

$$\underset{\Delta s = 8848}{s_m} = \frac{100}{8848}\,\Delta z_n = \Delta t_n = \frac{100}{u_{n\max} - u_{n\min}}\,\Delta u_n \tag{5}$$

Thus a natural system of boundaries with determined values can be obtained on each rational map of both types a and b. In the case of simple regionalization [24], based upon one feature, it suffices to interpret the map of megigradients or the map of the values of the boundaries of this feature, and to isolate the sought units. In the case of complex regionalization [24] the contents of all maps showing the values of boundaries and of megigradients of rational features characterizing the object of regionalization, are transposed to one common map. Only this map will provide the material on the basis of which we can obtain a complex regional division. This method of interpretation will be described using the example of the physico-geographical regionalization of Poland.

6. For the territory of Poland I based my computation upon 83 features of the natural environment, of which 7 were qualitative [1, 10,

11, 13]. On the basis of the experimental physico-geographical regionalization of two Lower-Silesian poviats I established that when undertaking the regionalization of Poland on the basis of the principal scale of maps 1 : 2 000 000, megigradients and boundaries with values smaller than 5 per cent need not be taken into consideration. I analysed all cartographical material of separate features mathematically; the results are presented in Table 1.

TABLE 1. The results of mathematical analysis of features

Problems	Number of features	of which features for which		
		no t_n can be determined	$s_m < 5\%$ $\Delta t_n < 5\%$	$s_m \geqslant 5\%$ $\Delta t_n \geqslant 5\%$
1. Relief	1	—	—	1
2. Geology	1	—	—	1
3. Soil	1	—	—	1
4. Geomorphology	1	1	—	—
5. Hydrography	13	9	—	4
6. Climate	56	25	21	10
7. Phenology	6	—	6	—
8. Geobotany	3	2	1	—
9. Zoogeography	1	1	—	—
Total	83	38	28	17

Thus, after an objective analysis, 17 rational features emerged whose values of boundaries and megigradients showed that they could be potential boundaries of physico-geographical units in Poland. The list of these 17 features is as follows: hypsometry [1], isotherms of the year, January and July at their real level [27], the number of days with ground frost [14] and with frost [16] and the durability of the snow cover [15], the march of summer and its durability [1], the percentage of snow falls in general precipitation [2], the number of cloudy days in the whole year [23], fashionability of the rocks on the basis of a covert geological map [1], the percentage of humus in the soils on the basis of the soil map [11], beginning and end of ice phenomena in rivers and the duration of the ice-cover on rivers [7], and also the proportion of lakes in sq.km per 100 sq.km of the total area [12].

7. On the basis of maps of the values of boundaries and megigradients of the features listed above I made a map of the values of boundaries and megigradient $\geqslant$ 5 per cent of Poland's physico-geographical environment (Fig. 1).

The analysis of the picture of value lines obtained permits us to differentiate (1) areas with high-value boundaries, bound by high-value boundaries (the Sudeten, the Carpathians), (2) areas with high-value boundaries bound predominantly by low-value boundaries (uplands), (3) areas with predominantly low-value boundaries, divieded by sequences of higher-value bonudaries (lowlands). I have classified areas of groups 1 and 2 as provinces, following to a certain extent the physico-geographical regionalization made by J. Kondracki [10]. Out of the network of boundaries of areas grouped under point 3 I selected a boundary composed of long sectors with values of 20—30 per cent. Thus I differentiated two provinces in the third area: the Baltic province and that of the central Polisch lowlands. The Baltic province is divided into two sub-provinces: Pommerania and Mazuria by three 5—10 per cent boundaries along the left bank of the Vistula. Both provinces are distinctly divided into regions by lines with values of 10—20 per cent, or sometimes 20—30 per cent. A number of sub-regions can be differentiated within the regions mainly on the basis of the density and orientation of boundaries, and partly according to their values. The province of uplands can also be divided into two sub-provinces: the Lesser Poland Upland and the Lublin Upland. Only the first sub-province can be divided into two regions. The Sudeten and the Carpathian provinces can be divided only into regions, the Sudeten into three, the Carpathian into two. The physico-geographical regionalization of Poland is presented in Fig. 2.

8. A comparison of Fig. 1 with Fig. 2 leads to the following conclusions: (1) the regional units embrace territories with non-uniform interior structures but with almost the same degree of interior differentiation, (2) the rank of units is determined by the value of boundaries or by the value of their interior differentiation inclusive of their size, (3) the boundaries of differentiated units are always formed by fragments of actual boundaries of regions of simple features, constituting the basic elements of regionalization.

In spite of the formal assumptions of regionalization, the strong correlation of vegetation, which was not among the features directly taken into consideration in the process of regionalization, with the differentiated physico-geographical regional units points to the functional character of the method described.

9. The above-described method of regionalization is a general method and can be applied to any subject of regionalization. It guarantees that two persons who prepare a regionalization of the same type and of the same territory, on the basis of the same cartographical material, in principle will obtain identical results. When the regionalization of two different territories is undertaken, rational features overstepping the lo-

Fig. 2. Physico-geographical regionalization of Poland based upon the interpretation of the values of boundaries and megigradients $\geqslant$ 5 per cent of rationl features of Poland's geographical environment. Borders of:
1 — provinces, 2 — sub-provinces, 3 — regions, 4 — sub-regions

wer, previously determined value of boundaries and megigradients will differ. In spite of that the results of both regionalizations will be fully comparable.

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MAPS OF A NATURAL GEOGRAPHICAL ENVIRONMENT

Mieczysław Dorywalski

A topographical map is the cartographical image of a part of the Earth's surface, illustrating the land relief and its cover. While this conventional form of recording geographical facts contains a considerable amount of information, it omits a number of important elements and their relationships to one another that would indicate the overall character of the geographical environment. To understand this character and classify it, a number of additional special maps must be used, while the method most frequently applied for presenting the environment as a whole is to add a descriptive text.

A great number of special maps is now available which supply detailed information on regional features. To give a picture of physico-geographical features geomorphological, geological or hydrographical maps are mainly used, together with maps distinguishing soil types or climatic and geobotanical conditions. Such maps may be prepared in different versions: as analytical representations of selected elements, or as synthetic, static and dynamic maps recording or interpreting established facts. For grasping the reality of the geographical environment, these maps are rather elementary. Attempts have been made to combine them into comprehensive cartographical images which would show the natural geographical environment as the synthetically expressed object of geographical research; however, so far the results of such efforts have been unsatisfactory. Neither does the concept of using very small scale maps appear to be more successful; the reason is that on such maps areas have to be joined of necessity into extensive spatial units where generalization of the features of an environment goes so far as to give the areas produced the character of small-scale general maps. The maps compiled by Dokuchajev (1900), Herbertson (1905), Unstead (1916), Berg (1947—52) and a great number of other atlas-type productions must be assigned to this category. Recently, however, for all the abundance of special maps of a variety of types which have appeared to serve both science and practical work, the lack of synthesizing cartographical presentations of geographical environments on large and very large scales has become acute. This will be the topic of the brief reflexions which follow.

Any large-scale mapping of a geographical environment runs into serious difficulties, because a number of dissimilar elements must be combined in separate compact environmental categories. At present no clearly defined theoretical basis is available for this kind of procedure; in consequence no suitable methodology exists. Moreover, the technical means are sadly deficient for presenting cartographically such a wide variety of phenomena. While for preparing general maps the relatively scanty set of principal elements selected suffices up to a point, and therefore makes it possible to define the character of an environment by assigning it to some general category, detailed mapping should in addition indicate local differences.

In the modern sense of the term, a physico-geographical environment is a combination of mutually interrelated groups of features comprising: the relief of the land and its geological structure and lithology, soils, hydrographical conditions, climate, vegetation cover, and natural animal life. Because of the disparity of these elements and the different parts they play in this combination, they must each be evaluated separately and a selection must be made. For a limited area the prevailing climate can be determined in general outlines by its situation; when smaller surfaces are mapped, usually no differences occur worth recording. The climatic element should therefore be omitted on detailed maps, and if topoclimatic differences are in evidence they should be relegated to special maps. Incidentally, certain features of the climate can be identified on a map indirectly by examining the relief and the exposure of the land surface.

Frequently soil conditions of a region are to a large extent governed by its geographical situation, depending on climatic zone and altitude; in detail, however, soil types are contingent on the lithological character of the substratum. A detailed soil map will show the land surface as a fine checkerboard with appreciable local differences. Processes of aggradation and accumulation of the finest material and organic particles take place in the smallest soil depressions occurring amidst cultivated fields where humidity conditions are different, in contrast with adjoining elevated regions where the soil is gradually being leached out. Soil fertility is also dependent on human activity, which leads to far reaching changes in cultivation through the use of fertilizer and the selection of suitable crops.

The natural vegetation cover has suffered far-reaching transformations. From descriptions of ancient forests the extent to which their tree composition has changed can easily be deduced: beech, maple, oak and yew have been replaced by pine and birch and whether a forest is today dry or humid or rather a valley meadow covered by forest depends on land relief, lithology and local humidity. The surfaces of land under cultivation are covered by synanthropic crops and by rudimentary plant species; because they are scattered chaotically they cannot be considered index forms which would identify the natural ecological conditions of the environment.

The far-reaching anthropogenic activities which have transformed the natural geographical environment make it necessary to avoid all elements that are subject to change or are incidental, using as a basis for cartographical marking only the more stable elements which have been established as representative. The image thus created is to some extent generalized but when compiled on a large scale it illustrates very well the properties of the environment and the differences that occur spatially. In conformity with K. Raman the author considers the lithology of the substratum, hydrographical conditions, land relief and the relative position of individual sections of a region to be stable elements, suitable for objective cartographical presentation. With this in mind the author compiled a map of the Piotrków Upland, taking in some 1000 sq.km, to a scale of 1 : 25 000. This region is situated in the central part of Poland and shows a relief of glacial accumulation with distinct features of postglacial denudation. For this mapping the author used material derived from hydrographical and geomorphological surveys and from soil examinations.

Morphologically, the author distinguishes two categories of land surface: lower-lying concave forms like valleys, basins and depresions between higher ground, and convex forms alternating with them. The concave forms show features of aggradation, associated with a shallow underground water table. Such surfaces are periodically flooded during snowmelt time in spring or after periods of torrential summer rains; they have thermal inversion from time to time. For hydrographical conditions and soil fertility the author divides the areas into four categories: oligotrophic basin-like depressions without surface drainage; eutrophic areas situated close to streams in valleys with a high groundwater level (down to 1 m below the surface) and a vigorous meadow-pasture vegetation; peripheral transition zones with a lower groundwater level (down to about 2 m) and partly converted into tilled land; and peat bogs.

On the map the areas have been distinguished by a blue colour in four shades; they constitute the elements which occur most commonly in the landscape and divide up the Piotrków Upland. Land of this pat-

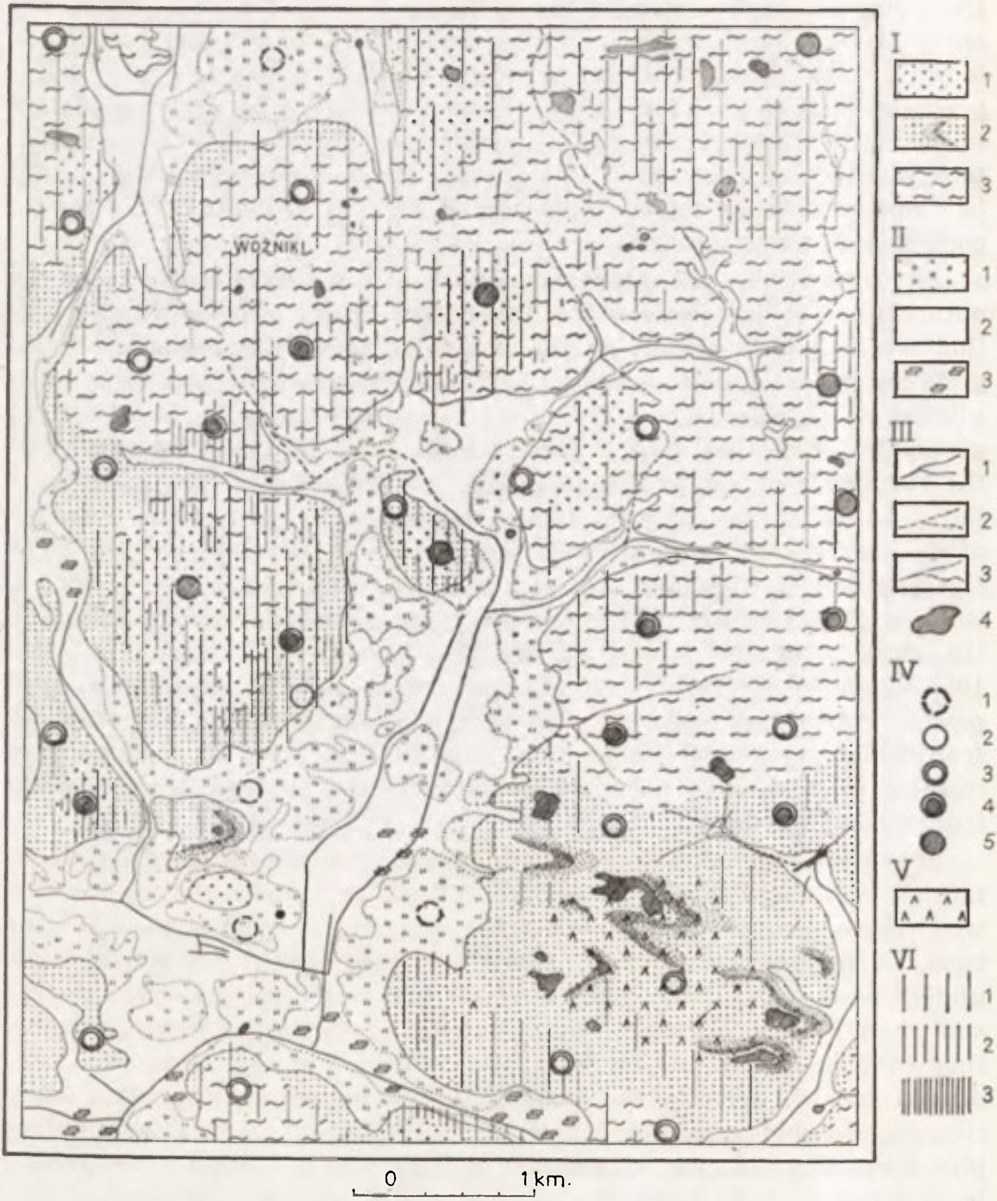

Fig. 1. Differentiation of the natural geographical environment

I. Upplands: 1 — gravels, 2 — sands and dunes, 3 — clays; II. Valley floors: 1 — with periodical water surplus, 2 — with permanent water surplus, 3 — peats; III. Surface waters: 1 — permanent streams, 2 — periodical streams, 3 — epizodic streams, 4 — water reservoirs; IV. Ground waters: 1 — from 0—1 m, 2 — 1—2 m, 3 — 2—5 m, 4 — 5—10 m, 5 — 10—15 m; V. Forests; VI. Inclinations: 1 — 1—3%, 2 — 3—8%, 3 — 8—15%

tern occupies large areas in the spring reaches of the various rivers, i.e. in the watershed between the Warta and Pilica Rivers. They are responsible for a variety of characteristic features in the landscape. Here one observes numerous minor basins, partly swampy, which by joining up with each other form erratic bands of depressions.

The various convex parts of the uplands form the second group of surfaces. They are covered by cultivated fields, pastures and patches of tree stands. These surfaces have been degraded more or less severely by a variety of denuding processes whose intensity depends mostly on slope inclination. Here the soil conditions are contingent on the type of substratum, its permeability, and on the depth of the highest underground water table. In view of technical difficulties in compiling cartographical images the number of lithological categories distinguished has been reduced to a minimum; thus only sands, loams, gravels, silts and clays are taken into account. Actually only the first three of these have been encountered in the field and they have been shown on the map by warm colours: yellow, orange and brown. Due to the high degree of variety and disturbance in the ground structures, the water table varies widely. The various depths are indicated within circles for surfaces which vary in slope and altitude; in this way a general picture of the underground water table is built up.

Differences in ground inclination, signifying the potential dynamic of denuding processes, are also recognizable in the cartographical picture compiled by the author. In an indirect way this indicates the use that can be made of particular surfaces. Inclinations of: up to 1‰, to 3‰, to 8‰, to 15‰, to 25‰ and more are indicated separately. For the sake of simplicity this element is shown by vertical hatching using lines of different thicknesses. The map shows the hydrographical network of surface waters and wooded land and contains a limited number of place names for orientation.

Prepared in this manner the map is a cartographical image of a given area, fairly detailed and easy to read. The two basic colour schemes clearly show the two prevailing categories of land surface: depressed areas in which the foremost element is a permanent or periodical surplus of water and diversified sections of dry elevated land in which the lithology of the substratum affects water circulation and soil type. Slopes, dunes, and wooded areas indicated on the map illustrate indirectly whether and how the ground surface can be put to use.

The map fails to give a full synthetic image of uniform landscape types but it emphasizes and links certain elements considered to be of primary importance. In this way the map supplies a variety of information which cannot be read from a topographical map nor from separate special maps. It is therefore a form of derivative map useful for theoretical purposes as well as for practical use. The wide difference observed in the groups of elements, the frequency with which these elements occur and the rhythm of their occurrence should greatly facilitate efforts to devise the proper physico-geographical regionalization of an area.

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LES MÉTHODES DE DIVISION DU PAYS EN MICRORÉGIONS POUR LES BESOINS DE L'ÉVALUATION DU MILIEU GÉOGRAPHIQUE

Tadeusz Bartkowski

On peut distinguer dans chaque évaluation du milieu géographique trois étapes:

1) l'étape d'analyse du milieu géographique — étape du discernement dans ce milieu de diverses „qualités" (parce que s'il n'existait pas diverses „qualités" il ne serait pas nécessaire d'évaluer le milieu géographique puisqu'il possédérait partout la même valeur!).

2) l'étape propre de l'évaluation, qui consiste à attribuer à chaque „qualité" certaine „valeur",

3) l'étape du bilan des „valeurs" du milieu géographique — étape de l'évaluation des ressources du milieu géographique sur la base des „qualités" enregistrées.

Pour pouvoir évaluer les „qualités" enregistrées dans le milieu géographique il faut trouver „l'unité fondamentale de mesure" une unité de la surface-soit „homogène" en ce qui concerne les „qualités", soit „hétérogène", mais au modèle „d'hétérogénéité" bien connu (pourcentage de la surface occupée par les diverses „qualités", participant an „modèle"!).

Cette „unité fondamentale de mesure" peut être une microrégion. Cette microrégion cependant ne doit être point une microrégion qui a été discernée sur la base de la méthode de division de „l'enveloppe géographique" („sphère géographique") qui est non différenciée, en des régions par la voie „d'en haut" (comp. J. Kondracki 1964). Le résultat final de cette division est toujours une microrégion, dont le contenu ne cesse point d'être non différencié. C'est une unité de surface de la terre toujours encore subjectivement et arbitrairement divisée (comp. la notion de „geomer" de H. Carol 1956).

La microrégion, qui doit être „l'unité fondamentale de mesure" doit être fixée sur la base de la méthode de „division d'en bas" (comp. J. Kondracki 1964) — de la méthode de „composition" ou de „fusion" en unités régionales plus grandes issues d'unités fondamentales. Ces unités fondamentales possèdent une superficie très petite elles sont considérées comme des unités en principe „homogènes" (comme des „cellules") et elles portent des noms divers: physiotopes, oecotopes, dalles (Fliese), cellules du paysage (Landschaftszelle) etc. A couse de leur homogénéité chaque région provenant de la fusion de ces „cellules" — surtout la microrégion — aura toujours un contenu bien défini, possédera toujours un „modèle" connu, qui pourra servir de base d'évaluation de ce contenu, de diverses „qualités" du milieu géographique.

Nous devons d'ailleurs, quand nous voulons les „évaluer", démembrer toujours en des unités homogènes chacune des régions, qui fût délimitée au moyen de la „méthode d'en haut". Par exemple, quand nous voulons évaluer un „plateau morainique" pour les besoins de l'agriculture, nous devons discerner la surface des „pièces" de diverses variétés de sols, d'utilisation du terrain (champs, prés, bois, étangs, etc.), le niveau changeant de la nappe phréatique etc. Il en résulte une „mosaïque" de diverses „qualités" discernées, dont la formule ou le „modèle" sont bien difficiles à établir. Il n'y a que la méthode de la „fusion" des régions qui nous permet d'éviter ces difficultés.

C'est cette voie qui a été choisie en Polcgne par A. Marsz (1967) pour élaborer la „méthode de voisinage" (de physiocoenoses) dans sa „division de l'ile de Wolin en régions physicogéographiques".

Bien que les avantages de cette méthode dans la régionalisation physico-géographique sont très grands, elle possède un désavantage fâcheux à savoir celui, d'exiger beaucoup de temps et de travail (de ce fait elle est très coûteuse!). Ces recherches doivent s'appuyer sur des „levées détaillés (puisqu'on y étudie des „cellules"!) du terrain accompagnées très souvent d'observations systématiques poursuivies pendant plusieurs années (p. ex. des observations météorologiques, des observations des oscillations de la nappe d'eau souterraine etc.). De cette manière, il ne faut pas compter terminer cette entreprise au cours de la vie d'une génération de géographes.

Cette constatation a conduit le Départament de Géographie Physique Appliquée de l'Institut Géographique de l'Université d'A. Mickiewicz à Poznan à élaborer une méthode simplifiée d'établissement de microrégions pour les besoins d'évaluation du milieu géographique. Cette méthode consiste à délimiter non pas des „cellules" mais des „ensembles de cellules" — de microrégions. Dans ces microrégions les diverses „cellules" se répètent d'une façon spécifique, ce qui constitue le critère de l'établissement du „modèle" de cette microrégion — du „modèle" de la mosaïque „ordonnée" des „cellules".

Le critère fondamental, et en principe unique, est ici la morphométrie ou, plus précisément, la mesure du dégré de la dissection du terrain.

C'est là un critère formal, mais c'est précisément pour cela même que nous obtenons un critère des plus objectifs. Il est très facilement vérifiable et pour cette raison également il est facile à appliquer dans le cas de cartes topographiques à grande échelle (1 : 25 000). Le relief du terrain comme la composante du milieu géographique, à côté de la géologie est en pratique, l'élément le moins changeant de ce milieu et se prête très bien pour la délimitation objective des microrégions. Toutes les autres composantes du milieu géographique, c'est-à-dire les eaux, les sols, la couverture végétale, la faune, le „topoclimat", l'utilisation du terrain, sont changeants. De toutes ces composantes c'est seulement l'utilisation du sol qui, bien qu'extrèmement instable, est cependant la plus facile à constater et à mesurer, à la base des aérophotos.

A cause de cette „facilité d'opération" le second critère, qui sert à la subdivision des microrégions, délimitées au moyen du critère de morphométrie, doit être considéré comme le critère important, d'autant plus que c'est le critère formel aussi et pour cela bien objectif.

Les microrégions formées ainsi ne sont point des microrégions complètes du milieu géographique mais elles sont des microrégions „approximatives" — des microrégions „naturelles". C'est bien dans celles-ci que toutes les composantes (les diverses „qualités" du milieu géographique) sont liées réciproquement — sont „entrelacées". De ce fait les limites des diverses „qualités" évaluées, se renferment dans les limites de ces microrégions. C'est la morphométrie ou le dégré de la dissection du terrain qui conditionne p.ex. la position de la première nappe d'eau souterraine et, par l'intermède de celle ci, la couverture végétale, tandis que par l'intermède de ce dernier facteur elle conditionne les sols et le topoclimat — naturellement en liaison avec le facteur d'utilisation du terrain. Ce dernier facteur illustre bien le rôle de „l'homme" — son rôle transformateur dans le milieu géographique, et représente aussi en quelque sorte les facteurs „instables" du milieu géographique, mentionnés auparavant.

Sur la base de ces deux critères on a poursuivi à l'Institut de Géographie à Poznań un certain nombre d'essais de division du terrain en microrégions de ce genre (comp. T. Bartkowski 1962, 1964), dont un exemple sera demontré ci dessous.

Le territoire en question — la lisière ouest et nord-ouest de la voïévodie de Poznań — d'une surface d'environ 9 000 km², a été divisé en 62 types de microrégions, formant en tout 390 unités distinctes de microrégions. La surface moyenne d'une microrégion est donc ici d'environ 20,3 km². Le „contenu" d'une telle microrégion est indiqué dans le tableau ci-dessous (tab. 1), où on a rassemblé la description de quelques microrégions typiques.

Les microrégions, délimitées de cette manière, ont été évaluées (d'après

TABLE 1. Division du terrain en microrégions

No	nom et génèse des formes du terrain	morphométrie: terrain:	utilisation du terrain		
			>50 %	>25 %	>10 %
5	plateau morainique — moraine de fond argileuse	plat ou un peu onduleux	agriculture	—	—
9	collines morainiques dans la zone marginale — moraines de la glace „morte"	collineux	agriculture	—	bois, prés
16	cône de sandre déboisé	plat	agriculture	—	—
17	cône de sandre boisé	plat	bois	—	—
44	chenal glaciaire lacustre	fond bas plat ou onduleux, côtes escarpées	—	prés	agriculture, bois, lacs
46	fond bas de la „pradoline" tourbeux	plat	prés	—	agriculture

les méthodes qui ne seront pas expliquées ici — comp. T. Bartkowski 1964), en raison de la valeur de la base locale de ravitaillement, dégré de menace de la part de l'activité économique de l'homme pour le milieu géographique, dégré d'attraction du milieu géographique pour le repos et le tourisme.

Comme on voit sur la Fig. 2 évaluation de la base locale de ravitaillement) la valeur la plus grande (plus de 10,1 item) a été attribuée aux terrains, situés à l'est-occupés par de vastes surfaces de plateaux morainiques argileux, tandis que la valeur la plus minime est „concentrée" sur le territoire des hauts niveaux terrassiques de la pradoline Toruń-Eberswalde, occupés par de vastes dunes et couverts par de grandes surfaces de forêts de pins avec les valeurs de 0 à 2,5 item.

L'évaluation du dégré d'attraction du terrain pour le repos et le tourisme présente une image tout à fait différente (Fig. 3.). Les terrains, qui ont été hautement évalués auparavant (base de ravitaillement) c'est-à-dire les plateaux morainiques argileux (agriculture) sont peu attrayants pour le repos et le tourisme (0,1 — 4,9 item) tandis que les terrains où la production de vivres est très petite (bois de pins sur les dunes) dans la partie nord-ouest du territoire évalué, sont bien plus attrayants (10,1 — 13,9 item). Les terrains les plus attrayants ce sont pourtant les chenaux glaciaires lacustres et les collines morainiques de la zone marginale (plus que 14,0 item) tandis que les terrains les moins attrayants sont les fonds bas plats tourbeux des pradolines (0,0 item).

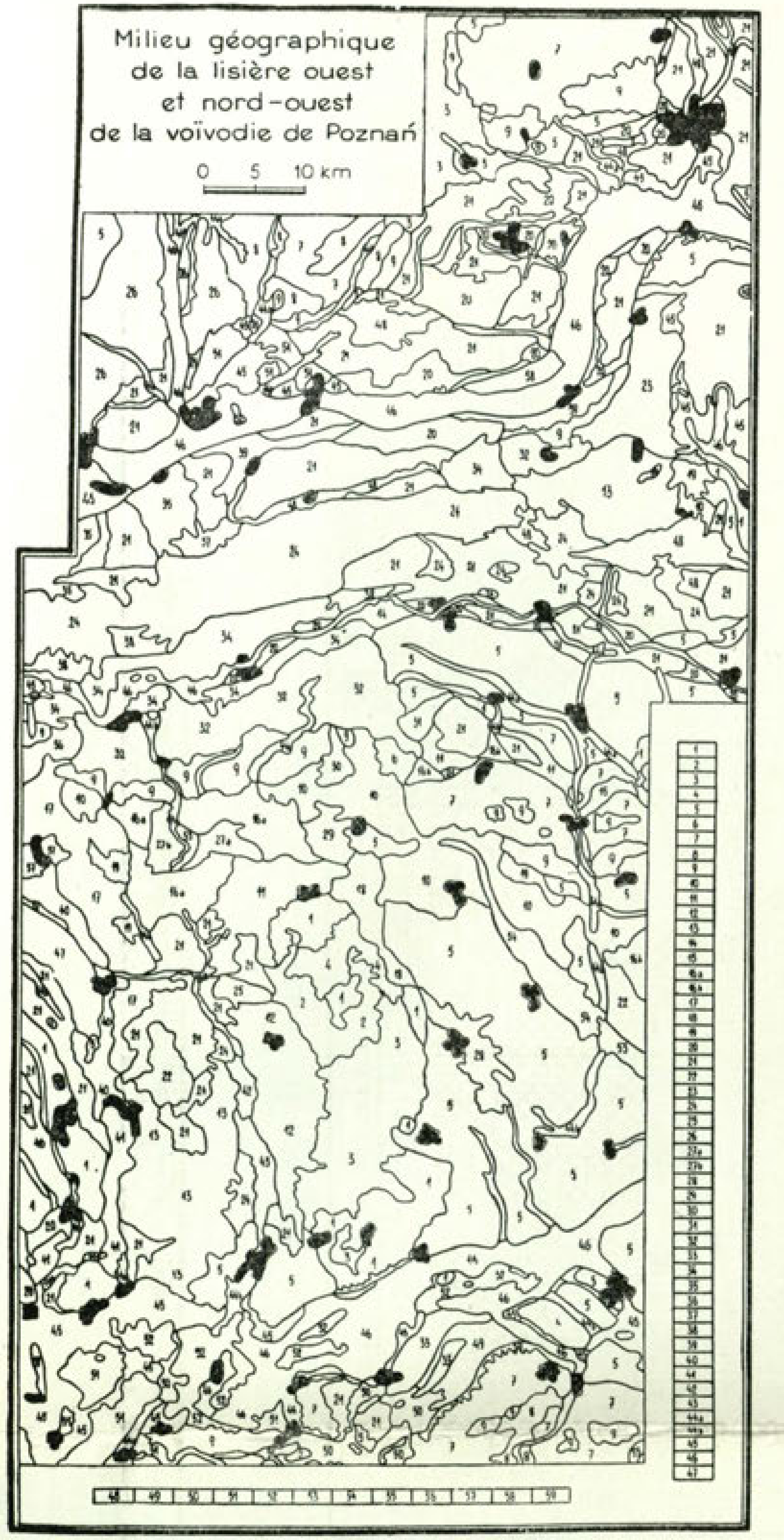

Fig. 1. Division suivant les microregions
1—59: La numeration des types des microregions

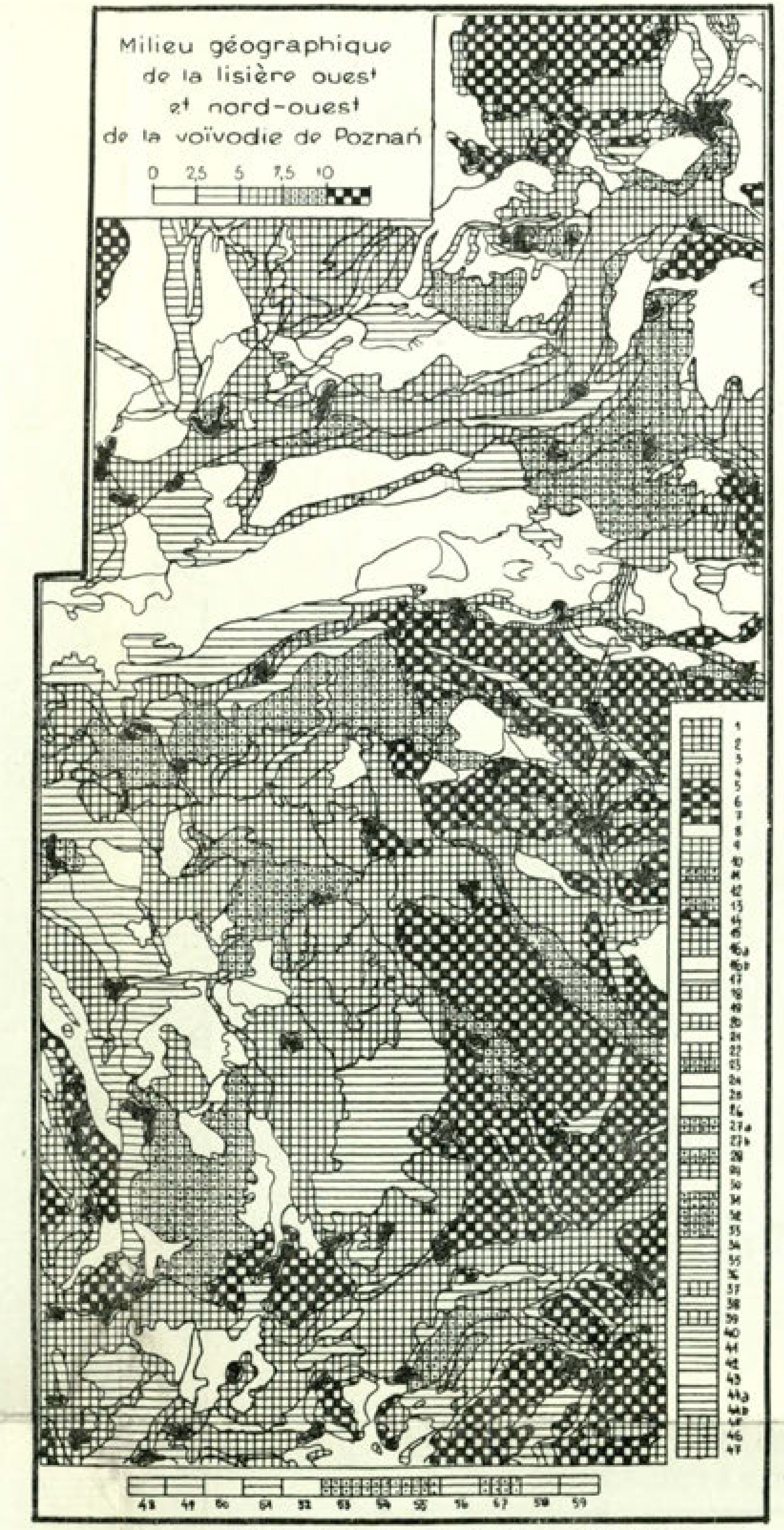

Fig. 2. Evaluation de la base locale de ravitaillement
1—59: La numeration des types des microregions

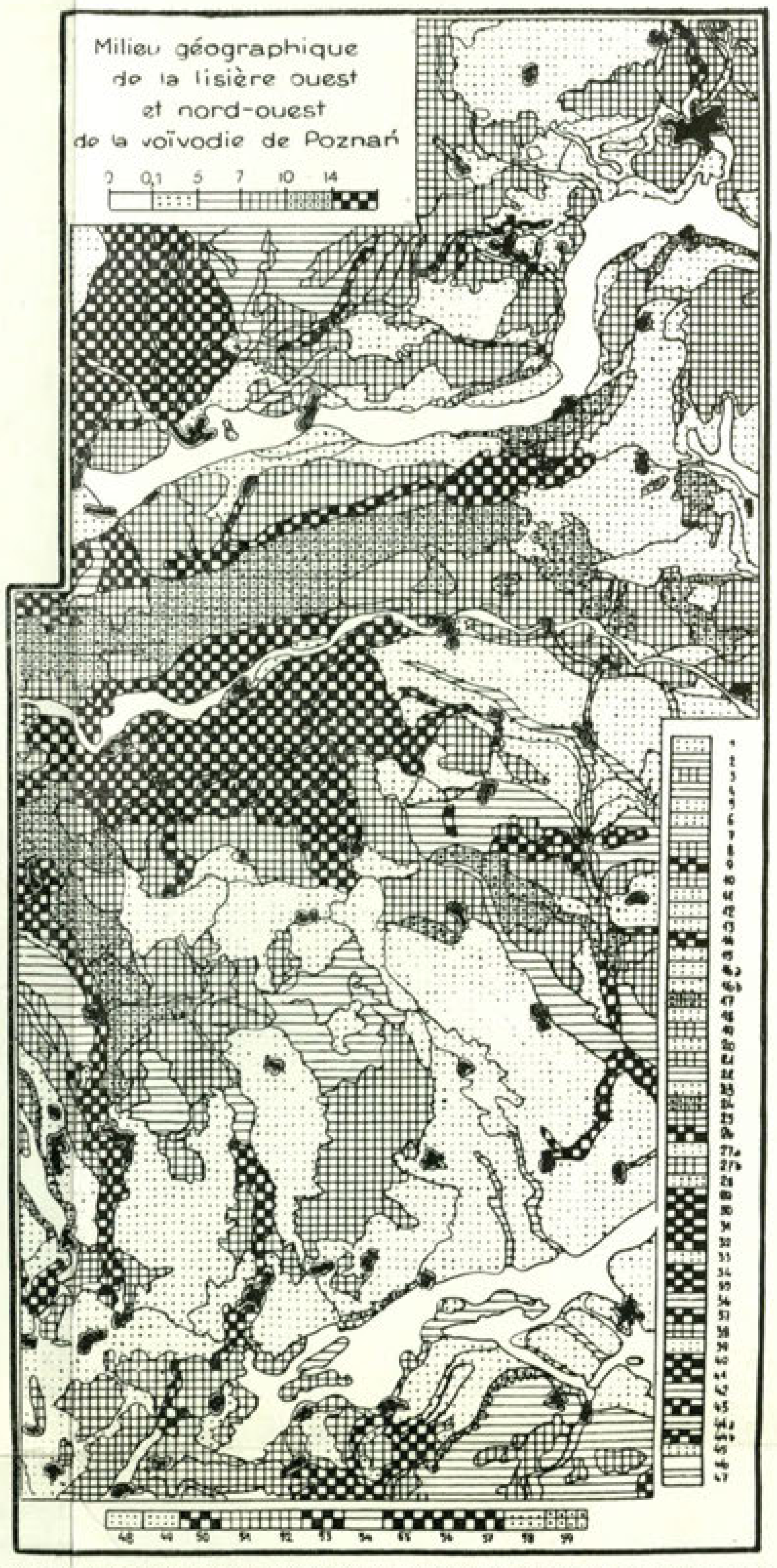

Fig. 3. Evaluation du degré d'attractivité du milieu geographique pour le repos et le tourisme
1—59: La numeration des types des microregions

Les deux exemples décrits ci dessus nous donnent bien l'image des possibilités d'application de la délimitation du pays en microrégions pour les diverses évaluations. La base de cette évaluation reste toujours la même — les microrégions — tandis que ce sont les diverses „qualités" du milieu géographique qui sont discernées et évaluées dans les microrégions, selon les divers buts de l'évaluation (agriculture, repos et tourisme, habitat etc.).

A la base de ces évaluations on peut:

1) choisir et indiquer quelques terrains, bien petits déjà, pour les recherches détaillées à grande échelle (et à cause de cela bien couteuses),

2) éliminer d'autres terrains (c'est-à-dire les terrains restants) des recherches détaillées et établir la hiérarchie de l'importance et la succession des recherches sur les microrégions, qui peuvent être prises en considération dans les étapes consécutives des recherches,

3) formuler des propositions de mesures économiques concrètes et par cela trouver la motivation des dépenses pour les recherches détaillées à grande échelle sur le milieu géographique,

4) obtenir les généralisations nécessaires pour le „plan général" du pays — pour la possibilité d'établissement d'un „bilan central de ressources du milieu géographique" (étape troisième et finale du processus d'évaluation du milieu géographique énuméré au début).

Selon l'auteur la méthode représentée ci dessus est efficacement „opérative" dans le domaine de l'aménagement du territoire et, puisqu'elle est peu coûteuse, elle peut être choisie et appliquée avec grand profit dans ces travaux. Naturellement elle doit être exécutée comme un travail collectif des géographes de tous les centres géographiques en Pologne. Elle peut être appliquée rapidement et peut fournir par cela un „outil" d'une analyse et évaluation rapides et effectives du milieu géographique, jusqu'au moment, où le développement de la géographie en Pologne permettra la délimitation de microrégions complètes du milieu géographique, postulée par le travail de A. Marsz (1967).

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EXEMPLE D'ÉTUDE DÉTAILLÉE DU PAYSAGE PHYSICO-GÉOGRAPHIQUE EN PLATEAU DE LOESS

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Des études détaillées du paysage physico-géographique ont été effectuées dans le bassin moyen de la rivière Opatówka qui se trouve sur le plateau de Sandomierz; c'est une des mezo-régions du plateau de la Petite Pologne (Małopolska). Le paysage de cette région est typique pour les plateaux de loess propices à l'agriculture. Les recherches avaient pour but: 1) l'élaboration d'une méthode d'étude détaillée ainsi que la cartographie d'un paysage physico-géographique, compte tenu des réalisations méthodiques actuelles de la cartographie géomorphologique et hydrographique ainsi que de la classification scientifique des sols en Pologne 2) mieux connaître le paysage physico-géographique de cette région, de ses composants et de leurs rapports mutuels. On s'est appuyé lors de ces travaux sur les réalisations des géographes soviètiques, adoptant, avec certaines modifications, les principes théoriques, méthodiques, la systématique et la taxonomie des unités naturelles qui ont été elaborés par eux. Les recherches ont permi de distinguer les unités suivantes: terrain, *uroczysko*, *poduroczysko*, faciés et leurs types compris selon les définitions données par les géographes de Moscou. La notion de „paysage physico-géographique" a été admise comme notion générale.

Pour réaliser ces tâches nous avons choisi dans le bassin de l'Opatówka un secteur „clé", c'est à dire un fragment de terrain dont le paysage était aussi représentatif que possible de tout le bassin L'extrapolation des résultats sur le reste du bassin devait être réalisée ensuite. Sur ce fragment ont été entreprises des recherches de caractère geologique, géomorphologique, hydrographique, pédologique, botanique et des études du paysage physico-géographique. Les recherches géologiques et géomorphologiques ont été realisées, selon la méthode de la cartographie, elle-même fondée sur les instructions et nomenclatures polonaises, après adaptation à l'echelle et au caractère particulier de l'étude. Le levé pédologique n'était pas executé puisque nous disposions des matériaux necessaires de la classification des sols. Ceux-ci ont été étudiés, en profils généralement, à travers les formes caractéristiques du relief, les groupements de végétations et les différents types de sols. Ces profils avaient pour but de déterminer les rapports entre les sols et les formes du relief aussi que les groupements de végétation et — dans le cas des fonds de vallées — les rapports entre les sols et les eaux et l'accumulation des delluviums. Les recherches sur la végétation ont été effectuées suivant les principes de levé phytosociologique de Braun-Blanquet. Les limites des secteurs caracterisés par chacun des levés, ont été determinées sur les photos aériennes en tenant compte non seulement de l'état de la végétation, mais également des formes du relief auxquelles ces secteurs étaient liés ainsi que des conditions hydrographiques et pédologiques. Dans le cas des forêts et de ravins on s'est limité à quelques dizaines de levés sur les éléments caractéristiques du relief. Les conditions climatiques locales n'ont pas été étudiées. Les études des composants du paysage ont été entreprises en deux étapes consécutives: la première était consacrée à la structure géologique, au relief, aux eaux de surface et souterraines. La seconde, s'appuyant sur les résultats de la précédente, concernait surtout les sols et la végétation. Au cours des travaux une attention particulière a été portée aux liens réciproques entre les composants. Pendant la cartographie de ces composants on a fait la cartographie des unités naturelles de quelques fragments caractéristiques choisis du terain et il en est resulté une division en unités naturelles individuelles: terrains, *uroczysko*, *poduroczysko* et faciés. Elles ont été classées sur la base 1) des résultats des recherches sur les composants, en s'appuyant sur la différenciation du terrain selon la formation de chacun des composants et le caractère de leurs relations, 2) des conclusions de l'analyse morphologique du paysage physico-géographique.

Après l'étude de chacune des unités il fut possible d'en déterminer différents types d'unités du même rang. On a adopté comme principe de réunion des unités individuelles en un type les traits communs du paysage, une structure morphologique semblable et une genèse similaire. On a distingué ainsi quatre types de terrains, 20 types d'*uroczysko*, et de nombreux types de *poduroczysko* et de faciés. On a fait aussi une coupe complexe, qui traverse la région entière selon la ligne de plus grande variété du paysage. Pour tous ces travaux on a utilisé des cartes au 1/10000 et des photos aériennes dont les informations concernaient le caractère et la répartition des formes du relief, les élements hydrographiques, les prés, les forêts, la nature des sols, les types d'unités naturelles et leurs frontières. A signaler ici un trait fondamental du travail sur un fragment „clé" sur l'Opatówka, à savoir que les recherches de toutes les composantes du paysage et la cartographie ont été exécutés par une personne — un géographe physique. Cela a permis une connaissance plus profonde du terrain et de sa problématique géographique et en résultat cela a facilité la découverte et l'explication des règles et des rapports entre les composants du paysage. Le paysage géographique lui-même devint de ce fait plus compréhensible. D'autre part furent ainsi évités les imprécisions et les désaccords que provoque le travail d'équipe.

