POLISH ACADEMY OF SCIENCES
INSTITUTE OF GEOGRAPHY

PRZEGLĄD GEOGRAFICZNY

POLISH GEOGRAPHICAL REVIEW

VOL. XXXI. SUPPLEMENT

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Five Years' Activity of the Institute of Geography of the Polish Academy of Sciences, 1953–1958

During the inter-war years, a clear tendency had already appeared among Polish geographers to connect their work with practical tasks resulting from state or social needs. Polish geographers participated in the work on improving the development of the eastern territories and mountainous lands, in regional planning etc., conducting commissioned work alongside their purely scientific and theoretical elaborations as well as fulfilling didactic and popularization activities.

This tendency appeared even more clearly after World War II. A task of new dimensions attracted their attention — acquainting the Polish people with the Western Territories. In People's Poland, where area development planning was being widely extended, geographers participated in regional and national planning, partly in local and town planning, creating with time a new branch of applied science called „urbanistic physiography" [1].

Geographers also participated in work directed by various economic institutions. The tasks were tremendous, but the number of geographers, relatively insignificant and dispersed in seven university centres. The scientific work of the university centres, burdened with basic educational tasks, did not keep pace with the pressing state needs.

In 1950—1951, an extensive and all-embracing discussion was conducted in Poland on the further development of science in preparation of the First all-Polish Congress of Science. Naturally, geography participated in that action. At the Congress in 1951, the future basic tasks for Polish geography were set [2]. These tasks required a body to coordinate the work and which had sufficient means at its disposal for their realization.

After the war, coordinating activity was in the hands of the Polish Geographical Society which as a social body could not, for a longer time, be a match for a permanent research centre. It was therefore necessary to establish the state geographic research institute.

On the one hand, state needs requiring speedy fulfillment substantia-

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[1] „Przegląd Geograficzny" XXVII, 3/4, Warszawa 1955.

[2] L e s z c z y c k i S. *The State of Geography in Poland and Perspectives for its development.* Report of the Geography sub-section at the First all-Polish Congress of Science (Polish only). „Przegląd Geograficzny" XXIII, Warszawa 1950—1951.

ted its existence by its efficient guidance in coordinating geographic research on a national scale. On the other hand, the deepening of geographic research required an ever further advancement of specialization and creating of theoretical basis for geographical sciences for which there was no longer any place at the universities parallelly fulfilling their educational functions. The far-reaching advances of specialization required at the same time coordination aimed at a universal undertaking of certain tasks such as regional ones; that is why specialized laboratories had to be within the framework of one institution.

In 1952, the Polish Academy of Sciences was set up as an academy of a new type, having its own research institutes. The Institute of Geography was established within the Academy a year later on October 15, 1953. It was set up on the basis of the Resolution of the Government of October 10, 1953. It obtained statutes in which the tasks and rights of the Institute were confirmed. The Institute's tasks are: conducting of scientific research work according to the established plan, making accessible the results of its research for practical needs, cooperating as well as exchanging experiences with other institutions in Poland and abroad in conducting and utilizing scientific research, issuing scientific publications, educating and perfecting scientific staff, organizing conferences and congresses as well as general scientific supervision over the work of the centres not belonging to the Polish Academy of Sciences (PAN) at the request of the respective authorities. The Institute is a legal body. Within its jurisdiction lies the conference of scientific degrees on the same principles as those in force at the Universities. The Institute obtains its own independent budget within that of the Polish Academy of Sciences, with a number of positions for employing permanent staff.

The establishment of the Geographical Institute of the Polish Academy of Sciences (IG PAN) was warmly welcomed by the majority of Polish geographers. This is attested to by the resolution of the Plenary Assembly of the Polish Geographical Society passed on December 13, 1953[3]. The resolution stated:

„The Plenary Assembly of the Polish Geographical Society gladly greets the creation of the Geographical Institute of the Polish Academy of Sciences as an autonomous research centre, seeing in this the fulfilment of its tasks and aims which it fruitlessly endeavored to achieve in the inter-war period, and which has only been fulfilled in People's Poland. Due to the establishment of the Geographical Institute of the Polish Academy of Sciences, geography gained an official institution (in addition to universities) which can fully concern itself with and heed the proper development of geography as a science in Poland. The Plenary Assembly of the Polish Geographical Society fully appreciates the historic significance of the establishment of the Geographical Institute of the Polish Academy of Sciences and that is why it transfers to it willingly a certain portion of its works as well as part of its property".

Due to this resolution, the Institute immediately gained a material base which consisted of a library containing 18,617 volumes, of books, serial publications and periodicals as well as 8,471 sheets of maps. In

[3] „Przegląd Geograficzny" XXVI, 1, Warszawa 1954.

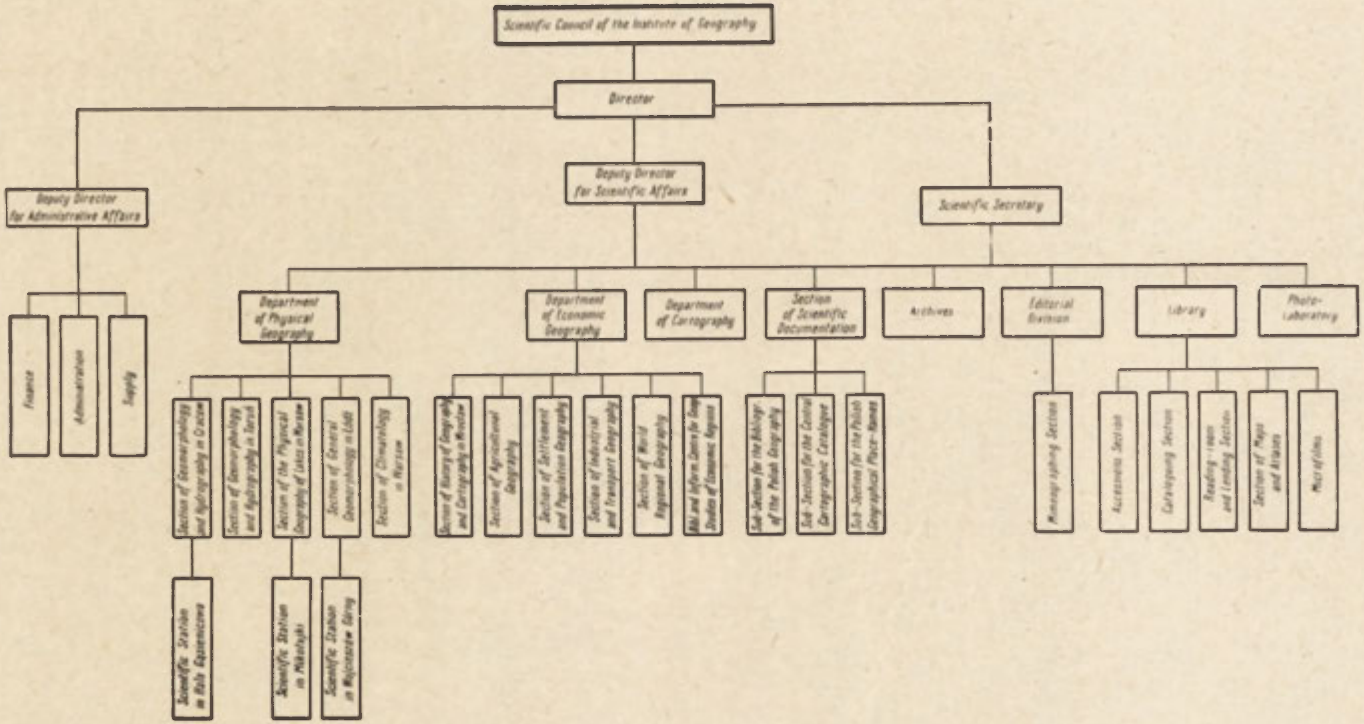

Fig. 1. The organization of the Institute

addition, the Institute took over from the Polish Geographical Society its main publications, a collection of instruments, furniture as well as three research stations in Wojcieszów (Sudety Mountains), Mikołajki (Mazury Lake District) and on Hala Gąsiennicowa (Tatra Mountains).

In this manner, there was established by the end of 1953, a geographical research centre, which due to its concentration of scientific means and forces could undertake the coordination of the scientific work on a national scale. Having at its disposal the means, possibilities for specialization as well as for essential and organizational scientific coordination, it elaborated a plan for the most important research for the coming period. This straitened the sphere of research conducted previously by the Polish Geographical Society. The limitation of the field of research permitted to deal more perfectly with the chosen topics. This gave speedier and better results for the work conducted. However, this caused, at the same time, overlooking certain fields such as medical geography, geography of culture. political geography or unsatisfactorily considering others such as regional geography, oceanography, geography of soils, biogeography, historic geography, geography of communication, etc.

In October 1953 the Institute's managing body was appointed made up of the director, a deputy director for scientific questions, a deputy director for administrative matters as well as a scientific secretary. In December 1955, the scientific secretariat of PAN appointed the first Scientific Council of the Institute of Geography of the Polish Academy of Sciences (IG PAN) for three years. The first Scientific Council was made up of 19 eminent geographers, mainly university professors as well as seven representatives from other institutions and central government offices.

It immediately proceeded to organize the Institute. The statutes provided for the establishment of four departments with numerous research sections. In the first phase, two sections of the Physical Geography Department in Cracow and Toruń were organized, a section of the history of geography in Wrocław, two sections at the Economic Geography Departament in Warsaw and the Cartography Departament with an independent section in Lublin. In addition the sections for Geographic Documentation and Publications were established. From 1954, a systematic expansion of the Institute ensued, with new research centres established as well as the expansion of the existing ones. The organizational status of the Institute was as follows as of July 1, 1959.

From the attached fig. 1 it can be seen that the specialization of the research divisions has been quite far-reaching. The organizational structure of the Institute, however is not altogether consequent since impeding it is the history of its rapid development which was conditioned to a great extent by the existing state of scientific staff [4]. For solving a complex of immediate problems, special teams are established for the period of the work conducted. And thus there exists a grup for elaborating an economic geographical monograph of the Voivodship of Białystok,

[4] In connection with this, a further expansion of the Institute is provided for the next 15 years, and the setting up of new specialized research centres of departments. In the future the Institute should be composed of laboratories and departments corresponding to the various fields of the geographic sciences.

editorial groups for the *Polish National Atlas, Atlas of Polish Industry* as well as an editorial group for *Geography of Poland.* To the extent necessary, new groups can be set up.

Independent of these, there also exists commissions appointed by the Scientific Council of the Geographical Institute of the Polish Academy of Sciences.

Table 1

The inventories of the Library

Status	31.12.58	31.12.57	31.12.56	31.12.55	31.12.54	31.12.53	31.12.52
Books	32.548	28.293	23.061	20.312	17.000	12.755	12.384
Periodicals	13.310	11.801	10.120	8.464	7.197	5.862	5.831
Total	45.858	40.094	33.181	28.776	24.197	18.617	18.215
Atlases	911	819	674	609	514	331	302
Single maps	5.764	3.831	3.191	2.826	2.305	1.803	1.744
Serial maps	16.082	13.048	11.250	10.898			
Special maps	6.455	5.755	3.989	2.031	9.583	6.337	6.209
Wall maps	264	114	27	24	—	—	—
Aerial Photos	925	—	—	—	—	—	—
Total	30.401	23.567	19.331	16.364	12.402	8.471	8.255
Microfilms	110	65	58	24	24	8	8
Photocopies	37	7	4	—	—	—	—
Records for Learning Foreign Languages	48	—	—	—	—	—	—
Grand Total	76.454	63.733	52.574	45.164	36.623	27.096	26.478
Loaned books and maps	21.464	20.443	18.323	17.331	12.428	—	—
of which: outside the library	4.517	4.217	2.498	2.325	1.233	—	—
amount of people using reading room	12.458	10.415	10.524	8.413	8.249	6.258	—

The Scientific Council is a control body, exercising the essential supervision of the activities of the Institute, and decides on the conferring of degrees and scientific titles, fulfilling a role of similar to the council in a University department. For examining the particular tasks which have to be confirmed by the Scientific Concil of the IG PAN the following commissions have been appointed: Publications Commission, Commission for Educating and perfecting scientific staff (which is responsible for proposals on conferring scientific titles for younger scientific workers, awarding scholarships and fellowships), Library Commission. Other Commissions have the character of subject groups, such as The Geomorphological and Hydrographical Maps Commission, Commission to Establish Polish Geographic Names, Bibliographical Commission, etc. Finally, there is the third group of Commissions which are advisory, technical bodies of the managing body of the IG PAN, for example the Committee on Commissioned Work, on Purchasing apparatus, on importing, etc. The Scientific Secretariat concerns itself with organizational scientific questions; it elaborates yearly, many-year and long range plans of geographic research, prepares reports and maintains contact with abroad.

During the last five years (1954—1958), the material base of the institute has greatly developed [5]. The property of the Institute, which on December 31, 1953 amounted to 1.342.000 zlotys (of which the library's value was 409.000) grew to 7.000.000 zlotys by 31 December, 1958 (of which the library's value was 2.148.000 zlotys).

The development of the library can be seen by the lively exchange with abroad, and by the growing inventories (see tables 1 and 2).

Table 2

The foreign exchange of letters and publications

	1958	1957	1956	1955	1954
Number of institutions with which exchange is carried on	781	766	749	606	554
Within Poland	85	64	64	39	27
Number of Foreign countries	94	90	89	80	79
Letters sent out	1.843	1.970	784	1.199	3.083
Letters received	1.280	—	1.197	1.115	1.578
Amount of items sent for exchange	5.571	3.496	1.332	1.893	1.724
Amount of items received by exchange	5.327	6.708	4.509	5.927	1.836

The Institute's budget grew from 3.000.000 zlotys in 1954 to 5.800.000 in 1958.

The Institute has 3 area research stations in Wojcieszów, Lower Silesia (own building), on the Hala Gąsienicowa in the Tatra Mountains, and in Mikołajki in — Mazurian Lake District. It has at its disposal one automobile, 2 trucks, a few motorcycles, many bicycles as well as two motor

[5] Reports of the Activities of the Geographical Institute of the Polish Academy of Sciences:
For 1958 „Przegląd Geograficzny" XXXI, 2, pp. 444—465, Warszawa 1959.
For 1954 „Przegląd Geograficzny" XXVII, 3/4, pp. 204—721, Warszawa 1955.
For 1955 „Przegląd Geograficzny" XXVIII, 3, pp. 658—677, Warszawa 1956.
For 1956 „Przegląd Geograficzny" XXIX, 2, pp. 422—444, Warszawa 1957.
For 1957 „Przegląd Geograficzny" XXX, 2, pp. 363—380, Warszawa 1958.
For 1958 „Przegląd Geograficzny" XXXI, 2, pp. 444—465, Warszawa 1959.

boats. It has quite a significant collection of instruments and equipment for conducting field research [6].

The Institute has at its disposal a collection well completed geographical library. Its development is illustrated by the tables given above. The number of employees in the Institute also attests to its growth. It amounted to 88 in 1954, 100 in 1955, 118 in 1956, 131 in 1957 and 133 in 1958. The employment status was as follows on December 31, 1958: 13 professors (among them 5 ordinary), 4 readers (docents), 13 lecturers, 33 assistants, 28 scientific technical workers, 12 librarians, 3 in the publications department, 14 administrative workers and 13 service workers.

One of the important functions of the Institute is the educating of scientific personnel. This takes place by the granting of scholarships: 1 (1953), 4 (1954), 6 (1955), 4 (1957), 8 (1958). The total scholarships granted in the last 5 years was 23. Great aid in attaining scientific degrees were 3-year scholarships for doctor's degree (aspirantura). The following number of doctorate scholarships were awarded: 1 (1953), 4 (1954), 2 (1955), 2 (1957), 4 (1958), making a total of 13. In addition, there were 4-year extra-curricular doctorate courses for people outside IG PAN. The status of extra-curricular doctorate scholarships awarded were: 1 (1955), 6 (1956), 6 (1957), 4 (1958). Doctorate channels without scholarship were opened for additional 12 workers of the IG PAN and for 3 workers outside the Institute.

In course of five years, three achieved the title of ordinary professor, 5 — extraordinary professor, 8 — reader, 66 — lecturer or assistant. One degree of doctor of geographical science and two doctor's degrees were conferred.

The second important function of the Institute is its publishing activity which consists of: „Geographical Studies" (Prace Geograficzne), „Polish Geographical Review" (Przegląd Geograficzny), „Geographical Documentation" (Dokumentacja Geograficzna), „Review of Foreign Geographical Literature" (Przegląd Zagranicznej Literatury Geograficznej), bibliographical publications, catalogues etc. (see table 3).

From the below table it can be seen that IG PAN has issued over 100 volumes of books and periodicals containing over 16,000 pages. In 1957, a multicoloured geomorphological map was issued of the Pogórze Karpackie (Carpathian Foothills) as well as 22 versions of Poland's land utilization maps in the scale of 1 : 1 000 000 (arable land, pastures and meadows, forests, network of waters, settlements and their combinations). The publication of tricolour geomorphological and hydrographical maps in the scale of 1 : 50 000 began to be issued in 1958. IG PAN publications embrace a significant part of the scientific work of Polish geographers.

[6] The Geographical Institute of Polish Academy of Sciences is located in a building of the University of Warsaw together with the University Geographical Institute. The IG PAN Library as well as the University Institute Library have a joint management, the catalogues and collections are joint (although the inventories are separate). Since the Library of the University's Geographical Institute has about 80.000 library items, the joint library collection is over 156.000 items of which 83.000 are volumes and 72.000 maps and atlases.

