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GEOGRAPHY IN POLAND: MAIN TRENDS AND FEATURES

Stanisław Leszczycki

ENTHUSIASM OF THE POST-WAR RECONSTRUCTION PERIOD

Like other disciplines geography suffered great losses in Poland during the Second World War. Several dozen research workers and almost all the heads of university geographical departments were killed, and the majority of university centres were completely destroyed during the occupation. Work could only be carried on in secrecy, but nevertheless scholars started then to lay the foundations for geographical research concerned with Poland defined by her new post-war boundaries. The liberation in 1945 brought new opportunities, which research workers welcomed with tremendous and unsparing enthusiasm. They set out to organize educational system, started numerous publications dealing with Poland within her new boundaries, and organized research, mostly into problems relevant to the reconstruction of the country. The job of organizing and managing university departments was undertaken by relatively young geographers, around forty years of age.

The authorities in newly liberated Poland were very generous in the allocation of funds for education; the rebuilding of schools and universities was given top priority. Given such a start enthusiastic young staffs, larger than in prewar years, rapidly made great progress. After only three years higher standards were attained than before the war.

There were organizational changes as well. Co-operation replaced the individualistic tendencies that predominated in the five university geographical centres existing before the war. The one Polish Geographical Society was reactivated which was entrusted with the task of co-ordinating geographical activities, including not only the preparation of university curricula but also of research plans. In 1948 the geographical research plan on a national scale was started and has been continued since. The plan not only took a general view of more important research subjects, but also was an instrument for the co-ordination of research work. As the result of many methodological changes during the 20 years period the central plan has finally become transformed into a document in which only the most important researches for geography as a science and for the national economy are listed. At the same time planning has been decentralized to the level of university or even a single chair. The number of geographical publications also increased; they now amount to about forty serial or periodical items (cf. the list at the end of the volume). This development has not been even and undisturbed. However, the enthusiasm helped to build up quickly a number of relatively large and well equipped centres. The post-war spirit of co-operation and the newly adopted method of work not only succeeded in reviving Polish geography, but also helped it to attain its present important position among other scientific disciplines.

NEW PHILOSOPHICAL APPROACHES

The interpretation of geographical phenomena and processes is based upon accepted theoretical principles. In the development of geographical science various trends could be observed. These included possibilism, an excessive and somewhat primitive geographical determinism, nihilism which, however, never enjoyed much popularity, as well as a moderate pragmatic determinism which dominates at present. In the interwar period, Polish geographers slowly abandoned geographical determinism and came quite close to possibilism. At the same time, they included on the scope of their research problems falling originally into the domains of neighbouring sciences, such as geology, physics, biology, history, sociology, economics, and others.

The situation changed radically after the war. The new socialist system promoted Marxist philosophy and Marxist laws governing nature and society. This change was quite revolutionary not only for geographers, but also for all scholars. In 1948 geographers started a discussion on the theoretical foundations of their discipline. This has not yet been exhausted, although its basic stage lasted from the First Congress of Polish Science, held in 1951, to 1956. The discussion has proved to be very fruitful and has been continued. Different theoretical and philosophical approaches have been confronted with each other. It helped every geographer to work out his own ideas. As materialist philosophy was generally accepted to be much closer to reality than any other system, and as geography was also closely associated with real life, the choice was not difficult. Geographers readily accepted this way of thinking and based on it their selection of research methods and subjects. Their knowledge of various pre-war schools of geography and of Marxist ideology, enabled them to pick out those new development trends which seemed most rational in the light of materialistic philosophy. This has greatly accelerated the progress of Polish geography. Its theoretical foundations have been widely discussed, and research objectives and trends established on the basis of the current socio-economic situation. Thus, geography has become a discipline of vital significance to the economy, and has developed rapidly. In certain branches Polish geography has even begun to overtake geography in many other countries.

LINKS BETWEEN GEOGRAPHICAL RESEARCH AND PRACTICE

The third factor to have influenced development trends in Polish geography was the selection of research subjects. Geographers, who had participated in the reconstruction of the country from the very beginning, adjusted their research work to current needs. They participated in regional planning, gave expert advice, prepared studies dealing with evaluation of geographical environment, compiled maps of the distribution of the population, of industrial and agricultural production, transport and communications, took part in the preparation of regional plans, and even some geographers joined the staffs of planning offices at town, regional or national level. On their initiative and owing to geographical work a new research discipline was introduced, known as urban physiography, which is of significance in town planning, as it has greatly increased the number of geographical elements and geographical methods in the construction of the plans. Their co-operation with spatial planners has been continued; Polish geographers play the important role in this field, taking part in the construction of plans, acting as experts and even participating in the organization and management of perspective macrospatial planning. Geographers acted as experts during the delimitation of Poland's boundaries, worked on the new administrative divisions, and co-operated in the repolonization of the names of localities situated in the territories with former German official nomenclature. They took part in the preparation of geological general survey maps and started the preparation of some detailed maps (e.g. geomorphological, hydrographical, and land use maps). This new trend has brought about the intensive development of applied geography, which encouraged further development of contacts with practice and enabled the confrontation of the research findings with real life, as well as increasing application of precise, quantitative research methods. At the same time the appreciation shown for these practical results has given the geographers great satisfaction. Since real progress in the applied sciences is hardly possible without the parallel development of theoretical foundations, as this would reduce research to narrow, even if concrete, expert opinions, geographers have also taken the theoretical side into consideration. Theoretical work has been carried on, and full use has been made of all current research by scholars in socialist and capitalist countries. When possible, the most up-to-date methods and views have been adopted. At the same time efforts have been made to develop original Polish methods. Results obtained by Polish research workers have often proved valuable and of general interest, and have made a real contribution to world geography. Works by Polish geographers are fairly often quoted in world literature. Thus, the selection of research subjects relevant to current problems of the national economy has proved to be of greatest importance for the development of Polish geography.

SPECIALIZATION WITHIN THE GEOGRAPHICAL SCIENCES

The geographical sciences cover a very wide scope. The ideal geographer of the interwar period was expected to have broad interests and combine field work with research into the widest possible range of topics. He would present his findings in a synthetic way, e.g., on a world scale, or prepare comprehensive monographs on certain countries, preferably those little known in world literature. Consequently, after the war, geographers who wanted to count as experts in specific fields, had to intensify rather than broaden their field and to select very narrow special subjects. Initially, the following three specializations were introduced: physical geography, economic geography and cartography. It should be mentioned here that in Poland the term "economic geography" denotes the whole range of geographical problems associated with man, his economic and cultural activities. Thus the discipline is not limited to studies of activities connected with production alone; on the contrary, it includes such specializations as settlement geography (even if this is restricted to historical outline only), population geography, etc. From the first post-war years physical and economic geography have gone separate ways. As a consequence, physical geographers moved closer to geologists and geophysicists of the earth, water and atmosphere, while economic geographers found a common language with economists, sociologists, demographers, and town planners. This led to a certain neglect of regional geography, which was then treated only as geographical "information", i.e. as a comprehensive description of a given area, or even as mere popularization of geographical knowledge.

Cartography, standing on traditional grounds has not developed so rapidly. The then existing division of the geographical science did not, however, affect the organizational unity of Polish geography. Uniform curricula were maintained in all the university departments of geography, the single geographical society acted for all geographers, and periodical publications continued to be issued jointly.

The process of specialization gradually gained ground. All the factors described above still applied and the growing demand for greater specialization made it necessary for geographers to concentrate on clearly defined subjects. At that stage specialists emerged within physical geography, including geomorphologists, hydrographers (hydrogeographers), and climatologists, other disciplines such as soil geography, biogeography, oceanography have not necessarily followed this pattern. Economic geography split into the following disciplines: population geography, urban geography, industrial geography and agricultural geography. The geography of rural settlement (in its historical approach) or transport geography developed more slowly, as did geography of services, including tourism. Besides, there have been more specialists in the history of geography and cartography, as well as in the methodology of geography. Thus, after a period of a dozen years or so, further differentiation took place among Polish geographers. These tendencies towards greater specialization also affected the scope of didactic work. Specialization was also introduced at the fourth and fifth year of university studies. This, in turn, induced the emergence of new organizational forms, namely the creation of a number of highly specialized research sections, chairs and laboratories.

ESSENTIAL FEATURES OF GEOGRAPHICAL RESEARCH IN POLAND

With the increased specialization of geographical research in Poland, the problem approach has begun to predominate over the descriptive approach. It has become more and more common for the problem approach, particularly to subjects of practical bearing, to blur the traditional boundaries of geographical research and to bring in other scientific disciplines. Thus geographical research has become much more penetrating, and geographers have had to enter into contact with other specialists, or to broaden their own knowledge of other disciplines. For example, geomorphologists investigating the Quaternary period have had to collaborate with geologists, climatologists with physicists of the atmosphere, agricultural geographers with agronomists, and geographers studying urban settlements with town planners. This process has grown in importance since the introduction of work on the physico-geographical regionalization of Poland, the evaluation of resources and the amenities of geographical environment, socio-economic regionalization, the delimitation of urban-industrial agglomerations, the spatial structure of the national economy, the spatial approach to the national income and similar projects.

It is understandable that under these circumstances the methodology of research has acquired new significance. It has become of paramount importance to keep up with modern methods applied not only in geography, but also in other related disciplines. As methods must be more and more exact, interest in quantitative (mathematical) methods has been increasing and the number of young geographers using mathematical methods is steadily growing. This is clearly reflected in recent geographical publications and in the number of original Polish contributions in this field. Certain Polish methods (e.g., in cartography and typology), have been adopted by other countries.

The general application of the problem approach has eliminated the former traditional division of geography into sections and branches. The main problems to be tackled now are these of complex nature and of great theoretical as well as practical significance. They clearly require long years of research, and this has become their particular attraction for many young geographers, who represent a new and different type of research worker. Numerous geographers are now experts in regional policies and economy, in the spatial structure of the national economy, in the investigation of problems of spatial planning on regional and national levels, in agricultural typology and the preparation of land-use surveys. They specialize in evaluating the natural resources and amenities, in the protection and rehabilitation of man's environment, they are asked for advice on the redevelopment of settlement networks, or the expansion of metropolitan areas, etc. etc.

It seems that the problem approach which constitutes a new stage in the process of specialization in Polish geography may exert a strong influence on the development of geography in Poland in the near future. This trend is represented by numerous young geographers.

THE KALEIDOSCOPE OF VIEWS AND OPINIONS

In view of the increased specialization, no Polish geographer could master all disciplines and branches that comprise the geographical sciences. The background of individual geographers may be varied, as the university curricula are subject to quite essential changes every several years; these alternations usually embrace both the basic and the supplementary subjects. This explains why present research workers have pursued university courses based on different programmes depending on their age groups. The greatest changes have affected the humanities (history, sociology, ethnography) and sciences (mathematics, physics, chemistry). Geographers have been influenced by various theoretical trends and are characterized by various preferences in the choice of special subjects, rarely included in geographical syllabuses. Research specialization, the type of university course and some other factors have brought about a variety of views on geography as a whole, on the scope of geographical research, or on the greater significance of one or another branch of geography. The situation can be compared to a kaleidoscope, where the components are determined quite precisely and remain the same, though the pattern changes after each rotation of the tube. In such conditions, however, promoting collaboration calls for much tolerance, which must be all greater if collaboration is closer. The separate geographical sciences and the problems they tackle can be compared to the bright bits of glass of various shapes and shades which rotate in the kaleidoscope. Each geographer may have his own views on geographical problems, and therefore the only solution is to assume that all of them have their specific value and never to reject them *a priori*, without good reason. Such an approach may result in the existence of many different schools of geography. This situation is quite typical in Poland today. Each school develops according to its own criteria, holds its own views and publishes its research in Poland and abroad. There are several schools in Poland and all of them are developing freely. Their number may even increase, as new generations of geographers are growing up. Thus, within the framework of a uniform organization and normalized forms, there is a very varied content and diversified approach to geographical problems.

PRINCIPAL RESEARCH PROBLEMS IN PHYSICAL GEOGRAPHY

In other contributions to the present volume the reader will find detailed descriptions of the most important research work carried out by Polish geographers. I will therefore only mention some topics which seem to be typical of general research trends in Polish geography.

Research in physical geography mainly covers three disciplines: (1) geomorphology, (2) hydrography, (3) climatology. Geomorphologists carry on studies on formations, relief and processes of sedimentation, mainly in the Quarternary period, in Poland as well as Central Europe. A few studies were concerned with the Tertiary formations, many more with contemporary processes. Geomorphological mapping, detailed survey and maps have become quite important, the maps serving as a basis for genetic studies. Outstanding results have been obtained in periglacial geomorphology, not only on a national but also on a world scale. Investigations of contemporary processes, of the evolution of the slope, of anthropogenic forms of terrain, have recently expanded. Hydrographical research has mainly been confined to hydrographical mapping, water circulation in small river basins and limnology. The interest of climatologists has focused on the dynamics of the Polish climate and its regional characteristics, heat balance, and the climate of urban centres and health resorts.

PRINCIPAL RESEARCH PROBLEMS IN ECONOMIC GEOGRAPHY

I have already mentioned that only certain branches of economic geography have been more intensively developed in Poland. These include settlement geography, with its two specializations: rural and urban. The geography of rural settlement, approached from the historical angle, investigates such problems as the pattern of fields and plots, the possible redevelopment of villages, the network of rural service centres. The geography of urban settlement concentrates mainly on the problems of urban networks, settlement systems and metropolitan areas. Changes in Poland's demographic structure, in spatial and time cross-sections, are the main subject of studies in population geography. In industrial geography researches are concerned with the location and distribution of industrial enterprises, delimitation of industrial centres and districts, and the investigation of links between industrial production and geographical environment. The geographical typology of agriculture and the methodology of land-use mapping are the domain of agricultural geographers. Changes in agriculture in industrializing areas have also been analysed. Transport geographers investigate the networks, nodes and servicing of the national economy by systems of transport and communication.

OTHER GEOGRAPHICAL PROBLEMS

As I have already stated, Polish geographers pay particular attention to physico-geographical and socio-economic regionalization. The principal field of study in physico-geographical regionalization is Poland, but neighbouring countries and even Europe as a whole have also been analysed in this respect. Soviet and to some extent German methods have been applied with certain modifications. Studies on socio-economic regionalization are treating mostly methodological problems. Poland has been responsible for the initiation of many projects and publications sponsored by the IGU Commission on Economic Regionalization, while attempts to carry out the economic regionalization of Poland have stimulated methodological discussions, particularly on the selection of delimitation criteria. Some of the methods have been utilized in spatial planning.

In spatial planning, geographers are engaged in research concerned with urban physiography and the evaluation of geographical environment in individual administrative units (poviats), carried out for agricultural purposes. The geographers' contribution to regional planning is many-sided; they prepare the analytical characteristics and evaluation of geographical environment, of population distribution, production, transport and recreation; they provide expert opinions for regional planning, and participate actively in the preparation of plans. Together with economists and town planners, they play a leading part in the preparation of the national plan. They concentrate mainly on studies of the spatial structure of Poland's national economy and the economic management of the macro-regions, with particular emphasis on the system of the principal nodes of the national economy, settlement networks and metropolitan areas. Although their work as of practical type, it also contributes to the development of the theory of space economy.

Thematic cartography, cartology and metacartography have recently aroused much interest among geographers. However, the development of new trends in cartography is limited by existing technical facilities.

The protection of man's environment has lately become another subject of research work. Studies have been started into the theories of a positive feedback in the interaction man-environment, on the one hand, and the investigation of the pollution and deformation of geographical environment, on the other. This type of research is closely associated with the work on the evaluation of the natural resources and amenities which should be preserved for the sake of future generations. Currently, two maps have been started, (1) sozological, i.e., of the areas which should be protected against incorrect utilization, (2) of damage, i.e., of the areas affected by various types of disfunctions.

Studies carried out by geographers of tourism are, in a way, connected with the same problem. Their main objective is to delimit and investigate areas of special value for recreational and tourist purposes.

All these research studies are of practical significance for the national economy in its spatial context. Their implementation, however, and the correctness of the results obtained depend on the application of theoretical findings and the use of the most up-to-date quantitative methods.

Institute of Geography PAN, Warsaw

GEOGRAPHIA POLONICA 22, 1972

SYNTHETIC PHYSICO-GEOGRAPHICAL RESEARCH

Jerzy Kondracki and Andrzej Richling

In 1964 "Geographia Polonica" discussed the problems of physical geography and physico-geographical regionalization in Poland [8], considering them in the light of the way that these research trends were developing in other countries. Work in this direction has been proceeding along three existing lines, covering: (1) physico-geographical regionalization accomplished by means of additional specifications of the criteria by which the discernment of separate units and their subdivision into smaller units should be governed, (2) the detailed mapping of basic geocomplexes directly in the field by classifying them according to differences in their typology, and (3) compiling all available analytical material, i.e. data on geology, geomorphology, topoclimate, hydrography, soil science and phytosociology, including data on land utilization. A problem of its own is how to apply in practice these synthetic physico-geographical investigations for each of the enumerated trends of procedure.

A concise comment on the research trends mentioned above, on the basis of recent progress made in physical geography in Poland and in other countries, can be found in the handbook "Principles of physico-geographical regionalization" by J. Kondracki published in 1969 [15]. Synthetic physico-geographical research is constantly developing and gaining attention. This found its expression, for example, in the reorganization of the Institute of Geography of the Polish Academy od Sciences (PAN). Here three former departments: Climatology in Warsaw, Geomorphology and Hydrography of Mountains and Uplands, in Cracow, and Geomorphology and Hydrography of Lowlands, in Torun, were replaced in 1970 by three new departments devoted to complex research in physical geography: the Department of Transformations of Geographical Environment, in Warsaw, the Department of Physical Geography in Cracow, and the Department of Physiography in Torun.

This reorganization of PAN's Institute of Geography may have far-reaching results in bringing progress to physical geography, although it is by no means an easy matter to adjust the present group of research workers to these new methods and trends, and because of the short time since this reorganization was introduced no essential results can so far be expected.

The Institute of Geography, PAN, is the co-ordinating agency for all scientific work falling under the so-called nodal problem "Basic factors of the space economy of Poland" which also embraces problems of natural resources affecting the spatial evolution of the country. The implementation of this programme rests not only with the Institute itself, but, also with all university geographical centres and some other scientific institutions. The scope of this work is to draw up a system of typological units valid for all-Poland and to join these units with the system of physico-geographical regional subdivisions, to prepare an analytical model of a geographical environment and to forecast the changes expected to take place in this environment. Finally, it is also hoped to prepare appraisals of the geographical environment with regard to the basic branches of the national economy and to correlate these estimates with the extent to which the environment and its natural resources are actually being put to use.

Studies tending towards a physico-geographical regionalization of Poland have made progress. Worthy of attention is the new handbook on the physical geography of Poland by J. Kondracki [11] which was first published in 1965 and its second edition in 1967. In 1966 a symposium on physico-geographical regionalization was held in Poland, organized by the Polish Geographical Society, in which 24 representatives from the Soviet Union, the German Democratic Republic, Czechoslovakia, Hungary, and Finland took part as guests. Excursions were held in the Carpathians and reaching as far as the north-eastern Poland. Discussions were held regarding the criteria for regional subdivisions, the hierarchy of spatial units, and the methods and standards of typological mapping of basic geocomplexes in the field. An effort was also made to link the regional units distinguished for Poland with corresponding physico-regional divisions established in neighbouring countries. The contributions and the discussions were published in 1968 in a volume entitled: "Problems of physico-geographical regionalization" [14]. At that time it was suggested to use the decimal classification for defining regional units, this was in line with the suggestion made by the Commission on the Classification of Geographical Books and Maps in Libraries and put forward at the XX International Geographical Congress in London. Decimal symbols have been co-ordinated on an international scale by the Commission of the International Federation of Documentation. J. Kondracki's suggestion made in 1968 to use a decimal classification with regard to Poland has been approved by this Commission with certain modification. In connection with the XXI International Geographical Congress held in New Delhi [13], J. Kondracki has written about the necessity of co-ordinating the physico-geographical divisions of the European countries. Also at the European Regional Conference, held at Budapest in 1971, he read a paper on the physico-geographical regionalization of the Carpathians in which a decimal classification was applied.

Professor T. Bartkowski in Poznań has devoted a lot of attention to physico-geographical regionalization of North-Western Poland. Complying in principle with J. Kondracki's notions he put forward a somewhat different pattern of regional units. He sets high value to a subdivision by micro-regions.

The Institute of Geography of the Warsaw University is paying particular attention to the detailed mapping of fundamental geocomplexes directly in the field. This Institute transferred into Polish research work much of the experience gained by Soviet geographers. Conforming to Russian terminology, basic units in this typology are facies ("Ökotop" in German terminology) and *uroczyska* [1].

A facies is the smallest homogeneous geocomplex. It is characterized by uniformity of the rock substratum, soil and microclimate. A facies is homogeneous with regard to humidity; it is characterized by a single type of phyto-

[1] *Uroczyska* (sing. *uroczysko*, pronounced oorochisco) means some sort of a particular site or spot, combining a certain number of different facies into a whole.

cenosis, and it conforms to one microform of relief (or to one part of a mesoform). To give an example, a facies may be a definite dune slope, the bottom of an undrained depression, part of a fluvial terrace.

Next in size among the units is the *uroczysko*. Admittedly, this is a composite unit built up of a number of facies, but genetically it is homogeneous. It is linked with the mesoforms of the land relief. An *uroczysko* may be defined as follows: it is a regular complex of facies which appear in nature in connection with different relief forms, with a non-uniform composition of the ground and with man's activities. Hence one may describe as an *uroczysko* a particular ravine, a moraine ridge, a kame or a dune.

Both these kinds of units are repeating geocomplexes and thus they constitute typological units. The accurate identification of types of these kind of units within a certain area makes it possible to expand the results previously obtained onto neighbouring areas where, dependent on their physiognomy, individual complexes are assigned to either of these different types. This is of considerable practical significance because it speeds up the rate of mapping. All units distinguished in landscape mapping are geocomplexes which embody complicated interrelations between their separate components; and in these geocomplexes each of their components affects the ones next to it and itself remains under their influence. However, among this multitude of components there are bound to be some which are crucial in characterizing a given unit, and other components of less importance. Briefly expressed, there are what might be called index components to which the remaining components are subordinate. From their correct choice can be defined the features of the remaining components, with the index components as the basis.

When it comes to distinguishing units of different taxonomic rank, a variety of components may take first place. For example, for distinguishing facies, biotic agencies (especially vegetation and soils) may be considered as index components, whereas in the pattern of *uroczyska* abiotic agencies are of more vital importance. Under definite climatic conditions the boundaries of individual *uroczyska* depend for the most part on relief and geological structure. These features are the most permanent, and they are least likely to change due to man's economic activities.

From what has been said before, it appears that the distinguishing of facies is, first of all the concern of certain disciplines such as phytosociology, pedology and forestry; hence, in fact, distinguishing such units lies outside the scope of geographic research. However, an understanding of facies is necessary to the geographer so as to make him understand the structure of *uroczyska*. In examining the pattern of groups of facies in the profile of a land relief one can trace the interrelation occurring between these units. To do this one has to apply the method of landscape profiles. The next sequel of facies (oecotopes) on a slope are what is called *catenas*. A *catena* indicates the effect which elements like shape of slope, type of rocks, hydrographic conditions, microclimate and vegetational features have upon the different parts of the slopes and which, under particular conditions, occur repeatedly in a characteristic manner.

There also exists a related concept called the order of facies. The order of a facies covers all positions observed in a full profile of the land relief, from the top of a rise down to its very bottom. Under identical conditions, there should always develop orders of facies of an identical type. The features of every facies depend for the most part on where it is situated.

A full understanding of the pattern of a facies enables one to define the characteristic of *uroczyska* — the study of which is a physical geographer's fundamental task.

An important part is played by preliminary investigations in compiling a detailed landscape survey. Before venturing into the field, all available material referring to the region in question should be studied in detail. Aerial photographs are of great value here. The result of these preliminary studies should be a preparatory map on which the boundaries of different units can be marked. The actual field work is done in order to correct the boundaries marked, and to collect data which would allow the characterization of particular complexes and the establishment of interrelations between individual components.

For landscape investigations, the following alternative methods exist:

(1) mapping from itinerary examinations,
(2) examinations made of key areas,
(3) stationary studies.

Mapping from itinerary examinations is done by entering onto the map the boundaries of complexes observed along routes followed in the field, and by filling in the space between these routes on the basis of data otherwise available. Research work of this kind is done when it comes to compiling maps of larger areas, in not particularly accurate scales. Obviously, the course of the routes should be suitably selected so as to cover all types of *uroczyska.*

Examinations of key areas involve selecting particular areas for which detailed landscape mapping is done. Both the number of such areas and their size depends upon the extent and the structure of the total area to be ex-

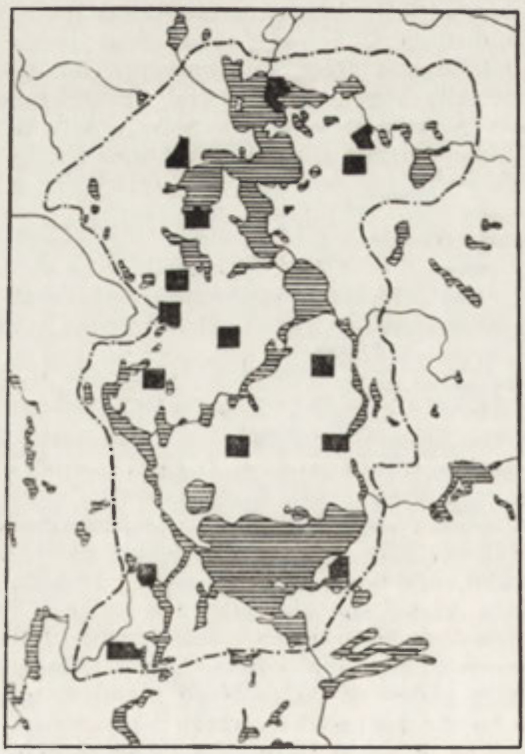


Fig. 1. Distribution of key surfaces within the range of the Great Mazurian Lake Country, after A. Richling

amined, and upon the scale of the map. The particular areas studied should be distributed in such manner that the examinations cover all types of units occurring in the area in question (Fig. 1). This procedure is customary not only in physical geography but in other natural sciences as well, such as phytosociology, because its application encompasses a wide range of problems. While working with key areas the geographer should be careful to enter onto his map all particular components observed, such as relief forms, geological structure and hydrological conditions, as well as soils and vegetation, he also should define and scrutinize the interrelations between these components, and mark the boundaries of individual units. This shows that this type of research is cumbersome and tedious. Apart from surface mapping, this work demands measurements of the groundwater table, test pits for soil studies, geological

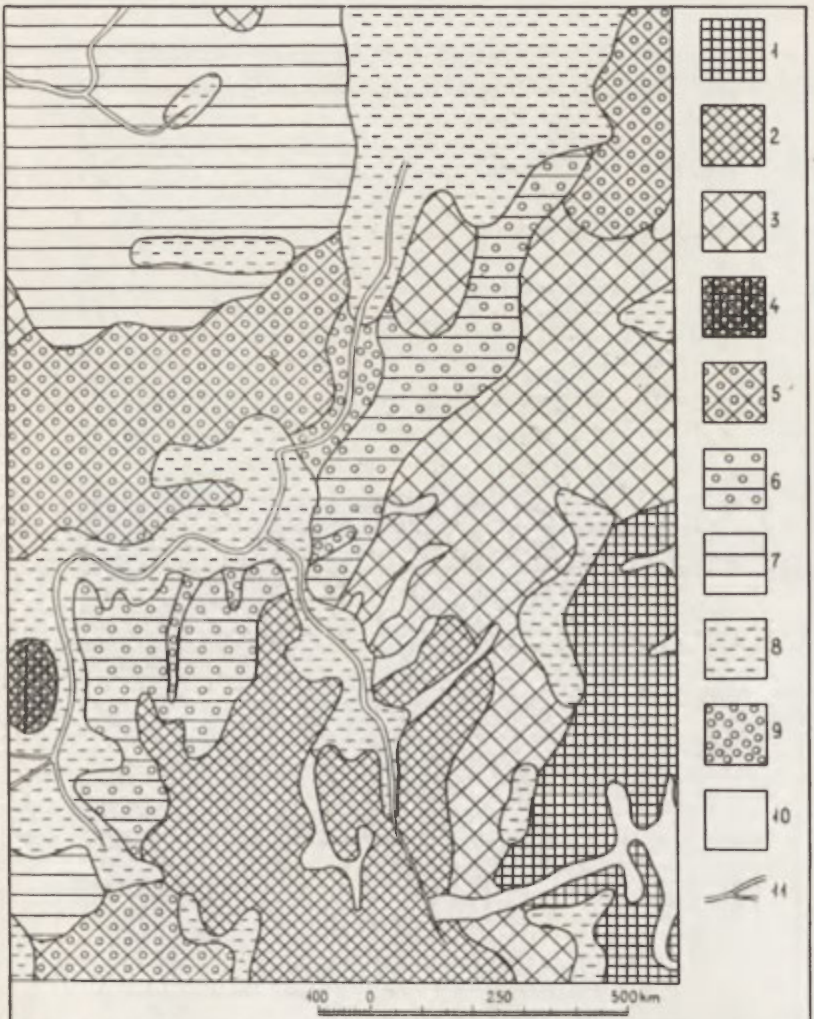


Fig. 2. Map indicating types of *uroczyska* in the region of Sterławki Wielkie village (Great Mazurian Lake Country), after A. Richling (see explanation at the end of the article)

drillings and descriptions of natural outcrops, moreover, it requires the collecting of samples for laboratory analyses. Often helpful in this work are special blanks onto which can be entered all the data obtained from particular points of observation. The final result of these examinations should be a map indicating the boundaries of particular *uroczyska* and also often of individual facies. As examples of this type of mapping the authors have added to their paper a map of the surroundings of Sterławki Wielkie, a village of the so-called Great Lake Country in the Mazurian Lake District (Fig. 2) and the fragment of a landscape map showing the drainage basin of the river Opatówka on the Sandomierz Plateau (Fig. 3).

After the maps for the examined key areas have been compiled, the next step is to extrapolate from the results obtained so far for particular components into conditions inferred in regions not investigated in detail. Very useful

Fig. 3. Fragment of a landscape map showing the Opatówka drainage basin on the Sandomierz Plateau, after R. Czarnecki (see explanation at the end of the article)

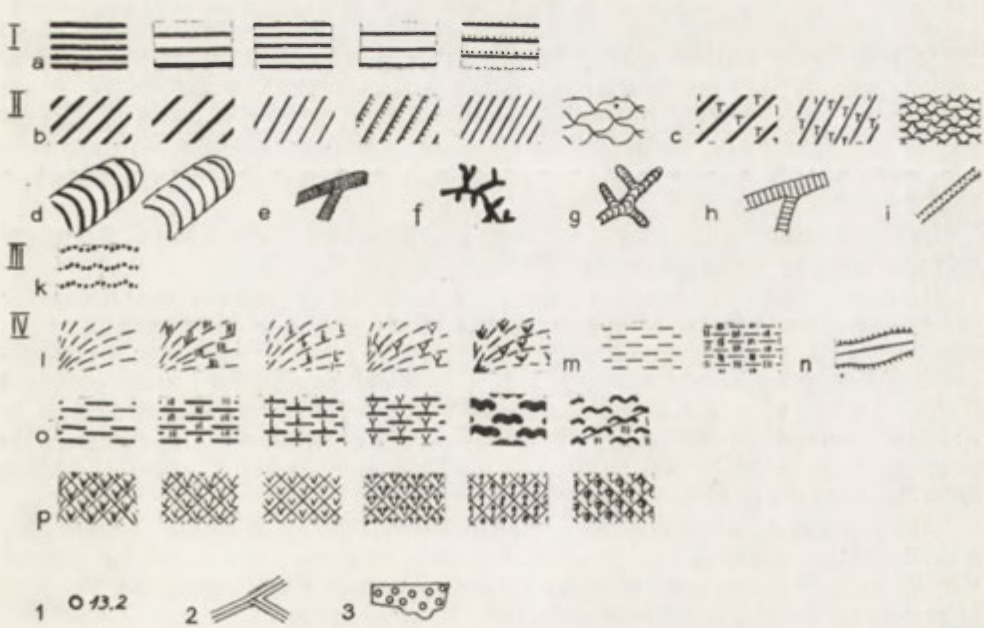
in this work is the investigation of those components which have been distinguished as index components in previous examinations of key areas.

Stationary studies should always be carried out for protracted periods of time. These sort of studies throw light on the seasonal rhythm prevailing in the landscape, and make it possible to draw balanced conclusions with regard to the investigated components.

From all that has been discussed so far one sees, that in investigating landscapes the geographer also resorts to methods applied by other branches of geography and by other natural sciences. An integral part of landscape mapping are elements of hydrographical, geomorphological, pedological, geological and phytosociological mapping. However, landscape examinations should by no means take the place of investigations of components, but they should be done one parallel to the other, because the principal aim of the landscape examinations is not to supply a characteristic of components but rather to perceive their mutual interrelations, to analyze the area of given landscapes and to divide it into natural units — in spite of the fact that, in regions so far only poorly investigated, these sort of landscape examinations may unfold not only natural units but their components as well.

In the discussion so far, the authors have left out the problem of typological units of a rank higher than that of *uroczyska*. But it will be seen that on both maps (Figs. 2 and 3) such higher-rank units have been marked. In the former map they were called "varieties of landscapes", in the latter "types of environment" involved. Both these terms are being applied to any area containing a regular group of *uroczyska* strictly specified in character, which are of identical value from an economic point of view. After J. Kondracki (15), varieties of the landscape result from differences in their topographic position with in one species of landscape. This author considers landscape species to be geomorphic complexes of definite ecological features, which in lowlands

Key to Fig. 3



are dependent on some definite type of mesorelief and in mountain areas on altitude stages. An example of landscape species may be seen in the landscapes of lake districts, on outwash plains or loess deposits, or altitude stages in mountains. A higher unit is the *genus* of a landscape which genetically comprehends related species, like maritime, young-glacial and old-glacial landscapes, or plateaus and mountain lanscapes. The highest rank in this classification occupy landscape *classes* which derive their existence from features of zonality; to these classes should be assigned lowland and plateau landscapes of tundras, taigas, steppes and deserts, or mountain landscapes with definite features of a vertical stage pattern.

Furthermore, in-the-field landscape examinations may be a sound basis for regionalizing the land. From the pattern of the types observed and from their frequency one may draw conclusions regarding regional boundaries. Often, as an auxiliary procedure, there is applied what is called the neighbourhood method. In Poland this latter method has been applied and described by A. Marsz [19]. This author based his regionalization on a map of "physiocaenoses", in other words, of typological units of the rank of *uroczyska*. After compiling his map he drew up cross-sections on which he marked the boundaries of particular units. Next, he adds, in a pattern drawn at right angle, this same cross-section at the end of the original cross-section, and with this system as a basis A. Marsz constructs a grid of field in a rectangular pattern. This grid covers all imaginable combinations of physiocaenosis neighbourhood occurring on the line of the cross-section drawn. Using the map he marks in his grid all truly existing neighbourhoods by dotting the respective fields. In this way he achieves a certain grouping of these dot-marked fields, arranged symmetrically to the diagonal of the diagramme. Between these groups of fields narrowed sections occur which correspond to boundaries of the smallest regional units. And because it is easy to locate these points on the map, one can mark the run of boundary lines on the basis of a number of cross-sections.

By this method of arranging analytical source material, particular administrative units of poviat or even voivodship size are being investigated in Poland. An example is the studies made for Pińczów poviat on the Lesser Poland Plateau [10], for Gorlice poviat in the Carpathians [23] and for the Cracow region [7]. The two last-cited papers, prepared by the Cracow centre, bring very extensive characteristic data on particular components of the natural environment, and contain in their conclusions a chapter dealing with physicogeographical regions, but without specifying the taxonomic rank of the distinguished units.

In studies showing a clearly directed practical trend, the following tendencies may be observed at present:

(1) A departure from appraising the suitability of natural conditions for the requirements of agriculture. In recent times studies of this sort, of necessity drawn up in a very generalized way, have lost their importance. Undoubtedly, this may be largely attributed to the compilation of the results obtained from a survey of soil classification executed in the form of soil maps in 1 : 25,000 scale. Moreover, the opinion is steadily growing that it is impossible to give an appraisal for agriculture as a whole, and that any appraisal of this kind might at the most consider definite crops.

(2) In papers concerning the requirements for establishing settlements a further standardization of methods has been reached. This found its expression in an instruction drawn up by "Geoprojekt" with definitions for the way to prepare general physiographical studies for this purpose.

(3) Increased interest is being noticeably paid to matters of tourism and recreation. So far these sorts of appraisal were usually done by means of analyses of particular components of the geographical environment, among which first place was assigned to relief forms as the dominant factor causing diversities of the landscape and affecting microclimatic conditions. In this way, the land relief was given priority when it came to defining curative and health-restoring conditions. As a rule, appraisals of this kind found their expression in a map on which separate markings indicated areas of higher or lower value for the definite purposes of recreation or medical treatment. Also, the method suggested by A. S. Kostrowicki [17] was sometimes adopted. He bases his classification largely on the vegetation cover. All the investigations discussed above are certain to grow in importance in the future. And it may be expected that improved and more unbiased methods of appraisal are likely to be developed.

EXPLANATION OF THE SYMBOLS SHOWN ON THE MAP OF TYPES OF *UROCZYSKA* IN THE REGION OF STERŁAWKI WIELKIE VILLAGE

(after A. Richling)

Variety of landscape of marginal landforms

(1) Type of *uroczysko* built of loamy elevations with relative altitudes ranging between 10 and 45 m, showing a predominance of brown soils of fertility classes IV and, more rarely, V; a deep groundwater table above which often a shallow, non--continuous top groundwater table is observed, occupied by cultivated fields and pastures which on slopes are megatherm, while in depressions they are humid.

Variety of landscape of ground-moraine landforms

(2) Type of *uroczysko* built of loamy hills with altitude differences from 10 to 15 m, showing brown and podsolized soils of classes IVa and IVb, characterized by marked differences in thickness of the dry layer (areas with a groundwater table at 2 to 3 m depth predominate), with fertile assemblages of pastures — a megatherm and humid landform.

(3) Type of *uroczysko* built of loamy hillocks and wavy plains with 3 to 10 m differences in relative altitudes, with a predominance of brown soils (a high participation of class III), but with high-class podsolized soils also occurring where the groundwater lies at various depths, but a shallow water table distinctly predominates associated with numerous patches of surface water; generally seen is a more fertile subassemblage of weeds of corn crops and fertile pasture assemblages with darnel and dogs-tail grass.

Variety of landscape of glacio-fluvial landforms

(4) Type of *uroczysko* of sandy-gravelly hillocks (kames and eskers) with altitude differences of 10 to 35 m, with brown soils of classes V and VI and an always low groundwater table; weeds of corn crops predominate; as to humidity this type is more dry and less fertile (growth of knawel).

(5) Type of *uroczysko* of sandy-gravelly hillocks (kames) with altitude differences of 5 to 17 m, with brown soils of classes V and VI where a groundwater table deeper than 4 m predominates, springs yield but little water; very like in the preceding type, a less abundant subassemblage of corn crop weeds predominates.

(6) Type of *uroczysko* of sandy slopes (kame terraces), altitude differences are from 3 to 10 m, brown soils of classes V and VI predominate while commonly at lower positions black earths of classes IV and V occur; a considerable proportion have parts with shallow (1 to 2 m) groundwater, while in higher parts tilled but low fertility fields occur, lower parts contain pasture associations — a more humid landform.

Variety of landscape of glaciolimnic landforms

(7) Type of *uroczysko* of wavy clayey plains (accumulation plains of Pleistocene lakes) with altitude differences of 4 to 10 m and a predominance of brown soils of classes III and IV; podsolized soils of classes IVa and IVb occur at times in slightly higher parts; of common occurrence are black earths of class IVa, and predominant are areas with groundwater at 1 to 2 m depth; the thickness of the dry layer is rarely more than 4 m; fertile pasture assemblages or a more fertile subgroup of an assemblage of corn crop weeds occur.

Variety of landscape of meltwater kettles and other glacigenic depressions

(8) Type of *uroczysko* of flat bottomed peat-filled basins, with swampy, peaty and boggy soils, of which the more fertile occur in larger depressions with water run-off, while the less fertile are found rather in the small-sized depressions; in this type *uroczysko* conforms to swampy lands (most of them permanent swamps). In the range where small stagnant water basins occur in great quantities, i.e. in assemblages of former peat bogs or relict fragments of overgrown lakes, one distinctly observes the prevalence of assemblages of humid meadows and pastures, but stands of alder-ash and alder swamps are also met.

(9) Type of *uroczysko* of flat bottomed sand-filled basins, with a predominance of brown soils mostly of classes V and VI and with black earths of class V; groundwater table usually low, although hydroisobathic lines always show differences in this depth compared with neighbouring areas; this type embraces poorly fertile pastures and tilled fields, or subcontinental high-stem mixed forests.

(10) Type of *uroczysko* of flat bottomed clayey depressions, with a predominance of soils of classes IV and III (brown and black earth, more rarely podzols), predominance of shallow ground water; of common occurrence are water basins; exploitation by fertile pastures and tilled fields.

(11) Water courses.

EXPLANATION OF THE SYMBOLS SHOWN ON THE LANDSCAPE MAP OF THE OPATÓWKA DRAINAGE BASIN ON SANDOMIERZ PLATEAU

(after R. Czarnecki)

The legend shows only types of *uroczyska*. Within their range the author distinguishes types of *sub-uroczyska* and types of facies — indicating symbols on his map which are correlated to each of these units. This is why some types of *uroczyska* are represented by more than one symbol. The full legned referring to the landscape map of the Opatówka drainage basin has been published in 1969 in Przegląd Geograficzny (vol. 41) under the heading "Z badań krajobrazu fizyczno-geograficznego w dorzeczu Opatówki" (Comment on physico-geographical research in the Opatówka drainage basin) by R. Czarnecki [4], and in J. Kondracki's textbook "Podstawy regionalizacji fizyczno-geograficznej" (Principies of physico-geographical regionalization) [15].

I. *Type of environment of a flat loess plateau*

(a) type of *uroczysko* of a loess plain where the barely eroded brown and black-earth soils, some slightly and others strongly degraded, have been ploughed in.

II. *Type of environment of dry valleys and slopes of a main valley, moulded in the loess cover*

(b) type of *uroczysko* of dry flat-bottomed Pleistocene valley, often asymmetrical in shape. This type shows: cold slopes gently (5–11°) inclined, built of loess with slightly eroded brown soils; warm slopes, more steeply (11–20°) inclined in which the loess is underlain by glacial deposits, where non-decalcified and mostly strongly eroded soils predominate, and a valley floor built of coarse-grained Pleistocene loess deposits, containing brown soils and gullies of incidental runnels; here the entire type is mantled by ploughland.

(c) type of *uroczysko* of bowl-shaped valleys from the Pleistocene, symmetrical in shape and formed by denudation. They show: loess slopes varying in inclination, indicating the effect of a variety of erosional intensity and containing a diversity of soils, and a bowl-shaped bottom built of Pleistocene loesses on which brown or black-earth soils have been silted up and where gullies of incidental runnels are ploughed over; here in the valleys dissected by ravines there is no floor cover of Pleistocene deposits.

(d) type of *uroczysko* with slope hollows formed by denudation and developed during the passage of the Pleistocene to the Holocene. These hollows are fully ploughed over and show: a concave fairly steep-sided and mostly eroded loess floor with brown soils, and loess slopes where brown soils decalcified to a considerable depth predominate.

(e) type of *uroczysko* of flat-bottomed Holocene ravines eroded in the loess. They show: steep slopes covered by xerothermic grass layers and shrubby assemblages containing *Corylus avellana* and *Cerasus fruticosa* (these plants grow in the soils of the initially undeveloped profile) and a flat muddy floor which has been accumulated by incidental surface flow and which is covered by a wet pasture land.

(f) type of *uroczysko* of Holocene V-shaped ravines, eroded in the loess with the co-action of suffosion and still being formed, which show: steep slopes and a rough-walled steep and narrow bottom which is unstable and subject to changes. This bottom is grown over with a shrubby assemblage containing *Corylus avellana, Cerasus fruticosa, Berberis vulgaris, Rosa* sp., growing in soils of the original, undeveloped profile.

(g) type of *uroczysko* of bowl-shaped ravines formed in loses with the co-action of man's agricultural economy and fully ploughed over. They show: fairly steep slopes with strongly eroded soils, and a concave, steep floor with a Pleistocene loess deposit and with ploughed over gullies of incidental runnels.

(h) type of *uroczysko* of ploughed-over flat-bottomed ravines showing: fairly gently inclined (some 20°) loess slopes with strongly eroded soils and a loess floor with swampy ground.

(i) type of *uroczysko* of road incisions, man-made and in current use, showing vertical and practically bare loess walls and a flat inclined floor cut into the loess, lacking natural vegetation and strongly eroded.

III. *Type of environment of overflood terrace levels in fluvial valley*

(k) type of *uroczysko* of loess levels of 5 to 7.5 m relative height, built of a thick bed of carbonate loess underlain by fluvial sands, with the groundwater table 5 to 9 m deep; showing a level and slightly slanting surface with ploughed-in black earth and with brown soils lying on Pleistocene loess, and steep but low slopes with brown soils overlying Pleistocene deposits.

IV. *Type of environment of flat fluvial valley floor*

(l) type of *uroczysko* of alluvial cones with stratified Pleistocene loesses deposited on grey muddy alluvia, where ground-water occurs at 2 to 7.5 m depth; containing silty muds, non-decalcified, which either are used as arable land or are covered with reed meadows.

(m) type of *uroczysko* of natural river banks, some 1 m high, built of stratified yellow alluvia, with silty, non-decalcified muds, containing gley spots in the lower parts of the profile and covered by reed meadows or, less often, by ploughed fields.

(n) type of *uroczysko* of dykes and artificial dams in the river channel, some 1 m high, built of non-decalcified muddy alluvia and containing soils of an undeveloped profile underneath reed meadows which are either grassy or grassy-sedgy.

(o) type of *uroczysko* of a dry and flat valley floor, built of sheets of deluvial or alluvial material of yellowish-grey colour and underlain by grey muddy alluvia containing organic remains; the groundwater table lied at 50 to 150 cm depth, and silty, non-decalcified muds occur here which are either used as arable land or are covered with reed meadows.

(p) type of *uroczysko* of water-logged valley depressions built of grey alluvial and poorly permeable muds, intercalated with clay beds and organic remains, where on artificially drained permanent or seasonal marshes boggy-miry soils occur, underlying reed meadows.

Supplementary symbols:

(1) characteristic depths of the first exploited water-bearing horizon,
(2) drainage ditches and their embankments,
(3) larger forested areas.

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HYDROGEOGRAPHICAL EXAMINATIONS OF SMALL DRAINAGE BASINS IN POLAND

TADEUSZ WILGAT

Hydrological research in Poland looks back upon a long tradition and has since expanded along a variety of paths, in connection with the evolution of engineering, geophysics, geology, biology and geography. Until recent times, geographers used to pay little attention to hydrographical problems. Certainly they did publish a few valuable papers but, in spite of this, hydrography was a distinctly neglected branch of geography. Undoubtedly, this was harmful in its effect upon the evolution of geography, and also harmful to the national economy. For two reasons, geographical research into hydrographical conditions became of ever growing importance to the national economy. Reason one is that from year to year man's interference with natural hydrographical conditions increasingly leads to definite and lasting changes in the geographical environment. Secondly, the urgent need to make the most rational use of all available water resources requires water consumption to be controlled not only through hydraulic structures but, likewise, by a geographical environment suitably adapted. Studies of the interrelation between water conditions and the environment as a whole have developed into one of the most important tasks of modern hydrology. And these sort of studies are *par excellence* of a geographical character, though they require co-operation of specialists from a variety of different disciplines.

Examinations of experimental drainage basins are commonly acknowledged as an excellent method for determining interrelations of this kind. In recent years, both the scope and methods of observation made in such basins have been the object of detailed discussions, and a specific programme has been laid down for this sort of research work [16]. In Poland, the study of experimental drainage basins has little to boast of. While more than a dozen such basins exist in Poland, several different institutions [1] carry on their observations without co-ordinated programmes, and their equipment leaves much to be desired. The participation of geographers in this work is negligible; it is only at the Institute of Geography of the Polish Academy of Sciences Station at Szymbark in the Carpathians [1, 13] that they actively take part in observations of water circulation. Recently this type of research has also been assigned to the Limnological Station at Borucino situated in the Pomeranian Lake District, and attached to the Institute of Geography at Gdańsk University.

[1] The State Hydro-Meteorological Institute, Research Institute of the Forest Service, Warsaw Central Agricultural College, and Institute of Drainage and Land Improvement.

The extent to which examinations of experimental drainage basins will prove useful depends largely whether the given basin may be considered as representative, because only then the results obtained can be extrapolated to similar areas. This is one of the shortcomings of this method of research. Further, in view of the necessity to equip the experimental basins with many reliable control instruments and also because of the considerable time required to execute a control programme of this kind, any operation in greater density of such basins to make the research work correspond to Poland's physiographic diversity is out of the question. Yet, the rapid economic growth of the country demands a steady improvement in our understanding of the entirety of Poland's water resources and of the conditions under which they can be made available. Hence the water economy is facing problems which are increasingly difficult to solve. From a socio-economic point of view the most rational way of using the available resources without deterioration of the geographical environment can only be accomplished through a comprehensive knowledge of the entire hydrology of Poland. However, every single drainage basin has an individuality of its own; the results gained in different areas may prove useful, but they can in no way take the place of separate monographic investigations.

In Poland, geographers have prepared a number of monographs on small basins which cannot be considered as experimental drainage basins. They started out by studying the methodology of how detailed hydrographic surveys should be made; and hydrographic field mapping, the method ultimately chosen, was initiated in the 1950s. The experience gained by the staffs of all the Polish geographical centres from this kind of work resulted in a group of scientists from several universities and from the Institute of Geography of the Polish Academy of Sciences drawing up official instructions which specify in detail the purpose and the extent of this sort of research, and the method to be applied [12].

The significance of this method lies principally in the fact, that this sort of mapping gives a full insight into all hydrographic features and characteristics of the area examined and, in addition, supplies much information about the agencies responsible for the local conditions observed. These examinations are comprehensive in character; they link as a common feature surface water and underground water, treating them as one of the elements of the geographical environment. Much attention is also being paid to the way the water is used, and to the changes in hydrological conditions caused by man's economy. This approach to research work makes it easier to elucidate the circulation of water and to arrive at rational conclusions with regard to proposed transformations of the hydrosphere. A number of papers have been published on the importance of this sort of hydrographic mapping [14, 28, 30].

Since the time when the method of detailed hydrographical mapping was introduced, some publications have appeared based on this method but bearing a widely divergent character.

— Following the initial instruction that the Hydrographical Map of Poland should be compiled with a 1 : 50,000 scale, a number of trial sheets including legends were prepared. In these papers the map is the principal part, while the legend supplements it by containing the description and explanation of the hydrographical features illustrated on the map.

— A second type of scientific paper contains the hydrographical characteristics of particular geographical districts. These represent a valuable contribution to the increase of our knowledge of given regions as to aspects hitherto not sufficiently comprehended, yet of high importance from an economic point of view.

— A third type is papers discussing the territory of towns, or industrial or agricultural regions. As a rule the area under investigation is not identical with physical-geographical units, and the character of research is usually directed by definite practical purposes.

— Even more specific trends are illustrated in some papers in which the authors concentrate their attention upon special problems encountered during detailed mapping. To these problems belong investigations into underground water, surface and subterranean watersheds, undrained areas, etc.

— Finally, a separate type is represented by papers dealing with fluvial drainage basins. From all the information mentioned above, published studies of these problems are less numerous. But papers dealing with this topic constitute a wide and important group and include much research material so far unpublished. Basins of relatively small size are the object of examination as shown by the method of research applied. In most cases these drainage basins are of the order of 50–150 sq. km, rarely exceeding several hundred square kilometres. The reason why most of the papers on drainage basins have so far not been published is that they are troublesome to print. Moreover, many of them originated as degree papers and do not fully come up to modern standards of scientific publications. Monographs dealing with small drainage basins were prepared for the first time in 1954/55 by the Cracow and Lublin centres [11]. In the following years this topic was also taken up by other university centres and here the first publications appeared in 1958 [15].

The scope of the basic material of hydrogeographical monographs on small drainage basins can be divided into two groups. Group one embraces papers dealing with "closed" basins, terminated by a water gauge installed by the State Hydrological Service [4, 5, 18, 24, 25]. These papers are based both on the results obtained from field examinations and on data supplied by the State Hydro-Meteorological Institute. The application of detailed field mapping as a basic method distinguishes these geographical examinations from typical hydrological studies. Balance calculations in hydrological monographs on drainage basins are the principal and, often the sole object of research. In contrast, this type of geographical paper supplies a detailed characteristic of local conditions under which water circulation is taking place, and aims at a genetic elucidation of the existing hydrological phenomena.

The second group of hydrogeological studies on fluvial basins consists of papers which refer to drainage basins without an official water gauge station at their final outflow. There is no difference in the way field examinations are made, but the lack of basic hydrometrical data makes it impossible to compile balance calculations. Whenever possible, the authors of such papers used to mount their own observation stations in the field, and apart from a watergauge in the end section of the network they usually added means of control for measuring ground-water conditions. Often they supplemented this work by periodical measurements of flow in open streams and of the yield of springs. From these sorts of measurements and observations, maintained for a year or two, comparisons can be made with drainage basins of a similar character equipped with recording water gauges. In these kinds of studies, balance calculations are rather approximations, and here only estimation can be made of flow characteristics. However, there are cases where a watergauge cannot be installed in the field, for instance where no settlements lie near the river or, at present at least, as long as mounting tele-limnigraphs is out of the question. Under these conditions the indirect way of estimating flow values only is possible.