Sur la base des materiaux réunis ont été realisés l'élaboration détaillée et des cartes des composantes du paysage physico-géographique de la région. Le résultat fondamental de ces recherches est la carte des unités naturelles typologiques et la caractéristique de leur paysage physico-géographique. Cette carte au 1/10000 a été préparée sur la base des resultats des études et de la cartographie de chacune des composantes du paysage, en s'appuyant sur l'analyse des photos aériennes et les résultats de la cartographie des unités naturelles. La cartographie des unités naturelles de certains fragments a permis de déterminer des types d'unités sur la surface étudiée. La distinction des unités sur les terrains non englobés par cette cartographie s'est faite à partir des traits différenciels, qui pouvaient être établis selon les matériaux dont nous disposions et convenaient aux conditions spécifique du terrain. Nous sommes en présence d'un plateau à relief d'érosion, couvert d'une épais manteau de loess, presque totalement dépourvu de végétation naturelle et fortement dénudé. La dénudation constitue ici le principal processus de formation du paysage physico-géographique et de toutes ses composantes. Cela se manifeste particulièrement dans la prédominance des sols bruns dont le caractère est très lié à l'intensité de la dénudation. Le relief du terrain décide dans une grande mesure de cette dernière. Le relief joue dans le paysage un rôle d'autant plus important qu'il influence considérablement, de façon directe ou indirecte le caractère de chaque composante et de l'ensemble du paysage. Dans chaque forme du relief, du fait de l'existence entre les composantes d'un caractère donné de rapports spécifiques se forme un complexe naturel précis. Ces complexes diffèrent selon les formes du relief. Il resulte de recherches executées et de la cartographie du paysage comme de la littérature existante, que le plus souvent ces complexes sont du rang de l'*uroczysko* simple on complexe. C'est pourquoi le relief du terrain (de même que la structure géologique) a été considéré en tant qu'élément de différenciation des *uroczysko* de la région étudiée. La carte géomorphologique, était ainsi l'un des fondaments de l'élaboration de la carte d'unités naturelles parce que sur la base de cette carte on a distingué le plus souvent les *uroczysko* individuels. Les limites des *uroczysko* coincident le plus souvent avec celles des formes du relief, quoiqu'il ait parfois fallu de les préciser à l'aide d'autres facteurs tels que les sols, la végétation etc.

Les sols et la végétation ont été adoptés dans les conditions du terrain étudié comme traits fondamentaux de différenciation des faciés. Les différences à l'intérieur des *uroczysko* totalement labourés peuvent résulter des changements lithologiques des formations superficielles, du relief du terrain et des sols. Parmi ces composants les sols ont une grande importance puisque dans leur caractère se refléte à la fois la lithologie, la situation sur un élément determiné du relief et des conditions d'humidité. La distinction des faciés dans les *uroczysko* labourés repose donc en fait sur la differenciation des couvertures pédologiques, en constante relation avec la lithologie et le relief, surtout dans la division en *pod-uroczysko*. Les conditions de végétation n'ont pu être prises en considération puisque la végétation des lisières n'était pas examinée ni cartographiée. Dans les *uroczysko* couverts de forêts, de prairies ou non utilisés les traits caractéristiques de la végétation ont, avec les sols, une grande importance car s'y reflète la différenciation apportées par les autres composants et tout le paysage physico-géographique. Pour la distinction des faciés sur la carte des unités naturelles on s'est donc servi des cartes des sols et de la végétation résultant de la cartographie du terrain. Dans les *uroczysko* labourés les limites de faciés ont été définies selon les limites vérifiées et corrigées des parcelles des différents sols. Dans le cas des prairies les contours des faciés ont été determinés d'après la carte de la végétation directement, puisque celle-ci distingue des types de prairies qui correspondent aux types de faciés des différents *uroczysko*. Dans la détermination des types de prairies il n'était en effet pas seulement tenu compte des conditions de végétation mais aussi de son habitat.

La distinction des terrains — des plus grandes unités naturelles — on reposa sur leurs caractères spécifiques contenus dans leur définition, compte particulièrement tenu de leur situation par rapport au relief et aux complexes déterminés de formes du relief. Les types de terrains représentés sur la carte ne se distinguent pas seulement par une unité d'aspect extérieure et de structure morphologique mais également par une genèse uniforme et une formation homogène des composantes du paysage.

La méthode du facteur directif, dont on s'est servi pour la réalisation de la carte des unités, a pu être appliquée tout simplement parce que les recherches sur le terrain ont revelé les liens entre chaque composante, chaque processus, à la fois sur toute la surface cartographiée, dans chaque unité individuelle cartographiée et dans les différents types d'unités. D'une part, cela a permis de déterminer les facteurs directifs dans les conditions du terrain étudié; facteurs dont les différences spatiales reflèteraient objectivement la différenciation dans le paysage de la région et qui décident en grande partie du caractère des autres composantes donc de toutes les unités naturelles. D'autre part la connaissance des rapports entre les composantes nous a donné la possibilité de juger, à partir du caractère de l'une des composantes, du caractère des autres. Ce fut particulièrement important pour la délimitation des unités surtout lorsque les limites des caractéristiques spatiales de chaque composante dominante étaient plus vagues par rapport aux autres composantes du paysage. En résultat, les unités ainsi divisées sont des unités de paysage et la carte qui les représente — une carte du paysage physico-géographique, non pas de l'une seulement des composantes, relief ou sols par exemple.

Nous avons distingué sur l'aire étudiée les types suivants de terrains et d'*uroczysko* qui les composent:

— type de terrain de plateau de loess plan — comprend 3 types d'*uroczysko*

1) de plaines de loess, 2) de cuvettes, 3) vallées de jatte, étendues et peu profondes.

— type de terrain de vallées sèches et de versants de vallées dé rivière comprend 10 types d'*uroczysko*

1) de vallées sèches à fond plat, 2) de vallées de dénudation, 3) de niches de versant, 4) de versants de la vallée de l'Opatówka, 5) de ravins à fond plat, 6) de ravins jeunes, 7) de ravins complètement labourés en jatte, 8) de ravins à fond plat labourés, 9) de ravins routiers, 10) de ravins de loess percés dans des roches dures.

— type de terrains des niveaux au dessus de la plaine d'inondation dans la vallée fluviale comprend deux types d'*uroczysko:*

1) du niveau de loess (5—7,5 m), 2) de la terrasse fluviale 15 m.

— type du terrain de fonds de vallées fluviales — se compose de 5 types d'*uroczysko:*

1) de cônes de déjection, 2) de levées naturelles de berges de la rivière, 3) de dègues et de levées du lit fluvial artificiel, 4) de fond sec et plat de la vallée fluviale, 5) de cavités guéables de fond de vallée.

72 types des faciés ont été distingués dans les types d'*uroczysko* exposés ci dessus.

La caractéristique du paysage de chaque unité typologique comprend la caractéristique de chacune de ses composantes dans leurs rapports complexes, mutuels, de cause à effet, en tenant compte de l'influence de l'action de l'homme de même que dans la mesure du possible, des observations concernant la valeur agricole et l'utilisation de cette unité. Comme exemple nous présentons ci-dessous les caractéristiques d'un type de terrain choisi, d'un type d'*uroczysko* et d'un type de faciés.

Le type de terrain de plateau de loess se trouve dans une zone de partage des eaux et concerne une surface unie, plate ou d'une pente de moins de 3%. C'est une plaine d'accumulation de loess sur laquelle se trouvent des nombreuses cuvettes ainsi que des vallées de jatte étendues et peu profondes. Une épaisse série de loess (atteignant 34 m d'épaisseur) composée de deux niveaux séparés par un sol fossile, repose sur la série de sables, de graviers et d'argiles provenant de la glaciation cracovienne et centre-polonaise. Plus en profondeur se trouvent dénudés des sables quartzeux, des calcaires à lithothamnies et des schistes cambriens. La grande perméabilité des dépôts quaternaires conditionne la profonde nappe d'eau souterraine de premier niveau exploitée qui se trouve le plus souvent dans des formations miocènes, et plus rarement pleistocènes. La faible inclinaison de la surface limite le ruisellement des eaux de précipitations. Dans les vallées de dénudation existent seulement des cours d'eau épisodiques et, dans les cuvettes où les sols sont moins perméables, se forment de petits lacs temporaires. Du fait du ruissellement peu important les processus de dénudation sont ici nuls ou très faibles. C'est seulement sur les rebords des vallées, des ravins, des cuvettes ainsi que sur les croupes entre les vallées, où les pentes sont plus grandes, que la dénudation plus intensive conduit à la formation de différents types fortement lavés de sols bruns ou de sols à profil tronqué. Sur les autres surfaces dominent des sols bruns non érodés avec de petites parcelles isolées de tchernoziom dégradés, et, dans le fond des vallées et des cuvettes, des sols bruns delluviaux on des tchernozioms d'alluvionnement. La haute valeur agricole des sols et les conditions favorables à la culture furent la raison d'un déboisement presque total et très prècoce de la région et de sa consécration à l'agriculture. C'est seulement sur quelques petites parcelles que se trouvent encore des restes de forêts composées d'arbres feuillus.

Les *uroczysko* de vallées sèches à fond plat les plus développés sont situés au N de l'Opatówka. Les formes existantes au moins de l'interglaciation Eems ont été soumises à une dénudation periglaciaire et recouvertes de loess qui a adouci le relief.

Actuellement ces formes sont larges, assez profondes, souvent asymétriques. Le versant uback plus doux (5—11°) est constitué exclusivement de loess, sur le versant adret (11—20° et plus) se découvrent par endroit sous le loess des formations pleistocènes dans les quelles sont creusées les vallées: de sables, de graviers et d'argile morainique. Les rebords des formes de relief sont peu apparents, le fond plat, large, divisé en deux par les lits des cours d'eau épisodiques, constitué de delluviums épais par les eaux temporaires.

Les fortes dénivellations, les pentes importantes, sur le loess non recouvert par la végétation — puisque toute la surface est labourée et est exposée à l'érosion — favorisent une dénudation intensive. Outre un écoulement en nappe et en sillon, se produisent sur les versants abrupts un écoulement et un glissement des matériaux. Ces processus provoquent un adoucissement des pentes et le comblement des vallées, un allongement des pentes, un dévoilement des formations plus anciennes, une accumulation de delluviums, un engorgement des sources. De plus, sous leur action, les sols primaires furent dégradés, leurs profils réduits et leur valeur agricole considérablement modifiée. Sur les pentes plus douces se formèrent donc différents sols bruns plus ou moins profondément décalcifiés, alors que, sur les versants abrupts, dominent des sols très érodés, a profil tronqué, souvent à profil complexe de deux couches géologiques. Les sols bruns delluviaux, présents dans les fonds de vallées, se sont constitués au dépens d'autres sols dans le bassin versant, c'est pourquoi leurs propriètés sont assez differentes, mais ils possèdent en général beaucoup d'humus et d'autres substances fertilisantes.

Les unités naturelles du type évoqué appartiennent à des *uroczysko* complexes et on peut y distinguer les *poduroczysko:* de versant adret, de versant uback et de fond de vallées. Chaque *poduroczysko* se compose de plusieurs faciés. Comme exemple de plus petite unité naturelle on peut prendre le faciès des pentes de vallées aux sols non décalcifiés à profil tronqué. On les rencontre très souvent dans ce type d'*uroczysko*. Ils occupent une grande surface sur les versants adrets dont la pente est plus de 6° et les versants ubacks dont la pente est supérieure à 11°. Ce sont des terrains très fortement dénudés. Il en résulte que les couches supérieures de sols bruns formés sur le loess qui s'y trouvaient des l'abord, ont été complètement détruits, et s'est dévoilé le loess calcaire. Sur ce loess, sous l'influence des travaux agricoles et des engrais organiques s'est formé une couche d'humus secondaire, représentant en totalité une couche labourable. Elle a une épaisseur de 10 à 20 cm, de couleur grise, pauvre en humus (0,5 à 1,4%), très calcaire (8 à 12% de $CaCO_3$). Dans le profil pédologique on découvre des concrétions calcaires et des agglomérats de Fe^{+++}. Ces sols constituent le cinquième stade de réduction des sols bruns. Les loess, en tant que roche-mère, leur assurent de bonnes propriétés physiques. Ils sont pourtant comptés dans la quatrième classe de la valeur agricole parce qu'ils sont périodiquement trop secs, pauvres en humus et très érodés. Quoique cette classification ne soit pas des plus mauvaises à l'échelle nationale, les faciés en question devraient être exclus en tant que terres labourables. En effet les récoltes y sont faibles, les travaux provoquent l'engorgement des fonds de vallées et une forte détérioration des sols de bonne qualité aux environs des rebords. En principe ces fragments devraient être boisés ou occupés par des buissons. S'ils doivent être utilisés par l'agriculture, il est nécessaire de former des terrasses tout le long des versants.

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V. ECONOMIC GEOGRAPHY

MAP OF ECONOMIC REGIONS OF THE WORLD

STANISŁAW LESZCZYCKI

In delimiting socio-economic regions various criteria can be used depending on purposes of regionalization. Some of them are of a more subjective and descriptive character and as such they generally reflect particular authors' experiences.

Other criteria are based on certain qualitative classifications that are generally accepted as suitable for determining the character of some aspects of economic and social life. Some of them are based upon the classifications generally used and agreed upon by such international organizations as UNO, FAO, UNESCO, and others. Criteria of this kind being more comparable are of greater help in delineating economic and social maps of the world than the individually elaborated ones. Some qualitative criteria can be transformed into quantitative ones and the results obtained are then more precise and appropriate for an objective discussion. The difficulty, however, still remains as regards the proper choice of such criteria as it is by nature subjective.

One of them is the index referring to the character of communication which reflects to what degree the economic and social demands of the community living in a given area have been met. This goal is, however, best achieved by communication maps which give a complex picture of the equipment in this field, namely of lines and nodes of all kinds of communication, thus pertaining to the transportation of people and goods and to the transfer of information. I still consider the maps by G. Köhler [7—12] to be most useful for this purpose. They were published in the years 1956—1959 in Petermann Geographischen Mitteilungen and their modification appeared in some other atlases, i. e. in "Československy Vojensky Atlas" [14] in 1965, and Haack's "Hausatlas" [6] in 1965. Similar maps were published in "Österreichischer Mittelschulatlas" [15] in 1962 and in Mc Nally "World Atlas" [17] in 1965. Communication regions as shown in these maps correspond to the level of economic development and investment (or the value of fixed assets) of a given area and, therefore, they can be used for delimitation of economic regions, for instance, by drawing lines eliminating the areas very sparsely populated (less than 1 person per 1 sq km). Thanks to these maps it is possible to delimit, in a more precise way, economic regions in particular continents and in particular countries.

The population distribution and its concentration, as shown in the maps of population density reflecting actual economic and social relations, is another important criterion in delimiting economic regions. When speaking about population indexes as important criteria for the economic regionalization of the world it is necessary to mention the publication of the United Nations (Department of Economic and Social Affairs) entitled "World Population Prospects as Assessed in 1963", published in New York in 1966 [19]. In this publication the prognostic considerations of the demographic situation of the period of up to the year 2000 were based upon the assumed 24 regions and major areas delimited according to the levels of economic and social development. Three categories of states were distinguished, namely: (1) less developed regions, (2) more developed regions, (3) sparsely inhabited arctic islands. The world was divided into the following 8 macroregions: a) East Asia, b) South Asia, c) Europe, d) USSR, e) Africa, f) Northern America, g) Latin America, h) Oceania. These were further divided into 24 regions but demographic data were given for 203 states and dependent territories.

However in delimiting the economic regions of the world the most important criteria are those characterizing the level of the economy, namely, the indices of national income, production, trade, consumption, and of other elements reflecting the living standard of the inhabitants as well as those illustrating internal relations within a region and interregional connections.

In delimiting world economic regions we accept as a unit of reference — a state or a dependent area enclosed within political boundaries, characterized by a certain degree of closure of their economy and controlled by custom barriers. From among the many indices the following are most significant: (1) the form of political control of the national economy, i. e. the socio-political system, (2) national income, (3) production and especially the part destined for export as it reflects production surpluses, (4) foreign trade, (5) political, economic, financial, customs and other agreements that either facilitate or impede co-operation between countries.

Taking into account indices of this kind, N. Ginsburg [4] and B. J. L. Berry [1] worked out synthetic a map of "Country Units and Major World Realms" included in the "Atlas of Economic Development" published in Chicago in 1961. The authors establish therein 10 economic macroregions of the world. Some other maps presented in this Atlas are extremely interesting as, for instance, the map of "Gross National Product", that of "Food Supply — Calories per Capita per Day", or the one of "Technological Patterns". The map of "World Economic Regions" published by H. Boesch in his excellent handbook on "A Geography of World Economy" (issued in the USA, in 1964 [2]) has been based upon foreign trade relations. He distinguished there four macroregions: 1) North America, 2) Western European, 3) Southeast Asian, 4) socialist countries.

M. Megee in her work on "Problems in Regionalizing and Measurement" [13] has analysed the system of world economic regions on the basis of 56 factors of socio-economic differentiation relating to 153 states and territories of the world. The many factors involved she finally reduced to four groups, and namely: (1) Industrial Development, (2) Social Overhead (Infrastructure) and Government Expenditure, (3) Domestic and Foreign Trade, (4) Social Dimension. As a result of this analysis she distinguished five groups of countries: 1. very underdeveloped countries in Africa, Latin America, Asia and Pacific, grouped in 6 sub-regions, 2. developing countries of Africa and Latin America, grouped in 4 sub-regions, 3. developing possessions and countries in Latin America, the Pacific Islands and Asia, grouped in 4 sub-regions, 4. developing countries in the Near East, 5. some highly developed countries of Europe and Anglo — America, grouped in 9 sub-regions. In the last groups the author included also other European countries and namely Poland, the Netherlands, the USSR, and the United Kingdom. A number of the remaining countries having varying indices have been grouped together by the author as "isolated", their indices being in general similar to those of the highly developed countries.

In my article published in Prague, in 1967, I presented a map prepared together with J. Barbag [16], in which 10 or rather 13 world economic regions were defined. As regards the criteria used, priority was given to the influence of the socio-political system upon the economic conditions and consequently, we divided the world into socialist, capitalist and developing countries. As a second criterion we have used the data illustrating the living standard of the inhabitants.

My further attempt to delimit world economic regions took place in 1967 when preparing a respective map for the "Atlas of the World" published in 1967 in Poland by the Topographic Military Service [18]. The principles accepted were as follows:

1. In order to exclude from consideration the economically passive polar areas, the external frontiers of the polar ecumene were delineated. In such a way the territories of the countries in the northern hemisphere

and particularly those of Canada and the USSR were somewhat reduced.

2. Also the internal frontiers of ecumene were marked to exclude uninhabited deserts, high mountains, etc. Due to the small scale of the map only the biggest "isles" of anecumene within the limits of ecumene were delineated.

3. Although the points of paraecumene, i. e. places permanently inhabited within the limits of anecumene, should have also been marked, this was not done because (a) of their small economic role, and (b) of the difficulty in locating them all on a small-scale map.

4. The following three demographic indices were taken into account:

a) areas very sparsely inhabited (less than 1 person per 1 sq. km),

b) areas of great population density defined by the isarhythm of more than 200 persons per 1 sq. km,

c) places of great population agglomerations, i. e. cities, ports and transport nodes of more than 500 thousand inhabitants. These are the cores (the nuclei) of the socio-economic life of various areas (hinterlands) as regards size.

ad a). The areas of subecumene, sparsely populated (less than 1 person per 1 sq. km) have an extensive socio-economic life. They are of certain importance mostly to strategy and communication but quite often these are the "reserve areas" for future more intensive economy provided they are more largely invested. Because of their exclusion from the "sensu stricto" economic regions, large areas of Canada, the USA, the USSR and China as well as those of northern, central and southern Africa, South America, Australia and quite a big number of smaller areas were omitted and were considered as underdeveloped.

ad b). The areas of great population density, marked out by the isarhythm of more than 200 persons per 1 sq. km. Two different concentrations of population were comprised here:

(1) in the urbanized and industrialized areas of the USA and Europe with highly developed trade, they constitute conurbations or megalopolia being the biggest agglomerations of socio-economic life whose influence usually surpasses the boundaries of one country;

(2) concentrations in Asia (India, China, Indonesia) and in Africa (the Nile Valley) are, however, of a different character. These areas are very often urbanized but population density here is based on intensive agriculture or rather gardening and also on handicrafts and local trade. Industrialization processes are quite recent here. In Japan, concentrations of population are of intermediary character between the two

groups mentioned above but they rather tend to approach the pattern of American conurbations.

ad c). Cities of more than half a million inhabitants are important socio-economic centres, capitals of political life and communication nodes (sometimes ports) with hinterlands of various size. When shown on a map the cities represent a network of centres and it is possible to guess their connections with hinterlands.

5. The indices referring to national income and production were, however, taken as the basis in delimiting economic regions. National income has been calculated as the gross national product per 1 inhabitant in accordance with UNO statistical data recalculated in US $. The calculations were based upon the currency exchange rate as accepted in UNO publications. The data refer to the period of 1960—1961. They must be considered approximate due to the estimative character of the initial data and the same character of the following recalculations. For comparative purposes the accepted world average of the gross national product per 1 inhabitant accounted for $ 520.— From this viewpoint countries have been classified into the following three groups: (1) highly developed countries i. e. those whose gross national product per capita is higher than the world average; (2) semi developed countries whose national product per capita is below the world average but not smaller than 2/5th of the world average (median); (3) underdeveloped countries whose national product per capita is lower than 2/5th of the world average (i. e. that it is below the median).

The gross national product is derived from all branches of the national economy. In these considerations, however, only two branches of production and namely (a) agricultural and (b) industrial were taken into account and their role was reflected in the value of the gross national product. The industrial production [5] was divided into 3 groups: a) production higher than the world average (more than 200 $ per capita); b) moderate production lower than the world average but higher than 2/5th of the world average (median); c) low production being smaller than 2/5 of the world average (median). Agricultural production was divided only into two groups — the higher and the lower one than the world average (60 $ per capita).

Through combination of all the above-mentioned indices the following eight economic types of the countries of the world were obtained[1]:

A 1 — developed, industrialized countries with gross national pro-

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[1] In determining this typology and in making estimating statistical data I was greatly helped by Dr. M. Najgrakowski.

duct higher than the world average; industrial and agricultural production are also higher than the world average values;

A 2 — developing countries of high (higher than average) national product and higher than average industrial production but with little developed agriculture (less than the world average). The characteristic feature of these countries is their very high output of crude oil.

B 1 — countries of medium national income (the value of national product is between the median and world average) with more developed industry (production value being between mediane and the world average) and developed agriculture (higher than the world average).

B 2 — a group of countries similar to the preceding one (B 1) but with agricultural production of lower value per 1 inhabitant (smaller than the world average).

Bc 1 — countries of medium national income (the value of gross national product being between the median and the world average) which is based on developed agricultural production (higher than the world average). Industrial production is little developed (its value being less than the median).

Bc 2 — countries of medium national income (the value of gross national product being between the median and the world average) where industry (mining) plays a considerable role but the value of industrial production and that of agriculture do not surpass the respective median or the world average.

C 1 — countries little developed with low national income per 1 inhabitant (the value of gross national product is lower than the median); their industry is relatively little developed (production value is also lower than the median) but agriculture is rather well developed (the production value being higher than the world average).

C 2 — countries least developed, the value of their gross national product and the value of industrial production being smaller than the median; the value of agricultural production is also lower than the world average.

The typology based on relative values per capita does not take into account absolute values of particular countries and their percentage share in the world production. In consequence, some states and even those having a considerable global industrial production as, for instance, China, India, UAR and others were included in the group of countries underdeveloped (C. 1) because the values of their industrial production per capita are relatively low.

On the basis of this classification the map of world regions was worked out. I distinguished there seven macroregions nearly corresponding to the continents and to the USSR. They were further divided into

TABLE 1. Economic regions of the world *

	Continents Regions	Population	Gross national product	Production			
				agriculture	manufacturing industry	electric power	crude oil
		in percentage of world totals					
	1 EUROPE	15	31	27	34	27	2
1.	1.1 Eastern Europe	4	5	7	7	5	1
2.	1.2 Western Europe	6	16	12	17	13	1
3.	1.3 North-Western Europe	2	8	4	9	9	0
4.	1.4 Southern Europe	3	2	4	1	1	0
5.	2 USSR	7	13	12	14	12	16
	3 ASIA	55	12	35	10	10	28
6.	3.1 Asian socialist countries	23	4	14	3	3	1
7.	3.2 Japan	3	3	4	4	5	0
8.	3.3 South-East Asia	8	2	6	1	1	2
9.	3.4 South Asia	19	2	10	1	1	0
10.	3.5 Near East	2	1	1	1	0	25
	4 AFRICA	9	2	7	1	2	4
11.	4.1 North Africa	3	0,5	2	0	0,5	4
12.	4.2 Central Africa	5	1	4	0	0,5	0
13.	4.3 South Africa	1	0,5	1	1	1	0
14.	5 NORTH AMERICA	7	36	11	37	40	32
	6 LATIN AMERICA	7	4	7	3	7	18
15.	6.1 Cuba	0,2	0,1	0,3	0,1	0,1	0
16.	6.2 Central America	2	1	2	1	1	1
17.	6.3 Caribbean South America	1	0,5	1	1	1	15
18.	6.4 Atlantic South America	3	2	3	1	4	2
19.	6.5 Pacific America	1	0,5	1	0	1	0
	7 AUSTRALIA AND OCEANIA	0,5	2	1	1	1	0
20.	7.1 Australia and New Zealand	0,4	2	1	1	1	0
21.	7.2 Oceania	0,1	0,01	0,1	0	0	0
	WORLD TOTAL	100	100	100	100	100	100
	Socialist countries	34	22	33	24	20	18
	Capitalist industrialized countries	19	65	33	69	69	33
	Remaining countries	47	13	34	7	11	49

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* Estimates by M. Najgrakowski from the Institute of Geography PAN.

21 economic regions[2]. They are shown on the enclosed map. Statistical data defining the role of particular regions in the world economy are given in the enclosed table. Besides the indices already mentioned also data on electric power and crude oil production have been indicated. The work on the map of world economic regions has not yet been completed and it will be further continued.

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[2] Explanation to the map of economic regions enclosed at the end of this volume.

Types of economic regions:

Distinguishing criteria of the economic regions		Types of economy Countries			
		Developed	Semi developed		Underdeveloped
Gross national product per capita		above world average	from 2/5 to world average		below 2/5 of world average
Agricultural production per capita	above world average	red	orange	green	blue
	below world average	light red	light orange	light orange	light blue
Industrial production per capita		above world average	from 2/5 to world av.	below 2/5 of world av.	below 2/5 of world average

Large dot — towns over 1Mn inhabitants, small dot — 500,000 to 1Mn inhabitants; violet shading — areas with population density over 200 person per sq. km; red shading — areas with population density under 1 person per sq. km; uninhabited areas left white; brown dotted line — northern and southern limits of permanently inhabited area; violet line — boundaries of economic regions.

[6] Haack Hausatlas, Gotha—Leipzig 1965.

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[9] Köhler G., Verkehrsgeographische Übersicht von Nordamerica (mit 3 Karten), *Petermanns geogr. Mitt.*, 100, (1956), 1, pp. 39—44.

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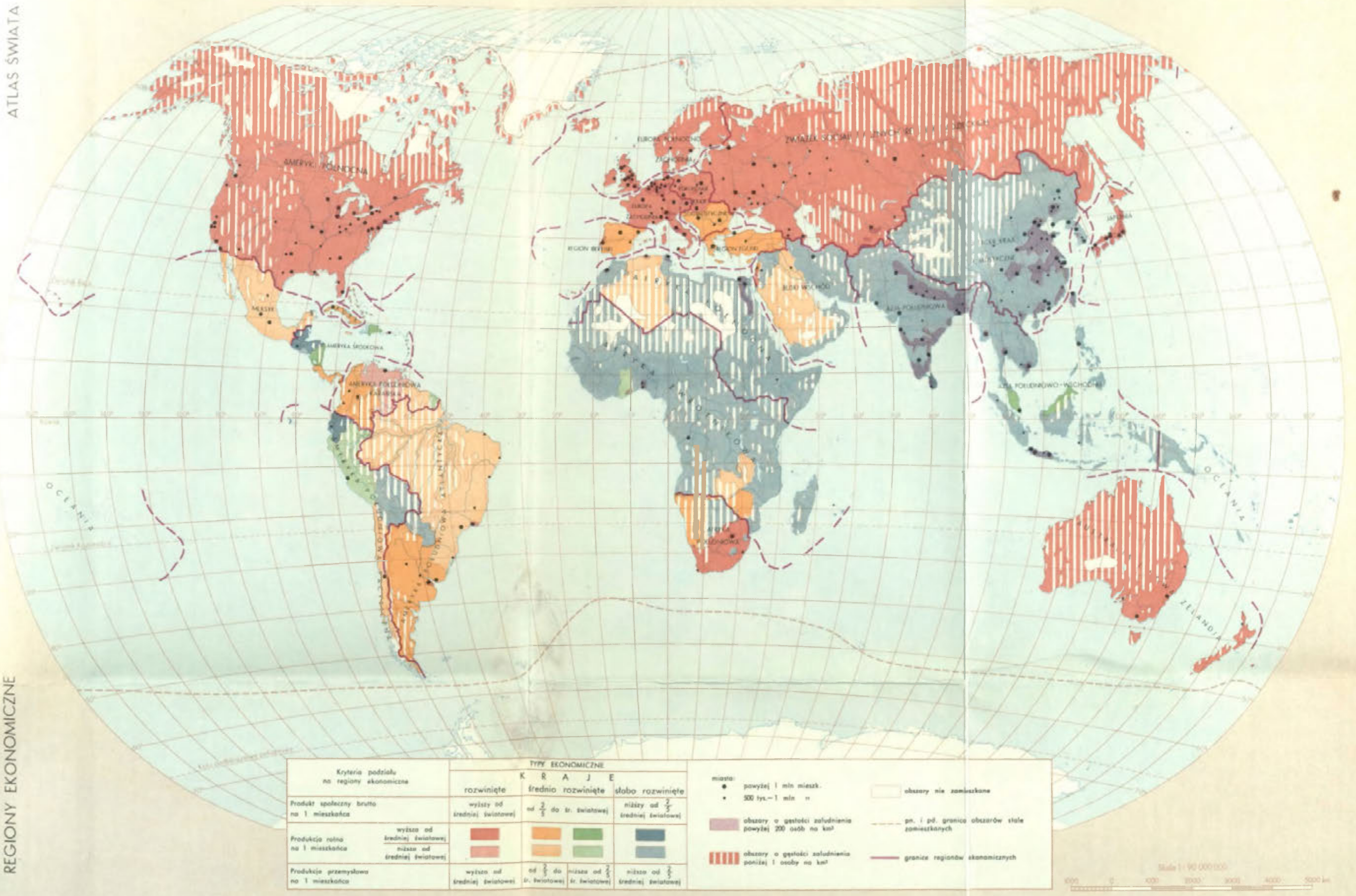
REGIONY EKONOMICZNE



Kryteria podziału na regiony ekonomiczne		TYPY EKONOMICZNE K R A J E rozwinięte	średnio rozwinięte		słabo rozwinięte
Produkt społeczny brutto na 1 mieszkańca		wyższy od średniej światowej	od $\frac{2}{5}$ do śr. światowej		niższy od $\frac{2}{5}$ średniej światowej
Produkcja rolna na 1 mieszkańca	wyższa od średniej światowej	🟥	🟧	🟩	🟦
	niższa od średniej światowej	🟥	🟧	🟩	🟦
Produkcja przemysłowa na 1 mieszkańca		wyższa od średniej światowej	od $\frac{2}{5}$ do śr. światowej	niższa od $\frac{2}{5}$ śr. światowej	niższa od $\frac{2}{5}$ średniej światowej

miasta:
- ● powyżej 1 mln mieszk.
- • 500 tys.—1 mln „

▨ obszary o gęstości zaludnienia powyżej 200 osób na km²

▥ obszary o gęstości zaludnienia poniżej 1 osoby na km²

☐ obszary nie zamieszkane

- - - pn. i pd. granica obszarów stale zamieszkanych

— granice regionów ekonomicznych

CLASSIFICATION RÉGIONALE DES GRANDS NOEUDS DES COMMUNICATIONS EN POLOGNE

STANISŁAW BEREZOWSKI

Pour découvrir dans l'essentiel la structure spatiale des communications en Pologne, il convient d'analyser les éléments de leur réseau. Il est possible d'y parvenir de deux façons: soit en étudiant les éléments de chacun des réseaux, soit en considérant les noeuds, les tracés, les flux, donc leur caractère regionale, synthétique. Pour la présente étude, la seconde voie a été choisie comme methode d'analyse plus géographique, menant à des généralisations spatiales synthétiques. Les grands noeuds de communications ont été considérés comme l'élément fondamental de l'analyse. Ils sont en effet le lieu où commencent, se déroulent et prennent fins les processus de transports et communications [1]. Les grands carrefours se confondent en général avec les grandes villes, souvent considérées comme centres vitaux et de ce fait font partie intégrante de la vie économique de l'Etat et de ses unités régionales. Puisqu'ils reunissent les différentes activités de transport et communications, s'y concentre une nombreuse population vivant de ce domaine de l'économie nationale.

Le système de données statistiques existant et la possibilité de les complèter offrent plus de facilités dans la réunion de matériaux concernant les villes — donc les noeuds de communications — que de matériaux relatifs aux lignes, aux flux, au réseau dans son ensemble. Quoiqu'elle n'épuise pas tous les problèmes, l'analyse des noeuds, pour les études de la structure spatiale, a une grande importance.

Le point de départ de cette étude pour la détermination des principaux noeuds de communications a été l'élément fondamental de leur définition: Point de rencontre et de ramification de tracés.

Il a été relevé sur des cartes au 1/500 000^{e} tous les grands carrefours possédant:

a) 4 embranchements ferroviaires

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[1] Sous le terme de communications, outre les transports, sont désignés les services suivants: postes, téléphone, télégramme, radio, télévision etc.

b) 3 embranchements de voies ferrées et au moins 4 de routes principales

c) un carrefour lié à la navigation intérieure ou maritime — c'est à dire les principaux ports.

Il s'agissait d'appréhender les principaux d'entre aux — 197 ont été dénombrés — qui furent affectés d'un „indice de ramification" considérant: le nombre de voies ferrées exploitées, de routes principales (nationales et secondaires), le nombre de lignes d'autobus, les ports fluviaux (comptant pour 2 embranchements), les grands ports de mer (comptant pour 3 embranchements), les aéroports (selon le nombre de lignes régulières), les stations emettrices de radio et télévision (suivant le nombre de programmes radio et les heures de programmes télévisés propres ou retransmis). L'indice ainsi établi varie de 63 pour Varsovie à 4 et 3 pour des petits centres ferroviaires: respectivement Siemkowice et Tunel. L'intention de l'auteur en embrassant par l'analyse une grande quantité de centres était d'en éliminer empiriquement les moins importants.

L'analyse fondamentale de classification a été effectuée selon la méthode d'échelonnement de quelques facteurs. Parmi les matériaux disponibles, les facteurs suivants sont apparus comme les plus représentatifs de la fonction étudiée:

1) les indices de ramification présentés plus haut,

2) l'emploi dans les communications en général; indirectement l'indice de cet emploi pour 10 000 personnes actives,

3) le mouvement de passagers et de marchandises à la gare ferroviaire,

4) le nombre de billets vendus par l'organisation de transports routiers PKS dans ses caisses locales, comme base d'evaluation de mouvement des passagers d'autobus,

5) le nombre d'abonnements téléphoniques.

L'analyse est fondée entièrement sur des données de 1960—65. Les 197 centres ont été classés dans l'ordre général de représentation de tous les facteurs étudiés. Ensuite ils ont été répartis selon la méthode de détermination des sauts qualitatifs dialectiques s'exprimant sous forme d'interruptions dans la succession hiérarchique — les seuils se répartissent de façon caractèristique permettant la distinction de différents types qualitatifs, comme le montre le tableau 1.

En accord avec le principe de classification régionale des transports[2],

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[2] S. Berezowski: Classification régionale des transports. Dans: Compte-rendu du colloque géographique franco-polonais sur l'aménagement du territoire, Mémoires et Documents, 10, fasc. 2, Paris 1965.

élargie ici aux communicationsen général, des types ont été distingués pour l'importance de leur sphère d'activité et les noeuds de communications groupés comme suit:

1) Capitale de l'Etat,
2) Centres suprarégionaux:
    6 centres de macro régions
    3 centres de voïvodies
3) Centres régionaux (à l'échelle de l'unité régionale de base):
    5 centres de voïvodies
    5 centres urbains subrégionaux.

Trois de ces centres appartiennent à des ensembles de communications complexes desservant des connurbations. A savoir:

a) la connurbation bicéphale Gdańsk — Gdynia y compris Sopot située entre ces deux villes. Gdynia est classée parmi les grands centres urbains de caractère subrégional. Sopot ne joue qu'un très faible rôle dans le réseau de communications et ne peut être considérée comme un carrefour, puisqu'il n'y existe aucun embranchement ferroviaire,

b) la connurbation multicéphale du G.O.P. Ici Katowice est le principal noeud de communications. Gliwice, en seconde position, est une ville de type subrégional, mais un carrefour d'importance régionale. Bytom et Chorzów ensuite ont un rôle subrégional. Parmi les centres microrégionaux Sosnowiec et Brzeziny Śląskie sont de plus grande importance, Będzin et Mysłowice de moindre importance. Quant aux autres villes, elles constituent des noeuds locaux, quoique le trafic-marchandises y soit important.

Les éléments de ces connurbations sont étudiés séparément, car ils jouissent d'une relative autonomie dans le domaine des communications. Nous disposons d'ailleurs pour eux de données statistiques individuelles.

4) Centres subrégionaux:
    a) principaux:
        1 centre de voïvodie Zielona Góra
        18 centres subrégionaux et importants chefs-lieux de powiats,
    b) secondaires:
        1 centre de voïvodie Koszalin
        5 centres subrégionaux et importants chefs-lieux de powiats.
5) Centres micro-régionaux
    a) principaux:
        21 chefs-lieux de powiats et powiats urbains
    b) secondaires:
        72 chefs-lieux de powiats et powiats urbains.

Les interruptions séparant les différentes classes dans l'échelle hiérarchique ont en moyenne, comme le montre le tableau 1, une importance de 30 • 4 points, alors que l'intervalle moyen dans la succession est de 5 • 9 points (1155 points pour 197 centres).

La classification ci-dessus a l'avantage de s'appliquer également au réseau urbain, facilitant ainsi la corrélation. Il est possible en particulier d'en faire une confrontation critique avec la hiérarchie théorique des villes en tant que centres de services. Selon les principes théoriques la distribution quantitative des centres en types taxonomiques se présente

TABLEAU 1. Schémat de classification régionale des centres de communication

Termes de la progression théorique quotient = 3	Nombre de centres de chaque catégorie en Pologne		Classification régionale des centres	Intervalles qualitatifs	Correspondance dans le réseau urbain
1	1		Nationaux	17	Capitale d'Etat
3	2		"		Centres supra-régionaux et 3 autres chefs-lieux de voïvodies
9	7		"	27	
27	35	10	Régionaux	36	Autres chefs-lieux de voïvodies (Centres de regions de base) et quelques importants chefs-lieux de powiats
		19	Subrégionaux principaux	15	
		6	Subrégionaux secondaires	44	
81	99	21	Microrégionaux principaux	19	Importants chefs-lieux de powiats
		78	Microrégionaux secondaires	15	Petits chefs-lieux de powiats et autres
243	?	41	Locaux supérieurs	44	Petits chefs-lieux de powiats petites villes osiedle
		?	Locaux moyens *		Petites villes, osiedle et principaux centres de gromada
729	?		Locaux inférieurs *		Autres petites villes et principaux centres de gromada

* Domaine non concerné par l'analyse.

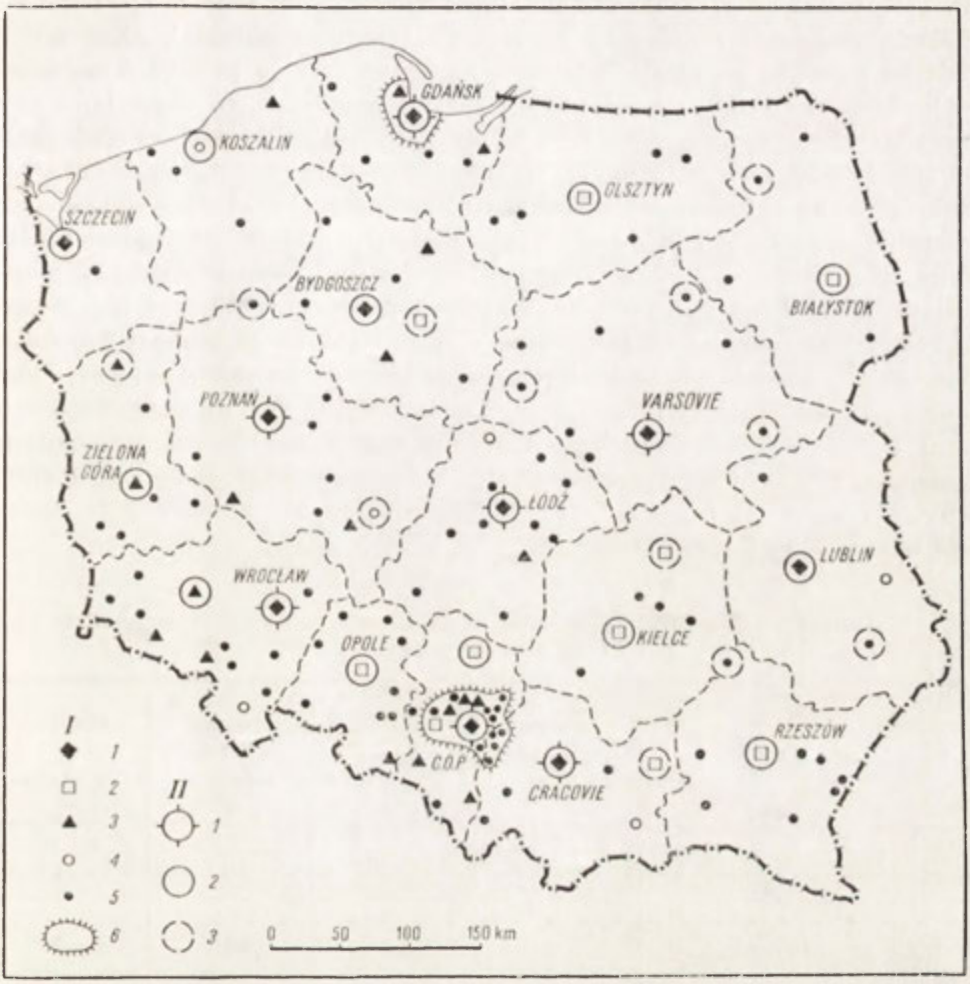

Fig. 1. La répartition des plus grands noeuds de communication en Pologne.

I Noeuds de communication: 1. du réseau national, 2. du réseau régional, 3. les plus importants d'intérêt subrégional, 4. les moins importants d'intérêt subrégional, 5. d'importance macrorégional, 6. les ensembles des noeuds, G.O.P. Bassin industriel de Haute Silésie (Katowice). II Les centres régionaux: 1. régions du degré le plus important, 2. régions fondamentales, 3. subrégions

en progression géométrique de quotient 3 (chez Christaller 2 • 71). Ainsi la comparaison de la répartition spatiale et quantitative réelle des noeuds de communications en Pologne avec la disposition théorique ci-dessus révèle-t-elle seulement un accord approximatif général et des divergences caractéristiques.

Il est évident surtout que les classes taxonomiques effectives qu'a determinées notre analyse ne se confondent pas avec les distributions théoriques en progression géométrique. Suivant une telle progression en théorie devraient exister 13 centres de caractère national, alors qu'en fait ils sont dix (capitale incluse). Ceci peut être la preuve d'un sous-développement des carrefours de communications correspondant aux grandes villes de voïvodies. En revanche il est plus de centres régionaux et subrégionaux en pratique qu'en théorie. Dans la répartition des centres subrégionaux il existe un net déséquilibre entre les centres secondaires et principaux au profit de ces derniers. Le diagramme théorique révèle donc une carence dans le développement des centres secondaires au nombre desquels il faudrait pouvoir compter certains centres micro-régionaux.

Le grand nombre de ces derniers apparait dans le tableau 2 comme une autre anomalie de la pratique. En théorie ils devraient être 81, alors que l'on en compte 97 (principaux et secondaires). Ces divergences dénotent un état de sous-développement des carrefours de communications polonais, lié au faible équipement des villes moyennes. Beaucoup d'entr' eux devraient en principe être développés jusqu'à accèder à la classe supérieure de la hiérarchie.

TABLEAU 2. Verification formelle de la distribution de fait des centres de communication

Classification des centres	Modèle thèorique pur	Distribution de fait	Modèle thèorique modifie	Modèle de Christaller
Capitale	1	1	1·0	1
Nationaux	3	2	3·15	2
	9	7	9·8	6
Régionaux et subrégionaux	27	35	31·0	18
Microrégionaux	81	99	99·0	54
Quotient	3·00	3·15	3·15	2·71

Nous sommes donc en présence d'une dispersion des noeuds de communications en Pologne, s'exprimant par un surnombre relatif des unités inférieures par rapport aux unités supérieures. Cette affirmation est totalement en accord avec le résultat des recherches effectuées sur le terrain par l'auteur.

De même que la répartition des forces productrices en Pologne, celle des noeuds de communications n'est pas équilibrée (comme le représente la carte ci-jointe, fondée sur l'analyse de la répartition territoriale des grands centres de communications). Furent considérés les centres d'importance nationale, régionale ou subrégionale et leur densité pour 10 000 km^2. Il est apparu que la mieux équipée est la voïvodie de Katowice qui en compte plus de 10. Cela n'est pas dû uniquement au développement du réseau de communications lui-même, mais surtout à la structure de l'armature urbaine, conditionnée elle-même par la richesse du sous-sol et la localisation des établissements miniers du G.O.P. L'existence d'une connurbation spécifiquement constituée, caractéristique d'ailleurs de certains bassins houillers européens, décide en effet du groupement de nombreux noeuds de communications. Au contraire — les voïvodies de Rzeszów, Varsovie (où il n'existe pas de carrefour en dehors

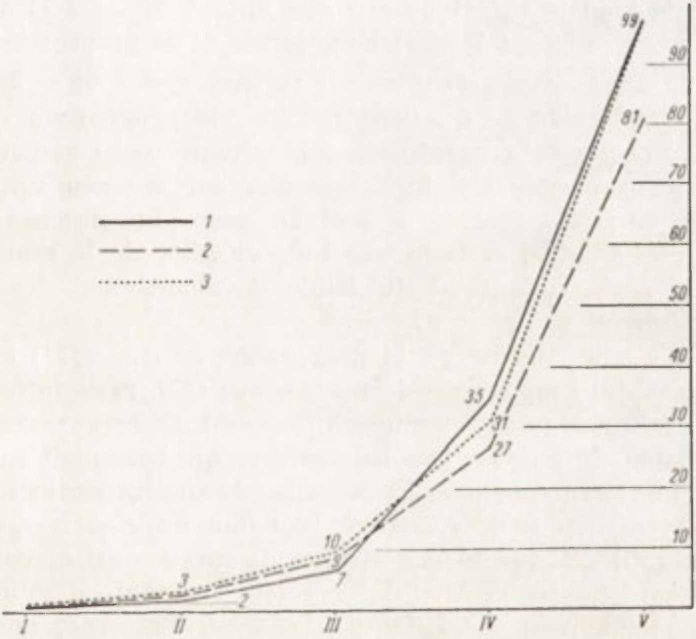

Fig. 2. Modèles existants et théoriques des types régionaux des noeuds de communication en Pologne.