The publishing activity of the Institute

Table 3

	1954		1955		1956		1957		1958		Total	
Amount:	b.	pp.	b.	pp.	b.	pp.	b.	pp.	b.	pp.	b.	pp.
Geographical Studies	3	220.8	2	236.8	4	1092.8	5	1260.8	4	568.0	18	3379.2
Geographical Review	4	1313.6	4	1128.0	5	1436.8	4	1339.2	4	1155.2	21	6372.8
Geographical Documentation	11	336.0	12	616.0	5	336.0	6	480.0	6	468.8	40	2108.8
Review of Foreign Geogr. Literature	10	521.6	4	316.8	4	427.2	4	472.0	4	412.8	26	2150.1
Bibliographical Publications		—	—	—	1	299.2	4	744.0*	2	128.0*	7	1171.2
Total	28	2392.0	22	2297.6	19	3592.0	23	4296.0	20	2732.8	112	15182.4
Maps							23	—	1	—	24	

* In this, 3 numbers of „Polish Analytical Bibliography" – a geography series edited by the IG PAN, but published by the Bibliographic Information Centre of the Polish Academy of Sciences. Because of this, their number of pages is omitted.

b — brochure (volume); pp — pages.

The Institute is the main representative of Poland in the International Geographical Union. Poles are ordinary members of six Commissions of the IGU and corresponding members in 3 others. The Institute is a member of 1) Coronelli Weltbund der Globusfreunde in Vienna, 2) International Limnological Association, 3) INQUA, 4) Regional Science Association Wharton School, Philadelphia, 5) International Society of Bioclimatology and Biometeorology. The contacts with foreign countries are summarized in table 4, which does not take into consideration private individual trips abroad nor group excursions. There were a total of 86 official trips in the last five years covering 22 countries. 102 geographers representing 20 countries visited the Institute during this same period. The majority of Polish geographers traveled to Czechoslovakia — 12, the Soviet Union — 11, the German Democratic Republic — 11, Hungary — 5, Austria — 6, France — 5, Brazil — 5, India — 4. The majority who came to Poland were from the Soviet Union — 22, Czechoslovakia — 17, United States — 16, the German Democratic Republic — 9, France — 6, Hungary — 5, the German Federal Republic — 5, Great Britain — 5. Exchange with foreign countries is developing ever more favourable.

In the period under discussion there were 17 sessions of the Scientific Council of the IG PAN, in which all organizational scientific matters were examined. In addition, a wide range of problems related to subject matter were also discussed. Since 1955, an annual public report session has taken place in which the most interesting achievements of the previous year are reported upon. Four such sessions have taken place thus far, in which over 100 geographers took part, and a few dozen studies in the form of communications were reported.

Table 4

Contacts with foreign countries

	1958		1957		1956		1955		1954	
Trips abroad Number of:	countries	people	c.	p.	c.	p.	c.	p.	c.	p.
At Congresses and Conferences	6	10	4	8	6	15	4	12	1	1
Within Academies' agreements	4	5	1	3	—	—	—	—	1	1
Exchanges without involving foreign currency	4	5	7	11	5	10	—	—	3	3
Foreign Scholarships	1	2	—	—	—	—	—	—	—	—
Total	12	22	10	22	8	25	4	12	5	5
Arrivals										
Conference or on invitation	12	20	4	4	—	—	2	2	3	3
Exchange without involving foreign currency	4	6	2	2	2	4	—	—	—	—
Miscellaneous individual	10	36	8	14	5	9	1	1	1	1
Total	16	62	10	20	6	13	3	3	4	4

Within the activity of perfecting scientific staff, two courses were organized: one devoted to the geography of soils (Academician I. Gierasimof from Moscow), the second on the „input-output" methods with application to inter-regional ties (Dr P. Sulmicki). Several scientific sessions are held yearly at which scientific workers outside the Institute, most often foreign guests, report on the results of their work (12 — 1958, 6 — 1957).

In addition a number of national conferences are organized yearly. Most of these were devoted to geomorphological maps *(9)* or hydrographical *(5)*. In addition a conference on drumlins was arranged (1954), on urbanistic physiography (1954), on the chronology of the Quaternary (1955). In the field of economic geography a general conference course was organized in Osieczna (1955), a discussion on regional economic geography (1959), a conference on land utilization maps (1957), geography of rural settlement (1958). In addition there was a conference on geography studies in the universities (1955), on teaching industrial geography (1958), as well as two conferences on working out the Polish Geography textbook (1956). In addition a conference on the general problem of methodology was organized with the participation of Soviet geographers in 1954, and in 1958 a periglacial session within the framework of the activities of the Commisssion on Periglacial Morphology of the IGU. In addition to Poles, geographers from 12 countries participated. In several other Polish conferences foreign geographers participated.

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Major emphasis was laid, however, on the direction of scientific work both theoretical and connected with the needs of the life.

In accordance with its principles, the Institute directed its main emphasis, from the beginning, on elaborating the most proper possible long-range plan of geographical research [7], drawing in for its realization all the country's geographical centres. Large, difficult and very painstaking problems were projected to the fore. A great deal of emphasis was also placed on coordination on a national scale. However, it soon became obvious that these tasks exceeded the possibilities of the IG PAN, and gradually the burden of investigation was transferred from all-national work to more limited elaboration conducted by the various research sections of the Institute. At the same time the coordination functions of the Institute began to be limited. A few years of experience showed that the major stress in geographical investigations should be placed on work conducted by specialized research sections and when the subject embraces a wide complex of problems — on work being conducted in specially organized teams.

After five years of activity, it is difficult to give a synthetic picture of the scientific achievements of the Institute. A great number of studies have not yet been completed (e.g. *National Atlas, Geography of Poland* — textbook), others are still being conducted and gradually arriving at a conclusion. The detailed maps made in the field embraced only a certain part of the country's area. It was necessary to withdraw from some themes since the possibilities for their realization were lacking. Part of the work, however, has been completed and published. In the IG PAN publications both partial and temporary results have been published.

In Physical Geography, first place is taken by investigations on the geomorphology of Polish territory. They were based on detailed geomorphological survey made in the field on the scale of 1 : 25 000. Much time was absorbed in elaborating the instructions for drawing up those maps [8]. In the first years, all of the university centres were mobilized for this work, that is why mapping was rapid — completing in a year maps for an area of 10—15.000 km². The pace slackened in the next years, only 2—4.000 km² were mapped. For, parallelly, it was necessary to work out

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[7] Leszczycki S. *National Plan of Geographical Research in Poland 1956 to 1960* (English only). „Przegląd Geograficzny" XXVIII, Supplement, Warszawa 1956.

[8] Klimaszewski M. *The Principles of the Geomorphological Survey in Poland* (English only). „Przegląd Geograficzny" XXVIII, Supplement, Warszawa 1956.

[9] Starkel L. *Morphological Development of the Escarpment of the Pogórze Karpackie between Dębica and Trzciana* (Polish with English summary).

geomorphological problems for the mapped areas. Nevertheless over 60.000 km² of Polish territory already has detailed geomorphological maps. A tentative multi-colour map was issued for part of the Pogórze Karpackie — Carpathian Foothills territory [9], but taking into consideration the considerable costs, the next maps were printed only in three colours in sheets in the scale 1 : 50 000. The profuse material gathered permitted the elaboration of many monographs of various Polish areas, such as the Upper Silesian Industrial District, the Tatras, the Dunajec and San river basins, the Sandomierz Upland, the Łódź and Poznań vicinities, areas such as the western part of Białystok Voivodeship, Mikołajki and Mrągowo areas, Toruń, the Brda river basin, the Dobrzyń Land, the Krajna Elevation and others. General, theoretical problems have also come to light and thus the Holocene geomorphology of the Carpathians [10], the Quaternary in Northern and Southern Poland [11], tasks connected with Karst lands, loess, etc.

Independent of geomorphological survey, investigation was conducted on contemporary denudation processes in the Carpathians, in the Tatras, in the Sudeten mainly based on the research stations of the IG PAN. The general geomorphology section occupied itself with periglacial geomorphology, research on the dynamics of slopes and valley bottoms, periglacial phenomena in various Polish territories, weathering covers in mountains, etc. Some of the results of the investigations were published [12]. During the period of research in the Upper Silesian Industrial District (GOP), a new classification of the anthropogenic forms was elaborated, the extent of the middle Polish glaciation in the southern part of Upper Silesia was established, etc. [13]. Part of these results were published in „Prace Geograficzne" (Geographical Studies), „Przegląd Geograficzny" (Polish Geographical Review) [14], „Geographical Documentation" [15], „The Periglacial Bulletin" and „Bulletin of the Polish Academy of Sciences", Series III [16].

Much effort and means were devoted to investigations of Polish

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Polish Academy of Sciences. Polish Institute of Geography. Geographical Studies No. 11, Warszawa 1957.

10 Op. cit.

11 G i l e w s k a S. *The Geomorphological Development of the Eastern Part of the Miechów Upland* (Polish with English summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies No. 13, Warszawa 1958.

12 Geomorphological Laboratory in Łódź of Geographical Institute of Polish Academy of Sciences: No. 1. K l a t k o w a H. *Monographie d'échantillon morphodynamique*, 1958. No. 2. K l a t k a T. *Limons antropogènes de la vallée de la et leur interprétation dynamique*, 1958. No. 3. M a ń k o w s k a B. *The dynamics of the valley floor of the river Czarnawka*, 1958. (Polish with English or French summaries).

13 G i l e w s k a S. *The Pre-Warta Interstadial at Brzozowica near Będziny* (English only). „Bulletin de l'Académie Polon. des Sciences", No. 1. Warszawa 1958, pp. 82—83.

14 K a r a ś C., S t a r k e l L. *Extent of the Middle Polish Glaciation in the Southern Part of the Silesian Upland* (Polish with English summary). „Przegląd Geograficzny" XXX, 2, Warszawa 1958.

15 Polish Institute of Geography. Geographical Documentation: 1957, No. 2, No. 3; 1958, No. 4, No. 6. (Polish only).

16 K a r a ś C., S t a r k e l L. *Boundary of the Middle Polish Glaciation in Southern Silesian Upland* (English only). „Bulletin de l'Acad. Pol. des Sciences"

hydrography. They were based similarly on detailed hydrographical maps made in the field in the scale 1 : 25 000 [17]. Detailed instructions were elaborated for the survey [18]. Work on hydrographical maps was organized in a similar manner; all university centres participated in this work at the beginning. One-fifth of Polish territory was mapped. Here, too, mapping tempo slackened with time since it was necessary to work parallelly upon the hydrographical problems of the mapped territory. This pertained mainly to investigations of the circulation of water in geographical environments, the crude water balance and its influence on the processes arising in geographical environments as well as understanding the specifics of hydrographic conditions in the various regions of Poland.

The following were elaborated: the Upper Silesian Industrial Region, the Zakopane area, the Biały Dunajec valley, the Wieprz-Krzna Canal area, the Toruń area, the Brda valley, the central part of Białystok voivodeship, and others. Part of the results were published [19], tentative hydrographic maps were issued, — 3 in three colour, in sheets, in the scale of 1 : 50 000.

Special interest was directed to lakes. By 1953 a catalogue of Polish lakes had already been issued covering over 9.000 lakes with an area of over one hectare each. Following that, an archives of bathometric plans of lakes was set up. Up to 31 Decemper, 1958, plans for about 800 lakes were collected. Research on the disappearance of lakes was conducted in Toruń centre based on the example of the Dobrzyń region. Major work, however was on defining the role of lakes in geographical environments. Investigation was conducted on the complex of the Mazurian lakes based on the Research Station of IG PAN in Mikołajki. Lake channels were investigated morphologically, by constructing the plummet allowing the extraction of sediment matter to a depth of five meters. Specially investigated were the physical features of lake water, and in particular thermic and insolation conditions, the intensity of radiation, evaporation, etc., as well as the microclimate of the lake vicinities. Investigation was conducted on the freezing of lakes by constructing a motorcycle with ice drill. Electric

V, 10, Warszawa 1957. Niewiarowski W. *Morphological Evidence of Deglaciation by Melting away of the Continental Glacier over Large Areas as Illustrated by Land Forms in the Region of Kowalewo, Golub and Wąbrzeźno* (English only). „Bulletin de l'Acad. Pol. des Sciences" V, 10, Warszawa 1957. Gilewska S. *The Pre-Warta Interstadial at Brzozowica near Będzin. Geological Characteristics of the Profile* (English only). „Bulletin de l'Acad. Pol. des Sciences" VI, 1, Warszawa 1958. Klimaszewski M. *Pleistocene Outcrop at Dobra near Limanowa, Carpathian Mts.* (English only). „Bulletin de l'Acad. Pol. des Sciences" VI, Warszawa 1958. Starkel L. *Stratigraphy of Holocene Deposits in the Carpathian Foreland* (English only). „Bulletin de l'Acad. Pol. des Sciences" VI, 6, Warszawa 1958. Tyczyńska M. *A Pre-Tortonian Karst Surface in the vicinity of Cracow* (English only). „Bulletin de l'Acad. Pol. des Sciences". VI, 6, Warszawa 1958. Szupryczyński J. *Relief and Geological Structure of Dębowa Góra* (English only). „Bulletin de l'Acad. Pol. des Sciences" VI, 6, Warszawa 1958.

17 Klimaszewski M. *The Detailed Hydrographical Map of Poland.* „Przegląd Geograficzny" XXVIII, Warszawa 1956.

18 Ibidem.

19 Wit K. *Hydrographic Characteristics of the Sub-Tatra Area* (Polish only). Polish Institute of Geography. Geographical Documentation, No. 2. Warszawa 1957.

resistant thermometres were placed in different depths of the ice. Research of bottom sediment and shores processes has been undertaken lately.

In the field of climatology, work proceeded in three directions: 1) Between 1952—1955, research was conducted by complex-dynamic methods of the characteristic features of the climate of different parts of Poland; this investigation was taken over by the Climatological Department of the Warsaw University. 2) From 1954 microclimatological research was begun in three areas, a) investigations on Slag Heaps, in Silesia [20], b) the nearest lake vicinity in the Mazurian lake regions, c) the small agricultural region in the neighbourhood of Mrągowo within the framework of group investigations on geographical environment. 3) The third and major direction were the investigations of local climate; this concerned a) agricultural areas on the central Vistula Valley [21], in Wojcieszów (Sudeten Foothills), Kaczawa Mountains (Sudeten) and on Mazury Lake District, b) urban and industrial regions [22] as well as health resort areas (Ciechocinek). Further investigations also aim to elaborate methods of climatic mappings on detailed maps.

Investigations were also conducted on dunes and the shifting sands in Puszcza Kampinoska [23] and in the neighbourhood of Łeba. They had the purpose of discovering their genesis and providing data for afforestating areas which became useless as a result of the incompetent activities of man in these areas.

For a number of years geographical forest investigations were conducted in the Gorce Mountains. Their purpose was to distinguish biogeographical units in the Gorce region.

Work on regionalizing Polish physical geography was also undertaken. A tentative division was published in „Polish Geographical Review" [24]. A detailed series of investigations of geographical environment was carried on parallelly. In the Toruń laboratory, a division of physical geographical units was elaborated for Bory Tucholskie. The Physical Geography Departament of the Geographical Institute of Warsaw University working together with IG PAN conducted a series of physical geographical research in the neighbourhood of Mrągowo. The results of the investigations are being printed.

Many studies were also made in the field of economic geography. They concern the geography of agriculture, industry, population and settlement.

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[20] Kozłowska-Szczesna T. *Results of Microclimatic Investigations on Slag Heaps from the Dymitrow Mine in Bytom (thermic conditions.)* (Polish only). „Bulletin of Upper-Silesian Industrial District", No. 11, 1957.

[21] Szczęsna T. *Local Climatic Investigations in Vistula Valley (in 1954)* (Polish only). Polish Institute of Geography. Geographical Documentation, No. 1, 1957.

[22] „Bull. of Upper-Silesian Industrial District", No. 2, 1956, Joint work. „Bull. of Upper-Silesian Industrial District", No. 10, 1957, Joint work. *Atmosphere Pollution.* „Bull. of Upper-Silesian Industrial District", No. 11, 1957, Joint work. *Microclimate of Slag.* (Polish only).

[23] Kobendza J. and R. *Les dunes éparpillées de la Forêt de Kampinos* (Polish with French summary). Wydmy śródlądowe Polski I. Polish Geographical Association, Warszawa 1958.

[24] Kondracki J. *Natural Regions of Poland* (English only). „Przegląd Geograficzny" XXVIII, Supplement, Warszawa 1956.

In the field of agricultural geography, general land utilization maps were made in the scale of 1 : 300.000. The following items were distinguished: arable land, forests, pastures and meadows, the network of waters and settlements. The picture obtained was reduced photographically to a scale of 1 : 1.000.000 and then land utilization maps of Poland were printed in 22 variations [25]. General map of land utilization for Poland are also being elaborated according to IGU instructions.

In addition studies have begun on land utilization detailed maps based on field work [26]. Mapping was begun in the vicinity of Sandomierz and in the village of Grabowiec in Bielsk Podlaski county (powiat); then mapping covered Mrągowo county [27]. Instructions were then prepared on the uniformity of the work [28]. A few university centres were drawn in to cooperate. Up to 1958, mapping was conducted in 18 counties, completing detailed maps for an area of over 6.000 sq. km. The maps are to serve, on the one hand, for elaborating the geographical typology of agriculture in Poland, and on the other to supply data for reconstructing the agricultural system, the intensification of agriculture, and rational distribution of crop cultivation and stock-raising, etc. On the basis of the maps made, agricultural-geographical studies of various powiats are being elaborated (the one on Mrągowo Powiat has already been issued), agricultural systems in Żuławy has been described as well as in Beskid Niski. In addition studies are being conducted on the changes in the distribution of cultivation and stock-raising in Poland from the end of the 19th century to 1958.

In the field of industrial geography work has been undertaken on the Atlas of Industry in Poland. In 1958, 65 analytical maps were completed illustrating the distribution of particular branches of industry. Studies on the areal structure of industry in Poland is being conducted, for example of the building materials, food, power and textile industries. The purpose of these studies is to establish the deciding factors about localization of different types of industrial plants. Studies were also being conducted on chosen industrial regions, for example, the Upper Silesian Industrial District, the Warsaw, Łódź and Częstochowa regions. The study on the textile industry in Białystok voivodeship has been published [29]. Investigations are also being carried out on the connection between industrial plants and geographic environment, for example, brick works, cement works and brown coal mines.

In the geography of population and settlement, concentration is on investigations of the resettlement processes in the Western Territories,

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[25] U h o r c z a k F. *Poland — Survey Map of Land Utilization*, 1958.