Hydrogeographical monographs of small drainage basins, even when lacking a constituent as important as a water balance, may represent contributions valuable both to science and to practical use. Their value is that they make full use of all available source data in order to obtain the fullest possible picture of the hydrography of drainage basins and of the use made of the water. The authors of such monographs collect all meteorological and hydrogeological data available, they gather information from administrative authorities as well as from institutions and enterprises interested in the water economy, and further material on land drainage, hydraulical structures, fishery centres, water consumption, etc. They take advantage of data reporting on the chemical properties of the water and on water pollution. They obtain the most valuable information from their own field surveys. Thus, while preparing his relevant maps, the student can appraise conditions of water run-off and ground infiltration. He can gain insight into the occurrence and the nature of underground waters, into the distribution and the type of surface waters, into the degree to which these are put to use, and into all changes in hydrographical conditions brought about by man's economy. As a result, these field studies make it possible to recognize spatial diversities in the hydrology within the limits of the drainage basin, and to distinguish regions differing in hydrological features. However, the principal drawback in hydrogeographical studies of drainage basins undertaken in Poland is the regrettable lack of modern control instruments, and the difficulties encountered in profiting from modern research techniques such as repeated air photographs, colour air photography, etc.

Hydrogeographical examinations of drainage basins are commonly executed by nearly all geographical centres of the Polish universities — at most of them through degree theses [6, 11, 23]. This procedure combines scientific research with schooling, because examinations of this type are probably the most effective method of making the student aware of the comprehensive geographical perception of water phenomena.

This sort of research is being carried out intensely by the Cracow centre, for the most part as the topic of degree papers on hydrogeography assigned by the Department of Physical Geography at the Jagellonian University [6]. Up to 1970, 96 papers of this type have been compiled, apart from several monographs by candidates for the doctor's degree. Also the Department of Physical Geography at the Cracow College of Pedagogy issued 20 papers for the degree of *magister* and one for the doctor's degree, with fluvial basins as the topic. Finally, the study of small drainage basins has been incorporated into the research programme of the Department of Physical Geography of the Institute of Geography, Polish Academy of Sciences in Cracow. Mainly the research work sponsored by the Cracow centre deals with the Carpathian drainage basins and with basins situated in the western part of the Lesser Poland Plateau (see map).

In the Department of Physical Geography at Warsaw University 30 degree papers, one of them for the doctor's degree, have been compiled on fluvial drainage basins. Some of these papers were based on hydrographical surveys, others by mapping representative regions. Drainage basins terminated (closed) by a watergauge of the Hydrological Service were selected for this purpose, and for each of the papers the water balance had to be calculated. The drainage basins examined are widely distributed in one meridional belt, comprising basins situated in the Carpathians, in the Lesser Poland Plateau and in Masovia, and extending as far as the Mazurian Lake District. The intention of the Warsaw centre is to discern differences in water circulation as they occur in different geographical latitudes of Poland.

Fig. 1. Location of the drainage basins under study

The drainage basins studied by geographical institutions of: 1 — Gdańsk, 2 — Cracow (Department of Hydrography of the Jagellonian University; Department of Physical Geography of the College of Pedagogy; Department of Physical Geography of the Institute of Geography, Polish Academy of Sciences), 3 — Lublin, 4 — Łódź, 5 — Poznań, 6 — Toruń (Department of Hydrography, Nicholas Copernicus University; Department of Physiography of Poland of the Institute of Geography, Polish Academy of Sciences), 7 — Warsaw, 8 — Various university centres

The Toruń geographical centre can also boast of a considerable number of papers of this type, initiated by the Department of Hydrography of the M. Copernicus University. 45 papers deal with fluvial drainage basins. Also, in several other papers lakes or the Vistula valley were the topic, and the authors had to make detailed hydrographical surveys of local drainage basins. The research work of the Toruń centre is concentrated on the area of the lower Vistula, and one of the principal purposes of the studies is to elucidate water circulation in the area covered by the last glaciation.

In the Gdańsk centre, hydrogeographical studies were conducted by the Department of Physical Geography at the College of Pedagogy, which was recently incorporated into the new Gdańsk University [23]. Of the 23 drainage basins investigated, part referred to areas near the coast. One of the problems to which much attention is given by this centre is to determine the extent of the zone in which the sea affects continental hydrographical conditions.

The Department of Meteorology, Climatology and Hydrography at Łódź University has on record so far 20 monographs on drainage basins. These investigations, made in the basins of the rivers Pilica, Bzura and upper Warta, have added to our knowledge of water conditions in the boundary zone between the European upland belt and its lowland.

The Institute of Geography at the A. Mickiewicz University at Poznań can look back on a protracted tradition in hydrogeographic studies, but so far little attention has been given to drainage basins. But recently the Department of Hydrography has initiated a comprehensive investigation, by a group of students, of the drainage basin of the river Wrześnica, a tributary of the Warta.

Research work done at Lublin University is concentrated on the Vistula–Bug interfluve. 36 papers compiled by the Department of Hydrography at the M. Curie-Skłodowska University are dealing with drainage basins situated in three landscape belts: the Sandomierz Basin, the Lublin Plateau, and the Middle European Lowland. Nearing completion are studies of parts of the Wieprz drainage basin also undertaken outside of the degree programmes. The final aim is to compile from detailed field surveys a monograph of the whole Wieprz drainage basin which covers an area of more than 10,000 sq. km.

Hydrogeographical investigations of drainage basins have undoubtedly supplied much new information with regard to hydrological conditions in different regions of Poland. It must be admitted that these investigations differ in value (the result of different approaches of individual authors, together with the steadily advancing standard set for research methods) so that today many of the papers compiled in former periods cannot be fully considered up to standard requirements. However, since official directives have been issued for a uniform method of surveying drainage basins and approved by the majority of geographers dealing with hydrographic problems, the possibility now exists of performing comparative studies. The first attempts at preparing comparative tables have already been made [31], although they do not refer to drainage basins but to selected land sections. The material thus collected can serve as a basis for comparative-synthetic studies for many regions of Poland. So far, only the western part of Poland lacks papers based on source data.

Monographs on drainage basins present geographical material not only useful for syntheses. They may also prove valuable in making conclusive decisions on the matter of using and transforming the geographical environment in keeping with the protection of its productive resources and its landscape values.

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STUDIES ON THE HEAT BALANCE AND ON EVAPORATION

Janusz Paszynski

The exchange of energy and the circulation of water are the two most important physical processes forming the geographical environment.

Therefore, the structure of both: heat balance and moisture balance on the earth-atmosphere interface may be considered as the basic characteristics of existing climatical and hydrographical conditions in a given place. The physical laws of conservation of energy and matter allow us to write down the equations of both balances in the following form:

$$S = R+L+A+E+\Delta q \quad (1)$$

$$P = D+E'+\Delta w \quad (2)$$

where: S is incoming solar radiation (global radiation),
R is reflected solar radiation,
L is long-wave net radiation,
A is the flux of sensible heat to or from the atmosphere by convection,
$E = \lambda E'$ is the flux of latent heat by vaporation,
λ being the latent heat of vaporization,
Δq is the change in heat storage below the interface,
P is precipitation,
D is run-off,
E' is evaporation,
Δw is the change in moisture storage below the interface.

The terms of the heat balance equation are expressed in the same units as energy, i.e., in $cal \cdot cm^{-2}$, while the terms of the moisture balance equation are usually expressed in mm of the liquid water layer.

As one can see, evaporation is the term connecting both equations. In reality, the term E in equation (1) and the term E' in equation (2) determine evapotranspiration which consists of evaporation from water surfaces, the evaporation of moisture from soil, and transpiration from the plant cover. As can be seen from equations (1, 2), the value of evaporation can be determined by solving either the heat balance equation or the moisture balance equation. This is because evaporation depends on two factors: the first one is the amount of water, liquid or solid, which can be converted into the vapour state, and the other factor is the amount of energy required for changing the physical state of water and for the transfer of water vapour from the evaporating surface. The first factor mentioned, i.e., the amount of water resources, is limited mainly by the precipitation rate, while the second factor is determined generally by the quantity of incoming solar radiation. Therefore, it seems to be important from both scientific and practical points of view to compare the amount of energy used for evaporation with the total quantity of energy obtained by the earth's surface. The ratio between these two values is an important climatological index which can be considered as a useful criterion in climatological classification [17].

This ratio is also of great practical importance especially when considering the water economy and the anticipated modifications of hydrological conditions as a consequence of human activity. It is especially important in the case of areas where the water resources are insufficient, this also includes a great part of Poland. For these reasons some detailed research on evaporation in connection with the heat balance have also been undertaken in Poland.

Studies of this type started several years ago. They were undertaken by K. Matul for practical purposes in respect of agricultural ammeliorations [9, 10, 11]. Matul introduced the concept of the biological-energy coefficient a_e, which determines the ratio between the latent heat of evaporation and the net radiation where $Q = S-(R+L)$ is net radiation (radiation balance). Studies of

$$a_e = E/Q \tag{3}$$

more general character, but comprised of the same problem, have been undertaken under the author's leadership in the Department of Climatology at the Institute of Geography of the Polish Academy of Sciences. The principal aim of these studies was an atlas of the heat balance of Poland [16, 18]. The atlas consists of maps of monthly and annual averages of the components of the heat balance, for the period 1951–1960. Using the data collected, it was possible to determine the role of evaporation in the heat balance of Poland, and to analyse regional differences due to climatic conditions. With this end in view, the ratio between amounts of heat used for evaporation (E) and global radiation (S) being the main term on the incoming side in the heat balance, has been examined as well as the ratio between E and net radiation (Q).

The average monthly and annual totals of the components of the heat balance were computed for the period 1951–1960, for about 35 meteorological stations in Poland.

For estimating mean values of E, the results of the studies of J. Jaworski [1] were taken into account, concerning the geographical distribution of the actual evapotranspiration in Poland. This study was founded on the water balance equation, and the mean yearly evaporation was computed as the difference between mean yearly precipitation and mean yearly run-off from individual basins ($E' = P-D$). As the final result of this study, a map of the actual evapotranspiration in Poland was made. Unfortunatly, such a method permits computation of E' totals for yearly periods only. When considering shorter periods, e.g. months or seasons, it is necessary to take into account changes in water storage, i.e. the term Δw in equation (2). The values of Δw are usually very small over longer periods, and may be therefore neglected.

For determining the mean monthly values of E', the annual totals of actual evapotranspiration presented on the above mentioned map, had to be divided into individual months. This division was made using the method of A. R. Konstantinov [4], based on meteorological data concerning air temperature and air humidity only.

Taking into account mean values of air temperature and air humidity for the period 1951–1960, the average monthly values of E' have been computed for each station mentioned. The results were converted into relative figures, determining the share of each month in the annual totals of E', which have been found for each of the meteorological stations considered by interpolation on the map.

Taking the constant coefficient $\lambda = 597$ cal·cm^{-1}, these relative figures were converted into absolute mean monthly values of E from the equation (1).

The mean values of global radiation (S) and of net radiation (Q) were also obtained by indirect ways. For computing mean monthly values of S the results of measurements of sunshine duration were used, according to Black's empirical formula:

$$S = S_0(a + b \cdot N), \tag{4}$$

where S_0 is the value of solar radiation at the top of the atmosphere,
N is the relative duration of sunshine, i.e., the ratio between actual and possible duration of sunshine,
a and b are numerical non dimensional coefficients.

Monthly totals of S_0 depending on geographical latitude (φ) and declination of sun (δ) only, were computed using published data [8]. The values of relative duration of sunshine were determined for each meteorological station considered, with the amount of hours between sunrise and sunset as the possible duration. The numerical values of coefficients a and b have been recently found by J. Podogrocki from actinometric data in Poland for the same period 1951–1960 [19].

Using the computed values of S it was possible to estimate the totals of short-wave net radiation

$$Q_s = S - R = S(1 - \alpha) \tag{5}$$

taking as α mean monthly values of the reflection coefficient for each of the stations. The values of α have been read out from the albedo maps of Poland, prepared by T. Szczęsna [6]. Those maps were made using values of α for various types of active surface, taking into account the seasonal changes involved due to the development of vegetation and the show-cover. For computing mean weighted values of albedo for administrative units, statistics on land use were taken into account.

The values of Q_s found in this manner were then used for computing mean monthly values of net radiation

$$Q = Q_s + Q_L = S - (R + L) \tag{6}$$

The long-wave component Q_L was determined as a function of air temperature, air humidity, and cloudiness, applying Angström's empirical formula slightly modified by I. L. Monteith [14]. The mean values of Q_L computed by this method for a number of meteorological stations in Poland have been published by M. W. Kraujalis [7].

The geographical distribution of the mean yearly values of the heat balance components (E, S, and Q) in Poland are then presented on the maps attached (Fig. 1, 2, 3). Isolines were drawn between 2 Kcal·cm^{-2}. Mountainous areas elevated above 500 m have been excluded from the cartographical representation because of rather complicated climatic conditions and strongly marked local differences in the structure of the heat balance in these regions.

It is clearly seen from the map that the amounts of heat used for evapotranspiration increase rather regularly from north to south. The lowest annual totals of E, even below 20 Kcal·cm^{-2} appear on the eastern part of Baltic coast, in the Gdańsk region. The highest values of E, exceeding 30 Kcal·cm^{-2} occur in the south-western part of the country, in Silesia.

The geographical distribution of the radiative components of heat balance over Poland's territory is more complicated, though a general trend of increasing values from north to south can also be observed, at least in the case of component S. The annual values of S in Poland are included in a wide range from about 85 $Kcal \cdot cm^{-2}$ to about 95 $Kcal \cdot cm^{-2}$. An exception is the Upper Silesian Industrial District, where the incoming solar radiation is strongly reduced due to pronounced air pollution.

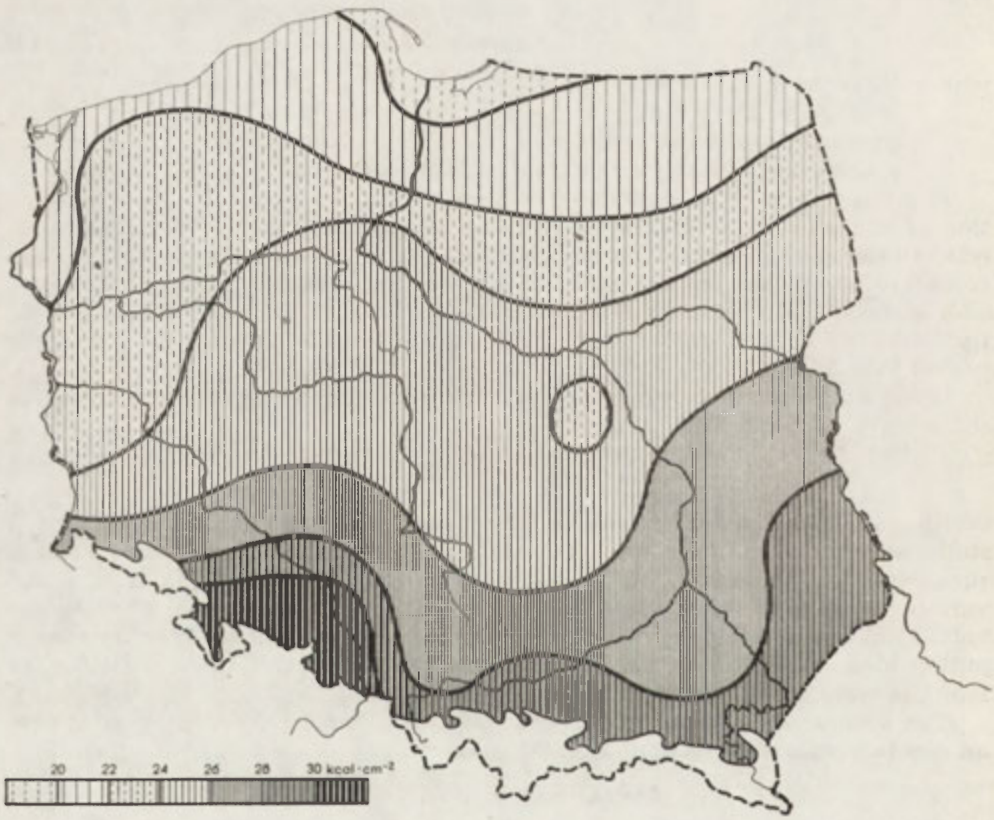


Fig. 1. Geographical distribution of mean annual values of the latent heat flux of evaporation = E ($Kcal \cdot cm^{-2}$).

As to the net radiation, the highest values of Q appear in the southern part of the country in Podkarpacie, in the central part of Greater Poland and in Mazovia, as well as in the northern confines in the Lake District and on the Baltic Coast. The Upper Silesian Industrial District also forms an island of reduced values of Q falling below 33 $Kcal \cdot cm^{-2}$, a similar island of reduced values being observed in the Warsaw metropolitain region.

As can be deduced from the maps described, the structure of the heat balance in Poland is unequally distributed over its territory. As characteristic examples, two diagrams representing the structure of the heat balance in two differently situated stations are shown here: Kołobrzeg — situated in the northern part of Poland on the Baltic Coast, and Opole — situated in the south-western part of the country in Silesia (Fig. 4, 5). A comparison of both diagrams indicates significant differences. The incoming side of the heat balance which consists mainly of net radiation does not substantially differ between both places considered, the values of Q being a little higher in the northern part of the country during summer months due to the different length of day in this season (the difference of latitude between both stations is about 4°). On the other hand one can observe important differences on the expenditure side of the heat balance. On the Baltic Coast energy is used for heating the atmosphere and for evapotranspiration, both terms being more or less equal ($A \approx E$), while in Silesia the share of latent heat used for evaporation in the

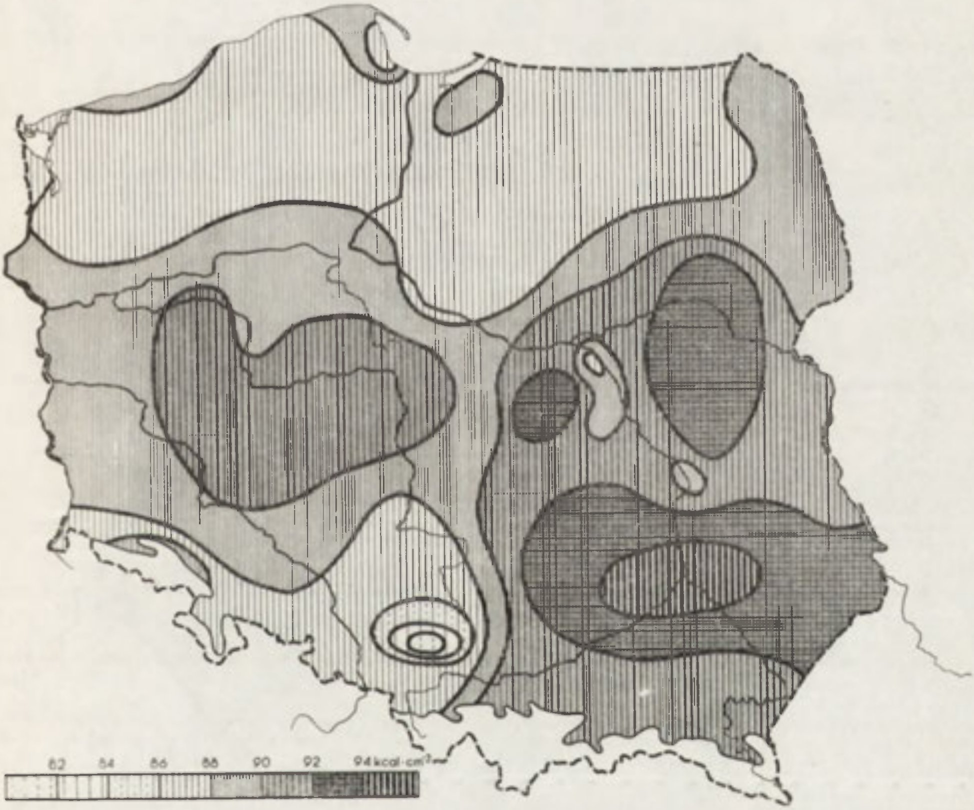


Fig. 2. Geographical distribution of mean annual values of the global solar radiation = S (Kcal·cm^{-2}).

expenditure side of the heat balance is much higher than the share of sensible heat transfered to the atmosphere by convection ($A \ll E$). In both cases the term Δq forms an insignificant part in the heat balance. It is worthy of note that net radiation during the winter season has more pronounced negative values in the interior part of the country than on the Coast.

It can be assumed that the ratio of energy used for evapotranspiration to the total amount of incoming energy, is not uniform in Poland. For more detailed analysis the ratio between latent heat and global radiation, i.e., E/S, as well as the ratio between latent heat and net radiation, i.e., E/Q, have been computed, and their geographical distribution has been shown on maps

(Fig. 6, 7, 8, 9), Calculations have been made for the annual period, as well as for the growing season from April to October.

Analyzing the maps mentioned, one can assume that in Poland evapotranspiration uses from below one fourth to above one third of incoming global radiation. The lowest values of the ratio E/S are observed on the Baltic Coast, the highest ones — in Upper Silesia, on the upper courses of Odra and Vistula rivers. The same ratio, but computed for the growing season, is somewhat higher being comprised of between 24 per cent in the northern part and 37 per cont in the southern part of Poland.

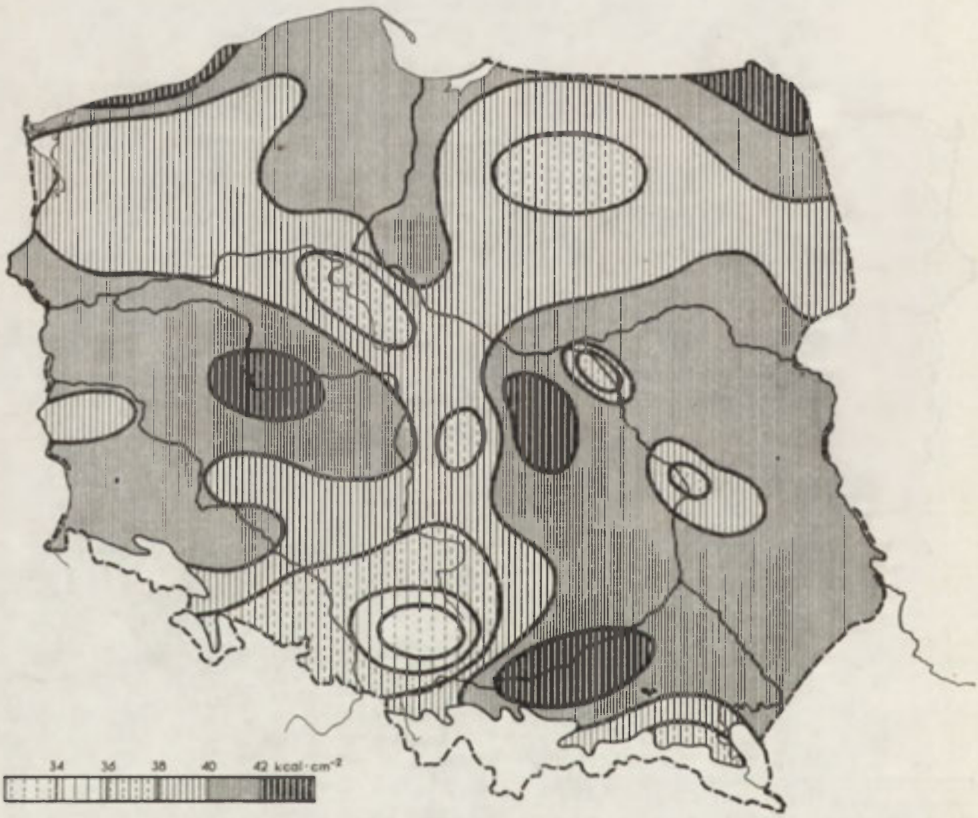


Fig. 3. Geographical distribution of mean annual values of the net radiation = $= Q$ (Kcal·cm^{-2}).

Let us now examine the ratio of heat used for evapotranspiration to net radiation, i.e., E/Q. This index changes in a wide range from below 50 per cent in the northern confines of the country, to above 80 per cent in the south–western area. The values of this index, calculated for the growing season, are somewhat lower being between 40 per cent in the north and 70 per cent in the southwest.

On all the four maps described, the lowest values appear in the northern confines of Poland mainly on the Baltic Coast, while the highest values apper in the south — western confine, in Upper Silesia and in areas bordering the Sudets mountains. The course of isolines on these maps is generally speaking latitudinal (west–east). It can be assumed from these considerations that the

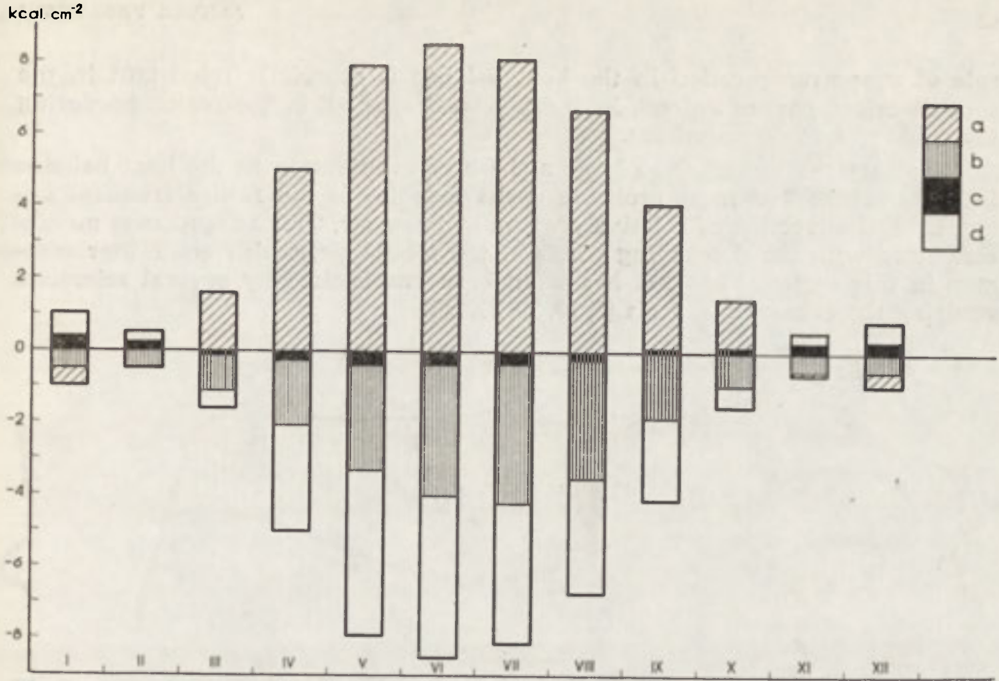


Fig. 4. Annual mean variation of the structure of heat balance at the earth-atmosphere interface in Kołobrzeg

a — net radiatson = Q, b — latent heat flux = E, c — changes of heat storage below the interface = Δq, d — sensible heat flux = A

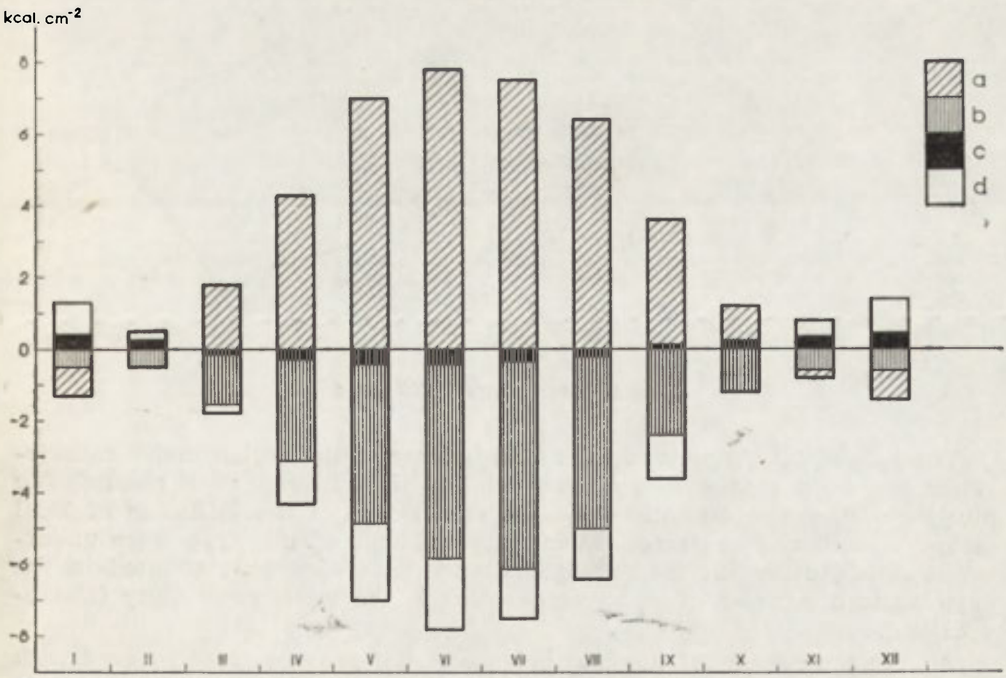


Fig. 5. Annual mean variation of the structure of heat balance at the earth-atmosphere interface in Opole

a — net radiation = Q, b — latent heat flux = E, c — changes of heat storage below the interface = Δq, d — sensible heat flux = A

role of evapotranspiration in the heat balance is especially important in the south-western part of Poland, in Silesia and first of all in the region bordering the chain of Sudets mountains.

What are the causes of so large a share of evaporation in the heat balance in these areas? The most probable decisive factor is the rather frequent occurrence of advection of relatively warm and dry air. This advection is mainly connected with the descending winds of the fohn type, which are rather common in this region. This fact has often been emphasised by several scientists studying the climate of Silesia [5, 13, 20, 21, 22].

Fig. 6. Mean annual E/S ratio

The role of falling winds in the heat balance of the region under consideration has been confirmed by some detailed field investigation results. The purpose of these investigation was the exploration of the influence of local factors on actual evapotranspiration. Investigations of this type were undertaken among others at the Research Station at Wojcieszów, situated in the north-eastern confines of Sudety mountains in the Kaczawskie Góry (Kaczawa Hills).

All the components of the heat balance of the active surface covered with short grass were measured continuously during selected periods. In this way, daily variations of the heat balance structure in different synoptic conditions were followed and analysed. The results of investigations carried out at Wojcieszów were published in [2, 3, 12, 15, 23].

As follows from the results obtained, the amount of heat used for evapotranspiration increases rapidly in the periods when descending winds occur in this region. The value of E can in such cases greatly exceed values of net radiation.

This phenomenon is clearly seen from the diagrams attached (Fig. 10, 11, 12). They represent examples of the structure of the heat balance for two consecutive days: 22nd and 23rd August 1965.

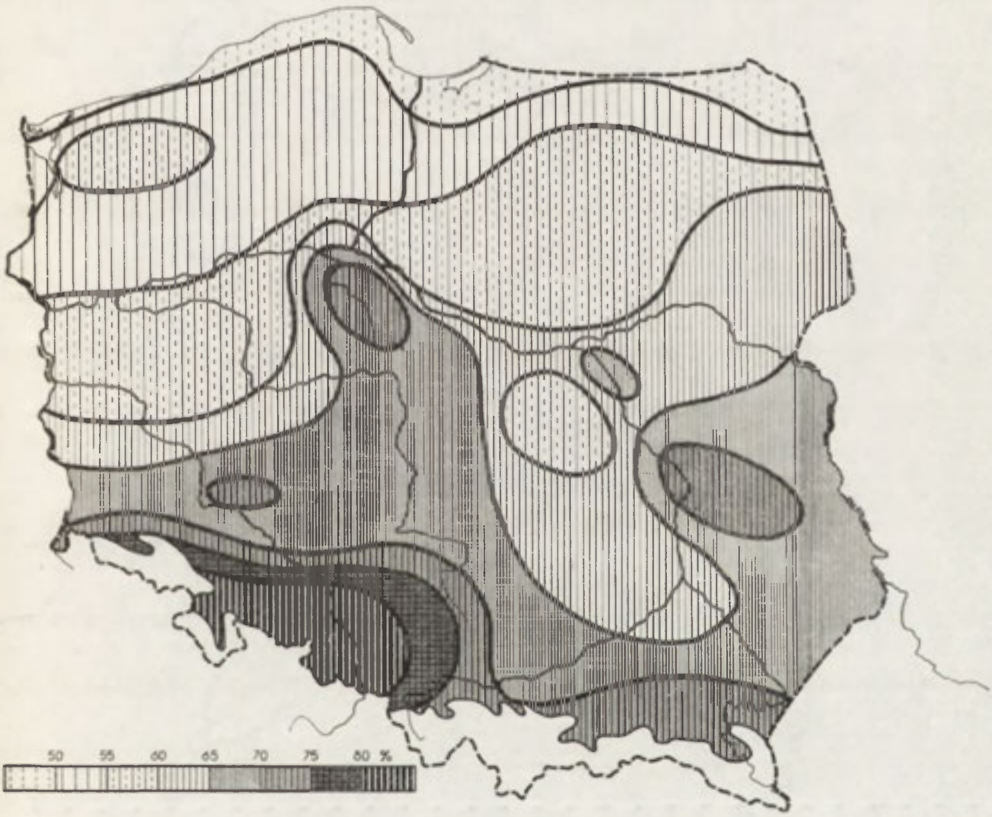


Fig. 7. Mean annual E/Q ratio

On August 22nd, the incoming side of the balance consisted uniquely of radiative heat flux — this is indicated by positive values of Q. The next day, however, the structure of the balance was altered due to advection of relatively warm and dry air by the wind descending from the adjacent Sudets mountains. As a consequence of advection, the turbulent flux of sensible heat was directed mostly from the atmosphere to the active surface, the term A being positive during this day. Therefore, the absolute value of E was much higher than Q.

On the other hand, the lack of cloud cover during the night involves rather strong outgoing radiation, which must be compensated by the turbulent flux of sensible heat from the air and by the conductive flux of heat from the soil, both terms A and Δq being positive. The value of component E is also positive during such nights, indicating condensation of water vapour instead of evaporation.

In our investigations several different methods were used for the determination of instantaneous values of the heat balance components.

Net radiation (Q) and both short-wave and long-wave components of the radiation balance (Q_s and Q_L) were directly measured by portable net radiometers specially designed for field studies, and screened either with poliethylene or with glass hemispheres.

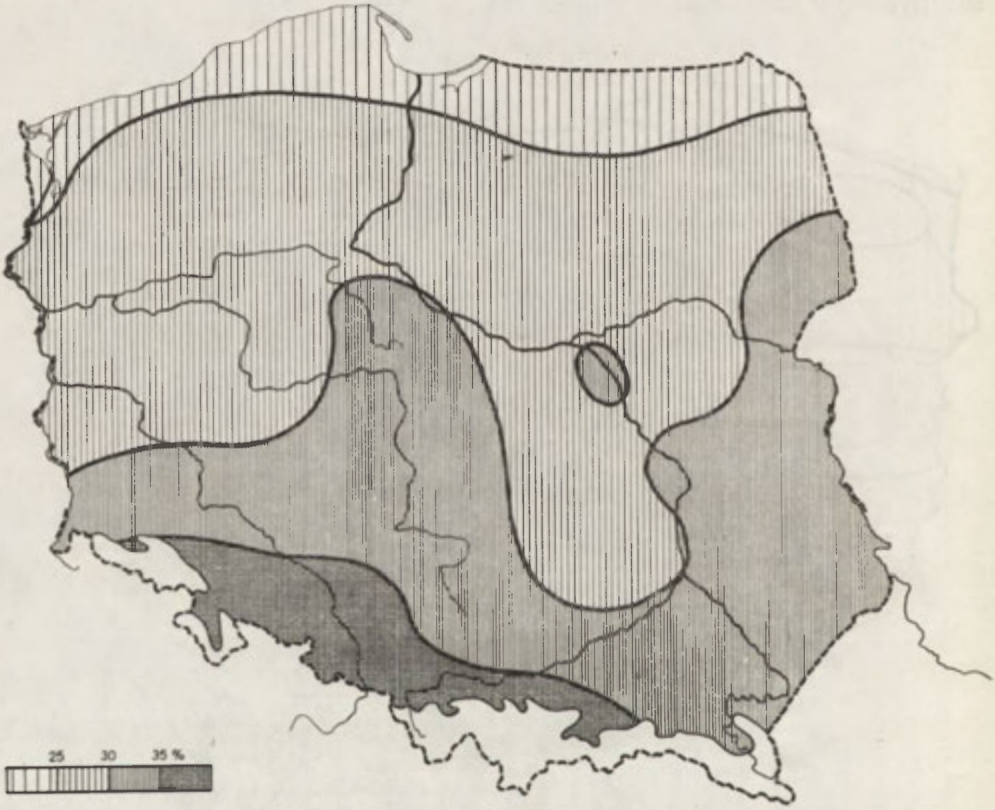


Fig. 8. Mean E/S ratio for the growing season

The heat flux to (from) the soil corresponding to the term Δq in the equation (1), was calculated from the soil heat capacity C_p and from the changes of soil temperature Δt, according to the formula:

$$\Delta q = \frac{1}{\tau} \int_0^{z'} C_p \cdot \Delta t \, dz \tag{7}$$

where τ is the period between two consecutive measurements of soil temperature, and z is the depth.

The temperature of soil was measured by electric resistance thermometers at several levels from the surface to a depth z' where no changes were observed in hourly time intervals τ.

The turbulent flux of sensible heat, i.e., the component A in equation (1) was determined from data concerning vertical differences of air temperature (Δt) and air humidity (Δe), both measured on two levels: 0.5 m and 2.0 m with electric psychrometers. Thus the method based on the Bowen ratio was used:

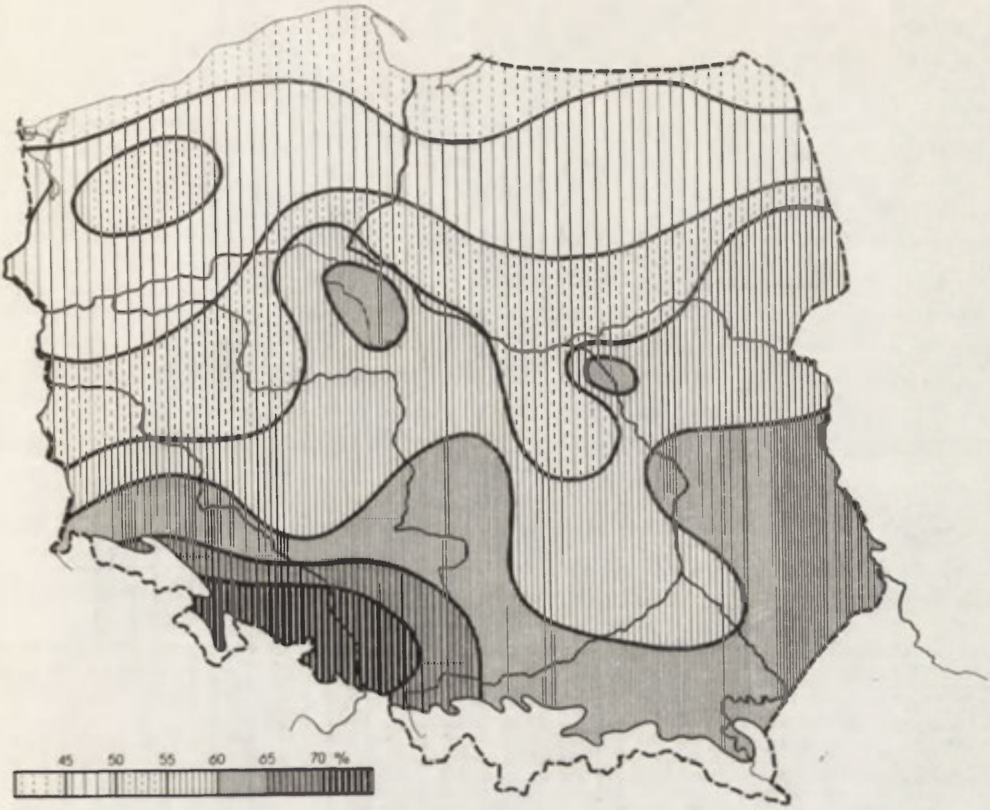


Fig. 9. Mean E/Q ratio for the growing season

$$A = -\frac{Q-\Delta q}{1+\frac{1}{\gamma}\frac{\Delta e}{\Delta t}} \tag{8}$$

where γ is a coefficient of proportionality depending on the atmospheric pressure. In the same manner, the value of component E was determined:

$$E = -\frac{Q-\Delta q}{1+\gamma\frac{\Delta t}{\Delta e}} \tag{9}$$

This method, however, is not always applicable. It does not give satisfactory results when the difference between Q and Δq is very small, or in the case when both fluxes A and E are close with regard to their absolute values but inversely directed. Another source of error often is insufficient accuracy attainable when measuring the vertical differences of air humidity, especially in the field experiments.

Therefore, the values of A were also determined independently by an aerodynamic method. In our investigations, the method described in [12] and based on the Monin–Obukhov's similarity hypotheses was applied. According to [24]

$$A = f(\Delta t,\ u,\ B,\ z_0) \tag{10}$$

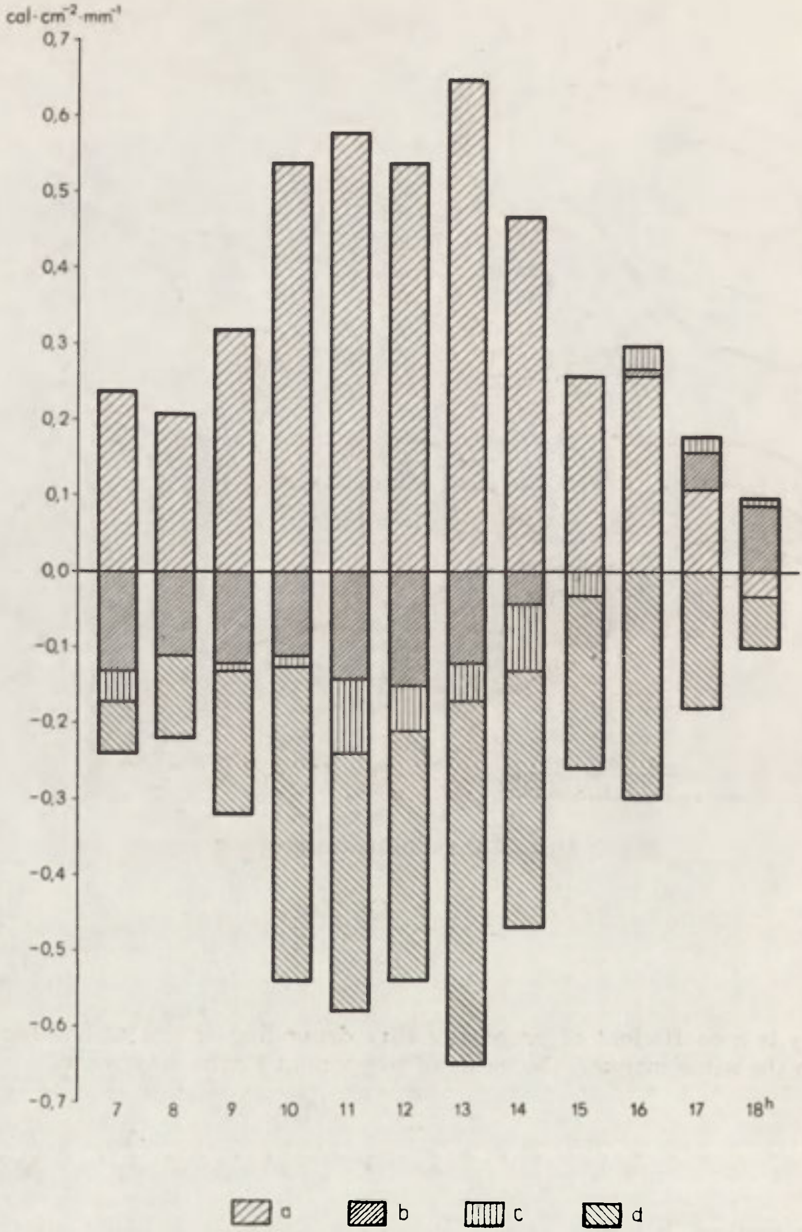


Fig. 10. The course of the components of heat balance at the earth-atmosphere interface in Wojcieszów during the day-time 22nd August 1965

a — net radiation = Q, *b* — turbulent flux of latent head = E, *c* — changes of heat storage below the interface = Δq, *d* — turbulent flux of sensible heat = A

where u is the wind velocity, B is the empirical Richardson number, and z_0 is the roughness parameter for the given active surface. The wind velocity u was measured by photoelectric anemometers at the level $z = 1\ m$ and the roughness parameter was assumed $z_0 = 5$ cm. For computations of A, special

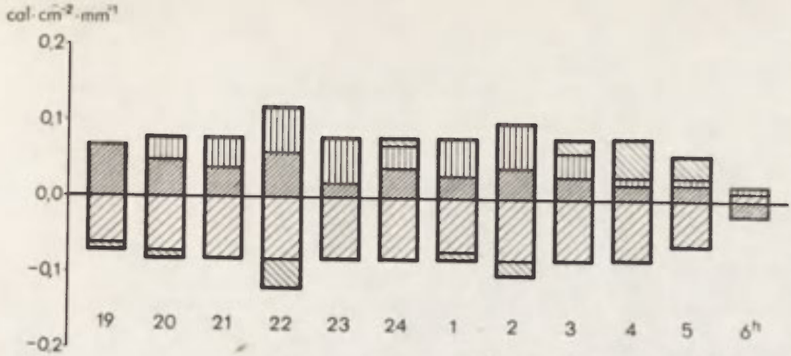


Fig. 11. The course of components of heat balance at the earth-atmosphere interface in Wojcieszów during the night-time 22nd/23rd August 1965

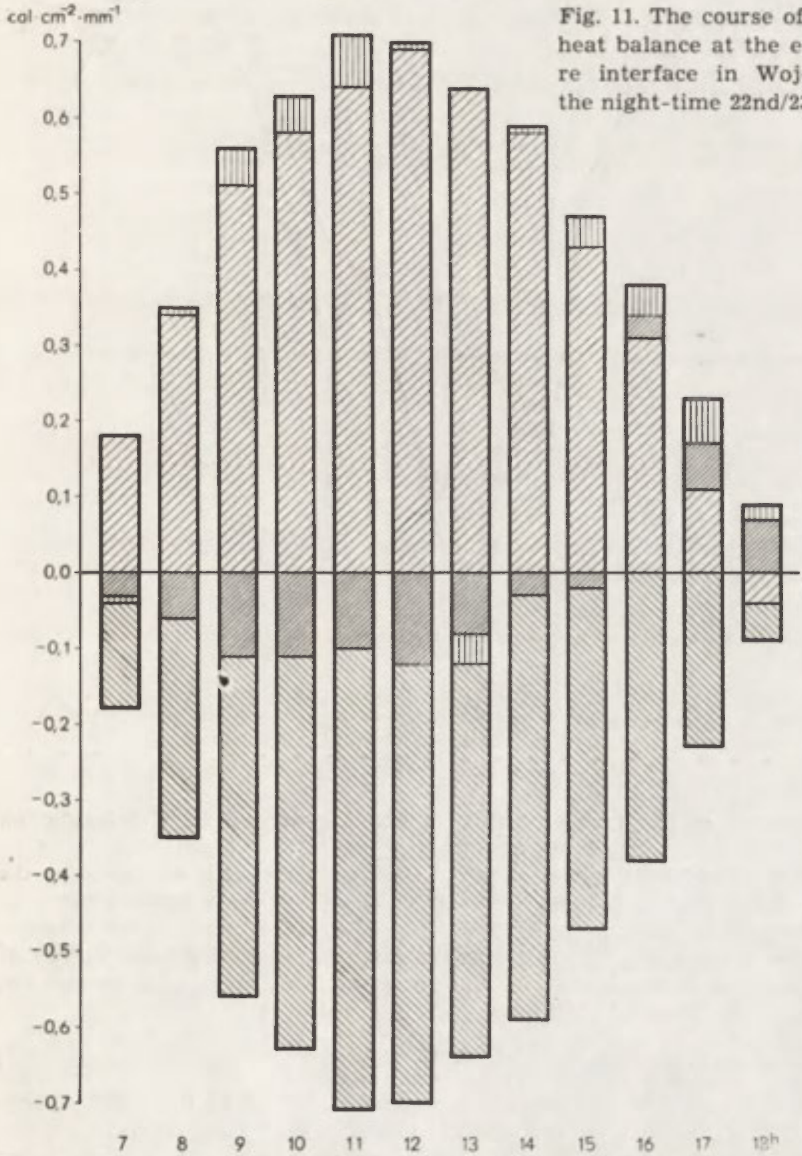


Fig. 12. The course of components of heat balance at the earth-atmosphere interface in Wojcieszów during the day-time 23rd August 1965

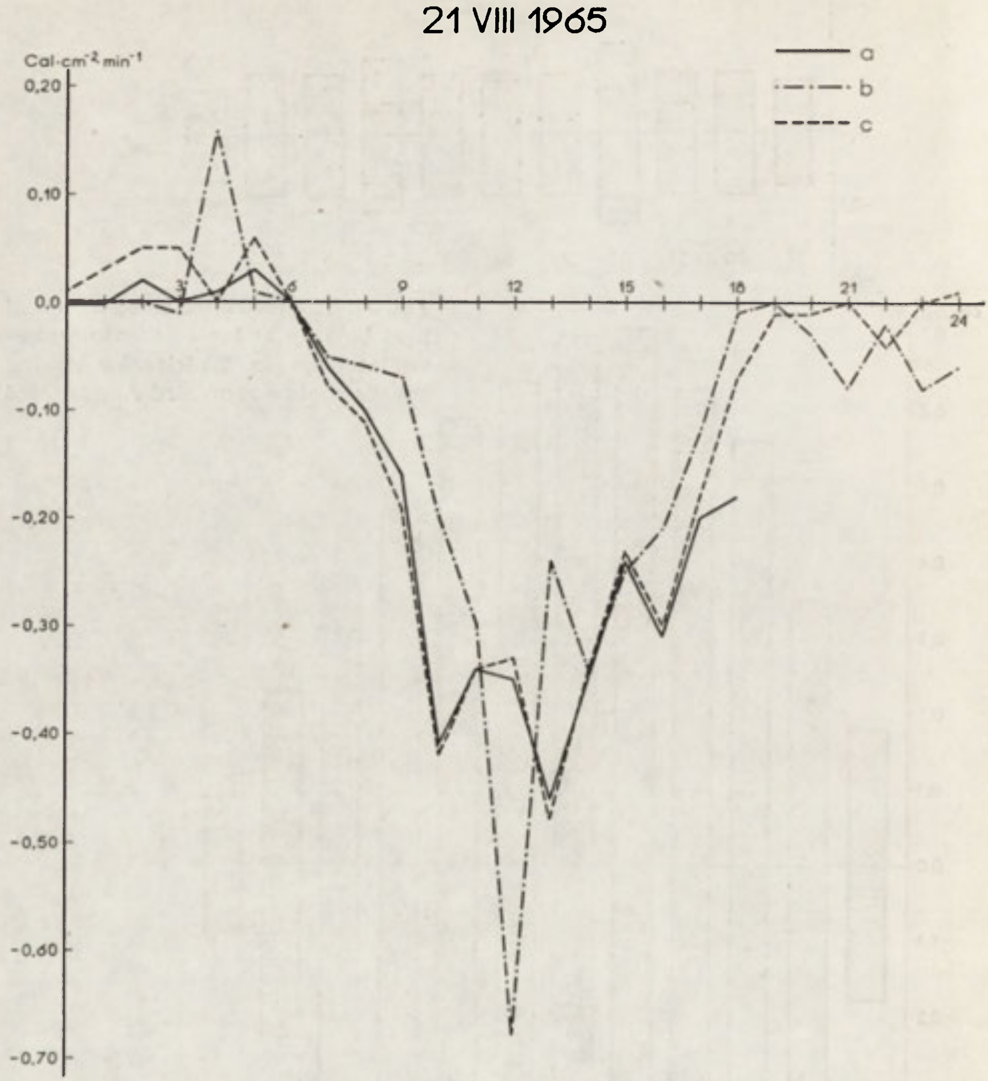


Fig. 13. Daily courses of the turbulent flux of latent heat $-E$ in Wojcieszów on 21nd and 22rd August 1965

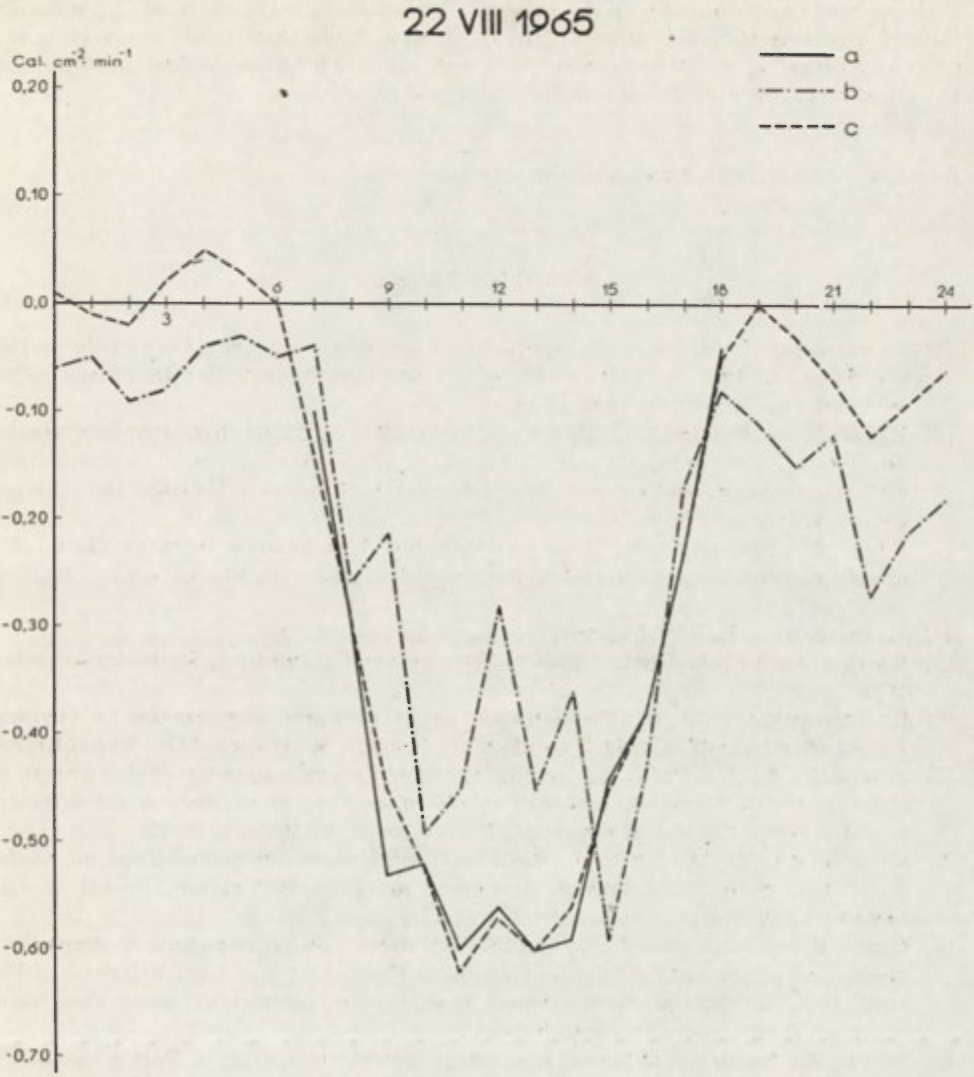
a — values of *E* determined by the method of Bowen ratio, *b* — values of *E* determined by the aerodynamical method, c — values of *E* determined by the method of heat balance.

nomograms were prepared [12]. In a similar manner, instantaneous values of the turbulent flux of latent heat, i.e., the component E, were also computed, using data concerning vertical differences of air humidity:

$$E = f(\Delta e, u, B, z_0) \tag{11}$$

In this way the actual evapotranspiration was determined by three different methods: (1) the Bowen ratio method, (2) the aerodynamical method, (3) the method of heat balance, where

$$E = -(Q + \Delta q + A) \tag{12}$$



The last method, where E is the residual term in the equation (1) is most advantageous, because it does not require any measurements of air humidity, which are rather complicated and not sufficiently accurate in the field conditions.