1. ordre existant, 2. modéle théorique pur, 3. modèle théorique modifié. I. de la capitale, II. du pays plus grands, III. du pays plus petits, IV. régionales et subrégionales, V. du district. Ligne verticale — nombre de noeuds

de la capitale régionale), Olsztyn et Białystok sont les moins bien équipées.

De la verification formelle générale de la distribution effective ressort qu'existent deux divergences fondamentales entre le schémat théorique et la pratique:

1) Choisi comme rapport dans cette vérification, le nombre de 99 centres micro-régionaux est très caractéristique du développement relatif des noeuds de communications en Pologne. En effet, leur progression géometrique générale nous révèle un quotient de 3·15, non 3·0 comme l'indiquait le modèle théorique pur et d'autant moins 2·71 selon Christaller. Le nombre 99 est le quatrième terme de la progression géométrique $x^4 = 99$. Le quotient sera donc le suivant $x = \sqrt[4]{99} = 3{\cdot}15$.

2) En considérant ce quotient modifié de progression et en construisant la courbe de représentation graphique, nous remarquons que:

a) Les deux premiers termes (sans compter le terme initial 1) de la progression corrigée, arrondis à 3 et 10, sont plus proches du modèle théorique pur (3 et 9) et beaucoup plus éloignés de la réalité (2 et 7). Ceci est un indice éloquent du faible développement des centres de niveau supérieur.

b) Le troisieme terme de la progression corrigée (31) est plus important que celui proposé par le modèle pur (27), mais inférieur encore à l'état réel du réseau de communications (35). Et cette marge est justement de 4, soit du nombre exact de centres qui manquait sur le terrain aux deux premiers échelons. Le manque de quatre centres à l'échelon national et le surplus de quatre à l'échelon inférieur nous impose la conclusion qu'il est possible de réduire la carence au niveau supérieur en y déplaçant quatre centres de caractère régional ou subrégional. En étudiant concrètement les villes de l'échelon concerné, nous trouvons parmi les principaux carrefours régionaux: Gliwice, Opole, Białystok et Toruń et les quatre suivants: Częstochowa, Kielce, Olsztyn et Rzeszów. Pour la plupart ce sont des centres de régions de base à l'échelle de la voïvodie ou de grands centres subrégionaux. Tous devraient effectivement jouer dans le système des communications en Pologne un rôle plus important que celui qu'ils jouent actuellement.

La conclusion méthodologique générale qui s'impose à la lumière de ces réflexions peut être ainsi formulée:

Les principes théoriques fondés sur des formules purement mathématiques donnent seulement une image générale, approximative, schématique de la formation et du développement effectifs des noeuds de communications en Pologne. Cependant ce schémat est utile à la fois à la vérification de l'analyse typologique et à la formulation de postulats hypothétiques dans le domaine de la planification et du developpement des éléments de la structure spatiale régionale de l'économie nationale. Dans le cas qui nous intéresse ces éléments sont les noeuds de communications. Ainsi la confrontation de la disposition réelle avec les modèles théoriques purs ou modifiés peut être appliquée comme l'une des méthodes de la planification régionale.

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GENERALIZATION MODELS IN ECONOMIC GEOGRAPHY *

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1

Methodological problems in geography can be approached from two principal points of view, concerned with either (1) the subject and methods applied in this science, or (2) the logical character of propositions which build up geographical knowledge. Economic geography is composed, as all empirical sciences, of a certain amount of propositions accumulated during researches carried out by geographers. This leads to a question of the type of such propositions, which can be answered at its simplest by a suggestion to include geography into idiographic sciences following a well known division, introduced by W. Windelband [15] and H. Rickert [14], into idiographic and nomothetic sciences. According to them both groups are radically opposed to each other; nomothetic sciences lead to scientific laws, idiographic ones — to singular statements.

Consequently, the problem of scientific laws has induced fundamental discussions on methodological questions in the geographical sciences. R. Hartshorne ([6] p. 146) wrote on this subject as follows: "Of all the problems of current concern in the thinking of geographers, the most disturbing appears to be the question whether geography 'like other sciences' can develop 'the knowledge of the principles, laws and general truths' — or whether its function is merely to describe innumerable unique areas".

As the discussion of this problem is difficult because of the ambiguity of the notion "the scientific law", used by many authors in their descriptions of the structures and cognitive tasks of the fundamental types of learning, it seems worth while starting this paper by defining its meaning.

Literature concerned with methodology describes many various con-

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* The author considers economic geography to be synonymous with human geography in its broad notion, as opposed to physical geography.

ditions which are required for a proposition to become a scientific law. These conditions, however, have been influenced by the notion of the scientific law as developed on the basis of exact sciences, especially physics. The main problem, therefore, consists of discovering what kind of propositions should be classified as scientific laws.

It is generally accepted that for a proposition to be classified as a scientific law (an empirical science), it is necessary to be of a strictly universal character, and furthermore to comply with the following conditions: essential significance in a given domain of research, compatibility with commonly recognized facts, confirmation by prediction, empirical contents and universal acceptance by specialists from within a given branch of knowledge (J. Giedymin [5], p. 155).

From among the conditions listed above the first one, i. e. the strictly universal character, deserves fuller investigation, as it is a condition sine qua non for a proposition to become a scientific law (law-like statement).

The proposition is strictly universal unless spatio-temporal limits of phenomena described arise from its contents. Such limits can occur either in the form of proper nouns (e. g. "in England"), or of terms which cannot be defined without using proper nouns denoting mainly time characteristics (e. g. "in the nineteenth century"). It should be noted, moreover, that all time characteristics can be defined only by using proper nouns, e. g. by the passage of time from the beginning of our era. The strictly universal proposition, therefore, can contain neither proper nouns nor terms denoted by means of proper nouns.

Statistical statements reflecting the relative frequency of observable random variable can be rated among strictly universal propositions on condition, however, that the variable is not bounded by spatio-temporal co-ordinates.

It should be stressed, however, that the strict universality of laws does not mean that they are unconditional statements. Usually, they are expressed as conditional sentences according to the following pattern "always whenever conditions $C_1 \ldots\ldots C_n$ occur, they are followed by phenomenon Z" or "always whenever object X possesses quality F, it also has quality G".

Such generalizations which similarly to laws go beyond the contents of the investigated material, i. e. outside the framework of a report and therefore are bounded by spatio-temporal co-ordinates, should be differentiated from scientific laws. They are called statements of numerical universality or historical generalizations. This differentiation, introduced by K. Poper ([13] p. 6) implies that strictly universal propositions (scientific laws) are statements with an unlimited number of individuals, and therefore cannot be replaced by a conjunction of a finite number of singular statements. Statements of numerical universality (historical generalizations) refer only to a finite class of specific elements within a finite individual or particular spatio-temporal region.

2

After this introductory analysis, aimed at eliminating any misunderstanding in the notion of the scientific law, we may return to the fundamental question set by R. Hartshorne ([6], p. 146): "does geography seek to formulate scientific laws or to describe individual cases". I would like to suggest analysis of the following three questions: (1) what kind of statements, as far as the degree of their generalization is concerned, are made within economic geography, (2) does the subject of economic geography permit us to formulate scientific laws, (3) should an attempt be made at formulating scientific laws in economic geography.

The answer to the first question cannot be given without analyzing what in fact geographers do.

Geographers rarely speak about making laws and above all stress the individual character of investigated objects and relations. At the same time the perusal of geographical works shows that they contain many generalizations. They are characterized by a tendency towards more or less clearly defined spatio-temporal limits, and are, therefore, shaped as historical generalizations and not as strictly universal propositions, i. e. scientific laws.

Historical generalizations in economic geography have been shaped as yet in their qualitative form. The following proposition may serve as an example: "The growth of old towns in the same way as the creation of new cities (west-European) is not due to increased urban activities but to their transformation as a result of confrontation with new forms of labour and groupings of the population" (P. George [4], p. 57). Even if we do not propose to discuss the accuracy of the terminology, we should stress that a great majority of generalizations formulated in such a way do not possess a clearly defined general quantificator. That is why it is hardly possible to classify them — even within the spatio-temporal framework — as conditional statements of the type "each A implicates B", and they should be included rather in the group of the statements built on the pattern "*B* sometimes follows *A*", i. e. in the group of specific statements. Such generalizations seem to be worded as if on the verge of descriptions, and therefore they are hardly checked up systematically, or reworded.

It is not the aim of this paper to analyze in detail the logic of such statements; it should be mentioned only that many of them can be classified as hypotheses serving as the base on which proper historical generalizations are made up, first of all through presenting them in the more accurate form of statistical statements.

A broader application of mathematico-statistical methods in economic geography was accompanied by a more general use of quantitative historical generalizations, or generalizations formulated in result of a quantitative research. They are mostly shaped in the form of statistical relations. A good example of procedure and difficulties arising when generalizations of such a type are formulated is provided by the use of multiple-regression analysis by H. H. Mc Carthy and others [10] when they defined the degree of areal association among manufacturing industries in Japan and the US. This relation expressed in the form of the regression equation reads as follows:

$$Y = 0 \cdot 68\, X_1 + 0 \cdot 37\, X_2 + 0 \cdot 42\, X_3 + 0 \cdot 46\, X_4 - 44 \cdot 56$$

where Y is the distribution of the machinery industry, X_1 — the printing industry, X_2 — the chemical industry, X_3 — the spinning industry, and X_4 — the food industry.

Such generalizations, so often used in social sciences, although alien to methodological rigorism of exact sciences, constitute a considerable progress in the process of introducing generalizations to economic geography. Undoubtedly, many of them are worded with a certain degree of caution, and might be treated as hypotheses for more universal propositions. This, however, makes it necessary to define the theoretical base for the construction and estimation of descriptive equations as models for presenting such relations.

It can be said with a great degree of reliability that propositions which can be accepted as strictly universal statements, i. e. scientific laws, in economic geography are scarce. Some authors as W. Warntz [16] in the case of his "law of price" did make an attempt at drawing up such statements, but a closer analysis reveals that they are in fact nothing else but typical historical generalizations with clear spatio-temporal limits, that they refer to the territory of the US only, and cannot be applied in a broader sense without further systematic cheking up and rewording.

I would like to end this chapter with saying that in economic geography generalizations in the form of historical generalizations (and not of scientific laws) predominate, and that only quite recently under the influence of a broader application of mathematical methods a tendency has been visible to carry out systematical research aimed at the introduction of quantitative generalizations.

3

The second question is whether the subject of economic geography permits us to formulate scientific laws. Two views are represented in discussions: (1) the negation of the possibility of formulating scientific laws in the domain of social sciences which also include economic geography, (2) the conviction that under the existing division of labour, economic geography represents a tendency to specify and not to generalize.

When the scientific law is understood as a strictly universal statement, in the domain of social sciences we are confronted with two characteristic views which — to use terms introduced by J. Giedymin ([5], p. 149) — can be called naturalistic and anti-naturalistic. The naturalistic approach maintains that the patterns of tasks and methods applied by natural sciences are applicable in investigations of social phenomena and therefore scientific laws can be formulated in social sciences. The anti-naturalistic approach is opposed to this thesis. It can be best exemplified by the doctrine of indeterminism quoted by R. Hartshorne ([6], p. 153). The thesis of inability to make experiments in social sciences, the thesis of the limited repetition of social phenomena, and the phenomenon of the influence exerted by the process of investigation on its subject and expressed in the self-destruction and self-realization of predictions — may serve as further examples of anti-naturalistic arguments.

Even without discussing in detail views expressed by anti-naturalists we may state that in the light of results achieved by such disciplines as sociology, social psychology and economics in the field of formulating scientific laws, their arguments cannot hold good. Such laws are, however, scarcer than in exact sciences, usually statistical in their character, often inadequately proved, and not always universally accepted. Lately, however, research on the basis of general hypotheses, systematically collected and verified, has greatly developed. This tendency has been hampered i. a. by the antagonistic approach to projects of applying statistical and mathematical methods, which form real progress in the procedure of making general statements.

The conviction that scientific laws can be formulated by social sciences does not necessarily mean that the same is true for economic geography, or that the scope of this discipline permits of their formulation. If, following R. Hartshorne ([6], p. 21) we state simply that geography is concerned with providing accurate, orderly, and rational description and interpretation of the variable character of the earth's surface, such a goal does not eliminate the possibility of constructing generalizations concerned primarily with spatial relations. A descriptive approach, or better the description of individual events and relations, can be treated as either (1) a goal in itself, with the main interest focussed on individual relations, or (2) a starting point for formulating a certain general relation. When we, for example, analyze the growing degree of industrialization in a given town, induced by changes occurring in the structures of settlement, trade and services, the geographer is fully entitled to describe either this single case, or a certain group of cases, or also — if he wishes — to extend his research of the relations between industrialization and the structures of settlement, trade and services also on other towns, and thus to a try to discover a universal relation concerned with a certain group or type of industrialized towns. The first approach, which we can call a particularizing analysis, belongs to the traditional domain of geography, the second one — a generalizing analysis — shares common ground with other social sciences.

Generalization is in principle an inductive method. The inductive procedure aimed at forming universal statements is in economic geography faced with fundamental difficulties. Even if we do not propose to mention such difficulties, well known and widely discussed by other social sciences as those connected with comparability, a great number of multiple factors and a high degree of functionalism in investigated phenomena, we must pay attention to one question which is of special significance for economic geography, i. e. the fact — which was discovered by S. Nowak ([11], p. 30) — that socio-economic phenomena, analyzed from the viewpoint of their spatial aspects, tend to occur stubbornly in some durably correlated complexes with a defined spatio-temporal location.

The reason why geography limits itself to presenting only spatial location of a given phenomenon is the difficulty in tracing among a great number of factors varying spatially those which determine the given consequence. The geographer knows that the region in which a certain socio-economic phenomenon occurs, differs from other regions in many qualities out of which only certain are of significance to the occurrence of this phenomenon. Not knowing, however, how to discover them, he only defines the area in which the investigated phenomenon occurs. Those unknown components which determine the occurrence of the phenomenon under investigation, are often replaced in geographical research by spatio-temporal co-ordinates (regions). Thus, spatio-temporal co-ordinates are used as substitutes in certain complexes of conditions whose causal influence cannot be fully recognized and defined.

Analyzing the problem from this viewpoint we are faced with the question of whether spatio-temporal limits are specific only to the subject and methods applied in geography. It seems that the answer must be positive. Spatio-temporal co-ordinates, however, are used not only as substitutes in historical generalizations when components of more universal relations are missing, but also to provide information about the range of occurrence of unknown factors. The discovery of such factors will permit of replacing spatio-temporal co-ordinates by some defined complexes of conditions, and thus make it possible to formulate strictly universal statements, i. e. scientific laws.

4

The third problem is to find an answer to the question whether or not geographers should make an attempt at formulating scientific laws.

Should the postulate of the maximal empirical evidence, or to put it in other words the least risk of obtaining distorted results, be a unique one which we have to fulfil when making scientific propositions — then it would have been necessary to give up beforehand all broad generalizations or generalizations entirely free from spatio-temporal limits. It is, however, a general requirement that the smallest possible number of scientific propositions should be able to explain the greatest possible number of phenomena. Such superfluous caution results in lack of economy in formulated statements; at the same time a too rash generalization creates a risk of their distortion. The dispute over the degree of generalization is above all a dispute over the approach — an empirical or a theoretical one — which the research worker should choose.

If we propose to implement the principle of economy in thinking, generalizations, i.e. the broadest propositions, make real progress.

In the domain of economic geography historical generalizations are much easier to make than strictly universal propositions; the danger of their distortion is lesser. Modern methodology requires, however, the formulation of the possibly broadest generalizations, free from spatio-temporal limits, i.e. strictly universal statements, because they contain more valuable information. Strictly universal statements make it possible to differentiate permanent relations and to arrive at the conclusion that the implementation of certain conditions (events) in any time and at any place is always followed by some defined consequences. The discovery and the making of such statements provide, therefore, knowledge needed for the transformation of reality.

In summing up I wish to state that in economic geography in contrast to the dichotomy (scientific law and individual fact) clearly visible in the works by W. Windelband and H. Rickert, and subsequently by R. Hartshorne, there is an intermediate phase, i.e. the historical generalization. At the same time an important methodological difficulty also occurs as to how to overcome the spatio-temporal limits. Mathematical and statistical methods, and particularly mathematical models, are means which may solve this problem. It is, therefore, advisable:

(1) to carry out theoretical studies of principal problem complexes in economic geography, such as: agricultural and urban land use, industrial location, trade location, location of towns and the transport network. This will make it possible to draw up a number of hypotheses for separate problems with various degree of generalization.

(2) to work out one's own systematic methods of verification and transformation of such hypotheses into commonly recognized propositions in the form of historical generalizations and strictly universal statements.

(3) to arrange loose sets of general statements into theoretical systems internally consistent and hierarchically ordered.

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TRENDS IN THE DEVELOPMENT OF THE POWER INDUSTRY IN POLAND COMPARED WITH TENDENCIES PREVAILING IN EUROPE

ANTONI WRZOSEK

Today electric current is the world's leading form of energy. Of the natural sources of energy utilized by man almost all water power is converted into electrical power, and the same refers to nuclear energy. Moreover, a large part of the coal, lignite, petroleum, and in particular of the natural gas output, is used for the production of electricity. Versatility, non-storability, and also intense concentration accompanied by widely dispersed consumption are the specific features of electric energy as a productive force which define the economy of electric power. Both the structure of its production and the structure of its consumption show, in various parts of the world, different features and phases of development, in spite of general analogies.

The electric power industry in Poland has in recent years evolved along different lines from that noted in the majority of the world's main power centres, particularly in the USSR and the main countries of Western Europe. A comparison between the structure of the power industry in Poland and the USSR would be useless because of enormous differences in the size, population, natural resources and spatial structure of the economy in these two countries. It might, however, be of interest to determine the similarities and differences between Poland and those main West-European countries of similar size and population figures, and therefore comparable internal economic structures.

The characteristic features of the evolution of the electric power industry in Western Europe over recent years are as follows:

1) the significance of solid fuel and in particular of coal is evidently diminishing whereas that of petroleum products and natural gas is increasing. In 1950—1958 lignite as a source of energy for power stations played an important role in the Federal German Republic, and to a certain extent in France and Italy, but no new power stations operating on lignite have been built since that time.

2) the replacement of coal as the energy-producing fuel by petroleum products occurs not only in countries such as Italy, which imports almost all of her coal, or France and Holland which partially import their coal, but also in countries such as Great Britain or the Federal German Republic with rich coal resources. Petroleum products are usually imported, often entirely, as in the case of Great Britain.

3) the output potential of installed generating power stations doubles approximately every ten years,

4) approximately half the new power stations are built in places possessing natural sources of energy, slightly less than half near places where there is demand for power, the remaining are what may be called "self-supporting" (based on local sources of energy and producing electrical power for local needs only). In recent years there has been a tendency to build numerous stations on the coast, near ports. These are oriented towards imported fuel and often built in such a way as to be easily converted from coal to oil or gas, or vice versa (they are known as „swinging power stations").

5) nuclear power stations have already successfully competed with conventionally fuelled power stations. As a rule they are localized in regions with an energy deficit. They are of greatest significance in the power balance of Great Britain where in 1964 already almost 10 per cent of the installed capacity was generated in nuclear power stations, of less significance in Italy and France, and of least importance in the German Federal Republic.

6) all the most convenient water-falls have already been utilized in all countries of Western Europe. But the steadily growing efficiency of conventional thermal power stations makes the building of new hydro-electric stations unprofitable. That is why the proportion of hydro-electric energy in the total electricity output is rapidly falling, in particular in countries where it has been quite high up to now (e.g. in France and Italy) and where hydro-electric stations are still being built. The only exception is Norway, where, because of exceptional natural advantages the cost of investing in hydro-electric stations is still much lower than the cost of a new conventional power station.

7) in the neighbourhood of large thermal power stations, which are inadequately adapted to fluctuations in the demand for energy, pumped storage stations which use cheap off-peak electricity produced in thermal power stations and transmit it in smaller amounts at peak periods, are being built more and more frequently. They are, therefore, a kind of a regulator which adapts the amount of energy produced to its consumption during the twenty-four hour day.

Before World War II Poland's electricity supply industry, was greatly underdeveloped, and she was classified among the least electrified countries. In 1938 the total energy output amounted to less than 4 thousand million kWh, i.e. only 114 kWh per inhabitant. This figure was half that for Switzerland and much less than those for Belgium and Czechoslovakia. In 1966 Poland's output already amounted to 47 · 4 thousand million kWh, i.e. 1490 kWh per inhabitant. Poland has largely made up for her backwardness in the development of power production and has overtaken the above mentioned three countries, while the per capita figure has approached the Italian level. During the first two six-year periods output doubled, first in 1946—1952, secondly in 1952—1958. Then the expansion of output slowed down and during the following eight years amounted to 98 per cent. Thus, during the whole twenty years of post-war Poland, from 1946 to 1966, there was an eightfold rise in the production of electric energy, which is double the average rise in world output. Poland's percentage share in world production increased from 0 · 85 per cent in 1938 to 1 · 3 per cent in 1965.

The number of power stations is steadily decreasing because old small stations with unsatisfactory economic indices are being closed down, and generating is being concentrated in new large modern stations. This process contributes to better technical and economic indices in the power industry. The average thermal efficiency of conventional power stations increased from 19 · 6 per cent in 1955 to 27 · 8 per cent in 1965, and the amount of fuel needed (expressed in comparable units) to produce one kWh of brutto energy decreased from 578 g in 1955 to 404 g in 1965.

The total number of power stations operating in Poland in 1965 amounted to 381, which included 44 public supply thermal and 123 hydro-electric stations, and 214 other stations belonging mostly to various industrial plants. The 60 thermal power stations generate as much as 83 · 8 per cent of the total output whereas hydro-electric stations are usually small, and generate only 2 · 1 per cent of the total electricity supply. Industrial stations supply 14 · 1 per cent of the total production.

Public supply thermal stations conform in size to similar stations in leading industrial countries. Poland's largest generating plant at Turoszow (1400 MW) is one of the largest in Europe, six other are capable of transmitting more than 300 MW, and fourteen more than 100 MW. Industrial stations are smaller, but also include two which transmit more than 100 MW. The chemical industry controls a third of the total generating capacity of industrial power stations, followed by coal mining, metallurgy, engineering and sugar refining.

A comparison with tendencies prevailing in West European electricity production reveals the following differences in Poland:

1) solid fuel as the source of electric energy has always played (and still plays) a dominant role. In 1960 the proportion of solid fuel in the total consumption of primary energy sources in Poland amounted to 97·2 per cent, i.e. was the highest in the world. It seems likely that in the next decade this proportion will decrease to a very slight extent only. Since 1958, however, lignite has been systematically replacing coal, and the proportion of electricity produced with lignite increased from 1·2 per cent in 1957 to 30 per cent in 1966 and will continue to increase.

2) liquid fuel and gas, contrary to trends prevailing in most countries, are not competitors to solid fuel as a raw material for the production of electric energy. It is true, of course, that Poland is better endowed with solid fuels than with liquid fuel and gas.

3) in spite of this seemingly obsolete structure of the power balance, with solid fuel dominating, the annual rate of increase in electricity production in Poland up to recently exceeded and now equals that of all the European countries.

4) as far as the location of new plants is concerned, there is a tendency in Poland (stronger than in West European countries) to concentrate these near raw material deposits, rather than in regions of demand. This is partly due to the closing-down of old, small power stations situated where demand was high, and their replacement by large new coal-fired plants located near coal or lignite deposits which in Poland are concentrated in few particular regions. As Poland does not import fuels from overseas, new power stations are not being constructed on the coast.

5) no nuclear power stations have yet been built in Poland and it is hardly likely that any will be built before 1975.

6) for Poland the period when it was more economical to build hydro-electric rather than thermal power stations coincided with a time when there was little chance of developing the Polish economy and expanding the existing electric grid. Therefore only a few hydro-electric stations remained from those times. Because of the absence of advantageous water-falls and the deconcentration of water power, hydroelectric station even now cannot compete with modern thermal power stations, or even contribute greatly to the Polish power industry. A number of hydro-electric stations are being and will continue to be constructed, but electricity production is only one of the aims of these investments which are also intended to aid flood control and river navigation, increase the public water supplies, and even contribute to irrigation schemes. These new projects will not, however, increase the proportion of water power in the production of electric energy.

7) up to the present day Poland possesses only one pumped storage station on the river Bobr with a capacity of 79 MW. Several new pumped storage stations will be constructed during the next few years thus bringing Poland into line with the system of adapting energy supply to demand, typical of Western Europe.

To sum up it might be said that the leading feature of the Polish power industry is its reliance on solid fuel to a much greater degree than in all other more industrialized countries. Such a system has its negative aspects, but also an important positive element, i.e. the fact that of all medium European countries Poland's power industry is based to the maximum degree upon her own resources and her dependence on imported sources of energy is negligible. In future the sources of energy will certainly be more differentiated, and oil and gas will be used on a larger scale. There are few grounds, however, for assuming that solid fuel will lose its significance and fight a losing battle against oil and natural gas. Of interest in this connection is the fact that in the USA, which has such rich oil and gas resources, the latest aluminium plants built after 1958 on the river Ohio in the NE central region, are based on conventional power stations fired by coal, which turned out to be more economical than oil or gas.

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AGRICULTURAL TYPOLOGY. AGRICULTURAL REGIONALIZATION. AGRICULTURAL DEVELOPMENT

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Although an attempt to approach the areal problems of agriculture in a more synthetic way is as old as agricultural geography itself, the last thirty years have witnessed a great expansion of studies of what is known as agricultural systems, types of farming, agricultural types and regions, farming type regions etc., carried out on world, national or regional scale. As it was already pointed out several years ago [1], the results of those studies are hardly comparable or can be used for further syntheses, since the criteria, methods and techniques applied to determine types or regions vary greatly.

At the same time geography, at present no longer satisfied with merely discribing the distributions of various phenomena over the earth's surface, seeks for a more synthetic approach to its problems. This, in view of growing specialization in geographical sciences, is becoming more and more difficult unless more accurate methods and techniques that enable comparative treatment of the objects studied and their scientific classifications are worked out and applied.

Besides, last but not least, the growing needs of world population for food and raw materials require not only constant improvement of agricultural techniques but also some type of agricultural planning or programming. As any type of planning in general the programmes of agricultural development require not only that studies of particular elements or phenomena should be made, but above all, a better and more synthetic knowledge of the subject which is to be planned, i.e. agriculture as a whole in relation to other — similar or different — more advanced agricultures. Such knowledge is of practical importance only when accurate methods, making comparisons possible, have been applied.

Here, the scientific and practical aims of agricultural studies meet, requiring both improvement and unification to a certain degree of

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[1] Derwent Whittlesey, Agricultural Regions of the World, Ann. Ass. Am. Geogr., 26 (1936), pp. 144—240.

methods and techniques used and also a more synthetic study of agricultural phenomena and their typological and regional classifications.

To cope with all these problems a special IGU Commission for Agricultural Typology was established in 1964.

The tasks of the Commission were determined as follows[2]:

(1) to establish the principles, criteria, methods and techniques of agricultural typology

(2) to initiate, to promote and to coordinate the regional studies on agricultural types based on the criteria recommended by the Commission

(3) to work out the typological and regional classifications of world agriculture.

To reach these aims two questionnaires on principles, basic notions, criteria, methods and techniques of agricultural typology were distributed in 1965—1966 among the interested scholars. Over 50 answers to the questionnaires provide a rich and interesting material, used as a basis for the present paper[3].

AGRICULTURAL TYPOLOGY

In result of the discussion on the Commission questionaires the following principles and basic notions for agricultural typology were accepted:

— "type of agriculture" without any adjective (tout court) should be accepted as the supreme notion in agricultural typology,

— type of agriculture should be understood in a broad meaning including all forms of crop growing and livestock breeding,

— type of agriculture should be understood as a hierarchical notion encompassing types of the lowest order, several intermediate orders of types, up to the highest ones — world types of agriculture,

— type of agriculture should be understood as a dynamic notion which changes either evolutionarily or revolutionarily along with the transformation of its basic characteristics,

— type of agriculture should be understood as a complex notion combining several aspects or characteristics of agriculture.

An agricultural holding, in the sense defined for the FAO international censuses, is considered to be a basic unit in agricultural typology. At the same time, however, despite all its deficiences, in macro-scale studies and particularly when dealing with a large number of small-scale

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[2] See IGU Newsletter, 16, 1965, 1, pp. 37—38.

[3] See the answers to the questionnaires mimeographed: Principles, Basic Notions and Criteria of Agricultural Typology, Discussion on the Commission Questionnaire No. 1, Warsaw 1966, 66 p. and Methods and Techniques of Agricultural Typology. Discussion on the Commission Questionnaire No. 2., Boulder, Colorado 1967, 88 p.

holdings for which no separate data are available (village agricultures etc.), there seems to be no other alternative than to use other units (e. g. administrative). We should be aware, however, that in doing so we have to deal with aggregate indices or averages for the areas in which a whole variety of characteristics of an agricultural holding are hidden in various ways. Such indices and averages might cover up various, often contrasting or complementary types of agricultural holdings and in consequence may reflect only more or less approximately the real pattern of agricultural characteristics. That is why even in the macro-scale typological studies the detailed surveys that not only check the magnitude of divergences between the averages and the real units of operation (agricultural holdings) but also assess the accuracy of statistical data are, wherever applicable, strongly recommended. On the other hand, once the agricultural types and their typifying characteristics have been distinguished on the basis of sample studies of individual holdings — the analysis of the range or distribution of those types over a given territory can be continued on the basis of statistical data reflecting only those characteristics.

In accordance with the opinions expressed by the majority of the answerers to the questionnaires and logic of any classification the definition of the type of agriculture should be based on internal or inherent characteristics of agriculture. External characteristics or rather conditions in which agriculture develops, however important they are for the explanation of the reasons why, and why exactly at a given place, a particular type of agriculture has developed, are not proper bases to determine types of agriculture.

What are, however, these external conditions of agriculture?

It is obvious that each particular type of agriculture is the result of a combined action of a complex of social, technical, economic and cultural processes developing in defined natural conditions so that no type of agriculture develops in isolation but is associated with the natural, social, technical, economic and cultural environment of a given time and place.

It is, however, more debatable whether the natural environment should be considered as an external condition of agriculture or not. According to classical economics — land, understood broadly as all natural forces and conditions, together with labour and capital were considered to be the three main factors of agricultural production. It seems, however, that in the light of more recent developments in geographical and related sciences, the uniform approach to the above three notions is no longer correct. While labour and capital (means of production) are actually such factors inasmuch as they actively enhance or promote the development of agriculture, land or more generally speaking natural environment can hardly be considered a factor actively determining agricultural development. Nature does not create or develop by itself any form of agriculture, but it creates conditions which — being better or worse utilized by agriculture through labour or capital inputs — only limit to some extent technical or economical possibilities of agricultural development.

Irrespective of their order and the area studied, the definition of types of agriculture should always be based on the same general principles and criteria. The difference is that in case of types lower in hierarchy the search for more detailed differences would require more indices and sharper and more precised techniques. On the contrary, for types higher in hierarchy, the indices and measures could be more and more general and less numerous.

The incompleteness and paucity of data available in some countries will make it necessary to base some typological studies on estimates rather than on statistical data. But even in the most developed countries agricultural statistics do not often contain all the items required for a sound agricultural typology and are seldom fully accurate. So even in those countries the estimates are used in many typological and other synthetic studies.

But in the countries that "are not so well developed as they might be" [4], where some data are either entirely lacking or incomplete and the statistics are not sufficiently reliable, the use of estimates based on a good knowledge of the country's or regional problems is not only inevitable but might even give better results than the use of unreliable statistics. The differences in typological characteristics between particular types of agriculture are usually so great that if only their range is established it might be sufficient for macro- scale studies.

The criteria or inherent characteristics of agriculture could be classed into the following three main categories: those of the social, organizational-cum-technical (functional) or economic (productional) nature responding to the three principal questions viz. (1) who is the producer, (2) how the produce is obtained, and (3) how much, what and for what it is produced [5]. Accordingly, these three categories should be considered as defining jointly the type of agriculture and none of them could be omitted although their importance for distinguishing various types of agriculture may greatly vary.

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[4] W. Van Royen, The answer to the 1-st questionnaire, see Principles ..... pp. 63—66.

[5] For more detailes see J. Kostrowicki and N. Helburn, Agricultural Typology, Principles and Methods (mimeographed), Boulder, Colorado 1967.

The social characteristics of agriculture are those indicating who is the producer, whether he is the owner of the land he cultivates or the tenant, what is then the form or system of land ownership and operation, who provides labour and capital, what is the scale of operation, etc.

The organizational and technical characteristics are those indicating how the produce is obtained, what are the measures, practices and means applied to achieve agricultural production and to maintain soil fertility. They could be divided into the following three groups:

— organization of agricultural land i.e. what is the setting of land holding, its pattern, land fragmentation etc., in other words, the problems connected with what is known as agrarian structure and land utilization,

— measures and practices applied in the management of natural conditions (land forms, water, soil, climate etc.), in crop growing (land or crop rotation systems, perennial crop cultivation systems, systems of grassland use), in livestock breeding etc.

— intensity of these measures and practices i.e. the amount of human, animal and mechanical labour applied (amount of labour and capital inputs = intensity of agriculture).

Production characteristics are those which indicate how much, what and for what it is produced i.e. what is the land, labour and capital productivity, what is the degree and level of commercialization of agricultural production and what are the dominant enterprises in agricultural production and in its commercial part (orientation and specialization of agriculture).

As a result of typological investigations several measures and indices characterizing various aspects of agriculture are usually obtained. The number of those indices varies according to the level and the accuracy of investigations. However, for the purposes of comparability a minimum set of such measures and indices should be established to characterize each possible type of agriculture of any order.

Yet it is to early to establish such a final and universal list of measures and indices. On the basis of up-to-date experience, of the answers to both questionnaires and of the discussions at the Commission meetings, the preliminary list of characteristics has been set up[6], subject to change as a result of further discussions and testing studies initiated by the Commission in various countries. While some of those characteristics may be found of little importance, it is almost certain that some features characterizing non-European agricultures were omitted and therefore should be supplemented.

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[6] See above.

The definition of a certain number of typological characteristics does not solve the problem of agricultural typology. The next question is how can one, having more or less numerous indices that characterize agriculture, come to combine them in such a way as to arrive at a definition of the type of agriculture.

There are several methods of combining or integrating areal phenomena that could be of use here. They are ranging from most simple and primitive ones such as cartographic superposition or scoring, through various graphic methods, cross-tabulation or deviations from model types, to the most sophisticated mathematical ones such as multifactor or latent structure analyses. These methods should be tested as to their applicability to agricultural typology.

AGRICULTURAL REGIONALIZATION

Similarly to agricultural types the definition of agricultural regions should be based rather on inherent characteristics of agriculture itself than on the conditions in which it develops. This, however, does not lessen the importance, for both scientific and practical purposes, of the regions delineated on the basis of assessing natural and other external conditions of agriculture.

As agriculture is a complex phenomenon such regionalization would be of more importance if the requirements of particular practices and techniques, individual crops or animals raised, particular systems or orientations of agriculture are assessed in relation to the natural conditions as a whole, than when the individual elements of natural environment are assessed separately from the viewpoint of the whole agriculture.

At the same time it is fully advisable to assess the areal differentiation of the role played by agriculture in national or regional economy as reflected in the total land utilization, and in the relation of agriculture to industrialization or urbanization or the other external conditions. All the regional divisions resulting from the above are not, however, and should not be confused with agricultural regions.

The latter are to be singled out and delineated on the basis of combinations, complexes or patterns of agricultural characteristics, in other words, of types of agriculture.

Since the same agricultural characteristics are also to be applied to define types of agriculture, the question may be raised what is the real difference between agricultural type and agricultural region. In fact, although the problem of differences between typological and regional classifications has been widely discussed elsewhere, these two notions are often confused not only in agricultural geography.

The most simplified answer is that type and region belong to two different categories of notions. Type is a systematic or taxonomic notion based on similarities or affinities between individual phenomena. Since certain associations of phenomena that determine particular types, repeat themselves in time and space, the same types could be found repeated in various periods or areas. As those sets of associations usually occur in space in the form of a mosaic, the resulting types do not necessarily form any continuous areas but usually are dispersed and intermingled with other types.

Region, on the contrary, is a spatial or territorial notion based on differences between individual areas rather than on the similarities or affinities. Consequently, region is a continuous portion of the earth's surface, extending within determined limits and characterized by a peculiar set of characteristics different from all the others, which impart it its unique character.

On the other hand, both type and region are hierarchical notions. The hierarchy of types is, however, of a systematic character. Based on their similarities, individual types of lower order are grouped together into the types of higher order irrespective of their distribution over the earth's surface, while regions of a lower order always form territorial parts of regions of a higher order, each of the latter comprising more than one region of a lower order.

In the past and sometimes also at present, agricultural regions have been delineated by the same primitive methods of superposition or summation of the scores. The accurate delineation of agricultural regions, when typology has not been made, has to undergo the whole procedure that was many times discussed in connection with economic regions in general and with integrated, homogeneous regions in particular.

When agricultural typology has been made, the regionalization procedure can be restricted to the generalization of results obtained by agricultural typology. Regional units could thus be formed on the basis of dominance, co-dominance or co-existence of particular agricultural types in a given territory. It is, of course, desirable that the generalization is based on some precise methods.

The above principles refer to complex agricultural regions. At the same time, one can stress the need for more elementary or partial regions, based on individual elements of agriculture (rice, sugar cane, etc. regions or zones), and singled out by both natural measures and relative figures, or for more synthetic notions, based on total or particular social, functional or production characteristics (size of holdings, crop rotation systems, irrigation systems, productivity, commercialization, agricultural orientation, specialization etc.).

AGRICULTURAL DEVELOPMENT

A better knowledge of agriculture on a world, regional and national scale, and sharper methods and tools of investigation acquired from typological and regionalization studies not only serve scientific objectives but also may be of some practical importance. In particular they may be used for:

— better assessment of the present use of agricultural resources and its future possibilities,

— better assessment of agricultural characteristics impeding the development of individual types of agriculture and of other features that accelerate such a development,

— based on better understanding of the characteristics and achievements of the same or similar types of agriculture — a better definition of directions of further agricultural development through transformation of present types of agriculture into other, more effective ones:

It seems that between the typological procedure concerning the present state of agriculture and that relating to a desirable one in the future, is not much difference as far as methods and techniques are concerned. Planning and programming of agricultural development is nothing else but an attempt to outline, on the basis of scientific premises, desirable future agricultural types and regions through prediction and change of their basic characteristics.

Once agricultural typology and good assessment of natural conditions in a given area are achieved, a careful study of the future external conditions, needs and possibilities of agriculture should follow. Possible changes in the general social structure and in technical level and economic status of the country or region concerning the general level of industrialization and urbanization, supply and demand for labour resources, food and industrial raw materials, degree of mechanization, future transportation facilities, accessibility to the markets and manufacturing centres, growth of the national income, foreign trade possibilities etc., etc. have to be assessed from the viewpoint of what is likely to be possible and practicable.

Having thus acquired a profound knowledge of the existing agriculture and its present and future potential possibilities one could proceed to establishing future model types of agriculture. These desirable and economical, perspective model types of agriculture to be attained in determined external conditions and in a determined period, understood as complexes, should be characterized each by a set of specific social, functional and production characteristics, by specific intensity, productivity and commercialization, by specific orientation and specialization.

Similarly to the typology of the present agriculture also the future model types can be built either on basic units (types of holdings), or on units of the higher order. And again the generalization of such perspective model types of agriculture can lead to the delineation of the future perspective agricultural regions, by similar methods and techniques to those used in the delineation of the existing agricultural regions.

The final task consists in outlining ways of transition from the existing agricultural types and regions to the future, desirable ones that are possible to be attained.

In practice agricultural planning often proceeds directly from the study of natural conditions and potential possibilities to the desirable objectives determined in terms of areal units, yields of particular crops and productivity of animals. Such a method is both oversimplified and insufficient. First because proper realistic planning cannot give up the analysis of the present state of things, which particularly in agriculture cannot be changed or shaped optionally because of their natural or non-natural dependences. Secondly, planning is not realistic if the ways of transition from the present to future state of things are not accurately determined. Here again a good knowledge of the present state of agriculture is necessary. Finally, planning of separate indices or effects of agricultural production and delineating future agricultural regions on this basis, without knowing which agricultural characteristics should be changed in order to obtain the desirable effects, make the results of such planning equally unrealistic. Agriculture is not a simple sum of individual elements but a set or system of interrelated phenomena in which a change of one of them may result in a change of the other. Therefore any realistic and competent planning or programming of the agricultural development should take into account all important characteristics of agriculture, it should predict and estimate their possible changes and consider how these changes could affect other characteristics. In other words, it should consider the nature and the direction of the change in the types of agriculture from the present to the future ones.

Because of the complex character of agriculture and its dependence or sensivity to changes of its natural and other external conditions, every plan of agricultural development should be general, specific and flexible. The plan should lend itself to easy verification, change of transformation as more knowledge is gained with respect to the potential conditions and way of their use, to the present state of agriculture or in the event of changes in methods or objectives of planning.

Agricultural typology approaching with unified methods and techniques, world and regional problems of agriculture, giving a synthetic and comparable assessment of its present status and characteristics, based on the methods and techniques possible to apply in agricultural planning — may contribute to a better efficiency of such planning.

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As we can see from the above, the whole problem of agricultural typology is important both for the future development of agricultural geography and for solving practical problems of agricultural development. But the task is hard and difficult and could be solved only by common efforts of the many.

May I end this paper with an appeal to all who feel interested in the problems presented above to join the Commission, and to help by discussing the principles, criteria and methods, by testing them in regional studies and by working out the agricultural typology on a world, regional and national scale.

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TYPES OF AGRICULTURE IN NORTH-EASTERN POLAND

(Białystok voivodship)

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The present paper is a tentative typology of agriculture in north-eastern Poland on the example of the Białystok voivodship, applying the main principles, methods and techniques of the typological studies now being used by agricultural geographers in Poland and also recommended by the Commission for Agricultural Typology of the International Geographical Union.

The Białystok voivodship covers an area of 23,100 sq km in north-eastern Poland; it is quite considerably differentiated both as regards natural environment and agrarian structure as well as the farming technics, the level and the orientation of agricultural production. For the above reasons it provides a good example for typological studies of agriculture on a mezo-scale.

The smallest administrative unit, the *gromada* was taken as a basic unit for study, the average area of this unit being about 70 sq km. Agricultural statistics covering the years 1963—64 and a few monographs provided the source material for study.

The complex character of agricultural production depending on natural, social, economic and organizational-technical condidtions, and on the level of agricultural production, its structure and purpose, clearly defines the range of problems that are the subject of agricultural research. The complex and manifold problems of the agricultural typology J. Kostrowicki reduces to three groups of problems [2] which he defines as the basic typological features of agriculture. They are: (1) socio-property relations; (2) organizational and technical features and (3) production (economic) features of agriculture.

The analysis of the above features, encompassing a number of essential problems which serve as further typological criteria, serves as a basis for distinguishing the types of agriculture on a studied area. Owing to the wide scope of the study and also the gaps in part of the statistical data, not all the typological features of agriculture have been elaborated with the same degree of accuracy. Sometimes, when analysing concrete problems, it was even necessary to resort to estimates or else apply unitary indices instead of synthetic ones. When examining the types of agricultural economy on a given area one cannot disregard the natural conditions and general socio-economic conditions in which certain types of agriculture have been developed.

As regards the natural background which determines the potential conditions of the development of agriculture, and plant production above all, the Białystok voivodship is greatly differentiated. The selected elements od the natural environment that were examined are: land relief, climatic and water conditions, and soils. They all are of essential importance for agriculture and decisive for the edaphic conditions of plants growth, and they revealed the existence of four natural-agricultural regions characterized by a different degree of influence of the natural environment on the farming techniques.

(1) The Northern Region, encompassing five powiats, apart from the good soils (3rd and 4th class) with a high percentage of brown forest soils and abundant rainfall (600—700 mm annually) does not provide favourable conditions for plant cultivation. The developed land forms (the slope inclination is more than 8°) over large areas, the short vegetation season (180 days) and the light frosts occurring late in the spring and early in the autumn — all create great difficulties for agriculture.

(2) The Region of Ice Marginal Valleys *Pradolinas* encompasses the area of the wide valleys of rivers Biebrza and Narew with extensive areas of sandy and boggy soils (5th and 6th class). The lack of a proper drainage and irrigation system (high level of the undeground water) and the specific micro-climate mean that at present it is an area marked by the predominance of permanent grassland not very well utilized for agricultural production.

(3) The South-Eastern Region encompassing 7 poviats: here light sandy soils (4th — 5th class) predominate and there is a great difference in the abundance of rainfall in various years, which means that the natural conditions for plant cultivation are not very good.

(4) The Western Region, encompassing 4 poviats has the best soils in the whole voivodship (average podzolized clayey soils 3rd — 4th class) and the best climatic conditions (vegetation period lasting 200 days). Agriculture has good development conditions there.