[26] D z i e w o ń s k i K. *Detailed Survey of Land Utilization in Poland* (English only). „Przegląd Geograficzny" XXVIII, Supplement, Warszawa 1956.

[27] *Studies on Land Utilization in Mrągowo District* (Material from investigations during 1955—1956, Joint work). (Polish only). Polish Institute of Geography. Geographical Documentation, No. 2, 1959.

[28] *Instructions for Detailed Survey of Land Utilization.* Joint work (Polish only). Institute of Geography. Geographical Documentation, No. 2, 1959.

[29] W e r w i c k i A. *Białystok Region of Textile Industry before 1945. Development and Location Problems.* (Polish with English summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies. No. 10. Warszawa 1957.

through several monographic[30] and partial elaborations. In addition an analysis is being made of the network of towns of Białystok voivodeship from the point of view of the variability of functions of various settlements. A few dozen monographs of cities, small towns and powiats in the Białystok, Warsaw, Olsztyn, Bydgoszcz and Łódź voivodeships were completed. These monographs were mainly elaborated from the point of view of the possibilities of the social economic activization of the investigated territories. Part of these studies have been published[31]. Further studies are being conducted mainly by the universities in Warsaw and Toruń. In the past few years studies on land utilization of several cities has been undertaken. Studies on rural settlement has also been undertaken; up to now, this latter problem had been overlooked even though during the inter-war period it stood out in the forefront among anthropogeographical studies. All of these studies aim to elaborate extensive monograph devoted to the geography of settlement in Poland.

A population inquiry for the Upper Silesian Industrial Region has been worked out up to 1970[32]. Studies on maps of the world population in the scale of 1 : 4.000.000 has been undertaken as well as calculation of world population distribution according to the hypsometrical[33] level and the equidistances from the sea.

For some years studies on economic regionalization have been carried on. Bibliographical[34] and terminological studies were undertaken and an evaluation was made of methods used up to now in the works by geographers, economists and statisticians[35]. A project has been elaborated for the division of Poland into economic regions for long-term planning[36]. Work has been undertaken on the economic subregional division of the Warsaw voivodeship. In addition a partial elaboration has commenced on the inter-regional economic ties and areas gravitating towards the main cultural centres (main educational centres)[37]. Also investigated has

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30 *Monograph on Trzcińsko-Zdrój* (Joint work). (Polish only). Polish Academy of Sciences. Institute of Geography. Geographical Documentation, No. 2, 1958.

31 *Geographical Studies of the Economic Revival of Small Towns.* Joint work. (Polish with English summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies, No. 9, Warszawa 1958.

32 *Population Characteristics in the Upper-Silesian Industrial Region and foreseen changes in sex and age figures and structure influenced by natural movement up to 1970.* Edited by Kosiński L. „Bulletin of Upper-Silesian Industrial District", No. 16, 1958.

33 Staszewski J. *Vertical Distribution of World Population.* (English only). Polish Academy of Sciences. Institute of Geography. Geographical Studies, No. 14, Warszawa 1957.

34 *Bibliography of Economic Regionalization Tasks.* Joint work (Polish only). Polish Academy of Sciences Institute of Geography. Geographical Documentation, No. 3, 1959.

35 Wróbel A. *Criteria and Methods of Delimitation of Economic Region* (Polish only). Polish Academy of Sciences Institute of Geography. Geographical Documentation, No. 3, 1956.

36 Dziewoński K. *Some Problems of Research for Economic Regionalization of Poland.* (Polish with English summary). „Przegląd Geograficzny", XXIX, 4, Warszawa 1957.

37 Wróbel A. *Service Regions of the Centres of Higher Education in Poland.* (Polish with English summary). „Przegląd Geograficzny" XXXI, 1, Warszawa 1959.

been railway transportation of certain goods[37a]. These studies have been concentrated in the bibliographical-information centre of geographic research on economic regionalization whose task is to coordinate the work in this field in the socialist countries. Some of the results have been published[38].

In the first years IG PAN coordinated the work conducted by university geographical centres for the aims of regional planning in certain areas of Poland (Cracow, Częstochowa, Łódź, Kamienna valley and others).

In 1956, a regional geography laboratory was set up. It began its work with a bibliographical compilation of the most important publications for world geography, starting with 1900. The bibliographies issued by foreign centres were included. A file was established with statistical data for the various branches of production as well as for countries, a file of press clippings and a file of administrative division changes. It proceeded to evaluate world achievement in regional geography. Monographic studies on Turkey, Syria and India were undertaken as well as a work on a demographic atlas of the Sudan at the request of the Sudanese government.

In cartography work proceeded on elaborating a National Atlas of Poland. The lay-out for the atlas has been worked out as have been the basic maps and a few dozen maps on geographical environment, on population and economic problems. For the IGU Commission on National Atlases a world bibliography of national atlases has been prepared. A few maps for the Polish geographic atlas were completed and issued after the war for school purposes[39]. In addition a new physical map of Poland was completed in the scale of 1 : 300.000 on the basis of new topographical survey in the scale of 1 : 100.000.

Quite extensive studies on the history of Polish geography and cartography were conducted. In the Wrocław section, two basic series of publications have been prepared: *Monumenta Poloniae Geographica* and *Monumenta Poloniae Cartographica* elaborating Polish maps from the 16th and 17th centuries (among them Wapowski's maps) as well as the works of Miechovita, Długosz, Kromer, and others. In addition a more popular publication has been prepared, *Orbis Polonicus*, which elaborated Broniewski's description of the Crimea and Święcicki's description of Mazowsze. Much material was gathered on the development of geography during the Renaissance[40] and Enlightenment periods. Studies on the history of cartography were under-

[37a] Morawski W. *Freight Traffic* (Status as of 1954, forecast for 1960). Polish Institute of Geography. Geographical Documentation, No. 5, 1958.

[38] Dziewoński K. *Some Problems of Research for Economic Regionalization of Poland* (Polish only). Bibliographical-information Centre for geographical studies on economic regional divisions, No. 1, 1958. Straszewicz L. *The Łódź Industrial Complex* (Polish only). Bibliographical-information Centre for geographical studies on economic regional divisions, No. 2, 1958. Neef E. *Wirtschaftsgeographische Gliederung und ökonomische Rayonierung*. Bibliographical-information Centre for geographical studies on economic regional divisions, No. 3, 1958.

[39] Janiszewski M. *Geographic Atlas of Poland*. State Establishment for School Editions. Several editions since 1954.

[40] Olszewicz B. *La géographie polonaise à l'époque de la Renaissance*. (Polish with French summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies, No. 12, Warszawa 1957.

taken (Ptolemy's revisions, Lelewel's elaborations, Korzeniowska's atlases, etc.) Lately a study was undertaken on evaluating 19th and 20th century geographic textbooks as well as a study of the influence of A. Humboldt's works on the development of Polish geography.

In Warsaw an evaluation was conducted of the achievements of Polish geographers mainly in the inter-war period from the Marxist point of view. It dealt with the views on the influence and significance of geographical environments in social development, on the geographic position of Poland, on the colonial question, the principle of the division of Poland into economic regions and the field of economic geographical divisions. Also conducted was an evaluation of the achievements in political geography, urban geography, agricultural geography and others. A study was made of the geographical achievements of F. Szwarcenberg-Czerny[41], A. Rehmann, A. Sujkowski, W. Ormicki and others. Studies were undertaken on the history of economic geography in Poland[42], based on the views of J. Śniadecki[43]. Lately a biography of A. Humboldt has been prepared.

From the beginning an editorial committee on basic geographical monographs of Poland existed. This work did not move ahead satisfactorily. Written and published were only a few chapters for the prepared monograph.

For a few years now a Białystok team has existed which is preparing an economic geographical monograph on Białystok voivodeship together with a regional atlas. Studies are considerable advanced, some of them have already been published[44]. Some others are in print.

Systematic bibliographical work is being conducted in the sphere of documentation. They deal with:

1. Current bibliography of Polish geography. The bibliography for 1936—1954[45] has already been published. The bibliography for 1955—1959 and 1918—1927 is being elaborated.

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[41] Krzymowska A. *Szwarcenberg-Czerny of Cracow University (1847—1917).* (Polish with English summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies, No. 3, 1954.

[42] Fleszar M. *On the Investigations Concerning the Origins of Economic Geography in Poland.* (Polish with English summary). „Przegląd Geograficzny" XXVIII, 1, Warszawa 1956. Fleszar M. *Wawrzyniec Surowiecki's Course of Lectures on the Economic Geography of Poland in the Central School of Law and Administration, 1811—1812.* (Polish with English summary). „Przegląd Geograficzny" XXIX, 2, Warszawa 1957.

[43] Staszewski J. *The Physical Geography of Jan Śniadecki Against the Background of his Period.* (Polish with English summary). Przegląd Geograficzny" XXVIII, 4, Warszawa 1956.

[44] „Przegląd Geograficzny" XXIX, 3, Warszawa 1957.

[45] Leszczycki S., Winid B. *Bibliography of Polish Geography 1945—1951.* Polish Academy of Sciences. Institute of Geography. Bibliographical Publications, Warszawa 1956. Leszczycki S., Piasecka J., Tuszyńska-Rękawkowa H., Winid B. *Bibliography of Polish Geography 1952—1953.* Polish Academy of Sciences. Institute of Geography. Bibliographical Publications, Warszawa 1957. Leszczycki S., Tuszyńska-Rękawkowa H., Winid B. *Bibliography of Polish Geography 1954.* Polish Academy of Sciences. Institute of Geography. Bibliographical Publications, Warszawa 1957.

2. An analytic, annotated bibliography for 1955—1957 has been worked out. Three volumes have already been published [46], two further ones are being printed.

3. A Polish bibliography is being prepared for the international bibliography of IGU, for the international cartographical bibliography of IGU and for „Referativny Jhurnal''.

4. A bibliography for Northwest [47] and Northeast Poland is prepared.

5. A compilation of foreign periodicals on Earth Sciences located in about 120 Polish libraries [48] has been issued.

6. A list of old globes in Poland according to the suggestions in „Coronelli Weltbund der Globusfreunde'' is being prepared.

In addition, Wroclaw section is continuing on:

7. Polish cartographical bibliography, XV—XIX century.

8. Retrospective bibliography of Polish geography to 1918.

9. Bibliography of the history of geography and cartography, 1939—1959.

A separate section has undertaken work on a central cartographical catalogue embracing atlases and maps up to 1950 which are in the more important libraries in Poland. On 31 December, 1958, the catalogues listed 11.174 items. The first volume covering 15th—18th century atlases is being printed. Further volumes are in preparation.

In another special section a register of Polish geographical names embracing about 20.000 entries has been prepared designed for general use. The register of names has obtained the approval of the Linguistics Committee of PAN and has been given to the printshop.

There is also an archive in the Institute which gathers material on geographical activities in Poland and abroad. It has a biographical file covering data on 275 geographers. The archive gathers material from geographical conferences and congresses on the IG PAN work; it also gives information about geography in Poland.

From the brief review given above, the disproportionate development of the various departments of the work of the IG PAN is evident. A further expansion of the Institute is envisioned by strengthening existing sections — departments, by making their work more determined, more limited and deeper. At the same time there is foreseen — to a greater extent than hitherto — more group work, both theoretical and linked with the needs of the community and the state. Provided for, too, is the undertaking of investigations of territories outside Poland. This will require a considerable increase of the material base and the development of scientific staff.

Translated by Mary Miller

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46 Edit. K o b e n d z i n a J. *Polish Analytical Bibliography, Geography* pp. 1—168, 1956. Edit. K o b e n d z i n a J. *Polish Analytical Bibliography, Geography* pp. 169—468, 1957. Edit. K o b e n d z i n a J. *Polish Analytical Bibliography, Geography* pp. 469—876, 1957.

47 Ś w i d e r s k i B. *Bibliography of Greater Poland Physical Geography.* Physiographical Investigations in Western Poland III, Poznań 1956, pp. 183—279.

48 K a c z o r o w s k a Z. *Compilation of Foreign Periodicals and Serial Publications on Science about the Earth in Polish Libraries.* Polish Academy of Sciences. Institute of Geography. Bibliographical Publications, 1957.

JERZY KOSTROWICKI

Economic Geography in Poland

(Development and present state)

The origins of economic geography in Poland should be looked for in the works of Polish economists and statisticians of the close of the 18th century and the beginning of the 19th, who, without using the term geography, gave many interesting descriptions of Poland's economy, its distribution and natural conditions, as well as a number of descriptions of other countries (J. Śniadecki, T. Czacki, F. Skarbek, W. Surowiecki, S. Staszic and others *(11)*).

About the middle of the 19th century the first lectures in the field of economic geography were organized, originally at the so called Real School in Lwów under the name of commercial geography (ca. 1840), and then by Wincenty Pol, a great patriot, geographer and poet, from chair of geography set up in Poland in 1849 at the Jagellonian University, in Cracow — the first to be established in Poland and fourth in the world. This chair existed for only four years. In 1853 it was liquidated by the Austrian government which saw in it a danger to the germanization campaign then in progress. During the following twenty five years Polish scholars cultivating the science of geography were compelled to work outside their own country. Many of them became known explorers of other countries (I. Domeyko, J. Kubary, B. Dybowski, S. Rogoziński and others). A chair of geography was restituted in Cracow in the year 1877. It was filled and conducted for 40 years by F. Szwarcenberg-Czerny, a conscientious but indifferent scholar, who, besides physical geography also took an interest in problems of economic geography, or, as it began to be called then under Ratzel's influence — in anthropogeography. He was the author of the first Polish general commercial geography, a serious and original work in its time. Somewhat later an analogous chair was created at Lwów and was filled by A. Rehman, geographer and botanist. At the same time, there worked in Warsaw an outstanding and progressive geographer, W. Nałkowski, who, in his capacity as secondary school master, introduced into Polish geography, including human geography, many new and original concepts. However, society did not grant him the recognition and understanding which he deserved *(31, 32)*.

Polish geography began to develop on a wider scale only during the years which immediately preceded the First World War, when a new generation of geographers emerged including a number of prominent individuals such as: E. Romer, L. Sawicki, S. Lencewicz, S. Pawłowski, A. Sujkowski, S. Srokowski, J. Smoleński and others. Many them later devoted their efforts entirely or partly to anthropogeography or economic geography.

Similarly as in many other countries, contemporary economic geography in Poland grew out of two sources: from anthropogeography or human geography, which became prevalent in the universities during the interwar period, and from commercial geography (later economic geography), which developed mainly in schools of higher learning of the commercial and economic type.

Research in the field of physical and economic geography was conducted jointly during the interwar years — similarly as in other countries — by the same university departments and often by the same lecturers. These university departments, as well as those of commercial academies, then gained important scientific achievements. The direction in which these studies developed in particular centres depended on the individual properties of the persons in charge and on the influence to which they were subject. Originally, the strongest influence on Polish geography was exercised by German anthropogeography, due to the fact that a majority of Polish geographers studied at German or Austrian universities; later, the influence of French human geography increased. The influence of English or American geography was practically nil. Contacts with Soviet geography were insignificant. S. Nowakowski, a very interesting personality, the first Polish Marxist geographer, author of a comprehensive volume devoted to the USSR, was then an exception in assessing favourably the achievements of this, then only, socialist state *(1)*.

During the years that intervened between the two world wars, human geography in Poland showed the greatest development in the Cracow centre. Under the direction of L. Sawicki, and after his death of J. Smoleński, investigations were carried out there in the field of geography of population and settlement, primarily of the adjacent Carpathian area. The studies of the transhumance in the Carpathians and of population problems carried out by L. Sawicki and his disciples (Z. Hołub-Pacewiczowa, W. Kubijowicz) are of perennial value. J. Smoleński engaged mainly in the study of the geography of population, devoting some of his writings to political geography. A number of detailed monographes were also written in the Cracow centre on individual towns and restricted areas (Z. Simche, S. Leszczycki, W. Kubijowicz, and others) — as well as several works on the geography of communications and tourism (S. Leszczycki, A. Wrzosek).

W. Ormicki, a scholar with a modern approach to economic geography, a prolific writer, who published several dozen greater and smaller works on a variety of topics almost exclusively within the domain of works devoted to the economic geography of what then constituted in problems of overpopulation and demographic optima, problems of migration, and of farming productivity; he also originated studies in industrial geography and other subjects. Ormicki published a number of works devoted to the economic geography of what then constituted the eastern provinces of the Polish State. This goes to show that, in the interwar period, the Cracow centre was an important research factor, primarily in the field of problems bearing on population and settlement.

Greater dispersion of the problems studied was a characteristic of the Lwów centre. The outstanding geographer E. Romer who directed that centre, generally speaking, did not concern himself with human geography, and for this reason gave no definite directions in this field. A number of works were carried out at Lwow on the geography of settlement, (A. Zierhoffer, J. Wąsowicz, I. Albert, A. Malicki, F. Uhorczak), on the geography of population (A. Zierhoffer), on the geography of agriculture (A. Zierhoffer, J. Ernst) and of communication (J. Wąsowicz, S. Polański). Geographic and statistical comparative studies on a world scale were published by J. Haliczer.

The Poznań centre, under the lively leadership of S. Pawłowski, developed primarily investigations on rural settlement in the north-western part of the country. Many valuable works were published there written by himself and by his disciples (M. Kielczewska-Zaleska, J. Dylik, J. Czekalski, S. Zajchowska).

A place apart was occupied in the Poznań centre by the chair of geography at the Commercial Academy, filled for a number of years by S. Nowakowski, who had to his credit a number of important works, written in Russian and English, bearing on the Far East; he was also the author of a number of writings of a theoretical character, of a comprehensive monograph on the economic geography of Greater Poland and the already mentioned geography of the USSR. F. Barciński was his disciple and successor. He wrote a monograph on the economic geography of the voivodeship of Kielce and a number of economic geography textbooks.