However, the results obtained by all three methods are in rather good conformity as can be seen from the diagram (Fig. 13). Thus the results of detailed investigations carried out in our research station confirm the assumption that in the climatic conditions of the south western part of Poland descending winds involve increasing evapotranspiration. Therefore, the share of the evaporation in the heat balance of this part of Poland is so important.

The results obtained can be of both scientific and practical importance, taking into account the possibilities of active modification of the water economy by altering the structure of heat and moisture balances for the ammelioration of existing climatical and hydrological conditions.

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DIRECTIONS OF GEOMORPHOLOGICAL RESEARCH IN THE DEPARTMENT OF PHYSICAL GEOGRAPHY IN CRACOW

LESZEK STARKEL

INTRODUCTION

In the autumn of 1953 professor M. Klimaszewski organised a Section of Geomorphology and Hydrography at the Institute of Geography of the Polish Academy of Sciences in Cracow. At the beginning, 2–4 geomorphologists were employed but later the number rose to eight. Research was concentrated at first on studies of the evolution of the relief, based on a method of geomorphological mapping. Afterwards research in dynamic geomorphology became increasingly more frequent. Two research stations became linked to the department: that at Hala Gąsienicowa in the Tatras, situated at the upper tree-line (1520 m a.s.l.), and from 1966 that in Szymbark in the Flysch Carpathians, situated on the border of the Carpathian Foothills and the Beskidy Mts. (300–740 m a.s.l.). In the autumn of 1968 professor Klimaszewski handed over his office as head of the Department to the author of this article and in 1970 the Department was renamed the Department of Physical Geography.

At present ten geomorphologists [1] are employed by the Department and a further three co-operate closely [2].

A. GEOMORPHOLOGICAL MAPPING — THE BASIC METHOD OF STUDYING THE RELIEF

In 1950 M. Klimaszewski, together with a group from the Jagellonian University, started the geomorphological mapping of the Carpathians, the Silesian-Lesser Poland Uplands and the Sub-Carpathian Basins. At first the scale of 1 : 100,000 was used, later 1 : 50,000, 1 : 25,000 and 1 : 10,000. The method was based on mapping all the features of the earth's surface, having previously noted their morphometric and morphographic features, their genesis and their age [61, 62, 72]. The purpose of the mapping, as was stressed by its initiator, was to get to know the evolution of the relief and to give it a full description. The geomorphological map showed in colour the forms with a different genesis and age in such way that allowed one to see the stages in the development of

[1] M. Baumgart-Kotarba, S. Dżułyński, W. Gerlach, E. Gil, S. Gilewska, K. Klimek, M. Kłapa, A. Kotarba, L. Starkel, A. Welc.

[2] L. Dauksza, W. Froehlich, J. Słupik. In former years C. Karaś-Brzozowska (1956–1960) and J. Cegła (1966–1968) were temporarily employed in the Department.

the relief. The method became widely accepted and groups of several tens of people (from 1960 up to twenty only) conducted the mapping in various parts of Southern Poland. The department co-ordinated this work. Many maps were published in a multi-coloured version [24, 32, 42, 62, 68, 94, 102] others in a simplified form [5, 35, 69, 71, 84]. The mapping of all features and the effort put into studying their genesis and age caused the development of problem research both into the evolution of the relief of various regions [2, 65, 68] as well as into the contemporary changes thereof. At the same time attention was drawn to the relief as a factor in an economic evaluation of the environment [68, 69, 92], and the geomorphological map became one of the basic methods of registering the geographical environment for the physiographic studies of planning offices [72].

From 1956 interest in M. Klimaszewski's method in other countries caused the formation in 1960 of a sub-commission of geomorphological mapping in the Commission of Applied Geomorphology of the IGU. M. Klimaszewski directed this sub-commission for eight years. Alongside numerous symposia and publications *Problems of geomorphological mapping*, (1963) [42]; a many-language legend for detailed geomorphological maps of the world was worked out by an international group with the co-operation of employees from the Department (S. Gilewska, M. Klimek). This was published before the International Geographical Congress in Delhi [79, 80].

At the same time the Department is conducting and co-ordinating, on a national scale (since 1966) elaboration of the general geomorphological map of Poland (working scale 1 : 300,000), whose aim is to present the basic types of relief of a complex age and genesis against the background of morphostructural units [43, 106].

B. STUDIES ON THE EVOLUTION OF THE RELIEF OF SOUTHERN POLAND

Studies are concentrated in three regions:

(a) the old Silesian-Lesser Poland Upland, built of paleozoic and mesozoic rocks and with traces of paleogenic relief; (b) the Carpathians, with a relief younger than the postoligocene folds built of flysch, apart from the crystalline and limestone Tatras; (c) the Sub-Carpathian Basins, features of the pre-Carpathian depression filled in with miocene and later quaternary deposits. The region of Southern Poland had a complex history in the Quaternary. Apart from the mountainous areas which were only in the periglacial zone, the other parts of the Carpathians, the Basins and Uplands were once or even twice covered by Scandinavian ice-sheets.

Studies into the evolution of the relief in the Tertiary

The oldest elements of the paleogenic relief in the Silesian-Lesser Poland Uplands, known already earlier, were studied on rocks of different resistance (limestones, dolomites, sandstones, schists and marls) and age (carboniferous, to cretaceous). Gilewska [37] showed that the old tertiary surface at a height of 400–450 m a.s.l. (with remnants of the old weathering cover in karstic depressions) was polycyclic and polygenetic. On the Silesian Uplands, which cover the remnants of the hercynian massive, fragments of permian and mesozoic levelling were included into this surface. On a karstic substratum this was a karst levelling. S. Gilewska [37, 39, 41] also showed that later karstic processes, evident in calcite strata with neogenic fauna, caused considerable changes in and the lowering of the surface. At the time of the Carpathian overthrust in the Miocene, warped in the form of a latitudonal ridge the Upland was cracked into blocks and the discarded parts fell into the piedmont trough flooded by the miocene sea [38]. M. Klimaszewski [65] and S. Gilewska [35, 37] describe the course of the exhumation of the southern part of the uplands from beneath the miocene sediments, which occurred in stages. It was shown by the research of S. Dzułyński, K. Klimek, and others [13] that the consequent valleys with epigenetic sections formed during the dissection of the southern part of the Uplands suffered desertion by the rivers with the uncovering of the clay-filled tectionic troughs.

As S. Gilewska [37, 38, 44] showed, denudation escarpments developed in the upthrust part of the Uplands when there were resistant mesozoic strata, which are related to tectonics. One of these, on middle trias limestones, formed on the line of a miocene fault has receded 13 km (Fig. 1). Fragments of

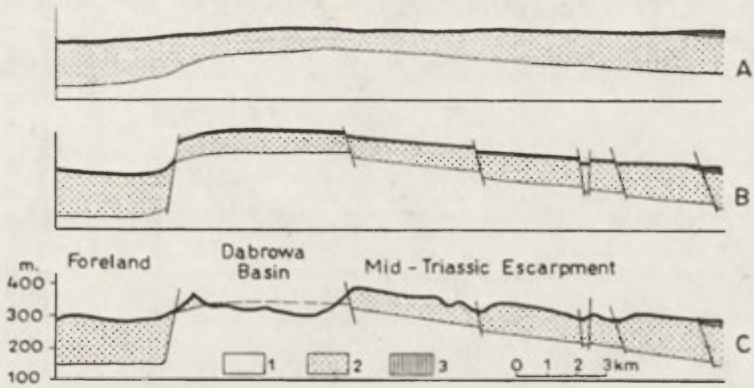

Fig. 1. Evolution of the Mid-Triassic Escarpment in the Silesian Upland (after S. Gilewska [40])

A — in Oligocene, B — during Miocene tectonic phase, C — in Pliocene, formation of basins connected with retreat of escarpment; 1. lower trias and older formation, 2. middle trias limestones and dolomites, 3. upper trias beds

destructive levels in areas of inter-scarp depressions [37, 84] and erosion terraces in narrow limestone gullies [13] correspond most probably to the levels of the planation surfaces in the Carpathians. However, this has not been proved so far.

In the Carpathians, just as in the Silesian-Lesser Poland Uplands, the study of old forms was based on detailed geomorphological mapping and an analysis of the relation of the form to the geological structure. M. Klimaszewski found hanging, unrejuvenated floors of pliocene valleys in the granite part of the Tatras and connected these with the extensive levels of the lower-pliocene planation in the Tatra foothills [66, 71]. The geomorphological mapping of the eastern part of the flysch Carpathians allowed for the recognition, apart from the two hitherto known planations [65], of a third lowest valley level shaped in the form of glacis-pediment [94, 101, 102].

Research in various parts of the Tatras showed that the rate of the maturing and rejuvenation of the relief and due to this the preservation of old planations depends on the resistance of the bedrock [1, 3, 75, 102, 110]. The oldest elements of the relief have been preserved in resistant rocks and at the same time the usually low resistance of flysch causes that the neogenic forms were remodeled and now the old relief must be reconstructed (Fig. 2; [102, 103]).

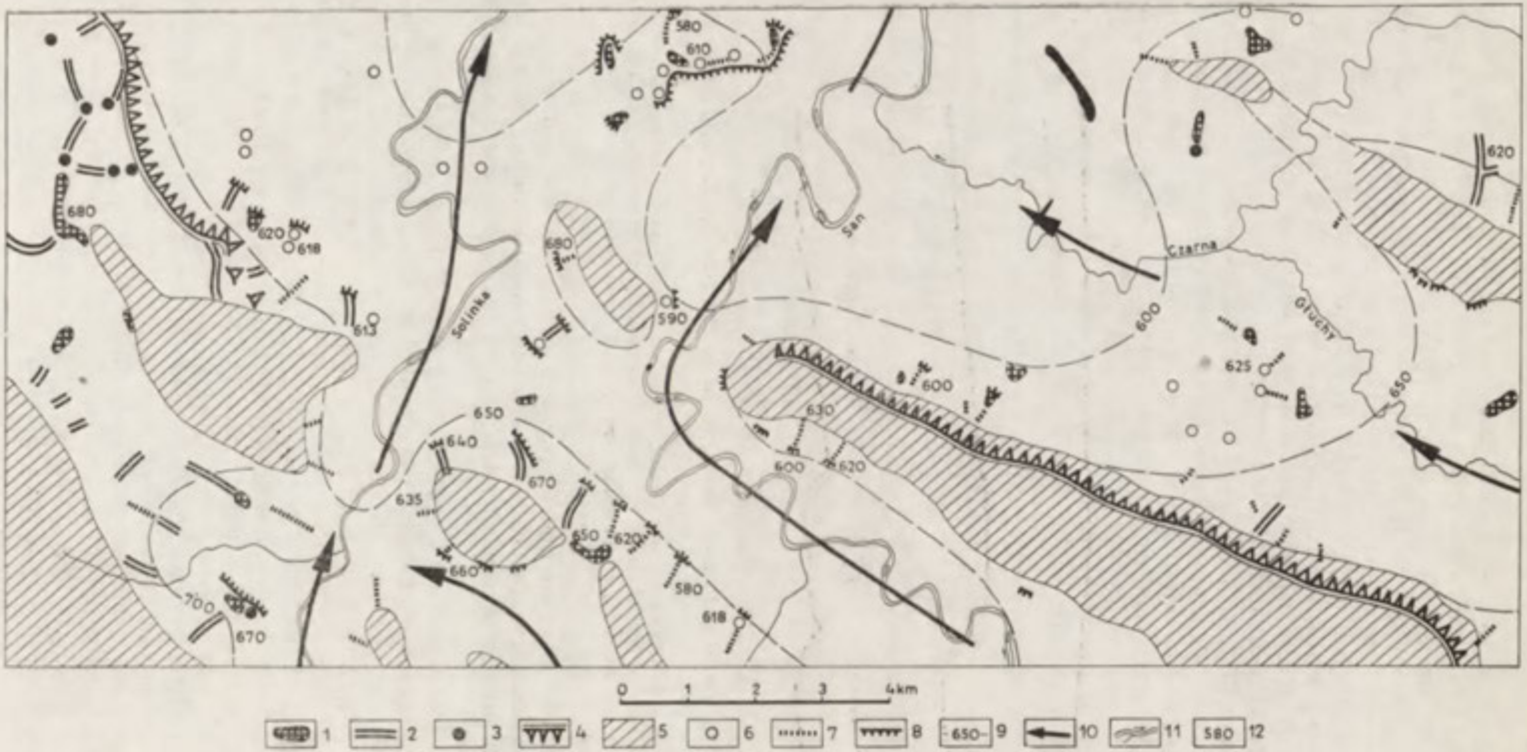

Fig. 2. Palaeomorphological reconstruction of pliocene 200 m level (above river bed) in San Valley (after Starkel 102)

1. flattenings in 200 m lewel, 2. wide rounded humps in niveau of flattenings, 3. monadnock hills rising above flattening, 4. structure controlled scarps in relief of level, 5. high hard-rock ridges rising above relief of level, 6. dome-shaped crest in level — lowered, 7. humps with levelled profile — lowered, 8. edges separating relief of level from younger slopes, 9. isohypses of 200 m level — reconstructed, 10. directions of rivers at level, 11. present rivers, 12. elevations above sea level

The levels were formed under the conditions of a temporary dry climate [75, 102]. Their uplift was not uniform which is reflected in the changes of the river network [75]. In any case, toward the end of the sedimentation of the flysch, the uniform uplift caused the cutting down of structures and the formation of the foundation of a structural relief [102].

Correlative deposits, the so-called gravels of Witów and Majdan with a thickness of 100 m and occurring in the subcarpathian trough, are evidence of the intensive degradation of the Carpathians (gravels with a diameter of 20–70 cm found 30–40 km from the mountains). The connection of this series with the lowest Quaternary (Villafranchian) similarly developed on the edges of other mountains of the alpine zone and the connection with the lowest level of a pediment type in the mountains indicates a similar evolution of the young mountains [14]. This fact encourages one to a discussion on the subject of rejuvenating the age of the Carpathian planations [111]. The old gravels mark different routes for rivers in the region where the Sub-Carpathian Basins were being formed (from the Vistula catchment basin to the Dniestr and the Oder [65].

Studies on the evolution of the relief in the Pleistocene

This period was studied by an analysis of well preserved groups of forms (geomorphological mapping) and a series of sediments studied by appylying sedimentological, mineralogical, paleobotanic and other methods.

This research in the Carpathians is in the greater part a continuation of the valley and glacial studies of M. Klimaszewski who had proved already earlier that the northern and Tatra glaciations were synchronous and he had also shown the tendency to uplift prevalent in many Carpathian valleys during the whole Quaternary.

Departamental studies, concentrated chiefly in the San and Dunajec basins showed that the deepening of valleys is still going on or else stopped in the last glacial. It was interrupted by a climatic accumulation in the glacials (Fig. 3); [3, 7, 70, 77, 78, 104]. The interfingering of river and solifluction sediments described by M. Klimaszewski in the profile in Dobra [63] became the basis of dating terraces on this criterion when a similar relationship of sediments and cut surfaces of lateral erosion in terraces from all three glacial periods were found in the San valley [8]. A detailed stratigraphy of river and slope deposits for the last glacial has been produced. It shows both the changes of the sedimentation in the long profile of the valleys and the influence of the fluctuation of climatic-vegetation zones [49, 70, 78, 91, 96, 100, 108, 113]. A delay of rejuvenation in the upper sections and tributary valleys was found in the development of valleys not only in the Tatras, where old suspended floors influenced the course of glaciation and deglaciation [67, 74], but also in the Flysch Carpathians [102, 104].

Much attention was given to the development of slopes. Apart from a climatic tendency to lower the slope and form a convex-concave profile, the influence of uplifting and of the differentiation of the geological structure was shown [1, 7, 9, 49, 63, 99, 101, 104, 113, 114]. Also the relationship between the types of modelling and sediments (scree, solifluction, deluvial) and the type of bedrock was shown [49, 113] and on crumbling sandstones even extensive deflation hollows were found [30]. An analysis of the slope sediments on the fossilised terraces allowed for an evaluation of the extent of the degradation of slopes built of less-resistant flysch at about 10 m in one glacial period [7, 91].

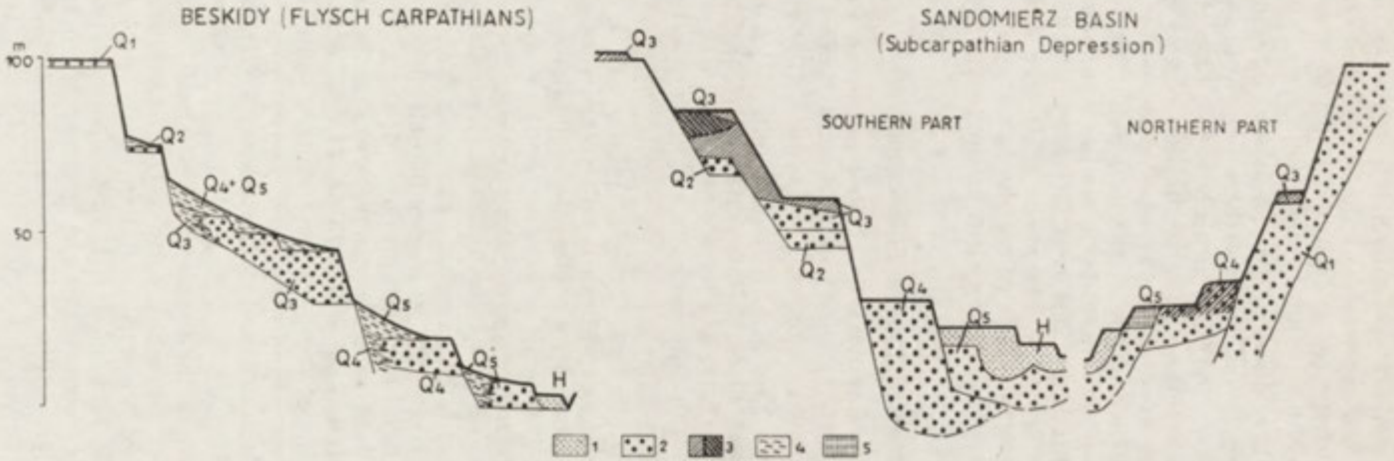

Fig. 3. Schematic sequence of Quaternary forms in Carpathian valleys and the Subcarpathian Depression (after Klimaszewski, Dziewański, Dżułyński, Starkel, Wysoczańska-Laskowska and others)

Age of sediments: Q_1 — Villafranchien, Q_2 — older than Cracovian glaciation, Q_3 — Cracovian (Mindel) glaciation, Q_4 — Middle-Polish (Riss) glaciation, Q_5 — Baltic (Würm) glaciation, H — Holocene. Types of sediments: 1. fluvial, Holocene, 2. fluvial — Pleistocene, 3. glacifluvial, and glacial, 4. slope (solifluctional and deluvial), 5. loess

The research in the Carpathians became the basis of wider studies on the actual role of the pre-glacial relief in the development of the mountains glaciers [67, 74, 76] and on the influence of climatic and tectonic changes on the deepening of valleys in various highland areas of the alpine zone [114].

Departamental studies in the Carpathian Foreland showed that the flow of fluvioglacial waters during the middle-Polish glaciation was from the front of the ice-sheet in Silesia to the Vistula valley [46, 51]. The periods of glaciation undoubtedly interrupted the deepening of valleys. The deepest of these date from the great interglacial [Fig. 3, 46].

The development of the relief of the Silesian-Cracovian Uplands was regionally differentiated. In the eastern part which was glaciated once, the older relief exposed from beneath glacial deposits was often covered by loess [35]. However, the twice-glaciated western part is to this day covered by a thicker series of glacial and glaciofluvial deposits, especially in depressions [46]. The direction of escarpments (NW–SE) influenced the course of the glaciation and the basin-like depressions were favourable to areal deglaciation (Fig. 4); [37,

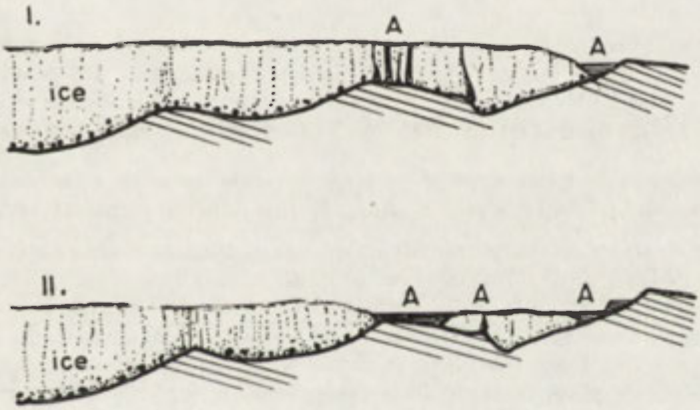

Fig. 4. Relation of the ice-sheet to the escarpments in the nothern part of the Silesian-Lesser Poland Upland (after Klimek) [84]
I. early phase of deglaciation, II. late phase of deglaciation. A. zones of kame accumulation

82, 84]. The forms of kames, eskers and outwash plains from this period underwent relatively little transformation so that morphological criteria may also be applied in comparisons of glacial landscapes of different ages [51, 83, 84]. The infilling of depressions and gorge sections caused the developement of a new valley network; many fossilised valley tracts and numerous epigenetic gorges were formed [37, 46, 81]. S. Gilewska's research also concerns the stratigraphy of valley deposits [47, 48], karst processes in the pleistocene [36, 41] and the modelling of slopes in a periglacial climate [37, 49]. The deepening of valleys did not attain the pre-glacial floors which is connected, among others, with the subsidence tendencies in the Subcarpathian trough and in the valley of the Oder (according to the geodetic and geomorphological research cf. L. Starkel [98], S. Gilewska and K. Klimek [46]).

Studies on the evolution of the relief in the Holocene

These were concentrated in the Carpathians [95, 97]. Various types of slope-formation were found, relating to the lithology of the bed-rock (wash-out, sufosion, erosion, the dissection of slopes by little valleys, landslips, rockfall).

The exhumation of rock slopes or their downgrading (accumulation at the foot) depends on their susceptibility to erosion. On the basis of the volume of erosional forms, measures of material removed in suspension and the volume of aluvium deposited on the forefield of the Carpathians, the extent of erosion in the Holocene was estimated at 500,000 m^3/1 km^2. In the area of aluvial cones at the edge of the mountains the occurrence of a few series of aluvia of the channel facies were found which are evidence of increased denudation towards the end of the last Glacial and in the more humid periods of the Holocene. The general rise in the intensity of the processes is linked to the deforestation of mountain areas.

In association with the research in the Carpathians, L. Starkel attempted to study the role of the Holocene in the relief of Poland [98, 107], Europe [105] and in various climatic zones of the world [109], where the Holocene is not always distinct morphogenetically.

C. RESEARCH ON CONTEMPORARY MORPHOGENETIC PROCESSES

Patrol observation of processes during snow-melt and torrential rain were carried out alongside the geomorphological mapping, and the newly developed forms were mapped in detail. However, systematic stationary observations started in the Carpathians in 1955 by T. Gerlach brought the research to its rise.

A registration of the forms and a study of the results of catastrophic processes

The registration of Holocene forms on maps included also active forms like landslides, gullies and river erosion and accumulation forms [24, 35, 94, 97]. The basis of the first characterisatics of a zonal differentiation of processes was mapping at the scale of 1:10,000 and occasional observations of processes [71, 97]. Based on these methods and the first results of simultaneously conducted stationary observations, an attempt was made at making maps of contemporary morphogenetic processes, constructed on the principle of selecting the main process [56]. Among detailed studies of individual forms mention ought to be made of the geomorphological mapping of the meanders of the San, where morphodynamic zones [53] on a scale of 1:500 or form made by windfallen trees [20], formerly considered as congelifluction forms, were distinguished.

Special attention has been paid to cause and results of catastrophic processes which are the main influence on contemporary changes in the relief. Mud flows and slumps were noted after torrential rains in the San basin in 1953 [97] and in the region of Jaworki. In 1958, 355 slumps and flows with a volume of 7097 m^3 on an area of 23 km^2 were registered — according to Gerlach [24]. T. Gerlach, J. Pokorny and R. Wolnik [31] studied in detail a landslip formed after precipitation on an artificially undercut slope and they showed that it coincided in time with an earth tremor. The catastrophic results of a wind of a föhn type with a force of 75 m./sec. on 6.V.1968 in the Tatras was studied by A. Kotarba [58], who found that, converted to an area of 1 km^2, the horizontal translocation due to windfallen trees was equal to 51,730 m^3, thus considerably exceeding the effectiveness of all other processes throughout the year. The effects of a sudden downpour in a valley cut in the jurassic limestones of the Cracovian Uplands were studied by L. Kaszowski and A. Kotarba [54, 55]. They made a geomorphological mapping of the river-bed at the scale of 1:500 reconstructing the distribution of energy, the intensity of the processes and the flood stages on the basis of an analysis of the distribution and volume of forms and deposits. The river-bed adapted to extreme hydrodynamic conditions is very slowly readapted to "normal" discharge after the flood. After the 1970 flood in the Carpathian valley of the Dunajec, K. Klimek and W. Froehlich [17] studied the course of transport and accumulation in the region of the river-bed and the flood terrace.

Studies of the results of the two and a half day downpour with a precipitation total of 1100 mm in the region of Darjeeling in the Himalayas were conducted by Starkel [115, 117] who found the extent of the tranformation of slopes by flows, gullies and landslides of the order of a 10 cm lowering of the whole surface with a simultaneous widening and deepending of valley floors by flood waves reaching 20 m in height.

Stationary research of morphogenetic processes

These range widely from the course of mechanical and chemical weathering through gravitation processes, slope wash, crionival and eolian processes and sufosion and ending on fluvial processes [23, 27]. The research is conducted by the Department at the stations at Szymbark (300–600 m a.s.l.), and on the Hala Gąsienicowa in the Tatras (1500 m a.s.l.); it is or was conducted in

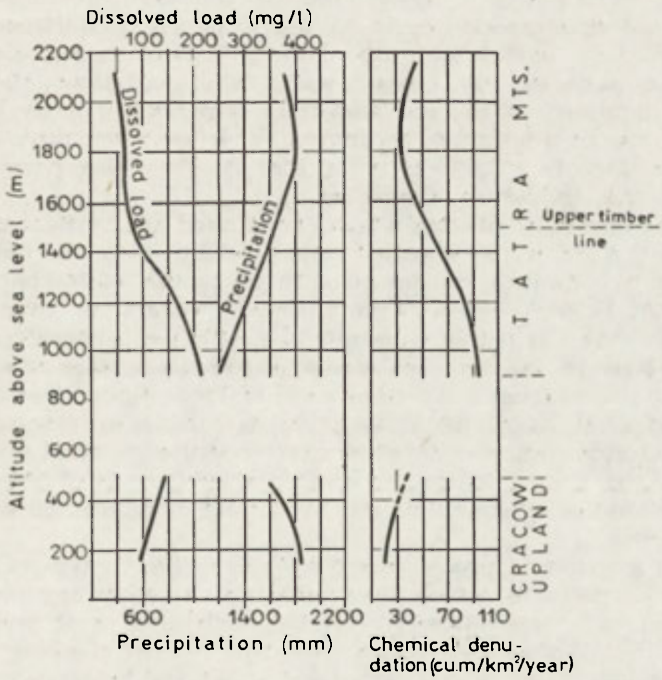

Fig. 5. Chemical denudation in vertical zones of the Polish Carpathians and Cracow Upland built of limestones (after Kotarba) [60]

Jaworki by Szczawnica (T. Gerlach), in the Gorce Mts. (T. Gerlach), in the Mała Łąka valley in the Tatras (A. Kotarba), in the Jasło–Sanok Depression (T. Gerlach) and in the basin of the Kamienica (W. Froehlich).

Observations of mechanical weathering are led by A. Kotarba [57] at various zones in the Tatras and also by M. Kłapa [90] who is analysing the rate of weathering of rock scree situated in and on the surface of the soil.

Research upon the course of solution at various vertical zones in the Tatras was conducted by A. Kotarba [59, 60] on the basis of an analysis of several types of waters (flowing over the surface, beneath the surface and in creeks) in an annual cycle. He showed that chemical denudation exceeds 90 $m^3/km^2/yr$ in the upper forest zones but falls beneath 40 $m^3/km^2/yr$ above the upper tree line (Fig. 5). The role of organic acids is thus greater than that of lower temperatures, conducive to the increase of free CO_2 in water.

Research upon slope wash was started in 1955 by T. Gerlach [18, 22, 24] by using two types of troughs. He showed a tendency towards the formation of a convex-concave profile of slopes by degradation in the upper and middle segments and accumulation in the lower segments. The average denudation of slopes by slope-wash in an area built of little-resistant flysch series ranges from 2.5 mm to 0.00003 mm p.a. and depends on the type of land utilization. Gerlach calculated that the rain-wash on ploughed unterraced slopes is of the order of 2500 m^3/km^2, on terraced slopes 400–900 m^3, on pasture 3.3 m^3, on meadows 0.4 m^3 and in woods only 0.03 m^3. A more important part is played by the summer periods with a high intensity of precipitation rather than snow-melt periods, which is confirmed by the first results of the research at Szymbark [33, 34, 120]. In 1968 stationary research of slope-wash was started at Szymbark on slopes of different land-use and exposure together with research into the entire water cycle on the slope [6]. Simultaneous measurements of the course of the intensity of the precipitation, percolation, surface run-off, sub-surface run-off, ground water level variations, the freezing of the soil, the humidity of the soil and other features currently being studied by J. Słupik are an attempt at getting to know the mechanism of water circulation on a slope in an annual cycle (Fig. 6). This also permits a deeper knowledge of the mechanism of sufosion.

Among the cryogenic process which are studied are vertical movements of the soil with the aid of the so-called soil movement-meter of the Bac system. At the upper tree limit, a movement of 12 cm in the winter half of the year was noted [88]. In the areas without a compact vegetation cover in the all height zones of the Carpathians the role of needle ice is considerable. According to T. Gerlach [19, 24] the translocation of the upper layer of soil downslope in one winter ranges from 2 m (600 m a.s.l.) to 3.8 m (upper tree limit).

In the Tatras M. Klapa [50, 87, 88, 89, 90] is conducting research upon avalanches, the disappearance of the snow cover and the crionival processes which accompany them, among others the horizontal movement of the earth on the surface by the aid of ceramic tiles and by the aid of segmented pegs in deeper layers of the soil.

Studies of gravitation processes are wide in scope. Of typical slipping processes in the Carpathians, which are studied also by other experts, the department is conducting observations of selected landslides, using repeated nivelation lines (6). Small slips and slumps indicating further creeping were studied by T. Gerlach [24, 26] by installing rows of sticks and by repeated nivelations. A movement of 3–70 mm p.a. was found. The translocation of talus cones near the upper forest boundary is analysed by the aid of sticks and painted rows of stones. The first observations of T. Gerlach [23] found a movement of the order of 5–100 mm p.a. The process of rock-falling is being studied by A. Kotarba [57] in an annual cycle by the aid of plastic nets stretched out at the floor of slopes at various height zones of the limestone Tatras.

The activity of wind, unappreciated apart from the sudden fohns, was begun to be analysed by semi-stationary methods. In the Tatras M. Klapa [88] observed accumulation on snow reaching 233 g/m^2. On the area of the in-

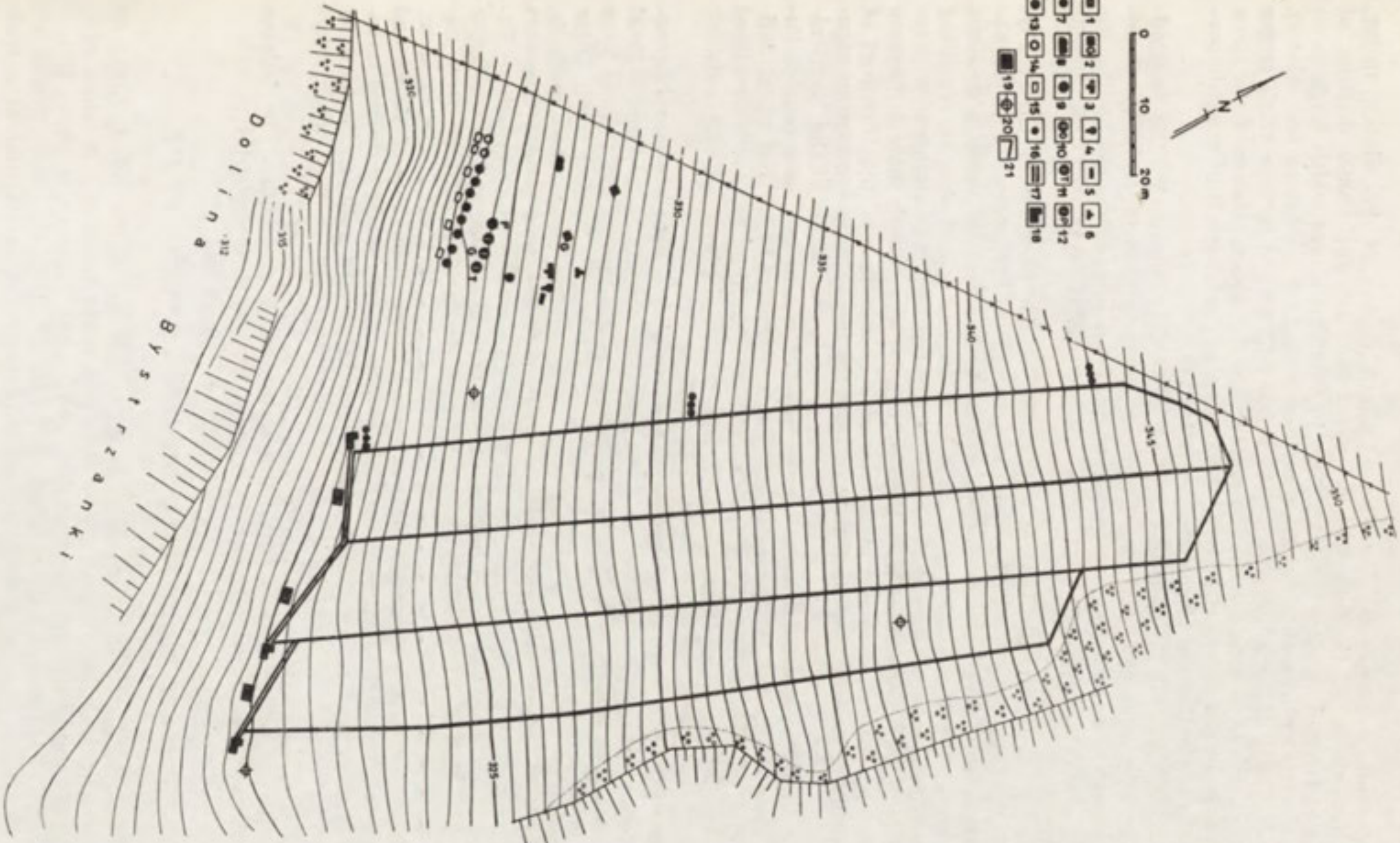

Fig. 6. Experimental slope with three plots at the Research Station in Szymbark (cf. Dauksza *et coll.* [6])

Distribution of measuring points:

1. temperature at level of 2 m, 2. temperature at level of 5 cm, 3. soil thermometers, 4. depth of frozen ground, 5. soil movement gauging device, 6. wind, 7. heliograph, 8. actinometers, 9-12. automatic and simple raingauges, 13. lysimeters, 14. raingauge of 1 sq. m surface, 15. water containers below lysimeter, 16. piesometric tube, 17. trough collecting the surface run-off, 18. dumping tray and counters for measurement of run-off, 19. measurements of subsurface run-off, 20. geodetic basic points, 21. boundaries of plots made of plastic folia

tra-montane Jaslo–Sanok Depression where there are in winter strong, southern winds T. Gerlach and L. Koszarski [28, 29] found drifting of snow and later of the soil from southern to northern slopes which leads to an asymetry of slope deposits (by lowering slopes up to 2 cm during one winter). Proved annual degradation amounts to 20 000 m^3/km^2 and is thus much larger than the amount of slope wash. The mapping of the disappearance of the snow cover, carried out in the vicinity of the station at Szymbark is of great importance for evaluating the intensity of deflation [5].

Research upon fluvial processes, limited formerly to measuring the suspended load at hydrometric stations, has been expanded considerably by stationary research in little catchment basins, initiated and developed by the Institute of Geography of the Jagellonian University (L. Kaszowski, M. Niemirowski).

Thee Department of Physical Geography of the Institute of Geography, Polish Academy of Sciences besides co-operating [54, 55] started detailed observations of the valley of the Ropa where L. Dauksza [6] made a geodetic mapping of the river bed at the scale of 1:500 and 1:2000 and by repeating the measurements, confirmed the size and the tendencies of changes. W. Froehlich [16], who co-operates with the department was able to show a decrease of the transport of dissolved material and a culmination of the transport of suspension preceeding the maximum of flow for the 1970 by conducting regular measurements of various types of transport in the basins of the Kamienica and Lubinka. Studies upon the mechanism of fluvial processes outside Poland were conducted in the region of Skeidararsandur in Iceland by K. Klimek [85] who showed, apart from the role of jokullhlaups, a differentiated morphogenetic regime of proglacial rivers within the area of one outwash plain.

Research upon the various processes aims to give a complete morphogenetic balance with due consideration to the economic activity of man and a zonal differentiation of processes (Fig. 7). Attempts at comparing the process have been made among others by T. Gerlach [23, 27] and L. Starkel [116]. These are imperfect as there is a lack of data collected by comparable methods. Gerlach [27], using measures of slope wash, deflation and fluvial transport accepted that in the lower parts of the flysch Carpathians (the Carpathian Foothills) slope-wash has a less important role than deflation, and in the upper parts (the Beskidy) it is much more intensive, similarly as off-take from basins. Meanwhile, a weaker denudation of slopes in the Foothills is apparent. This is linked with a tendency toward accumulation at the foot of slopes and on valley bottoms. According to Starkel [116] the reason is the differing transporting strength of rivers, linked with tendencies toward uplift in the Beskidy and with the lack of these in the lower zone, the Foothills. The valley floors in the Beskidy have a negative balance — they are deepended. It is the opposite in the valleys of the Foothills where there is agradation. The balance of the Western Tatras is currently being prepared by A. Kotarba [57].

D. TYPOLOGY AND REGIONALIZATION IN THE STUDY OF RELIEF

The development of research upon the evolution of the relief, based on geomorphological mapping at a detailed scale made possible a detailed division of the regions which were studied such as the Silesian-Cracovian Uplands [37, 52 et al.] and the Carpathians [93, 102, 110, 116]. However, it was not until the completion of general geomorphological map of Poland at a scale

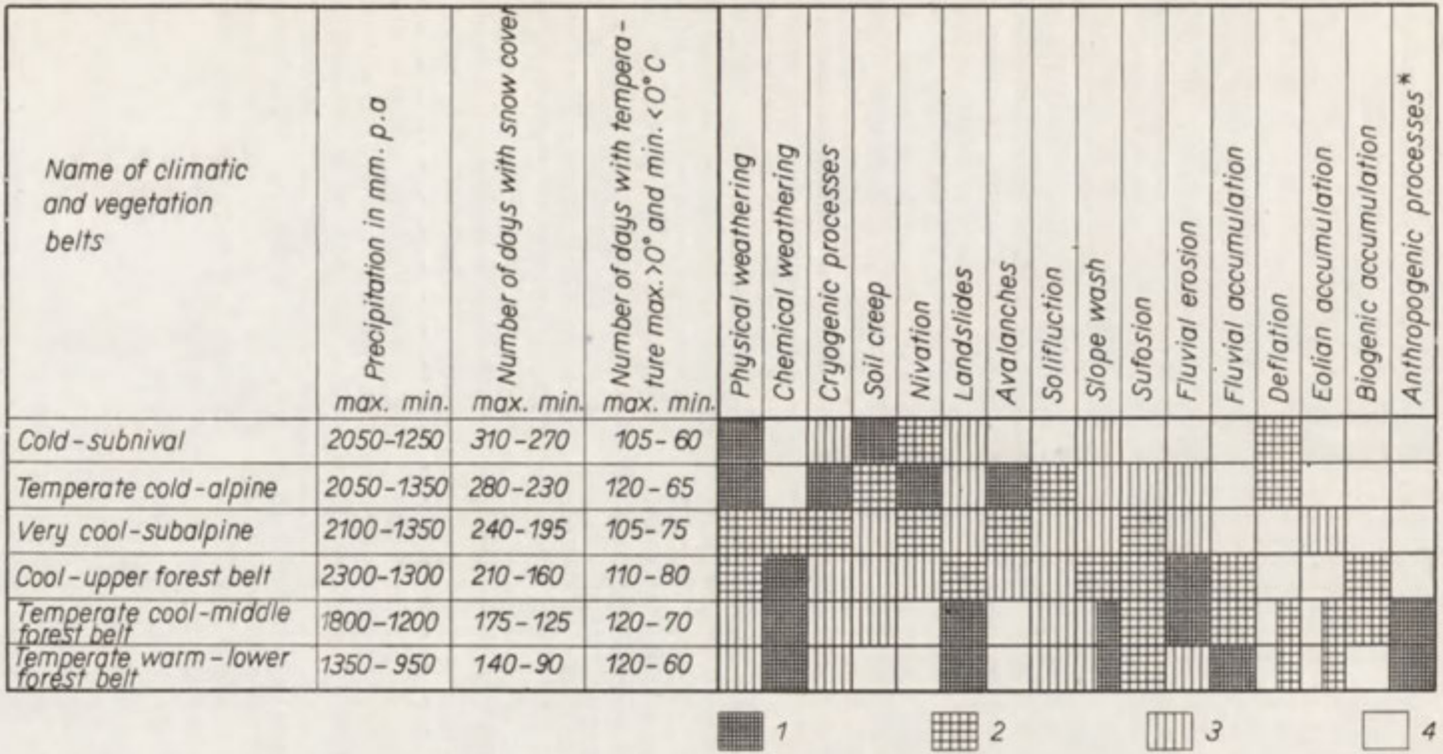

Fig. 7. Type and intensity of actual morphogenetic processes in vertical zones of the Carpathians (after Gerlach) [27]

Intensity of processes: 1 — great, 2 — middle, 3 — small, 4 — very small

* cultivated terraces and road cuttings on slopes

of 1:300,000 and the study of the geomorphology of Southern Poland led by M. Klimaszewski (in print) that a basis of a new typology of large forms was given. This was based not only on various morphometric-morphographic characteristics but also on a differentiation of the evolution of the relief.

E. ATTEMPTS AT EVALUATING THE RELIEF FOR THE NATIONAL ECONOMY

Even at the beginning of its development M. Klimaszewski [62, 68] stressed the practical meaning of the geomorphological map. In 1954 Starkel described [92] the meaning of the map for agriculture when he published an extract of an originally prepared geomorphological evaluation map, on which areas of different value for agricultural economy were designated, taking into consideration the morphometric characteristics of the forms, their structure and the existing threat of contemporary processes of a great intensity (landslips, flood areas etc.). An evaluative study of the Tatra foreland carried out for the purposes of regional planning indicated areas with different building conditions [93] and consequently induced the planners to alter their projects.

Geomorphological maps made in the department for the industrial part of Upper Silesia [52, 69] were the basis of a study of the suitability of relief forms for various branches of the economy, carried out by A. Jońca at the Jagellonian University [68, 69]. C. Karaś-Brzozowska [52] and S. Gilewska [40] drew attention to the anthropogenic transformation of the relief in the Upper Silesian Industrial District. Geomorphological evaluation maps with the aim of developing the surroundings of reservoirs on the San, were also carried out on the basis of geomorphological mapping (among others published in *Problems of geomorphological mapping*, 1964, cf. 72). A complex study of the environment from the point of view of the development potential of agriculture and settlement in the poviat of Ropczyce (situated at the edge of the Carpathians) was carried out on the basis of an inventory of relief forms as the leading feature [86]. An attempt at a comparison with the current land use indicated possibilities of changes to a more rational utilization [4, 112].

Recently, within the studies carried out by the Committee for the Management of Mountain Areas, a typology of the relief of the Polish Carpathians was carried out [116] showing the varying suitability of individual groups of features in a highland economy. A complementary morphometric study of various representative areas [119] showed that the cumulative curves of the gradients of slopes are closely linked with the differentiated types of relief.

Conclusions as to the influence of land use on the type and intensity of contemporary morphogenetic processes are important for the rationalization of the agricultural economy. For example the effectiveness of measures against erosion were studied. Among others Gerlach [21] showed in Jaworki that mid-field terraces retain on the slopes only 35% of the soil being removed. Some paleogeographic studies, e. g., that of S. Dżułyński (15) on hydrothermal karst have also an important practical meaning. This study explained the genesis of the zinclead ore deposits in the Silesian Upland.

F. RESEARCH PERSPECTIVES

The development of research requires the continual confrontation of results and the methods which have been applied. The undoubted needs of the economy and the intervention of man in the geographic environment cause geomorphologists also to get closely involved with studies of rational land utilization. This cannot, however, mean the neglection of other basic branches of research. The current studies of the Department of Physical Geography in geomorphology tend towards the concentration of research in a few directions.

(1) The condition of a knowledge of the evolution of the relief and the preparation of a forecast of its development is the simultaneous study of the past of the geographical environment (paleogeographic direction) and of contemporary morphogenetic processes (dynamic direction). The rate of processes can only be described for forms of a known genesis and age. Therefore, the Department conducts studies of the same phenomena both by historical and by physico-chemical stationary methods. In mountainous areas this allows one to get to know the relationship between the zonation of contemporary processes and the variations of the zones in past periods.

(2) A parallel study of all physical, chemical and biological processes (circulation of water and heat, soil-formation processes etc.) is indispensible for getting to know the mechanism of contemporary morphogenetic processes. Hence the notion of forming physico-geographical stations. The first articles of Slupik and Gil [33, 34] show that the mechanism of slope-wash can be understood only with a good knowledge of water and soil processes.

(3) Geomorphological research is increasingly linked with the economic needs of the country. Therefore, it is conducted both in an environment approximating to a natural one and in one which has been transformed by human economy. This forms a basis of a typology of the environment (the boundaries of forms are the most stable and are easy to distinguish in the field), which, however, requires the concentration of research on the correlation of various elements of the environment within the range of closely studied forms. On the detailed scale, the research of E. Gil aims to show the changeability of permanent features and physico-geographical processes in the profiles of mountain slopes. On a review scale similar studies attempting to describe the types of environments will be conducted by statistical methods by the Department with the cooperation of other centres.

(4) Getting to know the mechanism of processes observed in the field requires experimental, laboratory research. Due to the lack of technical facilities this research has been neglected so far. Interesting results have been obtained by S. Dżułyński [10, 11, 12] among others in the field of the reconstruction of so-called periglacial structures of which many turned out to be normal "load" structures.

(5) Research in southern Poland requires comparative studies in areas with an evolution and morphogenetic processes similar to those ones found by us contemporaneously or in past geological periods when the relief of Poland was being developed. Here belongs research in other mountainous areas, in a periglacial climate, a temperate one and different variants of tropical and sub-tropical climates. The results of this work so far are S. Gilewska's [39, 44] studies on the evolution of the relief of karst areas of Europe, M. Klimaszewski's on mountain glaciations [67, 76] and tropical karst [64, 73], L. Starkel's on holocene morphogenesis [105] and the evolution of mountain valleys in the Quaternary [114], and those on contemporary morphogenetic processes in a periglacial climate [85] and in a monsoon one [117, 118]. This research leads one to state that catastrophic processes in various morphogenetic systems are of basic importance in contemporary changes in the relief and the type of these changes depends on the relief and covering sediments inherited from periods of a different morphogenesis.

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This study is dedicated to Professor SHINZO KIUCHI
the eminent Japanese urban geographer

PRESENT RESEARCH TRENDS IN POLISH URBAN GEOGRAPHY

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During the last twenty years Polish geographical research is characterized by its efforts toward an implementation of a co-ordinated and concentrated plan. However, such a plan was continually evolving as a result of changing social needs, together with the obtained generalizations and conclusions. In later years it was marked by a definite transfer of attention to more interesting and promising problems. Organized research, mainly undertaken within the framework of the Institute of Geography of the Polish Academy of Sciences, and also by several university institutes, started with studies of small towns and their problems. In the early fifties, these towns were in serious difficulties. Nationalization of industry had led to reorganization and concentration of production with its side-effect in form of the closure of small and dispersed plants. At the same time reorganization of commerce was characterized by smaller towns loosing their intermediary wholesale functions, together with the transfer of many retail shops to the villages to serve directly the agricultural population. Therefore, the task of geographers was to define the existing reserves and possible new functions for such towns. At first their efforts produced a series of monographs on individual towns. Two lines of approach were used: one to study the potential resources of the geographical environment and the other — to analyse the relations between the town and its local sphere of influence. The latter approach had more adherents and the studies have quickly developed into the research into the structure of urban network at the local level.

Some efforts were later made to generalize the results obtained and to present an overall report on the state of small towns in Poland [1]. The results were presented among others at the Stockholm International Geographical Congress of 1960 [2].

In 1963 M. Chilczuk presented an ambitious study of the rural service centres of the whole territory of Poland [3]. This work was originally welcomed as representing a rehabilitation of Walter Christaller's concept and theory of central places, which had been earlier rejected by Marxist geographers. Its value has diminished with the progress of time, especially when the detailed studies had shown the schematic and perhaps even unrealistic nature of his

[1] Studia geograficzne nad aktywizacją małych miast (Geographical studies on the economic activation of small towns), Prace geogr. IG PAN, 9, Warszawa 1957.

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[3] M. Chilczuk, Sieć ośrodków więzi gospodarczej wsi w Polsce (Sum.: Rural service centres in Poland), Prace geogr. IG PAN, 45, Warszawa 1963.

basic assumptions. Now the complexity and much more differentiated nature of the local networks is better appreciated and the need for a thorough revision of the synthetic picture of this problem in Poland becomes obvious [4].

From the beginning, the study of small towns was recognized to be only a first step towards better understanding of the settlement geography of Poland. Detailed geographical studies of middle-sized and large cities were needed. Such research was jointly undertaken by the three geographical institutes connected with the Polish Academy of Sciences, the Jagellonian University and Cracow College of Pedagogy. The city of Tarnów was chosen, one of the reasons of its selection being the fact that the best prewar monograph had been prepared for this town by Z. Simche [5] giving an excellent basis for the comparison of changes which took place in the last 40 years. The new monograph of Tarnów [6] has brought out the important role of specialized large-scale industries in the urban development with the connected phenomenon of a complete transformation within the city's sphere of influence from a network of urban-rural central places to a strongly integrated settlement system of industrial plants, housing estates and dormitory villages, superimposed on the network of agricultural service centres and hamlets. In this way the foundation was laid for further studies of the role played by the specialization in urban functions, as well as the regional differentiation of local networks, especially under the influence of the spreading and growing intensity of the urbanization processes.

Different, though partly parallel problems, developed from the study of changes in the settlement network of the selected areas in Silesia under the influence of intensive industrialization. The research was carried on by the Geographical Institute of the University of Wrocław, under the direction of S. Golachowski. Two concepts were developed and widely used. First, changes due to the processes of industrialization and urbanization as taking place in an originally agricultural area, were defined as "semiurbanization" [7]. Then these changes were interpreted as the rise and growth of settlement "complexes" or local systems [8]. Later on an attractive deductive theory of their development was formulated [9]. Recently these concepts were tested by A. Zagoż-

[4] M. Kiełczewska-Zaleska, Zaplecze Tarnowa i jego struktura osadnicza (Sum.: The region of Tarnów and its settlement structure), in: Studia z geografii średnich miast w Polsce. Problematyka Tarnowa, Prace geogr. IG PAN, 82.

[5] Z. Simche, Tarnów i jego okolica (Tarnów and its environs), Tarnów 1930.

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[7] S. Golachowski, Urbanizacja wsi w województwie opolskim (Sum.: Urbanization of rural areas in the Opole voivodship), in: Problemy ewolucji układów osadniczych na tle procesów urbanizacyjnych w Polsce (The problems of the evolution of settlement patterns against the background of the process of urbanization in Poland), PWN, Warszawa 1966, 45–65.

[8] A. Zagożdżon, Problematyka zespołów osadniczych (sum.: Problematics of settlements complexes), Czas. geogr., 35(1964), 3–4, 387–398.

[9] A. Zagożdżon, Zespoły osadnicze o funkcjach nierolniczych jako forma urbanizacji wsi (Sum.: Complexes of settlements with non-agricultural functions as a form of urbanization of rural areas), in: Problemy ewolucji układów osadniczych na tle procesów urbanizacyjnych w Polsce (The problems of the evolution of settlement patterns against the background of the process of urbanization in Poland), PWN, Warszawa 1966, 103–128.

dżon[10] in an interpretation of the transformations taking place in the settlement network of the area between Legnica and Głogów, resulting from the discovery and exploitation of copper ore deposits (the so-called Lower Silesian Copper Basin). The changes can be now defined as the passage from a network characteristic of traditional agricultural regions to a unified industrial-urban complex, with former central place functions and local markets superseded by new functions of specialization within an integrated system of industrial towns, villages and housing estates.