The general alignment of socio-economic conditions in the past did not promote the development of agriculture in the Białystok region. The low level of industrialization and urbanization, the poor local market and inadequate transport links, as well as the geographical situation in the border zone, were the reasons for the low economic level of the voivodship, marked by an economy closed to a large extend, with a predominance of agriculture. Today also agriculture in that region is lagging far behind other regions of Poland. This is evident in the use of the three-field system with fallow land and common pastures, in low yields varying from year to year, in an insufficient development of stock breeding as well as the primitive technics and implements of land cultivation.

The various typological features were elaborated on the grounds of selected indices giving the best possible reflection of the essence of the problem.

The study of the socio-property relations includes an analysis of land structure.

Private peasant farms are the predominant form as far as land ownership is concerned (93 · 8% of agricultural land); the remaining 6 · 2% are socialized farms. In this connection the structure of private peasant farms was given more attention in the study.

As regards the size of farms, three groups were distinguished in the study: (1) up to 5 ha; (2) 5—10 ha; (3) over 10 ha; attention was paid to the differences in the amount of manpower, equipment with driving force and basic implements and agricultural machines, and manuring capacity (mineral and organic) occurring in the above groups.

The shape of the farm and land fragmentation is of essential importance for the agricultural economy. In this respect greatly advanced land fragmentation has been noted, particularly wherever the three-field economy based on the open field system has survived [1]. Areas characterized by land fragmentation, where one farm is composed of 10 — 40 plots and even more, cover over 200,000 ha; in this area there are great difficulties in organizing agricultural production and the production results are also lower.

As regards organizational-technical features, the following problems were examined: organization of farm area, the systems of farming applied and the intensity of agriculture. The author began by determining the area of agricultural land, expressed in percentages of agricultural land, the total area being taken as 100%. The share of agricultural land, varying from 30% to 90%, depicts the role played by agriculture in the various parts of the area under investigation. Also the percentage of permanent grassland varying from 20% to 80% in the structure of agricultural land illustrates the great regional differences, which are also evident in the structure of plant production.

The orientation of arable land utilization was defined on the basis of the structure of crops and their mutual proportions; plants being divided, in accordance with agrotechnical principles, into three groups:

extractive or exhausting crops, intensifying crops and structure-forming crops [3]. The main orientations are clearly correlated with other conditions or production factors. For instance, an outstanding rye orientation with potatoes ($E_4sc + I_1st$)[1] was recorded in 57 gromadas — 15·7% of all the gromadas which correlate with the three-field system; the rye and-potato orientation ($E_3sc + I_2st$) was found in 53 gromadas — 14·7% correlating with areas where permanent grassland predominates in the structure of land utilization, and also with areas situated closer to the urban centres; the rye or rye-and-oats orientation with potatoes and clover ($E_3sc,av + I_1st + S_1tp$) was found in 70 gromadas, 20·4%, having better soils and bigger farms. In towns and settlements the potatoe or potatoe-vegetable-rye orientation predominates ($I_3st,lg + E_2sc$).

It is difficult to present quantitatively the results of the study of methods of farming understood as all the operations and measures applied in agriculture in order to gain crops and to preserve soil fertility. This problem was examined on the basis of the systems of crop rotation applied, which is the most important agrotechnical measure, and on the basis of the scale of organic and mineral manuring.

In view of the lack of statistical data presenting the input of live and mechanical labour the problem of the intensity of agriculture was presented with the help of selected indices. The input of live labour was examined using the index of the number employed in agriculture per 100 ha of agricultural land. The input of mechanical labour was measured by the number of tractors. Apart from this, the intensity of agriculture was analysed with the aid of the following indices: driving force in agriculture, percentage of intensifying crops in the structure of sowings, livestock in terms of big units per 100 ha of agricultural land. The above indices give a fairly correct picture of the regional differences in the intensity of the agricultural economy.

Production (economic) features have been presented with the aid of indices of land and labour productivity, degree of commercialization and production orientation. Gross production expressed in grain units, was estimated on the ground of the structure of crops sown, the yields crops, the number and productivity of livestock. The level of productivity on the area investigated differed considerably: from 15 to 40 grain units per 1 ha of agricultural land.

Despite the general low productivity, labour productivity is relatively high. The average was about 80 grain units of gross output per one person employed in agriculture. Approaching the question from the

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[1] E — extractive crops; I — intensifying crops; S — structure-forming crops; sc — rye; av — oats; st — potato; tp — clover; lg — vegetable.

aspect of spatial distribution, a correlation of higher labour productivity with more advanced mechanization of agriculture has been recorded.

The structure of gross output and the proportions between the main sectors of production (plant and animal) have shown that there are two basic orientations in the investigated area: (1) mainly vegetal and (2) mixed vegetal-animal farming. Within the above two basic orientations, 10 sub-orientation have been discerned, defined by the branch structure of production. The rye-and-potato orientation with dairy cattle and pig breeding $[V_4(sc_2 + st_2) + A_2(bl_1 + ss)]$[2] is the most common in the crop growing orientation groups, and in the mixed orientation the rye-potato-meadow orientation with dairy-cattle and pigs $[V_3(sc_1 + st_1 + pt_1) + A_3(bl_2 + ss)]$ prevails. In suburban gromadas and towns the predominating orientation is potatoe with vegetables and pig and dairy cattle breeding $[V_3(st_2 + lg) + A_3(ss_2 + bl)]$.

The level of commercialization of agriculture calculated on the basis of the State purchases and estimated free-market turnover of agricultural produce is low, viz., from 3 to 14 grain units per 1 ha of agricultural land.

The degree of commercialization calculated in terms of the percentage of production for the market in relation to the gross production is also low: from 15% to 30% — a proof of weak ties between agriculture and the market and a low share of agriculture in the production of the national income.

The results of the study of typological characteristics, their mutual connections, similarities and differences served as a basis for distinguishing two basic types of agriculture:

(1) large-scale state farming
(2) small-scale private farming

The state farms are mostly located in the northern part of the voivodship, on areas with worse natural conditions. The farms are developing specialized production, so there are great differences in the arable land use combinations, crop rotation and general production orientation. At the same time these farms have many common features typical of state farms, namely: very large size (see table), compact farm area, large fields under one crop, a high percentage of agricultural land and the application of a long crop rotation. As regards intensity they are characterized in general by low manpower input (7 — 10 persons per 100 ha agricultural land), a high degree of mechanization of field work (2·5 — 3·0 tractors per 100 ha of agricultural land), a high index of mineral

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[2] V — vegetal production; A — animal production; sc — rye; st — potato; pt — permanent grassland; lg — vegetable; bl — dairy cattle; ss — pig breeding.

fertilizing (120 kgs NPK in terms of pure content per 1 ha of sown area). In gross output there is a great predominance of plant production (over 70%) the orientation being rye-barley-clover with wheat and potato or sugar beet. As regards stockbreeding, dairy cattle or dairy-and-beef cattle predominates. Apart from this, the State farm economy is characterized by average land productivity (18 — 24 grain units from 1 ha of agricultural land), and high labour productivity (an average of 180 grain units per one person employed) and a high degree of commercialization (about 50% of gross output).

The characteristic features of individual private farming are: small holdings, great fragmentation of land, family members being the basic manpower, high labour input and low level of intensity as regards fixed assets and floating funds engaged in production, weak ties with the market expressed by low level of market production and low degree of commercialization.

Ten sub-types of agriculture have been distinguished on private farms on the basis of differences in organizational-technical features, crop combinations, orientations and, above all, production effects (Table 1). In view of the nature of the present paper I shall confine myself to descriptions only of selected sub-types.

Suburban agriculture, most often found within the administrative boundaries of towns and sometimes in gromadas bordering on towns, is not very well developed or advanced. It is characterized by dwarf farms (75% holdings under 5 ha) and intensive utilization of arable land with potato- or potato-vegetable-rye orientation. The high percentage of intensifying crops (potatoes and vegetables account for 30—40% of the crop structure) and well developed stockbreeding with a predominance of pigs, but also dairy cattle and poultry, are the main orientations in agricultural production. Productivity is high (over 30 grain units from 1 ha), and so is commercialization, which amounts to over 10 grain units per 1 ha. The economy is clearly aimed at satisfying the demand of the market, mostly for potatoes and vegetables, milk, pork meat, poultry and eggs.

Agriculture in the part of the voivodship around Wysokie Mazowieckie encompasses a considerable part of the western natural geographical region. This is most intensive and productive sub-type of agriculture in the Białystok voivodship. Middle-size holdings (8—10 ha) predominate. Arable land accounts for over 70% of the agricultural land; many-field system is applied (4—5-year crop rotation), the orientation being rye-potato-clover. High labour input (over 40 professionally active persons per 100 ha of agricultural land) is accompanied by the highest index of tractors and agricultural machines as well as mineral fertilizing

TABLE 1. Types of agriculture in the Białystok voivodship

Types and subtypes of agriculture	Typological features																		
	social-property relations			organizational — technical features										production (economic) features					
				organization of agricultural area			farming systems			intensity of agriculture									
	forms of land ownership and kind of labour force	average size of a farm in ha	dominating system of fields and size of lots in ha	arable land in % % of total area	permanent grassland in % % of agricultural land	arable land use orientation	crop rotation	dung manuring, heads dung units of animals per 100 ha of arable land	mineral fertilizing NPK kgs per 100 ha of sown area	live labour inputs; employment per 100 ha of agricultural land	driving force: tractors, horses per 100 ha of arable land	intensifying crops in % % of sown area	livestock in big units per 100 ha of agricultural land	productivity in grain units per ha	labour productivity in grain units per worker	market production in grain units from 1 ha	degree of commercialization (market production in % % of gross output)	orientation in agricultural production	main products supplied to the market
A. STATE forming	social; hired labour	500—600	a 15—30	85—95	20—30	$E_3sc_1tv_1hs_1 + I_1st_1bs + S_1ti$	4—8 year rotation	40—50	120-160	7—10	tractors: 2·5—30 horses: 5	12—18	40—50	18—24	180	10—12	50	$V_3(sc_1 + tv + hs + bs + ti)A_1$	$sc_1\ tv_1\ hs_1\ bs_1\ bn_1\ l_1$ mbt
B. PRIVATE forming	private ownership; family members	2—12	all kinds	40—90	20—70	various	2—5	40—110	15—80	10—50	0·2—1 10—40	15—40	40—100	15—45	50—100	3—12	15—40	various	various
subtypes: 1. Suburban	private ownership; family members	2—3	b 0·3—0·7	85—90	20—30	$E_2sc + I_3st$	2—3	90—110	50—60	40—50	0·3 30	35—40	100	35—40	65	10—12	30—35	$V_2(st + lg) + A_2(ss_1 + bt_1l)$	$st_1\ lg_1\ l_1\ k_1\ oo_1\ m(bt + ss)$
2. Forest region	,, ,,	3—4	c 0·5—1·0	30—40	40—50	$E_3sc + I_2st$	3	90—100	15—25	35—40	0·2 45	30—35	90	28—32	60	8—10	20—30	$V_2(sc+st) + A_2(bt_1l + ss)$	$st_1\ l_1$ mbt
3. Valley	,, ,,	8—9	b 0·5—3·0	70—80	60—70	$E_2sc + I_3st$	3	80—90	10—20	10—20	0·2 40	30—40	40	16—18	75	3—5	15—20	$V_3(st + pt) + A_1(bt_1lm)$	$st_1\ l_1\ m(ss + bt)$
4. Kurpie	,, ,,	10—11	bc	50—60	60—70	$E_3sc + I_1st + S_1lp$	3—4	80—90	20—25	20—30	0·5 35	25—30	45	18—20	80	4—5	20—25	$V_3(sc + st + pt) + A_1(bt_1ml)$	$sc_1\ st_1\ l_1$ mbt
5. Wysokie Mazowieckie	private ownership family members and seasonal hired labour	8—10	d 3—5	70—80	20—25	$E_3sc + I_1st_1bs + S_1ti$	4—5	70—80	60—70	35—45	1·3 25	30—35	75	32—36	95	10—14	30—40	$V_2(st + sc + ti) + A_3(bt_1l + ss)$	$tv_1\ bs_1\ l_1\ m(ss + bt)$
6. Siemiatycze	private ownership; family members	6—7	bc 0·3—1·5	70—80	20—30	$E_3sc + I_1st + S_1lp_1sr$	3—4 with fallow	50—60	40—50	40—50	0·6 20	25—30	55	24—27	80	5—7	20—25	$V_3(sc + st) + A_1(btl + ss + ov)$	$sc_1\ av_1\ st_1\ ln_1\ m(ss + bt)$
7. Sokółka	,, ,,	5—6	c 0·3—1·0	65—75	25—35	$E_4sc + I_1st$		50—60	30—40	20—30	0·5 25	20—25	45	17—20	60	4—6	15—25	$V_3(sc + av + st) + A_1(btl + ss + ov)$	$sc_1\ av_1\ ln_1\ nt_1\ k_1\ l\ m(ss + bt)$
8. Dąbrowa	,, ,,	8—9	bc 2—4	70—80	25—35	$E_3sc + I_1st$	3—4	60—70	20—30	30—40	0·4 30	25—30	70	27—30	60	6—8	25—35	$V_2(sc + st) + A_2(ss_1 + bt_1m)$	$st_1\ sc_1\ nt_1\ l_1\ m(ss + bt)$
9. Kolno	,, ,,	7—8	d 1—4	65—75	20—25	$E_3sc + I_1st + S_1sr$	4	50—60	35—45	35—45	0·5 25	20—25	60	26—28	70	7—8	20—25	$V_3(sc+st + pt) + A_1(bt_1l + ss)$	$sc_1\ st_1\ l_1\ m(bt + ss)$
10. Northern	private ownership; family members and seasonal hired labour	11—12	e 5—8	60—70	25—35	$E_3sc_1av + S_1ti$	4—5	45—55	30—40	20—30	1·0 20	15—20	50	16—18	75	3—5	15—20	$V_3(sc + av + pt + ti) + A_1(bt_1lm + ss)$	$sc_1\ av_1\ l_1\ m(bt + ss)\ K_1$ w

Symbols used in the formulas: 1. Field systems: a — block, compact system, b — irregular dispersed lots, c — open field, irregular long strips, d — compact lots, e — colonies regular form. 2. Arable land use orientation: E — extensive (exhaustive) crops: sc — rye, hs — barley, av — oats, tv — wheat; I — intensive crops: st — potatoes, bs — sugor beets, lg — vegetables; S — structure forming crops: ti — clover, lp — lupine, sr — serradele. Notice: numbers after letters indicate the proportions of different crops. 3. Orientation in agricultural production — symbols as above and as follows: V — vegetal production: pt — meadow hay, A — animal production: bt — cattle, ss — pigs, l — milk, m — meat, ov — sheep. 4. Main products supplied to the market — symbols as above as follows: bn — rape, k — poultry, oo — egg, ln — flax, nt — tabacco, w — wool.

(60—70 kgs NPK per 1 ha of sown land) noted in private farms in the voivodship.

The orientation of the agricultural economy is a mixed one crop and livestock, potato-and-rye with dairy cattle (Polish red breed) and pig breeding. Productivity (30—36 grain units per ha), labour productivity (90—100 grain units per one person employed) and commercialization (30—35% of gross output) are the highest in the voivodship. It is also the most universally developed type of agriculture, which should be recognized as a pattern to be followed in the further development of the agricultural economy in the Białystok voivodship.

Agriculture in the Kolno and Dąbrowa sub-type is similar to that of Wysokie Mazowieckie particularly as regards productivity, but it is not so intensive. Labour productivity and commercialization are also lower.

The Siemiatycze sub-type encompassing mostly the southern part of the voivodship with worse natural conditions (poor sandy soils) is characterized by the predominance of middle-size holdings (6—7 ha), applying the three-field system, high labour input (40—50 persons per 100 ha of agricultural land) and low intensity. The land utilization orientation is rye-and-potato with cattle and pig breeding and, in some localities, also sheep breeding. Productivity (24—27 grain units per ha) and commercialization (20—25% of gross output) are low.

The Sokółka sub-type of agriculture occurring in a scattered form in the eastern part of the voivodship is the most under-developed type of farming. All the features of the three-field economy, often in its classic form i. e. fallow land, compulsive crop rotation and common grassland (pastures) have survived there. Land use orientation is outstandingly rye or rye-with-potato. In stock breeding, apart from the predominance of cattle and poorly developed pig breeding, there is a big share of sheep. All the production indices are the lowest in the voivodship.

The agriculture of big valleys and of Kurpie is marked by a predominance of permanent grassland (over 70%) in the structure of land utilization. The predominance of grassland has a visible effect on the specific shaping of the organizational-technical features of production orientation, which depending on the basis for calculations, is either very low (in relation to the agricultural land area) or very high (in relation to the arable land area), as the economy on arable land is very intensive.

The nothern agricultural sub-type is marked by a specific land use orientation (oats-and-rye with potato and clover) and low productivity resulting both from difficult natural conditions and the shortage of manpower and great difficulties in replacing live labour with machines.

The above presented typology of agriculture mainly based on correlation of characteristic features has not been elaborated in full as yet.

This is particularly true of the problem of integrating the particular features defining the types of agriculture and giving them their due place in quantitative and qualitative terms. This problem which is now the subject of research, calls for a more thorough study.

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AGRICULTURAL TYPOLOGY OF A MESOREGION AS EXEMPLIFIED BY PONIDZIE (CENTRAL POLAND)

Władysława Stola

This paper is related to the studies carried out by the Commission for Agricultural Typology of the International Geographical Union. The author makes an attempt to determine the agricultural typology of a relatively small area (5542 sq. km.), following the principles and typological methods suggested by the above mentioned Commission.

The type of agriculture [3] understood as a supreme notion in geographical and agricultural research, was defined on the basis of the analysis of internal characteristics of land utilization such as (1) social and property features (forms of land ownership, the size of farms, the degree of farm fragmentation and dispersal, and also the problem of labour), (2) organizational and technical features of land utilization forming what is called the system of agricultural land utilization (crop rotation systems, methods of crop cultivation, fertilization, irrigation, mechanization, arable land use orientation, stock breeding system, problem of agricultural intensity), (3) production features (orientation of gross and commercial production, land and labour productivity, the degree of commercialization). The structure of features listed above was analysed on the basis of the evaluation of external conditions and this permitted the author to define agricultural types occurring in the territory of Ponidzie. The gromada was accepted as the fundamental unit of investigation.

The area under investigation includes five poviats (Busko, Jędrzejów, Kazimierza Wielka, Kielce, Pińczów) consisting of 170 gromadas situated in the southern part of the Kielce voivodship, in the Nida Basin and Holy Cross Mountains, a region highly differentiated as far as natural conditions and socio-economic factors are concerned. Agriculture is the main economic activity there, and small-scale farming the predominant form. The percentage of the inhabitants earning their living as farmers ranges from almost 60 per cent of the population in Kielce poviat, which is relatively the most industrialized part of Ponidzie, up to more than

80 per cent in the poviats of Busko and Kazimierza. More than 90 percent of cultivated land is owned by individual farmers; the most common size of a farm is less than 0 to 5 ha (from approximately 60 per cent in Jędrzejów poviat to more than 80 per cent in the poviats of Kielce and Kazimierza.

The analysis of typological features started with a survey of land utilization on the scale 1 : 100,000 and investigations aiming at defining the orientations in land utilization on the basis of statistical data [5]. The results obtained revealed that the distribution of principal forms of land utilization is greatly differentiated. Among seven main orientations differentiated by this procedure the most common is the typically agricultural, field orientation. The survey made it possible to select some gromadas and villages, typical of larger areas, which, in turn, became the subject of further detailed case studies. During these, several problems such as methods of farming (in particular crop rotation, methods of cultivation, fertilization) field structure and land subdivision, which could hardly be deduced from mass statistics, were also investigated. As a result four zones were differentiated in Ponidzie. These vary in their methods of farming to a great extent under the impact of the different natural environment, in particular of the type of soil and the size structure of farms.

Gromadas cultivating specific crops on their arable land were differentiated on the basis of crop combination, according to the Polish method of the land utilization survey [4]. The problem being of a technical and organizational type, the differentiation of crop groups was based on the crop division from the viewpoint of agricultural techniques [6], i. e. its influence on the habitat (extractive, intensifying, structure-forming crops).

Crop combinations were computed on the basis of the following formula:

$$K = E_x (e) + I_x (i) + S_x (s)$$

where: K = arable land use orientation; E = extractive crops; I = intensifying crops; S = structure-forming crops; e, i, s = one or more crops dominant in a given group; x = symbol according to the following table:

percentage	symbol	name
over 80 per cent	5	outstanding dominance
60—80	4	dominance
40—60	3	relative prevalence
30—40	2	accompanying position
20—30	1	secondary position

0—20 per cent not taken into consideration for the determination of the orientation.

As a result 5 types of structures [1] (e.g. *IE, EIS*), 9 types of proportion (e.g. $I_3 E_3$, $E_3 I_2$) and 15 main arable land use orientations were differentiated.

The intensity of agriculture in terms of labour and capital input per territorial unit was determined by means of a method of scoring based upon methods described in German literature and adapted for Polish conditions by B. Kopeć [2]. The following formula was applied:

$$I = \frac{\Sigma(ps^1) + \Sigma(qs^2)}{100}$$

where: I = the determinant of intensity in agriculture (up to 2.0 = extensive, 2.0—2.5 = low; 2.5—3.0 6 = medium; 3.0—3.5 = high; over 3.5 = = very high intensity), p = percentage of fields, meadows and pastures in relation to the whole agricultural land; q = big animal units (500 kg) per 100 ha of agricultural land; s^1 = intensity coefficient for separate types of plant production; s^2 = intensity coefficient for separate types of animal production.

The results obtained were corrected by data gathered during field research, by indices of intensity (e.g. the amount of horses, machines, fertilizers — per territorial unit) and by symptoms of intensity (e.g. the proportion of intensifying crops in the total crop production, livestock numbers per territorial unit). This correction enabled the author to differentiate areas varying in size and in character of inputs.

Characteristics of agricultural production were determined on the basis of gross and commercial agricultural production. Grain units, which made differentiated production characteristics comparable, were used for the computation of agricultural production and its structure.

For the sake of the analysis of plant production crops were grouped according to their uses (food, fodder, industrial). In the absence of complete data pertaining to the use of certain products such as potatoes or barley (which can be used for three various purposes) the respective figures were estimated on the basis of amounts consumed by the population, and of non-obligatory and contracted sales. Comparable indices for live weight production were also to a certain extent based on estimates; livestock production was calculated on the basis of the division according to products (e.g. live weight, milk, wool) and the breed of animals.

Agricultural gross production [7] was determined as follows:

$$PgR = \sum_{n=1}^{n} [(a_n j_n + p_n j_n + i_n j_n) + (m_n \times ws_n)] + bt \times wl +$$
$$+ ov \times wv + gb \times wg + ai \times wa$$

where: PgR = agricultural gross production, a = food crops, p = fodder crops, i = industrial crops, j = grain units for separate crops, m = numbers of different kinds of livestock, ws = comparable live weight index calculated for separate animals (slaughtering index x the average live weight x grain units), bt = number of dairy cows for milk production, ov = number of sheep, gb = number of hens, ai = number of geese, wl = comparable index for milk production (milk in litres per cow x grain units), wv = comparable index of wool production (wool in kg per sheep x grain units), wg = comparable index for egg production (the number of eggs laid by a hen x grain units), wa = comparable index for feather production (the amount of feathers in kg per unit x grain units).

After agricultural gross production in grain units had been calculated, its orientation was determined by the method of successive quotients used in researches carried out by the Department of Agricultural Geography in the Institute of Geography of the Polish Academy of Sciences. This method consists in the selection of highest values (groups of products) from among a defined set of figures (in this case pertaining to gross production), and dividing them consecutively by 1, 2, 3, 4 etc. From among the results of the division a few figures, the highest in succession, are chosen (their number depends on how precisely the calculation is to be made) e.g. 4, 5, 7 etc., which determine the number of factors, i.e. elements, included in the orientation. In the procedure described in this paper a six-stage division was introduced, i.e. the orientation of each gromada included six components bearing the names of respective agricultural products. For the type of many-sided husbandry they may represent at most six various products, while in specialized husbandry this number will be smaller; in that case some products will be represented by more than a single component.

In result 12 principal orientations in gross production were found. The most common type, which appeared in nearly 90 per cent of gromadas under investigation, was that of prevalent crop production with stock breeding ($V_4 + A_2$). Most numerous are potato with rye, or potato with meadow hay and rye, combined with beef and milk production:

$$V_4 [a_1 (sc_1) + p_3 (st_3)] + A_2 [l_1 + m_1 (bt)],$$
$$V_4 [a_1 (sc_1) + p_3 (st_2 \, pt_1)] + A_2 [l_1 + m_1 (bt)]$$

as well as potato with wheat and rye, and pork and milk production:

$$V_4 [a_2 (tv_1 sc_1) + p_2 (st_2)] + A_2 [m_1 (ss) + l_1]$$

Degree of commercialization, measured in percentages of gross production with the exception of a few agricultural products (e.g. industrial crops) only, was computed on the basis of data collected during field research and certain estimates. It was computed first for the poviats for which data relating to centralized purchases of most of agricultural products and estimates of free-market commercial production were available. The orientation in commercial production was determined in the same way as that in gross production, i.e. by successive quotients technique.

When the above typological characteristics and their distribution were established against the background of natural and socio-economic conditions, it was possible to differentiate 5 main types of agriculture, a fact which reveals the great spatial differentiation of agriculture in the Ponidzie region. These types are characterized by the following features:

1) low-level land productivity (less than 30 grain units) and very low level of commercialization (6—10 grain units); orientations: potato with rye, beef, beef and pork, and milk production. This type occurs on the poorest soils — predominantly sandy or podsolized clay and also loamy sands, on loam or clay (mostly of class V), in the northern gromadas of Jędrzejów and Busko poviats and in the southern part of the poviat of Kielce. Three-year crop rotations are the most frequent form of cultivation. Stock breeding is carried out on a medium scale (over 60 big animal units per 100 ha of agricultural land); a small proportion of intensifying crops, poor fertilization and insufficient mechanisation result in a low degree of intensity (2 · 5 — 3 · 0). The degree of commercialization is only about 20 per cent. Main commodities are: beef or pork, and rye or potatoes.

2) medium- or low-level land productivity (about 30—35 grain units) and low level commercialization; orientation: potato with rye, or rye and potato with meadow hay, beef and milk production. This type occurs in the eastern gromadas of Busko poviat and in the majority of gromadas of Kielce poviat, which are characterised by great soil differentiation, with predominant brown earths and gravel and sandy podzols as well as podzols developed from clays and loams (class IV and V), and also soils in the first stage of evolution (ranker) and rocky or squeleton soils of various mechanical compositions with unfavourable climatic (relatively short vegetation period, less than 205 days, and lowest temperature below 13.5°C) as well as geomorphological conditions (soils likely to erode, erosion classes IV—VIII). Very high land subdi-

vision (almost 80 per cent of farms sized below 5 ha), faulty field pattern, traditional methods of agriculture with predominant three- or two-year, often intensive, crop rotations (1. potato + +, 2. rye) result in medium or high intensity (about 3.0) which demands a high labour input. Numerous agricultural population (95 persons per 100 ha of agricultural land) and a high proportion of farms owned by peasant-workers, producing mostly for their own use, result in low degree of commercial production, consisting mostly of beef or pork, and potato and rye.

3) medium land productivity (about 35—40 grain units) and medium level of commercialization (about 15 grain units) with a relatively high output per person employed in agriculture (about 80 grain units); high or medium intensive with the following orientations: potato with wheat and rye, beef or pork, and milk production, rarely wheat with potato and clover, and beef and milk production. This comprises the centrally gromadas of Jędrzejów poviat and some gromadas of Pińczów and Busko poviat, with prevailing „rendzina" soils, belonging mostly to soil class III. Four, occasionally three, or in larger farms five-year crop rotations dominate. Among land use orientations the most frequently found are wheat and rye with potato, and structure-forming multiannual plants (clover, lucerne, sainfoin). Livestock (about 80 big animal units per 100 ha agricultural land) provides the farms with sufficient natural manure. Chemical fertilizers are, however, insufficiently applied. Farmers specialize in the production of potatoes, mostly for seed, of rapeseed and pork (western gromadas), or potatoes, industrial and fodder crop seed, and of beef and milk (south-eastern gromadas). These tendencies are fully reflected in the orientations of commercial production.

4) high land (about 50 grain units) and labour (70 grain units) productivity, and medium level of commercialization (15 grain units); orientations: wheat-potato-clover or wheat with sugar-beet, pork and beef, and milk production. This type spreads over gromadas situated along the Vistula river in Busko poviat and the region of Pacanów with fertile alluvial soils, brown earths and podzols on loess layers (class II and III). Four- and five-year crop rotations dominate in this type. Land use orientations: wheat-rye with potato and clover, or wheat-rye with potato. Large or very large numbers of livestock (90—110 big animal units per 100 ha agricultural land) provide sufficient natural manure. Relatively high mechanisation, great number of horses, and sufficient application of chemical fertilizers make this type of agriculture a highly intensive one (3.5—4.5). Pork and sugar-beet (for root or seed production), or vegetables or fruit and wheat dominate in commercial production.

5) high land (about 50 grain units) and labour productivity and

medium or high level of commercialization (15—20 grain units); orientations: combinations of plant with animal production, potato-wheat-industrial crop-fodders, or potato with wheat and industrial plants, as well as live-weight and milk production. This covers Kazimierza poviat and some of gromadas in Jędrzejów and Busko poviats, endowed with excellent natural conditions for manifold agricultural production. Soils formed from loess (chernozem, brown earth) and medium or heavy alluvial soils (class I and II) prevail. Very high degree of fragmentation (farms of 0—5 ha amount to more than 80 per cent), dense agricultural population (80—100 persons per 100 ha of agricultural land), relatively high mechanisation, great number of horses (more than 25), intensive fertilization, both chemical (65 kg NPK in pure element per ha of the sown area) and natural (about 100 big animal units per 100 ha of agricultural land), large share of industrial crops contribute to very high intensity (over 4 · 0). Four- and five-year crop rotations dominate. Production is oriented in three directions, thus forming the following three sub-types: a) southern with tobacco (among industrial crops), fruit and wheat (among food crops), and pork (among animal products) dominating in production; b) northern with sugar-beet, fruit, wheat or barley, milk and beef or beef and pork dominating; c) central, covering a smaller area, with predominant production of vegetables then sugar-beet, beef and pork.

Intermediate forms often occur in the bordering areas of main types, with characteristics either similar to those which prevail in the neighbouring territories situated within or outside the boundaries of the area under discussion, or to types predominating in distant territories which have, however, been shaped under slightly different conditions.

The differentiation of typological features on the basis of external conditions which have influenced the development of agriculture was on the one hand a basis for the determination of types of agriculture, and on the other has supplied some rich material which may facilitate conclusions regarding rational land use, and thus provide a basis for some concrete steps leading to the further development of agriculture in the area under investigation.

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INDEX OF LAND CONSOLIDATION AS A CRITERION OF THE DEGREE OF CONCENTRATION

JÓZEF JANUSZEWSKI

Agricultural geography knows the following notions: concentration, deconcentration, consolidation, deconsolidation. These notions define the processes going on in the physical structure and property relations of farms and villages. Concentration means a growth of the size of farms; and consolidation means that dispersed plots of land are united by means of an exchange of land between farming units. These definitions suggest the dynamic aspect of changes occurring in time and space, yet they are recorded in definite times; in this sense any separate study has its statical meaning too. The notions of deconcentration and deconsolidation define the reverse processes. Apart from this, we also have the notions of fragmentation and dispersion characterizing the physical structure of farms. The notion fragmentation defines the situation at a given moment expressed by the number and size of plots in a farm. The notion dispersion refers to the distance between plots. As the above proves, these two notions are not identical with land consolidation and deconsolidation. The notion of consolidation will be discussed in the present study.

The plot is the simplest (smallest) physical unit of land ownership. It is also the basic unit in geodesy and cartography, and a unit of geographical calculus. It is used in the same meaning in the present work.

When describing the physical structure of a farm we try to define its physical configuration. This means the number and shape of plots, their size and situation with regard to farms. All these features are important from the point of view of economic calculus. The most advantageous arrangement is that of a circle with the farm buildings in the centre. This is an ideal arrangement never occurring in practice, but of theoretical value as a fiducial point. In such an arrangement the index expressing the relation of the area to boundaries is the smallest, the roads to the fields are the shortest, thus most advantageous. The index of farm lanes calculated by Kosicki [2] is expressed by the formula:

$$U = \frac{L_r}{L_i}$$

In the above formula L_r is the actual average distance between fields and farm buildings, L_i the ideal average distance calculated for a holding of the same size having the ideal circular form. The average distance in a holding of irregular shape is calculated with the aid of a network of squares. The average distance for the ideal arrangement is obtained from the modulus:

$$S = \frac{r}{2}; \ r = \text{radius of the circle}$$

The above indices should be supplemented with Moszczanski's formula defining the shape of the holding

$$U = \frac{O \cdot S}{P}$$

where $U =$ index of configuration, $O =$ its circumpherence, $S =$ the average distance from the economic centre, $P =$ surface of the holding.

The author of the present study wishes to add one more index to the above ones, in order to depict one more feature of the physical structure of the farm, namely the degree of consolidation of the holding. The „plot” defined by the symbol „a” in the formula, is the basic element of the calculation. The author takes advantage of the known arithmetical rule according to which the square root of the sum of numbers $\sqrt{(a_1 + a_2 + a_3 + a_4 + \ldots\ldots + a_n)}$ is smaller than the sum of their square roots: $(\sqrt{a_1} + \sqrt{a_2} + \sqrt{a_3} + \sqrt{a_4} + \ldots\ldots + \sqrt{a_n})$.

This can be expressed by the following general rule:

$$K = \frac{\sqrt{\sum_{i=1}^{n} a_i}}{\sum_{i=1}^{n} \sqrt{a_i}}$$

The index K defines the degree of consolidation of the farm. It is included between 0 and 1. Usually it is multiplied by 100. It is particularly useful in studying the transformations which have taken place in the physical structure of the farm. It also defines the present situation and is of comparative value, because it does not depend on the size of the farm, but only on the number of plots and their relative size. Table 1. shows the latter correlation.

TABLE 1

Size of holdings in ha	Number of plots	Size of plots in ha	Index of consolidation	Degree of fragmentation
20	2	18·0 2·0	79·1	20·9
20	2	15·0 5·0	73·2	26·8
20	2	10·0 10·0	70·7	29·3
20	3	16·0 2·0 2·0	65·5	34·5
20	3	10·0 5·0 5·0	58·6	41·4
20	3	7·0 7·0 6·0	57·6	42·4
20	4	15·0 2·0 2·0 1·0	58·1	41·9
20	4	10·0 6·0 2·0 2·0	56·3	43·7
20	5	16·0 1·0 1·0 1·0 1·0	55·9	54·1
20	5	4·0 4·0 4·0 4·0 4·0	44·7	55·3

The above table demonstrates three properties of the formula. The first is that the index of consolidation decreases with the growing number of plots: the second, that the index of consolidation decreases when the size of plots tends to reach the same value; the third, that it increases when the area of big plots increases and that of small plots decreases and the reverse.

The index K is, as mentioned earlier, a relative value, independent of the size of the holding. This is shown on the example of Table 2.

TABLE 2

Size of holdings in ha	Number of plots	Size of plots in ha	Index of consolidation	Degree of fragmentation
40	2	36·0 4·0	79·1	20·9
20	2	18·0 2·0	79·1	20·9
10	2	9·0 1·0	79·1	20·9
60	3	30·0 20·0 10·0	59·1	40·9
30	3	15·0 10·0 5·0	59·1	40·9
15	3	7·5 5·0 2·5	59·1	40·9

The index of farm fragmentation shown in the above two tables (1. and 2.) is obtained from the formula:

$$R = 100 - 100\,K = 100\,(1 - K).$$

The index of consolidation has a classifying value. The author of the present study has analysed 135 holdings in several sample villages in Lower Silesia chosen by drawing lots. Tables 3., 4. and graphs (fig. 1, 2)

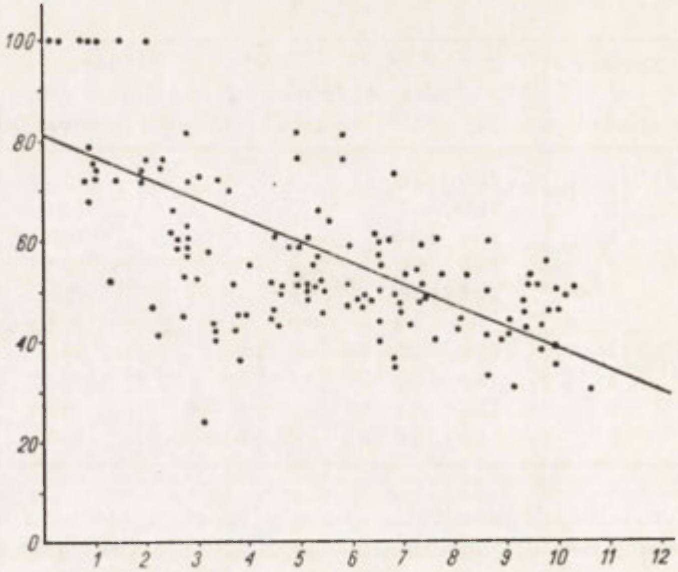

Fig. 1. Correlation between the consolidation index and the scale of farmer's holdings.

Vertical line — consolidation index; horizontal line — scale of farmer's holdings in ha.

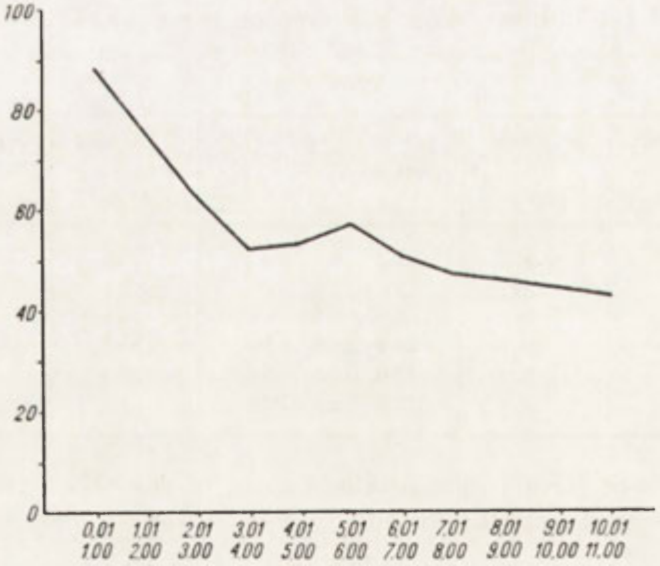

Fig. 2. Correlation between the mean consolidation index and the scale classes of farmer's holdings.

Vertical line — values of mean consolidation indexes; horizontal line — classes of farmer's holdings in ha.

show the results of this work. A certain correlation has been found between the size of holdings and the degree of consolidation. The index of consolidation decreases with the growth of holdings. In our examples small holdings have the highest index of consolidation (Table 4.). This regularity has been generalized (Fig. 2) by reducing single values to their arithmetical mean.

TABLE 3

	Classes of holdings according to their size (in ha)										
	0·01—1·00	1·01—2·00	2·01—3·00	3·01—4·00	4·01—5·00	5·01—6·00	6·01—7·00	7·01—8·00	8·01—9·00	9·01—10·00	10·01—11·00
Consolidation idices	67·6	52·5	41·4	36·2	42·1	46·1	35·3	40·1	32·8	24·4	30·5
	72·9	71·8	45·3	41·4	42·6	49·0	39·6	41·4	35·7	31·0	49·1
	75·0	72·3	47·4	42·0	45·1	49·1	44·2	42·6	40·4	34·7	50·1
	76·3	73·1	49·2	42·3	46·4	49·6	47·0	48·3	41·2	38·4	
	78·8	74·4	53·0	42·6	49·8	50·8	47·0	48·9	42·5	38·9	
	100·0	76·0	57·8	43·8	50·9	51·3	47·6	49·0	44·1	41·3	
	100·0	100·0	58·8	44·8	50·9	51·6	48·3	51·3	44·5	42·1	
	100·0		59·4	45·1	51·8	51·6	48·6	52·9	50·0	43·3	
	100·0		60·0	51·0	52·8	55·3	53·0	53·8	53·0	45·5	
	100·0		60·1	52·9	56·9	59·6	54·2		59·8	46·3	
			61·6	54·6	59·0	59·8	55·0		60·1	46·3	
			62.9	57·7	59·4	64·2	56·9			47·9	
			65·9	58·5	61·5	65·8	59·6			50·4	
			72·1	70·5	76·1	76·0	61·2			51·1	
			75·0	71·7		80·8	73·0			51·4	
			76·0	73·7						53·4	
			81·5							55·8	
			100·0								
No. of holdings	10	7	18	16	14	15	15	9	11	17	3

The same index can also express the degree of consolidation of crops or of a single crop cultivated in a holding or village. Usually there are more than one crop in one plot, but an arrangement is possible when several farmers who are owners of adjacent plots cultivate the same crop in a given year; if they apply the same system of crop rotation, then we have an example of consolidation of crops.

There are close correlations between elements of the arrangements shown earlier; these correlations are of practical value. They can be defined as follows:

(1) Consolidation increases when, as a result of an exchange of plots, we tend to concentrate them so as to form one spatial unit

TABLE 4

	Size of holdings		
	0·06—0·10	0·11—0·50	0·51—1·00
consolidation indices	100·0	100·0	67·6
		100·0	72·9
			75·0
			76·3
			78·8
			100·0
			100·0
No. of holdings	1	2	7
	100·0	100·0	81·7

(2) Concentration increases when the number of holdings in a village decreases

(3) Increasing concentration does not provide any indication of consolidation; the latter increases with the concentration of plots and decreases when the plots are scattered.

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VI. POPULATION GEOGRAPHY AND SETTLEMENT GEOGRAPHY

POPULATION GROWTH IN EAST — CENTRAL EUROPE IN THE YEARS 1961—1965 *

LESZEK KOSINSKI

INTRODUCTION

The present paper deals with the population growth in 8 countries of East—Central Europe: Albania, Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, Rumania and Yugoslavia. The area of 1,274,000 km^2 was inhabited by 121,600,000 people in 1965. The basic reference units for the analysis were countries and regions of similar size and/or population. It was decided to introduce regions, different in principle from administrative units, because the number of the latter was too large and also because their size varied a great deal, which would make any sensible comparison very difficult.

The aim of this paper is to analyse population growth and in particular: 1) total growth (relative growth and density of growth), 2) components of growth (natural and migrational) and their relationship, 3) components of natural increase. The statistical data were derived from national statistical yearbooks.

TOTAL GROWTH OF POPULATION

The total growth of population in the 8 countries during five years amounted to 4,366,000. The annual rate of increase was 0 · 7%[1]. The rate of increase varied from 0 · 5% in Hungary to 2 · 1% in Albania and only in Germany it was negative (—0 · 2%).

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* Statistical and cartographic work was done by Mgr Andrzej Gawryszewski. His contribution is gratefully acknowledged.

[1] Annual rate of increase (G) was computed according to the formula used by U. N. demograpic experts: $G = \left(\sqrt{\frac{\text{Population 1965}}{\text{Population 1960}}} - 1 \right) \times 100.$

TABLE 1. Division of countries under research into regions

Country	Number of regions	Average area in thousands km²	Average population in 1965 in thousands	Numbers and names of regions	Source
Albania	1	28·7	1891	1. Albania	—
Bulgaria	3	37·0	2733	2. Sofia, 3. Danube, 4. Rhodope and Thrace	E.B. Valev
Czechoslovakia	3	42·6	4731	5. Bohemia, 6. Silesia and Moravia, 7. Slovakia	author's concept
German Democratic Republic	5	21·6	3410	8. Mecklemburg, 9. Brandenburg, 10. Sachsen — Anhalt, 11. Thüringen, 12. Sachsen,	author's concept
Hungary	4	23·3	2540	13. Budapest, 14. North, 15. Great Plains, 16. Transdanubia,	B. Sarfalvi
Poland	7	44·5	4507	17. Central, 18. Northern, 19. West-Central 20. South-Western, 21. Southern, 22. South-Eastern, 23. North-Eastern,	Central Statistical Office of Poland
Rumania	5	47·5	3805	24. Southern, 25. South-Eastern, 26. Eastern, 27. Central, 28. Western,	J. Kremkv-Saloni
Yugoslavia	8	32·0	2438	29. Serbia proper, 30. Vojvodina, 31. Kosmet, 32. Croatia, 33. Slovenia, 34. Bosnia-Herzegovina, 35. Montenegro, 36. Macedonia	political structure
Total	36	35·4	3377	—	—

TABLE 2. Growth of population in the years 1961—1965

Countries	Population in thousands (at the end of a year)		Population growth 1961 — 1965		Average annual growth in %	Regions		
	1960	1965	in thousands	per km²		Total	Population growth	Population decline
Albania	1,633	1,891	258	8·97	2·9	1	1	—
Bulgaria	7,906	8,200	294	2·65	0·9	3	3	—
Czechoslovakia	13,733	14,194	461	3·60	0·7	3	3	—
German Democratic Republic	17,189	17,049	—140	—1·09	—0·2	5	2	3
Hungary	10,006	10,160	154	1·65	0·5	4	3	1
Poland	29,795	31,551	1,756	5·63	1·2	7	7	—
Rumania	18,403*	19,027*	624	2·62	0·7	5	5	—
Yugoslavia	18,402	19,508	1,106	4·32	1·2	8	8	—
Total	117,067	121,580	4,513	3·62	0·7	36	32	4

* July 1-st

The highest absolute growth was recorded in Poland and Yugoslavia. The rates of increase were also high in the two countries.

More detailed analysis of regions indicated that growth occurred in 32 regions and a decline only in 4 (in the German Democratic Republic and Hungary) [2].

The group of regions with the highest indices of increase is to be found in the southern part of the area. The top positions are occupied by Albania (29·3‰), Kosmet (28·4‰) and Bosnia-Herzegovina (20·7‰), which are relatively less developed and inhabited by moslems. Other groups of regions with high indices occur in Poland, especially in the recently resettled western part of the country and in Slovakia (10·5 — — 17·2‰). It should be emphasized that the range of indices was relatively narrow in Germany, Rumania and Czechoslovakia (5 — 7) but in Hungary the range amounted to 12·6 points and in Yugoslavia even as much as 22·2 points.