W. Winid, a highly original scholar and author of a number of interesting works on urban and industrial geography including monographs of the Bydgoszcz Canal, of Middle England, of Chicago, author of a study on the economic geography of Pomorze and of the volume on the United States in the Great Universal Geography, was also for some time connected with Poznań and Cracow. He was the sole representative in Poland of American and English geographical thought.

In the thirties, the Wilno centre also began to play a fairly important role, particularly in the field of the geography of settlement, devoting its attention primarily to the north-eastern territories of the then Polish State. The works of W. Rewieńska, J. Tochtermann and A. Melezin are here of outstanding value.

On the other hand, Warsaw University played a very insignificant role in the field of human geography during the interwar period. Until the arrival in Warsaw of B. Zaborski, the author of a comprehensive synthesis of rural settlement in Poland and of a number of works bearing on population and settlement, only a few studies of greater importance on anthropogeography were carried out here.

Among important contributors to the development of economic geography, on the other hand, were scholars lecturing at the Commercial Academy (later the Szkoła Główna Handlowa), the School of Political Science and the Free University of Warsaw. Here mention should primarily be made of S. Srokowski, author of a number of works devoted to East Prussia and of what is still the best, although largely antiquated, textbook on the economic geography of Poland, and of a handbook on general economic geography; next, of A. Sujkowski, author of a number of handbooks on general and Polish economic geography; of J. Loth — geographer and explorer — who wrote a number of studies on economic and political geography, textbooks on the economic geography of Poland and of the world, on political geography and several volumes of the Great General Geography, and finally, of W. Gumplowicz, also author of a textbook on general economic geography and of several volumes of the Great General Geography. Several interesting studies on urban geography were also published by S. Gorzuchowski, then working at the Warsaw Commercial Academy (SGH).

The general statement may be made that the growth of Polish geography, intensive on the whole, was not uniform. Geography of population and settlement developed in the most versatile manner in almost all centres, more attention being devoted to rural settlement than to the towns. Studies in the field of geography of communication were also fairly numerous but less comprehensive ones. The geography of agriculture showed weaker progress, while industrial geography was almost entirely overlooked. There appeared a number of important geographic and economic monographs on various sections of Poland; fewer studies were devoted to foreign territories. Political geography began to develop in two centres. A number of textbooks on general economic geography and the economic geography of Poland were published, some on political geography (J. Loth) and one on general anthropogeography (B. Zaborski and A. Wrzosek).

The Second World War wrought great havoc among Polish geographers. Some 50 scholars active in the geographical field died in concentration camps, on battlefields or as a result of difficult conditions under occupation. Among those devoting their time to economic geography were: S. Pawłowski, J. Smoleński, A. Sujkowski, W. Ormicki, W. Rewieńska, W. Gumplowicz, W. Winid and others.

The period that immediately followed upon the war was devoted to the restitution and organization of scientific outposts. At seven Polish universities 2 to 5 chairs of geography were set up, including everywhere at least one chair of physical and one of economic geography. Departments of economic geography were also created at academic schools of economics and pedagogical schools. The united Geographical Society (Towarzystwo Geograficzne) took charge of the coordination and organization of scientific work in Poland. Cooperation between particular university centres was established. numerous conferences and scientific discussions were held and a number of investigations were carried out by groups of geographers. This work was directed by S. Leszczycki, first chairman of the Polish Geographical Society and later Director of the Institute of Geography of the Polish Academy of Sciences, member of the Polish Academy of Sciences and its Deputy General Secretary.

The close connection established between Polish geography and planning, characteristic of its entire subsequent development, should be also emphasized. Some 30 geographers, including many in executive positions (J. Zaremba, S. Leszczycki, A. Wrzosek, R. Galon, F. Uhorczak) were employed by the Central Board of Physical Planning and by its agencies. Many geographers cooperated either directly or indirectly with the State Commission for Economic Planning, set up at a later date, carrying out in the framework of this cooperation a number of studies and investigations (J. Zaremba, K. Dziewoński, A. Wrzosek, J. Kostrowicki, W. Kowalski). The Departments of Geography at the universities prepared for the needs of planning many studies on physical and economic geography (M. Klimaszewski, R. Galon, A. Wrzosek, J. Kostrowicki). Cooperation with planning made accessible to many geographers statistical data and material that were not generally available in the period 1949—56. In subsequent years many geographers served on the Council for Regional Planning, on Regional Committees for Long-Range Planning, on the Planning Commission, and cooperated with local authorities in the field of physical planning; some of them also worked as members of scientific technical councils in particular voivodeships, (S. Leszczycki, K. Dziewoński, J. Kostrowicki, F. Barciński, A. Wrzosek, L. Straszewicz and others). The latest event in the domain of cooperation between geography and planning was the setting up in 1958 by the Polish Academy of Sciences of a special Committee on Spatial Investigations of the Polish Territory whose members include, besides economists, town planners and representatives of various social and natural sciences, also numerous geographers. S. Leszczycki, economic geographer, became chairman of this Committee.

In spite of this, however, unlike physical geography, which showed rapid development, particularly in some of its branches (geomorphology), economic geography, after an initial postwar period of lively activity when geographers participated in the work of developing and settling the Recovered Territories on the West, showed signs of a halt in the subsequent period. Several factors contributed to this situation. Outside of the difficulties experienced in obtaining and publishing material, the most important factors probably were undefined role and methods of economic geography in the newly created social and economic conditions. Clearly, the changed economic system had stronger influence on economic geography as a science dealing rather with social laws, than on physical geography. But the insufficient clearness of methods and aims of this science in the new conditions, has caused certain stagnation. This impasse continued for several years. It was not even cut short by the setting up in 1953 of the Institute of Geography of the Polish Academy of Sciences, (IG PAN), although the work of the Institute finally brought about a change in this respect.

The situation altered only in 1955 in consequence of a conference on economic geography at Osieczna, carefully prepared and organized by the Institute. As a result of bitter and stormy discussion which continued for three days, in spite of attacks both from the position of former anthropogeography and from that of pseudo-Marxist schematic thinking, the following working rules were adopted for the next few years:

1. The problem of choosing methods and outlining the proper course of development calls for a through knowledge of world achievements in human and economic geography and for the utilisation of all those that can be profitably applied in Polish conditions.

2. The general name of economic geography should be maintained to designate the entire social part of geography without reverting to the former division into human, and economic geography, both because of methological reasons (the economic aspect of the problem is of greatest significance to us), and since the process of a merger of these two disciplines into a single one is in progress throughout the world.

3. In the present state of development of that science, the range of problems investigated by economic geography is too comprehensive for one person to be able to carry out thorough studies of its whole range of problems. Hence, an exclusively regional approach to geography mostly reduces the depth of investigations and weakens the validity of the conclusions drawn from them. For this reason there is need for topical specialisation if investigations.

4. Similarly as physical geography, economic geography is a compound concept, denoting a group of more or less autonomous narrower disciplines. Similarly as in the framework of physical geography, where the followin branches are distinguished: geomorphology, hydrography, climatology, geography of soils and biogeography, economic geography consists of such disciplines as: geography of agriculture, industrial geography, transportation geography, geography of population, geography of settlement, and so on.

5. Topical specialisation at the universities should, for the time being, be limited, at least on the level of doctors degree, while on that of Master only lectures and class work on particular disciplines of economic geography conducted by appropriate experts in geographic science or possible appropriate diploma classes should be introduced.

6. A separate conference should be devoted to the subject of methods to be adopted by regional geography.

The conference at Osieczna released constructive initiative and provided a stimulus to the development of economic geography in Poland. The introduction of appropriate topical lectures and practical work made it imperative for lectures to approach more thoroughly the problems covered by them. At the Institute of Geography of the Polish Academy of Sciences there occurred a reorganisation of the Department of Economic Geography and its division into three separate laboratories: that of geography of agriculture (J. Kostrowicki), of geography of industry (S. Leszczycki) and geography of population and settlement (K. Dziewoński) was effected. The staffs of these laboratories were extended to 5 to 10 persons each conducting appropriate research work under the guidance of a responsible director.

These changes were reflected in Polish geographic publications, especially those of the Institute of Geography. While, before 1955, some 80% of the entire space was devoted in them to dissertations or articles bearing on physical geography, at present this proportion has been changed to such an extent that physical geographers are beginning to protest against the domination of economic geography. In spite of the brevity of the period of time which has elapsed since the conference at Osieczna, a number of valuable works on economic geography have already appeared. Further numerous works are now in preparation.

I shall now attempt to characterize briefly the postwar achievements and the present situation of Polish economic geography by separate branches, with particular emphasis on recent years and on the problems actually studied.

As is already mentioned, the geography of settlement was the best developed branch of economic geography in prewar Poland; this same branch also predominated over others after the war. However, unlike before the war, in connection with the intensive process of the country's urbanisation, Polish geographers have been mainly concerned in recent years with urban geography treated from a different point of view than before the war. Attention was paid not merely to the position of towns and their physionomy, but particularly to their economic foundations, i. e. their functions, the differentation of the internal structure of the population of the towns according to the functional type of a given town, as well as mutual relationships between towns. The application for the first time in geographic science of the concept of basic town functions as a factor playing a decisive role in determining the development and type of a town (J. Kostrowicki) is the achievement of Polish geography. This concept has been further extended by detailed studies of the population structure of several dozen towns, which demonstrated distinct differences in numerosity of the basic group, depending on the size and functional type of a town (L. Kosiński). Polish towns have been classified according to type and a distinguishing has been made between urban and rural settlements on scientific foundations (J. Kostrowicki, L. Kosiński, *15, 16, 17*). Another problem drawing the attention of geographers was that of the role of small towns in Poland. These towns, which are very numerous, showed signs of decline from the beginning of the 19th century. The political and social changes that occurred since the war further enhanced this decline by undermining their basic function which consisted in an overemphasized role of commercial intermediary between town and country. On the basis of numerous monographic studies, geographers attempted to find new economic foundations for the functions of these towns and to determine their role in the new Polish economy (M. Kiełczewska-Zaleska, J. Kostrowicki, K. Dziewoński). The findings of these investigations have had a wide repercussion in the country, and to-day the problem of activisation of the small towns taken up by the press and discussed by the Sejm (Parliament), has become one of nationwide problem *(18, 37)*.

On the other hand, contrary to the interwar period, studies on rural settlement have been completely neglected in Poland. Several studies in this field, mostly characterized by a historical approach and based on old methods, were carried out in the Poznań and Toruń centres (M. Kiełczewska-Zaleska, S. Zajchowska). New approaches are now sought by M. D o b r o w o l s k a and her collaborators *(5)*. A special scientific conference is being called in 1958 to deal with this problem on new foundations. During the period when it was difficult to obtain current data, considerable attention was devoted to historical geography of settlement which has some traditions in Poland (M. K i e ł c z e w s k a - Z a l e s k a, S. Z a j c h o w s k a, K. D z i e w o ń s k i, J. D y l i k, S. G o l a c h o w s k i, *6, 9, 13, 45*). A number of monographs on particular towns were also worked out, only some of which have been published *(37)*.

In the domain of the geography of population several studies were published on the subject of distribution and structure of Poland's population on the basis of the 1950 census (M. L i t t e r e r, B. W e ł p a, S. J e l o n e k), a few regional studies (H. M a r u s z c z a k), as well as studies on the distribution and changes of the world's population (J. S t a s z e w s k i, *38, 39*). The Laboratory of the Geography of Population and Settlement at the Institute of Geography of the Polish Academy of Sciences is now working on an analysis of the processes of settlement in the Recovered Territories, of the provenance of the population now inhabiting them, and on related subjects. K. Dziewoński gave a general study of the methods used by geography of settlement and population.

It was also K. D z i e w o ń s k i who provided the first postwar scholarly studies in the field of industrial geography. Nevertheless, this branch of geography showed but weak subsequent development. Only the setting up of a laboratory of industrial geography at the Institute of Geography of the Polish Academy of Sciences provided an impetus, especially as regards work on the localisation of the manufacture of building materials, and processing of agriculture produce and foodstuffs (J. G r z e s z c z a k, M. N a j g r a k o w s k i, *30)*. Work on a big atlas of Polish industries is now under way (S. L e s z c z y c k i, A. K u k l i ń s k i). A special issue of „Przegląd Geograficzny" (Geographical Review) has been devoted to the methods of industrial geography *(29, 36)*. An investigation into the problems of the Lodz industrial complex is being carried on by L. S t r a s z e w i c z *(41)*. At the Institute of Geography of the Polish Academy of Sciences work has also been conducted relative to the industries of Białystok district (A. W e r w i c k i, *44*) and of that of Warsaw (S. M i s z t a l). A popular monograph of Polish industry has been provided by A. W r z o s e k.

Geography of transportation shows even weaker development in Poland. Only a few studies can be mentioned here, notably those of S. B e r e z o w s k i, J. M i k o ł a j s k i and T. L i j e w s k i, scientific work by K. B r o m e k, of a popular character, as well as a monograph of transportation in the voivodeship of Białystok and a summing up to the achievements of Polish geography of transportation, now being prepared by Z. C h o j n i c k i *(3)*.

The growth of agricultural geography was also indifferent until recently. Up to the time of opening of a laboratory of agricultural geography at the Institute of Geography of the Polish Academy of Sciences it would have been difficult to name many studies in this domain. True, as early as 1946 some Polish geographers started a discussion on the preparation of a land utilisation map (A. J a h n and others), but, at the time, ways and means were lacking to carry out this project. It was therefore limited to the collective working out of general maps of land utilisation in Poland in a 1:300 000 scale, on the foundation of a topographical map published in the interwar period (F. U h o r c z a k). In these maps only the main uses of land are differentiated (arable, meadows and pastures, forests, water and settlements); they were already finished and, after having been diminished by photographic method, were published in a variety of combinations in a 1:1 000 000 scale as a map of land utilisation in Poland. A map in this scale and based on prewar material is, of course, mainly of didactic significance *(21)*.

But scientific interest and practical needs created the necessity of working out a detailed map of the land use. Work on such a map was undertaken in 1954 (K. D z i e w o ń s k i), and has been considerably extended in recent years after the setting up of the Laboratory of the Geography of Agriculture (J. K o s t r o w i c k i). Although this map follows mainly the rules adopted by the World Land Use Survey of the International Geographical Union, it goes much further, representing not morely the distribution of various land uses, but also the manner in which the land is farmed, i. e. agrotechnical systems, and economic directions in the farming of arable land, biological types and way of utilisation of meadows and pastures, biological types, age and way of utilisation of forests, biological types and way of utilisation of water, types of constructions, industry, communications equipment, kinds of waste land, etc. The map is carried out in the field and in this connection much additional material is being collected that will later serve, together with the map, as basis for working out a text on the use of land in the areas covered by the survey, and, through a comparison of the use of land with natural conditions in the investigated area, will make it possible to reach conclusions as to the rational or irrational character of the present economic utilisation of geographic environment and to formulate recommendations with a view of improving the existing situation. In the framework of investigations into the use of land, detailed research work of a representative character is also carried out on various types of farming (W. B i e g a j ł o, R. S z c z ę s n y, J. T o b j a s z). The laboratories of economic geography at the University of Warsaw (J. T o b j a s z, W. K u s i ń s k i), that of Cracow (A. W r z o s e k, L. B r o m e k, A. J e l o n e k) and that of Toruń (E. K w i a t k o w s k a) cooperate with the Laboratory of the Geography of Agriculture at the Institute of Geography of the Polish Academy of Sciences *(10, 26)*.

Besides investigations into the use of land, the Laboratory of the Geography of Agriculture also conducts analytical studies bearing on the distribution of particular crops and stock raising and on directions and types of agricultural economy in Poland. These investigations and the material collected on the use of land will provide a basis for working out a geographic topology of Polish agriculture. A special issue of the Geographical Review has been devoted to methods of the geography of agriculture *(21, 22)*.

Problems bearing on economic regions, mostly connected with the needs of planning, constitute a separate branch of investigations. A number of articles on this subject (mostly by K. D z i e w o ń s k i, also by J. K o s t r o w i c k i, J. C z y ż e w s k i, S. B e r e z o w s k i, A. W r ó b e l) habe been published in Poland since 1946. At the Laboratory of Geography of Population and Settlement of the Institute of Geography of the Polish Academy of Sciences work is now under way on methods of economic regionalisation *(11)*. In the autumn of 1957, Polish geographers presented five papers on this subject at a conference devoted to economic regionalisation held in Prague (S. L e s z c z y c k i, K. D z i e w o ń s k i, A. W r z o s e k, L. S t r a s z e w i c z, A. W r ó b e l). As a result of this conference an International Centre of Information on Geographical Studies and the Delineation of Economic Regions was set up in conjunction with the Institute of Geography of the Polish Academy of Sciences.

In 1959 the International Conference on economic regions has taken place in Kazimierz where various topics of economic regionalisation were discussed.

In spite of the fact that, for some years after the war, the view was propagated in Poland that economic geography is limited to regional geography, not many works in this field have appeared in Poland during that period. Abstracting from a number of earlier volumes devoted to the Recovered Territories, mostly destined for the general reader and published immediately after the war (S. S r o k o w s k i, J. D y l i k, B. K r y g o w s k i, S. Z a j c h o w s k a, A. W r z o s e k, M. K i e l c z e w s k a - Z a l e s k a) with a view to acquainting the Polish people with these lands, only several geographic monographs of the popular type, dealing with particular voivodeships can be mentioned (A. W r z o s e k, M. K i e ł c z e w s k a - Z a l e s k a, S. B e r e z o w s k i, L. S t r a s z e w i c z). Beginning from the year 1955, a special team of workers at the Institute of Geography (IG PAN) under the guidance of J. K o s t r o w i c k i, has been working in cooperation with the Planning Commission on a comprehensive geographic and economic monograph of the voivodeship of Białystok, which is the most backward section of Poland. This work is expected to recommend ways of galvanising the voivodeship into livelier economic activity. The first findings of these investigations were published in 1957 in a special issue of the Polish Geographic Review *(24)*. Further works are now in press.