The study of changes in the settlement network of the Copper Basin opened at the same time a new subject for further studies, i.e. the spatial characteristics of successive stages of industrialization and urbanization. However, this subject was developed more systematically in the analysis of great urban agglomerations.

Another centre of intensive studies of changes in settlement network of industrialized areas has developed in the Cracow College of Pedagogy under the direction of M. Dobrowolska[11]. The research was characterized by excellent field work, very thorough documentation and a keen appreciation of social (even sociological) implications. The main efforts were concentrated on the analysis of changes in the fringes of very large industrial and urban agglomerations together with the problems of rural-urban migrations both temporary (commuting to work) and permanent.

Metropolitan areas and conurbations have not been tackled so far on a larger scale in the Polish geographical research. The problem is really too large for a single scientist, or even for a single institution. This does not mean that studies on this subject were not undertaken, but they were only partial and limited to a selected aspect of metropolitan growth.

Very great attention has been and is being paid to the question of delimitating large urban agglomerations. An interesting method — in the form of the weighted aggregate feature index — was developed and applied by E. Iwa-

[10] A. Zagożdżon, Analiza sieci osadniczej rejonu uprzemysłowianego na przykładzie Legnicko-Głogowskiego Okręgu Miedziowego (An analysis of the settlement network in an industrializing area: a case study of the Legnica–Głogów Copper-mining District), Wrocław 1970 (Doctoral thesis).

[11] See for example:

J. Herma, Dojazdy do pracy w Polsce Południowej (województwo katowickie, kieleckie, krakowskie, opolskie, rzeszowskie) 1958–1961 (Journey to work in southern Poland — Katowice, Kielce, Kraków, Opole, Rzeszów voivodships, 1958–1961), Prace monogr. WSP, 5, Kraków 1966;

T. Jarowiecka, Przemiany społeczno-zawodowe wsi krakowskiej (Changes in the social and employment structure of rural communities in Cracow region), Prace monogr. WSP, 3, Kraków 1963;

L. Pakuła, J., Rajman, Ośrodek przemysłowo-usługowy Raciborza i jego funkcje (Industrial and service center of Racibórz and its functions), Opole 1968;

J. Rajman, Procesy urbanizacyjne w obrzeżu Górnośląskiego Okręgu Przemysłowego po drugiej wojnie światowej (Urbanization processes in the fringe area of Upper Silesian Industrial District after World War II), Prace monogr. WSP, 7, Kraków 1969;

J. Rajman, Uprzemysłowienie a przemiany ludnościowo-osadnicze województwa opolskiego (Industrialization and demographic-settlement change in Opole voivodship), Katowice 1965.

nicka-Lyra [12] for this purpose. This method included proposals for objectivization of subjective opinions of experts; it was met with interest abroad (cf. Harvey's comment in his "Explanation in Geography" p. 273) and started an interesting discussion amongst Polish scientists. In 1969 a special conference on the subject of the delimitation of metropolitan areas was organized by the Commission of Urbanization of the Committee for Space Economy and Regional Planning of the Polish Academy of Sciences [13]. Here geographers played a leading role, both in the presentation of papers and later in discussion. Various methods were proposed and their value discussed. Earlier and later the same problem was pursued within the Central Statistical Office. Several studies and the gathered data were published [14]. A simple method and measure were adopted after prolonged discussion with the geographers participating, i.e. all towns and communes (*gromady*) whose non-agricultural population was over sixty per cent of the total population and formed a continuous area (with enclaves included) around a city of at least one hundred thousand inhabitants, were considered as metropolitan areas. At present, on this basis all statistics for metropolitan areas are gathered. It should be emphasized that with this definition, the areas for every cross-section do change in time.

Recently, other features for delimitation of large urban agglomerations were taken into account by geographers S. Leszczycki, S. Herman, and P. Eberhardt in their study undertaken for the so-called Committee of "Poland 2000" of the Polish Academy of Sciences [15]. The results, though varying slightly from those of earlier studies, do not present an overall different picture. However, this study gives a much better understanding of the anatomy of such areas, by including both the strongly centralized cities with very high population densities and rather underdeveloped suburban zones, and widely dispersed industrialized communes around several not very large and centralized towns, with all intermediary forms of large urban agglomerations in between.

The spatial growth pattern of such areas were also studied. Two typical cases, of different origins and tending to entropical similarities were defined; one where an urban agglomeration grows around a metropolitan or capital city, and another where it arises out of a coagulation of dispersed industrial developments.

The first case is well known and is often described in the literature with its phases of growth from a single strong nucleus through subsequent phases of concentrated ring development, subordination and absorbtion of formerly independent centres up to the phase when new satellites develop at the cost of central areas which leads to their redevelopment and modernization. In Poland a young geographer P. Korcelli [16] has recently proposed a new way of

[12] E. Iwanicka-Lyra, Delimitacja aglomeracji wielkomiejskich w Polsce (Sum.: The delimitation of large urban agglomerations in Poland), Prace geogr. IG PAN, 76, Warszawa 1969.

[13] Delimitacja obszarów zurbanizowanych (Delimitation of urbanized areas), Biuletyn KPZK PAN, 57, 1970.

[14] See for example:
M. Klimczyk, A. Mijakowski, Próba delimitacji regionów metropolitalnych w Polsce (An attempt to delimit the metropolitan areas in Poland), Wiad. stat., 13(1968), 3, 27–30.

[15] S. Leszczycki, P. Eberhardt, S. Herman, Główne ogniwa przestrzenno-gospodarczego rozwoju kraju, 1970–2000. (The main nodes of the spatial-economic development of Poland, 1970–2000), in: Prognozy rozwoju sieci osadniczej, Polska 2000, 4, Warszawa 1971.

interpretation for such phenomena in the form of a wave-like theory of growth of metropolitan areas.

In the second case the stages of development have never been systematically described or interpreted. It is only recently that during discussions on the development of settlement in the Upper Silesian Industrial District a theoretical generalization of such processes was proposed by K. Dziewoński. Three typical stages were defined. First, a loose grouping of industrial villages and plants begins to grow usually on the basis of the exploitation of some mineral resources. When the state of certain saturation develops, the second stage occurs in form of the emergence of several large centres of services, from which the major centre finally evolves — as the capital. But the final stage takes place later marking the full maturity of a new urban region, when the originally heavily one-sided, industrial functions begin to change and to diversify. It is only when in such an area, its community is able to adjust to change and to modernize its economic base, that this final stage in development is reached. An interesting feature, as already mentioned, is the merging of these two distinct types in their final stage in development. Here we have, I think, a real case of social and economic entropy.

A different problem which was recently studied in the Institute of Geography of the Polish Academy of Sciences by P. Eberhardt[17] concerns the role played by large urban agglomerations in the evolution of the regional structure of the whole country. The subject was analysed first in detail. The study had wide repercussions and it was found by various specialists to be of interest and of value although it had some serious weaknesses. First, the agglomerations covered by the study were chosen arbitrarily, then the data had not covered all areas and had to be extended by rough estimates, and finally some of the conclusions were perhaps drawn overhastily. Nevertheless, some very significant phenomena were defined very clearly for the first time in the world literature. The import and export regions of the agglomerations, covered by the analysis, were found to be spatially quite different in all cases. The regions of both types for different goods only coincided in some exceptional cases. The economic and social region did not resemble one another. Although the region-forming importance of a large urban agglomeration came out very clearly in the study, the resulting regional structure turned to be rather confused, only rarely integrating into more definite and sharply delimited regions. On the basis of such conclusions, perhaps it is possible to say that the regional importance of large urban agglomerations is connected with their strong economic and social potential, rather than with their well defined and typical functions.

All the studies, so far discussed, dealt with the functional problems of various types of cities but some morphological studies, especially those concerned with urban land utilization were also undertaken. The results obtained do not so far support wider generalizations, but some methodological problems are already well-defined and solved. Several typological systems for urban

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[16] P. Korcelli, Rozwój struktury przestrzennej obszarów metropolitalnych Kalifornii (Sum.: Evolution of the spatial structure of California metropolitan areas), Prace geogr. IG PAN, 78, Warszawa 1969;

P. Korcelli, A wave-like model of metropolitan spatial growth, Papers, Reg. Sci. Assoc., 24(1970), 127–138.

[17] P. Eberhardt, Wielkie miasta jako ośrodki koncentracji działalności gospodarczej i społecznej w Polsce (Large cities as focal points of the economic and social activities in Poland), Biuletyn KPZK PAN, 47, 1968.

land uses were formulated, assimilating experiences and needs of modern town planning and, in particular, of zoning practices [18]. The most developed, although not entirely convincing system, was recently elaborated by a young geographer of the Łódź University [19]. A proposal for the integrated morphological classification of urban settlements had been presented by a representative of the Institute of Geography of the Polish Academy of Sciences about 1960 [20]. This found wide repercussions and many followers. An interesting cartographical method of generalization in urban land-use studies was applied, for the first time, in the Tarnów study [21] and its author is now trying to apply it to a larger number of middle-sized cities. His aim is to identify specific general types, both regional and historical, of spatial patterns in urban land utilization, but the results are not yet fully edited. Finally, an analytical sampling method for an analysis of land utilization of very large urban agglomerations was defined and applied for the first time for the Warsaw Metropolitan Area [22].

In spite of all such research, the morphological analyses are in Poland well behind the functional analyses, both in the study of phenomena and in the formulation of theories.

However, the study of single or partial problems in the geography of settlements is now clearly giving way to the overall studies of the entire settlement network both for the whole country and for the individual regions. In fact, even some comparative studies at the international level are already well under way.

First, in various studies [23] general patterns of urbanization were identified.

[18] K. Dziewoński, Program i wskazówki dla inwentaryzacji urbanistycznej w terenie (The progress and instructions for the field survey in town planning), Prace Inst. Budown. Mieszk., 6, 1952, 21–26;

J. Rakowicz, Trzcińsko-Zdrój, użytkowanie ziemi w mieście (Land use in a town), Dokum. geogr., 2, 1958, 27–46;

A. Jelonek, A. Werwicki, Struktura przestrzenna Tarnowa (Sum.: Spatial structure of Tarnów), in: Studia z geografii średnich miast w Polsce. Problematyka Tarnowa, Prace geogr. IG PAN, 82 (in print).

[19] S. Liszewski, Użytkowanie ziemi w miastach woj. opolskiego (Land use in towns of Opole voivodship), Łódź 1970 (Doctoral theses).

[20] K. Dziewoński, Zagadnienia typologii morfologicznej miast w Polsce (Sum.: The problem of morphological typology of towns in Poland), Czas. geogr., 33(1962), 4, 441–457.

[21] A. Jelonek, A. Werwicki; See note 18.

[22] J. Grocholska, Możliwości ustalania czynników wpływających na użytkowanie ziemi w miastach na przykładzie m.st. Warszawy (Possibilities of defining factors influencing urban land use: a case of Warsaw), Warszawa 1971 (Doctoral theses).

[23] See series of papers by K. Dziewoński:

Procesy urbanizacyjne we współczesnej Polsce. Stopień poznania, próba syntezy (Sum.: Urbanization processes in contemporary Poland. An attempt at a synthesis), Przegl. geogr., 34(1962), 3, 460–508;

Urbanization in contemporary Poland, Geogr. pol., 3, Warszawa 1964, 37–56;

Changes in the urban network of Poland. Festschrift Leopold G. Scheild zum 60. Geburtstag. I Teil. Wien. Geogr. Schr., 18–23, Wien 1965, 218–226;

K. Dziewoński, L. Kosiński, Rozwój i rozmieszczenie ludności Polski w XX wieku. Ludność Polski Współczesnej (Population growth and distribution in Poland in 20th century. Population of Contemporary Poland), 1, Warszawa 1967.

Procesy urbanizacyjne (Urbanization processes) in: Zarys geografii ekonomicznej Polski, Warszawa 1967, 83–113.

Then these were extended in depth, to cover the last two centuries i.e. as far as the existing statistical data on population allow. But perhaps even more interesting than temporal changes, there turned to be the regional differentiation. The variety of models of settlement, in particular of urban network developed simultaneously in — generally speaking — similar conditions of social and economic progress, showing clearly how important may be the influence of difference in geographical environment and natural resources, the historical past and traditions or of particular mixes of political, social, economic and technological factors. Those models may be divided into two very different families. This is a very significant dichotomy. To a certain extent these families represent successive stages of urbanization. However, once established, they are characterized by specific immobility and permanence. As a result they influence, sometimes even decisively, the changes taking place at present. They lead up to large agglomerations of urban population, which slowly grow in very definite urban regions and regional networks of urban-rural central places, with more or less sharply concentrated and defined settlement units of various hierarchical importance.

To present such phenomena in a general way and on the national scale, various new concepts have been evolved and tested. The concept of "semi-urbanization" has already beed mentioned. A set of such concepts were recently presented by S. Leszczycki and his collaborators [24]. They identify the following areas: "urban" (or central), "fully urbanized", and "in process of urbanization". The remaining areas, not separately named by these authors, may perhaps be called "rural". It should be remembered that E. Iwanicka-Lyra [25], studying metropolitan areas and following the example of various foreign geographers (to mention only G. Chabot), divided these areas into core, internal and external zones. There is a strong analogy between these areas and the criteria used for their identification, but the concepts are now used not for the description of the internal structure of one urban agglomeration, but for the analysis of the socio-economic space of the whole country. Clearly, the need to treat all the settlement problems in Poland leads simultaneously to the important changes in the whole theoretical framework of urban settlement or even human geography.

Another problem to be tackled on the national scale is the dynamic aspect, i.e., the changes occurring in the settlement network and settlement structure, not only from the point of view of the general direction and trends, but also from the point of view of their mechanism, of the processes of becoming. Since the settlement network, or system, is a close and immediate corollary of the population distribution, so its dynamics and changes are a function of population migrations both temporary and permanent.

Interest in migrations is traditional for Polish geographers. After the war, the main subject was the wartime movements and postwar resettlement processes. The problem of the Western Territories was analysed thoroughly, both on national and regional levels [26]. Interest then shifted to the phenomena of commuting. These were studied several times, for the whole of Poland, the

[24] See note 15.

[25] See note 12.

[26] L. Kosiński, Migracje ludności w Polsce w latach 1950–1960 (Sum.: Population migration in Poland in 1950–1960), Prace geogr. IG PAN, 72, Warszawa 1968.

best research being done by T. Lijewski [27] and J. Lewiński [28]. J. Lewiński developed an interesting method for the description of the character and structure of commuting and in the end he produced an urban typology from this point of view. Amongst the regional studies, a number of very detailed and methodologically excellent ones were executed in the Crącow College of Pedagogy for various areas and regions of Southern Poland [29].

In the last years, a strong interest in the tourist movements is developing although as yet no detailed results of the undertaken research have been published.

However, the permanent rural-urban migrations are of the greatest interest. Various, more or less detailed studies were executed and published by geographers as well as by demographers, sociologists and economists but the basic aspects — from the geographical point of view — were not satisfactorily analysed. Only recently, a number of such studies have been undertaken by the Institute of Geography of the Polish Academy of Sciences. In particular, two problems are to be classified.

First — the mechanism of rural-urban migrations: is this a one-way process, or a series of movements in which at least a part of migrants move back and forth or by stages? An interesting study on the role played by schools in such migrations is already finished [30] showing the complexity of the problem changing with time and space (region).

Secondly — the existence (or not) of a correlation between areas of permanent and temporary migrations with the solution of an additional problem to what extent the model of the intervening opportunity is a realistic one in Polish conditions.

The first results of these studies seem to be very promising but we have to wait patiently for their end before we shall be able to appreciate their scientific importance.

Two conferences played a special role in connection with theoretical and methodological approach in the human geography. The first conference, at Osieczna of December 1956, marked the starting point for the strong development of various specialized branched of geography; among these of the settlement geography [31]. The second meeting, held in Jabłonna in April 1966, dealt with general basic problems of geography such as its logical foundations, the importance of theoretical generalizations, model construction, the application of quantitative methods and others [32]. There was no specific paper or, in discussions, any direct reference to settlement geography. However, at the conference the theory of the economic region and economic regionalization

[27] T. Lijewski, Dojazdy do pracy w Polsce (Sum.: Commuting in Poland), Studia KPZK PAN, 15, Warszawa 1967.

[28] S. Lewiński, Dojazdy do pracy jako element typologii miasta (Sum.: Commuting as an element of towns' typology), Przegl. geogr., 38(1966), 4, 715–724.

[29] J. Herma, see note 11.

[30] J. Jaroszewska, Przestrzenne zróżnicowanie losów absolwentów szkół podstawowych w woj. warszawskim (Sum.: Further education and professional development of former pupils from primary schools in the Warsaw voivodship — territorial analysis), Przegl. geogr., 42(1970), 2, 309–334.

[31] K. Dziewoński, Geografia osadnictwa i zaludnienia. Dorobek, podstawy teoretyczne i problemy badawcze (Sum.: Geography of population and settlement — achievements, theoretical bases and plan for research), Przegl. geogr., 28(1956), 4, 721–764.

[32] See Przegląd Geograficzny, 39(1967), 1, 13–227.

was presented and widely discussed. In view of the present efforts to integrate this theory with the system analysis of settlement networks, this may be considered as a significant step in the evolution of the theoretical concepts used in the settlement geography.

As far as this branch of geography is concerned, the theoretical and methodological studies are undertaken in practically all stronger centres of geographical research, in particular of Cracow, Łódź, Poznań, Warsaw and Wrocław. Nevertheless, the most important among them is the Institute of Geography of the Polish Academy of Sciences. There a systematic reappraisal of recently developed concepts and methods is carried on.

First, the concepts of the urban economic base and of the functional structure of a city have been reviewed [33]. The achieved result may be considered as quite satisfactory; new methods, leading to interesting theoretical generalizations were developed. By simultaneous use of various indirect methods (in particular of the location indices and the minimum requirements) a better understanding of the structure of economic base was reached, and the subdivision of the exogenous activities into regional, spatially defined (or normal) and foot-loose, spatially undefined (or specialized) ones, leads to the integration of the economic base with the theory of the economic region as well as with the theory of central places.

The study of the empirically established rules i.e. of the rank-and-size rule (sometimes called, but not correctly, the Zipf rule) and of the diminishing ur ban density rule (also called the Clark rule) led to their reinterpretation. So far the results are not published, but they are to be discussed and tested in detail at the Rome European Congress of the Regional Science Association. They consist of a more formal and general formulation of the rules, and the definition of the conditions and possibilities for their correct use, both for the research and planning purposes.

Materials for the critical review of the central place theories are at present being collected. The perspectives for the identification of their place and role in the wider field of the theory of settlement system seem to be very propitious. Also, out of such a review a wider, more general and probably better formalized statement of the whole theory may grow.

Polish geographers are at present preparing the theoretical and methodological development of the concept of settlement, and in particular of urban system within a country (or within an economic region). It seems necessary that for such a purpose the following elements should be defined and identified:

(1) principles of the social territorial division of labour between various settlements and types of settlements, or at least between basic settlement subsystems;
(2) identification of basic subsystems within the whole national settlement system, as well as their delimitation;
(3) structure, cohesion and stability of the settlement system and subsystems;
(4) actual dynamics of the whole settlement system both in relation to the outside world and its internal structure.

[33] K. Dziewoński, Baza ekonomiczna i struktura funkcjonalna miast. Studium rozwoju pojęć, metod i ich zastosowań (Sum.: Urban economic base and functional structure of cities. A study of the development of concepts, methods and applications), Prace geogr. IG PAN, 63, Warszawa 1967;

K. Dziewoński, M. Jerczyński, Baza ekonomiczna i struktura funkcjonalna miast (Sum.: Urban economic base and functional structure of cities), Prace geogr. IG PAN, 87, Warszawa 1971.

However in this field of the settlement system we are still not yet able to go into any detail. This will not become feasible until the collection of the material, as well as the theoretical. methodological and empirical inductive studies, are much more advanced then they are at the present moment.

Recently a wide discussion has been started about the future development of the settlement system. The political and economic authorities have asked for a prognosis of such a development; this is needed for the revision of the present policies applied in the planning and management of cities, towns and other settlements. An ambitious programme of research was constructed and it is to be implemented in the coming years. However, before describing it in detail, the work on simulation models of urban system or network should shortly be mentioned as they may play an important role in forecasting future developments.

The work on the simulation models of urban network is at present centred in Wrocław (T. Zipser) and Poznań (R. Domański). The Wrocław studies have developed out of the models simulating the growth of individual cities. The Poznań ones, although more dependent on the American experience, are wider in scope and ambitions. The study of simulation models as carried out at Warsaw, is to be concentrated on the local rural-urban networks. Their aim is to estimate the probable direction of changes which with so many contradictory factors and tendencies are very difficult to define, especially as far as the concentration and dispersal of dwelling places and settlements of all sizes are concerned.

The proposed research for the years 1971–1975 is to be concentrated on one main theme: the settlement system of Poland. The research should provide a sound basis for the physical planning of settlements on all levels, i.e., national, regional and local. From the scientific point of view its interest lies in the development and testing of the concept of a "settlement system". The results may help in the crystalization of a theory which integrates all the more limited and so-far partially developed theories. This is certainly a very ambitious aim, but its implementation — although difficult — seems to be possible. It involves a study of the following subjects: (1) the definition of a settlement system in relation to the outside world, i.e., the open or closed elements in its social and economic structure and activities; (2) an identification of its internal structure, its subsystems, both spatial (regional) and functional; (3) a delimitation of the whole system and its subsystems; (4) an analysis of the cohesion of the system and its subsystems; (5) a study of its stability or its permanence, and finally (6) a study of transformations taking place in the system, in particulary of its growth.

There is no necessity to discuss such a programme here in detail. However, it should be added that three types of the subsystems were provisionally identified and they are to be analysed more closely. These are: metropolitan areas, regional systems of central places and a local system of rural-urban communities. Moreover, studies of simulation models for the spatial development of urban systems are to be continued on all three levels — national, regional and local, as well as the review of basic concepts, methods and theories of settlement, and in particular of urban geography.

It is hoped that this research programme will be closely tied to future work of the Commission on Patterns and Processes of Urbanization and that a report on its achievements and failures will be read in 1976, at the next International Geographical Congress.

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THE DEVELOPMENT OF THE AGRICULTURAL LANDSCAPE OF POLAND

HALINA SZULC

Research into the agricultural landscape of Poland has a rich and long tradition. The pre-war achievements in this domain are to be attributed mainly to historians (T. Wojciechowski, F. Piekosiński, K. Potkański, O. Balzer, K. Tymieniecki, H. Łowmiański, F. Bujak, K. Dobrowolski and others) who created the foundations of historical-settlement studies in Poland. As a discussion of these works is beyond the scope of the present paper, I have been forced to limit my considerations to only those post-war studies which have truly contributed to the knowledge of the development of the agricultural landscape of Poland.

In the post-war period the interest of archaeologists and historians in the early medieval period was stimulated, chiefly by the 1000th anniversary of the formation of the Polish state. Since 1948 archaeologists and historians have undertaken a large number of joint works to which specialists from the social and natural sciences have contributed also. Above all, excavations of settlements in Greater Poland deserve attention. These were started by J. Kostrzewski and his disciples in the interwar period and have been continued after the Second World War using new research methods mainly under the direction of W. Hensel, Z. Rajewski, K. Majewski and W. Kočka. Methodological studies and summaries have been supported by a large number of empirical monographs from various parts of the country, chiefly from the southern part of Greater Poland, Lusatia, Western Pomerania and Silesia and partly from Mazovia.

These studies have brought much new information and have revealed data concerning the beginnings of the Polish State. These data are not only written sources, which occur considerably later in the beginning of the 12th century although mainly in the 13th century but also from archaeological sources dating mainly from the 7th–11th centuries.

Due to their scope and methods, studies on the origin of the Polish State are considered a great achievement of Polish science. Results of these works have been summarized among others by J. Bardach, A. Gieysztor, W. Hensel, H. Łowmiański, K. Tymieniecki, S. Trawkowski. These works, besides extending the knowledge about the origins of the Polish State have contributed also to the study of other problems, among others of agriculture, animal husbandry, the history of handicrafts, the origins of towns and of art.

On the other hand the contribution of geographers to this research is smaller. Noteworthy works concern chiefly the reconstruction of the former geographical environment and of the topographical setting of forts and settlements

(J. Dylik [12], S. Zajchowska [67], M. Kiełczewska-Zaleska [28], B. Świderski [63]). The attention of geographers was concentrated mainly on later periods. Especially valuable is geographical research on medieval settlement. Retrogressive methods have been applied to these studies, namely the analysis of historical plans of settlements as the main source basis.

The history of the agricultural landscape is the history of the activity of settled man whose fundamental occupation was agriculture. The oldest agricultural areas within the present territory of Poland are the fertile loess soils with park and steppe vegetation.

The Lusatian Culture is the chief proto-Slavoic culture (1300–1200 B.C. until 300 B.C.) others being so called Pomeranian Culture appearing somewhat later, first in Pomerania and then in Greater Poland as well as in some regions of Silesia and Lesser Poland and the Cloche Graves Culture along with some groups of the Pit Grave Culture. There are strong resemblances between the Lusatian and the Pomeranian cultures as to the method of building homesteads, the type of farming and of ceramics [17].

Originally unwooded areas were brought under cultivation but later, along with the growth of population woodlands were cleared in order to obtain cultivated fields. In the so-called slash and burn agriculture the woods and the undergrowth were burned leaving large trunks which were difficult to remove. Ashes from the burnt forest were a good fertilizer for the soil. When the soil became barren the people moved to another area. In this way the economy was of a mobile character with a several year rotation.

Many forts which were situated near rivers or lakes have been preserved from the period of the Lusatian culture. These forts were situated in places which were not easily accessible, at fords and on islands and peninsulas of lakes. The largest among the Lusatian settlements we know, is a defensive settlement at Biskupin (Żnin poviat, Bydgoszcz voivodship), excavated on the shores of a lake. This settlement consisted of a row of homesteads arranged along streets and surrounded by a rampart of wood and earth as well as by a breakwater made of beams and piles. Handicrafts developed around the forts e.g. pottery found in Kujawy, around Kalisz and in the neighbourhood of Łęczyca and Sieradz.

The survival of settlements on the same sites from the times of the Lusatian Culture until the Roman period has been proved in many places. The continuity and the stabilization of settlement is connected with agriculture which facilitated the maintenance of larger groups of population.

In the Roman period, along with thriving trade, the agriculture developed further under the influence of the better methods of management of the peoples from the South, especially under the Celtic influence. Improvement of tools and of cultivation techniques followed [17, 64]. This process began first in the south of Poland (in Silesia and in Lesser Poland), then it passed to Greater Poland and further to the north. The contacts with ancient Rome are proved by the numerous Roman imports which are found, such as various vessels, ornaments, coins and objects of religious worship [41]. They occur not only on the so called "amber route" but also in the adjacent territories. The map compiled by K. Tymieniecki (Fig. 1) presents the hypothetical extent of the more densely populated, agricultural areas of that period. In the basins of the Vistula and the Oder there were at this time some better developed territories not linked with each other and the evolution of these in the system of tribalism led with time to the formation of the Polish State in the 10th century. To these territories belonged the fertile areas between Cracow and

Sandomierz, around Wrocław and Opole and the largest of them in Central Poland round Kalisz, Łęczyca and Kruszwica and in Pomerania round Kołobrzeg.

In this period millet was the main staple food; rye, wheat and barley not occurring until later. In connection with the archaeological research on the origins of the Polish State detailed studies on the vegetation finds were carried out. As a result, studies of the vegetation cover, of cultivated plants and of trees and vegetables in the Roman period are highly advanced in Poland.

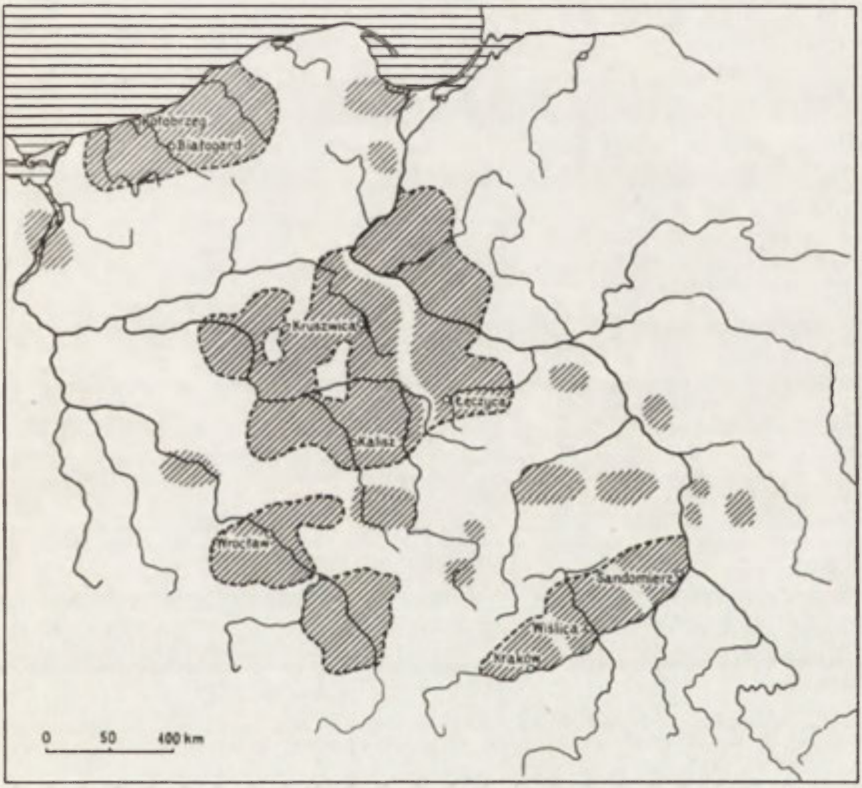

Fig. 1. Map of settlements and economic centres in the Roman period
On basis of the traces of imports and coins, according to K. Tymieniecki [64]

Some attempts at the periodization of the development of agricultural techniques have also been made.

Progress in agriculture did not occur equally in the whole country. The process of the development of a plough economy passed from the south to the north, e.g. in Greater Poland the cultivation of rye was not known until the 6th century (Bonikowo, Kościan poviat). The old forms of cultivation were maintained for a long time alongside the newer forms. These phenomena could have had a different development in various parts of Poland but this has not been studied adequately yet. The fact, however, that the agricultural landscape with a developed plough economy with draught animals was known already before the formation of the Polish State in large areas in the central and southern part of the country, has been well proved by recent research.

Poland, whose name is derived from "pole" meaning field, had in her early historical period (from 6th till 9th century) a few tribal territories, each of which had considerable unforested agricultural areas. "Opola" were the way in which family and neighbourhood units were banded together. Within these the arable land was the common property of certain families. According to K. Tymieniecki the "opole" was of an intermediate character between the tribal and the territorial organization. The size of the "opole" varied from 200–250 square kilometres in central Poland [45]. It is assumed that "opola" were established already before the 6th century A.D. [13, 14]. Later on, the "opola" became subordinated to the state authorities.

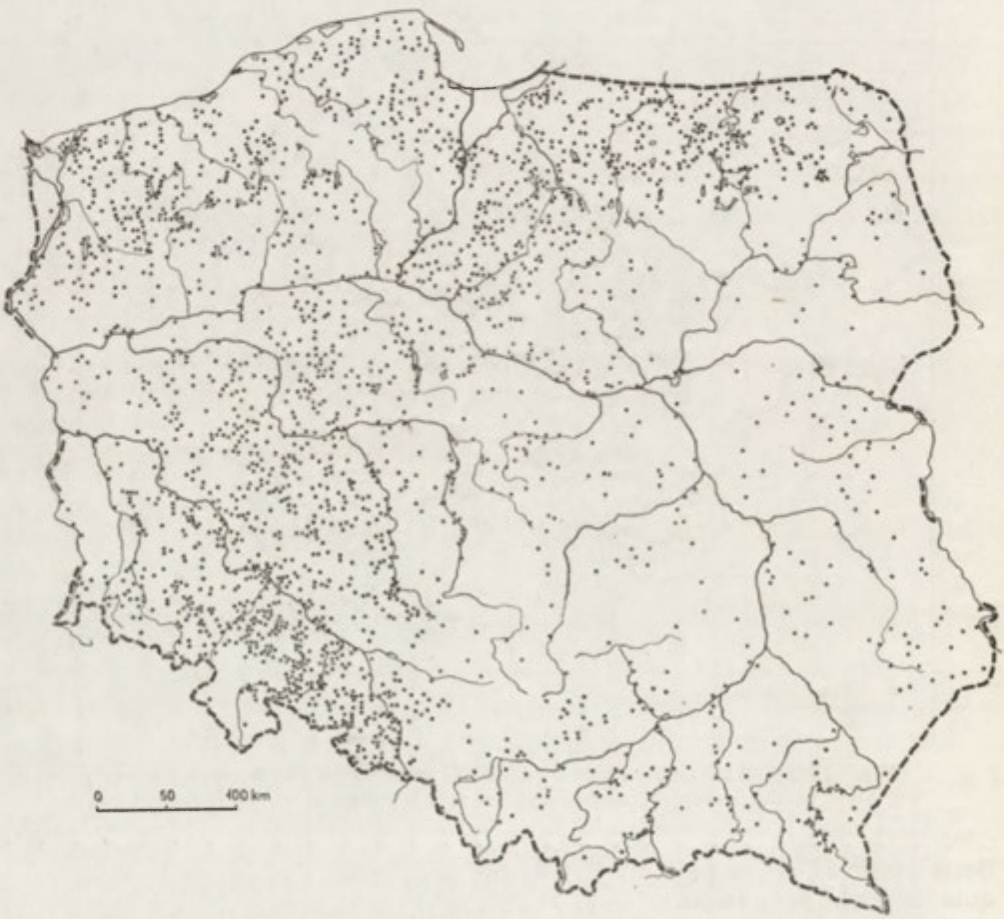

Fig. 2. Map of forts. Situation of research in 1964, according to W. Antoniewicz and Z. Wartołowska [1]

A permanent network of defensive settlements, the so-called forts was the basis of the territorial organization. What were these forts in the light of recent research? This is the problem which was studied especially in the archaeological research, carried out in view of Poland's millenium.

The forts developed in the most densely populated areas and in many cases on the site of an earlier settlement. Z. Podwińska [45] on basis of Z. Hilczer's

[20] studies has distinguished two types of forts: small forts with a diameter of 45–80 m and a surface area of 500–1500 m^2 and large forts with a diameter of 100–150 m and a surface area of 2500–8000 m^2, sporadically exceeding 10,000 square metres. The building of this type of a fort in a region caused the disappearance of smaller settlements situated nearby. In this way, according to Z. Podwińska, who summarized the archaeologists' statements, a temporary concentration of the dispersed settlement was effected in the forts. Forts were inhabited by members of territorial communities which subsisted by agriculture and animal husbandry. In connection with the above forts should be considered as rural settlements of a defensive character.

The greatest number of forts and of open settlements have been preserved in Greater Poland, in Lusatia and in Lower Silesia, while they are less numerous in Lesser Poland (Fig. 2).

According to the opinions of many archaeologists and historians, the building of forts occurred later, mainly in the 10th and 11th centuries and was connected with the military, administrative and fiscal requirements of state authorities or of great properties. On the other hand the rural population lived in open settlements surrounded by fences. In view of the growing demand for various services on the part of the feudal class, various servants and artisans came to settle round the forts. In this way the settlements arose around the forts and they together with the *suburbia* which were frequently also fortified became later the core of Polish towns.

According to W. Hensel's studies [17] the distances between larger forts amounted to 50–70 km between the large and medium forts — half of this distance while smaller settlements were situated half way in between these. In this way the basic settlement network of Poland was created at the end of the early Middle Ages.

Worth mentioning is the fact that within the last few years attention has been drawn not only to the study of forts but also of the open settlements, mainly the *suburbia* and of whole settlement complexes embracing a few small settlements or one large settlement surrounded by smaller ones.

It is very difficult to determine the layout of early medieval open settlements. An obstacle in many cases is the random selection of archaeological stands and mainly the impermanence of the building material. Z. Podwińska [45] has distinguished three types of buildings: (1) subterranean and semisubterranean huts (known mainly in the early medieval period, in 6th–7th centuries), (2) ground buildings with parts built into the ground, and (3) the real ground buildings. The type of building depended mainly on the surface morphology and the level of the ground water. Subterranean huts could only be built on higher ground or an artificial embankments, while the semisubterranean huts occurred in settlements situated in river valleys or on holms. The ground buildings had a framework of beams and piles.

On the basis of a detailed study of several open settlements around forts from the whole territory of Poland, conclusions can be drawn concerning the layout of the sites of early medieval villages (6th–11th centuries). These settlements had a dispersed, disorderly built-up area (e.g. settlements at Bruszczewo and Bonikowo in Kościan poviat and Szeligi, Płock poviat [62], or else they were compact. Among the dispersed built-up areas the following types can be distinguished: the row layout connected mainly with the relief (e.g. Lisewo, Wąbrzeźno poviat [8], Fig. 3, or Jarszewo, Kamień Pomorski poviat, Gołańcz, Kołobrzeg poviat) or settlements which had central squares. One of the best known settlements with a central square is the settlement at Biskupin, Żnin poviat [43, 45, 47].

Most archaeologists assume that settlements with a central square and with a compact built-up area, situated on heights, were of a defensive character and that these settlements played an important role in the formation of the oldest, early medieval forts which should be considered as fortified villages. On the other hand, in settlements with a loosely build-up area, the central place probably served the purposes of artisan production or was utilised for herding the cattle for the night. From this period both small settlements with one or two homesteads and large ones having 5–10 and even as many as 20 active homesteads have been discovered [45].

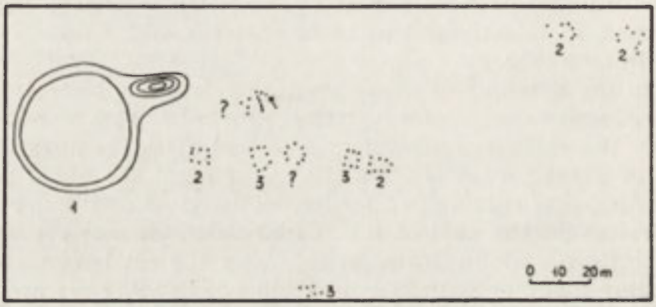

Fig. 3. Plan of the suburbium settlement at Lisewo, Wąbrzeźno poviat, Bydgoszcz voivodship, compiled by J. Dalekta [8]
1 — fortified site, 2 — hut, 3 — harm-hut

The topographic setting of settlements and especially of forts was highly dependent on the morphology of the land and on the hydrography, which has been discovered by the studies of Z. Rajewski, J. Kamińska [24], J. Kaźmierczyk and Z. Podwińska as well as by studies by geographers, mainly J. Dylik [12], M. Kiełczewska-Zaleska [28], S. Zajchowska [67].

On the other hand, the research on the early medieval field pattern, which most often was effaced by subsequent cultivation, is not very advanced. It is assumed that fields made in the forests were in the shape of blocks because according to the agricultural technique of that time, the field had to be "ploughed" twice, lengthwise and crosswise, by means of an ard. In result, the field took the form of a square.

The settlement regions delimited by the finds of Roman imports from the antiquity were also settlement centres in the early Middle Ages. Densely populated ancient tribal centres around Gniezno, Kruszwica and Poznań constitute the territorial centre of the Polish state. Round large forts along the oldest commercial routes, on the fertile soils of Silesia, Lesser Poland, Kujawy, the Chełmno Land and Pomerania, considerable concentrations of population were established. Also, the oldest iron-working centres of the early medieval period were found in these areas.

Centres of industrial and artisan production were at the same time centres of agricultural production intensely developed due to cultivation with the help of draft animals. Millet, rye, wheat and barley were cultivated mainly, and in the neighbourhood of forts vegetables were grown.

On the other hand on the untilled land in the forests, still fertilized by ashes, the slash-and-burn economy prevailed and millet was cultivated. The forest landscape remained in the mountainous and upland areas, on watersheds, in the lowlands of ancient river valleys and in river forks. The tribal centres were separated from each other by great forests which were not cleared until the late Middle Ages [7, 9, 10].

It is possible to get to know the agricultural landscape of Poland of the medieval period not only by way of archaeological research but also on basis of historical documents and of cadastral plans from the beginning of the 19th century, by the aid of which ancient forms of settlements can be reconstructed. Team research depending on the joint utilization of all accessible sources of information such as the results of field investigations, studies of historical and toponomastic documents and of historical plans make it possible to acquire a better knowledge of medieval settlement.

The Polish equivalent of the Latin word "sors" occurring in historical documents is "źreb" which in colloquial language means "lot". It is assumed that a "lot" defined a piece of ground which was assigned to particular families by drawing lots. Rural settlements of the 12th and the beginning of the 13th centuries constituted complexes of independent units, namely of "źrebia". Z. Podwińska [45], having studied the rich source basis for the period from the 12th century until the beginning of the 14th century distinguishes various types of settlements with a "źreb" structure: (1) single "źrebia" situated in isolation, (2) larger settlements with several homesteads based on "źrebia" and (3) settlements surrounded by "źrebia".

A "źreb" embraced only arable land, namely the inherited land obtained by drawing lots without the meadows and pastures which were common property. Opinions differ, as regards the size of a "źreb", or of the domain, i.e. the whole property belonging to one homestead, on account of different conceptions of this term depending on the time and place of its occurrence.

In Silesia the word "sors" was often replaced by the word "villa" or "pars villae". A few "źrebia" were joined together to form a village with a "źreb" structure, with several homesteads and with fields in an irregular block pattern. The uniting of the individual "źrebia" in order to make one village was accompanied by the so-called „ujazd" (*circuitio*) that is drive around the property for fixing its boundaries. The "ujazd" usually embraced one large property which was composed of a few "źrebia", or, especially in the later period, even of a few villages. The characteristic feature of the "ujazd" was the guarantee it gave to the proprietor of the exclusivity of the rights of the land within the "ujazd". Therefore, one should consider the "ujazd" as the first stage in fixing village boundaries at the time of the feudalization of the country and of the formation of great properties.

The "ujazdy" were effected above all in settlements which were the property of the church, more seldom in the properties of princes or the gentry. Particularly interesting are the documents relating to the "ujazd" of Trzebnica embracing 13 villages belonging to the monastery of Trzebnica, one of the oldest convents in Silesia dating from the 11th century. On basis of these documents some interesting scientific works were published, discussing villages included in this "ujazd" (K. Dziewoński [11], J. Kaźmierczyk and Z. Podwińska [26], M. Młynarska-Kaletynowa [42]).

According to many historians the "ujazd" appeared in the southern regions of Poland (Silesia and Lesser Poland) in the first half of the 12th century or at the turn of that century. "Ujazdy" became more widespread in Silesia and Lesser Poland at the end of the 12th century and early in the 13th century, while in Greater Poland, Kujawy and in the central regions of Poland not until about the middle of the 13th century [45].

The formation of "ujazdy", strictly defining the boundaries of a property was accompanied by the intensification of agriculture thanks to the improvement of tools and the introduction of a two- or three-field system instead of the long fallow system which was the repeated cultivation of the same piece of land until it became completely barren when it was left to lie fallow for many years.

It is assumed that the intensification of agriculture and the settlement by Polish Law associated with it took place mainly in the first half of the 12th century. In this period villages with an irregular three-field pattern (Fig. 4) represented the prevailing type. The "zreb" consisted of a few fields or open fields ("niwa") which name is derived from an area of land free of forest on which the three-year rotation was practised. This rotation concerned mainly the fields situated nearer the buildings. In villages located by Polish Law attempts were undertaken to integrate the fields and to change to the irregular three-field system in order to increase the arable area and to utilise the land

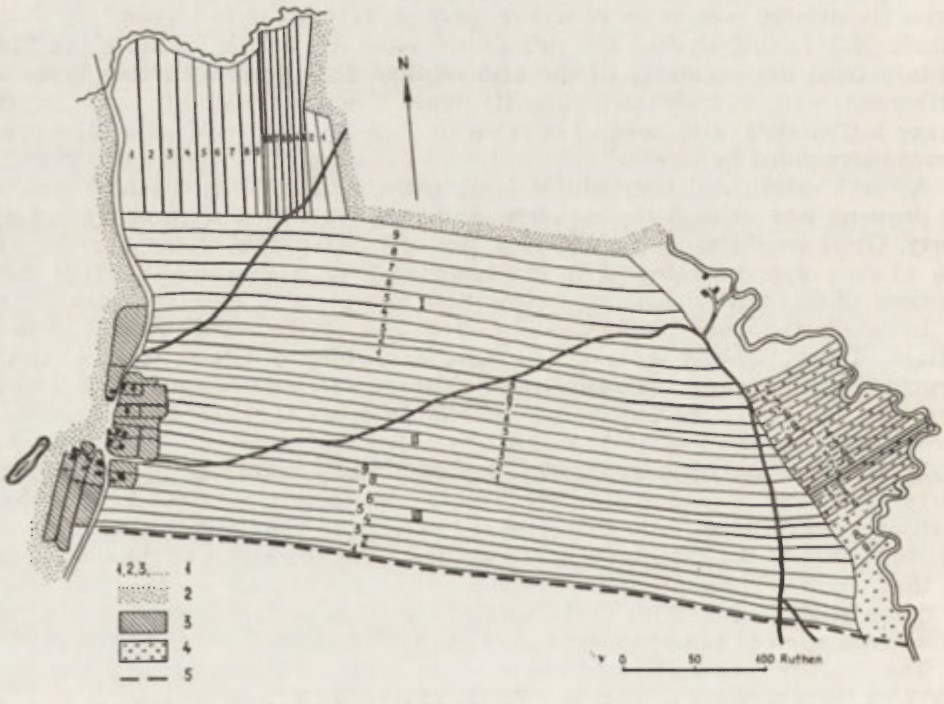

Fig. 4. The village Zabno, Miastko poviat, Koszalin voivodship

Redrawn from a 1797 plan of the village, which was reorganized in 1820. A round village with a three-field system. The village was inhabited by 9 peasants. The manorial property has not been marked on the village plan. 1 — 1,2,3,... peasants property, 2 — manorial property, 3 — nucleus, 4 — meadow, 5 — border with the neighbouring village

more intensively. This process was continued later (mainly from the 13th century onwards) in connection with the influx of colonists from Germany and Flanders and also in connection with the depopulation of the country after the Tartar invasions. The integration of fields and the three-field system brought about material profits, therefore the transformation of already existing villages or the establishment of new ones by the so called German Law was undertaken on a large scale and this was connected with the reorganization of the villages.

Thus superimposed on the ancient native settlement network, developed over many centuries of evolution of spatial forms of settlement under the tribal system, from about the 13th century onwards were new types of settlement forms linked with the German Law. Within this period the settlement network became more dense, new forms of land property were developed and this involved far going transformations of the agricultural landscape.

Great spatial changes of the country were also connected with the change to a rent economy and with the regulation of peasants' obligations. The colonization by German Law and the social and economic changes involved spatial changes through the integration of a few small villages and the demarcation of the boundaries of villages, nuclei and fields. In connection with the introduction of the three-field system, three open fields of their multiples were measured out in the village. These fields were divided into long strips ("zagony") and every farmstead in the village possessed a strip in each field (Fig. 4).

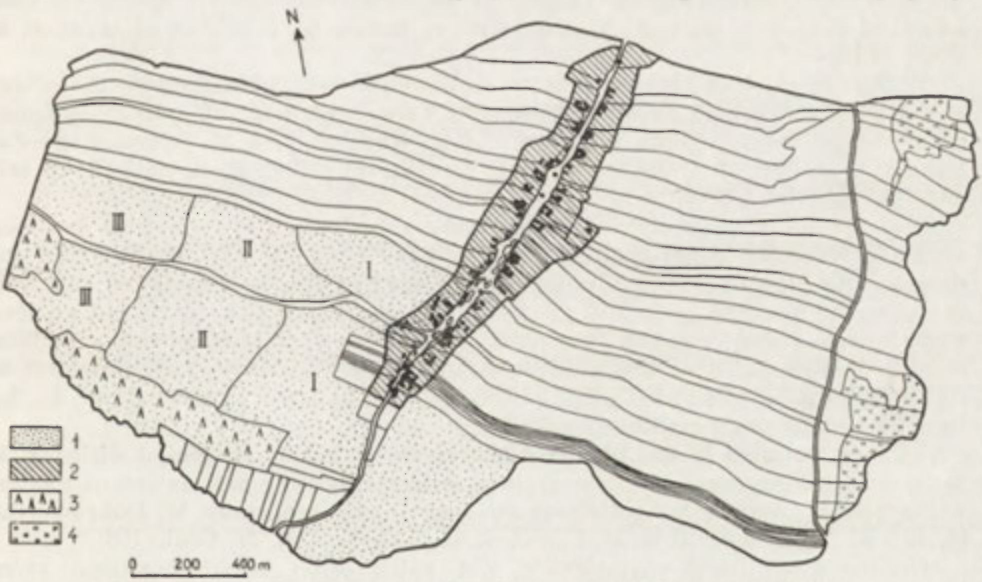

Fig. 5. The village Lubiatów, Grodków poviat, Opole voivodship

Redrawn from a 1825 village plan. A regular Waldhufen village, located on German law about 1300. The manorial property in blicks was created by the integration of a few open fields. Peasants property in strips [58]. 1 — manorial property in blocks, 2 — nucleus, 3 — forest, 4 — meadow

Long strips were characteristic of plough cultivation which was introduced in some farms in the first quarter of the 13th century and popularized by the middle of this century [40, 44]. The plough drawn by two or three pairs of oxen was not easily manageable and, in contrast to the ard, required considerable space. In connection with this so-called "uwrocia" (turnings) were formed at the end of the fields. Hence the longer the field, the smaller was the percentage of land lost at the end of the field. So in connection with the introduction of the plough as the basic tool of cultivation, there developed in the place of square shaped fields, long fields characteristic for this form of cultivation. These fields were usually measured anew in the units used in the Middle Ages at the transference of the villages to the German Law. In Silesia this was most frequently the Flemish or Franconian "mansus" [56, 58, 59]. The mansus ("łan") became the synonym of the former "sors" or "źreb" and at first it usually meant the property of one family (Fig. 5).

In the period of the colonization of villages by German Law Waldhufen villages were set up on new sites in hilly, wooded areas. Instead of dividing the village into open fields and holdings, long parallel strips were marked out and were given to the settlers.

Due to the introduction within the last few years in our country and abroad of new methods of analysis of historical plans of settlements [31, 57, 60]. One may state on the basis of a settlement plan whether the village was formed within a relatively long period of time by way of evolution, or in result of a single, planned action. For Polish conditions an analysis of the village plan answers the question whether the village has the old spatial layout traced back to the "źreb" type of village economy or whether it was established or reorganized in the Middle Ages according to the types prevalent at that time. Regular open field villages and Waldhufen villages prove that the area was brought under cultivation all at once at the location of the village by German Law and that the "mansus" was the unit of measure as well as of taxation in these villages.

Within the last 25 years numerous works have been published on the origin and reconstruction of ancient settlement forms on basis of village cadaster plans. These are primarily the works of F. Warężak [65], M. Kiełczewska-Zaleska [29, 30, 33], M. Dobrowolska [9], W. Schramm [51], E. Kwiatkowska [37] and H. Szulc [56, 58, 59].

Villages founded in the late Middle Ages had usually a compact built-up area and were for larger than villages on the Polish Law. It results from studies on the Opolan Silesian villages [58], that in the beginning of the 14th century, the average area utilized by one village with the open field pattern amounted to about 5 sq.km. Of course, this figure depended on many factors, chiefly on the origin of the village, the morphology of the land, the kind of soil and the size of the so-called "border belt" assigned to the village at the time its boundaries were delimited.

Villages planned in the Middle Ages were situated in the plains with fertile soils, on areas embraced by the earliest settlements. The association of medieval settlement with good soils was stressed among others by M. Dobrowolska [9, 10], S. Zajchowska [66], M. Kiełczewska-Zaleska [29], H. Szulc [58].

On the other hand on unfertile, wet soils, often situated within river meanders and in forests, small villages, which until the 15th century have been on the Polish Law, were preserved for a relatively long time.

Areas with fertile soils, as M. Kiełczewska-Zaleska has pointed out in her work on the Gdańsk Pomeranian villages [29], are not only areas of old settlement, but also the scene of the more rapid economic and social progress. Only later colonization penetrated the forests and the less fertile areas.

The process of the intensification of agriculture and the establishment of regular open field villages and of the three-field system advanced from the west to the east. In Podlasie it did not develop until the 16th century. In order to increase the returns from manors and from peasant holdings, an integration of villages and a reorganization on a large scale took place in the middle of the 16th century. The reorganization of villages by means of the so-called "pomiara włóczna", a method of re-measurement, was effected in Podlasie and in Lithuania, first on royal property and later also on private estates. Thanks to this reform the buildings were concentrated along one road, usually in the middle of the fields. These villages had a field pattern of two or three open fields and the nucleus was on one field only [33]. The open field pattern connected with this kind of measurement and based on the three-field system has been preserved until present times in the Białystok voivodship [3, 15].

The feudal period is very important in the evolution of the agricultural landscape of Poland, because settlements established at that time have become the basis of the settlement form which has been preserved until now. M. Kiełczewska-Zaleska proved [32] that villages of feudal origin still cover large areas of Poland (Fig. 6). Relicts of open field villages, with a nodal road system, can be seen in Silesia, in the southern part of Zielona Góra voivodship, in some parts of Greater Poland, of Pomerania and the Białystok voivodship. Such villages appear also in central Poland — although in a much transformed form as a result of the later evolution of the villages. In Lesser Poland such villages are much less frequent.