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[2] Regional indices (R) were computed according to the formula: $R = \frac{\frac{1}{5}x}{\overline{P}} \times 100.$ where x — number of natural or migration growth or decline, $\overline{P}$ — average size of population.

However if the density of population in an area is low then even a high index of increase does not result in fast changes of density. This leads us to the next stage of our discussion — density of growth. An index of density of growth similar to that suggested some years ago by J. Smoleński was used[3].

The average density of population increased during 5 years from 91·9 to 95·4 persons per km², or by 3·6 (annual average ca. 0·7) but for individual countries the change was between — 1·09 and + 8·97. The contrasts are even greater if we consider individual regions.

The resulting map differs from that showing the relative increase (Fig. 1). The southern regions do not dominate any longer although the indices are high in Kosmet (2·66), Albania (1·79) and Bosnia-Herzegovina (1·38). The highest density of growth occurred in Budapest (41·14) and in highly industrialized southern (2·88) and south-western Poland (1·62). The relatively high density of population in the German Democratic Republic, 1·5 times higher than the average, had no impact on the indices of density of growth due to the very insignificant rates of population growth or decline.

COMPONENTS OF POPULATION INCREASE

Increase of population depends on two components — migrational and natural. Both can be either positive or negative and depending on the relationship of the components it is possible to distinguish eight types of population change. The graphic method of analysis, introduced by J. W. Webb, was applied in order to distinguish the types. Migration gains or losses were calculated by comparing the total growth during 5 years (in Rumania, the last 3 years) with the natural increase. All indices were computed in relation to the average population. The resulting indices of migration relate to external as well as to internal movements. However, the former ones played more important role only in Germany and Yugoslavia.

In fact all the regions in East-Central Europe can be classified according to the 5 types. The majority of them belonged to the types characterized by dependence mostly on natural increase. Natural increase

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[3] Index of density of growth (c) was computed according to the formula:

$$c = dt = \frac{\overline{P} \cdot t}{A} = \frac{x}{A}$$

where d — average density of population, t — rate of growth, x — absolute growth, $\overline{P}$ — average size of population, A — area.

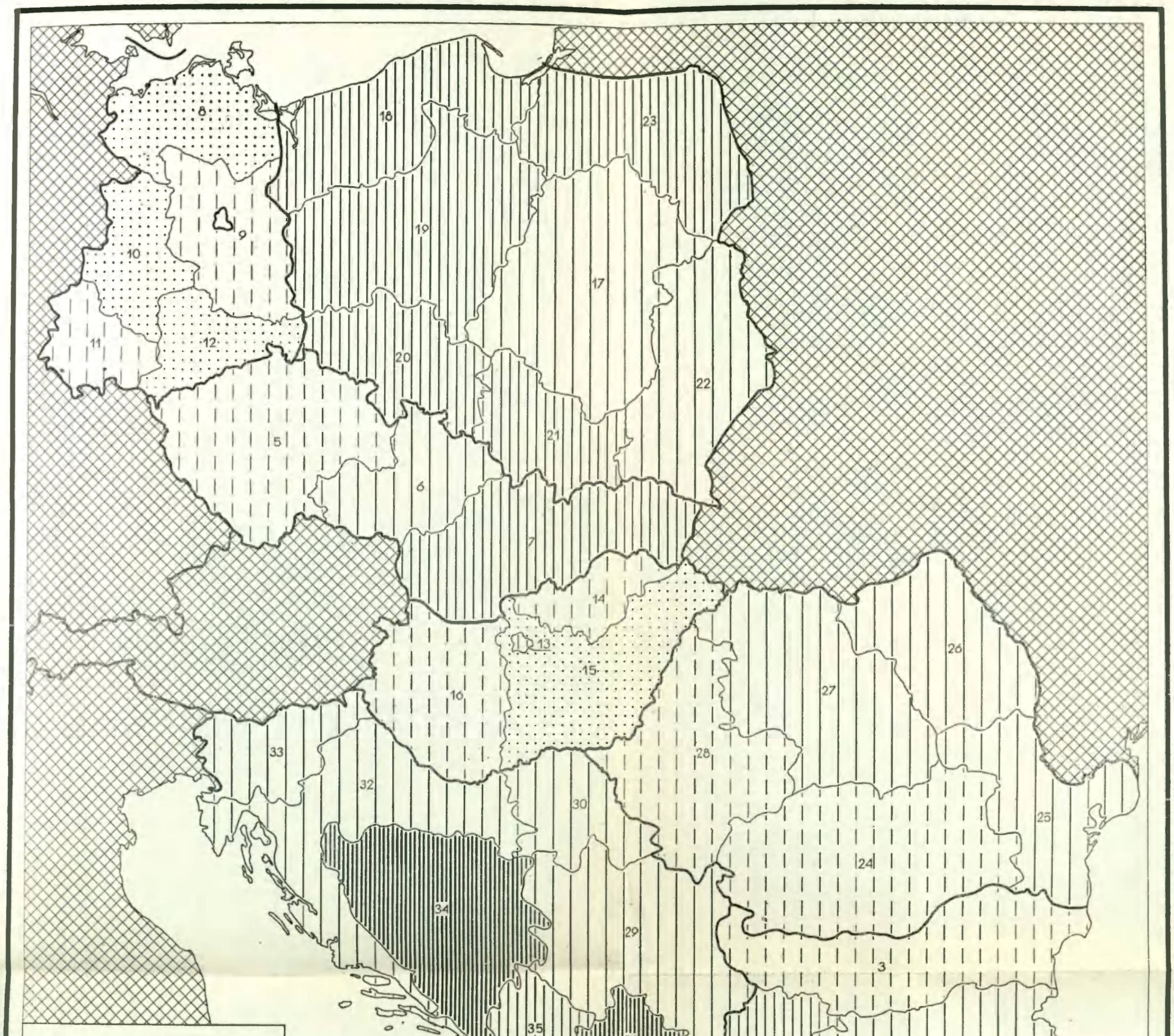

Fig. 1. Total growth of population as compared to the average population in 1961—1965 by regions
Annual average per 1000 inhabitants

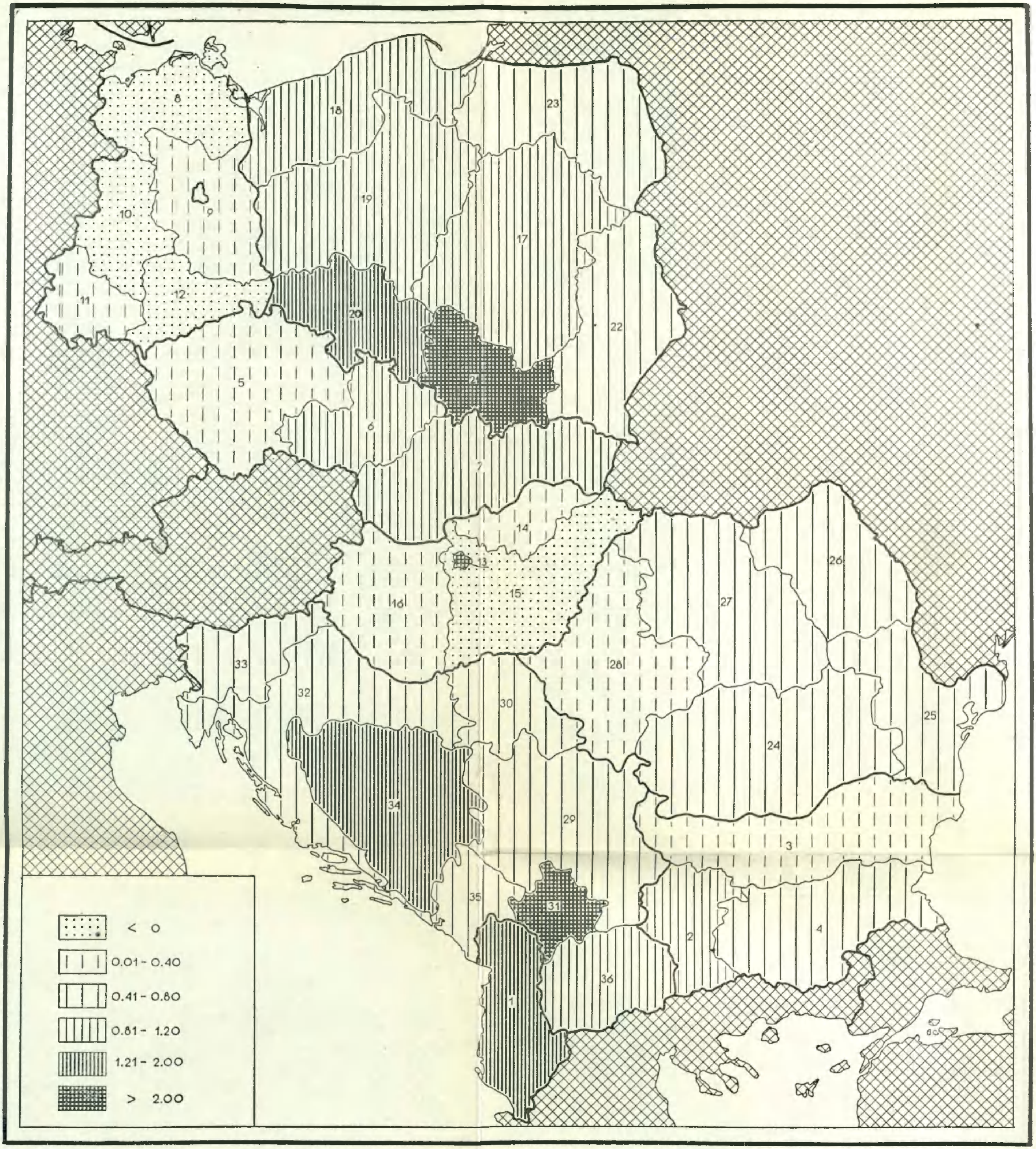

Fig. 2. Total growth of population in 1961—1965 as compared to the area by regions

Annual average per 1 km^2

dominated over migration gain in 9 regions inhabited by 34,383,000 persons in 1965. Nautral increase exceeded migration loss in 21 regions with 67,839,000 inhabitants. Migration gain dominated only in one industrialized region of Rumania where the natural increase is very low

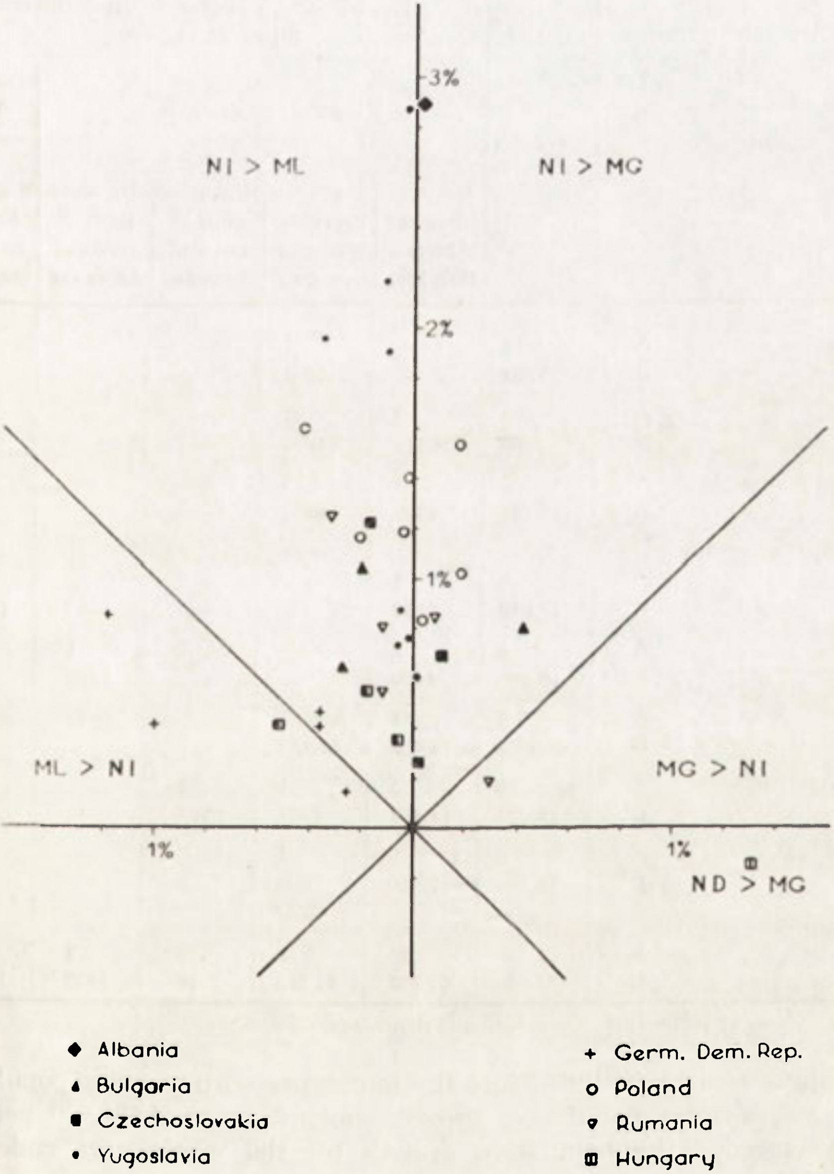

Fig. 3. Types of population changes in 1961—1965 by regions
ML — Migration loss, MG — Migration gain, NI — Natural increase (excess of births over deaths), ND — Natural decrease (excess of deaths over births)

and the total population is 2,796,000. Budapest is a unique region where the migration gain compensated for the natural losses [4].

TABLE 3. Types of demographic changes in East — Central Europe in 1961—1965

Countries		Total	Number and population in different types of regions				
			Population growth				Population decline
			Natural increase > Migration loss	Natural increase > Migration gain	Migration gain > natural increase	Migration gain > natural decrease	Migration loss > natural increase
Albania	A	1	—	1	—	—	—
	B	1891	—	1891	—	—	—
Bulgaria	A	3	2	1	—	—	—
	B	8200	6317	1883	—	—	—
Czechoslovakia	A	3	1	2	—	—	—
	B	14,194	4392	9802	—	—	—
German Democratic Republic	A	5	2	—	—	—	3
	B	17,049	6239	—	—	—	10,810
Hungary	A	4	2	—	—	1	1
	B	10,160	4406	—	—	1952	3802
Poland	A	7	4	3	—	—	—
	B	31,551	14,409	17,142	—	—	—
Rumania (1963-65)	A	5	3	1	1	—	—
	B	19,027	14,464	1767	2796	—	—
Yugoslavia	A	8	7	1	—	—	—
	B	19,508	17,610	1898	—	—	—
Total	A	36	21	9	1	1	4
	B	121,580	67,837	34,383	2796	1952	14,612

A — number of regions; B — population is thousands

In these regions included into the four types with growing population there was a total population growth amounting to 4,696,000 persons, which exceeded the population growth for the whole area under in-

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[4] A natural decline also occurred in Berlin, Praha and Banat. However, since those areas are included into larger regions the combined indices for regions are never negative.

vestigation. The difference was due to the population decline in three German regions and one Hungarian region inhabited by 16,564,000 people where the migration loss exceeded natural increase by 182,000 persons.

The classification of a region into a type depended in most cases on migrational gains or losses which were very small, much smaller than the rates of natural increase. Only in 6 regions did the migrational component dominate. Consequently both the total growth and the typology of regions depended mainly on the natural component. Differences in the latter can be observed on the diagram (Fig. 4), where the length of bars differs greatly. There was a high natural increase in Albania (28·9‰), many regions in Poland (8·4 — 15·9‰) and partly in Yugoslavia (19 — 28·7‰). In Rumania the highest indices were to be found in the east (8·4 — 12·5‰), in Bulgaria in the south (10·5‰), in Czechoslovakia in Slovakia (12·2‰). Internal disparities between regions were extremely high in Yugoslavia (6·1 — 28·7‰), Rumania (1·8 — 12·5‰), Czechoslovakia (2·8 — 12·2‰) and also in the German Democratic Republic, where the level of natural increase was generally lower (1·4 — 8·5‰). On the other hand indices in Poland, Bulgaria and Hungary were more uniform.

VITAL STATISTICS

A more detailed analysis of vital statistics indicates, that all the countries can be classified into 4 types. There was a very low increase in Hungary and Eastern Germany. It resulted from low natality and relatively high mortality caused by the advanced ageing of population. The second group includes Bulgaria, Czechoslovakia and Rumania, where both mortality (excluding Czechoslovakia) and natality was not very high and as a result the natural increase was relatively low. The third group consists of Poland and Yugoslavia where natural increase was relatively high due to high natality and low mortality. Albania must be considered as a separate type where the very high natural increase results from extremely high natality, unique in Europe.

By comparing births and deaths it is possible to calculate vital indices, they help to evaluate the level of natural reproduction[5]. In all the countries there was extended reproduction (e. g. births exceeded deaths) and the ranking of countries with respect to vital indices was similar though not identical to that of the rates of natural increase.

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[5] The vital index (v) was computed according to the formula: $v = \frac{B}{D}$ where B — birth rates, D — death rates.

TABLE 4. Vital statistics in the countries of East — Central Europe, 1961—1965 (annual average)

Country	Vital statistics (per 1000)			Vital index			
	Births	Deaths	Natural increase	National average	Total	Indices >1	Indices <1
Albania	38·5	9·5	29·0	4·05	1	1	—
Bulgaria	16·4	8·2	8·2	2·00	3	3	—
Czechoslovakia	16·4	9·7	6·7	1·69	3	3	—
German Democratic Republic	17·3	13·3	4·0	1·30	5	5	—
Hungary	13·2	10·0	3·2	1·32	4	3	1
Poland	19·1	7·6	11·5	2·51	7	7	—
Rumania	15·8	8·6	7·2	1·84	5	5	—
Yugoslavia	21·5	8·6	12·9	2·50	8	8	—
Total	19·8	9·4	10·4	2·11	36	35	1

Vital indices were also computed for individual regions (only for 1965). Except for Budapest, they exceeded 1 and the highest values, exceeding 3 were found in Albania, Kosmet, Bosnia-Herzegovina, Montenegro and Northern Poland. In the last mentioned region it was mainly due to the extremely low mortality (5·7‰).

CONCLUSIONS

The accepted method of analysis had to depend on the data available. Consequently, it was impossible to go into details as far as migrations are concerned. Development trends were also left aside.

However, the discussion proves, that even on the relatively small area, occupied by countries where the level of socio-economic development does not differ very much, there are great variations in the level and character of population growth. Unfortunately, space does not allow of trying to interpret those variations. They certainly reflect the existing differences in the economic development, cultural characteristics as well as the recent history of the area.

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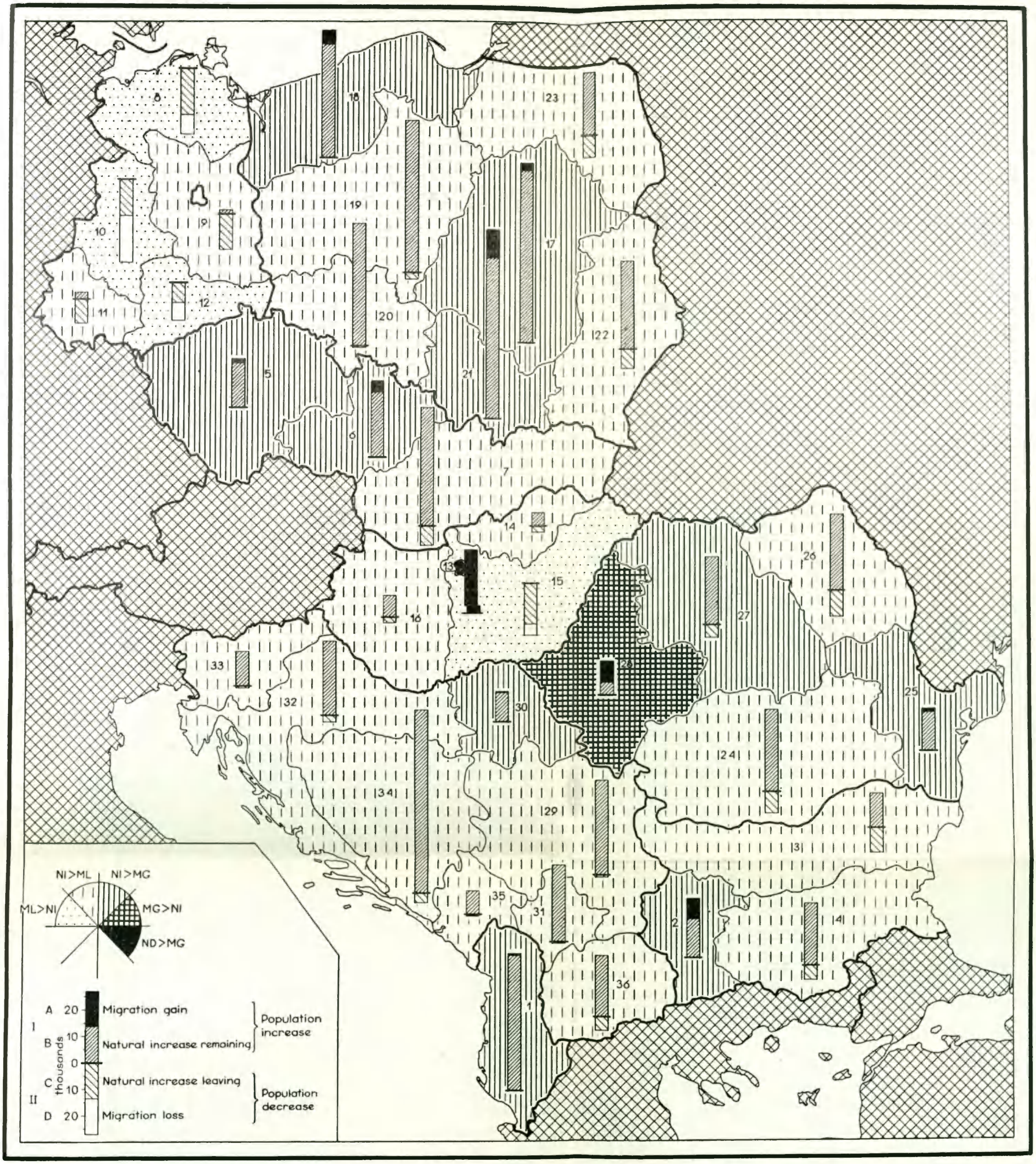

Fig. 4. Distribution of types of population changes in 1961—1965 in East — Central Europe by regions

ML — Migration loss, MG — Migration gain, NI — Natural increase (excess of births over deaths), ND — Natural decrease (excess of deaths over births). IN Budapest migration gain compensates partly for natural decrease (lower part of the bar)

STUDY ON EFFECTIVENESS OF MIGRATIONS *

WIKTOR BOREJKO

I

The description of migrations of population based on the analysis of the scope of immigration, emigration and their balance in absolute figures or per mil, does not give a comprehensive picture of the migration mobility of population on a determined territorial unit. The analysis is complicated by the need to take three indices into account because the balance of migrations, which usually is only an insignificalt percentage of the gross migration, is an insufficient criterion [1].

It seems purposeful to introduce another criterion when analysing migrations, apart from frequency of migrations (with regard to the population living on the examined area), namely the criterion of effectiveness of migrations. It could be named the index of effectiveness of migrations (M_e):

$$M_e = \frac{Im - Em}{Im + Em}$$

where M_e — is the index of effectiveness of migrations, Im — is the number of immigrants to the investigated area, Em — is the number of emigrants from the investigated area.

The index of effectiveness of migrations (M_e) may in theory take the values: $-1 \leqslant 0 \leqslant +1$.

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* On the example of towns in the Zielona Góra voivodship situated in western Poland; it borders on the German Democratic Republic and the Poznań, Wrocław and Szczecin voivodships. In 1965, it was inhabited by 847,000 people. Its area is 14,514 sq km, population density 58 per sq km (Poland — 101). The percentage of urban population is 50·7% (Poland 49·7%).

[1] See K. Dziewoński: Urbanization Processes in Present-day Poland. Przegl. geogr. 36 (1962), and L. Kosiński: Population Processes in the Regained Territories in the Years 1945—1960, Warsaw, 1963.

It results from the above formula that one can admit the following possibilities:

1. $M_e = -1$ when $Im = 0$ and $Em \neq 0$
2. $M_e = +1$ when $Im \neq 0$ and $Em = 0$
3. $M_e = 0$ when $Im = 0$ and $Em = 0$
4. $M_e = 0$ when $Im = Em$
5. $-1 < M_e < 0$ when $Im < Em$
6. $+1 > M_e > 0$ when $Im > Em$

The first three possibilities presented above do not actually occur on Poland, if sufficiently big territorial units are taken into consideration (a town, district, rural community) and over a sufficiently long period (a year, three months). The value $M_e = 0$ will only occur when immigration is numerically equal to emigration ($Im = Em$).

To avoid the use of fractions, the index should be multiplied by 100 or 1000 migrating people. In this forms the index shows the ratio of the balance of migrations to gross migration in percentages or per mils.

Using identical parameters another index can be computed depicting the effectiveness of migrations M_e', being the inverse of the previous one:

$$M_e' = \frac{Im + Em}{Im - Em} = \frac{1}{M_e}$$

The index M_e' defines the number of migration movements per unit of increase or decrease of population caused by migrations.

The absolute value of the index of effectiveness of migrations is of decisive value in this study, because the symbol (±) only indicates the character of the balance (growth or drop).

II

The Zielona Góra voivodship is an area of immigration. The migration exchange of population with other voivodships in the years 1950—1960 closed with an increase of 34,500 persons [2]. Comparison of the results of migrations shows that the co-efficient of migration growth depends on the balance, and is rather a rough index, lacking precision. The highest growth was obtained in population exchange with the Poznań voivodship, but the most advantageous in the exchange with the Kielce voivodship (Table 1).

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[2] Computation on the basis of data on changing the place of residence in the years 1950—1960. This data gives indirect information on migration movements but does not take into account multifold migrations.

TABLE 1. Migrations of population of the Zielona Góra voivodship in the years 1950—1960*

Voivodship	Immigration	Emigration	Balance		M_e	M_e'
	in thousand persons			‰		
Białystok	3·5	1·6	+ 1·9	+ 2·8	+ 37	+ 2·7
Bydgoszcz	7·9	4·4	+ 3·5	+ 5·2	+ 28	+ 3·5
Gdańsk	4·3	3·7	+ 0·6	+ 0·9	+ 7	+ 13·3
Katowice	4·8	10·0	— 5·2	— 7·7	— 35	— 2·8
Kielce	9·3	2·9	+ 6·4	+ 9·4	+ 52	+ 1·9
Koszalin	6·1	4·1	+ 2·0	+ 2·9	+ 20	+ 5·1
Kraków	6·3	4·8	+ 1·5	+ 2·2	+ 14	+ 7·4
Lublin	8·7	3·2	+ 5·5	+ 8·1	+ 46	+ 2·2
Łódź	11·2	5·2	+ 6·0	+ 8·8	+ 37	+ 2·7
Olsztyn	6·2	2·4	+ 3·8	+ 5·6	+ 44	+ 2·3
Opole	3·4	4·1	— 0·7	— 1·0	— 9	— 10·7
Poznań	38·1	24·4	+ 13·7	+ 20·2	+ 22	+ 4·6
Rzeszów	5·6	4·2	+ 1·4	+ 2·1	+ 24	+ 7·0
Szczecin	10·5	9·1	+ 1·4	+ 2·1	+ 7	+ 14·0
Warszawa	8·2	7·6	+ 0·6	+ 0·9	+ 4	+ 26·3
Wrocław	22·5	30·4	— 7·9	— 11·6	— 15	— 6·7
Total	156·6	122·1	+ 34·5	+ 50·9	+ 12	+ 8·1

* drawn up on the basis of the Statistical Yearbook 1966, Warsaw, 1966

Differences in the effectiveness of migrations were most impressive: from the index — 4 (city of Warsaw) to + 52 (Kielce voivodship).

Depending on the effectiveness of migration four types of population exchange through migrations can be discerned:

(1) Migrations consisting in population exchange with no clear direction when the effectiveness index is lower than 12, that is, immigration (or emigration) accounts for less than 125% of emigration (immigration). Migrations of this type took place with the city of Warsaw, and with the Gdańsk, Szczecin and Opole voivodships.

(2) Migrations consisting in population exchange with clearly defined direction, when the effectiveness of migrations oscillates from 12 to 20. Such exchanges of population took place with the voivodships of Koszalin, Cracow, Rzeszów and Wrocław.

(3) Settlement migrations with no clear direction, when the effectiveness reaches 20 — 33·3% of gross migration. Only two voivodships had this kind of population exchange with the Zielona Góra voivodship, namely Poznań and Bydgoszcz.

(4) Settlement migrations with clearly mapped out directions when the effectiveness of migrations is above 33·3% (that is, the number of

immigrants or that of emigrants is twice that of emigrants or immigrants respectively). Central and eastern voivodships belong to this group, namely: Olsztyn, Białystok, Lublin, Łódź, Kielce and Katowice (Fig. 1).

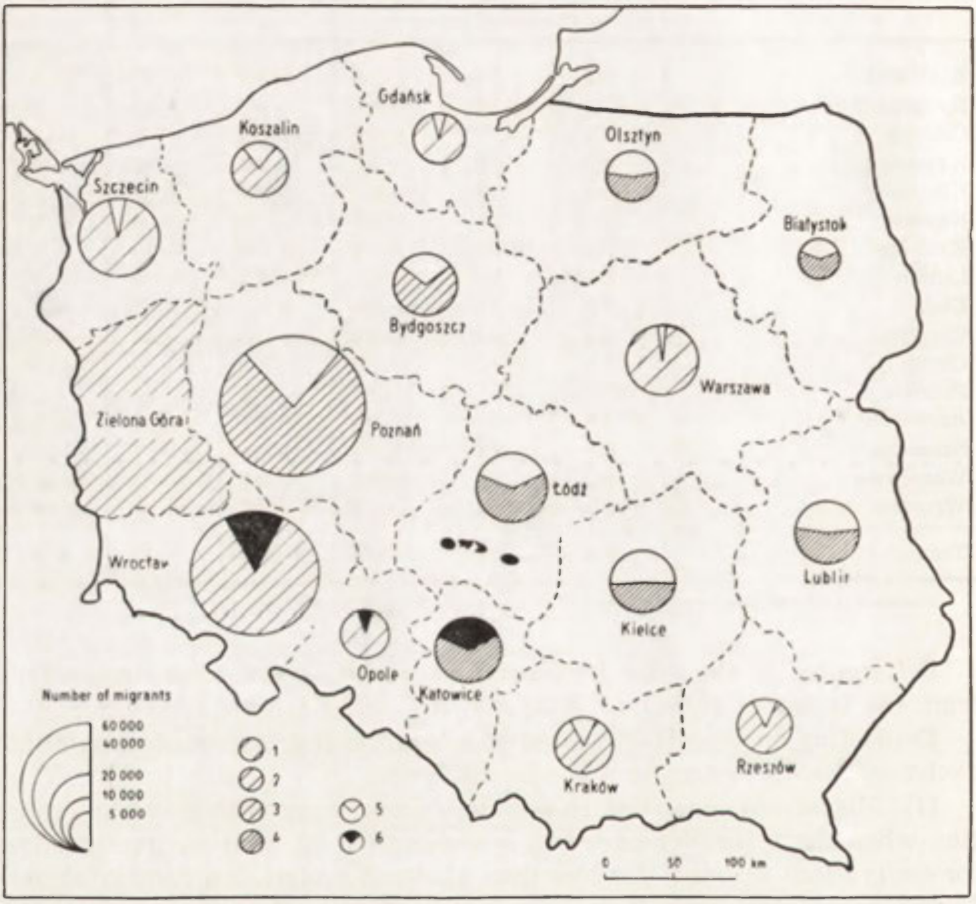

Fig. 1. Migrations effectiveness of the population of Zielona Góra voivodship in the exchange with other voivodships in 1950—1960.

Index of the effectiveness of migrations: 1 — below ± 12; 2 — ± 12 — ± 20; 3 — ± 20 — ± 33 · 3; 4 — above ± 33 · 3. Net migrations of the Zielona Góra voivodship : 5 — gains, 6 — losses

The effectiveness of the exchange of population of the Zielona Góra voivodship with the rest of the country through migrations is relatively low as compared to the partial indices. This is the result of the reduction of the final balance due to both favourable and adverse balances of population exchanges.

III

In the studies carried out in the towns of the Zielona Góra voivodship the following classification has been adopted of the population movements:

towns — villages in the same district (poviat)
towns — villages in other districts of the Zielona Góra voivodship
towns — villages in other voivodships
towns — towns within the Zielona Góra voivodship
towns — towns in other voivodships.

The results are seen on the diagram (Fig. 2) showing the value of the index of effectiveness of migrations in various categories. The values of the indices have been arranged on the graph in diminishing order.

In the period under review the most effective population exchange (with a favourable balance) was that between towns and villages of the same district (poviat). Taking into account that the district area in the Zielona Góra voivodship varies from 555 sq km to 1500 sq km, it should be stated that the most effective are migrations between towns and their surroundings (hinterland)[3]. The majority of towns in this type of exchange are centres of settlement migrations with clearly defined direction (growth). Only small townships showed a low effectiveness of migrations.

Next come migrations between towns and villages of other districts (poviats). As in population exchange with the surrounding zone, also in this case effectiveness is the highest in industrialized and developing towns[4] and the lowest in small poorly industrialized townships.

Inter-town migrations within the voivodship limits are much less effective. Most towns had only exchange migrations with no clearly defined direction.

Migrations between towns of the Zielona Góra voivodships and towns in other voivodships have clearly defined directions. Only six towns, including the voivodship town, gained a favourable balance from this exchange (i. e. population growth).

The total effectiveness of migrations in the towns of the Zielona

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[3] In big districts there are from 2 to 4 towns as a rule. All in all, there are 42 towns and urban settlements in the voivodship; the average area of a town being 345 sq km.

[4] The towns were badly damaged during hostilities; their intensive reconstruction and renovation as well as industrialization started in the fifties. This process has been called activation of towns. In the Zielona Góra voivodship Kostrzyn, Slubice and Gubin provide examples of „activated towns".

Góra voivodship in the period under review was insignificant. Although there was a growth of population through migrations in the majority of towns, yet it was the result of great migration mobility.

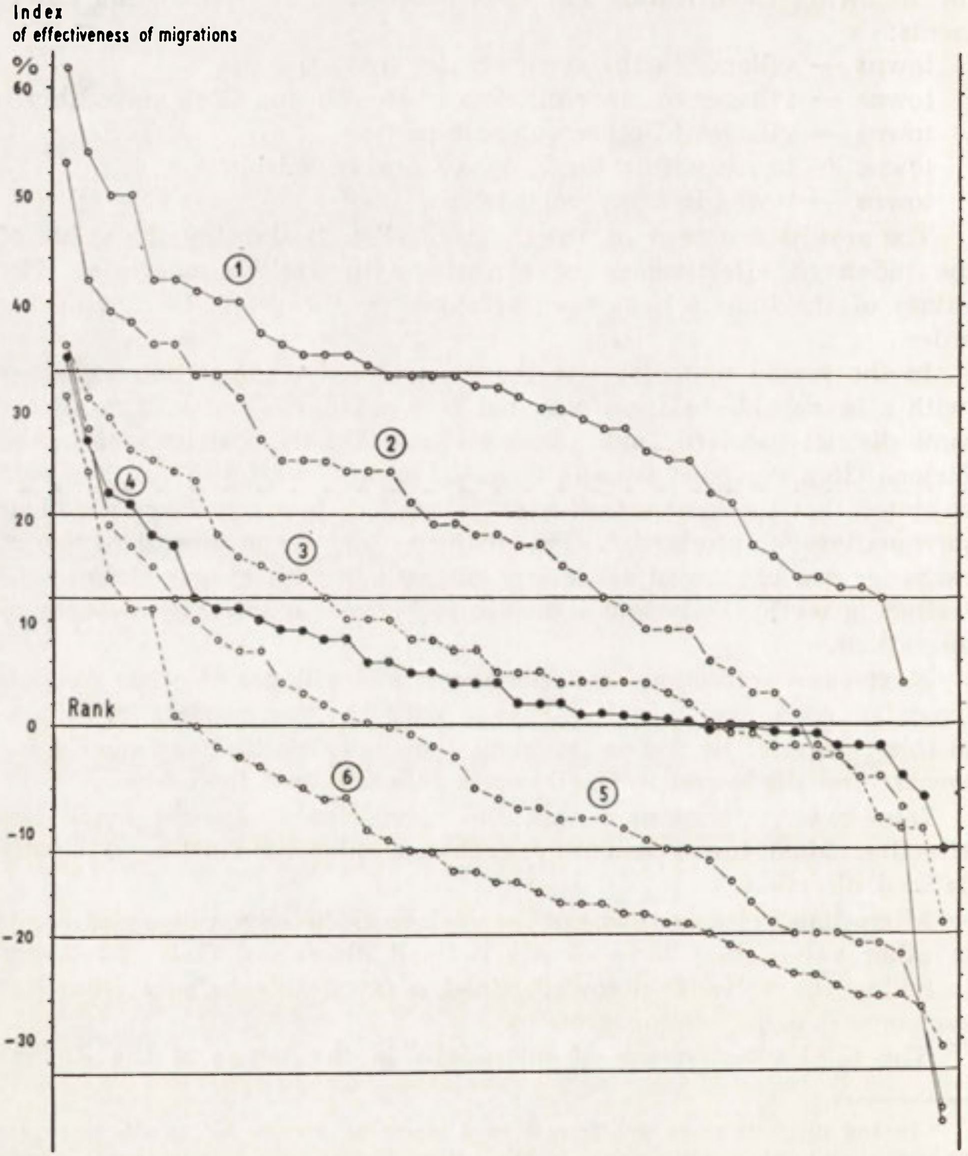

Fig. 2. Index of the migrations effectiveness of the population of towns situated in the Zielona Góra voivodship in 1957—1962 according to types of movements

1 — with villages situated in the same powiat as the town; 2 — with villages situated in other poviats of the Zielona Góra voivodship; 3 — total; 4 — with villages situated in other voivodships; 5 — with towns of the Zielona Góra voivodship; 6 — with towns situated in other voivodships

The index of effectiveness of migrations reveals the most rational types and directions of population exchange. The fact that the index is independent of the number of population living in the investigated area emphasizes the importance of the directions and types of exchange which were omitted in analysis with the help of the coefficient of migration growth, because of the insignificant number of migrating people. The index of effectiveness of migrations is an additional instrument helpful in carrying out an analysis of migration movements and evaluating the results of migrations.

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MOBILITY OF POLAND'S POPULATION AND ITS SPECIFIC REASONS

TEOFIL LIJEWSKI

Constantly growing mobility is a specific feature of Poland's present-day population. It is particularly striking when compared to the rather limited mobility of the population in the inter-war years. This mobility is best reflected by the continuously growing volume of traffic, including all means of transportation.

In 1966, Poland's population was 9% lower than in 1938 — this being the result of war losses and changes in state frontiers. On the other hand, the volume of traffic and the number of public transport vehicles increased several times. The number of train passengers increased 4·4 times, that of coach passengers 22·5 times, urban transport increased 13 times and air transport by the Polish Air Lines LOT 14 times. The number of motor vehicles (motor cars and motor cycles) was 41 times the pre-war figure.

Also the average length of journeys has increased: from 33 km to 35 km in rail transport, and from 21 km to 22 km in coach journeys. Horse-drawn vehicles have not been included in the above figures; in the inter-war years they played quite a big role in local traffic; at present their participation in the total traffic is insignificant.

TABLE 1. Structure of inter-settlement traffic according to public means of transportation (in percentages)

Means of transportation	1938		1955		1966	
	passengers	kilometres	passengers	kilometres	passengers	kilometres
Railways	84·4	89·4	85·8	91·4	51·8	62·8
Road transport (coaches)	15·2	10·3	13·9	8·2	47·8	36·4
Inland and coastal shipping	0·4	0·2	0·3	0·2	0·4	0·2
Air lines	0·01	0·1	0·01	0·2	0·03	0·6

Table 1. shows the structure of inter-settlement traffic according to means of transportation in three characteristic years. In view of the actual possibilities of obtaining data only public traffic has been taken into consideration. It results from the table that the bulk of passenger transport is carried by railways and coaches, and the percentage of these two means of transportation is nearly equal. Nevertheless, taking into account the length of journeys the share of the railway is much bigger. In 1965 — 66·6% of railway traffic and 33·3% of bus traffic were people commuting to work or school.

The upward trend in traffic has been maintained in almost all means of transport. In the 1955—1965 decade (for which the most complete statistical data is available), the average annual 1·4% growth of population was accompanied by a 20% annual growth of the number of motor vehicles, an 18% growth of the volume of road passenger traffic, an 11% growth of air lines passengers and a 7% growth of the volume of urban traffic. The rate of growth was the lowest in railway passenger traffic: the rise of fares in 1959 brought about a considerable drop in the volume of passenger traffic. But since 1960 the number of passengers has been growing by 3·4% annually on the average, and in 1965 it exceeded the level attained before the rise. During the last 17 years the number of railway passengers has doubled; in urban transport the traffic doubled within ten years, in road transport within 5 years and in air transport within 4 years. The number of motor vehicles has doubled within 6 years (Fig. 1).

The number of journeys made by public transport means increased from 8 per capita in 1938 to 57 in 1965 in inter-settlement traffic and from 130 to 494 in urban traffic (taking into account only the population of towns with public urban transport).

This considerable growth of the mobility of population was partly due to factors operating all over the world, and partly to specifically Polish factors. Some of the factors operating all over the world were particularly intensified in this country, which is also a specific feature.

Generally speaking, the increased mobility is the result of changes in the population structure, in the social and economic system, the change of state territory as a result of the Second World War and the increased possibilities of availing of means of transportation.

The most important changes in the population structure include changes in age structure and professional structure. Youth and working age people move from place to place most easily. Assuming that the above two groups are aged from 10 to 59, we see that they accounted for 69·4% of the population in 1965, as against only 67·4% in 1931. Young people aged from 10 to 20 are particularly mobile: in 1931, they

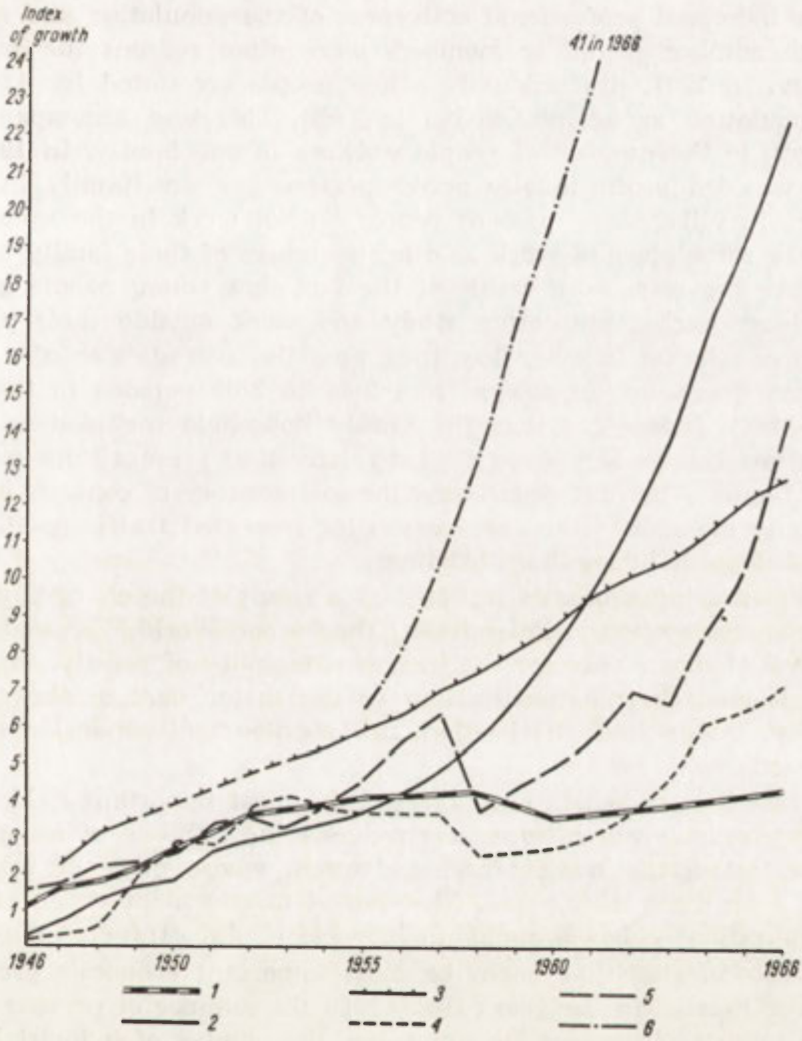

Fig. 1. Rate of growt of the volume of traffic by various means of transportation (1938 = 1)

1 — railway, 2 — intersettlement coaches, 3 — urban transport, 4 — inland and coastal navigation, 5 — aircraft, 6 — number of motor vehicles

accounted for 18·1% and in 1965, for as much as 20·7% as a result of the post-war population explosion.

Changes in the professional structure of the population were all the more impressive. In 1931, 60% of Poland's population derived their incomes from agriculture, as against 38·2% in 1960. In addition, in 1960 at least 800,000 persons linked work in agriculture with work outside agriculture, most often commuting to a non-agricultural place of work.

The increased professional activeness of the population and reduced average number of family members were often reasons for increased mobility. In 1931, professionally active people accounted for 42·5% of the population as against 46·5% in 1960. This was accompanied by a growth in the number of people working in one family. In 1960, the index was 1·5 professionally active persons per one family in towns and 2·1 in villages. At present people do not work in the same trade or in the same place of work as other members of their family as often as before the war. As a result of the fact that young people gain independence earlier and often study and work outside their place of residence, migrate to other localities, etc., the average size of a household has decreased (in towns from 3·66 to 3·09 persons in the years 1931—1960). Before the war the family household included as a rule all the family members, even distant relatives: at present some members of the family often live separately, the maintenance of contacts between all family members is another reason for increased traffic (particularly on traditional holidays like Christmas).