Difficulties connected with travelling abroad have also been responsible for limiting work on the regional geography of foreign countries. Only few geographic monographs of a popular character dealing with foreign countries have been published within recent years (T. O l s z e w s k i, J. M a c h o w s k i and others). After the setting up in 1956 at the Institute of Geography of the P. A. Sc. of a Laboratory of Regional Geography (B. W i n i d) work was taken up by this body on the countries of the Near East. Monographs on Turkey, Syria, and Egypt are now under way. Work is also in progress on a demographic atlas of Sudan commissioned by the Sudanese authorities (B. W i n i d, L. R a t a j s k i).

The situation as regards textbooks on economic geography is not too favourable in Poland. Only a few handbooks on the economic geography of Poland on the level of academic schools appeared in print since the war (J. Loth, Z. Petrażycka and a collective work under the editorship of A. Wrzosek) and three textbooks — obsolete in method — on economic geography of the world (J. Loth, J. Szaflarski, S. Srokowski). The preparation of textbooks for the newly introduced lectures on separate topics of economic geography requires time. A comprehensive work entitled: Poland's Geographic Environment (Środowisko geograficzne Polski) by J. Kostrowicki, reviewing natural conditions in Poland from the point of view of their economic use *(22)*, is on the boundary between physical and economic geography.

Despite shortcomings and non-uniform developments Polish economic geography is now experiencing a period of rapid growth. The Warsaw centre, comprising the Institute of Geography of the P.Ac.Sc. and the Institute of Geography of the Warsaw University, is now the strongest and leading factor as regards economic geography in Poland (S. Leszczycki, J. Kostrowicki, K. Dziewoński, A. Kukliński, L. Kosiński, A. Wróbel and many others). All branches of economic geography are developing there. A less significant role is played by the centres at Cracow (A. Wrzosek, K. Bromek, B. Kortus) and Poznań (F. Barciński, J. Czekalski, S. Zajchowska, Z. Chojnicki) — these being mostly concerned with regional economic geography, as well as with the geography of agricultural and population. In the Toruń centre, geography of settlement is the dominant discipline (M. Kiełczewska-Zaleska); in Łódź local regional problems and industrial geography are chiefly dealt with (L. Straszewicz); in Lublin — economic cartography (F. Uhorczak), in the Wrocław centre, now only being created — geography of settlement in its historical aspect (S. Golachowski). At the schools of economics (S. Berezowski, M. Fleszar, J. Szaflarski, T. Olszewski, T. Mikołajski, J. Moniak and others) and in the pedagogical schools (M. Dobrowolska, R. Mochnacki and others) scientific work is developing less rapidly; the topics are often of a dispersed and random character.

The results achieved within the last few years and a number of contacts and public appearances of Polish geographers in foreign countries confirm the correctness of the guiding rules adopted at Osieczna. Slowly but steadily we are eliminating our deficiencies, we are gradually reducing the distance between Polish geographical science and that of the most advanced countries that have arisen due to the war and the specific conditions in the subsequent period. We are forging our own approach to various geographic problems. We are utilising and attempting to adopt in a creative manner the scientific achievements of other countries but at the same time we are outlining our own trends in research. We are cooperating in many sectors with planning institutions and devoting much attention to the practical utility of our work. We have educated strong, competent and resilient young cadres, familiar with modern means and methods of scholarly work. It is our hope that, by common effort, we shall push forward Polish economic geography as a science, and that our investigations, by further developing geographic theory and methods, will yield practical results of importance to our country.

Translated by Zofia Wrzeszcz

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(38) S z a f l a r s k i J. *Population Movements on the Polish-German Borderland During the Last Century* (Polish only). Baltic Institute, Gdańsk 1947, p. 62.

(39) T o b j a s z J. *Review and Assessement of the Achievements of Polish Geography of Agriculture.* (Polish with English summary). „Przegląd Geograficzny" XXIX, 1, Warszawa 1956, p. 67—86.

(40) W e r w i c k i A. *Białystok Region of Textile Industry. Development and Location Problems.* (Polish with English summary). Polish Academy of Sciences. Institute of Geography. Geographical Studies No. 10, Warszawa 1957, p. 165.

(41) W r z o s e k A. *Aperçu sur les realisations actuelles de la géographie industrielle en Pologne.* (Polish with French summary). „Przegląd Geograficzny" XXVIII, 3, Warszawa 1956, pp. 487—500.

(42) Z a j c h o w s k a S. *The development of the settlement network in the environs of Poznań (XIX—XX century)* (Polish only). „Przegląd Zachodni" IX, No. 6—8, pp. 101—141.

LESZEK KOSIŃSKI

Problem of the Functional Structure of Polish Towns

Review of literature concerning the functional classification of settlements

The problem of functional classification of settlements has been known in literature for a considerable time — from the very beginning of the present century [1] but only within recent years on a larger scale, especially after World War II in connection with the development of the functional approach in the urban geography. This approach is replacing earlier one, where emphasis was placed on the analysis of the topographical location of settlements, their site, physognomy, and so on. Relatively the greatest number of studies on the subject dealt with here appeared in Anglo-Saxon and German geographic literature, English speaking geographers (mainly Americans) giving their attention primarily to towns, and German ones to administrative parishes (communes), a classification of the latter covering practically all settlements, including towns, under the German system of administrative division.

One of the first more important town classifications covering a larger area is a classification of American towns effected by Ch. D. Harris based on excellent American census data [2]. He chose as starting point the employement structure of the inhabitants and classified the towns according to the percentual proportion of persons employed in a given branch of economy.

Harris adopted different basic percentages for different types of occupation. For instance, he classified as of the industrial type with two sub-types towns where in industry worked over 60 per cent or over 74 per cent of the total number of persons employed jointly in industry and trade; but it sufficed for a town to have 50 per cent (in the case of retail trade) and 20 per cent (in the case of wholesale trade) of those employed in industry and trade jointly to be classified as a commercial town. Undoubtedly, this adoption of arbitrary criteria at the outset constitutes a shortcoming of his survey, but, in spite of this, the work was widely quoted and became a starting point for further studies of the subject.

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[1] Hettner T. *Die wirtschaftlichen Typen der Ansiedlungen.* „Geogr. Zeitschrift", 8, 1902, p. 92 et seq. Aurousseau M. *The distribution of population: a constructive problem.* „Geogr. Review" XI, 1921, 4.

[2] Harris Ch. D. *A functional classification of cities in the United States.* „Geogr. Review" XXXIII, 1943, s. 1, pp. 86—99.

A similar method was employed by W. William-Olsson in his well known classification of Svedish settlements [3].

In a recently published classification of American towns H. J. Nelson computed the average employment structure in U. S. towns counting over 10.000 inhabitants and, allowing for deviations from the standard, he regarded as specialised towns those centres, where the percentage of employment in a given branch was above the average plus the double value of the deviation. The majority of towns were of course, counted among the multifunctional type, but some towns having 2 or 3 outstanding functions were not regarded as multifunctional towns, but as towns with two specialities and counted twice, once in each specialised group. Later, Nelson devoted his attention to a further characteristic of the population in the various types of towns distinguished by him [4]. A similar method was adopted by L. L. Pownall for the classification of the towns of New Zealand. Here, the average structure for all towns was not taken as basis but that for particular size groups. On the other hand Pownall [5] does not take into consideration average deviations levelling down small inaccuracies. Here also a town having two outstanding functions is classified among the two appropriate types of towns and counted twice.

W. Wejchert made a classification of Polish towns on the same principles. This was published in the Studium Planu Krajowego I (Survey of National Planning) in 1947 [6]. The following types of towns were distinguished in an enclosed map: agricultural, industrial and those providing services, the classification of a town as belonging to a given type being decided by employment in excess of the average, computed separately for small, medium and big towns.

The characteristic trait of the above mentioned methods of classification is the adoption as point of issue of the average structure of employment of the population as a whole although the fact is well known that a part of the working population is employed exclusively in meeting the needs of local inhabitants and therefore has no influence upon the specialisation of a given town within the network of towns, specialisation being the main concern in functional classification. Nelson managed by leaving out certain branches of employment from his deliberations, e. g. public utilities, but then also in such branches as industry the line of demarcation runs somewhere in the middle and, besides industry working for larger areas, we also have industries catering for the local needs of the town. The same concerns trade, transport and a variety of services.

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3 W. William-Olsson. *Ekonomisk-geografisk karta över Sverige*. Stockholm 1946.

4 Nelson H. J. *A service classification of American cities*. „Economic Geography" XXXI, 1955, 3, pp. 189—210. Nelson H. J. *Some characteristics of the population in similar service classifications*. „Economic Geography" XXXIII, 1957, 2, pp. 95—109. Cf. review by Kosiński L. „Przegląd Geograficzny" XXIX, 1957, 4, pp. 827—829.

5 Pownall L. L. *The functions of New Zealand towns*. „Annals of the Association of American Geographers" XLIII, 1953, 4, pp. 332—350. Cf. review by Kosiński L. „Przegląd Geograficzny" XXVIII, 1956, 4, pp. 817—818.

6 *Studium planu krajowego*. Urban settlements — occupation structure — types of towns. Table 17 compiled by Wejchert K. Warszawa 1947.

Thus, the line of division may run also within individual section of national economy. As early as 1902 W. Sombart drew attention to the dual character of functions, making a distinction between basic (Stadtegründer) and complementary — non-basic (Stadtefüller) ones [7]. This concept could later be met with in works on sociology, economics and town planning. In his investigations of American towns the American economist H. Hoyt made a distinction between basic and non-basic functions [8], this concept beeing used in a large number of regional and town planning studies prepared in the United States [9]. By the way, this concept has recently been criticized in American periodicals devoted to planning [10]. The Soviet town-planners used the distinction into basic and service functions (gradoobrazuiushchije — gradoobslugivaiushchyje) in assessments made for the purpose of defining the future population of a town [11]. The first attempts at applying this concept to the functional geographical classification of towns date only from the 1950's, J. Kostrowicki having devoted a comprehensive work to the problem. A summary of his work was published in 1952 [12]. This was to the present author's knowledge the first geographical work dealing with the problem from a theoretical point of view. At the same time it contained a functional classification of Polish towns according to the 1949 situation. Kostrowicki covered by his classification not only towns enjoying urban status, but also settlements of an urban character (some 1200 settlements in all). The author based his study on employment data, as well as on other statistical and cartographic information. For instance, industrial towns were distinguished on the basis of the percentage of persons employed in key industries (over 50% of all employed persons worked in industry). Kostrowicki distinguished local centres constituting as a rule multifunctional towns, specialised settlements, including industrial settlements, those specialising in commerce and communications, and those providing communication and recreational services. A third, separate group was constituted by satellitic settlements. His classificational was based only indirectly on the functional structure method, since the absence of appropriate data constituted an obstacle.

In the same year, however, the results of fairly exhaustive investigations into the functional structure of small Polish towns were published [13]

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7 Sombart W. *Der moderne Kapitalismus*, 2 vol. Leipzig 1902.

8 Hoyt H. *Economic background of cities*. „Journ. of Land and Publ. Util. Econ." XVII, 1941, 1, pp. 185—195. *The economic status of the New York Metropolitan Region in 1944*. New York 1944.

9 Roterus E. G. V. *The Economy of the Cincinnati Metropolitan Area*. Cincinnati City Planning Commission, Cincinnati 1949. *Economic base study of the Philadelphia Area*. Philadelphia City Planning Commission, Philadelphia 1949.

10 Blumenfeld H. *The economic base of the Metropolis*. Critical remarks on the „basic-nonbasic" concept. „Journal of the Am. Inst. of Planners", Fall 1955, pp. 114—132.

11 Lewczenko P. *Planirovka gorodov* (Town-Planning). Moscow 1947. Dawidowicz W. G. *Planirovka gorodov* (Town-Planning). Moscow 1947.

12 Kostrowicki J. *Geographical Studies on the Network of Towns*. Warszawa 1950, p. 320, dissertation. Kostrowicki J. *Basic Functions and Functional Types of Towns*. (Polish with English summary). „Przegląd Geograficzny" XXIV, 1952, 1—2, pp. 7—64.

13 Kosiński L. Studies on the Existing Demographic Situation in Polish

and later complemented in 1954 by an article concerning medium and big towns [14]. The methods used in these investigations will be discussed further on in detail. Further studies devoted to theoretical problems of the functional structure method were published in Poland in 1955 and 1956 [15]. A similar point of view is represented by H. M. Mayer and J. W. Alexander [16] who systematized in 1953 concepts and studies that had already been published earlier in the West and presented the theory of basic functions in the towns, substantiating it by only a few instances of particular towns. Alexander underlines the necessity of separating basic functions from the non-basic ones and suggests as basis for such a distinction an analysis of the turnovers or incomes of firms, or the proportion of the number of employed in a given branch of economy in the town surveyed in relation to the country or state as a whole. Thus the criterion of division may vary, while employment always provides the index of the division.

The work of G. Alexandersson, a Swedish geographer who pursued his studies for some time in the U S, is a further contributions to the development of the theory of basic functions in the towns. In his classification of American towns [17] based on data provided by the 1950 census, he tried to distinguish between basic and non-basic functions. He considers as complementary (non-basic) employment not exceeding the average for 5% of all towns with the lowest percentages, plus the value of standard deviation which is expected to level down the differences that might arise out of small inaccuracies or errors, and as basic in character all remaining employment. Finally, the author classifies towns according to the ratio between production and service functions, but, before doing so, draws a distinction and analyses towns with a multiplicity of outstanding functions.

German classifications represent a different type; in this connection it is worth while to devote some attention to two recently published

Towns. (Polish only). „Biuletyn Inst. Urb. i Arch.", 1952, 2 (15), p. 2. Kosiński L. *Population Structure of Small Polish Towns.* (Polish with English summary). „Prace Inst. Urb. i Arch.", 1952, 1, pp. 35—43.

14 Kosiński L. *Population Structure of the Medium - size and Big Polish Towns.* (Polish with English summary). „Prace Inst. Urb. i Arch.", 1954, Nr 1, pp. 28—37.

15 Kosiński L. *Types of Towns.* (Polish only). „Seria prac własnych Inst. Urb. i Arch." Warszawa 1955, p. 42. Kosiński L. *Economic Basis of the Development of Towns.* (Polish only). Ibid. Nr 44, Warszawa 1956, p. 25.

16 Alexander J. W. *The basic-nonbasic concept of urban economic functions.* „Economic Geogr." XXX, 1953, 3, pp. 246—261. Cf. review of Kosiński L. „Przegląd Geograficzny" XXVIII, 1956, 1, pp. 182—187. Earlier works by Aleksander J. W. *Oshkosh, Wisconsin, an economic base study.* Madison, Univ. of Wisconsin, School of Commerce, 1951 and *An economic base study of Madison, Wisconsin,* Univ. of Wisconsin, School of Commerce, 1953; were concerned with indyvidual towns. Cf. also Mayer H. M., *Urban Nodality and the Economic Base,* „Journ. of Amer. Inst. of Planners", 1954, Summer.

17 Alexandersson G. *The industrial structure of American Cities.* London—Stockholm 1956, p. 134. Cf. review by Dziewoński K., „Przegląd Geograficzny" XXIX, 1957, 4, pp. 825—827.

classifications of administrative parishes (communes) by H. Linde and Lehmann[18].

It should be emphasized that, in German literature, classifications of administrative parishes are more frequent than those of towns. Linde (German Federal Rep.) as well as Lehmann (German Democratic Rep.) refer back to former German achievements in this field and, while basing their classification on the employment structure of the population, do not limit themselves to this factor. In dividing settlements into main types — villages, settlements of a transitory character and towns, — they distinguish, according to the size of farms, various socio-economic types of villages, and classify towns as belonging to a variety of types (Lehmann); they also take into consideration commutation to and from work, this enabling them to separate administrative parishes of a residential character from those employing workers from beyond their limits. Furthermore, Linde also takes into account the number of shops selling goods and providing services in relation to the number of inhabitants, this making it possible to establish trade centres catering to the needs of the hinterland. Generally, both these classifications arouse interest because of their specific approach; instead of looking differences between town and country, the characteristics of individual settlements are analyzed, and it is shown how one type transforms into another. Of course, deliberations of this kind are possible only when appropriate statistical data is available. It should be noted that German writers do not refer to the concept of functional structure, and even comment on it critically because of the subjectivism which it entails[19].

It is not the aim of this review to discuss exhaustively the problems raised. Attention is merely devoted to recent publications dealing with a functional classification of settlements, no mention being made of earlier works, as well as works on local centres, whose authors, referring to the theory of W. Christaller, study relationships between towns and their spheres of influence. The largest number of works appeared in Germany, but British and US writings also constitute an important proportion of all works devoted to the geography of settlement. Lately, a number of interesting works in this domain have appeared in the Scandinavian countries, particularly in Sweden[20], and also in Switzerland[21].

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18 Linde H. *Grundfragen der Gemeindetypisierung.* „Raum und Wirtschaft", Forsch. u. Sitzungsberichte der Akad. für Raumforschung u. Landesplanung, III, 1952, Bremen-Horn 1953, pp. 58—121. Lehmann H. *Die Gemeindetypen.* Beiträge zur siedlungskundlichen Grundlegung von Stadt- und Dorfplanung. Deutsche Bauakademie. Schriften des Forschungsinstituts für Städtebau u. Siedlungswesen. Berlin 1956, p. 67 plus 6 maps. Cf, review by Kosiński L., „Przegląd Geograficzny" XXIX, 1957, 4, pp. 822—825.

19 Lehmann H. (op. cit.) on the occasion of discussing the work accomplished by Kostrowicki J.

20 Tuominen O. *Das Einflussgebiet des Stadt Turku im System der Einflussgebiete SW Finnlands.* „Fennia" LXXI, Helsinki 1949, art. 5, p. 138. Godlund S. *The function and growth of bus traffic within the sphere of urban influence.* „Lund Studies in Geogr.", Ser. B., Hum. Geogr., No. 18, 1956, p. 80.

21 Carol H. *Das agrargeographische Betrachtungssystem.* „Geographica Helvetica" VII, 1952, 1, pp. 17—67. Trinks V. L. *Die zentralen Funktionen der Siedlungen im Kanton Zürich.* Zürich 1950, p. 60.

The main contemporary research problems of the geography of settlement have thus been briefly characterised. We shall now present in turn the results of investigations into the functions of Polish towns and settlements, illustrating the functional structure of the towns surveyed by data borrowed from various sources.