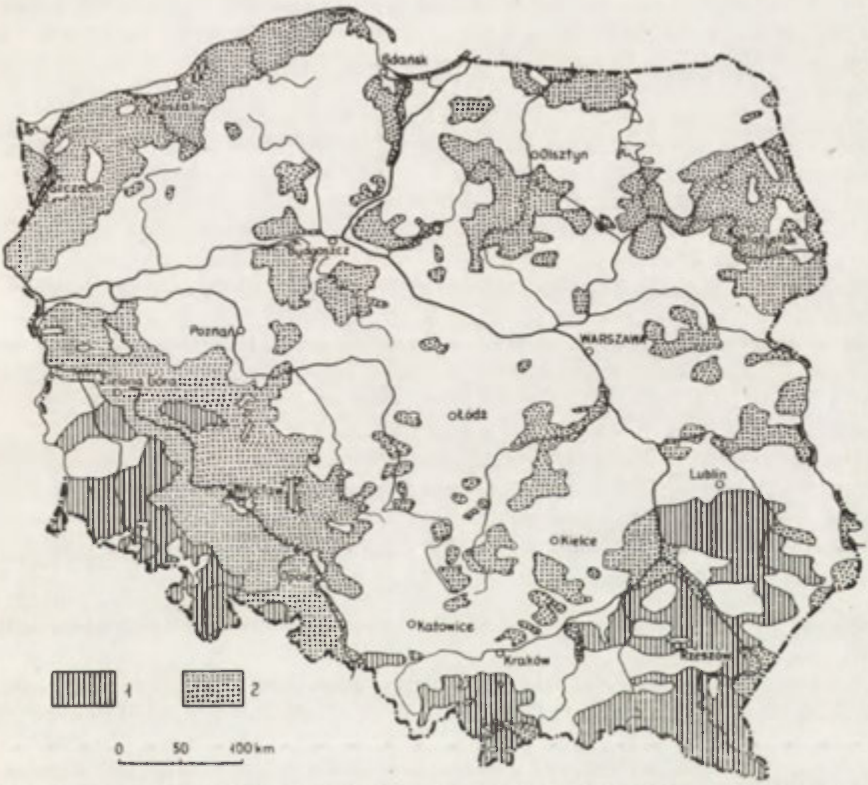

Fig. 6. Best conserved relicts of villages of feudal origin (after M. Kiełczewska-Zaleska [32])

1 — network of large concentrated villages, of over 100 homesteads, situated in rows along the valley (Waldhufendörfer), 2 — network of medium size villages (20–100 homesteads situated in the centre of fields and at a road crossing (primarily open-field system)

On the other hand relicts of Waldhufen villages have been preserved mainly in the south of Poland, in the Sudets and Carpathian mountains, in the south of the Lublin Upland, and also south of Zielona Góra and around Leszno. So the distinction made in the Middle Ages between the Waldhufen and open field villages is evident until now in the agricultural landscape of Poland.

Changes which occurred in the agricultural landscape in later periods are better known, so I shall limit myself to a short enumeration of the periods and the newer processes. Studies carried out lately have improved our knowledge of the re-feudalization processes of villages. Since the beginning of the 16th century great changes have taken place in the socio-economic development of Poland in connection with the introduction of the bondservice farming system. This process was connected with the increase of grain prices caused by the possibility of exporting grain abroad and of increasing supplies to the domestic market in view of the growth of towns. The growing demand for agricultural products exported to West European countries induced the gentry to organize manors based on bondservice labour. Private owners were the pioneers of this movement, therefore manors appeared in villages belonging to private owners and less often in royal or church property [51].

In Greater Poland, Pomerania and partly in Silesia manors were established on areas previously cultivated and later abandoned, often in small villages which until the 15th century had preserved the Polish Law [58]. On the other hand, the manors already in existence in villages were increased in area. This process was carried out in various ways. In the beginnings of this period the manor was increased in size by bringing under cultivation new areas from the so-called "lord's reserve", in this way getting rid of waste land. When the reserves were exhausted, there began the seizure of the common property of the village or of farms abandoned by peasants who had fled the village in view of the increasing oppression of bondservice. There were also cases that "sołectwa" (the village administrator's offices) or larger peasant holdings were purchased.

As a result of these processes the settlement structure of the villages changed. Manors were established in the centre of the former village or on its boundaries. In this way a new form, the so-called manor-and-bondservice village arose. Manor fields were usually mixed in with peasant fields.

The intensification of farming was carried out also by making the existing settlement network more dense and by bringing under cultivation the still existing waste land, that is forests, outwash plains, swamps and ancient valleys. Numerous cottagers and bordars settlements arose on these areas in this period. Two types can be distinguished among these settlements: (1) settlements of an organized character, planned and developed on more fertile soils, on the edges of meadows and of arable land and (2) small planless villages, which arose spontaneously by way of evolution.

Colonization processes carried out in the 16th and 17th centuries have been well analysed (B. Baranowski, S. Inglot, Z. Kaczmarczyk, J. Leskiewiczowa, W. Rusiński, J. Topolski). The purpose of this colonization was to develop the land after the Swedish wars, to drain the swamps and clear the forests. The influx of colonists from the Netherlands was caused mainly by religious persecutions there and in the case of Germany by a relative overpopulation of some parts of that country.

At the end of the 16th century the Dutch colonies were established at the mouth of the Vistula and in the subsequent centuries they extended also up the river, towards the lands on the Noteć and the Warta, to Kujawy, the regions around Łęczyca, Zgierz and Łódź [6]. This colonization caused changes in the agricultural landscape of Poland and increased the agricultural area by bringing waste land and abandoned villages under cultivation and by introducing rent farms [37].

After the partitions of Poland the initiative in establishing new settlements was taken over by the invading states: Prussia and Austria. The so-called Frederician and Josephinian settlement system constituted the new wave of colonization which was superimposed on the former settlement network in areas annexed by Prussia and Austria. The purpose of this colonization was to strengthen the German element in these areas. The colonies were established on abandoned lands and in forests. Often these colonies had industrial rather than agricultural functions (especially the colonies situated on the right bank of Odra river in Opolan Silesia [58]).

Some colonies disappeared after a certain time as also did some other settlements which had arisen spontaneously on too infertile lands, on peat bogs and in forests.

Further changes in the agricultural landscape of Poland in the 19th and in the beginning of the 20th century occurred in connection with the development of agricultural techniques and with the change from the three-field to the multi-course rotation and finally modern crop rotation as well as through socio-economic changes in Poland.

Changes in spatial systems of villages and of the settlement network occurred differently in the various parts of the country. These differences were connected with the different economic policies of the invading nations.

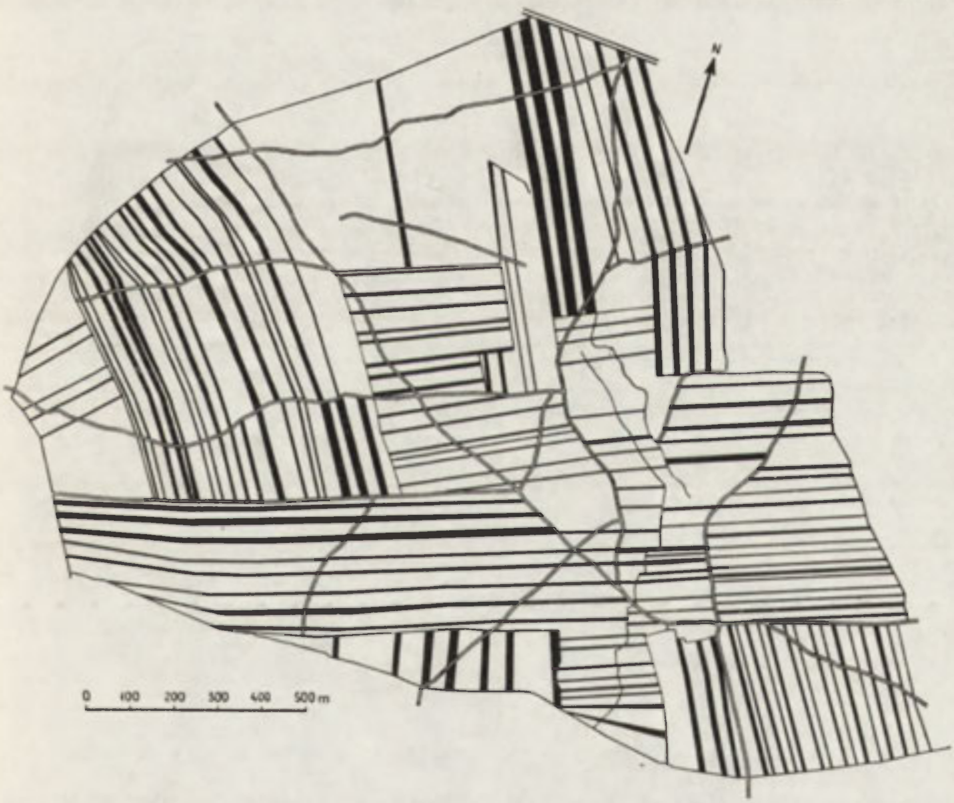

Fig. 7. The village Nosarzewo Polne, Mława poviat, Warsaw voivodship
Redrawn from a 1883 plan of the village before the integration of land. 125 strips of a joint area of 122 morgen and 217 rods belonging to one family are marked on the plan [49]

In Greater Poland, Pomerania and Silesia the agrarian reforms introduced in the beginnings of the 19th century in connection with the granting of freeholds to peasants, had a marked influence on the spatial system of villages. The integration of fields within the village area and the separation of the manor fields from those of the peasants were the sign of these agrarian reforms. This process was not equal in all the villages annexed by Prussia. The manor-and-peasant villages underwent the greatest changes at that time, as in these the manor fields had been mixed up with peasant fields. The manor property was integrated, peasant farmsteads moved elsewhere and peasant fields integrated into small blocks. Thanks to this the western territories have the most rational field pattern, best adapted to new techniques of cultivation.

On the other hand, the villages of the so-called Congress Kingdom, which were under the Russian rule, did not undergo any reorganization in the early 19th century. In the villages of the Congress Kingdom the granting of freeholds to peasants occurred only in the second part of the 19th century. This process was not accompanied by the integration of peasant and manor properties but by a further fragmentation of property holdings because of division by heredity. A great number of small farms arose at that time with mixed property holdings so characteristic to-day for the territory of Poland which had been under the Russian rule [35].

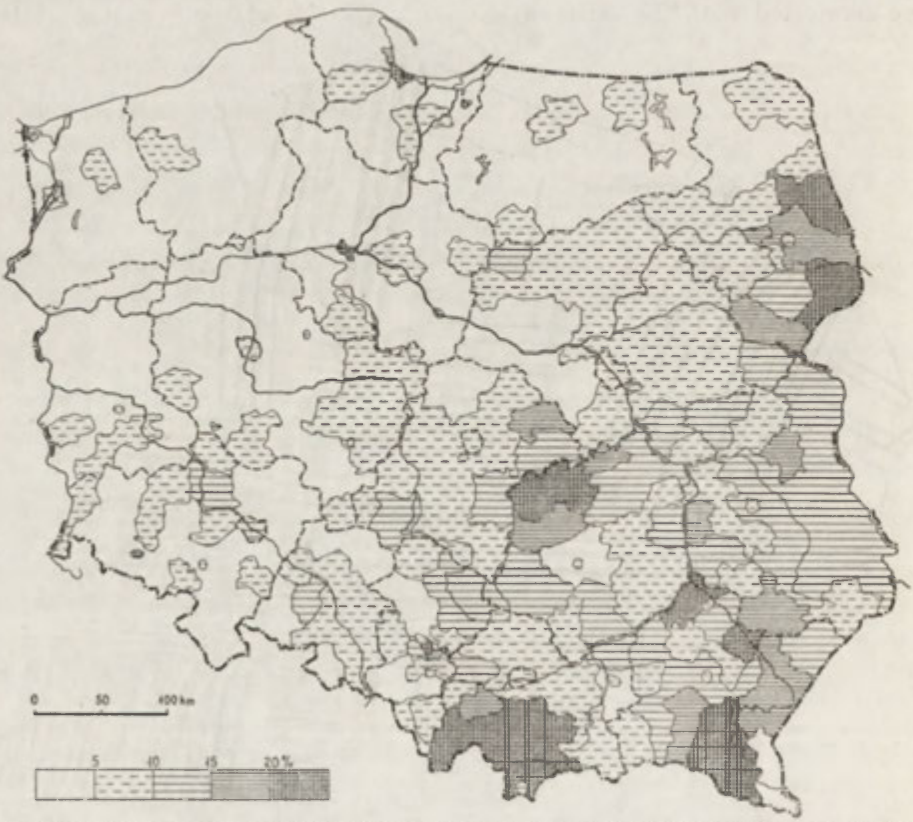

Fig. 8. Fragmentation of the property in private farms in 1960, compiled by W. Biegajło and R. Szczęsny for the National Atlas of Poland, Institute of Geography of the Polish Academy of Sciences (unpublished)
Percentage share of farms having their fields in 6 and more strips

An especially considerable fragmentation of the size of holdings occurred in villages belonging to the petty gentry in Mazovia nad Podlasie, because through privileges the gentry could here freely dispose of the land and usually divided the whole of one property between all the heirs [Fig. 7].

Similarly in the Austrian partition i.e. in Galicia, there was no integration of lands in the 19th century but the division of strips went on from one year to the next. The effects of such a fragmentation in the size of properties in the village which formed an intricate "chessboard of holdings", are evident even now in the south-western part of Poland (Fig. 8).

Only at the end of the 19th century was it undertaken in the Austrian partition to separate partially and to integrate the lands [46]. In Mazovia and Podlasie this was not done until the beginning of the 20th century.

The second process which markedly changed the landscape of Poland in the second half of the 19th and early in the 20th century was the parcelling of manors, thus eliminating the great disproportions in the structure of land ownership.

Industry and urbanization also caused great changes in the agricultural landscape of Poland of this time. Along railway lines, canals and roads leading to towns a built-up area of a semi-urban character arose and quickly growing capitalist towns absorbed the former suburban villages, relicts of which, such as the former nucleus shapes, roads and fields are found with difficulty in contemporary town plans [54, 55, 56, 61].

Changes in the agricultural landscape of Poland after the Second World War are very important; they constitute an agrarian revolution which the Polish countryside has not known since the Middle Ages. In this period various changes in the agrarian structure have been introduced and they reflect the deep social and economic transformations occurring in People's Poland. Above all this is the process of parcelling the manors and of creating new forms of socialized settlement, such as the State farms (abbr.: PGR) of the State Land Fund (abbr.: PFZ) and the agricultural co-operatives. However, the maintenance of about 85% of the land as individual peasant holdings has caused the preservation of traditional settlement forms. Certain changes of adaptation to farming on large areas were accompanied by the integration of fields into large blocks which occurred as a result of parcelling the manors. Apart from this, individual farms, fairly equal in area, were established. A consideration of these processes, however, goes beyond the purposes of the present paper.

The present rural settlement network of Poland is highly differentiated. Many causes have influenced the formation of such a rich mosaic of settlement forms and structures. They are to be looked for in the differentiated conditions of the geographical environment of Poland and in the centuries long evolution of the agricultural landscape. The development of the agricultural techniques caused the formation of new economic systems and these, in turn, have determined the formation of given settlement structures.

The explanation of the genesis and the evolution of all settlement forms is not easy. As an obstacle one can mention the great complexity of Polish culture, the roots of which can be traced back to the old proto-Slav Lusatian culture and to the cultures related to it, and doubtless the effect of foreign influences coming to Poland through colonization or by invasions. Also, not without importance for the differentiated picture of the countryside was the partition of the State by the three neighbouring powers and an almost 150 year long period of loss of independance. However, in many characteristics of the spatial structure of the country one may find relicts of ancient settlement forms and the continually progressing complex regional studies on the development of the agricultural landscape of Poland are of great assistance in this respect.

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LAND USE MAPPING IN POLAND

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Land use mapping started in Poland in the interwar years [17, 18]. Studies of that period normally encompassed only small areas and land use maps were drawn using various scales and methods. Also in the first post-war years, despite an urgent need for a detailed land use map, indispensable in a planned economy, it was impossible to carry out this task in view of the shortage of skilled personnel and material resources. For this reason, after several attempts and much discussion it was decided to draw up and print a general land use map based the interwar topographical maps. As a result of the collective work of all geographical centres under the guidance of F. Uhorczak, a set of maps to the scale of 1 : 1,000,000 [31, 43] was published, presenting the principal forms of land use (arable land, meadows and pastures, forests, waters, settlements) and their combinations. These maps, although they present a fairly faithful picture of the distribution of the principal land uses in Poland, are insufficient to satisfy the needs of researchers and practical users, because of their scale, outdated source materials and limited scope of information.

Between 1953–1956, therefore, new attempts were made at the Institute of Geography of the Polish Academy of Sciences to carry out a detailed land use survey (1 : 25,000) firstly under the guidance of K. Dziewoński, and later, J. Kostrowicki. The initial method, worked out in accordance with the recommendations of the IGU Commission on World Land Use, introduced several new features. Its later versions, while preserving full comparability with the world land use survey, developed classification and a system of symbols illustrating — within the framework of the principal land uses — different forms, methods, and orientations of land utilization. The main features of the developed classification of land use adopted in the Polish method of survey, as compared to the recommendations of the IGU Commission, may be summed up as follows:

In the group of arable land, marked with brown colour on the map, crop rotation systems and orientations (crop combinations) are distinguished by shades of the colour or marked by symbols [22].

In the group of perennial crops (carmine), the age of trees and predominant species are distinguished.

In the group of permanent grassland (yellow), natural types of meadows and pastures are mainly defined according to their plant associations, and forms of their use and improvement are shown (mowed meadows, pastures, mixed; fully or partially improved).

Apart from this, in the group of agricultural land, fragmentation of farms and subdivision of land as well as density of farm animals are marked by symbols.

In the group of woodland (green) types of forests are distinguished on the basis of predominant tree species, as well as the age of trees and the density of woodland.

Waters (blue) are divided according to their biological type and the forms of their utilization.

In the group of settlements (red) numerous forms of use have been distinguished (rural, urban, industrial, commercial, transportation, recreational areas, etc.).

In the group of unproductive land (grey) its origin is marked, as well as the nature of unproductive land.

In addition, forms of land tenure and permanent drainage and irrigation installations are shown in all the main land use groups.

The reason for so considerable development in the Polish method of survey was the fact that in Poland, a country with limited land resources, progress and more rational land utilization can take place not by means of replacing one form of land use with another (e.g. turning permanent grassland into arable land) but almost exclusively by means of the intensification of land use within the limits of existing resources.

This approach to the subject of research required such modifications in the method of survey as would allow the inclusion of information about the present methods of land use, orientations, intensity, and even, to some extent, the effects of land use [16, 20, 25, 26].

Land use survey in Poland, mainly based on field studies, is not limited to drawing up a map, but it also supplies a lot of additional data used in work on problems connected with land utilization in a given area.

Experience gained in field land use survey and the results of work carried out on this basis have proved that material obtained during field investigation may be very useful in micro-scale and meso-scale studies, solving problems of a wider scope. Studies based on field land use survey and taking into account all branches of the economy, allow conclusions to be drawn about geographical pattern, mutual links between various forms of land use and their influence on each other, and, together with the results of other field surveys (geomorphological, hydrographical, pedological, local climate etc.) about the degree of rational utilization of natural environment by human economy. Thus, after 1960, while continuing field survey [4], more attention has been paid to the method of processing data obtained in field survey [21], which served in studies on types of agriculture [15].

Up to the year 1970, nearly 17,000 sq. kms were mapped using the detailed survey method. After 1965, however, detailed field mapping to the scale of 1 : 25,000 was carried out in a limited scope, mainly as case studies of selected areas. This was due to the fact that this proved to be a very labour-absorbing work and the publication of colour maps is, consequently, very expensive. Carrying out such a work over the whole country would only be possible if a special service were established on the same pattern as the geological or pedological survey.

At the same time, as a result of the co-operation between the East Central European countries, about one hundred villages and collective farms in Bulgaria, Rumania, Hungary, Yugoslavia and Czechoslovakia were surveyed, using the Polish method. A number of land use maps were worked out and published by geographers of these countries. In Czechoslovakia a map of land use of the Kosice region to the scale of 1 : 50,000, and a map of collective farm

Krasna on Hornad, to the scale of 1 : 25,000 have been published [12, 30]. In Hungary, G. Enyedi published the land use map of Kerecsend and Maklár [11]. In Yugoslavia, the Ljubljana centre has used the Polish method in mapping sample areas in Slovenia and Herzegovina, and a few of these maps have been printed in Poland [26] and in the GDR by the Institut für Agrarökonomik der Martin-Luther-Universität Halle-Wittenberg. W. Biegajło successfully tested the same method in France [2, 3]. A special subcommission of the IGU Commission on World Land Use Survey was set up to promote and to co-ordinate these studies in East-Central Europe.

As a map of land use, covering larger areas, was needed both by researchers and practical workers, a method of more generalized and more simplified survey has been worked out. From the assumptions adopted and the experience gained when drawing up detailed maps (and by permitting quantitative and qualitative generalization), a method of such a map has been worked out. This method was presented and discussed at a conference of the subcommission held in October 1969 at Maribor (Yugoslavia) [5]. A draft instruction for general land use mapping was also submitted on this occasion [23].

The generalized land use map, while giving a faithful picture of the distribution of the principal forms of land use: arable land, perennial crops, permanent grassland, woodland, waters, settlements and other permanent investments, and unproductive land, contains the following information:

In the group of agricultural land: selected features of agrarian structure (land tenure), durable investments (terracing, drainage and irrigation of fields), orientations (arable land, perennial crops and classification of permanent grassland).

In the remaining main groups: dominant species and the age of trees are marked in woodlands, the saltiness of waters, and in the group of settlements, the map shows their distribution and functional character (industrial areas, transportation, public economy, etc.). In the group of unproductive land natural and derelict lands are distinguished. Several mixed categories have also been introduced.

The map is drawn up to the scale of 1 : 100,000, and it is envisaged that it may be reduced to the scale of 1 : 200,000 or 1 : 300,000, to allow comparisons with the existing geological and pedological maps drawn up to those scales. Such a map satisfies the needs of planning institutions of higher level. To reduce the printing cost, methods have been worked out for drawing maps using six basic colours or only black. Apart from this, work has been started on new principles of a general land use map which would be a picture of land use in the whole country. The map is to be drawn to the scale of 1 : 500,000, and possibly will later be reduced to the scale of 1 : 750,000. Both maps will be made with the maximum possible use of indoor work with the use of air photographs as supplementary material, which will permit the whole work to be done quickly and at reasonable cost.

The Polish method of land use was described in numerous publications [14, 17, 18, 19] and discussed at many international conferences. In general it was given a favourable reception and favourable evaluation. Many authors, to mention L. D. Stamp [39], L. Symons [42], Ch. Board [6], A. Rémy [34], A. Christofoletti [8] and recently M. Shafi [37] showed interest in it.

Critical objections were made at a conference in Austin — Texas (18–20 April, 1969) at which geographical problems in the countries of central and south-eastern Europe were discussed [35].

The static character of land use maps and their rapid outdating was the principal objection. This is, however, the feature of all maps of land use and even of all maps with the exception of maps presenting natural conditions (landforms, soils, waters, vegetation, etc.), which, as matter of fact, present features changing at a slower rate. The Polish method is rather less aging than other methods because within the framework of the most changeable group, viz., arable land, it does not present the utilization of separate plots of land which changes year by year according to crop rotation systems, but orientations in land utilization, which are more durable. Investigation has proved that the Polish land use map, depending on the area, becomes outdated after 10–30 years to an extent which makes it difficult to use. Is it worth while to carry out such an expensive and labour-consuming study and particularly to print expensive colour maps for such a period? This is a matter for discussion. It seems that surveys carried out at regular intervals would imply some dynamic features and would also be of practical importance in forecasting further changes, and in making correct decisions on the location of new investments, allowing a rational use of land.

Despite shortcomings, any land use map as it has often been confirmed by planning experts is a good base for regional planning and areal development programming. The usefulness of such map was first proved by the pioneer land use survey carried out in Britain by L. D. Stamp when in the hard years of the Second World War the full utilization of every plot of land was essential in order to survive the German blocade of Britain [38]. Since that time land use maps became an every-day tool of every expert on planning.

Another objection is the amount of labour and money involved in detailed mapping based on large-scale field studies. It is suggested that air photographs might be used instead, as the main source material in mapping. No doubt the use of air photographs shortens the period of mapping and reduces its cost. But the former advantage is obtained at the expense of reducing the amount of information and the latter requires the use of standard photographs, without carrying out special air investigation. This, in turn, will have even more an adverse effect on the interpretation of photographs. It should be also borne in mind that air photographs present the picture as it is at the moment of exposure, and are also quickly outdated.

As regards agricultural land it is relatively easy to interpret such features shown on an air photograph as field pattern and fragmentation, boundaries between woodland and arable land, but it is much more difficult to obtain data of essential importance for many countries, viz., methods of farming and crop combinations. Even panchromatic photos, colour photographs or infra-red photos do not guarantee a hundred per cent correct interpretation. The shade and colour, which are the basis of interpretation of a photograph, depend on many factors, e.g. the time of exposure, the period of plant growth, the moistness of soil, the light, the material used by photographers, etc. As a result, the same crop may be differently presented on the photograph. In addition, the scale of the photograph is a condition of its being useful for various research purposes. K. H. Stone [28, 41] distinguishes three categories of panchromatic photographs, according to their scale: below 1 : 30,000, from 1 : 30,000 to 1 : 10,000, above 1 : 10,000, and he claims that only the third group allows one to interpret crops on the ground of the photograph. Taking into account these factors, one can hardly speak of a fully correct interpretation of the land use pattern.

For those reasons, the second British land use survey, which was started by A. Coleman in 1960 despite the availability or air photographs, was carried out by traditional methods of field investigation, guaranteeing much more comprehensive information about the investigated area [13]. Tentatives made by

D. Steiner [40], K. Ruppert, P. Meienberg [29, 36] and others, are only the first step towards the elaboration of a method which would allow an increase in the degree of precision in the interpretation of crop combination on the ground of air photos. In Poland, A. Ciołkosz has been studying the method of microphotometric interpretation of crop orientation [9, 10]. The method consists in analysing the shades of black on the negative. It is difficult, expensive and, at its present stage, is not precise. In the optimum conditions, the precision of interpretation is about 80 per cent, and in areas with an advanced fragmentation of fields, the percentage is much lower.

In Poland, and also in other countries in which the cost of air survey is high and the use of standard photograps (usually made at a time unsuitable from the point of view of land use interpretation), cannot bring the desired result, field survey, although also expensive, seems to be preferable. The problem of what is more economical cannot be solved one and for all, since it depends, like in agriculture, on the cost of labour and capital involved. So it should always be considered whether in given conditions labour-absorbing field survey is more economical than capital-absorbing air photo survey. The advantage of field survey is that it supplies much more comprehensive information than air survey. Air photo interpretation would not provide so thorough and rich information as that obtained during field survey by L. D. Stamp or by the Polish survey.

Recent years have also brought new trends in land use mapping. Attempts are being made to depart from the classic methods applied so far, to more topical and special purpose mapping or to analyse and interpret land use patterns in selected small areas (sample studies). Such methods allow the study of changes taking place on sample areas. Ch. Board reviewed such studies at the third Anglo-Polish geographical seminar in 1967 [7]. A similar study was carried out in Poland by J. Rakowicz-Grocholska for the area of Warsaw [32, 33]. However, these cannot replace a land use map as a complete picture of land use over certain area [1].

The opinions, both positive and negative about the Polish method of land use mapping, only briefly presented here, give ground to doubts as to whether this line of research should be further developed. A univocal positive or negative answer, would be impossible, so it is necessary to discuss the main advantages and shortcomings of the Polish method.

No doubt the great amount of labour involved, the impossibility of mapping large areas without setting up a special survey staff, the high cost of field studies and of printing colour maps (containing a wealth of information) whose shortage is the reason for difficulties in popularizing the results of the work — are the shortcomings of the Polish method. Its advantages are: the presentation of a synthetic picture of land use encompassing all its forms — all lines of economic activity — and a wealth of supplementary material collected during field studies. Apart from basic studies of land use the method and the results of studies may also be used on many other occasions, e.g.:

— monographic studies of small administrative units for which no reliable statistical data are available,

— detailed studies on agricultural typology, for which the survey may supply much information about typological features of agriculture and their regional pattern,

— studies on the rate of development of various fields of economy on individual areas carried out by means of repeated investigation of the same area at determined time intervals, and by defining the dynamics of transformations (the method guarantees comparability of results in time and space).

The survey can also supply data needed for practical purposes e.g.:

— it may reveal the existence of latent production forces, not utilized in full as a result of incorrect land use and orientation, which is shown on the map and in the commentary to the map.

— it may be used to protect land resources and utilize them in a more rational way, particularly in agricultural areas. With general efforts to increase agricultural production, the constant loss of agricultural land to other branches of economy is a problem of paramount importance. A map showing the distribution pattern of agricultural lands against the background of their natural values and production level, will help to choose properly areas for technical purposes (residential and industrial building, roads, etc.).

— it helps rural planning in both its protective and developmental forms. A detailed map of land use and studies based on it serve as a point of departure in drawing up any long-range plans.

For such a planning, the land use map and comments to it are an excellent base for drawing up special or derivative maps for which there is a growing demand. For instance, there is the urgent problem of the protection of human environment which is seriously endangered as a result of rapid technical progress, growing density of population and intense economic activity. To prevent effectively further degradation of natural environment one must know the degree of present devastation and carry out inventory of devastated areas, and, on the other hand, areas which are particularly valuable for various reasons and deserve protection now and in the future, must be selected and singled out from the rest of the region.

A detailed land use map, showing the devastated areas: unproductive land and its categories, and particularly valuable lands: those intensely used for agricultural purposes, valuable forest associations, recreational areas, clear water reservoirs and current waters, etc., may be particularly useful in drawing sozological maps and maps of protected areas.

In the light of the above suggestions it seems that land use survey, as a research method, is not outdated and should be continued. It is, however, necessary to improve methods of mapping and survey and to make greater use of modern techniques in this domain [44].

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STUDIES ON THE SPATIAL STRUCTURE OF INDUSTRY

Stanisław Misztal

INTRODUCTORY REMARKS

Studies on the spatial structure of industry have only developed in Poland since the II World War. Indeed the term spatial structure of industry itself has appeared and has been popularized in Polish geographic-economic literature only in the post-war period. Although this concept has been defined differently by various authors, it is mainly understood to be the sum of relations occurring among the elements of the territorial pattern of industry. These elements may be single industrial plants and complexes of plants analysed according to administrative divisions (voivodships, poviats, settlements and rural communities) as well as industrial agglomerations (industrial centres and industrial districts).

Polish economic geography may demonstrate rather considerable achievements in the study of the spatial structure of industry. This work should be counted as applied geography because besides being of high cognitive value it is of a great practical importance. The results are utilized in the preparation of plans for the spatial development of the country. It should be added that studies on this subject are led not only by geographers but also by economists, statisticians, historians and sociologists.

The present paper is limited in scope, in that it draws attention only to works which are exceptionally interesting from the point of view of applied methods and of the results obtained.

Depending on the territorial and the substantive scope of the studies on spatial structure of industry the works can be divided into three main groups:

(1) papers concerning the spatial structure of the industry of the whole country,

(2) papers concerning the spatial structure of industry in particular parts of the country,

(3) papers concerning the spatial structure of the particular industrial branches or types of industry. A separate fourth group embraces theoretical and methodological papers.

SPATIAL STRUCTURE OF INDUSTRY IN POLAND

Research work on the spatial structure of industry of the whole country is carried out mainly at the Warsaw centre, co-ordinating a rather large team consisting of scientific workers of the Polish Academy of Sciences, academic institutions of university standing, the Planning Commission of the Council of Ministers and the Central Statistical Office. Outside Warsaw the Cracow centre also demonstrates considerable achievements.

Until now most authors have carried out research work on the spatial macrostructure of industry i.e. the subject of their analyses was the localization of industry in the country considered from the point of view of the largest administrative units of Poland, namely voivodships, 22 in number (5 of them urban). The spatial structure of the domestic industry was analysed in this way by, among others, K. Dziewoński [5], A. Kukliński [19], S. Leszczycki [22, 23], W. Kawalec [16], T. Mrzygłód [37], K. Secomski [38], R. Wilczewski [45], A. Wrzosek [47], and S. M. Zawadzki [50].

These authors have concentrated their attention mainly on the analysis of changes in the spatial macrostructure of industry in Poland from the point of view of falling or rising tendencies of areal disproportions appearing therein. They all have applied the method of comparing the structure in some time sections. Among the authors mentioned above only S. Leszczycki and A. Kukliński took as a basis for comparison the picture of the spatial structure of industry before the II World War, as reproduced according to estimated data of the Central Statistical Office. The other authors took as their starting point the spatial structure of industry in 1946 which had changed greatly as result of the devastations of the war because the destruction was spread very unevenly throughout the country.

The research work of all the authors has proved that, in conformity with the principles of the country's economic policy in the post-war years, there has been in Poland a tendency towards a reduction of the disproportions in the spatial macrostructure of industry inherited from capitalism. They used mainly the employment figures as a measure as well as indices and coefficients based upon these figures.

Some authors, among others S. Misztal [29], M. Opałło [33] and A. Wrzosek [46], besides analysing the spatial macrostructure of industry, have also analysed its spatial mesostructure i.e. they considered it in a territorial section by poviats, numbering 391 in Poland (74 urban poviats included). These studies have proved that in the spatial mesostructure of industry there is also a tendency, though less distinct, towards reducing the disproportions inherited from capitalism. On the other hand the research work carried out by S. Misztal on the changes in the spatial microstructure of industry considered in the territorial section of the smallest administrative units, namely towns, settlements and rural communities (*gromady*) of which there were 6129 in the country in 1965 and 7224 in 1960, have shown growing disproportions occurring in it.

The value of the coefficient of localization calculated on the basis of data concerning the employment in industry in towns, settlements and rural communities and their area has risen from 0.841 to 0.865 in the years 1946–1960. It is proof of the process of the areal concentration of industry taking place in Poland in spite of the reduction of disproportions in its spatial macro- and mesostructures.

Besides the research work on the spatial structure of industry in the units of administrative division within the last 15 years, research work has also been carried out in territorial units of industry or industrial agglomerations. The collective work of four geographers from the Institute of Geography of the Polish Academy of Sciences: S. Leszczycki, A. Kukliński, M. Najgrakowski and J. Grzeszczak has been a pioneer and inspiring work constituting in the Polish geographic economic literature the first attempt at delimitation and typology of basic areal industrial units according to objective criteria. By means of data concerning the absolute figure of industrial employment in the districts in 1956 and indices calculated on this basis, these authors have delimited in the territory of Poland 13 territorial industrial complexes, distinguishing among them (depending on the value of indices) industrial districts, industrial areas and industrialized areas. Research work on this subject was continued by A. Kukliński and M. Najgrakowski [21]. They have corrected, among other things, the borders of the respective areal units of industry and they have analysed the rate of changes in the areal structure of industry. From the calculations of these authors it is seen that, with the same rate of population and industrialization processes as in 1946–1960, disproportions between the industrialized and the unindustrialized areas distinguished by them in Poland will continue for a very long time.

In later years further attempts, based upon statistical data relating to poviats, were undertaken in Poland to distinguish and to delimit areal units of industry. For example, K. Secomski [39] and W. Kawalec [16] have identified some scores of industrial agglomerations distinguishing their two forms: industrial centres and industrial districts. The areal units of industry distinguished by W. Kawalec were, with only small alterations, for some years used even in official publications of the Central Statistical Office. An unavoidable consequence, in the above mentioned attempts, of basing the delimitation procedures on statistical data relating to poviats, was that thinly industrialized areas were included within the borders of some areal units of industry.

In the last years three new investigations were effected containing attempts at defining and delimitating industrial agglomerations by means of various methods, but using data on industrial employment in the smallest administrative units, namely towns, settlements and rural communities. They are the works of I. Fierla [8], S. Herman [14], and S. Misztal [29].

I. Fierla in her delimitating procedure has utilized data on the employment figures of industry, according to domicile. As the criterion of counting a given town, settlement or rural community in an industrial agglomeration she assumed the percentage ratio between the number of inhabitants employed in the industry and the total active population. As the lower limit of this ratio she assumed the average index for the whole country. In this way she found and delimited 36 territorial units of industry. Then she effected the classification of these units, taking into consideration mainly the industrial employment figures and the degree of industrial participation of the population.

S. Herman, in his attempt at delimiting areas of industrial concentration, has also utilized the statistical data concerning industrial employment in the smallest administrative units but according to place of work. In delimiting procedures he mainly utilized the absolute industrial employment figures and indices of industrial employment per 100 sq. km. In the areas of spatial *industrial concentration* he counted towns, settlements and rural communities having indices five times higher than the national average and which fulfilled some other conditions. In this way S. Herman found within Poland 250 areas of industrial spatial concentration, including 86 more important areas in which employment exceeds 4 thousand people per 100 sq. km. Among them he identified eight different types of industrial concentration.

S. Misztal based his attempts at delimiting industrial agglomerations or, more correctly, industrial districts on data concerning employment in the smallest administrative units according to both domicile and place of work. He counted among industrial districts those towns, settlements and rural communities, in which the employment indices in industry, according to place of work and domicile per 10 sq. km. and per 1000 inhabitants, are higher than the national average. In this way he found 22 industrial districts in Poland constituting the grouping of centres with a large total industrial potential. He assumed that an *industrial district* should be defined as having more than 1% of the value of the country's industrial production and 1% of the national industrial employment. These distinguished industrial districts are the most important nuclei of the spatial structure of Poland's industry. Embracing 18% of the area and 48% of the population, in them was concentrated, in 1965, as much as 80% of the domestic industrial employment, 82% of the value of capital goods, 85% of the industrial generating power and 86% of the poure industrial production value.

S. Misztal's work also contains an attempt at explaining the genesis of the respective industrial districts and of the whole spatial structure of industry of Poland. For this purpose he analysed the historical process of its development since the industrial revolution in the 19th century until the present.

Problems of the present structure of industry are presented in the first textbook on the industrial geography of Poland, prepared by a team of scientific workers at the Institute of Geography of the Polish Academy of Sciences, directed by S. Leszczycki and T. Lijewski.

Besides studies mentioned above interdisciplinary analyses of the industrialization process in Poland are worth attention. The volume of studies edited by J. Pietrzak-Pawlowska in 1970 and devoted to the industrialization of the Polish territories in the 19th and 20th centuries is the result of co-operation between geographers, economic historians, economists and sociologists. In it a good deal of space has been devoted to the spatial structure of industry [44].

Cartographic elaborations illustrating the localization of industry throughout the whole country deserve special mention. They constitute an indispensable tool for research work on the spatial structure of industry.

The greatest achievement of Polish economic geography in this respect is the *Atlas of Polish Industries* completed in 1960 at the Institute of Geography of the Polish Academy of Sciences (in co-operation with the Central Statistical Office and the Planning Commission of the Council of Ministers) containing 70 plates with 100 maps [1]. The maps, based mainly on data concerning employment in the respective industrial plants give an exact picture of the location of industry in Poland in 1956.

It is to be stressed that work on the second edition of the *Atlas of Polish Industries* is in its final stage. Its maps have been drawn mainly on the basis of data from the Central Statistical Office's detailed census of industry, 1966. The second edition of the Atlas differs from the first not only in the dynamic approach to the spatial structure of industry in Poland, but also by presenting its state in 1965 against many types of measurement. It contains among others maps illustrating the changes that occurred in the spatial structure of industry in the Polish territory in the period 1860–1965 and maps showing the present structure of Polish industry, not only by means of the employment figures, but also by such measures as the value of industrial production, the value of capital goods of industry, the generated power of machinery, the utilization of raw materials, the utilization of electric energy etc. Besides, in contrast to the first edition of the Atlas, which was of a highly informative character, the second edition will contain a number of thematic maps, e.g. maps of river and air pollution, distance between domicile and work in industry etc.

SPATIAL STRUCTURE OF INDUSTRY IN PARTICULAR PARTS OF THE COUNTRY

A much greater number of works published in Poland concern the spatial structure of industry in particular parts of the country, including some industrial districts. This work is performed mainly outside Warsaw in scientific centres situated close to the analysed areas. Most of the research work of this kind is carried out in Cracov, Poznań and Łódź centres. In the analysis of the spatial structure of industry for larger parts of the country and the voivodships, the basic territorial units employed are mainly poviats. In the research work concerning poviats or industrial districts the data for individual localities are generally used.

Interesting studies in this field include the works of S. Smoliński, M. Przedpełski and B. Gruchman on the changes of the spatial structure of industry in the western territories in the years 1939–1959 [40], and the work of K. Jeżewski about changes in the distribution of industry in Lower Silesia in the capitalist period [15]. A number of publications concern the spatial structure of industry in voivodships. Some of them contain the analysis of the long-term changes in this field e.g. J. Boroń's study concerning the development of industry in Zielona Góra voivodship from 1862 [3] or S. Misztal's paper concerning the changes in the spatial structure of industry in the Białystok voivodship since 1831 [28]. Other works present these changes within shorter periods of time, mainly in the period of People's Poland, taking into consideration the spatial structure of industry before II World War, e.g. B. Gruchman's work on the industry in Poznań voivodship [11].

Some other works contain the analysis of present conditions e.g. the studies of M. Grabania [10] and Z. Zioło [52] relating to the present spatial structure of industry in the Katowice and Rzeszów voivodships. Z. Zioło's work is rather interesting in that it contains the analysis of the present state of this structure in the Rzeszów voivodship effected by means of some measures (employment, the value of production, the value of fixed assets, the installed power and the consumption of electric energy).

Researches on the spatial structure of industrial agglomerations are less advanced in Poland. Until now they have concentrated mainly on a few more important industrial districts and centres. In these studies great attention is paid to explaining the genesis of the given agglomeration and to analysing the shaping of its areal structure and indicating the potential trends of further development. To this type of studies belong the works of F. Barciński on the formation of the new Konin Industrial District [2], S. Misztal on the Warsaw Industrial District [27], L. Pakuła on the West-Cracovian Industrial District [34] and on five other industrial districts developing on the borders of the Upper Silesian Industrial District [35], L. Straszewicz about the Łódź Industrial District [41] and J. Zieliński on the Old-Polish Industrial District [51]. As far as the spatial structure of larger urban industrial centres are concerned only Cracov, in the monograph of B. Kortus [17], Wrocław in Z. Tempski's monograph [42] and Sosnowiec in J. Ziolkowski's monograph have gained larger separate elaborations.

THE SPATIAL STRUCTURE OF PARTICULAR INDUSTRIAL BRANCHES

Many studies have been made in Poland on the spatial structure of particular industrial branches. They concern the territory of the whole country as well as the individual voivodships. The spatial structure of the various branches and lines of industry is, first of all, the subject of numerous academic theses. Some of them have not been published.

Most of the works on this subject effected by geographers concern those industries which show direct links with the geographic environment, and in particular the branches of mineral, food and timber industries. Some of these works contain the analysis of changes of the spatial structure of the given industry within longer or shorter periods of time. Other works deal with the present structure. Among works displaying more interesting methods are those of A. Kukliński on the spatial structure of the brickmaking industry in the Western Territories in the capitalist era [18] and of the cement industry in Poland between the years 1946–1980 [20]. In the later work there are interesting considerations on the optimal trends of the future location of this branch of industry. The following works, among others, also deserve special attention: Ł. Górecka on the actual location of the cement industry in Poland against the background of the raw materials [9], S. Misztal on the location of the mineral industry in the Białystok voivodship [26], M. Najgrakowski on the spatial structure of the building ceramics industry in Poland [31].

THEORETICAL AND METHODOLOGICAL PROBLEMS OF THE SPATIAL STRUCTURE OF INDUSTRY

In comparison with the results of empirical research work the theoretical and methodological achievements on the spatial structure of industry are modest. Nevertheless a number of works have been published in Poland on this subject.

First of all the trends and methods of analysing the spatial structure of industry have become a matter of interest. Considerations of the general trends of research in this respect are found, among others, in the works of S. Leszczycki [24], A. Kukliński [19], K. Secomski [37] and Z. Zajda [49] and the methods of research in the works of A. Kukliński [19], A. Fajferek [7] and others. All the authors dealing with these problems draw special attention to the necessity of applying, more than heretofore, quantitative methods and especially mathematical models in the research work on the spatial structure of industry.

At the same time attempts were undertaken to construct the socialist theory of the location of industry by K. Dziewoński [5] and K. Secomski [36] among others. These attempt to define general principles of location of industry and of its various branches in the conditions of socialist planned economy. In the collective work published on "Theoretical problems of the location of productive forces" [43] one may find a number of theoretical generalizations. Recently the problems of agglomerating factors of location, enjoy a great interest on the part of theoreticians. A serious achievement in this field is the work of B. Gruchman on the factors of agglomeration and deglomeration of industry in the socialist economy. It is difficult to fix the general regularity and tendencies in the scope of activity of forces concentrating and dispersing in the location of this branch of the national economy [12].

At the end of this short review it is to be stressed that Polish geographers carry out studies not only on the spatial structure of industry in Poland but also in other countries. These studies, however, are not numerous. Among works of special interest are those of L. Ciamaga on the spatial structure of industry in the Common Market countries [4], of M. Najgrakowski on the spatial concentration of industry in Switzerland [32] and of J. Grzeszczak on polarization tendencies in the spatial structure of industry in France [13].

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GEOGRAPHIA POLONICA 22, 1972

SOME MAJOR RESEARCH PROBLEMS IN TRANSPORTATION GEOGRAPHY IN POLAND

TEOFIL LIJEWSKI

Within the last 8 years[1] research work in the field of transportation geography has been carried out mainly by the Department of Industrial and Transportation Geography at the Institute of Geography of the Polish Academy of Sciences in Warsaw, at the Department of Economic Geography of the College of Planning and Statistics in Warsaw, the Department of Geography of Transportation at the Institute of Technology at Szczecin, the Department of Economic Geography at the College of Economics at Sopot (now at the Gdańsk University), the Department of Economic Geography of the Jagellonian University at Cracow and the Commission of Transport of the Committee for Space Economy and Regional Planning of the Polish Academy of Sciences.

Moreover, such research work has been carried out by various research workers at other universites and higher schools as well as by certain non-geographical institutions, such as the Institute of Motor Transport in Warsaw.

Besides theoretical and methodological problems nearly all the studies were concerned with Poland or parts of the country. Only studies in the field of sea transport have extended beyond Poland. This is connected with the extent of the Polish sea navigation.

In research problems, the following 4 groups of questions can be distinguished:

(1) Transport networks development,

(2) Flows of goods and persons,

(3) Poland's connections with other countries and the problems of transport abroad,

(4) Theoretical and methodological problems.

Within the frame of transport development problems the studies were first of all concerned with the evolution of transportation networks and the formation of transportation systems (complexes of networks), the improvement of transport accessibility of Poland as well as the accessibility of the main centres of various hierarchical levels.

Observing the evolution of the three most important transportation systems: the railway network, the roads network and the bus network one can

[1] A report on the former research work has been published in "Geographia Polonica" 1, 1964, under the title: "Some problems of transportation geography in Poland".

perceive the action of various factors shaping these networks and some general regularities in the development of such networks.

The decisions concerning the development of railway network have traditionally lain in the hands of central authorities. These considered primarily the administrative and military requirements of the whole country. In the case of Poland it has appeared rather unfavourably because the majority of railway lines were built before the World War I, when the territory of Poland was divided between the three states of Russia, Prussia and Austria. Each of them obviously followed a separate transportation policy, with their own purposes in mind. After the reunification of Poland, the railway network was not adapted to emerging needs and in spite of investments in the interwar period and after the war it still does not fully meet present requirements.

A similar situation existed as far as the first long distance main roads were concerned, but here the regional requirements have been considered to a higher degree and that is why Warsaw has become the centre of the roads system in the Congress Kingdom (then a province in the Russian State) in the first half of 19th century. This proved to be very favourable when Warsaw took over the function of capital of Poland. The majority of main roads were, however, constructed at the time of the railways' construction and were of secondary importance. Their construction was often delimited at a local level, and no centrally fixed plan was involved. With time, sections of main roads that were unconnected with one another and the local road systems have been integrated into one general state network though still not offering good long distance connections. It is only within the last 20 years, that main roads network is also being adapted to the requirements of long distance motor transport by the reconstruction and modernization of certain road sections, including those serving the needs of international transit.

The bus network evidences the most dynamic growth. This network began to be organized anew after World War II and in 20 years its length exceeded three times the length of the railway lines. Because of the motor car shortage buses have become the basic means of local transport in Poland. The bus network, the most flexible among all transportation networks, reflects to the highest degree the intensity of connections, gravitational trends, change in time etc.

The increase of the above mentioned transportation systems has brought about considerable progress in the transportation accessibility of the entire territory of Poland measured by equidistants from transportation tracts and by time distance from selected points. The areas situated at ten and more kilometers distance from the nearest main road or public transportation line have disappeared. Now it is possible everywhere to reach the poviat seat, which is usually a local service centre, within 3–4 h at the very most. Within about the same time it is also possible to reach the voivodship seat from each poviat town. The voivodship seat is a service centre of a higher rank. The time distance of voivodship seats to the capital of the country varies from 2–9 h, if air transport is not taken into account. From each poviat town it takes less than 11 h to reach Warsaw.

These spatial relations are important due to a high degree of centralization of the economic and cultural life in administrative centres. The majority of passenger traffic has these same centres as their destination. Their accessibility in time (and time distances, generally) at all become more and more important together with the increased value of time and the extended possibilities of spending it in a pleasant way.

The second group of problems, which are the object of the geographical transportation research, is the distribution of goods and passenger flows. Unlike technical or economic research it is not a question of fixing the size of flows, the loading of roads etc. but of flows as an index of various economic or social phenomena.

And so commodity flows by railway are treated as indices of interregional links, of the degree of "closure" of particular regions and as "criterion" of distinguishing the macroregions. The difficulty is that coal is the main railway cargo in Poland and it comes almost entirely from the Upper Silesian region. This region, however, is also leading in the manufacture of many other products, especially metal products. Therefore, all the voivodships show stronger links with Upper Silesia than with their neighbouring regions (this supports the hypothesis that Poland should be treated as one large economic region with its centre of gravity in Upper Silesia).

Motor transport of goods, which are of a more local character, serve to delimit regions of lower rank, especially nodal regions round larger towns. Here the main difficulty is the fact that motor transport, unlike railway transport, is decentralized (cars belong to various enterprises) and no joint statistics of traffic are available.

Economic and geographical studies, based on traffic data, are rendered difficult by the fact, that the statistics consider only the weight of commodities disregarding their value and the most valuable commodities of small volume are treated jointly in the group of "other items". Therefore, the attempt to convert the estimate of interregional flows from the weight approach to the value approach was of great importance [19].

The statistics of person trips register only the number of tickets sold according to the place of sale and the distance zones, disregarding the directions of the traffic. Transportation studies used, as a substitute, the number of trains or buses serving the particular lines and calculated the number of train–kilometers and bus–kilometers for the territorial units [13].

The majority of train and bus passengers are commuters who travel to work or school every day with monthly tickets. Mass analyses of commuting were carried out a few times (in 1959, 1964, and 1968) and have been utilized for scientific purposes, so that the spatial differentiation of this phenomenon is rather well known [11]. Travel to work is strongly spatially concentrated in some regions, especially in those which experience the process of industrialization. This is connected with the distribution of a double-job population (peasants-workers) and are the indices of the urbanization process in rural areas (the process of passing from agricultural to non-agricultural occupations without changing the domicile).

The passenger flows resulting from the spontaneously growing tourist industry are not so well known. A great part of the tourist traffic is carried on outside the night's lodging and is not subject to any statistical evidence. The knowledge of the spatial differentiation of the tourist traffic would be of great practical importance, as it would allow better planning of the service network, the transportation network and other infrastructural elements in regions attractive from the tourism point of view.

As in the case of commodity flows, motor and especially bus transport can serve as an index of regional gravitations and can be used as a basis for delineating nodal regions, as has been done in a number of other countries at the time when private car ownership was not so widespread.

Big urban and industrial agglomerations are characterized by the greatest traffic concentration. This refers mainly to the passenger traffic. Ten agglomerations formed by towns of over 250 thousand inhabitants and their suburban zones account for about 40 per cent of the passenger traffic on public transport means, although these agglomerations cover only 7 per cent of the total area and account for 30 per cent of the population of the country.

Studies of Polish transport links with abroad are concerned with Poland's situation against the background of the European transportation network, connections by land with neighbouring countries and connections by sea. Poland has a typical transit situation being in the geometrical centre of Europe. Poland's situation is also central with regard to the block of countries belonging to the Council for Mutual Economic Assistance which carry out extensive economic exchanges between themselves. The East–West transit between the Soviet Union and East Germany is of great significance here because the Soviet Union is the most important commercial partner for the German Democratic Republic. Also, the South–North transit from inland socialist countries (Czechoslovakia and Hungary) to the Baltic ports is quite well developed. Szczecin is the main port serving Czechoslovakia and is the base of the Czechoslovak fleet.

Poland's overland connections with neighbouring countries are especially important for commodity traffic because the three neighbouring states (the Soviet Union, Czechoslovakia and the German Democratic Republic) account for as much as 54 per cent of the general Polish foreign trade turnover and through their territories the commercial exchange is carried out with other countries of south and central Europe (the German Federal Republic, Austria, Hungary, Yugoslavia, Rumania, Bulgaria). The Polish-Soviet border, however, constitutes a certain barrier to rail transport because there the European normal gauge railways meet the broad-gauge Soviet rail network so that all the cargo must be reloaded. Reloading stations developed into so-called "dry ports" (the largest being Medyka and Małaszewicze), which in terms of the quantity of reloaded cargo surpass the Polish sea ports which, in turn, are amongst the largest ports on the Baltic Sea.

Polish maritime shipping, dealing mainly in trade exchange between Poland and Scandinavian, other West-European as well as oversea countries belongs to the most dynamic transportation branches in Poland. Within 20 years (1949–1969) the number of ships increased 5.5 times, their tonnage (by BRT) 8 times. Polish merchant ships maintain regular connections with the largest ports of Europe, Africa, South and East Asia, the eastern shore of North America, South America and even with Australia; besides they are extensively engaged in tramping. This is why scientific interest in world shipping has increased. This is evidenced by a recent monograph on the geography of sea transport [26].

In addition to empirical work, a number of studies on theoretical and methodological questions of transportation geography in Poland have been published. The latter were chiefly written by non-geographers; transport, however, is such a "spatial" branch of the economy, that all its theoretical considerations enter into the range of interest of transportation geography. For instance, in an important study on the general theory of transport a large part considers the problems of transport in the theory of settlement and production distribution and the theory of transport systems [20].