The following processes initiated as a result of the changed political and economic system in Poland after the Second World War, and having an essential importance for the increased mobility of population, should be mentioned first: nationalization of the major part of the national economy, intense industrialization, urbanization and expansion of most services.

Nationalization which encompassed the most important fields of the economy outside agriculture, has reduced the number of independent workers (especially dealers and craftsmen) whose place of work was at the same time their home. The central management — an effect of nationalization — has brought an increase of duty travels in its wake.

Industrialization has been the most important economic process in post-war Poland. In the years 1946—1965 the number of persons employed in industry increased 2·8 times, and the number of industrial enterprises by only 17%. This is a proof of the progressing concentration of employment in big enterprises. This concentration is accompanied by the location of industrial works in separated industrial districts, on the outskirts of towns or outside towns. This makes the distance from the place of residence to the place of work greater. In 1964, about 27% of the total number of persons employed in industry commuted to work. The building of new industrial works is, as a rule, ahead of new housing.

In Poland industrialization is the main driving force of progressing urbanization. The percentage of city dwellers increased from 30% in 1938 to 50% in 1966. This was the result of: migrations to towns, expansion of the administrative boundaries of cities and the building and laying out of new towns. A great part of the present urban dwellers are of rural origin. In the years 1951—1960 alone as many as 1·3 million persons from the countryside settled in towns.

The urban population is much more mobile than rural population. This is due, apart from the nature of their occupation, also to the territorial expansion of towns, different functions of various urban districts, expansion of services and their specialization, and, as far as people who came from the countryside are concerned, also maintenance of contacts with their previous environment.

Territorial expansion is above all the feature of big cities, e. g. the area of Warsaw — in comparison with the pre-war period — has increased (within administrative boundaries) 3·2 times, that of Cracow 4·8 times, of Poznań 2·9 times, of Łódź 3·6 times and of Katowice 2·4 times. The development of industry and services makes getting or changing a job easier; on the other hand, the shortage of flats and the administrative restrictions connected with it (e. g. prohibition of migration to big towns) make changing one's place of residence more difficult. As a result the majority of working people live in one town district and work in another, and about 25% commute to work from outside (the average length of the journey being 18 km).

The development of services which at present embrace much larger strata of the population than before the war, is another factor stimulating the growth of mobility. This is best seen on the example of schools. In the years 1938—1965 there was a fivefold increase in the number of pupils attending secondary general education and training schools and of students attending academic schools; 55% pupils attend schools in another locality than that where their parents live, and 31% are commuters. The percentage of people availing themselves of other cultural facilities, health service, etc., has increased in a similar proportion.

Tourism is that factor which has most direct influence on increased mobility. Unfortunately statistical data in this domain is incomplete and does not reflect the dynamic rate of growth, as a result of difficulties in recording individual tourist traffic. The following figures give an idea of this growth: in the years 1938—1965 the number of tourist hostels increased 3·4 times, and that of people who lodged there overnight increased 21 times. A new form of holidays was set up, the workers' holidays, partly paid for from state funds. In 1965, as many as 1,145,000 people availed themselves of workers' holidays, apart from holidays organized by various enterprises for their personnel and by travel agencies. The number of foreign trips of Polish citizens has increased 8·7 times as compared to 1938, and the number of foreign tourists visiting Poland 12·3 times.

The change of state frontiers after the Second World War was yet another reason of increased mobility. Poland returned the Soviet Union regions where the density of communication networks was the lowest, and regained the former German regions where this network was dense, although badly damaged. What is more essential, about 3·5 million people settled there who came from other parts of the country (apart from repatriates from outside Poland in her present boundaries), which has resulted in particularly lively contacts between the old and regained territories.

The growth of the mobility of the population was made possible — from the point of view of technical possibilities — owing to the intense expansion of the transportation network. This expansion revealed the existence of latent needs for transport means, not known so long as there was no means of satisfying them. The density of the railway network only increased during the first post-war decade; the length of railways built after the war accounts for no more than 3% of total length. After 1955 the increase resulting from the building of new railways was balanced by the liquidation of unprofitable sectors, mostly narrow-gauge lines.

On the other hand, the network of public road transport has been considerably expanded. In the years 1950—1955 the length of public bus service exceeded that of railways, and in the 1955—1965 decade it was doubled. In 1965, the network of public coach transport was 2·7 times longer than that of railways and the number of bus stops was 4·3 times more than that of railway stations. Road transport was first of all expanded in regions where there were no railways, the most neglected regions as regards economy and civilization, where people were the least inclined to move. In recent years the development of coach transport characterises to a lesser degree with an areal expansion than with an intensification of traffic on already existing lines.

Thanks to coach transport the degree of population mobility in various parts of Poland has been levelled up to some extent. In various voivodships the per capita number of long-distance journeys by public transportation means varies from 32 (Łódź voivodship) to 92 (Gdańsk voivodship). In the industrialized voivodships and those where there are big cities or conurbations the index is higher (Fig. 2).

Urban transport developed at a no less rapid rate. Before the war it was almost exclusively limited to tramways in a few big cities. After the war buses and trolleybuses were introduced and in 1950 urban transport already encompassed 75 towns with a total of 5·3 million inhabitants; in 1965, 161 towns with 10·3 million inhabitants, apart from suburban zones round big cities; that is, one third of the country's population availed themselves of urban communication facilities.

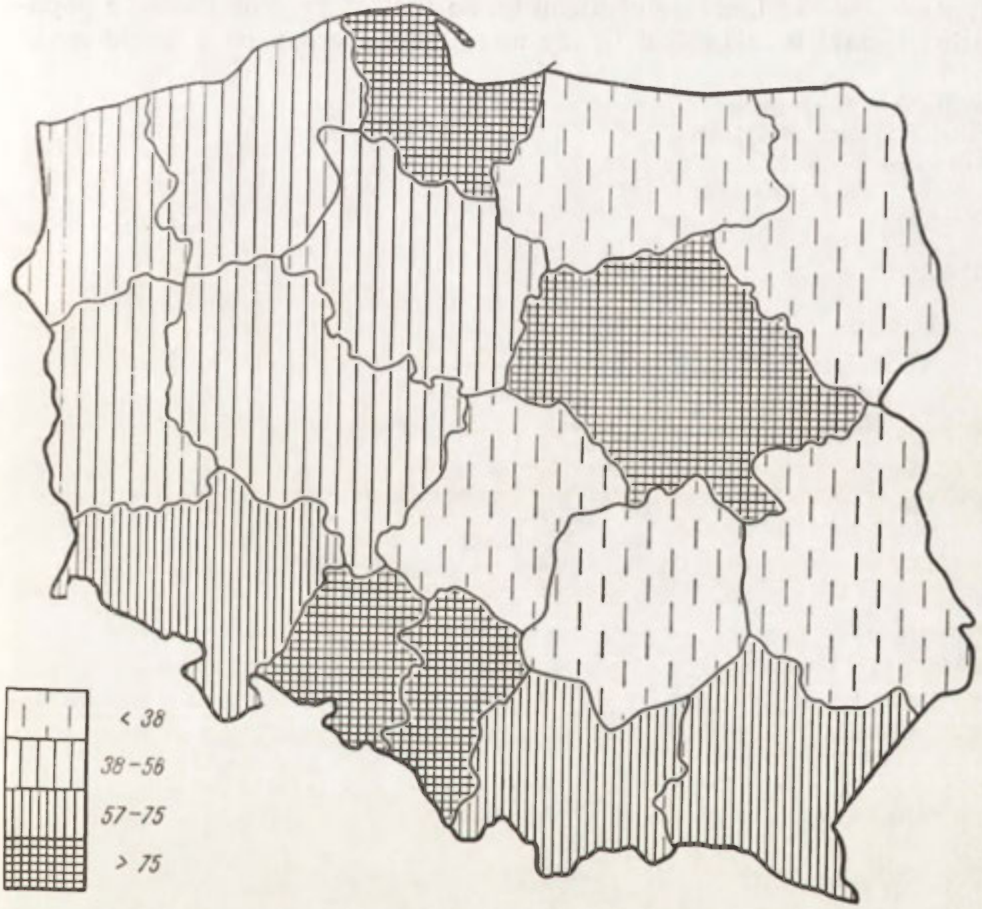

Fig. 2. Per capita number of passengers in inter-settlement public transport in 1965

The increased volume of traffic is enhanced by low cost. In comparison with the pre-war period the nominal prices of railway and bus tickets have increased sixfold with a 14-fold increase in prices of general use articles. Apart from this, the majority of railway passengers avail themselves of reduced tariffs (in 1965, 58·7% passengers were holders of monthly reduced price tickets and 13·3% paid reduced fares for single tickets). The public transport is so cheap that private motoring does not pay.

One should state in conclusion that although the mobility of the population is still below that in many countries of western Europe and North America, mostly because of limited number of motor cars and their limited exploitation, the distance is diminishing as a result of the dynamic rate of increase of mobility, so that at present Poland's population should be classified in the more mobile group on a world scale.

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MIGRATIONS OF MANPOWER IN SOUTHERN POLAND AS A FACTOR OF CHANGES IN REGIONAL STRUCTURES

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INTRODUCTORY REMARKS

Southern Poland which was a classic example of overseas and continental emigration at the turn of the 19th and 20th centuries, became the scene of mass movements of manpower within the country after the Second World War, the predominant feature being migrations from the rural areas to towns. This drive to towns assumed a different character and brought about other social and economic effects than emigration. The rapidly progressing industrialization of the country and the new industrial and socialized service enterprises continue to provide jobs for masses of rural population. Rural dwellers either move to towns and settle there for good in great numbers, or commute to work permanently or seasonally. The analysis of these complex processes, their typological and regional classification — is the subject of the present study [1].

The migration of manpower to towns calls for a detailed study of the components of this movement, the structure of migrants and the directions of mass migrations. The method of study consists in analysing migrations from the point of view of places of immigration and emigration, taking their economic structure into account. The objective of the study is to establish the correlations between various forms of migration of working people [2], to learn about the effects of these migrations on the process of urbanization and on the formation of the labour power resources. The sample investigations carried out in four voivodships (Cracow, Rzeszów, Opole and Kielce voivodships) in typical migra-

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[1] See: postulates of the study submitted by K. Dziewoński in his article "Urbanization Processes in Present-Day Poland" Przegl. geogr., 34 (1962) 3, pp. 504—506.

[2] See (—): G. Barbichon "Le devenir du paysan hors de l'agriculture. Recherches recentes" Études Rurales Nos 13—14, 1964 pp. 194—196.

tion regions, have been based on analysis of single cases with the aid of material available at workplaces, labour exchange offices, population registration offices, and also material obtained from direct inquiries among migrating persons and local administrative staff. Official statistical data, not uniform, providing narrow scope of information and based on sum totals of entries made in municipal registers in bigger administrative units (poviats or voivodships) shows the outflow and inflow of population as a whole without distinction between the movement of manpower and various forms of migrations[3].

FACTORS OF THE DIFFERENTIATION OF MIGRATIONS

The rapidly growing demand for labour as a result of investments and the employment policy is the main reason for mass migrations. The predominant movement in this respect is permanent migration from villages to towns, which encompassed about 2·5 million people[4] in the years 1946—1960, and also daily commuting to work from villages to towns — 1·53 million workers[5]. At the same time the uneven development of the infrastructure in various regions and differences in the wage scale in various branches of the national economy have resulted in a great territorial mobility of manpower and frequent changes of jobs. For instance, in the Cracow Voivodship the mobility of the rural population working in non-agricultural trades involving a change of place of residence, was almost three times bigger than migrations from villages to towns.

The basic directions of population movements are three. 1. the big process of migrations to the Western Regions connected with the settlement campaign (up to 1955). 2. inter-regional migrations to big urban centres (Upper Silesian Industrial District, Warsaw, Łódź, Cracow, etc.), and to newly formed industrial districts (Tarnobrzeg, Turoszów, Płock and others). Up to 1955, these migrations liquidated the so-called structural unemployment in the countryside. 3. Since 1963 there has been a growth of migration of young people born in the years of the population explosion, this being connected with their education and employment.

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[3] The situation is similar in statistics of other European countries, as pointed out by J. Schiefer in his work "Marche du travail Européen" Paris, 1961, pp. 18—22.

[4] K. Sokołowski: Odpływ ludności ze wsi (Outflow of population from the countryside) Warsaw, 1961, pp. 14—15.

[5] T. Lijewski: Dojazdy do pracy w Polsce (Commuting in Poland), Warsaw, 1967, p. 28.

The regional differences in the migration processes in accordance with the spatial relations between centres of demand for labour and regions where there is redundant manpower is an essential issue. The study of the structure of the national economy in centres experiencing a shortage of labour in souther Poland on the one hand, and an analysis of industrialization processes on the other hand, have allowed of establishing the relation between various categories of migrations and various stages of industrialization, as well as the zones of migrations.

The amount of migrations in search of jobs in southern Poland depends on the numebr of new jobs in the new localized industrial centres. Migrations to the following centres have attained the highest dimensions: to Nowa Huta (about 25,000 new jobs in industry up to 1964), to the sulphur region (5,100 new jobs up to 1964), and to the Rybnik Coal District. At the same time the progressing expansion of former industrial-urban centres, the resulting increase of new jobs in industry, services and the demand for qualified workers and administrative and technical staff, has raised the number of commuters and enhanced migrations of population to towns. These are typical processes in the Silesian-Cracovian industrial district and in rapidly industrialized medium-size centres situated along the main railway lines.

In new industrial districts migrations assume specific forms parallel to the course of investments. In the first stage: location and construction of new works, the predominant feature is the commuting of unqualified workers, mainly to the construction site. This is accompanied by periodical migrations of technical staff as a result of recruitment or specialists being sent elsewhere to work. The next stage: start of production and formation of permanent staff brings about migrations of qualified workers. It takes the form of a) permanent immigration of highly qualified workers earlier employed by similar enterprises in various parts of Poland (specialists sent to new posts), and of higher school graduates (holders of scholarships granted by the given enterprise), b) migrations of workers temporarily living in workers' hostels and earlier employed by building enterprises, as well as commuting, and the inflow from agriculture of people previously not working in a trade, c) inflow of workers from neighbouring enterprises, sometimes connected with commuting to work [6].

Analysis of new settlers according to their demographic and pro-

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[6] For detailed study see work by J. Herma "Napływ ludności do miast regionu siarkowego jako czynnik procesów urbanizacji (Inflow of population to the towns of the sulphur region as a factor of the urbanization processes), now in press. PAS 1966. The study contains also a map of Poland showing the territorial origin of immigrants employed in 14 towns of the sulphur district.

fessional features, conducted jointly with an analysis of the demand for workers according to their sex, education and trade, has revealed the existence of typical directions of migrations of male workers: a) to mining and heavy industry centres: workers with primary education and basic professional training who have learned the trade of a miner, quarryman, driller, or sintering plant worker, rolling mill worker, foundry worker, etc. b) to the sulphur region and chemical industry centres: qualified workers with basic and secondary professional training operating various apparatus, flotation machines, electric fitters, etc.; c) to centres of metal and engineering industry: — workers with basic professional education and trained in a trade: assemblers, mechanics, turners, welders, etc.

The striking feature is the continuous growth of the number of young qualified workers, who start work in a trade immediately after leaving school. Large numbers of these young people, mostly rural youth, enter the labour market every year: most of them settle in towns for good. For instance, in the Rzeszów voivodship over 50% of rural youth graduates from secondary schools has settled in towns (1960—1964).

At the same time there is a growing demand for workers who have been trained in new trades and specialities; this being the result of mechanization and automation of production as well as location of new production departments. These are typical factors in the Cracow Voivodship, where new centres of the iron and steel industry, coking chemistry and chemical synthesis have been built, and in the Rzeszów Voivodship in connection with the sulphur industry investments and the development of open-cast mining. The result of this is migration of qualified labour and training school graduates between various industrial centres.

The importance of supply for meeting the demand for labour in southern Poland, determined by the growth of working age population, is marked by the following two factors: 1. the growing disproportion between the steadily increasing demand for labour and the low increase of labour supply in main industrial-urban centres; 2. the growing disproportion between the increasing demand for workers in economically advanced industrial regions and the growing supply of manpower in economically underdeveloped mountain regions. For instance, in the Western Cracow industrial district the growth of local manpower has only met some 40—60% of demand, and in the mountain regions, despite significant migrations (over 15 per mil), there is still redundant manpower. The network of road transport organized by heavy industry enterprises connects the regions experiencing a shortage of labour with those of redundant manpower. In the Cracow Voivodship over 25,000 workers (about 13% of all commuters) avail themselves of coaches bringing workers to enterprises from a distance of up to 50 km. Recruitment of workers in mountain regions by mines, iron and steel works, and construction enterprises situated in the Silesian-Cracow district is another important factor.

Despite the considerable outflow of population to the Western Territories, the dwarfed farms of the overpopulated villages are still characterized by a surplus of manpower. In subarban zones and villages situated along railway and coach lines migration have taken shape of mass commuting. On the other hand, in the mountains, seasonal migrations of unskilled workers, resulting from the seasonal demand for labour in agriculture, have developed along with seasonal commuting and migrations to towns for good. The general trend for young people with professional training is to leave villages and small towns where there are limited possibilities of work outside agriculture and to settle in bigger centres.

TYPES OF MIGRATIONS OF MANPOWER AND THEIR CHARACTERISTICS

There are characteristic differences in the shaping of the regional structure resulting from migrations in southern Poland connected with changes of place of residence or place of work. In the hierarchy of these movements pride of place goes to commuting; permanent migrations (settling in towns, outflow from rural areas) coming next, youth migrations included. The bulk of migrations are taking place within the region. On the other hand, the transfer of labour for seasonal work and as a result of recruitment (temporary migrations) assumes the character of inter-regional migrations. Migrations from place to place are accompanied by inter-branch movements of manpower, a fact which is only partly connected with territorial mobility and belongs rather to the sphere of social mobility.

Daily and seasonal commuting is a mass form of labour migration in southern Poland. There are about 500,000 daily commuters (one third of commuters in Poland); most of them are people going from the countryside to towns (over 80%), but there are also some travelling from one industrial centre to another, typical for satellite towns (Cracow, Upper Silesian Industrial District).

The centres of daily journeys to work are: a) mining and iron and steel industry centres; centres of the metal and engineering industries in the Silesian-Cracow region, where commuters account for over 70% of the staff; b) medium-size towns with a well-developed industry, linked with the hinterland area by a dense network of transport (the Opole, Tarnów—Rzeszów and the Central Polish Industrial District, known as *Staropolski*).

As regards spatial distribution of the places of residence of the people who go to work from rural areas the following features have been noted: a) disproportions between suburban zones and villages situated along railway lines and highways, where up to 1,000 people commute from one locality (i. e. up to 30% and more of people professionally active on the one hand, and on the other hand the mountain regions where up to 50 persons, or 5% of all professionally active people travel to work; b) the concentration of some 60—80% of commuters within the 1-hour isochrone. This problem is closely connected with the pattern of the transportation network and has an essential influence on the passenger flow and traffic zones. Most travellers are peasant-workers, owners of dwarf farms and small lots of up to 2 ha. c) There are evident areal concentrations of commuters working in industry (more than 90% of all commuters living in villages come from localities situated in the hinterland of big industrial centres; up to 50% of all persons commuting from villages live in localities situated along railway lines[7].

Seasonal commuting has been mostly developed in mountain areas and encompasses first of all unskilled labour. In southern Poland, the main centres of seasonal commuting are the southern poviats of the Cracow Voivodship, supplying manpower to iron and steel works, mines, and construction enterprises situated in the Silesian-Cracow region.

Migrations of manpower to towns for permanent residence are carried out within the framework of the planned economy guided by the efforts to make good the existing disproportions between the growth of the number of inhabitants and the increase in the amount of flats which still lags behind. On the other hand, the outflow of population of the countryside is definitely spontaneous. Migrations of manpower from the countryside to settle in towns are usually preceded by a period of commutation. The specific feature of this category of migrations is that professionally passive people arre also involved. The immigration of manpower to towns (according to inquiries carried out in the Cracow and Rzeszów Voivodship) accounts for over 60% of the local inflow of

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[7] J. Herma: Dojazdy do pracy w Polsce południowej (woj. katowickie, kieleckie, krakowskie, opolskie, rzeszowskie) — [Commuting to work in southern Poland (Katowice, Kielce, Cracow, Opole and Rzeszów Voivodship)]. Cracow 1966, Monographs of the College of Pedagogy, p. 159. There, a map of daily commuting flows to work in different centres of nonagricultural employment and a map of areal concentrations in gromadas of workers commuting, is enclosed. Tha latter shows the percentage share of persons commuting in the total sum of working-age population.

the population. The basic part come from the surrounding localities (from 40% to 70% of the total inflow of manpower) which mostly supply labour with low qualifications. The percentage of rural and urban dwellers varies in these processes. In medium-sized and big industrial and urban centres with a great demand for qualified manpower a high inflow from towns predominates (over 50% of total labour transfer). As a result the new settlers come from all over Poland.

Analyses of the skills of new settlers, linked with an analysis of the functional structure of towns have shown that in specialized industrial towns, skilled manpower accounts for up to 75% of newcomers. Over 60% of them work in industry. On the other hand, in towns with a complex functional structure the share of whole families who come and settle there is relatively higher than that of single persons. The relatively high index of accompanying immigrants (40—50%) holds on the age structure of the town population.

Contrary to immigration, the trends of emigration from the countryside have not changed as compared to the inter-war years. Villages inhabited by farmers, both with a well-developed agriculture and economically under-developed mountain villages, continue to be regions of mass outflow of the population. Analyses of migrations carried out in the Cracow and Rzeszów Voivodships have proved that there is a great regional differentiation of emigration as regards professional skill. In the rural areas the mass outflow of young people with professional or technical education is the typical phenomenon (up to 65% of the total labour transfer). The main waves of emigrants go to big industrial centres (Upper Silesian Industrial District and Cracow), and to new developing industrial-urban centres (Tarnobrzeg, Oświęcim, Kędzierzyn, Tarnów and others). On the other hand, people from the under-developed mountain regions mostly supply the unskilled manpower (up to 70%) of the total number of emigrants professionally active. Most of them go to mining centres.

Detailed investigations carried out in several dozen villages of the Cracow Voivodship have demonstrated that single persons predominate among the emigrants (up to 75% of the permanent transfer of labour). They represent two age groups: young people of working age and school age youth. Most of them come from families with many children (over 5 persons), landless families and ones with small holdings (up to 3 ha). The bulk of emigrants (up to 50%) go to towns in the Silesian-Cracow region, the remaining go to new and bigger industrial centres. On the other hand, the small poviat towns situated in the vicinity, are most often the first stage of migration of unskilled labour.

FUNCTIONS OF THE MIGRATION OF LABOUR IN THE CHANGES OF REGIONAL STRUCTURES

In the present development stage, migrations of manpower sharpen the contrasts between industrially advanced regions on the one hand and the underdeveloped regions on the other.

The results of migrations in industrialized regions are first of all: acceleration of the urbanization processes in towns and suburban zones. The population growth resulting from migrations to towns, according to inquiries conducted in the Rzeszów and Kielce Voivodships, amounted from 20% to 65% (in the years 1950—1965). Immigration is the basic factor of population growth in industrial towns with rapid developing production and housing investments. Towns and settlements in new industrial districts provide a typical example in this respect.

Immigration to towns is accompanied by the rejuvenation of the town population. This is the effect of both the strong inflow of immigrants of the young working age group and the inflow of accompanying immigrants with a high percentage of children under 14.

The effects of this inflow on the transformations of the professional structure of city dwellers are evident. The directions of transformations mostly depend on the profession of the newcomers, the way they have come to the new place of residence and their professional promotion. The fact that the immigrants are for the most part living in new urban districts, has an influence on the changes in the functional system of urban quarters.

The migration processes take a different shape in suburban villages: the predominant features are great movements of population (inflow from more distant localities and outflow to the town) and intense commuting which effect the directions of demographical and socio-professional changes being a dominant feature of the suburban zones. The function of permanent migrations in these transformations are the numerical growth of the working age group of population and an increasing index of the density of population. Commuting forms social groups of peasant-workers and workers the percentages of which reflect the progress in the development of suburban zones[8].

Migrations in economically under-developed areas are most often connected with the outflow of the young, educated and professionally

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[8] These problems were the subject of separate studies. Comp. M. Dobrowolska, J. Rajman "The Socio-economic Structure and Dynamics of the Suburban Zone", Geogr. Polon., 7, 1965, pp. 115—132.

active group of population. The effects of this fact in agricultural regions with a low rate of natural increase (up to 5 per mil and over) in the Miechów and Proszowice poviats is a population decrease, a shortage of manpower in agriculture, (male labour above all), and the acceleration of the process of the growing old of the population. On the other hand, in the mountain regions with a high rate of natural increase (up to 20 per mil and more) despite the big outflow (over 10 per mil) there is still redundant manpower [9].

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[9] W. Czarkowska, M. Dobrowolska: Węzłowe problemy demograficzne regionu (Key Demographic Problems of the Region). Publ. in the collective work: Rozwój ekonomiczny regionu krakowskiego w dwudziestoleciu Polski Ludowej (Economic Development of the Cracow Region in the Twenty Years of People's Poland) Studies of the Economic Sciences Commission of the PAS, Cracow branch, Wroclaw—Warsaw—Cracow, 1965, 7, p. 307.

PRESENT NEEDS AND NEW DEVELOPMENTS IN URBAN THEORY

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In a article published in 1907 Werner Sombart, a German economic and social historian, presented a new concept, a definition of cities as economic phenomena. He identified the city as a specific kind of economic region, characterized by its inherent need to import food as well as other raw materials and, in consequence, to export finished products or services. In this way the division into exo- and endogenous groups was introduced. For Sombart those exogenous activities which supply means for obtaining necessary imports formed the economic base of the city. Its variants in different parts of the world and in time allowed him to establish a specific urban typology which he presented in the second edition of his monumental work "Der moderne Kapitalismus".

In the thirties Walther Christaller, a geographer, and almost simultaneously Alfred Lösch, an economist, introduced and developed another concept important in urban theory, namely the concept of central places. Although Christaller saw clearly the difference between a central place (as defined by him) and a city (which possesses in addition some specific, specialized functions) he did not attempt to determine any numerical relations which may exist in reality between the functions of a city as a central place and the remaining, specialized functions. For Lösch the problem was more complicated as his economic landscape took the form of a market area of the city and varied in size depending on the different economies of each product or service. His approach was more realistic but the specialized functions of a city were also omitted in closer analysis.

In the classical statement of the theory of central places as formulated by Christaller, another important concept was included, namely the existence of separate and definite levels of common central functions forming the basis of the hierarchical structure of the urban network.

In the early forties two American geographers, Chauncy D. Harris and Edward L. Ullman proposed the division of urban functions (the support of cities — in their terminology) into those of central places, transport points and specialized agglomerations (mining, manufacturing or recreational), distribution of the first being specifically areal in character and that of the second being linear, while the third is usually but not necessarily connected with concrete, highly localized resources.

Recently another German geographer, Kurt A. Boesler, tried to correlate the concept of the urban economic base (Sombart) with the theory of central places (Christaller) and economic landscape (Lösch). As a result he distinguished three types of urban functions, two of them being exogenous (supra regional and regional) and the last — endogenous (local). But a closely similar approach was presented in a much better developed and more logically convincing form in 1963 by the French geographers Françoise Carriere and Philippe Pinchemel. In principle they started from Sombart's division, but used different terminology. They split the active population of the city into specific and common groups (population active specifique et banale) but then modified the theory profoundly by noticing that the functions which the city fulfills in relation to its sphere of influence may also be called common (banal) ones, especially in modern conditions. In fact they proposed to move the frontiers of urban area to the limits of the urban region. However in the actual study of French cities, because of the difficulties in gathering statistical data, they kept to the traditional approach. Nevertheless in the typological classification, by differentiating economic activities from economic functions they were able to draw a distinction between types of cities with specific functions based on specific activities and those with specific functions based on common (banal) activities.

The proposed new terminology represented in reality new concepts which did not correspond to the old ones. This becomes clear if we modify these terms once more, replacing "specific" by "specialized" and "banal" by "common", adopting the terms "exo- and endogenous" to describe the Sombart division and abandoning the use of such pairs of terms as "basic-nonbasic", "city forming and city serving" or "primary and secondary".

With these modified terms it is easy to see that we have to do with two basic divisions and not one, as was too easily assumed. Both exo- and endogenous functions may be specialized or common in character although it seems that the endogenous functions are in the majority of cases common ones. Among the exogenous functions those of central places seem also to be common ones in the majority of cases. However before we accept the proposal put forward by the French authors of identifying the urban area of the modern city with the urban region (i. e. with the traditional city and its sphere of influence) we have to test whether Sombart's definition of a city as an economic phenomenon is still valid for the modern city: whether in reality it is still an economic region.

The historical city in all its aspects — economic, social, cultural and political — passed through a very long evolution, changing in both its content and its form. One of the highly characteristic changes which have taken place is the dissociation of places of dwelling, work and leisure. The technological revolution in communications has increased and is still increasing the mobility of man (as well as of goods and information) and by now it influences the boundaries of the city or urban area.

An economic region by definition (as a subspace of a socio-economic time-space) has to be a part of a larger community and economy and at the same time to form in some respects a closed community and economy. The first part of this statement is fairly obvious though some may raise objections to the second part. But if we deny or eliminate it, then any area would be a region, which is, of course, absurd. Even if we do agree with Sombart that a characteristic mark of the city as a type of economic region is the openness of its economy ("it is more open than other regions") — to have an economic region we still have to define under what aspects it is closed and what forms its closure.

In the Middle Ages a city was closed physically (by the city walls), socially, economically and even politically. It formed a closed system with well defined points of entrance and exit and therefore it was clearly an economic region. In later times, most of these limitations were broken, abandoned or weakened. However the closure of the city economy within the urban area still persisted, at least in social and economic custom and consciousness. But the increased mobility of man has now demolished it almost totally. What happens is that the potential size of the urban area has practically no limits and the actual size is constantly growing. The phenomenon is not even stabilized and this creates additional difficulties. If there were any prospect of stability all we should have to do would be to identify the new urban area and its boundaries.

If we assume on the basis of traditional concepts that there are two typical and basic areas: the urban area and the urban region (the city with its sphere of influence) then we may state that the urban area tends not only to become identical with the urban region but in specific cases of smaller and the largest cities it grows to be even larger than the urban region. As a result the functions of a city as the central place for some specific area become in the majority of cases its internal affair. In relation to the outside world the exogenous functions of a modern city are in principle specialized functions. But an additional phenomenon develops — the urban areas and spheres of influence of different cities, specially smaller ones, start to overlap. In this way the integration of the urban network begins to develop and some think that this will start some strong movements towards the concentration of urban populations in a smaller number of larger cities. It may be so but the present author is personally rather doubtful. At least there is no necessity. With the increased mobility and overlapping of the urban areas nothing changes numerically, i. e. each city has to serve the same number of inhabitants. What changes in reality is that the individual inhabitant, as a result of increased mobility, may choose from the services of several cities. There may be some definite probabilities as to where he will go in given circumstances but he will consider this new freedom of choice as an achievement not lightly to be abandoned. To a greater extent than before the growth of a city now depends on the enterprise of its active population, as the possibilities of competition as between cities are increasing rapidly. Naturally some cities may win in this fight for population to be served and will grow at the expense of the others but the weaker or losing cities always have one way of defence open: they may specialize. The modern city tends to specialize both in relation to the outer world and in relation to its new, polycentric internal area.

Various types of this new kind of structure and relations are developing. Three seem to be of greater importance and better defined than the others.

The first covers the case of small towns and cities. Here the overlapping of both urban areas and spheres of influence is typical and may even be total. Consequently individual cities cannot be analysed separately but have to be treated together as a complex and a polycentric urban network develops whose boundaries are defined by hierarchically higher regional units (e. g. an administrative and economic region of very high level or a state). In the future the statistically determined areas of dominance of specific central places may be superseded here by an extremely variable superposed network of specialized centres.

Secondly, we have the case of middle-size cities — the regional capitals. Here the traditional pattern still persists. The urban area (although much larger than before) is still smaller than the sphere of influence of the city as a central place (regional capital). Probably for this reason it is generally assumed that such a city is at present most satisfactory and at the same time most effective economically. But as the mobility of man and goods is still increasing, is its character really stabilized?

Finally we have the case of large cities which have grown into highly developed urban complexes — metropolitan areas and conurbations.

Here the urban areas are even larger than the possible urban regions. In the opinion of the author such cities are not really central places, their central functions becoming completely secondary — the only exceptions being national capitals. On the other hand, the original urban regions of various hierarchical levels survive within the internal organization of urban area. However even here the processes of specialization tend to develop, replacing the simpler organization of the local service centres by more complex patterns of various specialized areas.

These new systems of urban networks do not replace the old ones everywhere and at once. They tend to develop locally and regionally following the general rhythm of economic growth of the whole nation. In fact they may be used for measuring the progress in social and economic modernization of the given society or given nation. As they also represent the highest stage of urbanization they may and indeed should be used to measure the progress or urbanization in highly developed states where the traditional index, expressed by the percentage of urban population to the total population loses all meaning (when such percentages are very high it is difficult to obtain any clear picture of further increase). In place of such superseded indices we may use, for instance, the percentage of population living within the metropolitan areas and conurbations, or the percentage of the total area of the given country occupied by the polycentric urban complexes, or perhaps both these coefficients combined.

The existence of new urban phenomena, and not only those mentioned above, is easily observable. However it is only rarely acknowledged that a full description and convincing explanation requires revision of the basic concepts and the methods of analysis employed. The traditional ones commonly used are no longer adequate. In this paper the author has tried to point out the direction of changes taking place and in doing so has introduced specific generalizations together with definite qualifications of definitions and statements hitherto thought to be widely applicable.

Let us try to sum up these points.

We have two basic areas: urban area and urban region. The first one defines the area of a city as an economic region and in consequence it serves as the starting point in measuring the size of exo- and endogenous activities and groups of population; the second is directly connected with the theory of central places: generally speaking, it is an expression of the standard functions of a city and it may be identified as well as described as a larger economic region created by the existence and functions of a given city. However the specialized functions of a city overlap both the urban area and the urban region, and indeed they are not necessarily connected with specific continuous space defined once and for all. The characteristic feature of our time expressing the increasing mobility of man is the growth of urban area which often becomes discontinuous and engulfs the urban region. This destroys many traditional aspects of the city, its social and economic activities, and whole life. It presents us with the necessity for a redefinition of the city as an economic region with the specific characteristics of a functional economy open towards the larger (regional or national) society and simultaneously with a local economy closed within its area. There are strong reasons for acceptance as a working hypothesis that the closure of modern urban economy is to a very large extent only stochastic or even statistical and its open part depends basically on specialization.

Finally new types of integrated urban network have to be taken into account. Those of polycentric character are expressed either as regional networks of specialized, independent cities or as a very large city or urban complex (whether a megalopolis or a metropolitan area or a conurbation) composed of many, differing centres of varying size, often representing former cities completely engulfed by the growing urban sprawl. In both cases the integration of formerly independent units is strongly advanced.

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URBANIZATION PROCESSES IN THE HINTERLANDS OF TOWNS AND INDUSTRIAL CENTRES

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The object of the present study is the analysis of socio-demographic and settlement transformations in the hinterlands of industrial centres which gradually acquire an urban character; these transformations result in the formation of spatial structures characteristic of those regions. Starting with the assumption that the urbanization process is expressed not only by the growth of the number of urban dwellers but also by the transformations in the social and professional structure of the population, the author studied urban-industrial centres and the zones of their influence, aiming at a reconstruction of their origin and at the presentation of the dynamics and structural evolution of these centres in People's Poland. He discusses the above problems on the example of six economic districts which are coming into existence in the outer zone of the biggest Polish urban-industrial agglomeration, namely the Upper Silesian Industrial District.

The method of study consists in linking the changes in the structure of employment with the scope and specific character of the labour market and the demand for local and outside manpower. The analysis of the population employment structures of various centres, their zone of influence and of concrete villages has been supplemented with numerous field investigations.

The study has been based on both published and unpublished statistical data supplemented with single facts taken from the population registers of several dozen of villages.

The starting point in the reconstruction of the rate of growth and the differentiation of urbanization processes was an analysis of the growth of urban population and its share in the population of the economic regions and also the examination of the specific features of urban labour markets shaped under the influence of accelerated industrial investments. In the further stage of work the author's aim is to determine the role of urban places of work in the transformations of the socio-professional structures of the rural population.

The demand for labour has increased after the Second World War so that the population of the towns did not suffice to meet it. As a result the hinterlands of industrial centres have become the scene of rapid social and economic changes being the effect of commuting to work [1]. This way links have been created between rural population and the industrial centres and enterprises through labour relations; and this has been at the same time a transition period in the process of their urbanization [4]. The characteristic feature of this process is the formation of employment groups in the outer zone of big industrial centres and regions. These employment groups assume various forms, namely:

a) the first cathegory of an employment group is a production enterprise linked with individual peasant-workers' and workers' holdings by relation of work;

b) the second cathegory of a higher grade of evolution embraces an industrial centre with the surrounding village settlements gravitating to it;

c) the third presents agglomerations of industrial centres linked with peasant-workers' and workers' settlements supplying these centres with manpower (e. g. in Rybnik Coal District).

The spatial pattern of these structures is designated by indices of their gravitation to one or another centre of employment, taking into account the wide range of functional and service links resulting from the specific infrastructure of the town and its hinterland. These indices may also serve as a criterion for demarcating the social and demographic boundaries of a town. The fact that such structures are typical for hinterlands of all industrial-urban centres of southern Poland we have examined, is an argument in favour of the above suggestion [3].

The area of six economic districts: Bielsko, Częstochowa, Rybnik, Eastern Opole, Western Cracow and the Upper Silesian Industrial Districts — the latter situated in the very centre of the group [6], covers 15,900 sq km and was inhabited by 4·5 million persons in 1965, of which 68% were city dwellers. After the Second World War, this region was not uniform as far as the degree of urbanization is concerned. This was the result of uneven economic and population growth in various centres, depending on differences in geographical, historical and economic conditions, non-uniform development of industry, the transportation network, and also the differences in the scope of the demand for outside labour. The different conditions in the areas which have become the scence of industrialization after the Second World War, are an important factor of the differentiation of the spatial socio-demographic structure of the outer zone of the Upper Silesian Industrial District.

The area of the economic districts covered by the present study was marked in the years of People's Poland by dynamic urbanization processes which took place in several stages. As a result the percentage of urban population increased there from 44% in 1946 to 68% of the total population in 1965. The first stage, connected with the initial period of implementation of the investment tasks of the Six-Year Economic Plan, marked the formal conclusion of the urbanization process of the Upper Silesian Industrial Conurbation, a process that began in the middle of the 19th century. The area, where several dozen production and dwelling settlements had been created in connection with the development of coal mining, iron, steel and zink works and the manufacturing industry, together with the network of settlements dating back to the feudal period, formed a chaotic conurbation, out of which 15 urban districts (poviats) were demarcated up to the end of 1951, covering a total of 611 sq km with an average density of population of 2,060 per sq km. At the same time the network of urban settlements in the outer zone of the Upper Silesian Industrial Districts was developed: 13 new towns were formed there, most of them by means of granting town status to industrial centres and agglomerations which had come into being earlier.

The next stage of urbanization of the outer zone, which came to an end in 1959, took place in close correlation with the industrialization of the Silesian-Cracow region. As a result of this process, many old mining and industrial settlements were considerably expanded, and this brought in its wake the development of villages coupled with them as the place of residence of industrial workers. Beginning with 1954, more and more of these villages have gradually been granted the town status or the status of an urban settlement. In the first period of socialist industrialization of the country, based on an increased demand for labour, a period during which employment in the industrial plants of the Upper Silesian Industrial District conurbation increased by over 150,000 persons, and in its outer zone by over 250,000 persons, a total of 79 "new" towns and urban settlements were founded in the reviewed area which contributed to an evident increase of the density of the spatial structure of the urban settlements network.

In the third stage which began in 1960, new towns and settlements have not been set up, but the status of the existing ones has been changed by administrative regulations. In that period 4 settlements and one town have been included in big cities and 18 settlements have been granted with a town status.

The increased density of the network of urban settlements in the outer zone of the Upper Silesian Industrial District was reflected by the index showing the average area per one urban settlement. The index was 127 sq km for the whole of the outer zone, that is, 2·5 times smaller than the national index. In the most urbanized districts: the outer zone of the Upper Silesian Industrial District and the Rybnik Coal District, the index is one fifth of the national average (55·6 sq km and 73 sq km respectively). This dense network is, however, composed of small towns with a population of under 20,000, which in 1965 were inhabited by 54·9% and 83·1% respectively of all the urban dwellers of the district. In the Bielsko and Częstochowa districts where two big urban centres have grown, the population of small towns accounts respectively for 8% and 24·9% of the total number of city dwellers.

The analysis of changes in the number and distribution of urban centres has made it possible to reconstruct the rate of their population growth. It has been found out that the rate of population growth in the towns of the outer zone in the years 1946—1965 was more than two-and-a-half times higher than that of the Upper Silesian Industrial District Conurbation (227·3% as against 90·5%). Both inside the Conurbation and in the various economic districts of its outer zone essential differences could be noted, allowing of a preliminary classification of urban centres, encompassing big and medium-size towns. The rate of population growth was the lowest (under 50% of the starting point) at Świętochłowice, Ruda Śląska and Chorzów, that is, the most densely populated towns of the Conurbation, and also in Cieszyn in the outer zone. The second group (50—100% growth) includes 8 towns of the Conurbation and 9 old industrial centres in the outer zone. The third group (100—200% growth) comprises Bytom and Siemianowice Śląskie in the Conurbation and Jaworzno and Knurów in the outer zone. Towns in the last group with the highest rate of population growth are new industrial centres and satellite towns in the outer zone. Oświęcim and Tychy occupy the leading place here with an over 500% population growth, mostly resulting from the great inflow of the population to the new housing estates built near to the new industrial works. Over 49,300 persons have settled at Nowe Tychy during the last decade (1956—1965) and the number of new settlers in the new centres of the chemical industry: Kędzierzyn and Oświęcim was 20,000 and 18,300 respectively.