Fig. 1. Towns covered by survey. *1* — big towns of 100—200 th. inhabitants, *2* — medium towns of 30—100 th. inhabitants, *3* — small towns of less than 30 th. inhabitants

Functional Structure of Polish Towns

S o u r c e s. The survey covered: small towns with populations ranging between 2.000 to 30.000 inhabitants, medium towns with populations of 30.000 to 100.000, and, finally, big towns counting from 100.000 to 200.000 inhabitants.

It was based on data obtained from the Institute of Town Planning and Architecture (IUA), some of which were published earlier in the

Works of the Institute [22] while some are still in manuscript form. These data concern the functional structure of a number of towns.

Theses for Master's degree written at the Geographic Institute of the Warsaw University [23] constituted another source. These are economico-geographic monographs of small town foreseen, to become county seats in future, discussing a. o. the characteristics of functional structure.

In estimating these sources the difference in their value to the present survey should be underlined. The data obtained from the IUA gives a full reflection of the problem discussed, although it contains some generalisations and the aim for which they were collected is different from that of the present survey.

The situation is somewhat less favourable as far as the monographs are concerned. In these, population analyses were carried out for the purpose of discovering existing labour reserved and, for this reason, only marginal attention was paid to functional structure. These works contain data for the years 1950—54. Although the great majority of them date from 1950, not all the data quoted are contemporaneous, and this, of course, diminishes their value.

The present article deals with an analysis of functional structure amounting to a distinction of three population groups: basic, non-basic and professionally passive, the role and range of activity of the employing body providing the criterion for classification in the basic or non-basic group. Special emphasis was placed on an analysis of the basic group, this being divided into separate branches of national economy. Such a division made it possible to bring out the dominant functions and the character of particular towns. In order to obtain a more complete picture, the towns were grouped according to size, being roughly divided into small, medium and big ones, and the functional analysis was carried out only in the framework of these size groups.

The survey covered: 45 small towns (less than 10% of all towns of this size), 10 medium ones (ca. 20%) and 6 big ones (about 40%, or, more precisely, 50% of towns with a population of 100.000 to 200.000).

While selecting towns for the survey, it was attempted to choose those that were most representative in their territorial and functional aspect. Another consideration was to choose towns of various sizes. For technical reasons it was impossible to cover all towns by the survey and, therefore, it was attempted to make this fragmentary survey as representative as possible.

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[22] K o s i ń s k i L. Population Structure of the Small Polish Towns. „Prace IUA", II, 1952, No. 1, pp. 35—42. K o s i ń s k i L. Population Structure of the Medium-size and Big Polish Towns. (Polish with English summary). „Prace IUA" IV, 1954, No. 1, pp. 28—38.

[23] Because of the small number of copies these works are very difficult of access. Although several dozen such works were written at the University — only ten were available as sources for the present study; Brańsk, Ciechanowiec, Iłża, Knyszyn, Myszyniec, Łapy, Reszel, Staszów, Szydłowiec, Wyszogród. Other works either did not comprise functional structures, ore were of no avail. A selections of monographs is contained in the collectiv work: Geographical Studies an the Economic Reviwal of Small Towns, Pol. Ac. of Sciences, Institute of Geography, Geographical Studies No. 9, Warszawa 1957, p. 526.

Method

Since not all the material came from the same source, the method of collecting and analysing it was not uniform.

The towns surveyed at IUA, constituting 85% of all those investigated, were studied on the basis of data provided by the Population Census 1950. Owing to the accessibility of rough census material — census sheets „A" — a representative method was applied in order to reduce the cost of the survey and to cover a larger number of towns. Samples comprised some 10 to 20% of all census sheets in big and medium towns. Samples of this proportion were considered to be sufficient after consultations with statisticians. In the second stage of the investigations the method of random choice was improved upon, and this made it possible to obtain more reliable results. The census sheets were arranged in folders containing several score sheets and were marked with separate numbers for each individual area. The number of sheets corresponded, in principle, to the number of separate homes. In the investigations, all the areas were taken into consideration, 10% of all sheets being chosen at random from each, in the following manner. First that sheet was taken whose successive number in the folder corresponded to the last digit of the area's number. If, for instance, the folder covered the areas numbered as — 2, 82, 122 or 162 — the investigation began with the second sheet, to be followed by the twelfth, twenty-second, and so on, until the contents of the folder were exhausted. In this manner an almost ideal 10% representation was achieved (10.58% in the medium towns, 10.28% — in the big ones), as well as a uniform incidence of samples in the material covered by the survey, without giving preference to the first or last sheets, or those, which, if chosen at random (as was actually done in the initial phase of the investigation which covered small towns) would open more easily containing another form inside (G., H., and so on). In the case of big towns the situation was more favourable in that, given large numbers of inhabitants, even the 10% samples comprised a considerable number of people (e. g. in a town of 100.000 inhabitants 10.000 persons were registered) this bringing into play the effect of the law of large numbers. As may thus be seen, the data obtained for the bigger towns are more accurate than those referring to small towns.

The results of investigations carried out on the basic of the original census material (census sheets) constitute an overwhelming proportion of the material used in this survey. As has already been mentioned, these investigations were rather involved and, by the very nature of things, the representative method had to be adopted in the selection of towns covered by them, as well as in the choice of particular towns to be actually surveyed. The representative method provides no safeguard of accurate results, particularly when applied to restricted investigations and registration material, especially as regards more accurate distinction between functional groups by branches of national economy, where only several people were often registered. In such an instance the probable error may be as high as 20% or even higher.

The second factor affecting the accuracy of the results obtained is the subjective manner of classifying employed persons into the basic or non-basic groups. In spite of efforts to adopt uniform criteria for such classification it has not been possible to eliminate altogether differences resulting from a subjective approach of the persons effecting the registration. The use made of averages in this survey rendered it possible to level down to some extent errors resulting from the above causes.

When speaking of the shortcomings of the method adopted attention should be devoted to the manner of classifying pupils of professional schools, half of these having been classified in the basic group, in accordance with the views then held [24], and the other half in the professionally passive group. All university students and those among secondary school pupils who came with certainty from suburban zones (staying in dormitories or digs) were counted among the basic group. If the sum of the basic and non-basic group is treated as the total number of professionally active persons (as opposed to that of professionally passive persons), then the classifying of pupils in the basic group must be viewed as an inconsistency. The Institute of Housing (Instytut Budownictwa Mieszkaniowego) attempted in its work to make a distinction between the basic and non-basic group in a wider sense, and the narrower concept of professionally active persons. Finally however these concepts were not adopted, and it has recently been decided to eliminate completely from considerations in town planning practice secondary school pupils, and to take solely into consideration university students counted among the basic group [25].

The functional structures of the following towns have also been obtained from the IUA: Tarnowskie Góry, Zabrze and Białystok. These were surveyed on the basis of later local data covering employment in particular branches, and collected in connection with demographic forecasts for the towns planning worked on by A. Chramiec and L. Kosiński.

Extracts from geographic and economic monographs of towns prepared at the Warsaw University also illustrate somewhat later situation. Functional structures were surveyed on the basis of data collected in particular towns and relating to employment in individual enterprises. This was made possible by the fact that investigations of this type covered small towns only.

Data on functional structures derived from IUA manuscripts and from monographs do not always agree in their distinctions, this making their utilisation difficult. Nevertheless, they were all established on the basis of the same concept of a distinction between basic and non-basic functions and concerned non-agricultural population.

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24 Lewczenko P., op. cit.

25 This approach was used in the study of the functional structure of Białystok utilized in the present work.

Table 1

Comparative list of towns surveyed

Town	Source	Year when data was collected	% of farming population according to Population Census 1950	Number of inhabitants in 1955 (in thousands)	Dominant functions
1	2	3	4	5	6
Small towns					
Myszyniec	monographs	1953	52.8	1.9	K
Wyszogród	"	1952	17.1	2.4	Z
Reszel	"	1954	9.5	3.3	Z
Brańsk	"	1954	57,6	2.7	Z
Knyszyn	"	1954	63.3	2.1	Z
Ciechanowiec	"	1952	43.1	3.4	Z
Iłża	"	1950	46.3	3.3	SP
Szydłowiec	"	1953	42.2	4.9	SP
Ciechocinek	IUA-publ.	NSP-1950	6.9	5.9	W
Staszów	monographs	1954	31.3	5.1	P
Trzebinia	IUA-publ.	NSP-1950	2.6	6.1	P
Łapy	monographs	1954	6.1	6.7	P
Darłowo	IUA-publ.	NSP-1950	7.0	6.7	M
Świnoujście	"	"	0.4	9.3	M
Kudowa	"	NSP-1950	11.4	5.5	PW
Lubartów	"	"	12.8	6.6	Z
Koluszki	"	"	5.5	6.7	S
Strzelin	"	"	2.1	7.7	P
Iława	"	"	4.2	9.5	KP
Andrychów	"	"	7.7	7.3	P
Błonie	"	"	11.7	9.1	S
Aleksandrów Kuj.	"	"	7.3	7.5	Z
Międzyrzec	"	"	30.2	9.2	Z
Koźle	"	"	1.4	8.8	Z
Bielsk Podl.	"	"	17.2	9.2	Z
Kościerzyna	"	"	8.0	9.5	Z
Giżycko	"	"	14.4	13.1	Z
Ostrołęka	"	"	18.3	12.3	Z
Konin	"	"	6.9	14.2	Z
Milanówek	"	"	0.7	14.4	S
Łowicz	"	"	6.7	16.1	Z
Ciechanów	"	"	7.6	11.8	Z
Chrzanów	"	"	4.2	18.0	P
Krosno	"	"	15.9	17.2	P
Chojnice	"	"	3.5	17.7	KZ
Żary	"	"	2.9	19.9	P
Zduńska Wola	"	"	1.9	22.9	P
Otwock	"	"	0.2	31.1	SW

continued

1	2	3	4	5	6
Skarżysko-Kam.	IUA-unpubl.	"	2.2	30.9	P
Zakopane	IUA-publ.	"	16.3	23.6	W
Chełm	"	"	7.6	26.7	Z
Tarnowskie Góry	IUA-unpubl.	"	1.8	26.2	SP
Żyrardów	IUA-publ.	"	0.5	27.2	P
Siedlce	"	"	8.3	28.8	Z
Pruszków	"	"	1.7	34.4	S
Medium towns					
Słupsk	IUA-publ.	"	3.9	44.2	Z
Przemyśl	"	"	3.8	41.9	Z
Tarnów	"	"	9.2	58.8	Z
Dzierżoniów-Bielawa	"	"	3.1	50.9	P
Elbląg	IUA-publ.	NSP-1950	2.0	65.9	P
Kalisz	"	"	2.6	66.1	P
Białystok	IUA-unpubl.	1955	2.5	97.2	Z
Radom	IUA-publ.	NSP-1950	1.8	118.1	P
Toruń	"	"	5.4	92.5	Z
Big towns	IUA-publ.	NSP-1950	1.0	111.2	P
Wałbrzych	IUA-publ.	NSP-1950	1.0	107.7	P
Częstochowa	"	"	1.8	111.2	P
Lublin	"	"	3.9	116.3	Z
Chorzów	"	"	0.4	128.2	P
Bydgoszcz	"	"	9.7	161.8	Z
Zabrze	IUA-unpubl.	"	0.7	172.4	P

Note: the towns are grouped according to the number of inhabitants in 1950. For orientation, the number of inhabitants in 1955 is given. NSP means Population census.

Functional: Z — multifunctional towns; P — industrial t.; S — satellite t.; W — recreational and health resorts; K — communication t.; M — harbour and fishing t.

It was decided to leave out agricultural population from these considerations for the reason that its numbers primarily depend on the manner of demarcating the administrative boundaries of towns, the latter often comprising to-day, similary as twenty years ago, considerable rural areas, inhabited by a farming population [26]. It would be difficult to count the farming population among the basic group in towns in view of the

[26] Rewieńska W. in her work: Surface and Population Density of Urban Communities in Poland, (Polish only). „Wiad. Geogr." XIII, 1935, Nos. 3—7, pp. 34—39, drew atention to administrative frontiers.

Table 2

Agricultural population in medium and big towns.

Towns	Per cent of population	
	According to IUA investigations	According to provisional data of the Chief Statistical Office
Medium		
Toruń	1.2	5.4
Radom	2.6	1.8
Kalisz	3.0	2.6
Elbląg	3.4	2.0
Dzierżoniów-Bielawa	4.2	3.2
Przemyśl	4.8	3.8
Tarnów	5.7	5.2
Słupsk	6.9	3.9
Big		
Chorzów	0.4	0.4
Bydgoszcz	0.7	1.0
Wałbrzych	1.6	1.0
Częstochowa	1.8	1.8
Lublin	2.8	3.9

fact that agriculture is not sufficiently intensive to constitute the course of subsistence of a small town [27]. On the other hand, the farming population cannot very well be regarded as non-basic, since its emergence is not conditioned by the existence of a basic group, and its numbers are not correlated in the least with the latter. One more reason for eliminating farmers was the inaccurate manner of classifying the population in this group. In connection with the greatly restricted basic group in the small towns, as a result of war devastation as well as of certain processes occurring since the war, there were, in the small towns, growing numbers of people drawing their living from obscure sources, from casual work, illegal trade, and so on. Persons owning small plots of land, quite certainly insufficient to provide a living, were registered as farmers. For these reasons the number of registered farmers inhabiting towns is not true to fact. In the table below, besides a characteristic of the data, the percentage

[27] George P. in his work *La ville*, Warszawa 1956, p. 420. (Polish translation), in discussing French towns draws attention to the fact that in many small towns an important role is played by intensiv truck farming, especially vegetable and fruit growing, nurseries, vine cultivation, seed growing, and so on (p. 90).

of farmers registered in the Census has also been given. As was to be expected, the highest percentages of persons living from farming is shown by the smallest towns. In some instances, in 1950, the agricultural population exceeded one half of the total number of inhabitants.

A comparison of provisional data of the Chief Statistical Office with data obtained as a result of the investigations of IUA shows how considerable differences in the percentages of agricultural population computed in various ways can be. These difference are largely the outcome of a non-uniform manner of classifying population in the agricultural group (State-owned Farms), but also of the application of the representative method (the differences are less conspicuous in the big towns).

Structure of basic group in small towns

Forty-five towns, belonging to various functional types have been assigned to this group. Taking into consideration the structure of the basic group the towns were classified according to the role played by particular functions in terms of percentual proportion of total employment. Those towns in which over one half of the total number of employed persons in the basic group worked in some one branch of national economy were counted as specialised towns. In the absence of distinct predominance of some one branch, the town was classified as multifunctional. In some cases not one but two branches predominated, and therefore some towns were considered as doubly specialised. Thus, for instance, Andrychów was counted among industrial towns, since 27.2% of its population was industrially employed, i. e. over one half of the basic group counting in all 42.9% of the total population. Milanówek, where 27.7% of the basic group accounting for 40.3% of total population commuted to work — was classified as a satellite town. Iłża is a good example of a satellite-industrial town, 11.5% of its population working out of town and 9.2% in industrial plants, while the total basic group accounted for 34.6% of all inhabitants of the town. On the other hand, Aleksandrów Kujawski may be quoted as an example of a multifunctional town, since no one single occupation stands out in its basic population group accounting for 20.8% of all inhabitants. Administrative functions are relatively of greatest significance, but even here employment amounts to only 5%.

An analysis covering all small towns jointly did not appear to be of particular use in view of the differences in the functional structure as between towns belonging to various types.

After a comparison of all towns they were classified on the basis of the criteria referred to above and the following types of small towns were distinguished: multifunctional towns (18), specialised: industrial (11), satellite (4), satellite-industrial (3), various-including 2 resorts (Ciechocinek and Zakopane), 1 industrial-and-recreational (Kudowa), 1 satellite-and-recreational (Otwock), 1 communication (Myszyniec), multifunctional where communications play a subdominant role (Chojnice), 1 communicational-and-industrial (Iława) and 2 seaside towns (Darłowo and Świnoujście) — 9 in all.

It should be emphasized that the considerable preponderance of specialised towns does not reflect the true situation actually obtaining in the network of towns in Poland, where an overwhelming majority is constituted by multifunctional towns [28].

The distortion in proportions resulted from a wish to distinguishe as many types as possible and to illustrate their functional structure by several examples wherever possible (see table at the end of article.

Table 3

Structure of basic group in small multifunctional towns
(in percent of total population)

Branch of national economy	Extremal values	On an average
Industry	0.3÷12.0	4.7
Building	0.0÷ 2.5	0.9
Communications	0.0÷ 7.8	2.4
Commerce	1.4÷ 7.4	3.7
Educational, cultural and social services	0.0÷ 9.8	3.2
Administration	0.0÷ 7.5	3.8
Schools (Pupils)	0.0÷ 8.6	3.3
Various	0.0÷ 4.9	1.9
Persons employed out of town	0.0÷ 6.7	1.5
Basic group total	19.0÷32.5	25.5

Small m u l t i f u n c t i o n a l towns comprise towns constituting county seats as well as those without any significant role in the administrative hierarchy. On the average, one fourth of the population is here employed in the basic group, and ca. 15% in the non-basic. The proportion of professionally passive inhabitants being as high as 60%.

In the basic group, industry and handicrafts come to the fore, but employment in these branches does not exceed one fifth of the basic group and only slightly outstrips employment in commerce, cultural and social services and administration. The share of pupils of professional schools is similar (only one half taken into consideration). The remaining branches of employment do not play any considerable role. The averages

[28] Cf. classification of towns and urban settlements given by K o s t r o w i c k i J. in his work *Basic Functions*, op. cit., p. 45. Local centres or multifunctional towns constitute there ca 68%.

mask, of course, the differences existing as between individual towns. The extremal values shown in the table point to considerable discrepancies.

This problem is better illustrated by stellar diagrams, whose arms symbolize particular branches of national economy [29].