Other works are devoted to terminology; to the analysis of main trends in research into the field of spatial problems of transport, and to methods applied in the analysis of selected transportation problems.

Works concerning transport network models referring to the work of older theoreticians such as Kohl, Christaller, Losch and others are interesting. These works deal with abstract transport systems whose adoption in a pure form would only be possible in an ideal economic environment. They are looking for reflections of these models in real systems [3, 4].

Work in the field of transportation geography is not only of a cognitive value, but is often of practical importance for the planning of transport systems, or of the spatial structure of the country, or of some part of it. After all some of these studies have been written by practicians working with the planning or transport institutions.

The enclosed bibliography contains the more important works in the field of transportation geography published after 1962. (The list of earlier works can be found in "Geographia Polonica" 1, 1964).

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GEOGRAPHIA POLONICA 22, 1972

THE METHODS OF SYNTHETIC STUDIES OF THE SPATIAL STRUCTURE OF ECONOMY

Ryszard Domanski

The development of research methods has imperceptibly come to a point at which a precise set of methods for solving one of the fundamental problems of geography can be identified. It is impossible to indicate the exact date on which this situation came about. Nor is it possible to identify the method that was complementary to the earlier ones. No definite breakthrough occurred. The development has been proceeding by gradual changes, it still continues, and it is only by a retrospective analysis of its results that we can find the elements that taken together may provide a definite system of methods permitting the solution of our problem. It is necessary to recapitulate what has already been achieved, to describe that system and integrate it, as a whole, into the methodology of geography. The next step should be the further development of this system without having to refer to the remote past.

The problem itself was variously defined. Moreover, terms of vague meaning were employed without essential qualifying definitions. Regional synthesis was the most frequently used term, but in the fifties another term started to be widely used: regional structure. Its meaning was different from the previous term and in this modified formulation the problem appeared better suited to scientific analysis.

What is the essential difficulty in studying the regional structure? Geography is mainly concerned with the structural attributes of the geographic environment and of the economy of a definite area, and it leaves the study of the specific components of these complexes to its auxiliary sciences. By "structural attribute" we mean an attribute pertaining to the region as a definite system but not pertaining to the particular elements of which it is composed. Interdependence, connectivity or hierarchy are some examples of structural attributes. From the other sciences, which also study the structural properties of their objects, geography differs specifically in that by definition it studies the spatial variation of the structure, that is, how this structure changes from place to place. Moreover the components of geographic structures have different dimensions (areas, lines, points).

Thus in answer to our question we can say that more than one factor accounts for the difficulty of studying regional structure. First, the particular components of the analysed structure may be of different extent. When these are represented on a map, and especially in cases when a large number of components is involved, the resulting tangle of lines makes it impossible to identify the structure, let alone study it. Another difficulty is connected with the different spatial dimensions of the components. How to map, it was asked, a structure composed of elements as different as uniform and nodal regions which are represented on maps by planes, lines and points? These two are not the only difficulties, to mention but the absorbing effect of administrative boundaries, or the sectoral and spatial interdependencies of the structure (here complications result from lack of statistical data).

What methods can be employed to overcome these difficulties [1] and to represent the intricate spatial economic structure? Let us recall the relationships between simple surface-type spatial systems. A method of representing the covariance of such two systems has been developed by A. H. Robinson and A. R. Bryson [6]. It consists of the following steps. First, isarithmic maps representing the distribution of the two phenomena are prepared. It is convenient to think of them as of maps representing three-dimensional statistical spaces. Each point of the covered area is defined by three dimensions: its latitude, its longitude, and its intensity of occurrence. A characteristic property of statistical spaces is that the vertical scale (i.e. values of the control points) may be changed without altering the horizontal scale (i.e. the positions of the control points). This fact is of great importance in the study of the covariance of elementary spaces, for it makes it possible to compare the isarithmic maps representing these spaces, irrespective of the type of phenomena considered, if the vertical scale of one phenomenon is transformed in a way that makes it comparable with the vertical scale of the other. The comparison of two elementary spaces may be brought as far as their quantitative measurement and the graphical mapping of the relationship between them.

The next step is to standardize the network of the control points for both elementary spaces. To do this, the map of the area concerned is covered with a regular grid, each intersection of the grid being recognized as one such point. By interpolation, the values of both variables for each point are determined. The third step consists in the transforming of one elementary space into the other, thus providing the possibility of a quantitative comparison of the attributes originally expressed in incomparable units. The transformation is made by the equation: $y = ax+b$. The concluding procedure is the quantitative determination and the cartographic representation of the divergences in the spatial distribution of the two phenomena examined.

A transformation of more than two spaces seems never to have been done before. Such a transformation is possible after some extension and development of the same method. It is desirable to develop such a method, for it is only by a transformation and a synthesis of many elementary spaces that the more complex spatial structures can be represented. What follows is an attempt to give a synthesis of four elementary spaces by way of their transformation. These spaces are composed for four respective sets: population, manufacturing, agriculture, and transport.

The measuring units for these sets are, respectively: population density per 1 sq. km, industrial employment per 1000 population, yields of 4 cereals per 1 ha. and density of hard-surfaced public roads per 100 sq. km.

Now we must identify the units in which the synthesis of all four elementary spaces can be expressed. As such units may be taken the numerical characteristics of the particular spaces being transformed or some other units. In selecting the unit it must be borne in mind that the unit which is to characterize the synthesis should be easily associated with fundamental and well-

[1] The author sets down the relevant methods and subjects them to empirical tests on the example of the Konin–Łęczyca–Inowrocław Industrial District [1].

known phenomena and thus be easy to interpret. For such a unit we take the population density per 1 sq. km.

Let us now transform successively the sets of industrial employment, of the yields of the 4 cereals, and of hard-surfaced public roads, into the set of population density. As before, let us employ the simple transformation:

$$y = ax + b.$$

After estimation of the parameters, on the basis of data for the Konin–Łęczyca–Inowrocław Industrial District, it assumes the form:

$$y_1 = 0.3834\,x_1 + 65.9406,$$

$$y_2 = 3.1212\,x_2 + 11.9199,$$

$$y_3 = 0.6149\,x_3 + 55.0779.$$

The population densities calculated by transforming the industrial employment, yields of 4 cereals per 1 ha. and the density of hard-surfaced public roads are added together; to the resulting sum the actual population densities are added.

Thus each point is now characterized by 4 features expressed in the same unit — the number of persons per 1 sq. km. By arithmetically averaging these features we obtain a convenient index of intensity of development of the District. After connecting all points of equal value an isarithmic map is obtained; this is not only a representation of the synthetic development of the District (i.e. including the major domains of socio-economic life) but also of its spatial variation.

A subsequent, and a less satisfactory is a solution of the problem of synthesis of uniform and nodal regions [1]. The distinction between these two categories of regions makes possible a better representation and analysis of spatial economic structures, which is closer to reality. But at the same time a new dichotomy has been introduced into geography. It seemed to create many new difficulties on the way to a regional synthesis. It appeared, though, that the transformation method may prove useful in this respect too.

We assume that uniform regions are multidimensional spaces, whereas nodal regions are unidimensional spaces. Our problem reads thus: how to transform the regions of the former type into those of the latter type, and how ought that transformation to be interpreted? The first part of the problem will be solved by a linear transformation of vector spaces of different dimensions.

Uniform regions must not be identified with two-dimensional spaces. They may be more than two-dimensional, and this is even desirable, for if they are, more complex structures can be mapped. In our case it is assumed that uniform regions are four-dimensional spaces, i.e., the particular elements constituting the sets called uniform regions are defined by four features. The selection of those features is conditioned by that in the further considerations the referents of the nodal regions will be certain transport systems. Accordingly, for the dimensions of uniform regions must be taken such factors that affect the transport operations. We take the following: population, industrial output, investment expenditures, and the value of purchases of agricultural produce.

By a linear transformation of vector spaces we mean the function:

$$y = Ax,$$

in which the set of arguments X and the set of values Y are vector spaces.

This function pairs the points $(x_1, x_2, ..., x_n)$ of the n-dimensional space S_n with the points $(y_1, y_2, ..., y_m)$ of the m-dimensional space S_m. Such pairing transforms space S_n into space S_m. Thus space S_m may be called the image of space S_n in a transformation defined by the matrix

$$A = \begin{bmatrix} a_{11} a_{12} \dots a_{1n} \\ a_{21} a_{22} \dots a_{2n} \\ \dots\dots\dots\dots\dots \\ a_{m1} a_{m2} \dots a_{mn} \end{bmatrix}.$$

This matrix, which is composed of elements $a_{11}, a_{12}, ..., a_{mn}$ with the variables $x_1, x_2, ..., x_n$, will be called the transformation matrix. At a given space S_n we can find its image S_m in transformation A, and conversely, at a given image S_m and at a given transformation matrix A, space S_n can be found.

We shall focus our attention on another problem, namely, on finding the transformation matrix from data concerning space S_n and its image S_m. It is in this operation that the essential element of the synthesis of uniform and nodal regions consists. It is assumed that information concerning uniform and nodal regions is available. The latter are regarded as images (S_m) of uniform regions (S_n). The transformation matrix will be what holds the two types of regions together. It will be an attribute pertaining to the uniform and nodal regions taken together and not one pertaining to each of these categories of regions separately. Thus we can regard it as a synthetic (structural) attribute which gives the character of a "whole" to the uniform regions and the nodal regions (we have presented a similar reasoning before, but a transformation of many uniform regions of the same dimensions rather than of different dimensions has been involved).

Empirical studies were carried out for the Konin poviat. The transformation of the actual regions of gravitation to transport lines and nodes demands data grouped by small territorial units (*gromady* and towns) or even data characterizing particular industrial plants. Both the collection and the processing of these data for larger units stumbles over statistical and calculation difficulties.

In the transformation of our region uni-equational models will be used. Each equation will represent the operation pattern of transport in the region of gravitation which is specific from the point of view of a definite factor. The transformation of the whole poviat, which is regarded as identical with the operation of synthesizing, will be defined by a set of horizontal vectors.

In our case the uni-equational models are sufficient as a method of mapping. They are additionally convenient in that they can be evaluated by the classical least-squares method. This accounts for the remarkable simplicity of the calculations. Models with simultaneous equations should obviously be a more adequate method, as they would make possible a study of the mutual interdependencies between transport operations in the different regions of gravitation. But for the estimation of the parameters the application of Theil's double method of least squares, which involves more difficult and cumbersome calculations, would be indispensable.

The Konin poviat can be divided into three zones of different economic and transport characteristics: (1) The zone of new mining and manufacturing investments to the north of the town of Konin ("Jóźwin" and "Kazimierz" mines, "Pątnów" power station, "Konin" aluminium works). In connection with the investment activity and the industrial production, heavy transport flows are concentrated on the roads Konin–Ślesin and Konin–Kazimierz Biskupi

(2) The zone extending along the road Poznan–Warsaw. Within the boundaries of the poviat, the town of Konin is the biggest centre of manufacturing and investment activity. The total volume of road traffic includes a considerable amount of through-traffic. (3) The remaining part of the poviat covering the *gromady* in the north and the whole southern part. It is still predominantly agricultural, and large shares of the total transports belong to agricultural produce and to commuting to work at Konin and in the main zone of investment activity. Now we shall transform the economies of the zones into transport points. The transport points are assumed to be the points at which road traffic is measured.

The general formula of the transformations applied is:

$$y = a_1 x_1 + a_2 x_2 + a_3 x_3 + a_4 x_4 + T + \xi$$

where y denotes the volume of traffic at the transport point (in metric tons), x_1 stands for the population number in the region of gravitation around a given transport point, x_2 is the value of industrial output (,000 Zl), x_3 are investment expenditures (,000 Zl), x_4 denotes the value of purchases of agricultural produce (,000 Zl), T means through-traffic, ξ is a random value, and a_1, a_2, a_3, and a_4 are the parameters of transformation.

The random component ξ is equal to the difference between the observed values of variable y and its theoretical values, i.e. a function of the explaining variables x_1, x_2, x_3, and x_4. It expresses the effect of factors that are not directly incorporated in the formula (subsidiary factors) on the endogenous variable. The inclusion of the random component makes the whole model stochastic in character.

After the estimates of the parameters the transformations assume the following form:

$$\begin{aligned} y_{\mathrm{I}} &= -102825x_1 - 3.5x_2 + 18.7x_3 + 838x_4 + T + \xi, \\ y_{\mathrm{II}} &= -7578x_1 + 3.0x_2 + 3.2x_3 - 11.1x_4 + T + \xi, \\ y_{\mathrm{III}} &= 493565x_1 - 73.8x_2 + 69.3x_3 - 68.6x_4 + T + \xi. \end{aligned}$$

The estimated parameters have values that do not immediately correspond to the expected transport coefficients. Therefore, to determine the dependence of the endogenous variable upon the explaining variables, correlation procedures must be employed.

The above solution is not entirely satisfactory, even after the additional calculation of the correlation coefficients. It would only be fully satisfactory if there was one single solution of the system of transformation equations. But our system — and this will be the case with many other empiric systems — has more equations than variables. Such a system, if it is not principally contradictory (then it has no solution at all), includes dependent equations and has an infinite number of solutions. What are the possible remedies in this case? Since the equations of our system are records of observations made at different places (points) of the area studied, it is difficult to say anything about their interdependence and/or eliminate the dependent equations from among the others. Instead of elimination we introduce additional (fictitious) variables, thus obtaining the system of equations in a more convenient form at the expense of somewhat extending it. It will be solved on the basis of the empiric data recorded in the second zone of the Konin poviat.

We define the objective function for the additional variables and subject it to extremization (minimization). Each variable has its corresponding equation. The most convenient situation would occur if all variables were of zero value. In our solution this is the case with half of the additional variables, the other one having positive values. This means that in half of the system there are differences between the free terms and the original terms on the other side of the equations. These differences can be interpreted as expressing the effect of the variables not included in the original system on the transport operations. By comparing the differences with the free terms we get an idea of how strong that effect is. In the examined zone, the ratio of values of differences to those of free terms amounts to 8.2%, which is rather small.

The parameters sought for were not to exceed the value of 1000. Thus it was assumed that road transports per 1000 population (per 1000 Zl of industrial output etc.) should not exceed 1000 tons per year. With this restrictive condition, the following solution has been obtained:

$$y_{II} = 1000x_1 + 16.8x_2 + 2.1x_3 + 7.1x_4 + Z + \vartheta,$$

where Z stands for the value of the additional variables.

Formally, this is a problem in linear programming. Accordingly, the obtained values are optimal, and from the program it follows that there is but one optimal solution.

The interpretation of this solution is no longer difficult. From the comparison of the values of parameters it follows that the weight of agricultural output (in relation to value) is more than eight times greater than that of industrial production. This fact is easy to explain: a large share in the total industrial output of the Konin poviat belongs to electric power conveyed by a special system. The 3.5-fold "weight" of investment activities as compared to industrial output (per 1000 Zl) is also clear in view of the above remark concerning the industrial structure of the Konin poviat. From the fact that the parameter characterizing the population mobility achieved its highest possible value it may be inferred that we have imposed a too rigidly restrictive condition upon it. After some moderation the parameter would rise to a more realistic value, whereas the values of the additional variables would be diminished and would come close to zero.

A particularly valuable method of representation of the spatial economic structures is the regional and interregional input-output analysis [2, 4]. It makes possible the representation and the study of the general interdependence integrating the regional economy into a whole and of its interrelationships with the economies of other regions. But this method has more applications than the mere description of interrelationships. It can be employed to anticipate economic developments in space. Given the final demand of a commodity in a definite region this method may help to define the desirable alterations in the gross output of that commodity in all regions (in economic prognoses, the determination of the planned input coefficients and of the interregional coefficients has not been satisfactorily solved yet).

In mapping the horizontal pattern of interregional links it is customary to take into account their intensities. But this is only one aspect. In a comprehensive approach to the study of the spatial structure of economy we cannot neglect the effects of factors that diminish the intensity of the links ("barriers"). One group of such factors are boundaries. The state boundary is the most conspicuous example of a factor that diminishes the intensity and deforms the directions of the links and moreover has a selective effect on the qualitative structure of exchange. But administrative boundaries have their specific effects too. Therefore it is necessary to measure their diverse influences.

J. R. Mackay started a new approach to the study of the boundary (barrier) effects. It was a quantitative approach yielding measurable and comparable data [3] and based on the gravitation model and on regression analysis. A few years later Yuill suggested a different methodological approach [7]. For his point of departure he took the idea of diffusion waves borrowed from T. Hägerstrand. Employing the Monte Carlo simulation procedure he examined the effects of four typical barriers in the process of diffusion of information.

The present author made measurements of the barrier effect in the Konin–Łęczyca–Inowrocław Industrial District. This district is situated in the meeting-point of three voivodships: Poznań, Łódź, and Bydgoszcz. The intensification of the industrialization process commenced in the mid-fifties created in each of the three constituent regions (i.e., Konin, Łęczyca and Inowrocław) a number of similar economic and social problems. In view of the fact that the economic and social problems were very similar in all the three regions, while each of them belonged to another provincial government, a special interregional and interministerial commission was created with the task of developing a long-term comprehensive plan for the development of the whole district. The administrative boundaries between the three voivodships have not been changed yet.

In scientific discussions it has been frequently asked if the industrialization in the three adjacent regions has led, or is leading, to the development of a new economic district with intensive internal links and a specific character as compared to the neighbouring areas, or whether it produced merely a significant increase in the number of industrial establishments which co-exist within the boundaries of the district but which have no marked mutual technological or economic links. This question may also be put differently: have the similar development trends of recent years diminished the effect of the boundaries of the three adjacent regions thus giving the district the character of a homogeneous economic whole, or has that effect not diminished and the district is but a loosely bound set of three regions? If the former alternatives of the two questions prove to be true, we should have to consider the practical consequences of the new situation.

The author's measurements concerned three problems: the migration of school children to secondary vocational schools, the number of marriages, and the number of telephone calls. In the first two cases, the administrative boundaries were responsible for a twofold reduction of intensities of the links. In the case of telephone calls, which suffered a 12-fold reduction, there was a marked effect of the organization of economic and social life on the territorial basis. Unless further measurements should fail to reveal similarly declining effects, the hypothesis that notwithstanding the adjacency, the District is not an integrated self-contained socio-economic whole and that the processes of industrialization and the corresponding social trends conditioned by them in recent years have not diminished the effect of the provincial boundaries, should be accepted as true.

The methods presented so far constitute but a framework of a system that would enable the mapping of the vertical and horizontal spatial structure of economy. This framework can be complemented in different ways, depending upon the respective purposes of study. In particular, on the basis of correlation coefficients and of other data we may formulate statistical hypotheses concerning different aspects of the spatial structure of economy, and subsequently subject them to verification procedures.

Parallel to the development of the methods of mapping, the methods of forming the spatial structures of economy are being developed. This justifies the expectation that we shall soon be able to present a normative model of such structures [5].

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NEW OPINIONS AND TENDENCIES IN POLISH CARTOGRAPHY

LECH RATAJSKI

An extremely rapid development of techniques observed in the last twenty years strongly affected various domains of our life and science. A considerable increase in both amount and kind of information, as well as an unusual "rise of price" of time seems to be the most visible effect of this development. Thus, both social and economic aspects forced some scientists to focus their efforts on the problem of "psychological digestibility" and on the possibility of the consumption effects caused by these processes. A verification of the role of individual scientific branches in general human knowledge, an intense perspective on the contiguous and related scientific branches, a mutual comparison and an adaptation of the methods and results obtained within the other scientific domains, became necessary. As a result, new previously unknown scientific branches appeared, having in view a unification of various trends that apply similar research methods, although dealing with somewhat different subjects of study. Meta-sciences also developed, and many scientific theories and domains were devoted to the transmission and consumption of information, as well as to the efficiency in activity of the performance of tools.

This also concerned cartography. Both the revision and change in opinions were the result of different technical and theoretical reasons. On the one hand, a rapid progress in techniques has affected and still affects all technological processes of map production, i.e. in editorial work and in reproduction procedure, also resulting in the development of new forms of cartographic transmission (maps on oscilloscope screens, animated maps, illuminated maps, new kinds of plastic maps, introduction of holography into cartography, etc.). On the other hand, various maps are increasingly used by numerous circles of receivers, mainly due to the heterogeneous nature of map contents, and the conditions of utilization. In addition to purely informative and didactive functions, a map today becomes a work tool which is also governed by the principles of praxeology and engineering psychology. Both speed and ease of use of maps are here of considerable importance, too.

At the same time new scientific theories and domains dealing with efficient transmission of information developed on so great a scale that they also became highly important to cartography. This, especially, concerns information theory and semiotics. Attempts to introduce into cartography these theories and results obtained from the above scientific branches must naturally have resulted in some revisions of previous notions, and in a reconstruction of certain views on cartographical problems. It is thought that these revisions and the attempts to develop new opinions are reflected in many recent publications devoted to the world's cartographical and geographical questions, e.g.

those written by A. Moles [1], W. Bunge [2], J. Bertin [3], M. K. Bocarov [4], A. Aslanikasvili [5], A. Kolačny [6], K. A. Saliscev [7] a.o. In Polish cartography, such attempts were made by J. Gołaski — a proposal concerning a new definition of map [8]; L. Ratajski — suggestions on the theory of cartology [9]; J. Pasławski — a discussion on cartographical methods in geographical studies [10]; or W. Ostrowski — polemics with W. Bunge [11].

The outlines of the theory of cartology result from a working definition of cartography as a dynamically defined activity which is contrary to the old and rather static formulations. According to this conception, cartography is a sphere of human activity, comprising both the creation and functioning of all forms of cartographic transmission. The activity appears in both scientific and practical forms [12].

In this light, a duplication of this activity may be distinctly observed, as in many other sciences.

So far, the scientific part of cartography has been and is now determined as scientific cartography, or cartography as science, or even theoretical cartography, being always contrasted with applied cartography. In the author's opinion, theoretical cartography has not so far constituted any uniform theoretical system without clear definition of its general theory. On the contrary, it has been considered as only qualification of research activity in the field of cartography.

Recently a new notion and term "cartology" has been proposed in Polish cartography. It is thought to represent both a theory, and a system of theoretical cartography based on this theory. The fact of the functioning of a cartographical information transmission has been taken here as a basis for consideration. This functioning can broadly be understood as a process of information collection, a process of transformation, and the transformation of the re-

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[12] L. Ratajski, see note 9.

ceiver [13]. With reference to the definition mentioned above, cartology may be briefly determined as an activity that consists of a scientific elaboration of theoretical principles and estimations, which leads to an improvement of cartographical products, and to the maximum functional optimization.

Like any other branch of science, cartology has its own subject, range, and research methods. Thus it is necessary to work out a theory that will define all these aspects. If we consider cartography to be a domain of human activity, we cannot discuss the theory of cartography as a whole, but only its scientific aspect, i.e. about the theory of cartology.

A map (broadly understood as every possible cartographical product) and the processes that lead to the production and application of this map are also the subject of cartological researches. Simultaneously, the map is thought to be a specific form of chronological information transmission i.e. of information transmission about spatial relations. This form of chorological transmission, executed by means of cartographical mediums [14], is called cartographical transmission. It is characterized by a particular and specific form, expressed by means of plastic arts, for example graphical elements which are also capable of directly illustrating the chorological substance. Like any other information transmission it subsequently behaves as an information source, transforming the receiver. According to the efficiency of transmission, the extent of transformation of the receiver is different. Estimations of the form of transmission, i.e. of a map, and of its function, helps the recognition of the efficiency of transmission, and the effectiveness in transforming the receiver.

Thus, the theory of cartology may briefly be formulated as follows: Cartology is a science, whose subject of study is the expression and the transmission of chorological information by means of cartographical form, i.e. maps that act as a source of information which is already transformed, transforming the receiver in order to recognize reality. The research comprises: the source of chorological information, processes of transformation, and processes of reception of this information, and form of transmission (i.e. the map) — being executed using both deductive and empirical methods.

The methodology of cartography determines research methods, relations with deductive and empirical sciences in scientific procedure, the position of cartography in the general system of knowledge and human activity, and relations with other sciences and domains of practical activity. Used in this way, the concept under consideration is somewhat broader than the notion of metacartography proposed by W. Bunge. His notion is concerned with the determination of the position of cartographical transmission (i.e. the map) amongst other kinds of chorological transmissions.

Naturally, the above theoretical considerations must have resulted in the development of a new division of cartography. Such a division has not only to arrange and to group all trends, both in research work and in practical cartography, but also must take into account existing achievements, simultaneously pointing at the means of developing this scientific branch by producing a wide range of questions. An attempt at presenting such a division has already been made at the Department of Cartography of the Geographical Institute, at Warsaw University. A general scheme of this proposal is shown below (Fig. 1).

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[13] Transformation of a receiver is here understood as the remodelling of consciousness due to the new information received.

[14] Cartographical means are thought to be a system of cartographical signs, which in their activity consist of a reflection of the spatial structure of reality being presented.

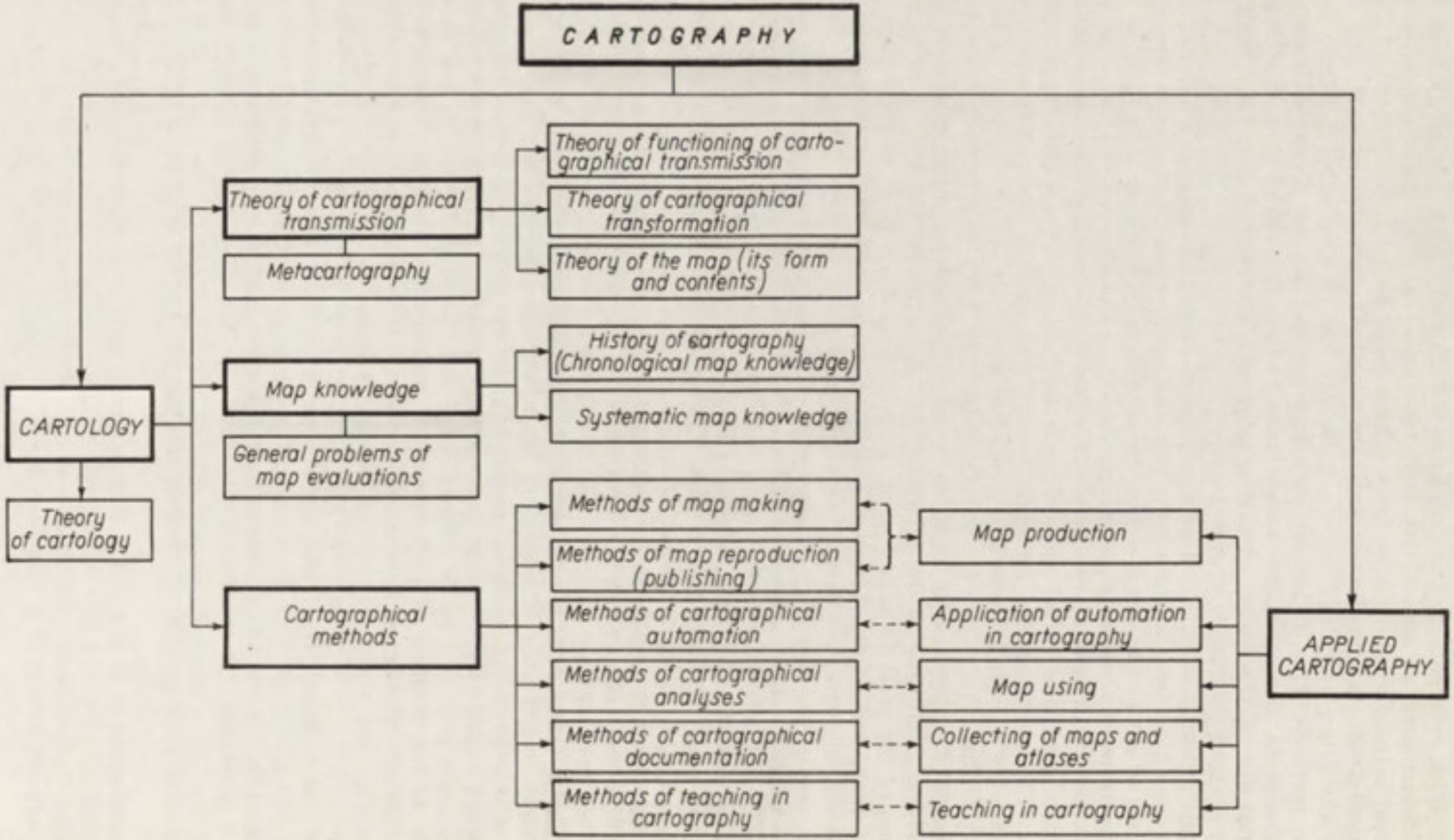
CARTOGRAPHY
CARTOLOGY
Theory of cartology
Theory of cartographical transmission
Metacartography
Map knowledge
General problems of map evaluations
Cartographical methods
Theory of functioning of cartographical transmission
Theory of cartographical transformation
Theory of the map (its form and contents)
History of cartography (Chronological map knowledge)
Systematic map knowledge
Methods of map making
Methods of map reproduction (publishing)
Methods of cartographical automation
Methods of cartographical analyses
Methods of cartographical documentation
Methods of teaching in cartography
Map production
Application of automation in cartography
Map using
Collecting of maps and atlases
Teaching in cartography
APPLIED CARTOGRAPHY

Fig. 1

For lack of space, the present scheme illustrates only the most important hierarchical grades [15], showing the two-way division of cartography mentioned above. The division of cartology in turn takes into account theoretical problems, map knowledge, and cartographical methods.

The essence of the theoretical problems has generally been explained in the discussions on the theory of cartology, the additional subdivision only being the result of these discussions. The theory of cartographical transmission is composed of problems that are concerned with the source of chorological information, the efficiency of cartographical transmission [16], the transforming of the receiver, and the reproduction of the source reality. Thus, both physiological and psychological aspects and processes related to map perception are included. The theory of cartographical transformation takes into account the proper transformation of the contents contained in a map, the cartographical projections (mathematical cartography), and the cartographical generalization. The notion of map theory includes both the theory of the map form, and the theory of the map contents, i.e. the amount of information transmitted by means of a map. The former deals with cartographical semiotics, the theoretical problems of the methods of presentation (cartographical presentation), and the aesthetic aspects of a map. The latter, in turn, is concerned with the problems of the information elements of a map, the cartographical symptoms, the information capacity of a map, and others.

Map knowledge leads to an elaboration of the norms and systems of evaluation, and to the classification and systematization of cartographical products (maps). These may be produced either by an historical approach (history of cartography), or according to an essentially typological approach (systematical map knowledge). The former notion deals both with the evaluation criteria of chronological systems, the classification of maps according to the period of production, to the cartographical school, to the map makers, a.o. Moreover, the notion also includes the problems of discovery, research, and description of historical works and facts concerning the cartographical activity. Systematical map knowledge is thought to be a study of cartographical products, from the point of view of typology and from problems that result from the map contents; that is, it deals with the methodical and thematic aspects, as well as the range of map functioning.

As a matter of fact, cartographical methods are a transition from cartology *sensu stricto* to practical cartography. Studies and considerations that result in the discovery of laws and regularities are used to work out all the principles and instructions for map production. This concerns both the results of theoretical-cartographical research, and the results of these sciences, the achievements of which are particularly useful to cartography. Included here are methods of map-making, methods of map reproduction, automation, as well as cartographical analyses, cartographical documentation, and teaching in cartography.

Recently, some work has been initiated in Poland to realize all the postulates resulting from the proposals mentioned above, or from those related to them.

An analysis of the cartographical transmission model [17] that shows that the-

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[15] A more detailed scheme will be presented in the author's paper in "Polski Przegląd Kartograficzny".

[16] The problem of the efficiency of a cartographical transmission has been broadly discussed in the author's paper "Cartology" (see note 9).

[17] L. Ratajski, see note 9.

re are some dependencies which affect the estimation of map efficiency. This may be illustrated in a mathematical-logical formula as follows:

$$Z = \prod_{i=1}^{4} \frac{s_{i1} \cdot s_{i2}}{S_i},$$

where

i = number of stages of information flow,

s_{i1} = the relation of emission i.e. quantity of information emitted by the sources, of i stages of information flow,

s_{i2} = the relation of perception, i.e., quantity of information received during i stages of information flow,

S_i = relation of recognition, i.e., quantity of information obtained by a receiver.

The maximum efficiency of a cartographical transmission of information depends upon the intensity of disturbance that appears in each stage of the transmission. These disturbances may be a result either of external reasons, i.e. environmental conditions, or of internal reasons, which are influenced by the map proper, and by the degree of its elaboration, editorial work and reproduction. In the latter case, we may speak about disturbances and deformations, in both semantic and pragmatic aspects, about necessary or useless deformations, a.o. Some work and consideration has been devoted to the above problems at the Department of Cartography of the Geographical Institute at Warsaw University.

The problem of disturbance and deformation is strongly related to cartographical generalization. This topic, too, has recently been throughly studied in Poland. Some aspects of this question are worthy of note, i.e. the total problem of generalization, expressed in model systems [18]; the influence of generalization upon the cartometric accuracy of maps [19]; and principles of selection and rules, of objectivization in generalization. Research on the retention of cartometric accuracy on thematic maps resulted in a theory of pairs of methods and of nodes of changing methods. This theory says that each cartographical method of presentation is always accompanied by another method that distinguishes itself by having the same, or an approximate graphical appearance, differing however by another presentation of numerical values, that is by a continuous manner (in the individual unit notations), or by an interval manner. In the process of generalization, one pair of such methods has one common moment, at which the cartometric accuracy is identical. This moment is called the node or point of changing methods.

The principles of selection and the rules of objectivization are an additional problem in cartographical generalization. Studies carried out to explain this problem take into account some attempts at applying information theory with the reservations, which result from the fact that in this case the transmission of information is of a spatial and not of a linear nature. The question here is: to what extent may the relative entropy be a criterion for selection and for

[18] L. Ratajski, Phénomènes des points de généralisation, International Yearbook of Cartography, 7(1967), 143–152; A model of cartographical methods, Geogr. pol., 11, Warszawa 1968, 372–378.

[19] L. Ratajski, Mapy przemysłu, ich właściwości metodyczne i kartometryczne (Sum.: Maps of industry — their methodological and cartometrical attributes), Prace geogr. IG PAN, 56, Warszawa 1966; The point of change for methods in thematic cartography, Geogr. pol., 18, Warszawa 1969, 177–182.

the correctness of this selection in the procedure of generalization. In addition to this problem, the study also tends to search for rules of objectivization in the generalization of linear elements on maps [20], in belief that the map will take geometrical formulae, which might be expressed by using fairly simple algorithms only.

The theory of cartographical transformation also discloses an important problem of the relations of reference systems. Starting from the notion that space is thought to be a sphere of activity for all relations that result from its nature [21], we may discuss this problem from a somewhat different point of view. In geographical and cartographical practice we very often deal with the notions of geodetic space, physico-geographical space or natural environment space and socio-economic space. Since each of these spaces has different systems of intrinsic relations expressed by various mental categories and by various measures, the representation of elements of one space in another one, produces considerable difficulties for the cartographer when making projection of one space onto another one the more so that these spaces distinguish themselves in having specific means of presentation. Nevertheless, all the spaces mentioned above have a lot of contiguous points, or fields of co-operation. This is due to the fact that human activity and human environment are always binding agents here. Thus, both the means and the method of mutual projections should be sought exactly in the zone of these contiguities. This may be illustrated by means of a fairly simple diagram (Fig. 2).

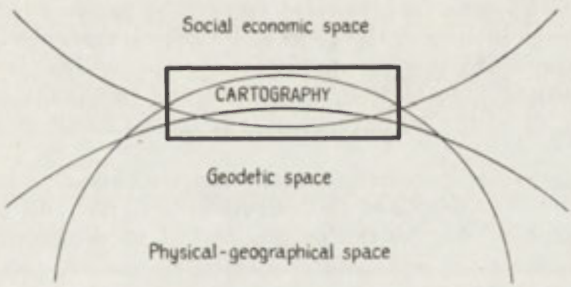

Fig. 2

As a result of a long practice and due to considerable experience in cartography, geodetic space is best thought of as a projection. Usually, such a projection to this form is called a map, and we are accustomed to this form. Difficulties only arise at projecting other spaces, particularly those of a socio-economic nature, in terms of geodetic space. The solution of these difficulties will strongly affect the successes of thematical cartography in the future. Discussion on cartographical methods [22] and on the method of concentration are considered to be the first attempt of this kind. The latter problem has been

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[20] G. Bonatowski, Metodyka generalizacji sieci rzecznej (Methods of generalizing river networks), Acta Univ. Carolinae (in print).

[21] K. Dziewoński, Zagadnienie integracji analizy kartograficznej i statystycznej w badaniach geograficznych (Sum.: Problems of integration of statistical and cartographical analysis in geographical research), Przegl. geogr., 37(1965), 4, 585–596.

[22] J. Pasławski, see note 10.

discussed in several papers by Prof. F. Uhorczak [23], and by his students [24]. They propose, amongst other things, to replace the so-called mozaic concentration by a method which shows dense zones of concentration, and expresses more geographically the mutual representation of two spaces.

The question of map-form is a world-wide subject, discussed by many cartographers. Standardization of cartographical signs now appears to be a particularly burning issue, because it is one of the main ways of increasing the efficiency of the map as a medium of information transmission. This problem depends largely upon the theoretical discussion focussed on map language, as governed by the general rules and laws of semiotics. Map language is said to be an ideographic medium of communication, presented in the form of a cartographical code. The code is a system of active cartographical sings, i.e. sings doing their duty as a map [25]. According to this notion of the code, there are distinguished both categories of information elements and the information proper. These are a source of the fundamental relations of semiotics, that is the relations of syntactic, semantic and pragmatic nature. These problems have been preliminarily discussed by the present author in a paper published in the *Internationale Jahrbuch für Kartographie* [26].

Some remarks on the history of cartography seem to be worthy of mention. Most works so far published on this theme have dealt predominantly with historical methods of study and evaluation. As a rule, most scientific elaborations have been made only by historians. This fact can be explained by the insufficient development of cartographical methods of evaluation and of analysis of cartographical works in historical aspects. A paper published by J. Gołaski [27] led to distinct change in the field of Polish cartography. All cartographical works are seen from the viewpoint of a map, which is thought to be a form of transmitting information, and from the viewpoint of all the consequences in opinion of historical nature, which are the result of such an assumption.

The present paper, of necessity briefly written, aims to present the state of Polish cartography in the field of theoretical activity, and emphasizes some attempts at introducing the results of theoretical investigations into practice.

Warsaw University

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[23] Mapa "Gęstość zaludnienia 1960 r." (The map "Population densities"), in: Geografia Powszechna, 2, PWN, Warszawa 1963.

[24] K. Warakomska, Kartograficzna metoda przedstawiania koncentracji ludności w odniesieniu do dróg i przystanków autobusowych (Sum.: Cartographical method of presenting population density in relation to roads and bus stops), Pol. Przegl. Kartogr., 2(1970), 3, 111–122.

[25] Compare the opinion on a specific character of a cartographical sign, presented in the article by A. F. Aslanikasvili (see note 5).

[26] L. Ratajski, The methodical basis of the standardization of signs on economic maps, Int. Jb. Kartogr. 11(1971).

[27] J. Gołaski, Kształtowanie się mapy wsi w Polsce do końca XVIII w. Studia nad genezą wielkoskalowej informacji kartograficznej (Sum.: The formation of the map of villages in Poland till the end of XVIII century. Studies on the origin of cartographic information on a large scale), Zakł. Nar. im. Ossolińskich, Wrocław–Warszawa–Kraków 1969.

GEOGRAPHIA POLONICA 22, 1972

This article is dedicated to Professor SHINZO KIUCHI
the distinguished Japanese geographer

THE GEOGRAPHERS' PARTICIPATION IN SOLVING PROTECTION PROBLEMS OF THE HUMAN ENVIRONMENT

STANISŁAW LESZCZYCKI

INTRODUCTION

The expansion of human activity in many socio-economic fields has led to far-reaching changes and transformations of the natural environment. Above all it concerns highly developed countries, where negative changes in man's environment appeared parallel to positive civilization changes. Destruction and pollution of the natural environment have often become very acute and have begun to cause reductions of positive human life conditions. Simultaneously, the range of pollutions (disfunctions) stopped being only local; it has extended over considerable parts of the continents. Some pollutants, e.g. of air and water, have menaced the whole world. When we consider the fact that the era of nuclear energy has begun, which will multiply the energy man disposes, then further and far more stronger disfunctions may be expected in the coming decades. Thus we speak not only of the deterioration of life conditions of societies, but of threats to their health and even to their very existence. These facts are widely known; much is written and said on environmental problems. Therefore, it is not surprising that not only scientists but also politicians and social workers are interested in environmental problems.

Considering the vast areas, which are under the influence of disfunctions caused by human activity, international organizations are also interested in environmental problems. There is an univocal opinion about the necessity of international co-operation in environmental policy. The environmental problems have become the target of interest and co-operation of United Nations Organization. In recent years many actions have been undertaken, and environmental problems have become very vital.

GEOGRAPHERS' ROLE IN ENVIRONMENTAL STUDIES

For the scientific community the problems of the environment are not new. Science has been dealing with them for years. However, the negative results of human activity through centuries were not too harmful, and therefore the problems were rather of a theoretical character. Among the scientists concerned with man-environment interaction there were also geographers. For more than a hundred years German, French, Russian, and other geographers pointed out the interrelationships between man and environment. The works of K. Ritter, F. Ratzel, P. Vidal de la Blache, E. Semple, J. Brunhes, W. Nałkowski, and others, may be quoted as examples. In these works, interrelationships between the natural environment and societies' activity were discussed. Analytical studies were already carried out, a huge body of factographic materials, from all over the world, was collected, a series of generalizations was proposed, and the primary basis of man-environment problems was established. The results of these geographical studies were not sufficiently known among other sciences, and they were to a large degree forgotten within several decades that followed. This may explain the fact that when, after the Second World War, the problems of the environment became important and vital, there was no reference to the old geographical studies. A number of investigations, from the different sciences, was initiated, not realizing that these problems had already been investigated. Under the new circumstances of growing interest in man–environment problems geographers were not able to take key-positions. Priority was given to the representatives of other sciences, e.g. biologists, physicians, town-planners, architects, and other technicians. Naturally, the development of contemporary science has nowadays gone so far that it is impossible to solve these problems without the co-operation of many specialists. However, it seems that the role of geographers in the man–environment studies, on both local and international scales, could be greater. One of IGU tasks is to undertake such action, co-operative investigations included, to fully utilize the achievements of the geographical sciences. Therefore, it seems that the man–environment problem is of utmost importance to geographers, and that the research carried out in this field may have a decisive influence on the further development of geographical sciences and their position among other sciences concerned with natural environment and society. It appears that we may approach the above mentioned problems concentrating on human environmental disfunctions and environmental policy.

THE FOUNDATIONS OF SOCIO-ECONOMIC POLICIES CONCERNING THE ENVIRONMENT

I. THE FUNDAMENTAL PREMISES FOR THE DEFINITION OF HUMAN ENVIRONMENT

In order to analyse the whole complex of man's environment together with the processes occurring in it, the individual constituents of this complex must be studied. I have adopted the following assumptions concerning the interactions of the system, man-environment.

A. *The laws and forces of nature.* The laws and forces of nature act in a rather similar way in all zones of the human environment throughout the world; they are, however, subject to slow variation in time, to seasonal variation within the year, to variation resulting from the respective geographical latitude, etc. In accordance with their laws, the forces of nature have multifarious effects on man and his activities. Some of the most powerful effects are the sporadic natural calamities such as earthquakes, volcanic eruptions, tsunamis, typhoons, floods, droughts, mass invasions of vermin, bacteriological epidemics etc.

B. *The expansion of human activity.* In addition to the growth of the world population, the whole body of activities of societies, which dispose of increasing resources of energy, is being strongly intensified. Theoretically, man covers with his activities the whole Earth and a small portion of outer space, but in fact these activities are very unevenly distributed over the globe: they are characteristically concentrated in relatively small areas.

C. *The influences of nature on man and his activity.* The particular components of nature exert diverse influences on man and his activities. Climate and water constitute the most powerful factors. Next come vegetation and mineral resources. Further, soils, relief, seas and oceans must be mentioned. Other major influences are exerted by the respective geographical situation and, in the densely populated areas, by the proportion of open spaces. Specific effects are brought about by natural calamities (see Fig. 1).

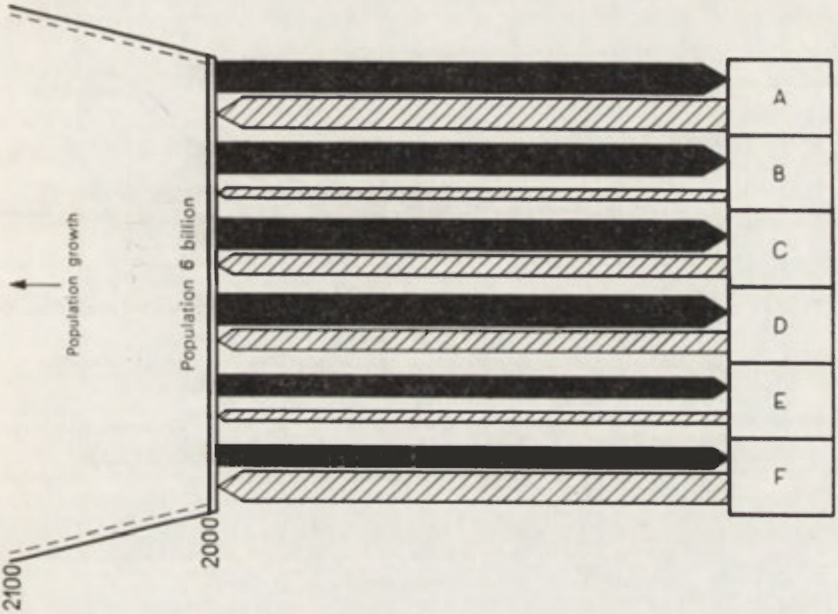

Fig. 1. Model of interaction: man and environment
A — Lithosphere, B — Pedosphere, C — Biosphere, D — Continental Hydrosphere, E — Oceans and Seas, F — Atmosphere

D. *The influences of human activities on environment.* By adapting the environment to his needs man affects it by his activities, both as a whole and its particular components such as the lithosphere, hydrosphere, biosphere, pedosphere, atmosphere, and others. Man introduces anthropogenic elements into the natural environment. The incorporation of anthropogenic elements into environment produces its new quality. I call the transformed environment a geographical environment. If the anthropogenic elements are in clear predominance, we have to do with a man-made environment (e.g., in big cities). Nevertheless, man-made environments are subject to the laws and forces of nature too (see Fig. 1).

E. *The limited potential resources of the environment.* Although the exploitation of the environmental resources and values is in continuous progress, the potential resources of the Earth are limited. Together with the growth of the population and the expanding activities of man, the proportion of resources that have been used up is growing too. The rate of this latter process is accelerating due to developments in technology and to growing demands concerning the living standard aspired to by the population. As long as the population's needs can be satisfied with the exploited resources of the Earth, the development of life on Earth is secured (see Fig. 2).

F. *The model of human activities in space.* Man's activities are at their most intensive in the vicinity of his settlement. The intensiveness of his activities decreases stepwise together with increasing distance. Accordingly, the pollutions resulting from man's activities diminish together with increasing distances (see Fig. 3).

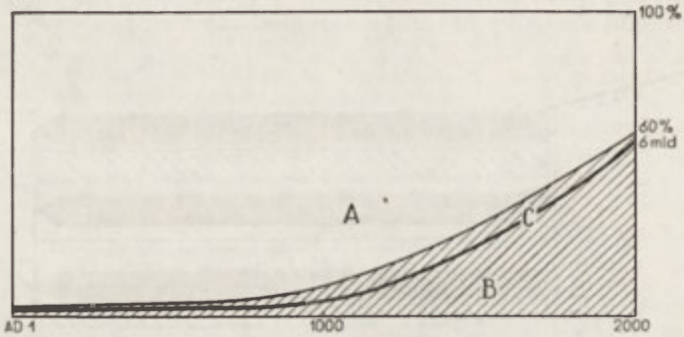

Fig. 2. Model of utilization of potential natural resources in time and the population increase

A — Potential resources, B — Utilized resources, C — Population increase

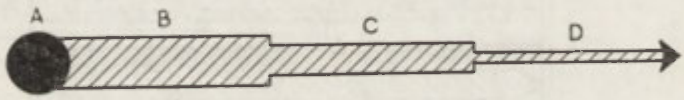

Fig. 3. Model of human activities in space

A — Settlement area, B — Intensive activity zone, C — Extensive activity zone, D — Sporadic activity zone

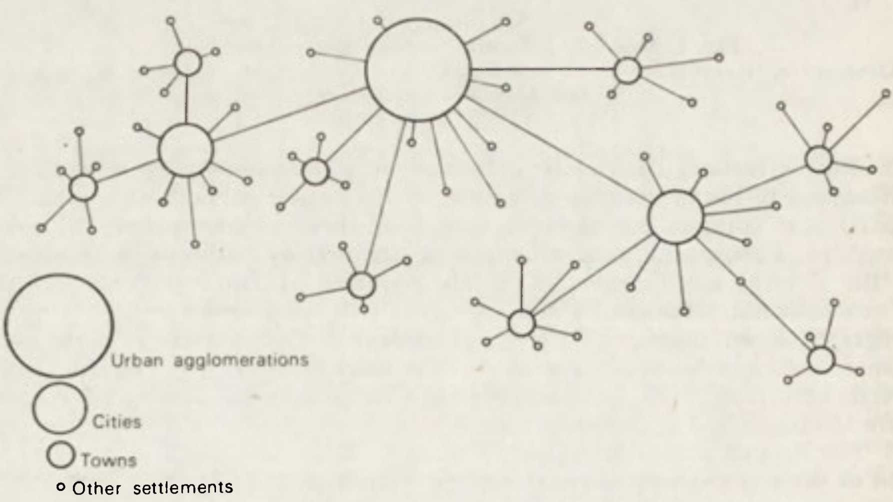

Fig. 4. Model of concentration of population in Europe in XIX and XX century

G. *Man's activities tend to concentrate.* Due to economic and social reasons, man's activities tend to concentrate in specific areas and points of the Earth. Agricultural population living in sparsely populated areas or in small rural settlements abandons farming and moves to towns and cities. Industrial production and the developing services stimulate the growth of big cities and urban-industrial agglomerations. Population tends to concentrate too, which finds its reflection in the congestion of built-up areas (see Fig. 4).

H. *Accumulation of disfunctions.* The growth of production is accompanied by a rise in living standards but also by a growth of environmental disfunctions which deteriorate the living conditions. Production grows steadily thus contributing to the improvement of the living standard. But the rise in the latter is not simply proportional to the production growth for it depends upon the distribution of the national income, that is, upon the socio-political relations. Increased production and consumption are usually followed by a further

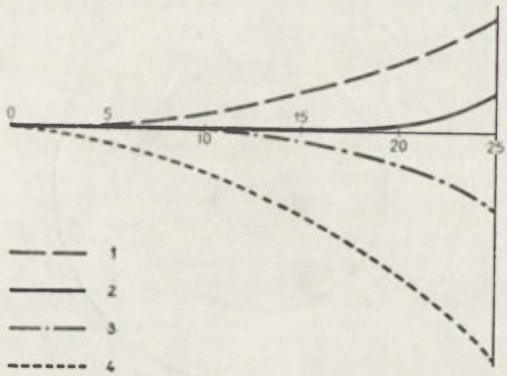

Fig. 5. Relationship between standard of living and environment improvement costs
1 — Rise in standard of living, 2 — Increase of environmental disfunctions, 3 — Rise in environment costs, 4 — Rise in total production value

degradation of the environment, which adds to the deterioration of the living standards. If the degradation of the environment is to be prevented, definite expenditures on its protection or rehabilitation have to be incurred. The total expenditure on environmental activities is determined in relation to the volume of national income, the living standards and the intensiveness of destructive activities in the environment (see Fig. 5).

II. THE THREE ZONES OF THE HUMAN ENVIRONMENT

The above assumptions allow me to distinguish three zones of the environment. In each of them the specific environmental problems are different; hence the socio-economic policies implemented in them must also be different as also the principles of the optimal allocation of resources between the environmental improvements and the other needs of the society.

A. *The zone I of urban-industrial agglomerations.* This zone covers small areas of concentration of production and services, where a large population density (more than 600 persons per 1 sq. km) is observed. This zone is dominated by man-made environment with the highest pollutions and deformations. The resident population has frequently substandard living conditions. The environmental policies in this zone should be mainly concerned with the rehabilitation of the environment and with the improvement of the living conditions, especially with the protection of health.

B. *The zone II of intensive productive and non-productive activities.* The areas constituting this zone usually have a considerable population density (more than 100/sq.km). It is in this zone that the very intensive processes transforming the geographical environment occur. Environmental disfunctions are either local or regional; occasionally they may occur in high concentration. In this zone, the fundamental problems are the protection of the natural resources and environmental values and efficient methods of their exploitation. This zone may include minor centres of high population density, in which the existing problems are analogous to those occurring in the agglomerations.

C. *The zone III, of potential resources and values of the natural environment.* Here, man's activities are sporadic, extensive and only locally intensive.

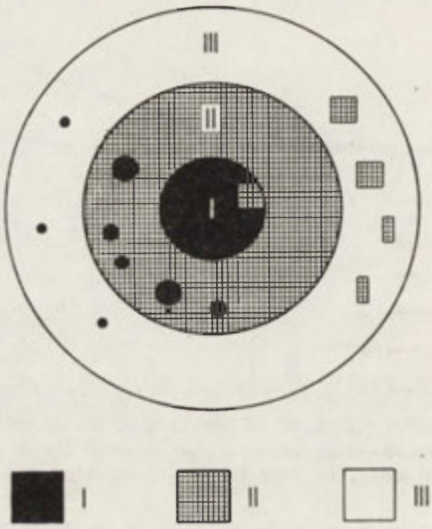

Fig. 6. Three zones of human environment

I — Urban-industrial agglomerations and centres — Population density over 600 persons per sq. km. Man-made environment — Living conditions — Health protection

II — Zone of intensive productive and non-productive activities — Population density over 100 persons per sq. km. Transformed geographical environment — Protection of natural resources — Optimal methods of utilization

III — Natural zone — Potential natural resources and amenities — Sporadic and extensive production activities — Nature protection

This zone covers also the seas and oceans as well as the areas of recreation and tourism. Pollutions are similarly sporadic and rather small. The primary problem in this zone is the protection of the potential resources and values of nature as it is to this zone that man may expand his activities in the future (see Fig. 6).