Changes in the number, geographical distribution and size of towns are only one side of the complex urbanization process. They are accompanied by changes in the number and character of work places, conditioned by numerous factors: the type of industry, the stage of its development, the fact whether and to what extent the network of ser-

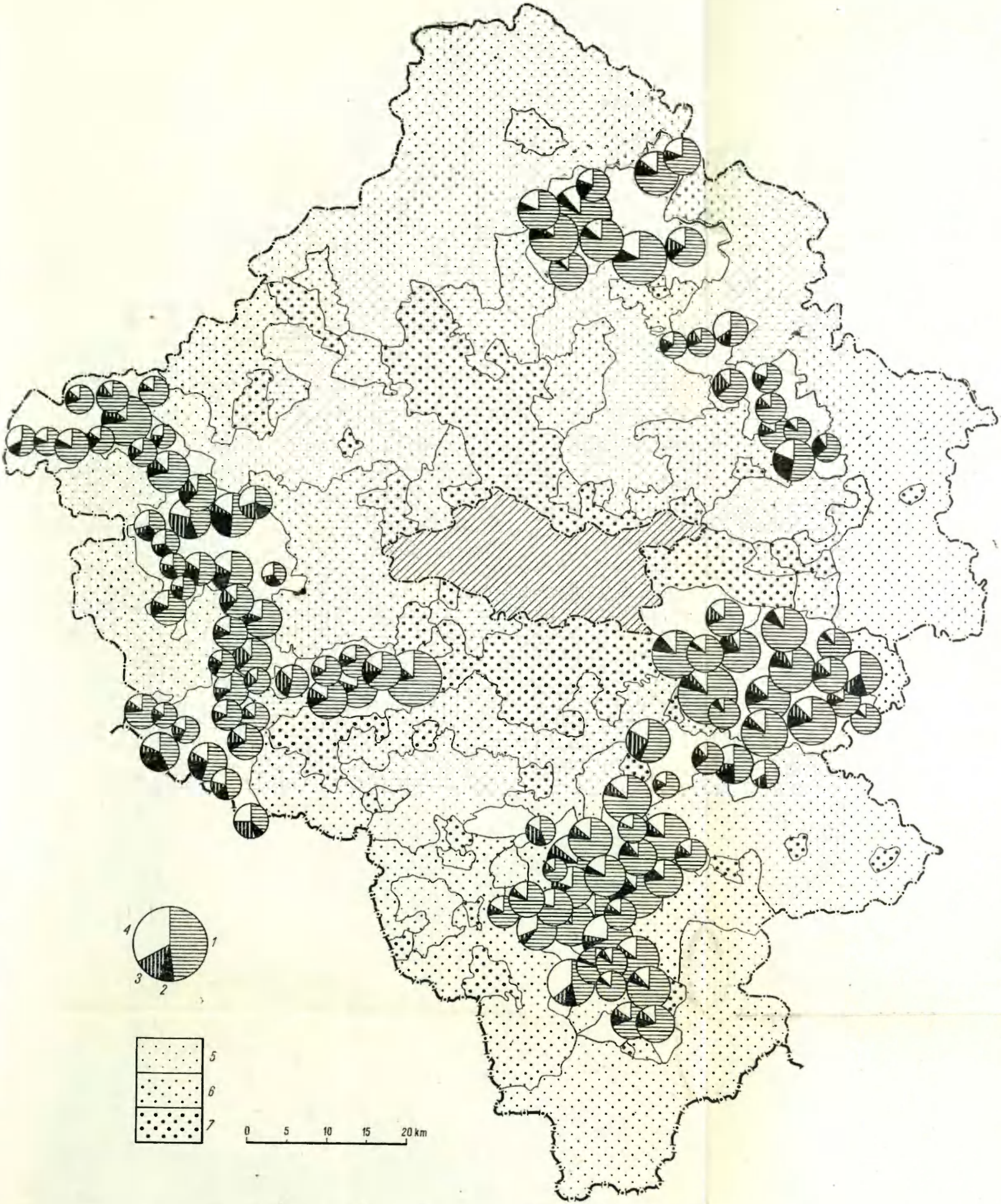

Fig. 1. Structure of the employment outside agriculture of the rural population in 1960

1 — industry; 2 — construction; 3 — transport; 4 — others outside agriculture. Share of nonagricultural employees in the total number of persons professionally active: 5 — up to 50%; 6 — 50·1 — 75%; 7 — above 75%

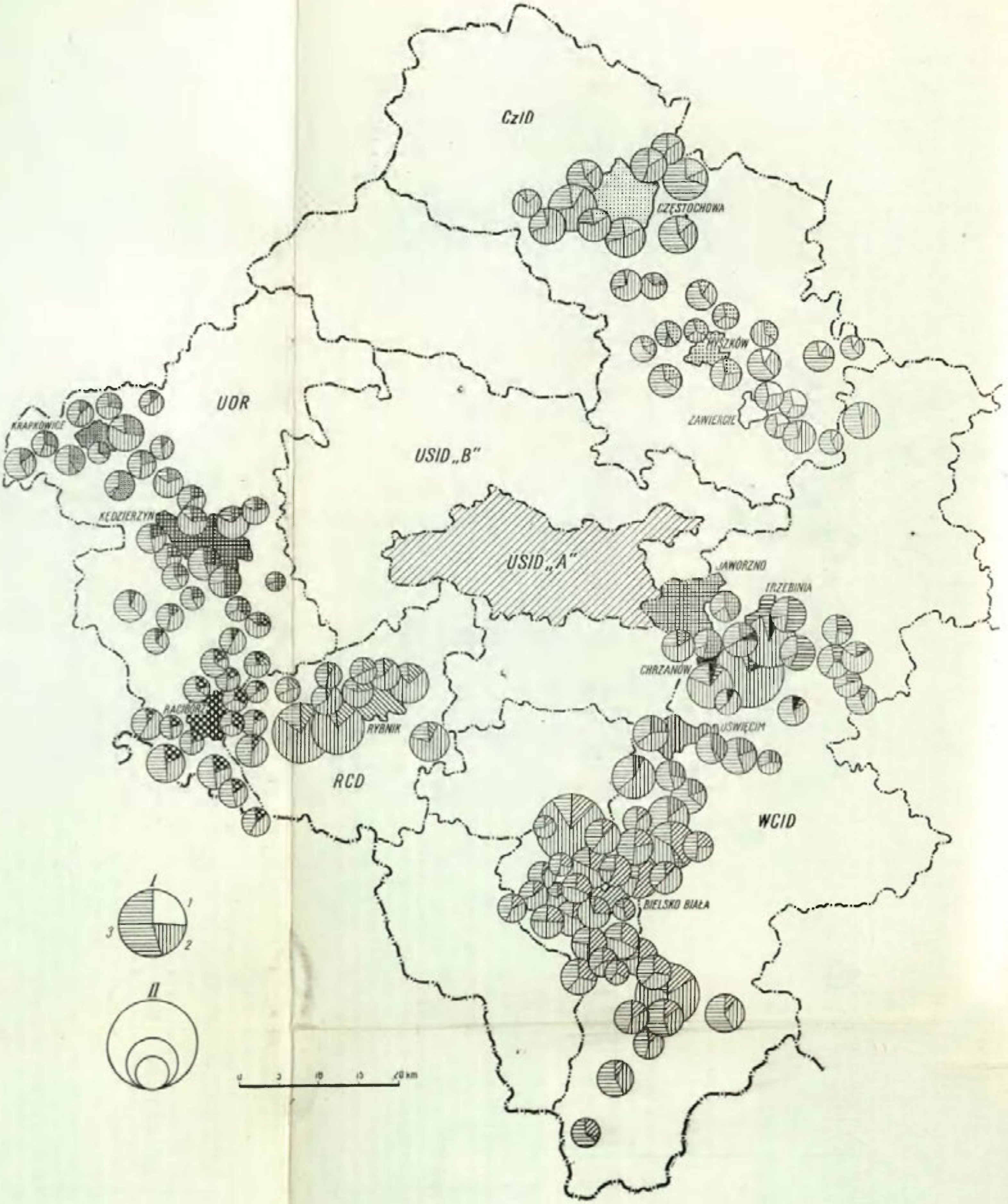

Fig. 2. Spheres of employment of towns in the outer zone of the Upper Silesian Industrial District in 1960

I — Place of employment: 1 — persons employed in central places; 2 — persons employed in other places and in the place of residence; 3 — persons employed in agriculture. II — Employment — circles proportional to the number of persons employed. CzID — Częstochowa Industrial District, USID — Upper Silesian Industrial District, UOR — Upper Odra Region, RCD — Rybnik Coal District, WCID — Western Cracow Industrial District vices meets the requirements, etc. The number and character of jobs in towns exert an influence on the formation of the specific employment links between the industrial centre and its rural hinterland; between the enterprises and concrete villages, contributing to the formation of the concrete employment groups. The study of labour relations in over a dozen instances taken from the outer zone of the Upper Silesian Industrial District has enabled us to trace the successive development stages and to classify the groups into various types in connection with:

(a) manifold raw material and power industry base, on which various types of industry have been developed, which, in turn, determined the demand for labour (e. g. the mining centres of the Chrzanów and Rybnik Coal Districts mainly need male manpower with rather low professional skill; the Chełmek and Otmęt footwear production centres are mostly based on female labour, and the chemical centres: Kędzierzyn and Oświęcim employ highly skilled workers, permanently trained at the factory training courses and in technical schools).

(b) various stages of industrial development and the ensuing different stages of industrialization (old centres, now being developed on a large scale, situated in close proximity to the Conurbation and in the Bielsko Industrial District, and completely new ones, e. g. Kędzierzyn—Blachownia Śląska—Zdzieszowice, or Oświęcim).

(c) non-uniform infrastructures of rural hinterland.

The detailed statistical and field analysis of old and new industrial centres which have come into existence in the outer zone of the Upper Silesian Industrial District, shows great differences as regards the number of employees and demand for outside labour. The number of commuters varies from several hundred persons in local production centres to over 9,000 at Czechowice (47·7% of all employed in that centre), Częstochowa (17·2%), Kędzierzyn (56·7%), Trzebinia—Siersza (57·7%), and 30,000 at Bielsko-Biała (46·1% of all employed). Over 35,000 persons commute to Katowice, the biggest employment centre in the Conurbation (only 18·9% of all employed). The investigation carried out in various centres has not revealed any correlation between the number of employed, that of commuters and the size of the town. The disproportions existing in this respect all over the country were already emphasized by T. Lijewski [7].

The demand for labour from outside is particularly big in the mining industry centres: the percentage of commuters is more than 75% of employment in extreme instances (e. g. Siersza in the Chrzanów Coal District). In view of the great concentration of mining centres on a relatively small area and the unattractiveness of work in collieries, the latter have developed vast spheres of influence, sometimes extending to several hundred localities (e. g. Brzeszcze 236, Jaworzno 189). The employment groups of these centres, comprising suburban professionally urbanized settlements (i. e. settlements where over 10% of professionally active population work in their place of residence and more than 40% of inhabitants are employed outside agriculture), are, as a rule, not very large and they overlap with the employment groups of neighbouring labour centres. Most often several villages situated in the nearest vicinity of the centre, show strong links with it (over 45% of the professionally active population have a job in that centre) and only several persons commute to it from more distant localities (the Brzeszcze colliery, for example, brings its workers by factory coaches from the far distant Żywiec Valley and the Żywiec Beskid mountain villages [5], and the Jaworzno collieries from the distant villages situated in the Miechów Uplands). Old industrial centres with a differentiated structure of work places and old traditions of influences in the surrounding zone, employ in their productive activity a much higher proportion of the professionally active population of suburban villages. Their groups of employment as a rule encompass more settlements (Fig. 1).

The size of the centre and the specific features of its employment structure as well as its traditions of influence, was the reason of non-uniform transformation of the villages situated in the outer zone of the Upper Silesian Industrial District. (Table 1).

TABLE 1. Stages of transformation of suburban villages

Zone of the centre of employment	Percentage of persons employed outside agriculture		Percentage of professionally active population of villages employed in the centre		Population density per 1 sq km
	total	in production	total	outside agriculture	
Rybnik	73·5	83·5	20·5	27·8	191
Chrzanów	71·3	89·0	12·9	18·1	174
Jaworzno	70·2	88·9	32·2	46·0	181
Bielsko-Biała	69·0	85·0	28·6	41·5	232
Kędzierzyn	64·5	81·5	23·4	36·4	106
Krapkowice	63·6	83·0	24·6	38·6	104
Częstochowa	63·4	86·6	12·6	20·1	166
Trzebinia-Siersza	62·3	87·3	28·2	45·2	130
Myszków	59·1	83·0	31·0	52·5	142
Racibórz	55·6	81·0	17·8	32·0	144
Oświęcim	54·0	82·5	20·4	37·8	159
Zawiercie	53·5	87·5	15·8	29·5	90

Apart from villages belonging to the Bielsko, Chrzanów and Rybnik zones of employment, already well advanced as regards professional urbanization processes, there are also partly transformed rural settlements. Along with rural communities where several hundred people work in the employment centre, there are other communities, sometimes bordering on the town, with only several dozen people permanently employed in the town. These facts contribute to sharpening the contrasts that are the inheritance of earlier political and socio-economic formations.

The structural differentiation of the zone of employment of urban and industrial centres is the specific factor recorded in all the zones studied. Each zone comprises several production-settlement groups connected with the local plants (e. g. that of Blachownia and Gnaszyn in the Częstochowa zone, that of Kuźnia Raciborska on the border between the Kędzierzyn and Racibórz zones, that of Czechowice in the zone of Bielsko, etc). On the basis of labour relations local and commuting population is encompassed by the process of production and this fact, combined with the influence exerted by the central urban settlement, brings about transformations in the structure of employment of the population. These production-settlement groups, found round almost every centre, are the specific factor of their spatial structure. Hence the indices showing the percentage of non-agricultural workers in the total number of working population in suburban villages are the resultant of the influence of work places situated in the town and of local production centres being often ancillary works of those in the town.

The detailed statistical and field analysis of the employment links allows the reconstruction of the role played by concrete plants in the processes of the professional urbanization of rural dwellers. In all the zones a decisive role of industrial, construction and transportation enterprises in shaping the structure of employment has been confirmed. These enterprises provide jobs for over 80% of the population employed outside agriculture, although there are essential differences between the various zones of influence in this respect (Fig. 2). As a result of the influence of given enterprises, specific agglomerations of workers employed in a certain production branch come into being in the hinterland of towns: e. g. miners' villages near Jaworzno, Brzeszcze and the Rybnik Coal District; villages of metal workers and railwaymen in the Racibórz hinterland, villages of textile workers in the zones of Bielsko and Częstochowa, and of chemical workers in the vicinity of Kędzierzyn and Oświęcim. The professional skills of workers living in the countryside, including technical workers with secondary professional education, depend on the specific character of the centre and of its work places, production profile above all. The share of skilled workers in the group of rural people employed outside agriculture is as much as 29·3% in the hinterland of Bielsko, where the transformation process is most advanced, while in other zones it is much lower: near Zawiercie it does not exceed 15%.

The above analysis of changes in the number and distribution of urban settlements and their role in shaping the structures of employment of the rural population has given us an idea about the typical processes taking place in the hinterland of big economic regions and industrial centres and a knowledge of the specific systems of regional structures. These structures and their great variety are the feature of the hinterland of all the towns of southern Poland we have studied [2, 3].

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PROBLEM OF LOCAL SETTLEMENT COMPLEX

ANTONI ZAGOŻDŻON

The progressing process of the urbanization of rural areas has brought the formation of new residence patterns in its wake. These new forms do not fit into the traditional categories of a village and a town. The local group of settlements with non-agricultural functions is one of these forms.

The notion "local settlement complex", as I understandt it, is a group of neighbouring urban and rural settlements which, as a whole, fulfil certain superior functions, i.e. exogenous functions [3] and which are mutually linked by strong inter-relations (endogenous functions [3]) and sometimes forming a topographic clutch in which the existence of each settlement as a component of the group is indispensable for the correct functioning of the whole system [9]. For instance, within the complex, certain settlements satisfy residential needs, others — the needs to earn a living (they provide jobs), still others — the needs for services.

From the theoretical aspect this problem may be illustrated by a graph showing functional inter-settlement links. The graph is drawn according to the fundamental principle that various groups or functions can either exist in one settlement jointly, or each one separately in different settlements. In the first instance the settlement is self-sufficient as far as the satisfaction of its basic needs is concerned. In the second instance, it is quite the reverse; hence relations with other settlements to make good the lacking functions [1].

The relations may be classified as follows from the point of view of those concerned: personal relations, that is, relations between single persons; relations between single persons on the one side and institutions on the other side; and inter-institutional relations.

Approaching the problem from the point of view of geography, we draw attention to the two last mentioned categories of relations which,

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[1] The graph simplifies the phenomenon as it does not take into account cases when there is more than one settlement of a given type.

in turn, may either be based on commuting to work and services[2] or on production and organizational links[3].

Thus the links between settlements belonging to a complex are double, as it were: firstly, the link resulting from superior function (part of the functions of settlements are connected with this function), and secondly, links resulting from the satisfaction of the needs of inhabitants within the group of settlements.

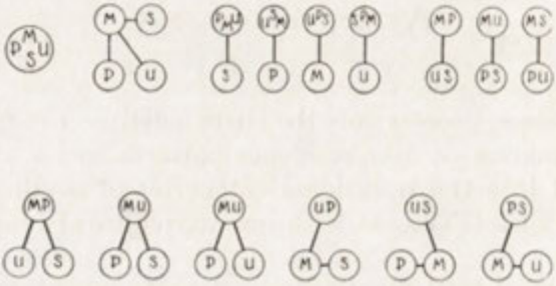

Fig. 1. Theoretical graph showing functional inter-settlement links
Functions: M — residential, U — services, P — production, S — other special functions

Although the definition is sufficiently broad to „encompass” all kinds of similar systems, irrespective of their size, the nature of the superior function, etc., the present study only deals with the urban-rural groups of settlements satisfying elementary needs. These groups are not tantamount to e.g. and urbanized region [5] which means certain types of settlements forming a whole on a “macro-scale”. These are rather groups as Malisz understands it [6] that is, areas coming within the range of daily travel to work; he draws attention in this connection to the fact that only such whole areas should be the object of planning.

Nevertheless the forms of settlement complexes which come into being as a result of separating the place of work from the place of residence are not the only ones. Malisz's definition does not solve the problem of the existence of other groups of settlements, e.g. touristic, and yet „exogenous” tourist-service functions often result in the formation of determined settlements systems composed of both permanent and seasonal settlements.

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[2] Relations between single persons who are connected with the respective institutions either by labour relations, or as customers in shops, or who are serviced by those institutions.

[3] That is, links between two institutions which can be based on input-output to a much greater degree (not on commuting to work and services because this kind of relations belongs to the previous category), e.g. input-output of goods, cash, information, etc.

The conception of complexes as an organizational form of settlements has been also discussed by Pokshyshevsky [7]. For instance, his pattern of the network of timber exploitation includes a system of settlements (differentiated according to hierarchy and functions: from a seasonal settlement linked with the tree felling to the timber processing centre) parts of which are not only organizationally linked with each other, but also connected by production and transport relations, etc.

The above remarks and the tentative definition of settlement allow to see certain similarities between the settlement complex and town. They consist in the similarity of non-agricultural function creating the complex and the town; next, in functional specialization of the parts of the whole: settlements and urban functional units or districts.

These analogies are even more evident in the case of the so called dispersed city where, as a rule, there is no single multifunctional centre and where, usually, there is no topographical clutching of units functionally united, each of them being specialized in a single function [1, 2, 8].

In the functional analysis attention was focussed on relations of two kinds: 1 — resulting from the separation of the place of work and the place of residence expressed by daily commuting to work; 2 — resulting from the separation of the place of residence and that of service institutions, expressed by journeys to service centres with varying frequency. The latter relations are sometimes reduced to the role of supplements to the basic relation, that is, commuting to work.

So if we regard as a group only a system of production and residential settlements, then it may be assumed that the relation between the number of commuters and the permanent working residents of the settlement will express the inter-settlement links.

Indicator computed (for a number of complexes) according to the above principle, allow of separating settlements actually belonging to the given complex. The index is the criterion of division; when the index is lower than 10 it defines links between settlements which supplement each other; when it is 10—20 and 20—30, it provides a typical example of competing centres; when it is 30—40 and above 40, this means that the settlements constitute a formed entity. In the latter case the settlements are functionally fully united, because the links with a certain centre are several times stronger than the "sum total" of the remaining links[4].

The above problem is seen on the map (Fig. 2) of one of the examined regions, situated in the marginal zone of the Upper Silesian Industrial District (it is a part of the Strzelce district, Opole voivodship). In that region single small industrial centres form visible local complexes.

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[4] Of course the above values and classes pertain to concrete examples only studied by the author.

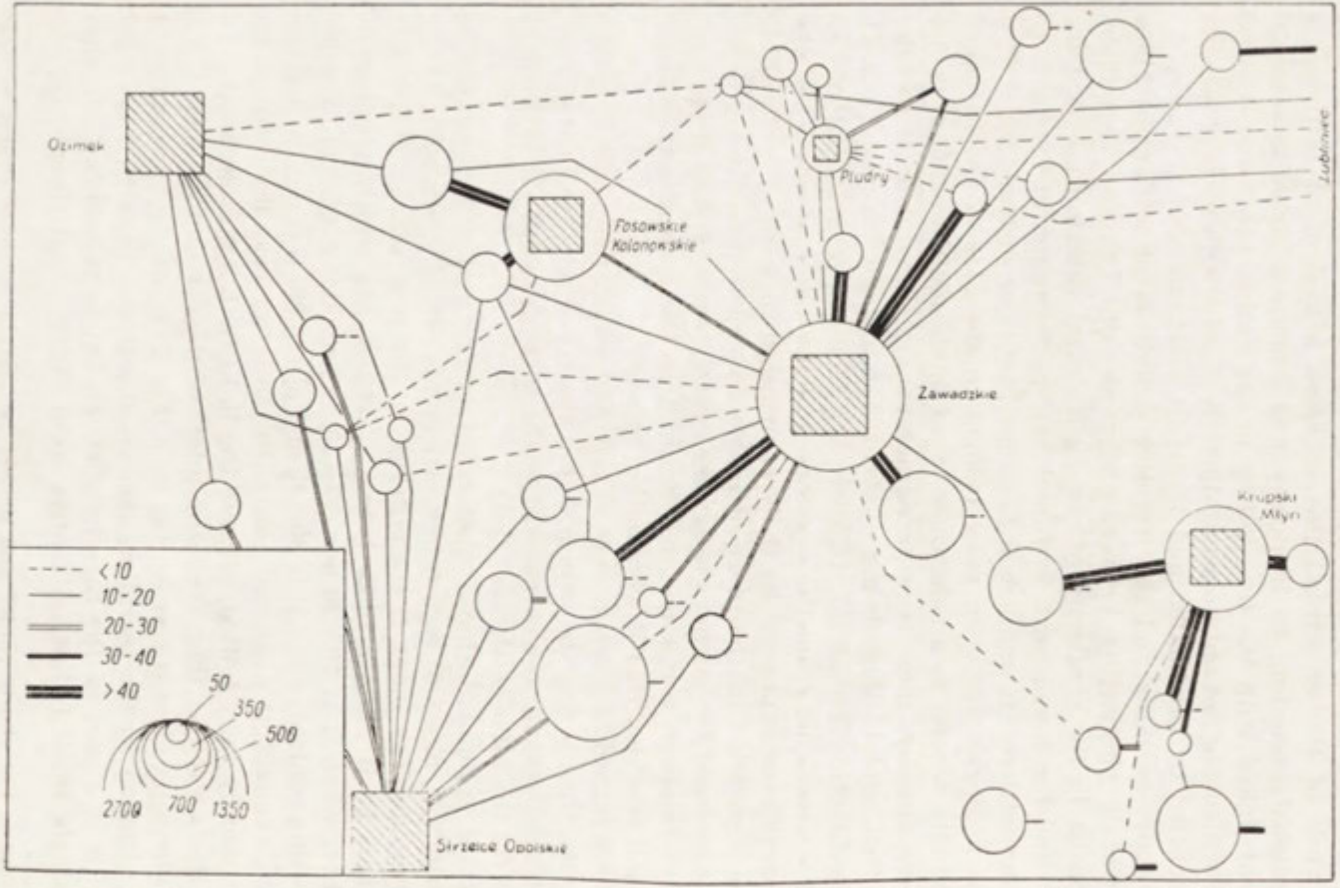

Fig. 2. Production — Settlement Complexes. Degree of linkage = the rate of persons working outside their place of residence in the number of professionally active population. Squares — main places of work. Circles are proportional to the number of professionally active statistical inhabitants

The innner structure of the complex, understood as the union of the settlements with the superior function and expressed by the number of employed, can be shown by a diagram [Fig. 3].

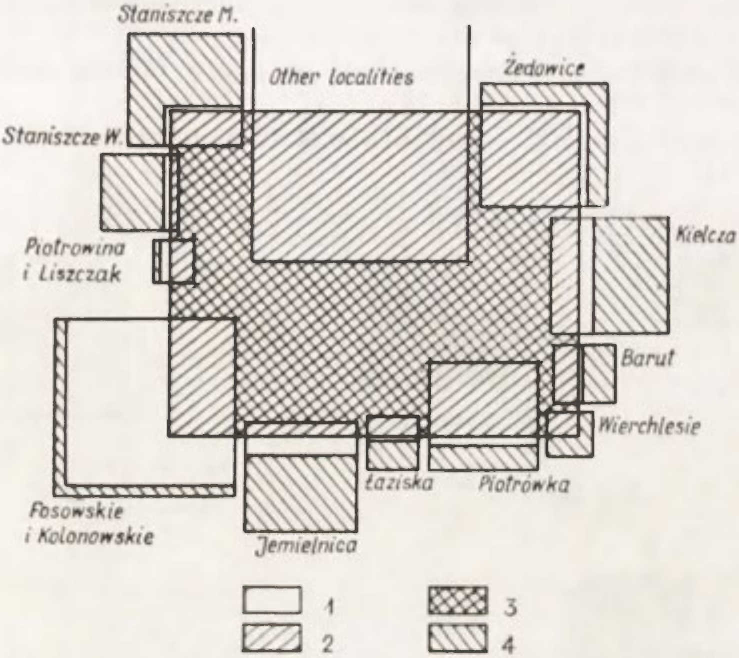

Fig. 3. Structure of the Zawadzkie settlement complex. Degree of linkage with the complex-generating functions expressed by the number of commuters

1 — persons employed in their place of residence, 2 — persons employed in Zawadzkie, 3 — local employees working in Zawadzkie, 4 — persons employed outside the complex

The complex taken as an example (Zawadzkie) is to be seen on the map. Each settlement of the complex has been analysed in the aspect of people working in a job, (a) in the complex, (b) in their place of residence, (c) outside the complex.

Thus the actual link of the given settlement, which in this case plays the role of a residential satellite settlement, has been marked by the degree in which the given rectangle overlaps the big rectangle — the latter being proportional to the number of jobs in the superior functions of the complex.

The comparison of complexes with regard to their superior function, size and development stage has brought interesting results. This is shown in the graph of several complexes (including the Zawadzkie one already discussed earlier), drawn on similar principles, but simplified [Fig. 4].

(1) Prochowice — a local production-residential complex. Microsystems of this kind were a characteristic feature of the Legnica—Głogów

region before its industrialization; recently they became integrated in a larger group;

(2) Zawadzkie, also a local complex, but with a more complete functional and morphological structure; its exogenous functions are based on the existence of an iron and steel plant;

(3) Turoszów — a complex based on lignite mining and its use as a fuel for a power-generating plant;

(4) copper complex — now in the state of formation, based on new investments.

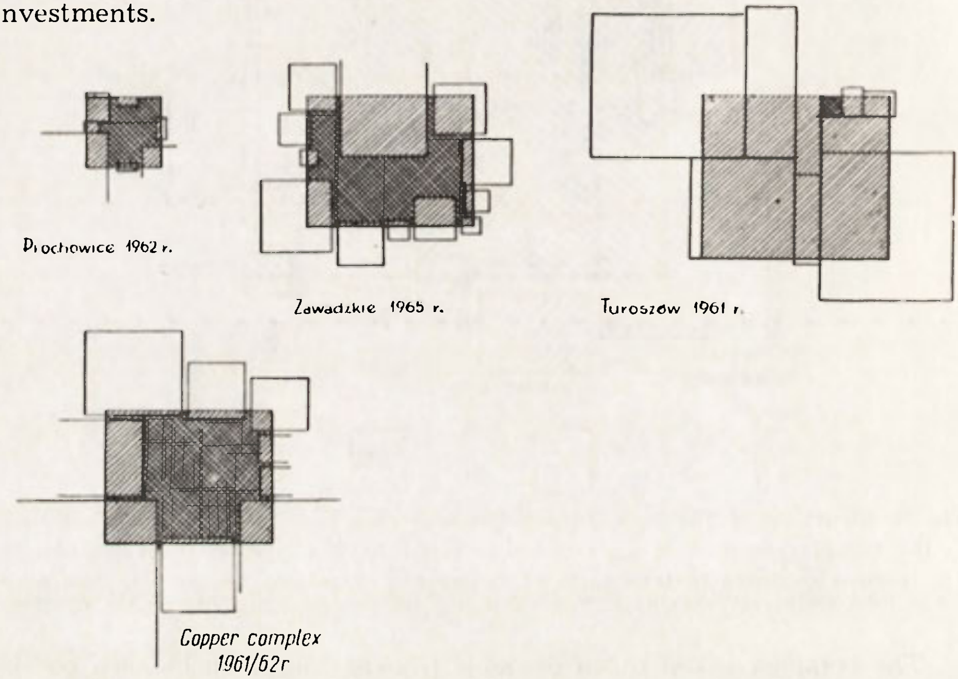

Fig. 4. Complex structure. Links between settlements and the superior function expressed by the number of commuters (selected examples)

In view of the decentralization of plants, all those working in all institutions connected with the new industry were classified in the group of persons working in superior functions. It results from what has already been said that the complex is a certain entity as far as its function is concerned; following the concentration of plants in certain settlements, the shortage of manpower is made good by commuting.

Such systems in which certain parts are deconcentrated can only function effectively in the long run if the time of journey to work is shortened and convenient means of transportation ensured. The latter factor is particularly important in service relations, because travelling to service centres can only partly be combined with journeys to work.

The local settlement complexes discussed here constitute one of the forms of decentralized settlement. This fact means that attention should be paid to the morphology of the complex. Detailed morphological analyses reveal a wealth of forms that are derivatives of original system and a certain amount "layers" marking the various stages of the formation of the network of settlements.

The simplified analysis of the morphology of the complex has been carried out on the basis of the morphological classification proposed for towns by K. Dziewoński: simple, composite and manifoldly composite complexes [4].

Simple complex — consisting in the direct linkage of several settlements, e.g. residential settlements, with the centre. Single settlements are its parts.

Composite complex — with a two-grade hierarchy of links. Simple complexes are its parts. There is more than one centre of the complex (e.g. one service and another production centre).

In manifoldly composite complexes there is a more advanced hierarchy of subordinated component parts. There are many centres of various ranks, single- and multi-functional. The number of components of the complex grows, and the relations become more complicated (multidirectional and criss-crossing). Examples of various systems of complexes are shown in Fig. 5.

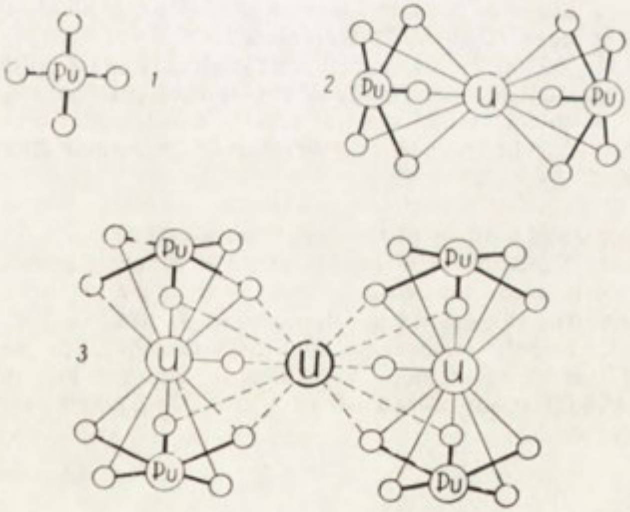

Fig. 5. Morphology of complexes (abstract examples)

1 — simple complex, 2 — composite complex, 3 — manifoldly composite complex. Functions — as on Fig. 1. (residential functions are not marked — empty circle). Lines mark relations within complexes; thickest line — simple relations; thin continuous line — composite relations; dotted line — manifoldly composite relations

The above outline of local settlement complexes as a form of partial urbanization — semi-urbanization, is one of the forms of decentralized settlement.

Decentralized settlements will not replace big urban centres. So it seems that this kind of organization of a settlement network should be regarded as possible to be adopted along with the urban settlement and not instead of it.

So it may be hoped that the development of this form of settlement in determined conditions may become the most effective action removing the main source of the troubles experienced by big urban organisms, namely their excessive expansion.

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NOTES SUR LES ÉTUDES MÉDICO-GÉOGRAPHIQUES DANS UN MILIEU INDUSTRIEL

JULIUSZ BRAUN

L'intérêt de plus en plus croissant porté par les géographes aux études sur la différenciation spatiale des phénomènes de la pathologie biologique — les maladies, les allergies, les changements somatiques (Medical Geography, Ecology of Health and Disease) — domaine défini récemment encore par L. D. Stamp [19] comme un no-man'sland — demande un échange d'expériences à l'échelle internationale. C'est probablement par ce moyen seulement qu'on pourrait réaliser l'uniformité des méthodes de recherches (ce que postule entre autres A. A. Shoshin [18]).

Le but de ce rapport est de présenter le déroulement et les résultats des deux séries de recherches effectuées dans le cadre des travaux du Comité de l'Académie Polonaise des Sciences pour les Affaires de la Région Industrielle de Haute Silésie, qui — sous la direction du prof. S. Leszczycki [12], a développé une activité scientifique multilatérale dans le domaine des problèmes, liés aux conditions d'existence des populations dans un milieu transformé par le développement industriel.

I

On a étudié la répartition des foyers de certaines maladies à Częstochowa, ville en voie de rapide industrialisation [2, 3, 4]. Les études concernaient quelques maladies pour lesquelles on pouvait admettre qu'elles étaient en relation directe avec les conditions climatico-sanitaires et d'autres traits inhérents du milieu géographique. C'étaient: la tuberculose, où le surpeuplement des logements [6, 14], pouvait jouer un certain rôle, les maladies rhumatismales (le niveau de la nappe phréatique), l'asthme, les diverses formes du cancer.

Les recherches avaient un double but: l'expérimentation des méthodes utiles pour saisir des relations éventuelles et pour fournir des indices pratiques pour la planification du développement spatiale de la ville.

On avait commencé les recherches par des études approfondies des conditions écologiques dans le système généralement admis [4]: 1) les facteurs orographiques, 2) les facteurs climatiques, 3) les facteurs édaphiques, 4) les facteurs biotiques. Fig. 1.

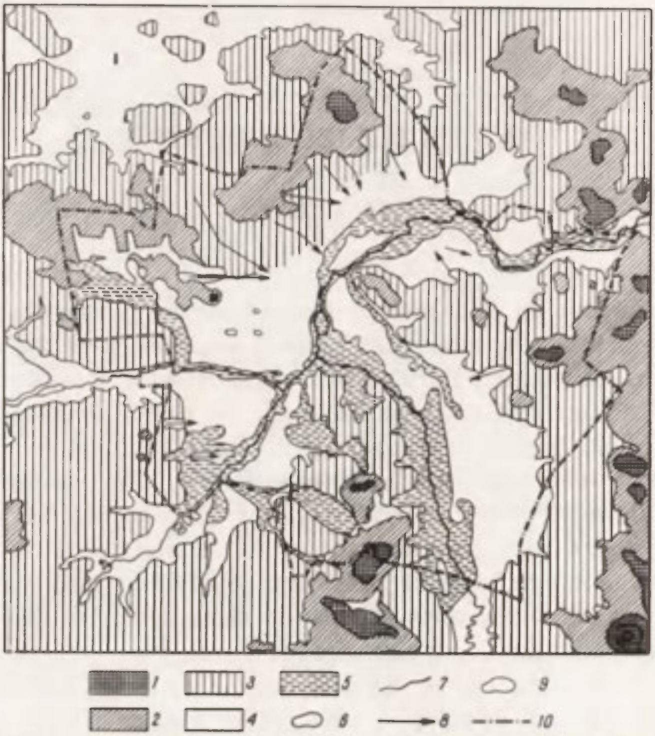

Fig. 1. Częstochowa — Physiographie

1 — altitude de plus de 290 m; 2 — altitude de 270 à 290 m; 3 — altitude de 250 à 270 m; 4 — altitude de moins de 250 m; 5 — nappe phréatique au niveau de 1 m; 6 — eaux stagnantes; 7 — cours d'eau; 8 — couloir d'écoulement de l'air froid; 9 — limite des terrains d'inversion thermique; 10 — limites de la ville

On a utilisé à cette fin des cartes élaborées par l'Entreprise Géologique, Physiographique et Géodésique du Bâtiment „Geoprojekt" à l'échelle 1 : 10.000: 1) l'hypsométrie, 2) l'épaisseur de la couche sèche, 3) les couches du sol jusqu'à la profondeur de 2 m. et à 2 m. en prenant en considération les couches plus profondes. Puis on a élaboré (M. Tarajkowska) une carte d'estimation du terrain de point de vue climatico-sanitaire. Le degré de la pollution de l'air était enregistré sur la base des études de la Station Sanitaire-Epidémiologique de Ville, faites à l'aide de la méthode sédimentaire. Tout en considérant ces données on a fait avec la méthode de patrouilles une estimation des unités minimes sur l'étendue de la ville, qui représentaient aussi l'unité statistique (les zones d'inscription des locataires) en y appliquant une échelle de 6 points, élaborée spécialement à ce but. Sur la base de cette élaboration on a fait une carte généralisée d'estimation des conditions de salubrité. Fig. 2.

Les données concernant la tuberculose et les rhumatismes étaient basées sur les fiches des centres médicaux de la ville, qui enregistrent tous les cas dépistés de maladie. Quant à l'asthme et le cancer on a passé en revue près de 100 000 fiches de congés de maladie accordés par les médecins aux travailleurs en un an. Fig. 3, 4.

Fig. 2. Częstochowa — évaluation généralisée des terrains du point de vue climatique et sanitaire

1 — terrains du Ier groupe; 2 — terrains du IIe groupe; 3 — terrains du IIIe groupe

La juxtaposition des cartes élaborées avec celles qui représentaient des traits caractéristiques particuliers du milieu (l'estimation du point de vue climatico-sanitaire, la densité du peuplement des logements etc.) permet d'observer certaines dépendances. Fig. 5.

Les resultats des recherches ont été soumis au contrôle statistique en calculant une moyenne équilibrée des traits particuliers do milieu géographique de la surface comme balance selon la formule

$$\bar{x}_p = \frac{1}{p} \sum_{i=1}^{n} x_i \, p_i$$

et analogiquement — avec le nombre des habitants comme balance.

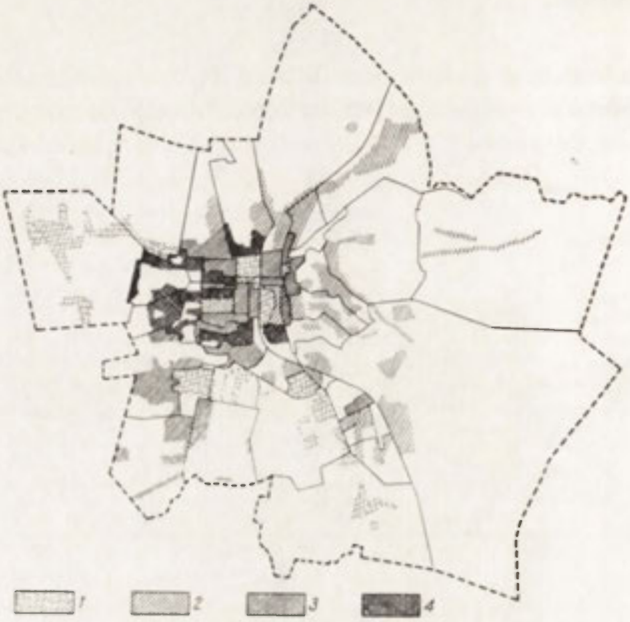

Fig. 3. Częstochowa — Localisation des cas de maladies rhumatismales.
1 — moins de 2 cas pour 1.000 habitants; 2 — de 2 à 4 cas pour 1.000 habitants; 3 — de 4 à 6 cas pour 1.000 habitants; 4 — plus de 6 cas pour 1.000 habitans

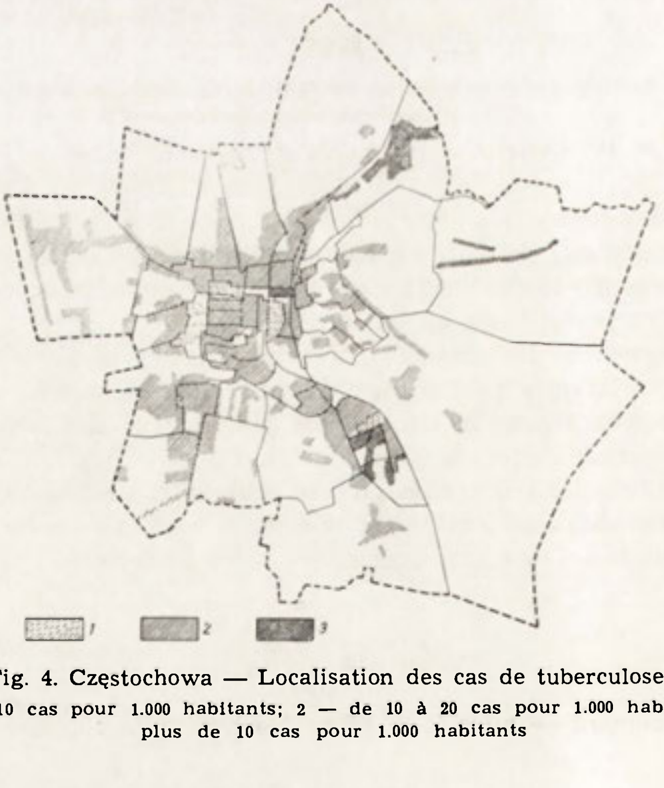

Fig. 4. Częstochowa — Localisation des cas de tuberculose
1 — moins de 10 cas pour 1.000 habitants; 2 — de 10 à 20 cas pour 1.000 habitants; 3 — de plus de 10 cas pour 1.000 habitants

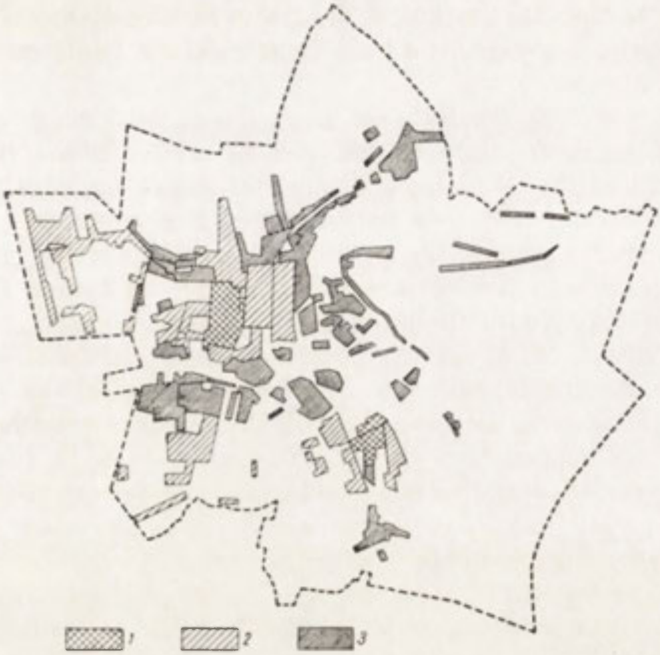

Fig. 5. Częstochowa — Structure de la densité de peuplement des logements

1 — densité du I^{er} groupe jusqu'à 1,6; 2 — densité du II^{e} groupe de 1,6 à 2,0; 3 — densité du III^{e} groupe au dessus de 2,0

Ensuite nous cherchons des relations entre des traits caractéristiques du milieu et du phénomène (maladie). Le coefficient de corrélation — en cas de l'application de la surface (p) comme balance et prenant en considération la dispersion comme la mesure de la différenciation des matériaux statistiques — entre le phénomène (a) et la trait du milieu (x), peut être exprimé par la formule

$$\varrho^{(a\cdot x)} = \frac{\frac{i}{p}\sum_{i=1}^{n} p_i\, a_i\, x_i - a_p\cdot\overline{x}_p}{p^{(a)}\cdot p^{(x)}}$$

Quant aux corrélations entre un ensemble des traits du milieu et un phénomène, on les trouve à l'aide des relations linéaires:

$$a = \alpha_1 x + \alpha_2 y + \alpha_3 z + \alpha_4$$
$$b = \beta_1 x + \beta_2 y + \beta_3 z + \beta_4$$
$$\dots$$

où ces phénomènes (a, b, ...) sont des fonctions d'un nombre convenable de variables (x, y, z). Les quantités α_1, α_2 . . . β_1, β_2 ce sont des coefficients déterminant le degré de l'influence des traits sur des phénomènes étudiés. On peut calculer les valeurs de ces coefficients à l'aide de la méthode des carrés minimes.

En interprétant les résultats obtenus, il faut tenir compte [1], qu'une preuve de la relation n'est pas toujours la preuve d'une relation causative coïdentionnelle. Mais un contrôle statistique des résultats obtenus par l'observation des cartes — instrument de base pour un géographe — peut être très utile pour lui en précisant l'image qu'on reçoit des cartes convenablement faites, en les superposant l'une sur l'autre. Dans un cas concret de hautes valeurs climatiques et sanitaires des zones de la partie du nord de la ville [2, 4] sur des pentes ensoleillées, libre de l'influence polluante de l'industrie, qu'on avait démontrées à la base des études, ont constitué un des motifs qui ont décidé de la transformation essentielle des plans de développement spatial de la ville — on a abandonné les projets prévoyant l'agrandissement de la ville sur des terrains insalubres, a portée des pollutions de l'air par les gaz et les poussières et, par contre, on a dirigé les investissements d'infrastructure et la construction d'habitations et des services d'Etat sur les terrains les plus salubres. On a procédé de la même manière avec les coopératives de construction de logements financées par les moyens propres des membres et avec l'aide de l'Etat. Cette direction du développement de la ville a reçu une appellation lapidaire: „La ville du peuple en bonne santé" [21, 5]. Les enquêtes sociologiques, réalisées quelques années plus tard, ont démontré l'approbation complète des habitants pour cette politique de localisation.

II

Un des thèmes les plus essentiels auquel porte un intérêt particulier la géographie médicale c'est l'influence de la pollution de l'air sur la santé de la population [10, 11, 12, 17, 20].

Dans ce domaine il ne suffit pas seulement de se contenter d'une conception cartographique et statistique, mais il faut poursuivre des recherches de caractère médical. C'est là donc un terrain de collaboration fructueuse entre les géographes et les médicins.

A la Section de l'Ecologie de l'Homme de l'Institut des Recherches Scientifiques de la Région Industrielle de Haute Silésie de l'Académie Polonaise des Sciences a Zabrze ont été poursuivies des études concernant l'influence de la pollution de l'air atmosphérique sur la santé des enfants des écoles de la ville de Chorzów. Les recherches médicales étaient menées par un groupe de médecins de différentes spécialisations sous la direction de J. Rzepka [17]. Les résultats n'ont pas encore été publiés.

La ville Chorzów couvre une surface de 32,89 km^2 et comptait le

1.I.1966 153.721 habitants, c'est-à-dire 4672 habitants au km². C'est le plus haut degré de densité de peuplement dans le pays. L'indice de peuplement des logements est de 1,43% habitant par chambre. Il y en a dans cette ville 9 grandes usines où travaillent 67% de la population professionellement active. La chute des poussières oscillait en 1955—1962, selon J. Paluch [15], entre 12—32 mille t/km² par an et jusqu'à 88 g/m² par jour. La concentration de SO_2 dans l'atmosphère était en 1956 au voisinage de l'usine de fer „Kościuszko" 5,45 mg/m³; la concentration moyenne de SO_2 en 1964 était, selon J. Just [8] 0,01 mg/m³ — 1,27 mg/m³ maximum[1].

Les études ont compris un groupe important (près de 2000) enfants d'école, agés de 7 à 14 ans, habitant dans le quartier Chorzów Stary, où on a constaté le plus haut degré de pollution de l'air dans toute la ville. D'après les différences de pollution, relatives à la situation des usines, on a divisé l'étendue étudiée en 4 régions, ce qui donne une image plus complexe des conditions locales.

Le quartier en question se trouve dans la zone de l'abaissement de la radiation directe du soleil [9, 16] d'environ 15—30% et de l'agradissement du coefficient de la turbidité de l'atmosphère 1,0—2,0. Cette situation a une signification essentielle pour le mécanisme de la synthèse de la vitamine D dans l'organisme de l'enfant; elle provoque aussi des troubles dans le développement du squelette et — par conséquence — du développement somatique.

On a déterminé le degré de la concentration de pollution de l'air atmosphérique dans le quartier donné — le quartier Chorzów III — aussi bien théoriquement (W. Kozłowski) qu'à l'aide des mesures (J. Rzepka, W. Kozłowski, K. Nowak, R. Dukat). La détermination théorique était faite à la base d'analyse des sources d'émission d'après les données des usines et d'après les conditions de la diffusion dans l'atmosphère. Les calculs se basaient sur la théorie de la diffusion atmosphérique de Sutton. Les valeurs calculées étaient comparées avec des tolérances admissibles par le Décret du Conseil des Ministres PRL de 13.IX.1966 en matière des concentrations admissibles des substances dans l'air atmosphérique (Dz. U. nr 42, poz. 233).