True, as a rule, the diagrams for multifunctional towns are generally of a fairly regular shape in comparison with those for specialised towns, nevertheless, besides the more regular ones (Aleksandrów, Bielsk Podl,,

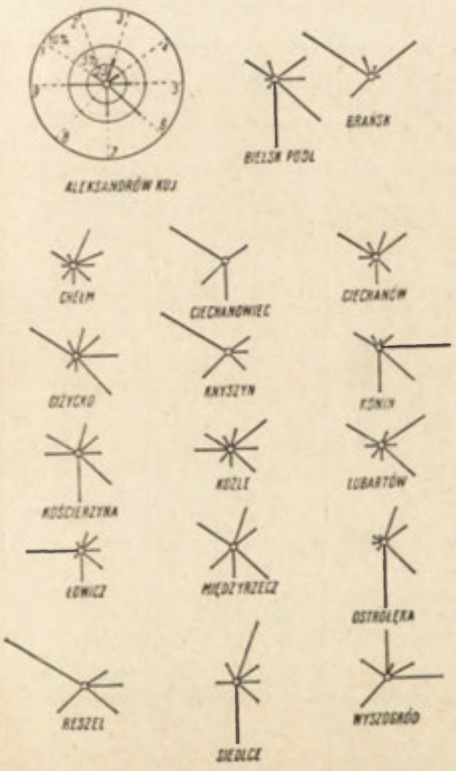

Fig. 2. Small multifunctional towns. *1*— industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half on the pupils of professional schools, *8* — others, *9* — persons employed out of town

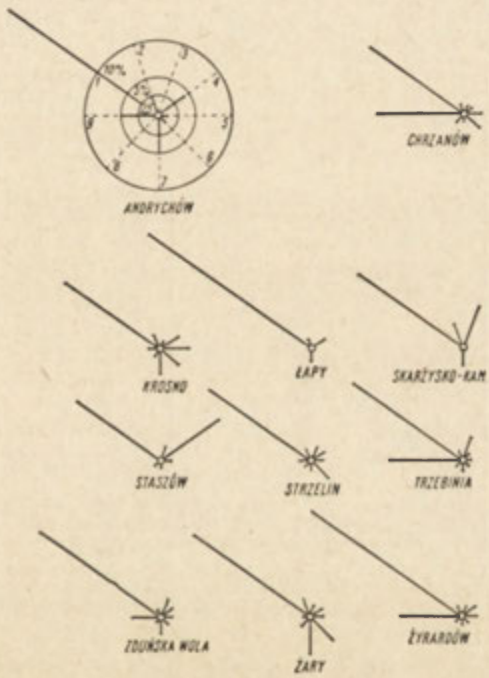

Fig. 3. Small industrial towns. *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — others, *9* — persons employed out of town

Chełm, Ciechanów, Giżycko, Kościerzyna, Koźle, Lubartów, Międzyrzec) there are also such, where some particular branch stands out, e. g. industry (Brańsk, Ciechanowiec, Knyszyn, Reszel), transport (Siedlce), services (Konin, Wyszogród). By and large, towns constituting county seats have

29 See explanations to Fig. 2 and 3.

more diversified basic functions, while in the small multifunctional towns that do not constitute county seats some one functions often stands out. This does not mean, of course, that these centres are becoming transformed into specialised towns. Ciechanowiec, for instance, is a typical local centre where the more highly developed industry, or more precisely speaking, handicraft is adapted to cater to the needs of its hinterland and no longer has the wider significance that it had before the First World War. A similar situation obtains at Knyszyn and Brańsk.

Table 4

Functional structure of the basic group in small multifunctional towns, as divided into county- and non-county centres (in per cent of total population)

Branch of national economy	County centres		Non-county centres	
	extremal values	arithm. mean	extremal values	arithm. mean
Industry	0.3÷12.0	3.3	3.0÷12.0	8.4
Building	0.0÷ 2.5	1.0	0.0÷ 2.4	0.5
Communications	0.0÷ 7.8	3.2	0.0÷1.9	0.5
Commerce	1.4÷ 7.4	3.8	2.4÷ 6.6	3.7
Educational, cultural and social services	1.5÷ 9.8	3.4	0.0÷ 6.8	2.7
Administration	2.4÷ 7.5	4.7	0.0÷ 4.2	1.4
Schools (Pupils)	0.0÷ 8.6	4.2	0.0÷4.9	0.9
Various	0.0÷ 4.9	1.2	3.3÷ 4.9	4.0
Persons employed out of town	0.0÷ 6.7	2.1	0.0	0.0
Basic group total	20.8÷32.5	26.8	19.0÷27.9	22.1

In order to assess the differences between county seats and other towns a separate table was prepared, irrespective of the average structure for all small towns having composite functions, for those towns which constituted county seats at the time when the survey was carried out. Among the 18 towns belonging to that group, 13 occupied such a position in the administrative hierarchy, while a much smaller number, only 5, played no role whatever as administrative centres [30]. Generally speaking, county seats exceed other towns considerably in size.

A comparison of the two groups of towns surveyed shows that the county towns have a more developed basic group, in which a smaller role is played by industry or other occupations, while they reveal higher percentages for communications, commerce, cultural and social services,

[30] Among them is also Reszel, because, although there is a Reszel county, Biskupiec is the seat of county authorities.

and particularly for administration, i. e. for those branches which reflect the ties between the town and its suburban zone. The percentage of pupils of professional schools and of persons commuting to work out of town is also higher here. The differences between individual towns as regards employment percentages in particular branches of national economy are greater in county seats (differing more in size) than between other towns.

Table 5

Structure of basic group in small towns having industrial functions (in percentages of total population)

Branch of national economy	Extremal values	Arithm. mean
Industry	15.0÷29.1	21.1
Building	0.0÷ 2.5	1.1
Communications	0.0÷ 6.2	1.7
Commerce	0.5÷ 9.8	2.4
Educational, cultural and social services	0.1÷ 3.5	1.4
Administration	0.0÷ 4.7	1.4
Schools (Pupils)	0.3÷ 4.7	1.8
Various	0.0÷ 2.3	0.5
Persons employed out of town	0.0÷11.1	3.9
Basic group total	28.6÷42.9	35.3

Small towns with specialised functions comprise self-contained towns (industrial, resorts, and others) and dependent (satellites) ones. Among industrial towns are centres of various types, differing in size (from 5.000 to 31.000 inhabitants in 1955) and in the development of their industries. The textile industry predominates in Żyrardów and Zduńska Wola among other towns; the engineering industry at Skarżysko-Kamienna, Łapy and others. The mining settlements of Silesia [31] do not figure in this group.

In all industrial towns industrial functions predominate distinctly over others, more than one half of the total basic group being industrially employed (cf. tables and diagrams).

Over 21% of inhabitants on an average are employed in industries, as compared with 35% accounted for by the basic group as a whole. The share of industry ranges from 15% in a handicrafts centre such as Staszów, to almost 30% in Łapy and Żyrardów, the range of differences being thus quite considerable. The remaining branches of economy are, generally

[31] Mining and iron and steel industry centres are among the bigger towns — Wałbrzych, Chorzów, Zabrze.

speaking, poorly represented. Exceptions here are — a higher percentage for communications at Skarżysko, for commerce at Staszów, and for commuters to work out of town at Trzebinia, Chrzanów and Żyrardów. Out of 11 industrial towns — five constitute county centres. True, in these towns employment in commerce, services and administration is somewhat higher than in the remaining ones, but here also industry distinctly outstrips all the other branches.

Table 6

Structure of basic group in small satellite towns
(in percentages of total population)

Branch of national economy	Extremal values	Arithm. mean
Industry	0.5÷12.0	6.0
Building	0.0÷ 1.8	0.7
Communications	0.0÷ 8.2	2.5
Commerce	0.1÷ 2.0	1.0
Educational, cultural and social services	0.0÷ 1.9	0.9
Administration	0.0÷ 1.6	0.5
Schools (Pupils)	1.0÷ 5.0	2.8
Various	0.3÷ 0.8	0.6
Persons employed out of town	16.8÷27.7	22.0
Basic group total	35.0÷40.3	36.9

A distinction of satellite-towns was made possible by the method employed in the survey. A division of persons employed according to particular branches of national economy was only applied to persons employed locally, while those commuting to work out of town were separated into a special branch and counted among the basic group.

In the satellite-towns the average proportion of persons employed out of town amounted to 22% (group M — 37%). Of the remaining branches, industry stood out (especially in Pruszków, and to a much lesser degree in Błonie and Milanówek), and communications (in Koluszki).

Of the four towns of satellite character, three are satellites of Warsaw and one (Koluszki) of Łódź. There is a distinct predominance of persons employed out of town at Błonie, Koluszki and Milanówek, while the structure of Pruszków is, precisely speaking, an intermediate one between satellitic and satellitic-industrial type, i. e. that of a semi-dependent town, industry taking first place (Szydłowiec) or second to commutation of persons working out of town (Iłża).

In Tarnowskie Góry communication is the third prominent branch, next to industry and commutation (cf. diagram).

Of these three towns one is a satellite of bigger centres (Tarnowskie Góry — of the Upper Silesian Industrial Region, primarily of Bytom) and the remaining two are linked with the industries of the Kamienna valley (Iłża with Starachowice, and Szydłowiec with Skarżysko-Kamienna).

The population of satellitic as well as satellitic-industrial towns varies greatly in numbers, ranging from 3.000 to 35.000, its size increasing as a rule together with that of the centre with which they are linked.

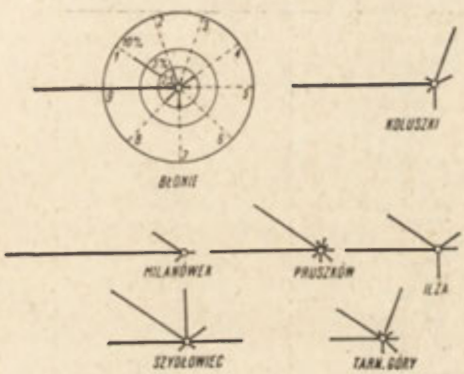

Fig. 4. Small towns of the satellitic and mixed satellitic-industrial type, *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — others, *9* — persons employed out of town

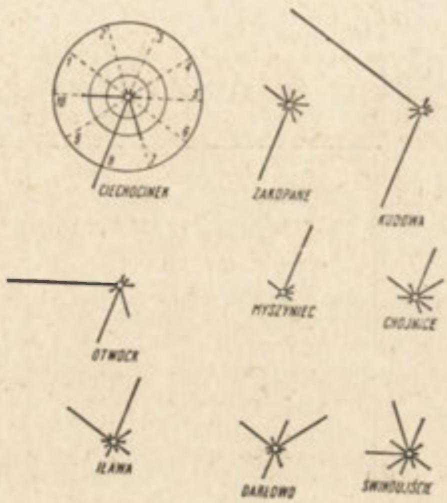

Fig. 5. Small towns specialized in various functions. *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — miscellaneous, *9* — others, *10* — persons employed out of town

Outside of the three groups of specialised towns mentioned earlier there are nine further towns. with a variety of other dominant characteristics.

Two resorts — Ciechocinek and Zakopane differ one from another, especially as regards the size of the non-basic group which in Zakopane is twice that of Ciechocinek [32].

Zakopane, speaking precisely. does not fulfill the conditions of the definition adopted at the beginning, since services to sanatoria and recreation-homes do not exceed half of the basic group. This branch, however, exceeds all the others to such an extent that the town may be classified as a recreational and health resort.

[32] It seems possible that a subjective classification of employment might have contributed to the magnitude of the nonbasic group.

In the two towns next in order health resort services are only a secondary function exceeded by industry (Kudowa) and by commutation to work out of town (Otwock). Both these double-functional towns have a smaller non-basic group, especially Otwock, which, in this respect, resembles satellite towns.

The small settlement of Myszyniec (in the Kurpie region) is the only town with a predominance of communications, where all the other branches are relatively insignificant in spite of the fact that, with regard to its hinterland, the town plays the role of a local centre.

Table 7

Structure of basic group in small industrial-satellitic towns
(in percentages of total population)

Branch of national economy	Extremal values	Arithm. mean
Industry	8.4÷13.5	10.4
Building	0.0÷ 0.2	0.1
Communications	0.0÷ 7.9	2.6
Commerce	1.1÷ 2.9	2.2
Educational, cultural and social services	1.2÷ 8.2	3.9
Administration	0.0÷ 2.6	1.1
Schools (Pupils)	1.8÷ 8.7	3.5
Various	0.0÷ 0.5	0.2
Persons employed out of town	8.2÷12.0	10.6
Basic group total	31.5÷37.0	34.3

Communications are also important in the structure of the basic group at Chojnice and Iława, although in neither of these towns do they predominate in a distinct way; for this reason both towns have been classified as double-functional — devoted to industry and communication — (Iława) or as multifunctional with a considerable share of communications (Chojnice).

Darłowo and Świnoujście were classified as seaside towns, although, if merely the structure of the basic group were taken into consideration, they could be regarded as multifunctional towns (cf. diagram). They were, however, treated distinctly because, besides fishing, which enjoys only a slight predominance, their other activities are also connected with maritime economics; in Darłowo, for instance, industry is adapted to the processing of fish, and commerce comprises almost exclusively the strongly developed local branch of the Central Fish Enterprise. At Świnoujście an important percentage was constituted in 1950 by building in consequence of a major investment project covering the construction of a fishing base then in progress.

The above characteristic concerned principally the basic group in small towns, since an analysis of this group provided a basis for classification.

Structure of basic group in medium towns

Towns counting between 30.000 and 100.000 inhabitants in 1950 were classified as medium. Nine towns of this magnitude were divided into two groups on the basis of an analysis of the basic group carried out by the method already discussed. Five towns were classified in the multifunctional group: Przemyśl, Słupsk, Tarnów, Toruń and Białystok [33], and four in the industrial group — Dzierżoniów-Bielawa, Elbląg, Kalisz and Ra-

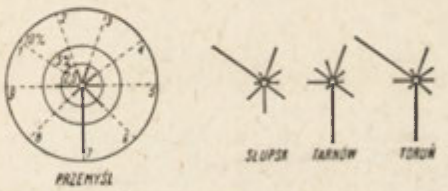

Fig. 6. Medium towns multifunctional. *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services. *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — others, *9* — persons employed out of town

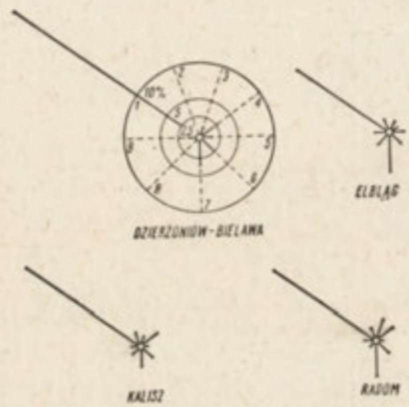

Fig. 7. Medium industrial towns. *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — others, *9* — persons employed out of town

dom. It should be noted that the number of functional types is much smaller here than for small towns, since industry becomes the main dominant feature of towns in this class.

In medium multifunctional towns the percentage of pupils of professional schools stands out most prominently, out-of-town secondary school pupils having been classified in this group [34]. This proportion is higher even than that of industry. All these towns are railway junctions, thence

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[33] Data for Białystok, taken from other sources, are presented in a somewhat different division, which makes difficult a comparison of these data with data for other towns.

[34] A similar procedure was also followed in the case of other types of towns.

Table 8

Structure of basic group in medium multifunctional towns
(in percentages of total population)

Branch of national economy	Extremal values	Arithm. mean
Industry	2.6÷ 9.6	5.8
Building	0.9÷ 2.5	1.5
Communications	2.4÷ 4.4	3.7
Commerce	1.7÷ 2.4	2.1
Educational, cultural and social services	1.0÷ 2.0	1.2
Administration	2.5÷ 3.3	2.8
Schools (Pupils)	3.5÷ 7.6	6.3
Various	0.3÷ 2.5	1.3
Persons employed out of town	0.8÷ 3.4	2.5
Basic group total	23.5÷32.3	27.3

Table 9

Structure of basic group in medium industrial towns
(in percentages of total population)

Branch of national economy	Extremal values	Arithm. mean
Industry	14.8÷30.8	19.9
Building	0.4÷ 1.8	1.3
Communications	0.7÷ 2.3	1.4
Commerce	1.6÷ 2.5	2.1
Educational, cultural and social services	0.4÷ 1.1	0.7
Administration	1.6÷ 2.2	1.8
Schools (Pupils)	2.6÷ 5.0	3.7
Various	0.3÷ 1.7	0.8
Persons employed out of town	0.6÷ 1.3	0.8
Basic group total	29.9÷40.0	32.7

their higher proportion of communication in comparison with medium towns of the industrial type (cf. diagrams). All the towns comprised by the table (with the exception of Białystok, which is not included) are merely county seats, although they considerably exceed in size the average magnitude of county centres in Poland.

This circumstance explains the relatively inconsiderable percentages of commerce, services and administration in the basic group, where not many more persons are employed than in the average county town.

The preceding table does not include Białystok, where the percentage of commerce, services and administration is 13,4% i. e. almost twice that in the remaining medium multifunctional towns. This instance clearly illustrates the effect of the presence of authorities on a voivodeship level upon the structure of the basic group.

Among industrial towns the Dzierżoniów-Bielawa urban complex stands out distinctly [35], where over 30% of the inhabitants are industrially employed. As may be seen, this is the most highly industrialised of all the towns surveyed (cf. diagram). Besides three towns with a distinct predominance of industry, Elbląg has also been classified as belonging to this type, although employed in industry does not exceed there one half of the basic group. Similarly as in medium towns with multiple functions, the group of pupils also stands out in industrial towns.

The role of commerce in industrial towns is the same as in multifunctional ones, while percentages for communications, cultural and social services, and administration are definitely lower.

Generally speaking, differences in the magnitude of employment percentages in various branches of national economy between individual medium towns are smaller than between small towns.

Structure of basic group in big towns

Six towns with a population of 100.000 to 200.000 (according to 1950 data) have been counted in this group. Two of them are seats of voivodeship (Lublin and Bydgoszcz), while the four remaining ones are highly industrialised, big urban centres (including the two Upper Silesian towns of Chorzów and Zabrze). As shown by the enclosed tables and diagrams there are fairly big differences between industrial towns and multifunctional regional centres, and for this reason it was decided to establish and present separately the average structure of two towns having multiple functions and separately the average structure for four industrial towns.