III. THE PATTERN OF ACTIVITIES RESPONSIBLE FOR THE DISFUNCTIONS IN THE THREE ZONES OF THE ENVIRONMENT

A. Industrial production constitutes the most potent factor in polluting and deforming the environment. It concentrates in zones I and II. In the zone of agglomerations, industrial production exhibits no territorial expansion as the deficit of area imposes the necessity to switch over to increasingly intensive production methods. The I zone, however, is characterized by the highest degree of industrial disfunctions. Zone II, in which industrial production exhibits the broadest expansion, is also threatened by industrial disfunctions. In zone III industrial production is but sporadic and covers mainly the exploitation of raw materials (e.g. whaling).

B. The air pollution and noise disturbances resulting from transportation

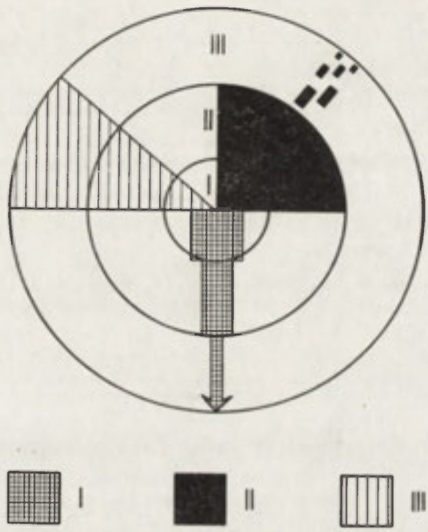

Fig. 7. Model of human activities causing disfunctions in three environmental zones
I — Decrease in transport intensity — Zones of noise disturbances and air pollution
II — Decrease in industrial production (mining included) — Pollution of air, water, soils, plants and relief degradation — Danger to health
III — Intensification of recreation and tourist activities — Environment and landscape damage

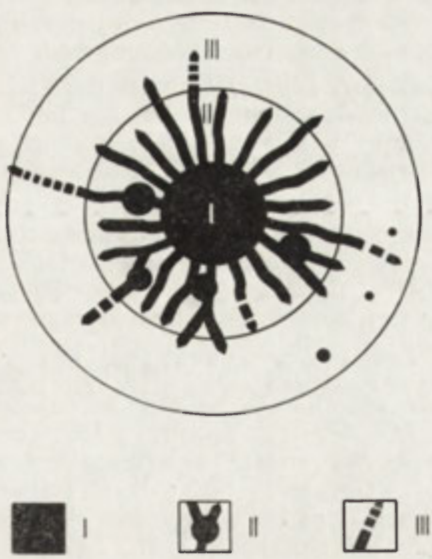

Fig. 8. Disfunction intensity in three environmental zones
I — Zone of concentrated disfunctions
II — Zone of local sources of disfunctions and their expansion
III — Zone of sporadic disfunctions

occur most frequently in zone I, to a much smaller extent in zone II, and in zone III they are rather rare (except perhaps for shipping and airlines).

C. Agriculture concentrates mainly in zone II, forestry in zones II and III, and fishing in zones III and II.

Recreational and tourism areas become important the greater the distance from zone I, but the degree of equipment with tourist facilities exhibits the opposite tendency. Pollution is proportional to the intensity of recreational and tourism activities (see Fig. 7).

D. The spread of disfunctions in the three environmental zones. The highest concentration of pollution and deformations of environment is mainly due to the fact that the different types of disfunctions accumulate in the same area. Zone I is generally the main source of pollution. Not all types of pollution, though, have only a local extent. Some of them may spread over the whole region and thus extend to zone II. There is even pollution of a still wider scope extending over large parts of the world, such as nuclear radiation and nuclear substances, or chemical poisonings of the oceans (see Fig. 8).

IV. MAP OF ENVIRONMENTAL POLLUTION

Any rational environmental policy should be based on an extensive knowledge of the actual state of the human environment and its disfunctions. Such a full picture of the actual state may be given by the special detailed and general maps presenting the distribution of the disfunctions.

A. *The purpose of the map.* The map of environmental pollution is aimed at registering spatially the areas of high environmental pollution. The map has, therefore, to present the spatial distribution of particular pollutants. Only those types of pollutants will be registered which are of constant character and are threatening man's health, his environment, and bring serious disadvantages to the national economy. The map will present the actual state of pollution and will indicate the areas mostly endangered.

B. *The scale of the map.* A general map on the scale of 1 : 1,000,000 will be the basic one for the environmental protection in Europe. For particular countries, general maps may be elaborated in various scales (as e.g. in the scale 1 : 200,000 for smaller but highly developed countries like Benelux countries).

C. *The contents of the map.* The map will contain the following elements:

(1) Air pollution by dust and gases measured in tons per 1 sq.km per day. This index will allow the comparison of data referring to particular localities and centres as well as to territorial administrative units and industrial regions.

(2) Water pollution will involve pollution of rivers, lakes and artificial basins. The pollution of rivers will be illustrated by vectors, the width of the ribbon indicating the average flow in millions of cubic meters, whereas the amount of pollutants will be shown in a three or four grade scale as it is used most frequently in European countries. Moreover, there will be also indicated the thermal pollution of water as resulting from effluents from e.g. power stations, and especially nuclear power plants, and also possible bacteriological and radioactive pollution. Different colours will be used for various types of pollutants. The same colours will also be used when presenting pollution of lakes and artificial basins. If it is possible, bigger communal sewage treatment plants will be indicated as well as the areas manured with communal effluents.

(3) Pollution of seas. The map will show the different types of sea pollu-

tants as well as their amount (three degrees of intensity). Particular attention will be paid to coastal, territorial waters and to those directly surrounding the ports. These pollutions will be presented in colours, in the form of ribbons.

(4) Devastations of relief and soil. They will be divided into (a) those resulting from mining and (b) from different building activities. The following relief deformations will be distinguished: convex (waste heaps, piles etc.) and concave ones (clay pits, quarries, open-cast mining etc.). Each type of forms will be denoted by symbols. The degree of pollution of soil will be shown in colours. Possibly the areas completely devastated by industry ("moon landscape"), as well as disturbances of natural water conditions, will also be shown.

(5) Plant devastation. Areas with devastated plants, mainly forests will be shown by means of colours, different for various devastation intensity.

(6) Mining of radioactive resources and atomic plants (nuclear power stations, reactors, deposits of radioactive wastes etc.) will be shown by symbols to indicate the areas being subject to potential danger.

(7) Noise disturbances and air pollution of transport routes. All kinds of transport systems will be included, i.e., railways, highways, air routes and routes of inland navigation. More important transport nodes e.g. airports, railway stations, dispatching railway stations, main sea ports etc. will be denoted. The number of cars in larger cities will also be given.

(8) Low-standard settlements and slum areas. The percentage of houses (dwellings) without bathrooms, piped water and sewerage, central heating, gas, will serve as a basis to distinguish settlements and urban areas of substandard (slums). Such districts and settlements will be designated using symbols.

Besides the analytical maps showing particular kinds of pollution, an attempt to elaborate a synthetic map for Poland on the 1 : 1,000,000 scale has been made. Using different colours for dust and gas emission, air pollution has been marked on it (the height of a column denotes the number of tons per day). The places threatened by ionizing radiation (mines, atomic energy plants and nuclear research institutes, deposits of radioactive wastes) were marked by symbols. The pollution of surface waters, such as rivers, lakes, artificial water tanks, as well as of Baltic coastal waters, have been shown.

Disturbances of natural ground water conditions, transformation and devastation of relief, degradation of soil, and devastation of forests has also been given.

Transport noise disturbances and air pollution have also been denoted. Distribution of cars in different cities, airports, and air routes which will cause increasing disfunctions, deserve a special mention.

The map is the first attempt at this kind of cartographic elaboration and it requires further improvements. Construction of such types of maps for many countries, e.g. European countries, could be proposed.

A counterpart of disfunctions of the human environment map is a sozological map, i.e., a map of areas, localities, and sites which due to their merits contribute to stability of improvement of environmental conditions, and, therefore, deserve to be protected. National parks, reservations, nature specimens, beautiful landscapes, clean rivers and lakes, areas with only slightly transformed nature, human monuments of artistic and historical importance, specimens of contemporary architecture and town planning, are included. The work on sozological maps has also been recently undertaken in Poland.

V. CLASSIFICATION OF THE HUMAN ENVIRONMENT DISFUNCTIONS

A. The disfunctions may be different. Each of them demands separate treatment. For practical reasons and for regional planning the following classification can be put forth:

(1) air pollution
(2) surface water pollution
(3) ground water pollution
(4) pollution of seas and oceans
(5) deformation of the Earth's surface relief
(6) degradation of soil
(7) devastation of vegetation (including forests and utilized land)
(8) devastation of wild life
(9) noise disturbances and vibrations
(10) obnoxious odours
(11) damage from ionizing radiation and nuclear substances
(12) problem of household rubbish and solid industrial wastes
(13) utilization of post-production waste materials
(14) dangers involved in the low standard of dwellings, of sanitary and other municipal facilities.

Geographers may deal with the problems of the air, water, sea pollution, deformations of relief, degradation of soil, devastation of vegetation and wild life. The special target of geographers is to link studies on particular disfunctions with urban and regional planning intended to protect the human environment.

B. The model of the three zones of environment can be practically applied in an individual country aiming at solving many complex environmental problems. Furthermore, this model can serve as the foundation for environmental policies provided that adequate measures are at hand and that governmental intervention in the implementation of environmental programmes is secured.

C. In each country, specific zones of environmental policies can be distinguished from the point of view of land use and from that of intensity and quality of environmental disfunctions. The following types of areas can be distinguished:

(1) cores, centres of urban-industrial agglomerations,
(2) medium and small towns, and industrial centres,
(3) urbanized areas (suburban areas),
(4) urbanizing areas,
(5) transportation areas,
(6) agricultural areas,
(7) forest areas,
(8) surface waters, including territorial sea waters,
(9) other and waste land,
(10) recreation and tourism areas.

VI. THE APPLICATION OF ENVIRONMENTAL POLICY TO INDIVIDUAL COUNTRIES

It may be most effective to connect environmental policy with spatial planning, through which the policy can be carried out in a comprehensive manner. These connections are of a particular importance for the geographer as they constitute a spatial approach.

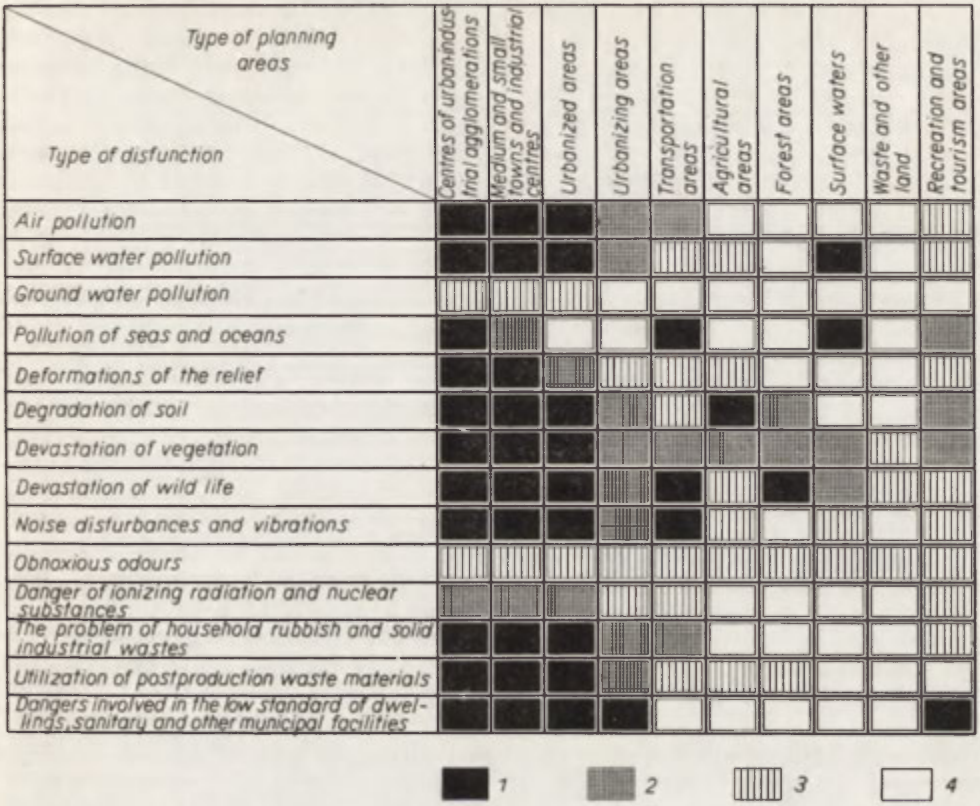

Fig. 9. The relation of various types of disfunctions with individual planning areas

Disfunctions: 1 — intensive, 2 — medium, 3 — weak, 4 — absent

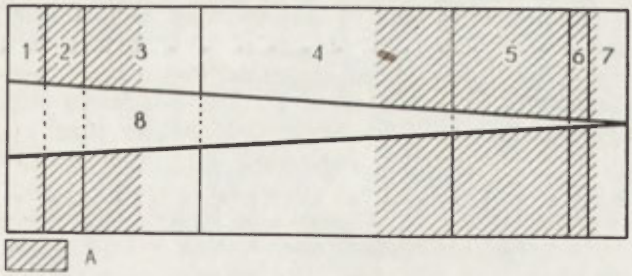

Fig. 10. Intensity and types of disfunctions within the three environmental zones (A model for one country)

A — Recreation and tourism areas — disfunction caused by tourist activities

1 — Centres of urban-industrial agglomerations — highest concentration of various disfunctions, 2 — Urbanized areas — various disfunctions, regional, 3 — Urbanizing areas — various disfunctions, local, 4 — Agricultural areas — pesticides, fertilizers, soil erosion, 5 — Forest areas — vermin, chemical substances, 6 — Surface waters — chemical, physical and bacteriological pollutions, 7 — Waste and other land — sporadic disfunctions, 8 — Transportation areas — noise disturbances, air pollution

The distinguished types of human environment disfunctions appear in a characteristic way in the particular planning zones. Figure 9 illustrates these types of disfunctions; the vertical column lists different types of disfunctions, while the horizontal one gives different planning zones. The intensity of particular disfunctions is presented in a three grade scale: intensive, medium, and weak. The figure clearly shows the interrelationships between the kinds of disfunctions and planning zones.

The closer spatial relationships occurring between different types of disfunctions and planning zones in a country are illustrated in Fig. 10. It is worth noting that the disfunction intensity is reduced from zone 1 to zone 7 and transportation intensity is reduced in an analogous way. However, recreation and tourism areas appear in different planning zones partialy covering areas of different land utilization. The first zone of recreation and tourism appears on the peripheries of urban-industrial agglomerations. The second zone of recreation and tourism areas partialy covers forest, water, and agricultural areas, and even waste-land.

These problems may be traced in a more detailed way according to particular zones of regional and urban planning.

1. *The cores, centres of urban-industrial agglomerations.* These are marked by a high concentration of population and of productive and non-productive activities. The urban-industrial agglomerations are the most important elements of the national economy. In these areas pollutions and deformations are highest and superimposed one upon another. The fundamental problems here are the conditions of living, of work and of recreaction and the facilities for satisfying material, cultural and other needs. Not unimportant is the satisfaction of preferences and the need for convenience. The principal task of environmental policies is the prevention of further degradation of the environment and the rehabilitation of the damaged environment. It will require some restriction of individual liberties on behalf of public welfare and the improvement of living conditions. Attention should also be paid to the preservation of green areas and the remnants of still undamaged nature. Environmental policies ought to be implemented within the wider framework of the long-term local plans. The needs of environmental policies are usually so great that efforts must be made to obtain some additional governmental grants and subsidies. The main purpose of these policies is the protection of human health and the improvement of living conditions in the agglomerations.

2. *Medium and small towns, and industrial centres.* The environmental policy in medium and small towns and industrial centres is formed similarly to those of urban-industrial agglomerations. They are of lesser importance in the national economy, but each of them has a national meaning. Their population concentration, industrial production, material and non-material services, are far weaker, what is implied is a smaller disfunction intensity. Generally, they are of a rather local character than a regional one. It does not exclude the possibility that a certain kind of disfunction may appear with a great intensity, e.g. air pollution caused by a cement mill. The protection of the natural environment, forming health conditions for the population is of the major importance.

3. *The urbanized areas.* An integral part of the urban agglomerations are the suburban zones, which are as a rule less densely populated. The urbanized area fulfills several functions: it furnishes residences for people commuting to work in the centres of the agglomeration, it is an area of expansion of housing construction and business, of intensive agriculture, of recreation, etc. The suburban zone is a natural area for the expansion of the agglomeration centres; the state of its buildings and municipal facilities may stimulate or encumber

urban developments in the future. Pollutants are generally less intensive and are less frequently superimposed upon one another than in the agglomeration centres. But they are rather numerous and occasionally quite intensive. Along the transportation lines and in its nodes may occur noise disturbances and air pollution. Municipal and industrial sewage systems as well as refuse dumps and other piles of non-perishable waste or production scraps are also troublesome. The quality of housing may also in some cases be below standard, without adequate sanitary or municipal facilities, etc. With regard to these areas, environmental policies are very complicated because of different individual and group preferences; moreover, public interests may be in conflict here. The urbanized areas should also be subjected to long-term development planning.

4. *Urbanizing areas.* This type of areas is typical of the rapidly developing countries. The resident population has abandoned farming but continues to live outside the city. There is intensive commuting to work. Traditional patterns of rural life are being superseded by a new urban style borrowed from the city. This environment still retains a number of natural features. Disfunctions are remarkably smaller, though locally they may be considerable. The problems of protection of the environment come to the fore.

Environmental policies should primarily be aimed at preserving the balance between intensive and many-sided productive activities on the one hand, and the economical use of the environmental resources, on the other. The main emphasis ought to be on adequate economic policies, for if we fail to maintain a high rate of development in these areas the resident population will move from them to the cities. But rapid economic development must not contribute to the degradation of the environment. The problem of adequate methods of exploiting natural resources acquires particular urgency in these areas.

5. *Transportation areas.* These areas consist of lines and nodes of transport development. The transportation belts include railway lines, motor roads and water routes, whereas seaports, railway stations, marshalling yards and airports are the major types of nodes. Transportation is troublesome because of noise disturbance and air pollution (mainly fumes). Transportation is most intensive in the urban-industrial agglomerations, and attenuates centrifugally through the suburban zones toward the urbanizing areas. Major pollutions occur along the long-distance routes.

6. *Agricultural areas.* From the environmental point of view, soils of the highest quality should be protected against uses other than agricultural. Care must be taken to prevent soils from erosion which may occur in different forms and may be stimulated by inadequate human activities. The effective reasonable use of artificial fertilizers and pesticides, especially of chemical insecticides, herbicides and fungicides is important here. Different forms of soil amelioration are also of importance.

7. *Forest areas.* The various types of area covered with woods are functionally differentiated. Only some of them are used for gaining timber, the remaining parts being either potential (i.e. non-usable) forests or under protection. Forests in the mountainous areas perform protective functions against erosion and floods and those in dry areas have a positive effect on the local humidity. Sometimes forests constitute isolating zones. Moreover, they fulfill important sanatory functions, as the assimilators of carbon dioxide and producers of oxygen, and provide extensive facilities for recreation and tourism. In view of these functions, forests must be exploited rationally. Strongly protective economic measures are desirable. Forests must be protected against vermin, excessive wood cutting, against inconsiderate tourists etc. Environ-

mental policies are not too complex in these areas but they must take into account economic and social factors.

8. *Surface waters.* Surface waters include lakes, ponds and reservoirs as well as rivers, streams, and sea territorial waters. Surface waters may be put to many uses. They must be protected against pollution. The whole body of problems in this respect is entirely in the care of official institutions responsible for the water economy. The latter plays a very important role in environmental policies.

9. *Other and waste land.* Each country has some areas recognized as barren or waste land (industrial waste areas are not included here). Human activities in these areas are very scanty, and thus there is no pollution. Nevertheless, the problem of activating the non-utilized areas does exist.

10. *Recreation and tourism areas.* Sufficiently large areas must be reserved for recreation and tourism. In view of the reduction of the number of working hours, green areas should be located within the boundaries of agglomerations, or in their closest vicinity. In connection with the reduction of the working week, areas of recreation for weekends should be located in the suburban zone or at fairly short distances. For purposes of annual leave, areas of particularly high value for tourism at home and abroad should also be conserved. Special attention must be paid to health resorts, spas and areas of outstanding landscape beauty. Depending upon the function to be performed, their adequate development must be assured.

11. *Spatial structure of the national economy.* The areas mentioned in items 1 to 5 make up the settlement network which constitutes a certain system through mutual exchange, contacts and transportation links. The framework of the settlement network is filled by the areas mentioned under items 6 to 10.

The above elements constitute the spatial structure of the national economy. Although it exhibits many traits of permanence, which it has acquired in the course of its historical development, it nevertheless requires further changes to adjust it to the needs of contemporary socio-economic life. This latter is the task of regional planning on both the national and the regional scales. What it has to do is to consider more extensively the problems of protection of the human environment. Geographers can make considerable contributions to these works, especially if they master the methods of forecasting regional development. One composite manifestation of these works is the execution of perspective balances of land use.

VII. IMPLEMENTATION OF ENVIRONMENTAL POLICIES

A. Environmental policies are aimed at stopping the process of degradation in the future, and moreover at the rehabilitation of the destroyed parts of environment — both the natural and man-made environments — with a view to securing the optimal living conditions for the resident population. Each country should work out both a perspective, i.e., long-terms plan, and a short-term plan to be implemented in the immediately following years.

Such plans ought to be extensively explained to the population so as to secure the broadest approval possible and support of the majority of people.

B. The short-term plan must be approved by the authorities. In addition to the plan on a national scale, there also ought to be regional (for provinces) and local (for towns and villages) plans. What is important here, is the decentralization of decision-making. The population groups affected by local pollution will be capable of considerable effort on behalf of a common benefit.

Scientific advisors should be consulted in working out the plans and making the decisions. In order to attract the interest of the population in environmental plans public advisory commissions could be instituted.

C. The expenditure on the implementation of the environmental policies must take into account: (a) the possible investment outlays (such as sewage-treatment plants, dust separators, industrial waste-heap rehabilitation etc.), (b) the cost of operation of such appliances and (c) means of paying for the losses (resulting from environmental disfunctions) both for the national economy and for individual persons.

D. It is a fairly common opinion that environmental conditions deteriorate in spite of a considerable growth of welfare. In turn, the deterioration of environmental conditions causes serious losses of both social and economic nature. But these are losses difficult to calculate, and not all of them can be expressed in monetary terms. Losses may also result from natural calamities. Other losses may be due to inadequate human activities (e.g., mining damage, advancing soil erosion, excessive use of pesticides and artificial fertilizers etc.). Losses may be also indirectly caused by pollution (e.g., of air) which may accelerate corrosion, degradation of soil, climate etc. The calculation of the total volume of losses due to the disfunctions of environment would permit an estimate of profitability of environmental investments.

E. It is worth drawing attention to the fact that environmental policy is to a large degree conditioned by the socio-economic development level in a given country. If we divide countries, with regard to socio-economic development, into three groups, taking into account their national income per head, namely:

(a) Countries of yearly national income $ 200 per head,
(b) Countries of yearly national income of $ 201 to
$ 1000 per head,
(c) Countries of yearly national income of over $ 1000 per head — then differences in approaches to the environmental policy will be noticed.

In the richest countries (Group c), and particularly those in which the national income has already exceeded $ 2000 a year per head, the interest in the quality of the human environment is increasing. These countries are inclined to spend considerable public expenditure on protection and rehabilitation of human environment. They are even prepared to restrict somewhat the rate of economic development for the sake of maintaining healthy conditions for their people.

The poorest countries (Group a) do not generally manifest any interest in environmental policy. These countries want at any price to increase the population's living standard in the shortest time possible. Therefore, they do not consider the increase of natural environmental protection expenditures necessary, as their natural environment is destroyed in a relatively small degree.

The countries of intermediate group (Group b) show some understanding of environmental policy. They assign some sums of money for protection and rehabilitation of the human environment, although they put the further and fast increase of living standards in the first place; thus environmental problems are most frequently regarded as secondary.

When proposing and arranging co-operation in the field of human environmental protection, it is necessary to consider the various approaches to environmental problems in particular countries, depending on the level of their socio-economic development.

F. The economic effectiveness calculation is a basic factor in industrial plant location. The main problem is to preserve the proper proportions between production and non-production investment outlays and expenditures on human environment protection and recultivation. This is very important for creating optimum development conditions for man not only in the present time but also in future. Thus, an attempt should be made to incorporate the quantitatively evaluated resources of the geographical environment and amenities into the general economic calculation.

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STUDIES ON THE TRANSFORMATION OF THE NATURAL ENVIRONMENT BY MAN

Andrzej Samuel Kostrowicki

INTRODUCTION

The aim of this article is to present the theoretical and methodical assumptions of the research carried out at the Institute of Geography, of the Polish Academy of Sciences. It constitutes part of the research on "The Theoretical Basis and Methodology of Interaction Studies in the Man–Environment System".

The present condition of the natural environment in Poland [11] is reported in the collective edition "The State of the Contemporary Natural Environment (biosphere) in Europe and Means of Preservation". This publication was prepared for the Montreal Congress by the Institute of Geography of the USSR Academy of Sciences (editor — I. P. Gerasimov).

The concepts presented in this article are an attempt to find theoretical and methodological answers constituting a comprehensive approach to the problems of interaction in the man–environment system.

GENERAL PROBLEMS

One of the basic present-day problems, faced by many sciences, and especially by geographical sciences, is the formation and conservation of man's life environment. In a geographical system, diverse interactions occur between man, his various activities and the natural environment.

The natural environment is not only the arena of human communities, a field of their multiple activity, but the environment influences this activity and its effects. A particular influence is exerted not so much by the natural features of the environment, as by changes introduced into it by man. The effects of changes are sometimes hard to predict as they do not always result from simple interactions. Therefore, recognition and prevention form influences which occur between particular types of human activity and a single element or feature of the natural environment. This is not sufficient at present.

Analytical studies concerning isolated problems are of great practical importance. As a result of these, it was possible, if not to retract, then at least to stop the devastation of some elements of the environment. The studies formulated premises to undertake the actions aimed at the correct formation of natural surrounding of man. However, their part in the recognition of the whole complex of processes occurring in man–environment system is rather limited. The results achieved in analytical studies permit actions to be initiated on a "fire brigade" principle. To extinguish a fire, there where it has already started. But it is important not to let it start, to be able to foretell it, and prevent the negative results caused by socio-economic development. The results are not simultaneously revealed. Some of them are at once visible, others accumulate unnoticed, to be revealed in future. The isolation of reversible influences latent today and definition of their potential meaning are rendered possible only by a synthetic approach to the entire phenomenon.

It is impossible to understand the essence of a system by analysing single processes occurring in it, as a certain kind of complementarity occurs between analytical and integral treatments of phenomena. L. von Bertalanffy [1] has drawn attention to this fact. He stated that we may either choose single processes and analyse them, though in this case the interrelations will be unnoticed, or formulate integral laws concerning a particular system, but then we must resign from analytical description.

In studies of the man–environment system both approaches, i.e., the analytical and integral, should be applied. Up to now most research carried out has been of an analytical character. It resulted from two premises, i.e., necessity of prompt reaction to negative changes introduced into the environment by human activity, and the theoretical and methodical difficulties in the integral study of a system. These difficulties mainly consist of:

(a) the complexity of interacting subsystems (social, economic, natural),

(b) the complementarity of structure and function in the subsystems,

(c) the impossibility, resulting from multilateral possibilities of phenomena treatment, of creating a single and universal model,

(d) terminological ambiguities make a universal definition of the essence of a phenomenon more difficult.

Taking into consideration the first of the above mentioned difficulties, we may state that if we wanted to analyse all the properties of the natural or social environment and their interrelations, then every field of interaction would be a phenomenon unique in time and space. Besides the variety, the far reaching similarities in many details are noticed. They are manifest not only by the fact that particular subsystems possess a series of common properties, but also because of their similar functional and spatial interrelations.

The enormous variety of conditions where interaction occurs between both systems is merely a small fraction of the possibilities that may theoretically occur. However, in practice not all the theoretical combinations can be realized. This is due to several causes, such as:

(a) fitness of the particular types of natural and socio-economical environments,

(b) occurrence of environmental types, or their components, which exclude each other in space (so-called allopatric environment) or in time (so-called allochronic environment),

(c) introgression, i.e., a secondary incorporation of the features of one type of environment into a set of the features of another,

(d) resistance of the systems which tends to set back the entropy process.

Thus, of the theoretically possible structural — spatial systems only some exist that are relatively stabilized. But other systems appear only ephemerally (as far as natural systems are concerned, man plays a particular part in their formation), or they cannot be realized at all. Therefore, the former difficulty in the synthetic approach to the man–nature relation may be avoided by concentrating the investigations on relatively stabilized systems.

The second problem concerning the possible complementarity of structure and the functions of interacting systems has to be investigated further. It seems appropriate to find out whether in the subsystems examined any function changes without structural transformations may occur, or, if functional properties are always the result of their structure. At present it is better to assume that structure and function are equivalent aspects of the system being examined and that they are both complementary and exclusive. It does not decrease the research possibilities, but rather expands them.

The third difficulty, i.e., the impossibility of creating a single and universal model of the man–environment system, does not only concern the problem discussed here but all scientific problems. In a given case each of the subsystems (natural and socio-economic) should be examined from many points of view, and the following points should be considered:

(a) the conforming elements of both systems (in natural environment especially components such as the atmosphere, hydrosphere, lithosphere or biosphere; and in socio-economic environment, forms of space utilization),

(b) the organization level within the systems,

(c) the transmission of information within and among systems.

And, finally terminological ambiguities. These really do exist. They may be faced when comparing the definitions of environment presented by various authors. We are not concerned with wrong definitions; our concern is with the fiducial point of particular concepts. Accepting one or another definition implies a course of research as well as an approach to the integral phenomenon. To illustrate this, three types of environmental definition will be presented,

(a) from a geographical approach, it is assumed that environment is a real surrounding where people live and work. It has natural as well as anthropogenical elements.

(b) from an ecological approach, it is the totality of factors, abiotic, i.e., physical environment, biotic, i.e., biological environment, and social, i.e., social environment. These are of immediate importance for the life and development of live organisms and human society. Ecological factors exert mutual influence, and by co-operation they form definite sets of conditions in which the organism of human population exists.

(c) from a physical approach, it is the material surrounding in which definite physical phenomena, such as matter and energy conversion, information exchange, etc. occur. They effect the differentiation of thermodynamic levels of the individual components.

All these approaches are correct, but each of them distinguishes the place of man in a different way.

The first one, considers environment as the arena of life and man's activity, and thus in a way opposes, environment elements with man. The second one places man in his environment, man being one of its components although man is distinguished as a subject, the main target of interest. The third one, however, levels man with the other elements forming the physical environment of the earth. For the investigation purposes of man–environment system the second approach, i.e., the ecological one, seems the most appropriate.

THE STRUCTURE OF A SOCIO-ECONOMIC SUBSYSTEM

As mentioned above, a set of phenomena and elements forming a socio-economic subsystem within a man–environment system should be examined multilaterally. The simplest subsystem division is made according to the types of space utilization. The following types may be distinguished:

(A) aggressive types as related to space, virtually transforming natural environment conditions;

(1) industry,

(2) urbanization,

(B) passive types as related to space, only partially changing the conditions of the natural environment, and influenced by forms of aggressive pressure;

(3) agriculture,

(4) forestry,

(5) recreation,

(6) fishery.

Each of the mentioned types of space utilization influences the environment differently, and is modelled to a different degree by natural conditions. If the types in group B show a high degree of natural environment dependence, then group A is apparently independent of the natural environment. Apparently, a town or an industry may be regarded as specific forms of the natural environment created by an animal species, *Homo sapiens*. They constitute an artificial structure but it is woven from natural elements supplemented only by the products of human minds and hands. However, these products have their equivalents in extra-human nature. The particular elements forming the natural environment (i.e., atmosphere, hydrosphere, lithosphere, etc.) are not totally destroyed or changed by human activities, but they are only modified not even qualitatively but quantitatively.

The division of the socio-economic subsystem according to the forms of space utilization is definitely of a practical character. It should be applied when evaluating the correctness of spatial utilization, and when estimating the fitness of a given area for particular forms of utilization. However, it does not answer many essential problems, and, above all, it does not permit an integrating approach to a system in informational and thermodynamic categories. Human influence on the natural environment may be classified from the point of view of the applied intervention technique. It may be schematized as follows:

Action

(A) intentional (effects conscious)
- (a) direct
  - (1) physical (mechanical),
  - (2) physico-mechanical,
  - (3) chemical.
- (b) indirect
  - (1) physical,
  - (2) physico-chemical,
  - (3) chemical.

(B) unintentional (effects unconscious)
- (a) direct
  - (1) physical,
  - (2) physico-chemical,
  - (3) chemical.
- (b) indirect
  - (1) physical,
  - (2) physico-chemical,
  - (3) chemical.

Every human intervention into surrounding nature can be classified into an appropriate group. A gradual change of intervention techniques, in time as well as in space, can be also traced. Thus, e.g. environment transformation by primeval agriculture had the character of intentional, direct and physical activities (Aa1), while modern agriculture is of a rather different character. It is an intentional, direct and physico-chemical activity. While primeval agriculture did not influence its surroundings to a high degree, the modern agriculture models them in an unintentional, indirect, and mainly chemical way.

This type of classification permits the use of the intervention technique for detection and the tracing on a map of transition boundaries between the particular techniques. Applying a proper numerical classification, it is also possible to define the intensity of each intervention in a surrounding, although it does not offer an integral view of the essence of phenomena occurring in a system. Such approach can be obtained by joining the above mentioned classifications with another classification based on the theory of levels. According to the assumptions of this theory [1, 2, 19], the division of every system, therefore of a socio-economic subsystem as well, can be based on the differences in organization levels of its components.

It is known that the structural development of matter does not constitute a continuum; it is not a continuous line, but it forms definite organization levels. There are individual laws at every level, governing a respective level. In addition, these laws are not related in a simple way to laws defining the course of processes occurring at other levels, and they do not issue from them. Therefore, every level has its specific properties which do not occur on the lower or higher organization levels.

It is, therefore, obvious that processes occurring at a higher level may only partially be explained as a compound of more elementary phenomena. It is not possible, e.g. to deduce the integrating character of social functions from studies on man's individual nature.

The non-continuous, but nor evolutionary changes of organization structure, manifested by the existence of specific level laws, allows comprehension of why even the most conscientious analytical studies do not integrate into a set approach an entire phenomenon. Therefore, anticipating that a view of the essence of phenomena occurring at other organization levels will be achieved, a method of accumulating detailed information (a common practice in geographical sciences) is to be considered *a priori* a failure. It seems that it is more correct to proceed from the initial synthesis, which is tested experimentally, to the final synthesis. Therefore, a hypothetical model constructed in the initial stage of studies on complex phenomena is of great practical importance. It enables the choice of suitable methods, as well as a target of detailed studies, without erring in the analyses of a large number of individual phenomena.

From the point of view of the theory of levels a socio-economic subsystem of a man–environment system can be divided into the following levels,

(1) The individual personality level of man. This is a set of factors either within an organism or external ones, which defines a psychical, physical and intellectual state of the respective individuals.

(2) The micro-populational level. This is characterized by a system of laws and factors endogenic, as well as exogenic which enable co-existence, reproduction and the satisfaction of the basic needs of small human communities.

(3) The macro-populational level. This is determined by a set of factors resulting from the collective life of men, and it is manifested in a model of behaviour, functional and social stratification, physical state, and in a system of information exchange within a level.

(4) The socio-technical level. This is characterized by a system of laws and

factors, established in highly developed communities due to the dynamic progress of technology. Population and technological progress feedback results in technology governing the behaviour model and all the material, as well as non-material needs. It also imposes new laws of social stratification and influences the health of a given community. If the phenomena characteristic of a personality level are a field of interest of the widely comprehensive biological sciences, then the phenomena occurring at other levels are, primarily the research object of the social sciences, including geography.

In spite of the great independence of the particular levels, they are linked. It is shown by the occurrence of collisions. These collisions, appearing between the levels, as well as within them, are the subject of sociological studies. They will not be considered further. On the other hand, collisions between the particular levels and space are a geographical problem.

In this case, space may have a double implication, i.e., as areal space and as information space. By areal space is understood an area, a section of the earth's surface which for a given population or a social system group formation is an arena of life. However, the information space is a system of circulation and information exchange. In this approach, the structure, extension and efficiency of the information network, its capacity and speed of action, and not space, are essential features. All kinds of products of human activity, physical as well as intellectual, material and non-material, are considered to be information. They promote social conscience and activity to a higher organization level (in the meaning of thermodynamics and cybernetics). The correct system of the information network, technical and social equipment to prevent information noise, are not less important for the existence and development of society than areal space.

Collisions between a duplex concept of space and particular levels of social organization are generally easily detected. They can not be neglected in studies on the interaction of a man–environment system since they affect the ways of utilization and transformation of the natural environment.

THE STRUCTURE OF A NATURAL SUBSYSTEM

Similar to the socio-economic subsystem, the natural environment can also be classified in a different way. The simplest division is into components which together form a particular spatial system of the natural environment. These components, in a general approach, are atmosphere, hydrosphere, lithosphere and biosphere. Each of these elements can obviously be subdivided into units of lower rank (e.g. biosphere into vegetation, the animal world and soils, and these can be further subdivided into respective horizontal and vertical groups). All the elements are inter-connected, and are highly inter-dependent. They possess a different degree of stability, and they yield to man's pressure in a different way. Each of these elements can be studied independently, i.e., the definition of their position and function in the landscape, the degree of deformation caused by man, etc. However, as already mentioned, this kind of study does not only permit the comprehension of the essence of the natural environment (conceived as a spatial functional and structural system), but it also does not permit classification of a number of phenomena occurring within the examined element. This follows from the existing relations and interdependences, and from the fact that none of the elements together forming an environment is a closed system, and its current state depends on the states of other natural components. These dependences are particularly apparent in the environments transformed by man (Fig. 1). Therefore, it seems more reasonable to adopt a natural environment classification not according to its basic components, but on the basis of the differences in organizational levels of the internal physico-geographical space. Such a division, based on

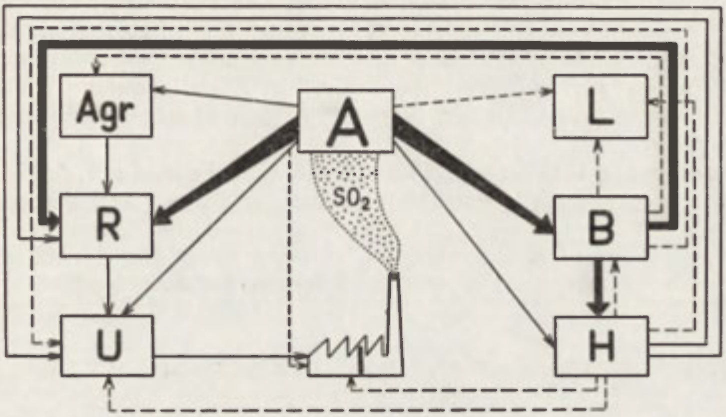

Fig. 1. Diagram of the influence of the emission of sulphur dioxide into atmosphere on the selected environmental elements

A — atmosphere, H — hydrosphere, B — biosphere, L — lithosphere
Agr — agriculture, R — recreation, U — urban-areas, I — industry

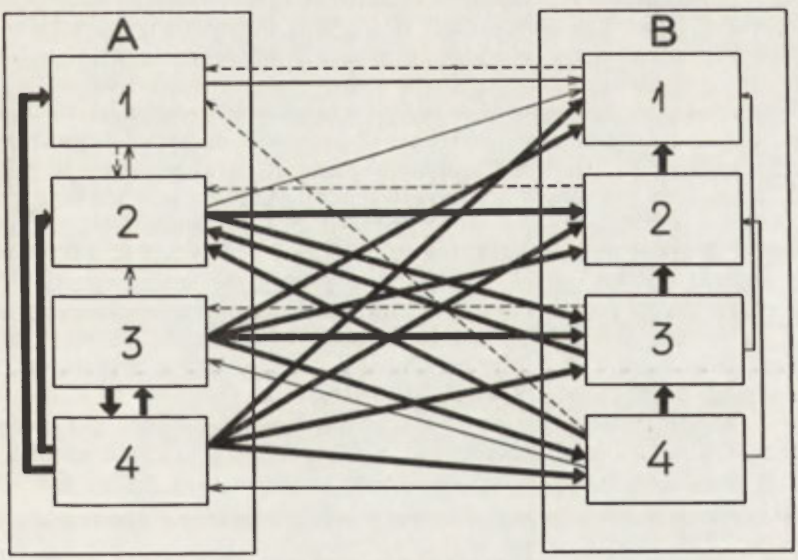

Fig. 2. Diagram of the basic functional links of the man-environment system

A — socio-economic subsystem, (1) — personality level, (2) — micro-population level, (3) — macro-population level, (4) — socio-technical level
B — natural environment subsystem, (1) — facial level (ecotope), (2) — catena level, (3) — eco-geographical system level, (4) — landscape level

structural-typological properties of environments, with the emphasis on the degree of their compactness, would enable the balancing of the interaction between the two examined subsystems. Such a classification would lead from the smallest, totally mononatal basic units, with a small degree of independence, of a facial type, through more complex but internally mononatal (of subassociation, the type in geobotany) up to independent environment units, corresponding to the concept of association in phytosociology. Units of a higher rank may be classified in two ways, i.e., either based on their similarity, when we obtain units of the phytosociological type, i.e., alliances, orders and classes, or on the functional basis. In this case we would have heterogenic units joined with a degree of comprehension of matter and energy circulation. Accepting the second variant seems more reasonable, but it will demand a classification of units of higher range, higher than the catena or eco-geographical system, to be worked out.

Some attempts in this direction have been already made [7, 8, 12, 14, 18, 21], however, the proposals presented require further studies and theoretical specification.

The arrangement of basic relations between particular levels of organization in the man–environment system is illustrated below (Fig. 2).

FEEDBACK WITHIN THE MAN–ENVIRONMENT SYSTEM

The influence of the human economy upon the natural environment is multilateral and, to a different degree, is reflected in its elements. In general, it may be stated that there is a simple dependence between the level of internal organization, the level of complication of the environmental co-forming element, and the lack of resistance to human intervention. This results from the II law of thermodynamics, which states that the more inert a given system is and the higher a degree of entropy present, the more transformable a system is.

Man utilizes the environment mainly to elevate his own system to a higher level, or to put it differently to ensure the growth of social negentropy. It is apparent, first of all, that man utilizes those natural systems in which the level of entropy is the lowest. The differences in degree of mutual influences of particular elements of a system are presented in a general outline in Fig. 3. It should be pointed out that the input variables presented in Fig. 3 are basically dependent on the model. Their value equals the intensity of interaction. On the other hand, the influence on individual system co-forming elements depends on constant features, not influenced by changes, as well as on the character of the output variable, returning in a way to the transmission source and modyfying them in their specific manner.

Not all man-initiated changes of the natural environment, and not all feedbacks, are of a negative character, i.e., a decreasing energy-structural level of a given system. Generally speaking, these changes may be of the following character:

(a) suppletive — enriching a given system,

(b) compensatory — in which the decrease of a thermodynamic level is compensated by a different form of human activity,

(c) reductive — affecting only separate, usually the least stable, elements of a system,

(d) destructive — affecting a total system and introducing disorganization symptoms to all constituent elements.

The positive influence is illustrated by improving soil fertility due to many years of cultivation, increase of environmental variety, differentiation of their information levels, etc. [16]. Figuratively speaking, owing to man the world has become more differentiated; changes have appeared for the realization of environmental variants, which could not have emerged in nature. In future, they may appear to be of particular importance. The rejuvenation of the earth's surface has followed, and processes of matter and energy circulation have been accelerated. On a terrestial scale these phenomena are unquestionably positive, however, locally they may be strenous for men. To become acquainted with the correctness of the functioning of a system, it is more essential to master and minimize the negative influences. Generally, they are caused by

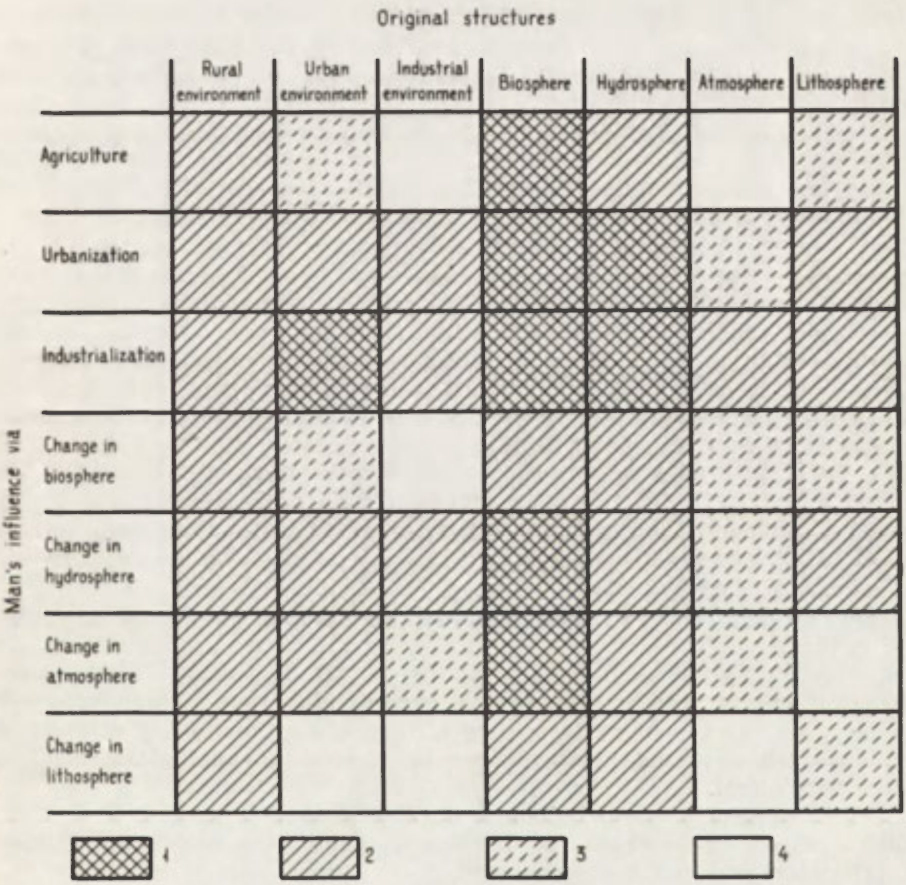

Fig. 3. Intensity changes effected by man upon the existence of environmental structures

(1) — very strong, (2) — strong, (3) — weak, (4) — very weak

the emerging of unwanted phenomena. There are unwanted from the point of view of the environment as from man. In most cases they are not *conditio sine qua non* for the further development of human communities, but a result of short-sightedness and a lack of knowledge. The classification of these influences has recently been presented in detail by St. Leszczycki [13].

In relation to the atmosphere, negative changes caused by man are primarily unsettling the balance of the chemical features of air masses, mostly a balance between oxygen and carbon dioxide content, and gradual devastation of atmosphere structures by thermo-nuclear explosions, rockets, etc.

The increase in atmospheric pollution, mainly concerning the lower layers, influences the air masses circulation system. The increase in the number of condensation centres causes, on one hand, the limitation of radiating energy supplied to the terrestial surface, and on the other hand, the disturbance of the rainfall system. The emission of volatile chemical substances, mostly toxic gases, although influences to a minimal degree the atmosphere itself, this is essentially reflected on other environmental elements, as well biological ones [17] as socio-economical [23] elements.

Human activities as related to the hydrosphere cause essential changes. All kinds of water ameliorations, river and stream regulations, and changes of vegetation cover accelerated water circulation, and in particular, its confluence. Chemical features of surface waters and partially underground waters, caused either by artifical fertilizers' action or by plant protecting chemicals, or resulting from communal and industrial sewage inflow into rivers, lakes and seas, has caused biological inactivity and the decrease of the utility value of the majority of open waters [3, 17, 20, 22].

However, the biosphere has undergone the greatest changes. In the most land areas, primarily biocenotic structures have been liquidated. Self-control of vegetation cover has been limited, and primary and secondary productivity has been also reduced. Social bonds connecting particular organism into complexes have been broken. The controlling role of the biosphere as related to processes occurring in an abiotic environment has been reduced. Soil, the very delicate product of living organisms, has been degradated or has been completely devastated in many areas [10, 16, 22].

The lithosphere, and specially its deeper layers, have undergone relatively the least damage. Under the influence of human economic activity geomorphological processes, such as denudation, erosion, solifluction were activated or accelerated. New anthropogenic forms, characteristic of a modern urbanized landscape, have developed [20, 22].

All these negative results of human intervention in the natural environment influence in a particular way the society and its products. Feedbacks arose, which have not been fully investigated [13]. The results of these feedbacks, although very often annoying to the individual, are mainly reflected in the sociosphere and technosphere; they influence the functioning of these systems. Generally speaking, feedbacks can be divided into biological, social, and economic-technical.

The following phenomena belong to the first group:

(a) increased disease rates of the human population under the influence of the chemical features of environment,

(b) decreased resistance of individuals, and the population to stresses,

(c) the limitation of adaptive ability caused by the unification of life conditions,

(d) the restriction of natural elimination causing the gradual deterioration of the population's genetic structure.

The following phenomena may be included in the second group:

(a) the existence in over-populated conditions,

(b) restriction of the life area in the work–home system,

(c) restriction of physical and psychological regeneration facilities, especially in big cities.

In turn, these factors restrict social bonds to an absolute minimum; the increase of aggressive, anti-social types of behaviour and attitudes causes imbalance in a population, and then a decrease of receptivity to different stimuli which are very often irrational. In the third group, two kinds of feedback are included. The first kind refers to the phenomena of the decreasing utilitarian value of the work environment, e.g. the generation of lower economic effects. Here some already well recognized phenomena belong, namely the decrease of the soil's productive value, diminution of utilized water resources, diminution of farming, forest, recreation area, etc.

The second kind includes a negative set of effects of the changed environmental influences upon the results of human activity. Primarily these are, corrosion accelerating phenomena, urban infra-structure, as well as buildings, the means of production, etc. which result in the changes of the chemical features of water and air masses. These changes do not only increase corrosion processes but they also restrict the freedom of choice of locating many industries, particularly sensitive to pollution (pharmaceutical, photochemical, electronic, and some branches of food industry, etc.). The influences of a physical character, such as those induced by vibrations, noise, thermic changes of water, etc., additionally increase the above mentioned difficulties.

CONCLUSIONS

Summing up the above considerations, it may be stated that acceptance of the theory of systems in interaction studies of the man–environment relation is the most appropriate. Analytical studies on the influence of a single human action upon the natural environment should be continued because of their unquestionable practical merit. Analytical studies are not, however, the basis of the integral approach to the problem. System treatment of man–environment interaction requires further theoretical studies and confirmation of the already constructed models.

Further studies of this kind should lead to:

(a) the choice of the most adequate model to represent reality,

(b) the choice of models with the greatest practical implication (a model which is the closest to reality does not simultaneously need to be a model of the greatest practical merits, as the former is of a cognitive character, and the latter of a pragmatic one),

(c) the elaboration of methods of quantitative approach to information flow, within the analysed subsystems as well as among them,

(d) the elaboration of quantitative methods of estimating profits and losses, resulting from interaction. The estimate should be transposible into the language of economics.

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A MODEL OF INTERACTION BETWEEN THE SOCIO-ECONOMIC SYSTEM AND THE GEOGRAPHICAL ENVIRONMENT

Zbyszko Chojnicki

So far, analyses of the relationships between man and the geographical environment dealt mainly with the problem of the changes in environment that are due to the growth of population and of industry and to the advance of urbanization. Less attention has been paid to the reverse effects, that is, how those changes in turn affect man, his health, his conditions of living and work, and thus the conditions of economic life.

The adverse effects produced in the course of performing his economic activities on the geographic environment have both immediate and indirect economic consequences.

The immediate economic consequences include the diminution of the existing resources and the deterioration of their quality, and lead to reducing the ecological capacity and disturbing the natural equilibrium of the environment and thus to decreasing its productivity. The indirect consequences consist in decline of the landscape values and in vitiating man's health conditions.

Without going any deeper into the problem of the different forms of man's adverse influences on his environment it must be stressed that they are highly complex in character and have not only one-way consequences. Parallel to destructive or reductive consequences, there are also compensatory effects which level out the losses incurred by introducing other elements or suppletive effects which increase productivity.

In the analyses of man–environment interactions it has been becoming more and more necessary to give an integrate treatment of the diverse relations considered in the economic aspect. To provide the theoretical fundation for this it is necessary to construct a model that will permit the economic interpretation of the relations in terms of two-way flows between the socio-economic system and the geographic environment. Such a model seems to constitute some advance with respect to what has been done in recent years in introducing spatial concepts into economic studies.

As a model for such an analysis we may take the system of interactions in economy as presented in W. Leontief's [13, 14] analysis of production inputs and outputs (cf. also P. Sulmicki [20], and B. Szybisz [21]). The essential element of this analysis is the set of relations between the individual branches of an economy in the form of commodity flows.

The two fundamental systems: environment and the socio-economic system are both subject to changes themselves and, moreover, act upon each other. All changes in the environmental conditions deteriorate, by a feedback effect, man's conditions of living and work. It must be observed here that the attempt to determine the scope of "deterioration of conditions" of the environment has to be based on such an analysis of the changing conditions that leads to the concept of environment ecosystem. This can be explained by the specific role of the biosphere in the relations between man and environment. In his discussion of this role A. Kostrowicki ([11], p. 4) writes: (1) "Most of the forms of human activity consist in the adaptation of nature, mainly of its organic constituents, to man's needs, and it is through this organic nature that most of the feedback actions take place — from environment to human populations and societies." (2) "The relations between man and the elements of environment that are not ecological factors are relatively simple". (3) "Organic nature is not only the intermediary between man and most constitutents of the natural environment but, to a large extent, the creator of this environment".