On avait constaté de hauts dépassements des valeurs de la norme: pour le SO_2 3,5—7 fois, les poussières non-toxiques 9—17 fois, pour les acides 2—4 fois, pour les oxydes d'azote 1,4—2,8 fois. Les résultats théoriques se sont montrés proches des résultats des mesures. Les mesures du degré des poussières étaient faites à l'aide de la méthode sédimen-

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[1] L'émission totale des produits polluant la région du GOP est estimée pour environ 1,1 millions de t de poussières et 0,5 million de t SO_2 annuellement.

taire pendant une période de 7 ans (1.VI.1959—31.V.1966). La concentration des poussières non-toxiques, exprimée en moyennes mensuelles, était d'environ 0,2—0,6 mg/m^3. La concentration de SO_2, mesurée du 1.III.1962 au 30.VI.1966 à l'aide de la méthode du contact, était de 0,15—0,75 mg/m^3. Dans la structure des poussières déposées on a relevé entre autres des substances goudronneuses renfermant des hydrates de carbone aromatiques aux propriétés cancérogènes, constatées expérimentalement Fig. 6. Les études comparatives analogues étaient exécutées sur un groupe contrôle d'enfants d'école, habitant la cité Ochojec, un quartier de Katowice, relativement le plus salubre, ou le degré des poussières — ainsi que la concentration de SO_2 — se tiennent dans les limites proches des normes admissibles.

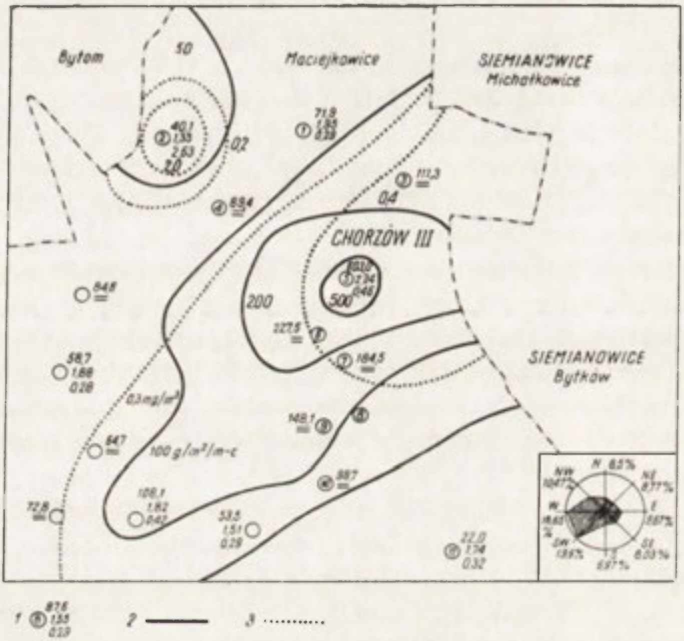

Fig. 6. Quantité moyenne de poussières et de cendres issues de la pollution de l'air dans les années 1959—1966, ainsi que concentration de SO_2. Valeurs moyennes et maxima mensuels moyens dans les années 1962—1966 sur le territoire de Chorzów Stary

1 — point de mesure. On indique à côté dans l'ordre: la chute de poussières et cendres en g/m^2 (mois); concentration de SO_2 (mg/100 cm2 (jour), concentration de SO_2 (mg/m^3). Maximum mensuel moyen. Le trait signifie que la mesure ne fut pas effectuée. 2 — Ligne de dépassement de la valeur citée de chute de poussières; 3 — Ligne de dépassement de la valeur citée des maxima mensuels moyens de SO_2

Les études étaient conduites dans la direction:

1. pédiatrico-laryngologique, surtout des organes respiratoires,

2. du développement somatique — surtout à la base des mesures anthropométrique de la taille et du poids ainsi que des mesures de la cage thoracique, de l'avant-bras, des cuisses, de la spyrométrie etc.,

3. de l'hématologie, relativement de l'image du sang périphérique.

Les études ont été faites au cours d'une première étape à l'aide d'enquêtes, dans la second étape — cliniquement par des médecins spécialistes. Les résultats furent analysés statistiquement.

On a constaté que, dans les conditions de la pollution, on remarque le plus souvent:

1. La pneumonie, les états allergiques, la tuberculose et les malformations du coeur.
2. L'agrandissement des noeuds lymphatiques et de déformations rachitiques du thorax.
3. La dynamique négative de l'agrandissement de la taille et du poids.
4. Un rendement plus bas de la ventilation du système respiratoire dans la région caractérisée par la spécifique de la pollution de l'air.

On n'a pas constaté de différences significatives de quelque importance des mesures de la cage thoracique, des cuisses et de l'avant-bras.

On n'a pas constaté non plus d'influence sur l'image du sang périphérique. Peut être d'autres composants de la pollution gazeuse exerçaient une influence positive, mais ceci n'était pas constaté.

Il serait indiqué de poursuivre des études particulières de toutes les substances gazeuses relevées dans l'atmosphère et liées avec le profil spécifique des usines représentées sur la zone examinée.

On propose de continuer les études. Des recherches effectuées en une seule fois et dans une seule direction, peuvent avoir un sens surtout méthodique et ne justifient pas les conclusions plus poussées. En tout cas, il parait évident, que la collaboration du géographe et du médecin, ainsi que l'application d'un arsenal large de moyens d'études de ces deux disciplines, peuvent fournir des résultats intéressants de point de vue scientifique, ainsi qu'utiles pour la pratique de la planification spatiale, ce qui avait déja eu lieu dans le cas mentionné.

Institut des Recherches Scientifiques
de la Région Industrielle de Haute Silésie
de l'Académie Polonaise des Sciences
Zabrze

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VII. REGIONAL GEOGRAPHY AND REGIONAL PLANNING

PROBLEMS OF GEOGRAPHICAL ENVIRONMENT IN THE SYSTEM OF SPATIAL PLANNING IN POLAND

MICHAŁ WIĘCKOWSKI

The present system of spatial planning in Poland has been defined by the act of 1961[1]. Its scope covers: 1-regional planning, strictly connected with the planning of the spatial economic management of the whole country, 2-local planning (urban and rural planning) that should be based on regional plans.

It is the purpose of spatial planning to distribute economic activity in order to ensure proper development of various areas of the country and the links between them, ensuring them an adequate role in the economy of the whole country and, establishment of proper spatial relationships between production and services that, in turn, should ensure the proper development of production as well as the protection of nature and of the natural resources of the country.

It is the task of spatial planning to establish the predestination and the ways of developing various areas of the country in order to secure their economic and social development. Spatial plans are based on statements of economic long-range plans for the development of the whole country (the present period of prospective planning includes 1985), and of the several-year plans (5-year plans), as well as on geographical surveys. The technical elaboration of the plans is based on the conclusions drawn from these statements and their synthetic representation in adequate spatial patterns on the maps. Such tasks provide great possibilities for the practical application of geographical knowledge[2]; S. Leszczycki has been doing this for over 30 years now.

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[1] The Spatial Planning Act and Rural Building Areas Designation Act, both of 31st January 1961.

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In the preliminary stage of his work, a geographer makes spatial surveys and analyses which make possible the definition of the actual state of an area. There are surveys concerning physical geography, i.e. mineral resources and possibilities for their exploitation, results of the exploitation, conditions for settlement and for development of the transport network etc., and also surveys dealing with economic geography, i.e. demography, settlement, agriculture including problems of land utilization, transport etc. In the course of drawing up conceptions of spatial management, the geographer is a co-designer helping to draw the correct conclusions from the estimation of the resources and conditions of a geographical environment and from the economic-geographical situation. In the final stage, the geographer confronts the drawn up plan with the existing physical-geographical and economic-geographical conditions. He also estimates the results occuring in the actual balance of the geographical environment and the spatial-economic situation, especially the negative results.

Such work is done also by other specialists, e. g. geologists, hydrologists and economists. The scientific and professional preparation of geographers is decisive as regards whether a physical geographer (physiographer) treats a geographical environment as an integral unit, taking into account the existence and the interrelationship of both, the natural and antropogenic components in it, which influence the formation of the geographical environment. An economic geographer analysing the problems of population, settlement, industry, agriculture, transport, the water economy and others, will consider not only their interrelationships but their dependence on geographical environment as well.

In recent years the need for the practical application of physical geography in spatial planning is being appreciated more. This problem will be considered now. First of all, it seems necessary to define the

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basic tasks of spatial planning and their interrelationships, including decisions on general and detailed localization. These decisions make a link connecting spatial planning with the implementation of investments [3]. This problem is illustrated in Figure 1.

The long-range plan of spatial management of the country is elaborated by the Planning Commission at the Council of Ministers,

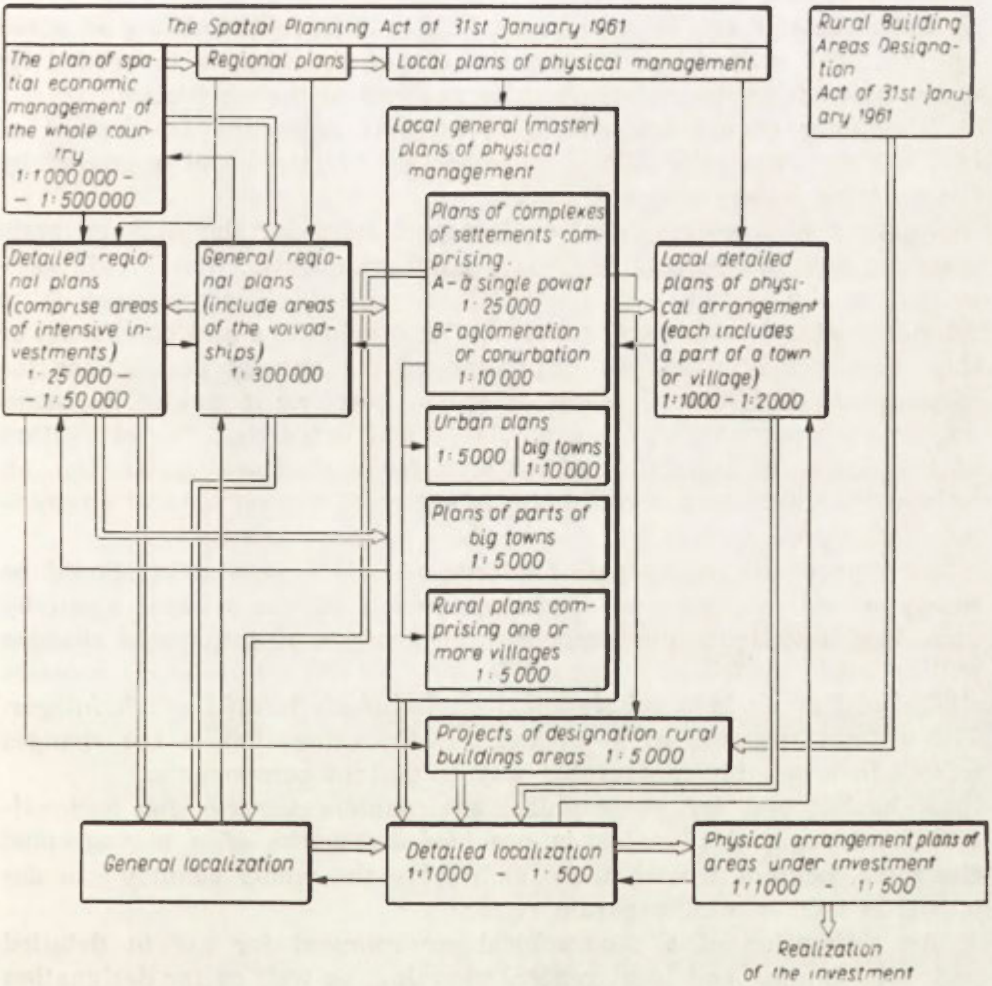

Fig. 1

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[3] According to the binding regulations, the economic planning authorities define the general localization. This is a definition of a locality in which an investment is to be made. The local spatial planning authorities define detailed localization i. e. an area on which an investment is to be made.

whereas regional plans are drawn up in the Voivodship Offices supervised by that Commission. Local plans of spatial arangement and projects of the designation of rural building areas are made in offices controlled by the Ministry of Construction and the Building Materials Industry (until 1964 they were controlled by the Committee of Construction, Urbanisation and Architecture). Such offices exist in all the Voivodship and Poviat People's Councils.

Both, regional and local plans are legally in force after being accepted by the local authorities. The acceptation of the plan is proceeded by a discussion with the citizens and by analysis of their criticism.

The plans of management of investment areas are an element of building documentation. They are made by investors and approved by the building supervision authorities.

Surveys of a geographical environment used for the national scale planning and for general regional planning comprise, first of all, estimation of the various environmental components. Their purpose is to estimate natural resources as well as the possibilities and conditions of their proper utilization. An estimation of the natural possibilities for agricultural development is an exception here, as it cannot be based on one component only, for example on soil properties. For estimation of the degree of suitability of an area for agricultural utilization, an estimation taking into account the integrity of a geographical environment is necessary.

Surveys of the resources of a geographical environment should be supplemented by prognoses of changes which will be brought about by man. Beginning from one component, an analysis of anticipated changes will be made by taking into consideration all the interrelated processes which will occur in a geographical environment treated as an integer. The ultimate purpose of a prognosis is the estimation of the changes related in a possibly measurable way to various components.

A background for geographical environment surveys for national-scale and regional planning is provided by works of a monographic character, beginning with those embracing the whole country[4] to detailed ones concerning separate regions.

An estimation of a geographical environment for use in detailed regional planning and local general planning, as well as for designation of rural building areas, gives a synthetic estimation of the suitability of various areas for a settlement network or various kinds of planned investments.

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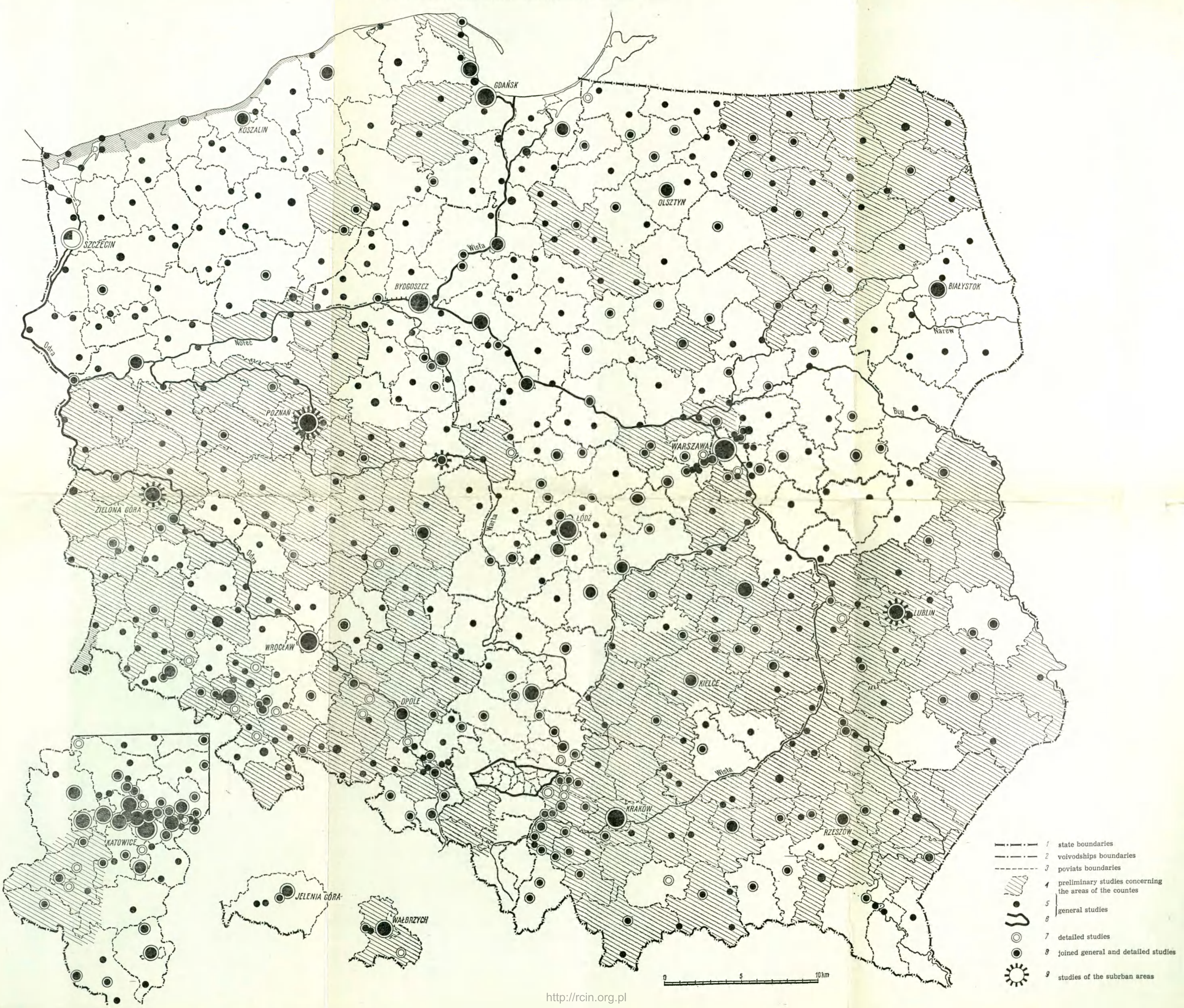
Fig. 2. Studies in applied physical geography for local spatial planning before december 31-St. 1965



VIII. CARTOGRAPHY AND PHOTOGEOGRAPHY

A MODEL OF CARTOGRAPHICAL METHODS

LECH RATAJSKI

A precise definition of the means of representation used in cartography would seem to be an important aspect of thematic cartography. Various criteria can be accepted to determine and define each particular method. In my opinion, however, it is of special significance for this branch of cartography to investigate whether these methods are adequate for the presentation of characteristic quantitative phenomena and facts. To put it in a different way, the analysis of the problem should be based on the cartometry of maps.

So far cartometry has made particular contribution in the domain of topographical and general geographical maps. The degree of precision and correctness in the location of separate elements on the map, such as rivers, contour lines, settlements, surface outlines, etc. decisively influence the results of measurements made on maps of this type.

The problem becomes more complicated in relation to these thematic maps on which both the value of objects or facts and their location are presented, i. e. maps prepared by means of quantitative cartographical methods. In such cases the cartometrical correctness depends greatly on how precisely the dimensions of the signs representing definite values on the map can be read. This, in turn, is conditioned by a number of factors, and in particular: a) the capacity of the map, b) the precision of design, c) the eye's precision, d) the kind of cartographical method applied.

Each factor exerts a different influence on the procedure of the preparation and editing of the map.

Every change in the capacity of the map makes it necessary to generalize its contents. The capacity of a thematic map does not necessarily depend directly on its scale. The whole generalization process is contained between the simplest degree of registration of phenomena and the highest, synthetic and quantitative degree referring to given fields, while the area of these fields also varies in the course of generalization.

The whole generalization procedure can be contained within a certain hierarchy.

The original map which results from the immediate survey of the territory notes some qualitatively varied elementary facts. The first stages of generalization aim at the elimination of secondary facts. This procedure, which is determined by the need to preserve the character of the fact or group of facts is, however, limited to a certain extent. This limit can be overcome only when a certain number of elementary and single observations are replaced by a new qualitative or quantitative concept.

The changing capacity of the map can be presented by means of a triangle where the base equals the initial capacity of the map and the vertex the limits of its capacity. Each horizontal section of this triangle corresponds therefore to each capacity of the map where one and the same cartographical method has been applied (Figure 1). Thus, when the location of the capacity of the map approaches the vertex of this triangle the qualification of the phenomenon will have to be changed an another cartographical method applied, so as to make it possible in turn to begin a new generalization cycle using a new method. This enables one to avoid an extreme deformation of reality through an excessive impoverishment of contents. I have called this moment of transition "the generalization node".

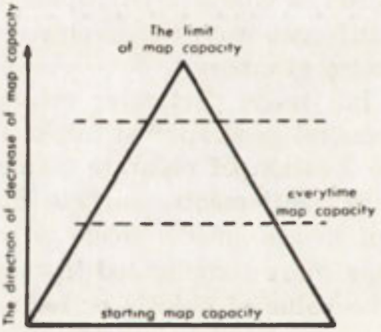


Fig. 1

Although I explained the principles of the concept of the generalization node during the conference of the International Cartographical Association in Amsterdam in 1967[1]. it seems to me worth while recapitulating them briefly.

If, for the sake of the explanation, we use the example of settle-

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[1] International Yearbook of Cartography, vol. 7.

ments, the original map will only show individual houses. As the capacity of the map diminishes, the picture and concept of houses will, at a certain moment, have to be replaced by the picture and concept of a whole settlement in outline. As a result of the change of concept the symbol method will have to be replaced by the areal method. In due course the areas of the settlements will have to be replaced by a quantitative expression (settlements according to the population figures) and the continuous cartodiagram method substituted. Subsequently, quantitative definitions will be replaced by a synthetic approach, which involves grouping at intervals in order to obtain less classification types. The continuous cartodiagram will, therefore, be replaced by an interval cartodiagram. Finally, the new basis of generalization can be introduced when the idea of a separate settlement is replaced by a collective idea, e. g. urbanization, and the phenomenon is referred to the surface units, first absolutely and then in groupings.

This whole process can be presented by means of a general generalization model (Figure 2). Consecutive triangles represent the subsequent

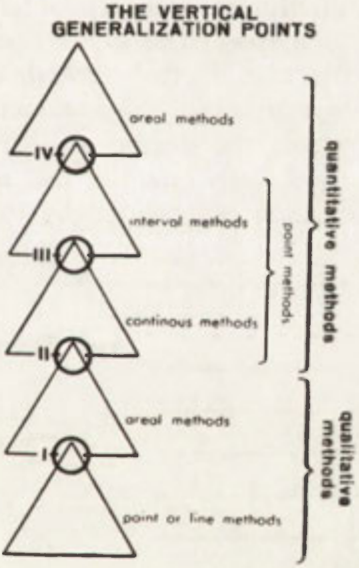


Fig. 2

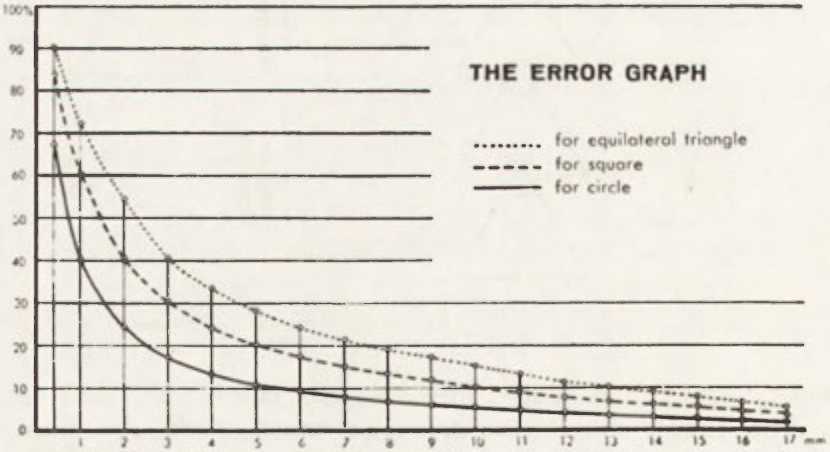
stages of generalization, placed in the appropriate hierarchy of generalization. The circles where the triangles touch mark the consecutive generalization nodes. Each horizontal section mentioned above corresponds to a separate generalization step.

I have decided to call the generalization nodes described above "vertical nodes" to differentiate them from another type I have called "horizontal nodes".

When I investigated the characteristic features of cartographical methods from the viewpoint of their cartometrical applicability I came to the conclusion that the consistent use of one and the same cartographical method for one generalization stage does not ensure equal precision in the representation of quantitative characteristics. It turned out that with each cartographical method at certain values of numerical series there exist points at which the degree of precision begins to diminish quite rapidly. This is due to the influence of the two remaining factors out of the four mentioned above, namely the precision of design and the precision of the eye.

The precision of the design of the map is limited by technical factors and depends upon the theoretical possibility of obtaining a 0·1 mm thin line. In practice, however, the thinnest obtainable line on printed maps equals 0·2 — 0·3 mm. As far as the second factor is concerned, the empirically proved lowest limit for the eye's precision amounts to 0·2 mm, which is the maximum accuracy obtainable in setting down the legs of a pair of compasses. The error resulting from this when values are read from the map is therefore doubled as inaccuracy of design is added to the inaccuracy of measurement itself.

Both these reasons affect the degree of correctness in reading the dimensions of a sign, and consequently the magnitude of error in reading the quantitative value represented by this sign. Graph (Fig. 3)



On the horizontal axis are plotted the longitude of measurement units: — the radius for a circle, the side for a square and the height for a triangle

Fig. 3

illustrates the magnitude of this error, which can be even greater than 50 per cent for relatively small figures.

The factors mentioned above are of great significance for cartographical methods based on the continuous system. For methods based on the interval system, however, it is the principle of the construction of intervals (class divisions) which is decisive. This principle is usually based on a geometrical or arithmetic progression.

To express the magnitude of systematic error for intervals constructed on the principle of geometrical progression I have used the following formula:

$$X = \frac{50\,(q - 1)}{q + 1} \quad \text{where } q \text{ is the quotient of the progression}$$

When q equals 2 the error amounts to approximately 16·7 per cent and can maximally proceed to 50 per cent. When an arithmetic progression has been applied, however, the magnitude of error is constant and its absolute value depends solely on the common difference equal to 25 per cent.

From all that has been said on this subject the conclusion can be drawn that comparing two methods based on different approaches to value it is possible to define the moment of the lowest common error. When comparing the continuous and interval-cartodiagram methods it appears that from the moment of the lowest common error in the same direction this error increases for the first type and at the same time diminishes for the second type of a diagram in one direction, while the opposite occurs in the reverse direction. To preserve the greatest precision in measurements it seems necessary to replace one method by another at this point which I have called "the changing methods node".

The changing methods node exists as a rule when we deal with a pair of cartographical methods. A pair of methods is formed by two cartographical methods, similar in their graphic design but differing in their representation of value (i. e. in the continuous or interval form).

Both the continuous and interval cartodiagrams fulfil the requirements of a pair of methods (Figure 4) as do the continuous and interval cartograms (Figure 5) or the one-scale and multi-scale dot methods (Figure 6). It is to be hoped that further similar pairs exist, but the confirmation of their existence is now the subject of further investigations.

From what was said above, the following conclusion can be drawn: among the separate, leading types of cartographical methods, analysed from the point of view of their function of presenting values on maps,

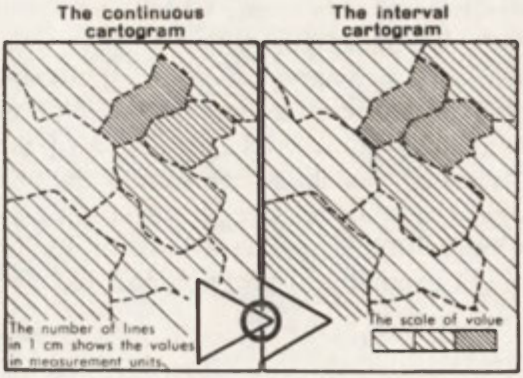


Fig. 4

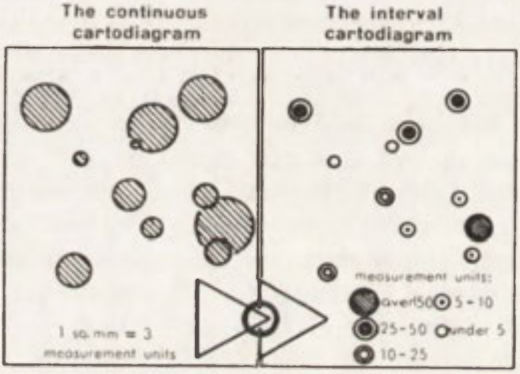


Fig. 5

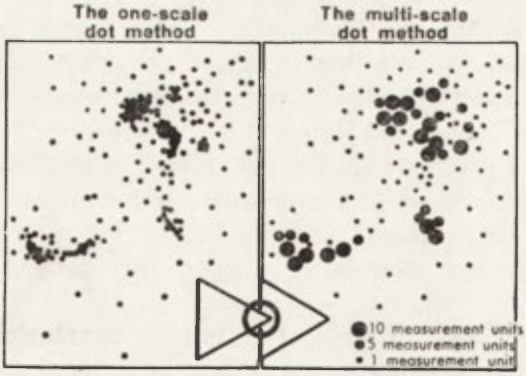


Fig. 6

there exist certain defined correlations, both in the vertical (generalization) and in the horizontal (cartometry) direction. These correlations can be presented on a special model (Figure 7).

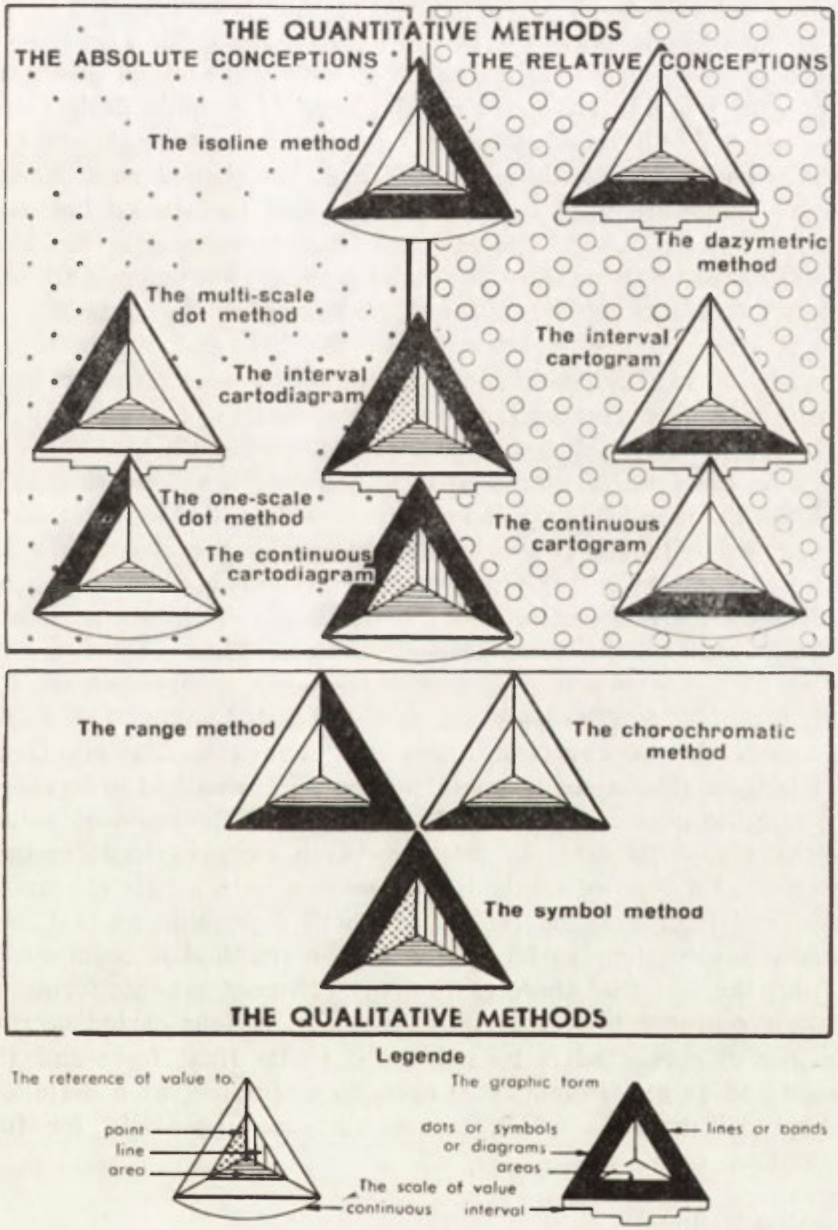


Fig. 7

This model is composed primarily of two basic fields: the field of qualitative methods at the foot and the field of quantitative methods at the top. This latter field has been subdivided into a field of absolute conception on the left hand side and a field of relative conception on the right hand side. Each cartographical method is represented by means of an appropriate triangle set in the appropriate field. The triangle is composed of two concentric triangles, an external and an internal one. The external triangle characterises the type of graphic design used in a given method. The shaded left hand side of the triangle shows that this method uses points (dots or diagrams), the shaded right hand side that linear signs are used (lines or bands) and the shaded bottom side that area signs are used. The internal triangle represents the element of the reference of value. The left hand part of this triangle filled with dots shows that the value is referred to the point, the right part filled with vertical lines shows reference to the line and the bottom part filled with dense, horizontal lines reference to area. An arc line put under the triangles denotes the continuous system of presenting value, whereas a broken line denotes the interval system (in intervals).

Thus, in the field of qualitative methods we see three methods: the symbol, the areal and chorochromatic (popularly called surface) methods. In accordance with the generalization hierarchy the symbol method is placed at the bottom and the quantitative methods above the qualitative. Methods which present phenomena only either absolutely or relatively are wholly situated in their respective field. Those, however, which enable us to present phenomena in both ways are situated on the border area of these fields. The pairs of methods listed above are presented on the model by appropriately coinciding triangles. The similarity of these triangles (the same graphic design and identical reference elements) is quite noticeable, and only the lines of the scale of value put under them are different. In this way each cartographical method, if approached as a type of method, will emerge with all its characteristic features, and their position on a model will determine mutual correlations. Any reservations as far as the type of method is concerned may arise from the fact that there exist many different graphic forms which fulfil the requirements of a certain type, e. g. various cartodiagrams.

The model presented is by no means in its final form and should be considered as an attempt, still open to discussion, at a definition of cartographical methods which leaves quite a large field for further investigation.

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A METHOD OF MOVING AVERAGES APPLIED TO MAPS OF POPULATION DENSITY

Leontyna Barwinska

There are two essential problems to be solved when drawing maps of population density: (1) delimiting the most characteristic features of the "distribution" of the population density, that is, areas homogenous as regards density of population; (2) demonstrating in measurable form the time changes and differences in the population distribution.

Both problems are opposed to each other. In the first instance the calculation of the population density cannot depend on a haphazard superimposing of the base area on the map. The solution of the second problem requires a rigid arrangement of areas and a determined procedure of superimposing the base area system.

The ideal solution would be to locate infinitely successive positions of the base area, and then to determine the population density for each position of the area and later refer the obtained value to the centre of the given area. Then it would suffice to draw a line surrounding control point values within the given class interval. This line would be a delimiting one. This means that, in principle, in any position of the superimposed area — within the area (region) delimitated this way — the population density would always be included within the limits of the given class interval in which the said area has been classified. At the same time this would be an isopleth line representing a definite limit value between the two successive class intervals.

Assuming that the area has changed its position an infinite number of times, we suppose that all possible changes of situations have been made. In this case the problem of haphazard superimposing of the area, which could affect the pattern of the population distribution, would be non-existent. Within the limits of the adopted methodical principles, the pattern on the map would represent the actual geographical distribution of population density. Discussing this problem theoretically one could calculate values of various phenomena or of one phenomenon at various times. The control point data obtained this way could serve as a basis for the determination of differences or time changes in each point statistically measurable, because each position of the area in the first instance would be identical with the position of the superimposed area in the second instance. But this is unattainable in practice. The number of changes in the area position must be limited and practically possible to attain.

Helmer Smeds [9] singled out areas with population density corresponding to the determined class intervals, irrespective of the situation of the base area. To attain this he applied the method of a moving area, the essential feature of the method being that the area is moved in such a way that its successive positions are overlapping. The role of the moving area is performed by a circle cut out of transparent celluloid. Smeds computed population density on the basis of dot map of the population distribution. He chose the area of the circle in such a way that each dot within the range of the circle meant an increase in population density by one person per sq km. Smeds moved the circle around the map until areas of population densities corresponding to the given class interval could be delimitated. He then drew a line marking the contour of the separated area[1]. The class intervals and their limit values were established earlier. Circle positions devoid of dots correspond to areas with population density below 1 person per sq km; from 1 to 5 dots correspond to areas with a density of 1 — 5 persons per sq km and so on.

So it may be assumed that Smeds's method allows delimiting areas with a uniform population density — within the limits of the adopted class intervals. The degree of precision and possibility of error are defined by the scale of the map and the scale of the dot. The method has the advantage of making the obtained pattern independent of accidentality in superimposing the base area on the map; its disadvantage is the impossibility of repeating the successive positions of the freely moved area. And the solution of the second problem, i. e., the comparison of values representing the distribution of different phenomena occuring in the given region, or else of one phenomenon occuring in various times, demands precisely the application of such superimposing of the area which could be repeated as many times as one wishes, the position being identical every time.

Janiszewski [5] followed this idea when drawing a map of relative

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[1] D. Hannenberg (1937) and C. F. Schmid (1955) chose a somewhat different way. They, too, freely moved the area but only to trace the line joining the successive positions (centres) of areas having the same value. Of course this solution of the problem gives no idea of the values of population density between these lines.

altitudes in Poland. He chose a circle as base area. He then divided the map of the country into squares, the side of each square being equal to the radius of the circle. He drew circles around the angles of all the squares and computed the respective value of each position of the area, then related it to the centre of the given area.

Thanks to this method, Janiszewski reduced the accidental character of superimposing of the area, but he failed to eliminate it completely. The degree of mutual overlapping of areas and the density of control points — which in this concrete instance corresponded to a threefold shifting of the system of areas — is insufficient. Moreover, a circle as a base area has also its disadvantages. The circle does not cover the total surface: not all the parts of the map are taken into account the same number of times when computing the values of the area. The system of computing the area value is complicated. The value of each position of the area must be determined individually, so it is impossible to eliminate the error resulting from accidental classification of dots cut by the limit of the circle. Janiszewski's manner of shifting of the circle does not form a correct arrangement of control points required for a network of interpolation axes.

A system of areas covering the whole surface and shifting in accordance with the method of moving averages — analogous to that of consecutive averages in climatology, will be a step forward [1]. The author started from the assumption that the number od shifts is sufficient when the density of data control points in practice exhausts all the possible situations of the area. Revealing differences and time changes of the studied phenomenon is only correct when the properties — values of identical arrangement of control points are to be compared, and the control points represent identically overlapped areas.

In this way the following advantages are attained: a rigid system of superimposed areas is created. The areas should be superimposed in such a way that the network of interpolation axes linking the control points form a network of equilateral triangles. This condition results from the fact that the value attained on the basis of moving averages represents overlaped areas. This is why they can only be shown on a map with the aid of isopleths.

The above conditions are fulfilled by a system of hexagonal areas with 12 superimpositions of the hexagonal grid. The control points (centres of gravity of the areas) for all superimpositions should coincide with all the angles and in the middle of all the sides of six equilateral triangles formed by the division of the hexagon in the initial superimposition. Twelve superimpositions is the optimum figure. The successively higher degree of density of control points requires 48 superimpositions, but this would provide too many details considerably exceeding the limits of error indicated by the very method of moving averages. A lower number of positions would be three and this is too little to eliminate the chance factor [2].

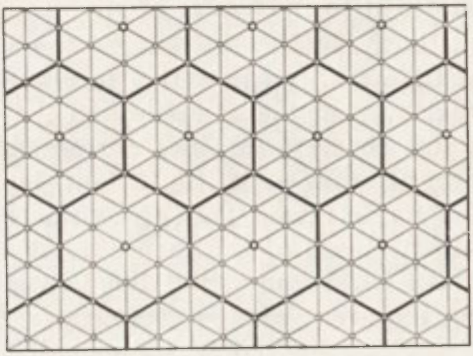

Fig. 1. The distribution of control points and the network of interpolation axes by twelvefold superimposition of the hexagonal grid

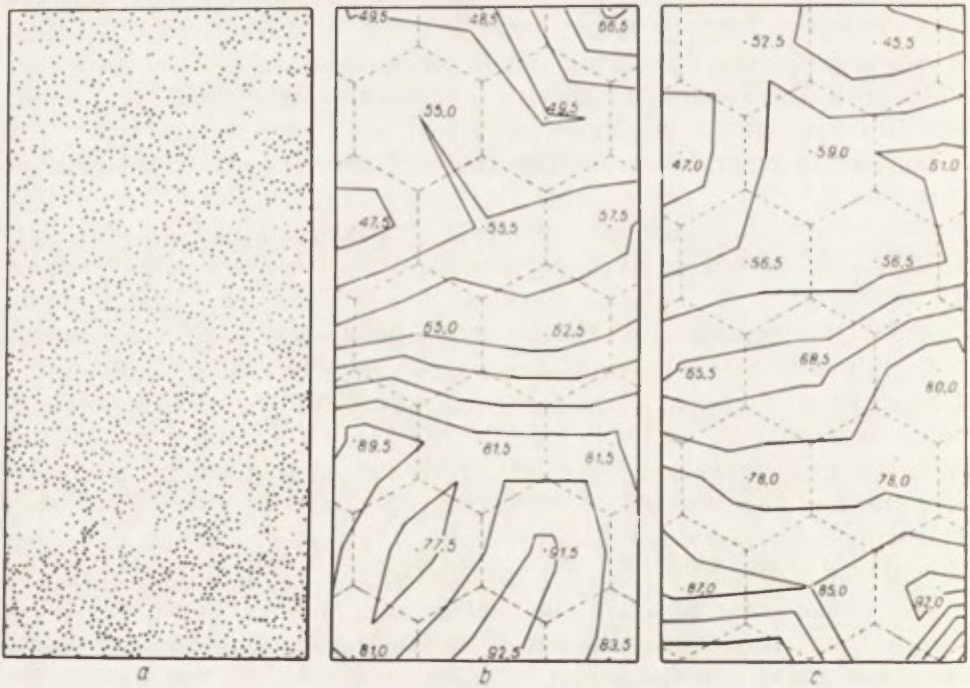

Fig. 2. Fragments of maps

a) dot map of the population distribution; b) and c) data control points and the course of the isopleths for two different superimpositions of the hexagonal grid

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[2] The said problem was extensively dicussed by the same author in her

The stable triangular — correct network of interpolation axes is an advantage of the hexagonal grid[3]. Triangles formed by the interpolation axes are repeated in all the superimpositions of the area system. So it suffices to compute the value of each element separately. The computing of the value of the hexagonal area in each position is limited to adding the values of the respective triangles. In the case of 12 shifts there are 24 triangles on each area.

Two single superimpositions of the area system on the same dot map (Fig. 2a) give two different patterns of the control point values and that of the course of isopleths. (Fig. 2b and 2c). The pattern of the course of isopleths with moving averages computed on the basis of 12 shifts — in two different periods of time is shown in Fig. 3a and 3b. As the method of moving averages produces a rigid arrangement of

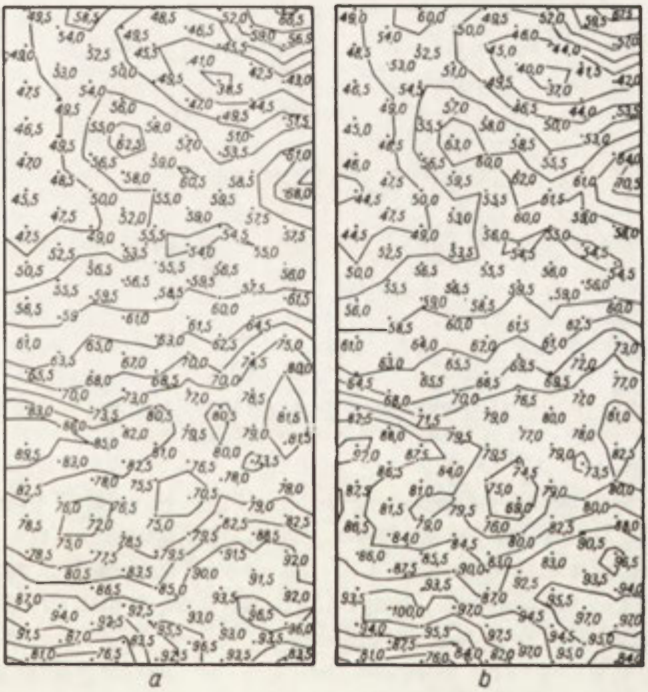

Fig. 3. The distribution pattern of the population density by twelvefold superimposing of the hexagonal grid for two different time cross-sectional data: a) initial moment, b) terminal moment

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dissertation "Density of Population in a Choropleth Map (Cartogramm) and a Geographical Map".

[3] The triangular arrangement of interpolation axes allowing to avoid the problem of alternative interpolation, was first applied by F. Uhorczak (1930) and J. Czekalski (1933).

control points, it is possible to trace changes: increase and decrease of population density in a given period of time (Fig. 4). Changes have been calculated by comparing the cross-sectional data for one year with those for the other, in a similar way as that suggested by A. H. Robinson [4].

Fig. 4. Time changes in the population density distribution — increase and drop (difference between 3a and 3b)

The annexed parts of maps give an idea how the increase in the number of data control points changes the pattern. On the one hand it eliminates the rapid and accidental changes in successive values. On the other hand it emphasizes the most characteristic features of the pattern of the population density distribution.

The method of moving averages allows for drawing of a geographical pattern of the population density distribution. In practice the pattern is independent of the accidental superimposing of the system of areas. At the same time it allows of showing — in measurable values — even small differences and time changes in the density of population and the character of this distribution. This is possible first of all because the

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[4] A. H. Robinson (1957, 1961) refered the values of compared phenomena to the same control points. The very procedure of the computation of the control point data however, was different from that in this paper.

method allows of carrying measurements of chosen phenomena by using always the same system of areas and their control points [5].

The calculation of values of moving averages should be made on the basis of a sufficiently detailed dot map based on a system of co-ordinates (Hägerstrand 1955, [3]). The map should be made as to allow of counting the population within any position of the superimposed area with the aid of a computer, for it is a very time-consuming job [2].

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[5] Of course the reservation must be made that the compared phenomena may be determined in relation to the same areas and that there is a logical motivation for their being compared to each other.

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WARSZAWA

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