The concept of ecosystem demands closer elucidation. The term was first used by A. G. Tansley [22] as the fundamental organizing concept of ecology denoting both the biome and its habitat. E. P. Odum [16] denotes by ecosystem, or else ecological system, any space (constituting a natural whole) in which matter is being permanently exchanged between the organic and inorganic constituents of this space as a result of the mutual interaction of living organisms and mineral substances. All components of the ecosystem — both organic and inorganic, the biome and the habitat — can, according to A. G. Tansley ([23], p. 207), be regarded as mutually interacting factors which in a mature ecosystem nearly attain equilibrium, and it is this interaction that preserves the whole system.

In terms of the attributes of general systems, the ecosystem is structured and functional in its character. To use the terminology of Bertalanffy's [2] general systems theory, the ecosystem is an open system tending toward a steady state in accordance with the laws of open-system thermodynamics. Ecosystems in a steady state, i.e., in equilibrium, possess the property of self-regulation, which is similar in principle to homeostasis in living organisms, feedback principles in cybernetics, and servomechanisms in engineering.

Ecologists identify and study ecosystems of different size and on different levels of complexity. F. C. Evans [7] emphasizes that the concept of ecosystem includes a hierarchy of systems at different levels of complexity and extent. It seems that the concept of ecosystem may refer both to the elementary level of organization, on which "biocoenosis" or "geobiocoenosis" are taken as the fundamental units, and on higher levels of organization, on which the term ecosystem incorporates a number of fundamental units. E. P. Odum [16] says expressly that as long as the fundamental components continue to exist and function and as long as their functioning exhibits some degree of equilibrium — even for but a short time — so long the given system may be treated as an ecosystem".

The fundamental process that determines the functioning of the ecosystem is the energy–flow in the form of food from its source through a number of organisms. This process is called the food chain. Food chains are not isolated series of organisms but intervene with one another constituting mutually interrelated circuits (systems).

Leaving aside a more detailed discussion of the concept of ecosystem, let us merely point out those among the ecological concepts which include in their research scope the problem of man. However, the attempts at extending ecological studies over problems of man that have been made so far have failed to yield the expected results, perhaps because of the basically different character of the laws governing the socio-economic sphere. If we conceive of human behaviour as merely a higher variant of the "behaviour" of the animal world, or if we treat human populations as component parts of biocoenoses and ecosystems, we are likely to commit a gross simplification and fail to explain the essential links in the evolution of the relations between society and nature.

In studying the man–nature relations we have to employ a very broad understanding of the ecosystem; it should be treated as a macrosystem. Now, to understand adequately any macrosystem it is necessary to study its organization (cf. D. R. Stoddart [19]).

Organization may be seen as a set of elements which, as a group, are capable of fulfilling certain functions such that cannot be fulfilled by any of the individual types of elements in isolation from one another. Each element affects the others and is itself affected by them; moreover, each element operates so as to maximize the effects of its operation for its own benefit. A system attains the highest level of organization when each element maximizes the effects of its own operation. Conversely, whenever the elements operate randomly the system has a low level of organization.

The concept of "organization" is applicable both to the ecosystem and to the socio-economic system. In studying the "man–nature" interdependencies it is essential to clearly define the mutual relations of these two organizations, or, more strictly, the interpretation of the two organizations. The growth of negentropy, that is of organization, which is specific for all systems, is connected with the growth of disorganization within system of lower organization. The dominance of the socio-economic system is an essential factor disturbing the equilibrium between the two systems.

The study of the two systems is based on the observation of definite analogies between the mechanisms of operation of each of them. According to H. E. Daly [5], one such analogy exists between the processes of metabolism and the economic processes. The scheme below illustrates this analogy:

The attempt to define the mutual interrelationships between the socio-economic system and the ecosystem may be based on identifying the different influences inducing changes in the one and the other system. The explanation of the character of that influence may also include diverse elements of each of two systems. In simplified form, this influence can be presented as flows from one system into the other, for each of them has its internal and external flows connecting the two systems. The external flows not only change the volume of the substance of the system but also change the conditions of its influence.

TABLE 1. "Man–nature" model

	Socio-economic system	Ecosystem
Socio-economic system	I	II
Ecosystem	III	IV

After some extension, Leontief's model of input–output flows makes possible the integration of the two systems into the metasystem "man–nature". In its simplest form, this model is presented in Table 1. Field I in this Table stands, in accordance with Leontief's model, for the input–output flows in the

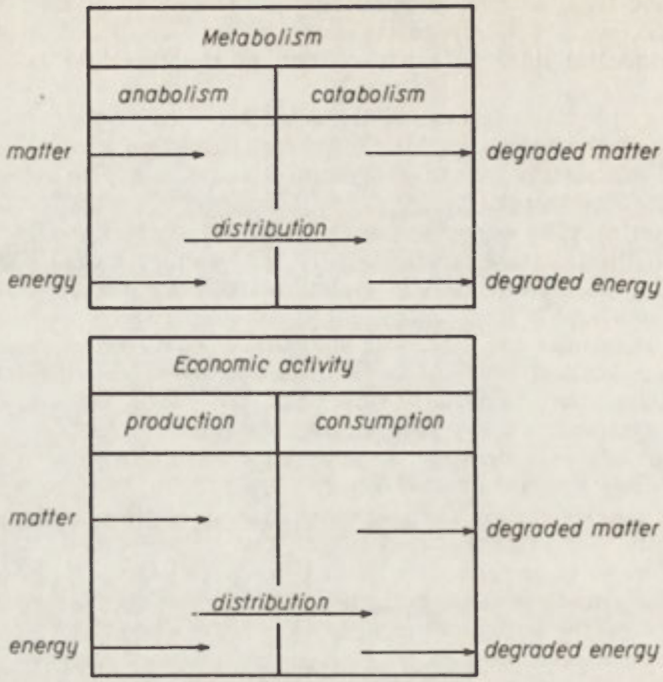

Fig. 1

socio-economic system. Isard ([9], p. 310) points out that "the strength of this analysis lies in its detailed presentation of (1) the production and distribution characteristics of individual industries of different regions, and (2) the nature of the interrelationships among these industries themselves and among these industries and other economic sectors". Accordingly, it represents the essential features of the structure of multi-industrial economic system on the regional and the interregional planes.

The ecosystem of the geographic environment can also be analysed in terms of the input–output model, provided we treat it as a set of mutually interrelated processes that demand certain inputs and yield definite outputs. The system of flows within the ecosystem is represented by field IV.

By their activity the two systems provide themselves mutually with definite final inputs and outputs which get outside each of them. These flows constitute the foundation of the mutual dependencies and influencies. Field II represents the flows from the socio-economic system to the ecosystem which are in fact the subsidiary, i.e., side-effects of the society's production activities. Field III, on the other hand, represents the inputs of nature that enter the sphere of the society's productive and consumptive activities.

The dimensions that characterize the flows of the integrated system constitute three groups of phenomena:

(1) flows, that is the values produced or consumed within a definite period such as, e.g., the output of coal, the consumption of plankton;

(2) resources, that is the values existing at a given moment, e.g. water resources;

(3) conditions, that is the values that are attributes varying with time, e.g., air temperature.

TABLE 2. An extended model of inputs and outputs of the metasystem "Man–Nature"

	To / From	Socio-economic system			Ecosystem							
		(1) Agriculture	(2) Industry	(3) Population (consumption)	(4) Vegetative world	(5) Animal world	(6) Microorganisms	(7) Atmosphere	(8) Hydrosphere	(9) Litosphere	(10) Degradation of energy and matter	x_n
Socio-economic system	(1) Agriculture	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	$x_{1,10}$	x_1
	(2) Industry	x_{21}			x_{24}							
	(3) Population (Labour)	x_{31}			x_{34}							
Ecosystem	(4) Vegetative world	x_{41}			x_{44}							
	(5) Animal world	x_{51}	x_{52}	x_{53}	x_{54}	x_{55}	x_{56}	x_{57}	x_{58}	x_{59}	$x_{5,10}$	x_5
	(6) Microorganisms	x_{61}			x_{64}							
	(7) Atmosphere	x_{71}			x_{74}							
	(8) Hydrosphere	x_{81}			x_{84}							
	(9) Litosphere	x_{91}			x_{94}							
	(10) Sources of external energy (Sun)	$x_{10,1}$			$x_{10,4}$							x_{10}

The proposed extension of the model is presented in Table 2. Separating the two fundamental systems by a dividing line this table furnishes a tentative outline of the basic relations occurring both within the systems themselves and between them.

Within the socio-economic system we have, in analogy to the traditional input–output analysis, to distinguish two fundamental sectors of production and population as an autonomous sector. The proposed division of production into agriculture and manufacturing is of course a simplification intended merely to expose the two principally different modes of transforming matter and energy in production processes, i.e., through the participation of living organisms, on the one hand, and by transforming inorganic matter, on the other. An operational model, however, would demand a more detailed division into production branches. Moreover, the criteria of such a division would also have to be different from those employed in "traditional" analyses. To cite a simple example, it is necessary to give separate treatment to thermal and water power stations, for although their respective products are identical, their impact on the ecosystem is dissimilar as their respective "inputs" to the particular components of the ecosystem are entirely different.

Still greater difficulties have to be overcome in dividing the ecosystem into "sectors". The division presented in Table 2 is intended to identify the fundamental sectors of the ecosystem. These latter represent: (1) the fundamental groups of organic nature, including man as an element of biological reproduction, (2) the fundamental physical systems of the geographical environment, and (3) moreover, the volume of the solar energy that enters the system and, in accordance with the laws of thermodynamics, the corresponding degradation of an organized into an unorganized system.

Without entering the complex issue of application of the principles of thermodynamics to ecological energetics it must be said that a general idea of the energetics of the ecosystem can be obtained by determining the volume of energy flowing through the ecosystem and adding to it the consumption of the energy accumulated in this system (cf. J. Phillipson [17]).

Table 2 is no more than a mere conceptual framework; it has to be filled in with concrete data drawn from a knowledge of the interrelations resulting from the inputs and outputs occurring between the diverse sectors of the two systems. To be more adequate to reality, the table would have to include a very detailed classification by sectors as well as relevant factual data. An analysis of ecological studies shows that abundant research materials that could be employed in devising such a table are available. But the most realistic approach, though, seems to consist in the elaboration of certain parts of the table including but some relations only, namely such that would solve definite problem issues, for instance that of water economy on interregional scale. Such a research undertaking would obviously necessitate the participation of a large team of experts in many fields.

But the elaboration of the table or even of its parts only is hardly more than a collection of data concerning exchange processes within the system "man–environment". In order to pass from pure description to the identification of the relationships referring to this exchange, which are necessary for later prognostication and planning, we have to determine the input coefficients in analogy to the procedure adopted in Leontief's model. Theoretically these coefficients can be derived from the balance equations expressed in material units by the formula:

$$X_i = \sum_{j=1}^{n} x_{ij} \qquad (i = 1, 2, \dots, n)$$

On the basis of this formula, the coefficients can be defined as:

$$a_{ij} = \frac{x_{ij}}{x_j}$$

Obviously, the evolution of the system "man–nature" will proceed harmoniously under the prevision that adequate proportions between the inputs of each system will be maintained, that is that the coefficients a_{ij} will have adequate values.

From the definition of the coefficients it follows that $x_{ij} = a_{ij}X_j$. Hence, if the coefficients are assumed to be known, we can formulate a system of balance equations consisting of n first-order equations with n unknowns

$$\sum_{j=1}^{n} a_{ij} X_j = X_i \qquad (i = 1, 2, \ldots, n)$$

The coefficients may be constructed either in virtue of statistical studies of inputs and outputs or may be derived from the results of studies of the natural sciences.

The system of interrelations presented in Table 1 suggests that the coefficients should be divided into four groups.

The first group consists of coefficients referring to the socio-economic system (field I); they have the character of socio- or economico-technical coefficients.

The next group consists of what may be called natural coefficients (field IV) as they refer to the inputs and outputs within the ecosystem. Such coefficients may be calculated primarily from data provided by ecological studies. The results of studies of food chains and networks in different types of ecosystem provide the possibility to obtain an approximate quantitative determination of the respective input and output coefficients.

The third group consists of technical-natural coefficients referring to field II; they cover the problems of inputs from the socio-economic system to the ecosystem. These inputs represent the secondary system of relations which results from the side-effects of economic activity and which manifests itself as a rule (though not exclusively) in the adverse changes in the geographical environment. Many studies concerning the utilization of resources, especially in water economy furnish rich materials which may prove useful in calculating this type of coefficients.

The fourth group of coefficient comprises the technical-natural coefficients referring to the field III, that is those which cover the relations of inputs connected with natural resources and conditions that pass form the ecosystem to the socio-economic system.

A number of methodological difficulties will certainly result from both the diversity of the feedbacks and from the character of the coefficients themselves (their diversity and indirectness). In theory, these coefficients provide no considerable difficulties; it may be said that some of them (field II) are of a more stable character than those of field I, though at the present stage of research we may still lack adequate foundations for their relevant estimation. But fundamental difficulties will arise in case of attempting to construct a table of flows in terms of value, specifically in monetary terms. It will be necessary to estimate the monetary value of ecological goods, which have so far been regarded as free goods. This problem demands separate discussion. The initial stage in the construction of the extended input–output table should consist in building a system of natural units, and it is only the interpretation of results that can be expressed in value terms.

The attempts to analyse certain relations between the socio-economic system and the ecosystem made so far as well as the results at hand suggest that the practical application of the input-output model within the system "man–environment" should be restricted to studying a relatively simple region (ecosystem) with the predominance of certain relations, e.g., the industrial system–water economy (ecosystem).

The reductive and destructive impact of economic activity on the structure of ecosystems and on the equilibrium of the "man–nature" system lead to a deterioration of the quality of environment to the extent that eventually adverse economic and ecological effects for man himself are produced. As seen from the angle of economic activity, these adverse effects are due to the side-effects of production, which — though incidental to the purpose of that activity — by deteriorating the environmental conditions may essentially affect the economic life and man's health (cf. O. C. Herfindahl, A. V. Kneese [8]).

Although we have a relatively good knowledge of the processes leading to the degradation of the quality of the environment, no theoretical foundations for the economic analysis of the impact of the secondary effects of economic activity are at hand. With reference to the economic units this impact concerns the processes of production and conservation. With reference to human individuals it is a direct impact in that it affects their health. Moreover, it brings in consequence a deterioration of the landscape values and thus encroaches on the sphere of satisfying the needs of individuals. But these two elements of the impact are mutually dependent, for they express the impact of environmental conditions on man's psychophysical and economic situation.

The theoretical foundation for the economic analysis of the impact of the side-effects of economic activity must be sought in the system of mutual relations of the economy whose simplified model is the input–output analysis. In addition to the basic system of interrelations expressed in the form of flows of commodities and services, it is necessary to study the system produced by side-effects of economic activity and manifesting itself in the adverse changes in the environmental conditions. For instance, a growth in the output of starchworks which increases their profitability may at the same time add to the volume of detrimental sewage which in turn may encumber the production conditions of other plants, if only by increasing their outlays on water purification. These sewage wastes may moreover have a direct negative effect on human health and may disturb the equilibrium of the water biocoenoses (fishing). This example illustrates the emergence of many secondary relations in the course of economic activity, and the economic effect of these relations has no immediate connection with the system of primary relations (i.e. the input–output flows), and the development of the relations as well as their adverse effect on the other economic units and human individuals is no proportion to the advantages gained by the economic unit responsible for the activity in question. Thus, starchworks which refuse to purify their sewage diminish their production cost and increase profit but, by the same, the transfer of these costs to other economic units or human individuals who happen not to be consumers of starch. Transferring the costs to other units is a factor distoring the adequate economic calculation of the economic units. From the standpoint of both the economy and the society, a specific trait of the side-effects is that they distort the economic calculation based on a system of costs and prices. Consequently, the side-effects of economic activity affect the equilibrium of the system of costs. In this connection it must be observed that in adequate economic calculation it is primarily imperative to charge the producer of the side-effect with the costs of preventing the degradation of environment; a more complex problem is the economic calculation of neutralizing the detrimental changes in the environment also from the standpoint of health and aesthetic criteria as well as of restoring a high quality of environment (cf. Z. Chojnicki [4]).

To be effective, the principle of preserving a high quality of environment — both for the benefit of long-term developments in production and of the ecology of man himself — must be supported not only by a relevant system of legal acts but also by an adequate economic calculation incorporated in the country's economic life. Whether or not a progress will be made in this respect depends on overcoming the difficulties involved in the formulation and implementation of the principles of such a calculation and on establishing a socially based hierarchy of values concerning the present and the future needs in the utilization of the geographic environment of high ecological quality.

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LIST OF GEOGRAPHICAL INSTITUTIONS IN POLAND

Geographical institutes in Poland are attached to the following academic schools: universities and colleges of economics as well as certain colleges of pedagogy, teachers' colleges and technical universities. The main research centre is the Polish Academy of Sciences Institute of Geography. This institute also fulfills some teaching functions i.e. it supervises doctoral studies in the field of economic geography.

Institutes of geography are located in the following cities: Gdynia, Katowice, Kielce, Cracow, Lublin, Łódź, Poznań, Szczecin, Toruń, Warsaw, Wrocław.

At universities geographical institutes are in the Biology and Earth Sciences or in the Natural Sciences Faculties. At Warsaw University the Institute of Geography forms a self-contained unit. From the point of view of the organization, the institutes of geography are divided into departments and sections. There are smaller geographical centres attached to the institutes, chairs and departments, at colleges of economics, colleges of pedagogy, and technical universities. Because of its character as the main centre, the Institute of Geography, Polish Academy of Sciences forms a larger unit with a better developed organizational structure. Besides departments (8) and sections (4) it has laboratories and field research stations, as well as a large library.

The following academic titles are used in Poland: ordinary professor and extraordinary professor. The titles are conferred by the State Council.

Among the academic degrees obtainable in Poland are:

Magister (Mgr.) — obtained on the basis of a thesis submitted after 4–5 years of study at academic schools.

Doctor (Dr.) — obtained by persons holding the degree of magister on the basis of a doctoral dissertation which is prepared during several years of graduate studies;

Habilitated Doctor (Dr. habil.) — obtained by persons holding doctorates on the basis of a habilitation dissertation which constitutes a major academic achievement.

Academic posts:

Asystent — Assistant;
Starszy asystent — Senior Assistant;
Adiunkt — Lecturer or Research Associate;
Docent — Assistant Professor or Reader;
Profesor nadzwyczajny — Extraordinary Professor;
Profesor zwyczajny — Ordinary Professor.

The position of Senior Scientific-Research Worker, which exists at the Polish Academy of Sciences Institute of Geography is comparable to the Docent position in the institutes of higher education. The posts of Lecturer (*Wykładowca*) and Senior Lecturer (*Starszy Wykładowca*) are associated with academic schools.

CENTRAL AUTHORITIES

POLISH NATIONAL COMMITTEE OF THE INTERNATIONAL GEOGRAPHICAL UNION (IGU)

The National Committee of the IGU was called into existence by the Presiding Body of the Polish Academy of Sciences' Scientific Secretariat (resolution of 25th Febr., 1958). Term of office is three years. The Committee operates at the Polish Academy of Sciences, Section III. The members of the Committee are eminent Polish scholars in the field of geography.

The tasks of the Committee include:

— co-ordination of the co-operation of Polish geographers within the framework of the IGU scientific programme including: co-operation with various higher schools of learning and scientific organizations as well as with other institutes;

— selecting Polish candidates for delegations to scientific conferences organized by the IGU or the IGU National Committees in other countries;

— naming delegates for other major scientific conferences;

— assessment of scientific materials prepared for the conferences and particularly among socialist countries with regard to scientific co-ordination within the IGU programme;

— proposing candidates from among the representatives of Polish geography to the IGU authorities.

Members to the IGU Polish National Committee are: Prof. Dr. Mieczysław Klimaszewski (Chairman), Prof. Dr. Jerzy Kostrowicki (Deputy Chairman), Prof. Dr. Jan Dylik, Prof. Dr. Kazimierz Dziewoński, Prof. Dr. Rajmund Galon, Prof. Dr. Alfred Jahn, Prof. Dr. Jerzy Kondracki, Prof. Dr. Stanisław Leszczycki, Doc. Dr. habil. Lech Ratajski (Secretary).

COMMITTEE OF THE GEOGRAPHICAL SCIENCES, POLISH ACADEMY OF SCIENCES

The Polish Academy of Sciences Committee for Geographical Sciences is an organ which co-ordinates the research work, and teaching and popularizing activities in the field of geography in Poland. Its basic tasks are: supervision of major research; assessment of results in the domain of the geographical sciences; directing further development; analysis of the quality of the scientific staff; analysis of geographical publications; supervision of the activity of the scientific societies.

The members of the Committee are the representatives of the geographical institutes. The decisions, taken at plenary sessions are put into operation by working groups and a permanent secretariat. The period of office lasts three years. The members of the 1969–1971 Committee are:

Permanent members (members of the Academy):
Prof. Dr. Mieczysław Klimaszewski (Chairman), Prof. Dr. Jan Dylik, Prof. Dr. Rajmund Galon, Prof. Dr. Stanisław Leszczycki.

Appointed members:
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THE POLISH GEOGRAPHICAL SOCIETY

The aim of the Geographical Society is to co-operate in the development of the geographical sciences, dissemination of research achievements, raising the level of geographers' qualifications, improving the teaching of geography in schools, propagating principles of correct management of natural resources, conducting tourist activities.

Plenary sessions are held twice a year. The period of office of the Presiding Board lasts three years.

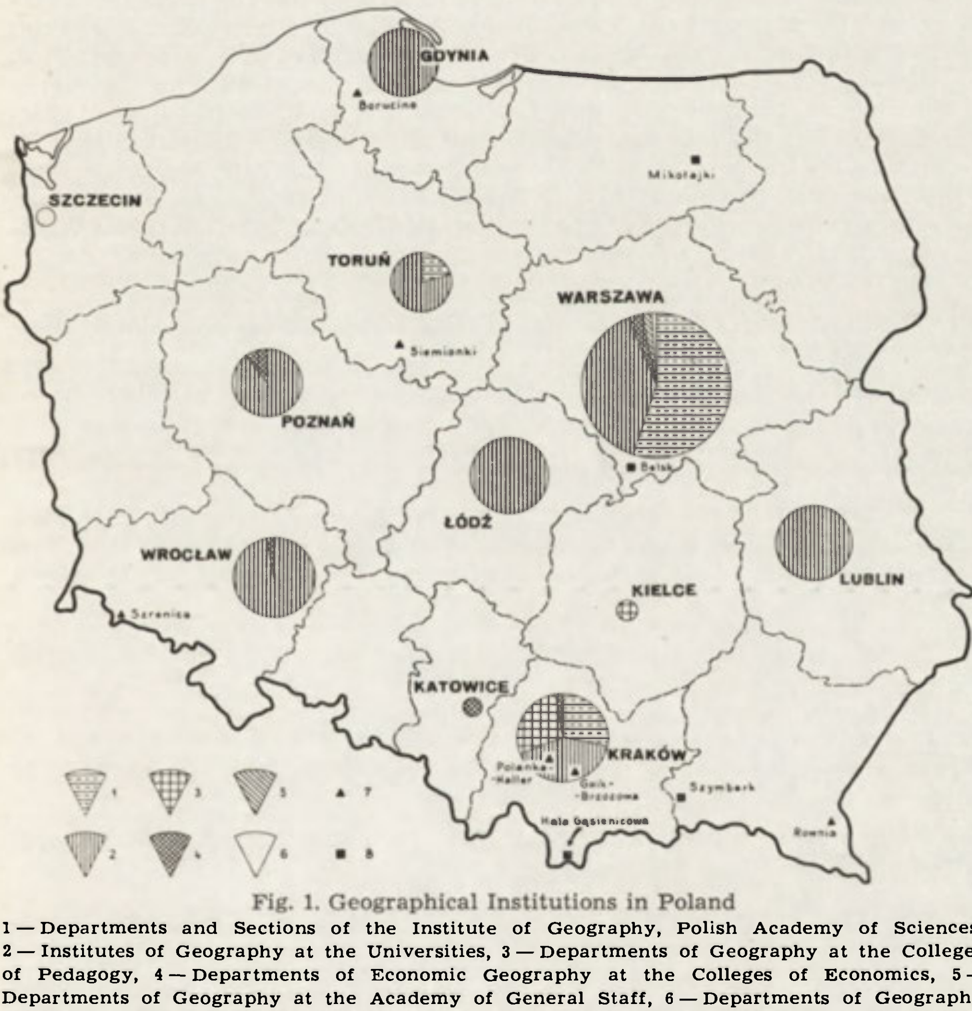

Fig. 1. Geographical Institutions in Poland

1 — Departments and Sections of the Institute of Geography, Polish Academy of Sciences, 2 — Institutes of Geography at the Universities, 3 — Departments of Geography at the Colleges of Pedagogy, 4 — Departments of Economic Geography at the Colleges of Economics, 5 — Departments of Geography at the Academy of General Staff, 6 — Departments of Geography at the Technical Universities (Politechnics), 7 — Geographical Research Stations of the Universities, 8 — Research Stations of the Institute of Geography, Polish Academy of Sciences

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[1] The library of the Institute of Geography, Polish Academy of Sciences has been linked for many years very closely with the departmental library of the Institute of Geography at Warsaw University. All the work connected with the book collections is done jointly for both these libraries. Only the book inventories and book-stacks are separated.

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Prof. Dr. Bogumił Krygowski (Scientific Consultant), Dr. Alojzy Woś

Department of the Geography of Settlement and Population:

Prof. Dr. Stanisława Zajchowska (Head), Doc. Dr. Wiktor Borejko, Mgr. Aleksander Schwartz

Department of Economic Geography:

Doc. Dr. habil. Zbyszko Chojnicki (Head), Dr. Teresa Czyż, Dr. Benicjusz Głębocki, Mgr. Kazimierz Polarczyk

Department of Regional Geography and Geographical Didactics:

Prof. Dr. Tadeusz Bartkowski (Head), Prof. Dr. Maria Czekańska, Doc. Dr. Eugeniusz Biderman, Dr. Ludmiła Czechówna

WYŻSZA SZKOŁA EKONOMICZNA (College of Economics) Faculty of Commerce, Institute of Trade Economics — ul. Marchlewskiego 146/150, Phone 512-01, 557-22

Department of Economic Geography:

Prof. Emeritus Dr. Florian Barciński, Prof. Dr. Ryszard Domański (Head), Mgr. Barbara Skrobiszowa

SZCZECIŃ

POLITECHNIKA SZCZECIŃSKA (Institute of Technology — Politechnic) Faculty of Engineering and the Economy of Transport, Institute of the Economy of Transport — ul. Mickiewicza 66, Phone 724-11

Department of Integrated Transport Research

Section of Geography:
Prof. Dr. Juliusz Mikołajski, Dr. Bronisław Dziedziul

TORUŃ

UNIWERSYTET IM. MIKOŁAJA KOPERNIKA (Nicholas Copernicus University), Faculty of Biology and Earth Sciences, Institute of Geography — ul. Fredry 6/8, Phone 73-07, 73-08

Director: Prof. Dr. Rajmund Galon

Department of Physical Geography:

Prof. Dr. Rajmund Galon (Head), Doc. Dr. Ludmiła Roszko, Dr. Anna Tomczak, Mgr. Eng. Romuald Zapolski

Department of Geomorphology:

Doc. Dr. habil. Władysław Niewiarowski (Head), Dr. Zofia Churska.

Department of Hydrography:

Doc. Dr. Władysław Mrózek (Head), Dr. Zygmunt Churski, Dr. Czesław Pietrucień

Department of Climatology:

Doc. Dr. Ludmiła Roszko (Scientific Consultant), Dr. Gabriel Wójcik

Department of Economic Geography:

Dr. Eugenia Kwiatkowska (Head)

Department of Geology:

Doc. Dr. Andrzej Wilczyński (Head), Dr. Irena Dmoch, Dr. Zygmunt Kurlenda

Department of Mineralogy and Petrography:

Prof. Dr. Jan Wojciechowski (Head), Dr. Stanisław Krążewski, Dr. Leopold Mazur

Library — Mgr. Halina Krzywicka

Research Station in Siemionki (Gopło Lake, Poviat Mogilno)

WARSZAWA (WARSAW)

UNIWERSYTET WARSZAWSKI (Warsaw University) Institute of Geography, ul. Krakowskie Przedmieście 30, Phone 26–74–51 extension 631, 633, 641

Director: Prof. Dr. Jerzy Kondracki

Department of Physical Geography:

Prof. Dr. Jerzy Kondracki (Head), Dr. Ryszard Czarnecki, Dr. Andrzej Rychling, Dr. Jadwiga Stasiakowa

Section of Geomorphology:

Doc. Dr. habil. Cecylia Radlowska (Head), Dr. Mirosław Bogacki, Dr. Elżbieta Dowgiałło, Dr. Irena Gieysztor, Dr. Danuta Suffczyńska

Section of the Geography of Soils:

Doc. Dr. Marek Prószyński (Head), Dr. Michał Kmita

Department of Hydrography:

Prof. Dr. Zdzisław Mikulski (Head), Dr. Beniamina Tchorzewska, Dr. Helena Werner-Więckowska

Department of Climatology:

Prof. Dr. Wincenty Okołowicz (Head), Doc. Dr. habil. Zofia Kaczorowska, Dr. Jerzy Boryczka, Dr. Urszula Kossowska, Dr. Maria Stopa-Boryczka

Department of Economic Geography:

Doc. Dr. Witold Kusiński (Acting Head), Doc. Dr. habil. Bogumił Rychłowski, Doc. Dr. habil. Józef Tobjasz, Dr. Alicja Krzymowska-Kostrowicka, Dr. Maria Irena Mileska

Department of Regional and Political Geography:

Prof. Dr. Józef Barbag (Head), Doc. Dr. habil. Bolesław Dumanowski, Prof. Dr. Bogodar Winid, Dr. Andrzej Bonasewicz, Dr. Jadwiga Kaczyńska-Winidowa, Dr. Bohdan Kikolski, Dr. Stanisław Otok, Mgr. Adam Bajcar, Mgr. Joachim Koczy, Mgr. Janina Kremky-Saloni, Mgr. Maksymilian Skotnicki

Department of Cartography:

Prof. Emeritus Dr. Stanisław Pietkiewicz, Doc. Dr. habil. Lech Ratajski (Head), Mgr. Gabriel Bonatowski, Mgr. Witold Maculewicz

Section of Geographical Didactics:

Dr. Konrad Świerczyński (Head)

Laboratory of Statistical Machines:

Doc. Dr. habil. Józef Tobjasz (Head)

Section of Photointerpretation:

Prof. Dr. Bogodar Winid (Head), Dr. Andrzej Ciołkosz

Laboratory of Photographic Reproduction:

Mrs. Janina Jungowa (Head)

Library [2]

Mgr. Janina Kunicka (Head)

SZKOŁA GŁÓWNA PLANOWANIA I STATYSTYKI (College of Planning and Statistics) ul. Rakowiecka 6, Phone 25–12–51

Faculty of the Economics of Production
Department of the Economic Geography of Poland:

Prof. Dr. Stanisław Berezowski (Head), Doc. Dr. habil. Irena Fierla, Doc. Dr. habil. Tadeusz Hoff

Faculty of Foreign Trade
Department of the Economic Geography of the World:

Dr. Krystyna Dybczyńska

POLITECHNIKA WARSZAWSKA (Institute of Technology — Politechnic) Faculty of Geodesy and Cartography, PI. Jedności Robotniczej 1, Phone 210–07 extension 690

Department of Cartography and Photogrametry
Section of Geography:

Dr. Urszula Urbaniak-Biernacka, Mgr. Jędrzej Kotarbiński

AKADEMIA SZTABU GENERALNEGO IM. GEN. KAROLA ŚWIERCZEWSKIEGO (General Karol Świerczewski Academy of General Staff) Warszawa–Rembertów

Department of War Geography

WROCŁAW

UNIWERSYTET IM. BOLESŁAWA BIERUTA (Bolesław Bierut University) Institute of Geography, Plac Uniwersytecki 1, Phone 351–84

Director: Prof: Dr. Stanisław Szczepankiewicz

Department of Physical Geography:

Prof. Dr. Stanisław Szczepankiewicz (Head), Dr. Jerzy Cegła, Dr. Piotr Szczypek, Dr. Adolf Szponar, Mgr. Tadeusz Komar

Department of Geomorphology with Section of Soil:

Prof. Dr. Alfred Jahn (Head), Doc. Dr. Hieronim Piasecki, Dr. Stanisław Baranowski, Dr. Janusz Czerwiński, Dr. Marian Pulina

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[2] For organizational details see footnote 1.

Department and Observatory of Meteorology and Climatology — ul. Cmentarna 6/8, Phone 830–41

Prof. Dr. Aleksander Kosiba (Head), Mgr. Maria Dubicka

Department of Social and Political Geography:

Prof. Dr. Stefan Golachowski (Head), Doc. Dr. Andrzej Jagielski, Dr. Beniamin Kostrubiec, Dr. Janina Piasecka, Dr. Antoni Zagożdżon

Department of Economic Geography:

Doc. Dr. Józef Januszewski (Head), Doc. Dr. Zbigniew Wysocki

Department of Regional Geography:

Prof. Dr. Wojciech Walczak (Head), Doc. Dr. habil. Leszek Baraniecki, Doc. Dr. habil. Helena Migaczowa, Doc. Dr. Leszek Pernarowski, Doc. Dr. habil. Edward Tomaszewski

Department of Cartography:

Prof. Dr. Władysław Migacz (Head), Dr. Władysław Pawlak

Section of Photography:

Mr Jan Behrendt

WYŻSZA SZKOŁA EKONOMICZNA (College of Economics) Faculty of National Economy — ul. Komandorska 118/120, Phone 610–21

Department of Economic Geography:

Doc. Dr. habil. Jadwiga Pilawska (Head)

Compiled by *Jacek Królik*

LIST OF CURRENT GEOGRAPHICAL PERIODICALS IN POLAND

This list does not include all the journals and publications where one might find geographic works but only those of a predominantly geographical character. Thus, the general university series in which separate volumes or subseries deal with geography, and only those regional publications where there are separate geographical series were included. The list does not include journals on geology, meteorology, geodesy, economics and town planning, nor regional journals of a more comprehensive character, although these might sometimes contain articles of a geographic nature or interest.

Each journal or series was characterized in the following way: original title and its English translation, frequency of publication and editor and the adress of the editorial office, the year the first volume was published and publisher, average no. of copies issued, language of summaries.

INSTITUTE OF GEOGRAPHY, POLISH ACADEMY OF SCIENCES

Geographia Polonica, Serial publication. Institute of Geography, Polish Academy of Sciences. Stanisław Leszczycki, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1964). Państwowe Wydawnictwo Naukowe, 1000 copies. In English, occasionally in French.

Contains materials from international conferences and symposia organized in Poland or with participation of Polish geographers; results of scientific investigations conducted in Poland and abroad; studies based on habilitation and doctoral dissertations.

Przegląd Geograficzny (Polish Geographical Review). Quarterly. Institute of Geography, Polish Academy of Sciences. Stanisław Leszczycki, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1918). Państwowe Wydawnictwo Naukowe. 2050 copies. English (or French or German) and Russian summaries.

The leading Polish geographical journal. Contains: articles, notes, reports, discussions, book reviews, chronicles. Papers by Polish and foreign authors covering all fields of geography. Some issues deal with special subjects. English supplements to vol. 28 (1956), 31 (1959) and 32 (1960).

Prace Geograficzne (Geographical Studies). Serial publication. Institute of Geography, Polish Academy of Sciences. Maria Kiełczewska-Zaleska, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1954). Państwowe Wydawnictwo Naukowe. 800 copies. English and Russian summaries.

Monographs in the field of physical, economic, historical and applied geography (mainly habilitation and doctoral dissertations); in English: Vol. 25. Problems of Applied Geography, Vol. 27 — Problems of Economic Region, Vol. 31 — Land Utilization. Methods and Problems of Research. Vol. 46 — Problems of Geomorphological Mapping.

Dokumentacja Geograficzna (Geographical Documentation) Successor since 1952 of the *Biuletyn Geograficzny Polskiego Towarzystwa Geograficznego.* Six issues per year. Institute of Geography, Polish Academy of Sciences. Teofil Lijewski, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1955). Instytut Geografii PAN. 500 copies.

Contains detailed results of scientific research, scientific documentation, materials from congresses and symposia, habilitation and doctoral abstracts: Volume 1/1970 in English: International Geographical Union, Commission on Agricultural Typology; "Agricultural Typology".

Bibliografia Geografii Polskiej (Bibliography of Polish Geography). Irregular. Institute of Geography, Polish Academy of Sciences. Stanisław Leszczycki, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1956). Państwowe Wydawnictwo Naukowe. 800 copies.

Nine volumes containing bibliography for 1936–1966 published by the end of 1970.

Przegląd Zagranicznej Literatury Geograficznej (Review of Foreign Geographical Literature). Predecessor from 1950 was Przegląd Radzieckiej Literatury Geograficznej. Quarterly. Institute of Geography, Polish Academy of Sciences. Andrzej Samuel Kostrowicki, editor. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1955). Instytut Geografii PAN. 500 copies.

Contains translations of more important foreign publications (articles, book sections) in the branch of both physical and economic geography (mainly theoretical and methodological papers).

OTHER GEOGRAPHICAL PUBLICATIONS OF THE POLISH ACADEMY OF SCIENCES

Bulletin de L'Académie Polonaise des Sciences. Sér. des Sciences Géologiques et Géographiques. Quarterly. Polish Academy of Sciences. Kazimierz Smulikowski, editor. Editorial office: Warszawa, Pałac Kultury i Nauki. Vol. 1 (1960). Państwowe Wydawnictwo Naukowe. 750 copies. Articles in French, English and Russian. English and Russian summaries.

Contains communiqués, scientific notes devoted to geology, hydrogeology, geochemistry, geophysics and geography. From Vol. 19 (1971) Bulletin de l'Académie Polonaise des Sciences. Séries des Sciences de la Terre.

Folia Geographica. Series Geographica-Physica. Irregular. Board of Geographical Sciences, Polish Academy of Sciences. Kraków. Mieczysław Klimaszewski, editor. Editorial office: Kraków, Sławkowska 7. Vol. 1 (1968). Państwowe Wydawnictwo Naukowe. 500 copies. English summaries.

Selection of papers devoted to the geographic environment of the city of Cracow as well as other papers on geomorphology, climatology, and hydrography.

Folia Geographica. Series Geographica-Oeconomica. Irregular. Board of Geographical Sciences. Polish Academy of Sciences. Kraków. Antoni Wrzosek, editor. Editorial office: Kraków, Sławkowska 7. Vol. 1 (1968). Państwowe Wydawnictwo Naukowe. 550 copies. English summaries.

Papers dealing with economic and geographical problems in southern Poland (mainly settlement, population and industrial geography).

Studia Geomorphologica Carpatho-Balcanica. Irregular. L'organe de la Commission géomorphologique Carpate-Balcanique. Board of Geographical Sciences, Polish Academy of Sciences. Leszek Starkel, editor. Editorial office: Kraków, Grodzka 64. Vol. 1 (1967). Państwowe Wydawnictwo Naukowe. 620 copies. In French, English, Russian.

Papers by geomorphologists belonging to the Carpathian and Balkan Geomorphological Commission.

Studia i Materiały z Dziejów Nauki Polskiej (Studies and Documents from the History of Polish Science). Ser. C. Historia nauk matematycznych, fizykochemicznych i geologiczno-geograficznych. (History of Mathematics, Physics, Chemistry, Geology and Geography). Irregular. Polish Academy of Sciences, Department of the History of Science and Technology. Waldemar Voise, editor. Editorial office: Warszawa, Pałac Kultury i Nauki. Vol. 1 (1957). Państwowe Wydawnictwo Naukowe. 450 copies. English (or German) and Russian Summaries.

Studies on the history of the development of the Earth sciences. Geographers' biographies.

UNIVERSITIES AND ACADEMIC SCHOOLS

GDAŃSK

Zeszyty Naukowe Wydziału Biologii i Nauk o Ziemi Uniwersytetu Gdańskiego. Ser. Geografia. (Scientific Papers of the Gdańsk University, Faculty of Biology and Earth Sciences. Ser. Geography.) Successor since 1970 of Zeszyty Geograficzne WSP Gdańsk. Yearbook. Kazimierz Łomniewski, editor. Editorial office: Gdańsk-Wrzeszcz, Sobieskiego 18. Vol. 1 (1959). Wydawnictwo Morskie. 400 copies. English summaries.

Contains papers dealing with physical, economic and regional geography, geology and cartography, as well as oceanography.

KRAKÓW (Cracow)

Prace Geograficzne. Seria Nowa (Geographical Studies, New Series). Serial publication. Zeszyty Naukowe Uniwersytetu Jagiellońskiego. Prace Instytutu Geograficznego U.J. (Scientific Papers of the Jagellonian University. Works of the Geographical Institute). Mieczysław Klimaszewski, editor. Editorial office: Kraków, Grodzka 64, Vol. 1 (1960). Uniwersytet Jagielloński. English and Russian summaries.

Studies dealing with climatology, physical, urban, industrial geography.

Prace Monograficzne Wyższej Szkoły Pedagogicznej w Krakowie. (Monographic Studies of the College of Pedagogy). Irregular. Editorial office: Kraków, Smoluchowskiego 10, Vol. 1 (1963). Wydawnictwo Naukowe WSP Kraków. 250 copies.

Monographs — mainly doctors' and habilitation dissertations by research workers at the College of Pedagogy.

Rocznik Naukowo-Dydaktyczny. Geografia (Scientific and Didactic Yearbook. Geography). Irregular. College of Pedagogy in Cracow. Władysław Danek, editor. Editorial office: Kraków, Smoluchowskiego 10. Vol. 1 (1951). Państwowe Wydawnictwo Naukowe. 300–400 copies. English and Russian summaries.

Contains articles and results of investigations conducted in southern Poland by research workers of the College of Pedagogy, Department of Geography.

Zeszyty Naukowe Uniwersytetu Jagiellońskiego. Prace z Geografii Ekonomicznej. (Scientific Papers of the Jagellonian University. Studies in Economic Geography). Irregular. Antoni Wrzosek, editor. Editorial office: Kraków, Grodzka 64. Vol. 1 (1960). Uniwersytet Jagielloński. 600 copies. French and Russian summaries.

Articles from all branches of economic geography, mainly industrial and population geography.

LUBLIN

Annales Universitatis Mariae Curie-Sklodowska. Sectio B. Geographia, Geologia, Mineralogia et Petrographia. Yearbook. Adam Malicki, editor. Editorial office: Lublin, PI. Litewski 5. Vol. 1 (1946). Uniwersytet im. Marii Curie-Skłodowskiej. 1000 copies. English, French, German and Russian summaries.

Papers mainly in the field of physical geography, geomorphology and geology.

POZNAŃ

Prace Wydziału Biologii i Nauk o Ziemi Uniwersytetu im. A. Mickiewicza. Seria Geografia. (Studia of the Faculty of Biology and Earth Sciences of the A. Mickiewicz University in Poznań, Ser. Geography). Irregular. Bogumił Krygowski, editor. Editorial office: Poznań, Fredry 10. Vol. 1 (1962). Uniwersytet im. A. Mickiewicza. 300 copies. Mimeographed. English, French and Russian summaries.

Large selection of papers mainly in physical geography (geomorphology, hydrography).

Zeszyty Naukowe. (Scientific Papers). College of Economics in Poznań. Irregular. Seweryn Kruszczyński, editor. Editorial office: Poznań, Marchlewskiego 146/150. Vol. 1 (1961). Wyższa Szkoła Ekonomiczna, Poznań. 300 copies. Mimeographed. English and Russian summaries.

Articles on economics, statistics, planning; some papers contain studies of economic geography; articles by research workers of College of Economics in Poznań.

Zeszyty Naukowe Uniwersytetu im. Adama Mickiewicza w Poznaniu. Seria Geografia. (Scientific Papers of the Adam Mickiewicz University in Poznań).

Ser. Geography. Irregular. Bogumił Krygowski, editor. Editorial office: Poznań, Fredry 10. Vol. 1 (1957). Uniwersytet im. A. Mickiewicza. 600 copies. English, French, German and Russian summaries.

Monographs and papers in both physical and economic geography.

TORUŃ

Zeszyty Naukowe Uniwersytetu Mikołaja Kopernika w Toruniu. Ser. Geografia. (Scientific Papers of the Nicolaus Copernicus University of Toruń. Ser. Geography). Irregular. Rajmund Galon, editor. Editorial office: Toruń, Fredry 8. Vol. 1 (1956). Państwowe Wydawnictwo Naukowe. 400–700 copies. English summaries.

Broad selection of articles devoted to geomorphology and the hydrography of northern Poland.

WROCŁAW

Prace Zakładu i Obserwatorium Meteorologii i Klimatologii Uniwersytetu Wrocławskiego im. Bolesława Bieruta. (Reports of the Meteorological and Climatological Department and Observatory of the Bolesław Bierut University in Wrocław). Irregular. Scientific Society, Wrocław. Aleksander Kosiba, editor. Editorial office: Wrocław, Cmentarna 8. Vol. 1 (1947). Wrocławskie Towarzystwo Naukowe, 680–1000 copies. English summaries.

Deals with results of meteorological observations of the Wrocław and Szrenica stations; studies on the climate of Wrocław.

Studia Geograficzne. Acta Universitatis Wratislaviensis. (Geographical Studies). Successor since 1956 of *Zeszyty Naukowe Uniwersytetu Wrocławskiego.* Ser. B. Nauki Przyrodnicze. Seria Nauki o Ziemi. (Papers of the Wrocław University. Ser. B. Natural Sciences. Ser. Earth Sciences). Irregular. Stefan Golachowski, editor. Editorial office: Wrocław, Pl. Uniwersytecki 1. Vol. 1 (1963). Państwowe Wydawnictwo Naukowe. 400–650 copies. English and Russian summaries.

Articles, doctors' and habilitation dissertations mainly in geomorphology, climatology and economic geography of southern Poland.

WARSZAWA (Warsaw)

Biuletyn Katedry Klimatologii Instytutu Geograficznego Uniwersytetu Warszawskiego. (Bulletin of Chair of Climatology. Institute of Geography, Warsaw University). Irregular. Editorial office: Warszawa 64, Krakowskie Przedmieście 30, Vol. 1 (1959). Uniwersytet Warszawski. Mineographed.

Results of meteorological observations conducted at the weather station of the Institute of Geography, Department of Climatology at Warsaw University.

Prace i Studia Instytutu Geograficznego Uniwersytetu Warszawskiego. Katedra Geografii Fizycznej. (Reports and Studies of the Institute of Geography, Warsaw University. Chair of Physical Geography). Irregular. Jerzy Kondracki, editor. Editorial office: Warszawa, Krakowskie Przedmieście 30. Vol. 1 (1967). Uniwersytet Warszawski. 500 copies. English summaries.

Mainly master's and doctoral dissertations; studies by research workers of the Department of Physical Geography.

Prace i Studia Instytutu Geograficznego Uniwersytetu Warszawskiego. Katedra Klimatologii. (Reports and Studies of the Institute of Geography of the University of Warsaw. Chair of Climatology). Irregular. Zofia Kaczorowska, Wincenty Okołowicz, Maria Stopa, editors. Editorial office: Warszawa 64, Krakowskie Przedmieście 30. Vol. 1 (1964). Uniwersytet Warszawski. 500 copies. English summaries.

Selection of works produced in the Department of Climatology including summaries of doctoral dissertations.

NOTICE: Since the year 1970 there also appear General Series and Economic Geography Series.

Zeszyty Naukowe Szkoły Głównej Planowania i Statystyki. (Scientific Papers of the College of Planning and Statistics). Irregular. Wiesław Sadowski, editor. Editorial office: Warszawa, Rakowiecka 6. Państwowe Wydawnictwo Naukowe. 550 copies, English and Russian summaries.

Articles on economics, planning and statistics. Papers: 7, 17, 41, 51, 54, 57, 59, 63 contain works concerning economic geography.

POLISH GEOGRAPHICAL SOCIETY

Czasopismo Geograficzne (Geographical Journal). Quarterly. Alfred Jahn, editor. Editorial office: Wrocław, Pl. Uniwersytecki 1. Polish Geographical Society. Vol. 1 (1923). Państwowe Wydawnictwo Naukowe. 3000 copies. English or French, and Russian summaries.

Articles devoted to various branches of geography, mainly to physical and regional geography. Geographical news, book reviews, Society news.

Polski Przegląd Kartograficzny (Polish Cartographical Review). Quarterly. Polish Geographical Society. Franciszek Uhorczak, editor. Editorial office: Warszawa, Solec 18. Vol. 1 (1969). Państwowe Przedsiębiorstwo Wydawnictw Kartograficznych. 1000 copies. English and Russian summaries.

Selection of articles and scientific information in the field of cartography, reviews of maps and atlases, reports from conferences, and section concerning changes of the map of Poland and of that of the world.

Fotointerpretacja w Geografii (Photo-interpretation in Geography). Annual. Polish Geographical Society, Committee of Photo-interpretation. Bogodar Winid, editor. Editorial office: Warsaw University, Institute of Geography, Section of Photo-interpretation, Warszawa 64, Krakowskie Przedmieście 30, Vol. 1 (1964); Warsaw University. 300 copies. English summaries. Mimeographed.

Articles, notes and reports showing the degree to which air photography is used in various branches of geography in Poland.

Poznaj Świat. (Know the World). Monthly. Polish Geographical Society. Edited by the Committee of the Praesidium of PGS. Editorial office: Warszawa, Nowy Świat 49. Vol. 1 (1948). Państwowe Wydawnictwo Naukowe. 110,000 copies.

Popular, ilustrated geographical magazine. Contains articles and reports from various countries, photos, statistical information, maps, geographical news, book reviews and question-and-answer exercises in the field of geography.

OTHER SCIENTIFIC SOCIETIES

LUBLIN

Biuletyn Lubelskiego Towarzystwa Naukowego. (Bulletin of Lublin Scientific Society). Folia Societatis Scientiarum Lublinensis, Sectio D, Geographia. Irregular. Edward Michna, editor. Editorial office: Lublin, Pl. Litewski 5. Vol. 1 (1961).Wydawnictwo Lubelskie. 400 copies. Text partly in French. English summaries.

Papers by geographers of the Lublin centre mainly in the field of physical geography, geomorphology, climatology.

ŁODŹ

Acta Geographica Lodziendzia. (Successor since 1962 of Acta Geographica Universitatis Lodziensis). Irregular. Societas Scientarium Lodziensis (Scientific Society of Łódź) Sec. III. Mieczysław Dorywalski, editor. Editorial office: Łódź, Sienkiewicza 29. Vol. 1 (1948). Państwowe Wydawnictwo Naukowe. 700 copies. English, French or German and Russian summaries.

Papers and larger monographs, mainly concerning the physical geography (geomorphology) of the Łódź and Kielce regions.

Biuletyn Peryglacjalny (Periglacial Bulletin). Irregular. Societas Scientiarum Lodziensis (Scientific Society of Łódź). Sec. III. Jan Dylik, editor. Editorial office: Łódź, Marii Curie-Skłodowskiej 11. Vol. 1 (1954). Państwowe Wydawnictwo Naukowe. 800 copies. Papers in English or French.

The Editorial Board includes the representatives of various countries. The periodical became an official international publication devoted to periglacial phenomena.

Bulletin de la Société des Sciences et des Lettres de Łódź. Cl. III. De Sciences Mathématiques et Naturelles. Irregular. Łódź, Scientific Society Editorial office: Łódź, Sienkiewicza 29. Vol. 1 (1947). Państwowe Wydawnictwo Naukowe. 350 copies. In English or French.

Vols. 3, 4, 8, 12, 19 contain papers by geographers mainly about physical geography. Vol. 19 (1968) published for the International Geographical Congress, India 1968, contains papers by J. Dylik.

POZNAŃ

Badania Fizjograficzne nad Polską Zachodnią. Ser. Geografia Fizyczna. (Physiographical Studies on Western Poland. Ser. Physical Geography). Irregular. Society of the Friends of Science. Department of Natural Science and Mathematics. Physiographic Committee. Bogumił Krygowski, editor, Editorial office: Poznań, Mielżyńskiego 27/29. Vol. 1 (1948). Państwowe Wydawnictwo Naukowe. 450 copies. English, French or German and Russian summaries.

Papers in geomorphology, sedimentology, granulometry of sediments and climatology of Greater Poland and Western Pomerania.

Prace Komisji Geograficzno-Geologicznej (Studies of the Geographical and Geological Commission). Irregular. Poznań Society of the Friends of Science. Department of Natural Sciences and Mathematics. Editorial board. Editorial office: Poznań, Mielżyńskiego 27/29. Vol. 1 (1936–1938), Vol. 2 (1956) Państwowe Wydawnictwo Naukowe. 400 copies. English (or German) summaries.

Articles and doctoral dissertations of research workers from A. Mickiewicz University, Institute of Geography. Studies devoted to geomorphology, hydrography, and sedimentology in Western Poland.

TORUŃ

Studia Societatis Scientiarum Torunensis. Sec. C. Geographia et Geologia. Irregular. Scientific Society in Toruń. Rajmund Galon, editor. Editorial office: Toruń; Fredry 8. Vol. 1 (1951). Państwowe Wydawnictwo Naukowe. 300–500 copies. English summaries.

Papers on the geomorphology, hydrography and geology of northern and central Poland.

OTHER PUBLICATIONS (SELECTED)

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Vol. 2. 34 papers prepared by Polish geographers for the XXth International Geographical Congress in London, July 1964, 259 pp., 91 Figures, 1964, $ 6.65

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Vol. 4. Methods of Economic Regionalization. Materials of the Second General Meeting of the Commission on Methods of Economic Regionalization, International Geographical Union, Jabłonna — Poland, September 9–14, 1963. Reports, communications and discussion, 200 pp., 6 Figures, 1964, $ 4.15

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Vol. 15. Economic Regionalization and Numerical Methods. The volume contains the final report on the activities of the IGU Commission on Methods of Economic Regionalization, as well as a collection of 8 papers by American, Canadian, Soviet, and Polish authors, 240 pp., 54 Figures, 1968, $ 5.60

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