The multifunctional towns have fairly well developed industries, industrial employment accounting for one third of the basic group. Similarly as in medium towns, the share of school pupils is considerable, taking second place next to industry. Commerce, cultural and social services and administration account jointly for some 9% of the population, i. e. somewhat more than in the medium multifunctional towns, but much less than in Białystok. This may be explained, among other reasons, by differences in the size of these towns.

In the industrial towns industry plays a much more important role at the expense of almost all the remaining branches. The percentage of

[35] In spite of the fact that the towns of Dzierżoniów and Bielawa are distinct administrative units, they have been considered here as a single urban complex, which they form in actual fact.

commuters to work out of town is an exception here; it is higher in the towns of the Upper Silesian Industrial Region (especially in Chorzow), and this raises the average.

Functional structure of population

The structure of the basic group having now been discussed and individual types of towns having been characterised, the functional structure of the population will now be analysed, i. e. it will be divided into-basic, non-basic and professionally passive, the percentages for each differing in the several types of towns.

In the table 11 types represented at least by two towns were taken into consideration, and this is the reason why data are lacking for certain double-functional towns.

The fact should primarily be noted that multifunctional towns, irrespective of their size, have a lower basic and a higher non-basic group than specialised towns, and the larger the town the higher the percentage of the basic group.

In industrial towns, on the other hand, the highest percentage for the basic group occurs in small towns and the lowest in medium ones. Percentages differ here within a more restricted range than in the case of multifunctional towns.

If we adopt the size of the basic group as an index of the intensity of the economic activity of a town, the small satellitic-industrial and

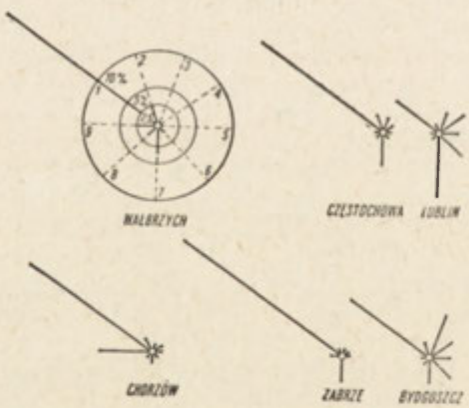

Fig. 8. Big towns. *1* — industry, *2* — building, *3* — communications, *4* — commerce, *5* — educational, cultural and social services, *6* — administration, *7* — students of academic schools and one half of the pupils of professional schools, *8* — others, *9* — persons employed out of town

industrial-satellitic towns must be regarded as the most active (34.3 — 36.9%). The population of towns of this type is worse off as regards services, as witnessed by the very low percentage of the non-basic group (8.4 to 11.8). The inhabitants of satellitic towns largely satisfy their needs outside their place of residence owing to close ties with the central town, and for this reason the smallness of the non-basic group does not necessarily mean in this instance an inadequate supply of services. The situation is quite different in the self-subsistent industrial towns.

Big towns, where the basic group is fairly large (ca. 34%) irrespective of their specific type, come second as regards intensity of functions. Their specificity is reflected, on the other hand, in the size of the non-basic group which is smaller in industrial towns (10.0) than in multifunctional ones (14.9).

The remaining specialised towns come third, both the medium (industrial ones) and the small (fishing and recreational) ones, where the basic group amounts to 30.8—32.7%. There are considerable differences

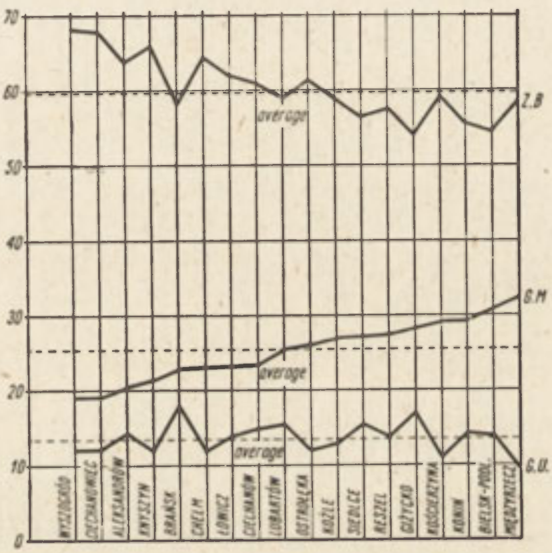

Fig. 9. Functional structure of small multifunctional towns. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

on the other hand in the non-basic group which is much larger in resort (17.7%) than in the small fishing towns and the medium industrial towns (ca. 13%). At his opportunity it should be stressed that those towns where recreational functions appear alongside of other functions have very much lower percentages for the non-basic group similarly as industrial or satellitic towns (the satellitic health resort of Otwock — 8%, industrial and recreational Kudowa — 10.5%), which might indicate that these recreational functions appear alongside of other functions have very much alongside of another function — have a smaller influence on the functional structure of a town.

And finally, the lowest percentages of the basic group are shown by small and medium multifunctional towns, where, on the other hand, the size of the non-basic group is much greater.

As regards the size of the professionally passive group, it is, to some extent, the negative of the share of the former groups. The largest

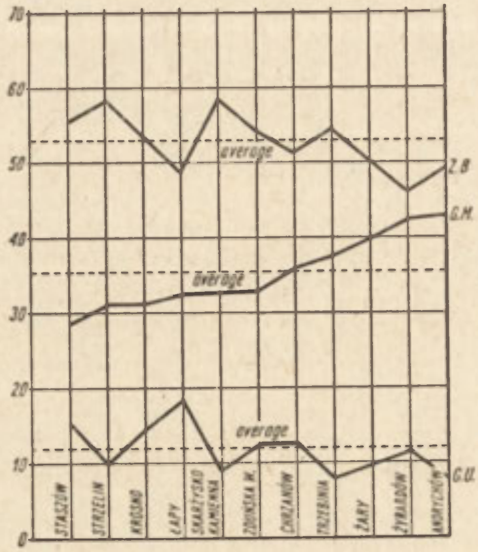

Fig. 10. Small industrial towns. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

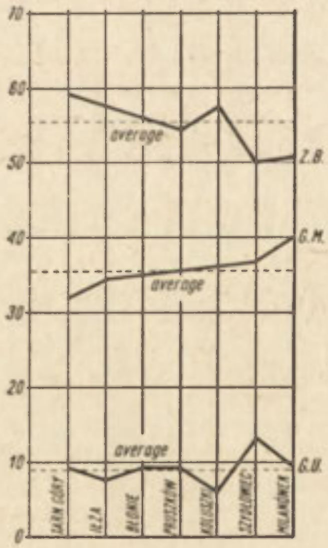

Fig. 11. Small towns of the satellitic and mixed satellitic-industrial type. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

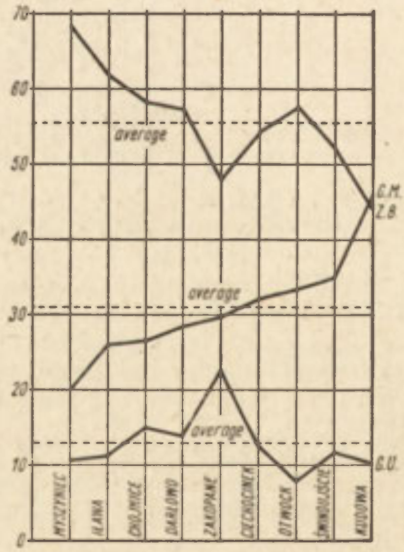

Fig. 12. Small towns specialized in various functions. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

Table 10

Structure of basic group in big towns (in percentage of total population)

Branch of national economy	Multifunctional towns		Industrial towns	
	Extremal values	Arithm. mean	Extremal values	Arithm. mean
Industry	7.5÷13.9	10.7	21.8÷26.4	23.9
Building	0.8÷ 2.1	1.4	0.5÷ 2.4	1.4
Communications	2.8÷ 6.0	4.4	0.4÷ 1.8	1.0
Commerce	3.2÷ 3.6	3.4	0.5÷ 1.3	1.0
Educational, cultural and social services	1.9÷ 2.4	2.1	0.3÷ 1.1	0.6
Administration	3.5÷ 4.2	3.8	0.1÷ 1.1	0.5
Schools (Pupils)	3.6÷ 8.9	6.6	0.8÷ 4.4	2.7
Various	0.9÷ 1.3	1.1	0.0÷ 0.6	0.2
Persons employed out of town	0.2÷ 0.4	0.3	0.3÷ 7.4	2.5
Basic group total	31.7÷35.5	33.5	32.0÷36.0	34.0

numbers of people work in recreational and industrial (small and medium) towns, the highest percentages of professionally passive inhabitants occur in multifunctional towns (small and medium). The low percentage of professionally passive inhabitants is connected with the relatively high employment of women and old people this being much easier to achieve in resorts, where services of every kind play a predominant role in employment. This may be considered as the reason for the relatively low proportion of passive population in towns of this type. On the other hand, the high proportion of professionally passive persons in satellitic towns which show, at the same time, fairly intensive activity, may be explained by the fact that their populations are largely recruited from pensioned off workers of central towns. This conclusion in confirmed by an analysis of the age structure in the IUA survey already cited [36]. The percentages of superannuated persons are highest in satellitic towns [37].

Attention should be devoted in turn to the enclosed diagrams, where the course of the curves reflects the mutual proportions of the three main functional groups in particular towns arranged in order of size of the basic group. Small multifunctional towns (county and non-county),

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[36] Kosinski L. *Population Structure of the Small Polish Towns*, op. cit.

[37] This analysis was not repeated here; it could not be carried out for all towns in the absence of available data. Moreover, the age structure is of less significance to the study of functional structure types, since it primarily reflects the phase of arrival of new settlers (Recovered and Old Territories).

industrial, satellites, satellitic-and-industrial and towns of various types have been distinguished here. Medium towns are treated jointly without being divided into industrial and multifunctional ones. A similar procedure was followed in the case of big towns. As may be seen from these diagrams, there is mainly a relationship of reverse proportionality between the basic and professionally passive groups, while differences in the level of the non-basic group do not show such distinct tendencies. The largest

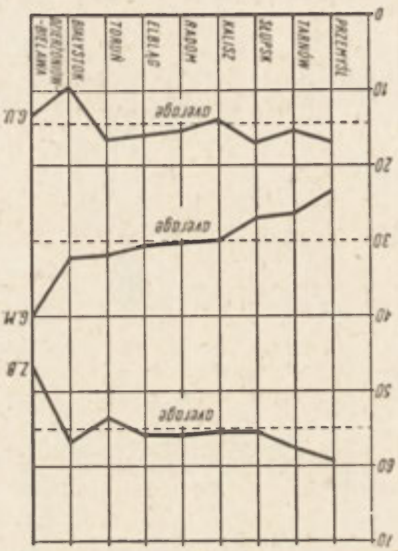

Fig. 13. Medium towns. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

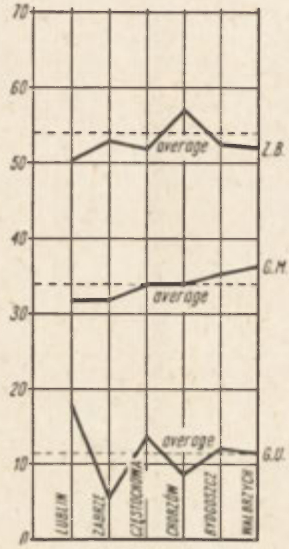

Fig. 14. Big towns. *G. M.* — basic group; *G. U.* — non-basic group; *Z. B.* — professionally passive persons

differences between individual towns occur in the multifunctional group of medium towns. In the remaining towns deviations from the average are relatively less significant. An analysis of the diagrams confirms the conclusions drawn from an analysis of the numbers comprised in the comparative table 11.

In view of the fact that the survey did not cover all Polish towns, and not even all towns of some one type or some one size — it is difficult to give a characteristic of the phenomena investigated from the spatial point of view. This, however, was not the objective of the present article which has been devoted to problems of typology of towns.

The fact, however, should be emphasized, that not merely the type of town but also its geographical location is reflected in the structure of its population. On the one hand, certain types of towns occur exclusively or largely in definite regions of the country. It is understandable that the geographic and economic location of towns conditions in certain instances their specific character (e. g. towns providing communication services).

Table 11

Functional structure in different types of towns
(in percentage of total population)

Towns	Groups					
	Basic		Non-basic		Professionally passive	
	extremal values	arithm. mean	extremal values	arithm. mean	extremal values	arithm. mean
Small towns						
Multifunctional	19.0÷32.5	25.5	9.0÷18.7	13.9	54.2÷68.5	60.0
Specialised;						
industrial	28.6÷42.9	35.3	7.6÷18.8	11.8	15.0÷29.1	52.8
satellites	35.0÷40.3	36.9	6.2÷ 9.3	8.4	50.6÷57.3	54.7
satellitic-industrial	31.5÷37.0	34.3	7.5÷13.0	9.9	50.0÷59.4	55.8
resorts	29.2÷32.5	30.8	12,4÷23.1	17.7	47.7÷55.1	51.4
fishing harbours	28.8÷35.2	32.0	12.4÷13.9	13.1	52.4÷57.3	54.8
Medium towns						
Multifunctional	23.5÷32.3	27.3	13.8÷17.2	15.9	53.9÷59.4	56.7
Industrial	29.9÷40.0	32.7	13.4÷14.4	13.7	46.6÷56.2	53.6
Big towns						
Multifunctional	31.7÷35.5	33.6	12.1÷17.7	14.9	50.6÷52.4	51.5
Industrial	32.0÷36.6	34.0	5.2÷14.0	10.0	52.0÷62.8	56.0

Thus the towns situated in the Recovered Territories have, on an average, a higher percentage of professionally active inhabitants, which stands in some connection with the higher proportion of work-able inhabitants. Satellitic towns occur only in the vicinity of big towns, and satellitic-industrial towns or industrial ones with a big proportion of commuters — in industrial regions (e. g. the Upper Silesian Industrial Regions, the valley of the river Kamienna).

CONCLUSIONS

Functional structure is a tool for the investigations of the functions of towns more precise than that provided by an analysis of occupational structure. Investigators in a number of countries have reached this conclusion, as witnessed by recently undertaken attempts at classifying towns [38]. If the investigation deals with individual towns in an administrative aspect, towns constituting in reality sections of urban aglomerations (satellites), the use of the traditional professional structure would

[38] Cf. works discussed in the beginning, particularly that of Alexandersson G.

Table 12

Towns	Functional structure groups: basic	non-basic	passive	Distinctions in basic group: industry & handicrafts	building	communications	commerce	cult. & other serv.	administration	schools pupils	various	others	inh. empl. out of town	Number of inhabit in 1955 in thous.
	per cent													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Small towns														
Multifunctional towns														
Aleksandrów Kuj.	20.8	14.7	64.5	1.3	0.0	2.6	1.4	2.6	5.0	3.2	—	0.7	4.0	7.5
Bielsk Podlaski	30.8	14.3	54.9	4.2	2.5	0.4	4.7	3.2	7.5	7.1	—	0.6	0.6	9.2
Brańsk	23.1	18.7	58.2	9.7	2.4	0.6	6.6	0.5	—	—	—	3.3	—	2.7
Chełm	23.2	12.1	64.7	2.6	1.2	5.2	4.2	2.1	2.5	2.4	—	1.9	1.1	26.7
Ciechanowiec	19.1	12.3	68.4	8.3	—	—	2.4	—	—	4.9	—	3.5	—	3.4
Ciechanów	23.6	15.5	60.9	4.7	1.7	3.2	4.7	1.5	2.4	3.2	—	0.7	1.5	11.8
Giżycko	28.5	17.3	54.2	5.7	1.1	3.1	3.7	4.8	6.3	2.2	—	1.6	—	13.1
Knyszyn	21.6	12.3	66.1	9.1	—	—	3.3	2.3	2.8	•	—	4.1	—	2.1
Konin	29.4	14.7	55.9	3.3	1.4	0.8	2.5	9.8	6.0	4.5	—	0.3	0.8	14.2
Kościerzyna	29.3	11.2	59.5	4.4	—	3.4	3.4	2.9	5.4	6.0	—	—	3.8	9.5
Koźle	27.4	13.4	59.2	3.1	1.5	2.5	5.4	3.0	4.2	1.7	—	1.6	4.4	8.8
Lubartów	25.6	15.8	58.6	4.9	0.1	1.3	7.4	1.8	5.4	1.7	—	1.6	1.4	6.6
Łowicz	23.5	14.6	61.9	2.1	0.8	1.9	2.6	1.9	3.2	3.3	—	1.0	6.7	16.1
Międzyrzecz	32.5	9.0	58.5	4.6	0.7	4.6	3.2	6.8	5.4	3.2	—	3.8	0.2	9.6
Ostrołęka	26.3	12.4	61.3	1.2	0.4	4.8	3.1	1.5	5.3	8.6	—	0.6	0.8	12.3
Reszel	27.9	14.2	57.9	12.0	—	—	2.9	3.9	4.2	—	—	4.9	—	3.3
Siedlce	27.7	15.6	56.7	0.3	2.0	7.8	2.7	2.0	2.8	7.1	—	0.8	2.2	28.8
Wyszogród	19.0	12.5	68.5	3.0	—	1.9	3.3	6.8	—	—	—	4.0	—	2.4

Table 12 cont'd (II)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						Specialised towns								
						b) industrial								
Andrychów	42.9	7.6	49.5	27.2	1.3	0.5	4.1	1.0	0.4	4.0	—	0.0	4.4	7.3
Chrzanów	35.7	12.5	51.8	16.9	0.9	0.7	0.9	2.1	2.8	0.3	—	0.8	10.3	18.0
Krosno	31.8	14.7	53.5	16.8	1.5	0.3	2.5	3.5	2.8	2.6	—	0.6	1.2	17,2
Łapy	32.5	18.8	48.7	29.1	0.5	—	1.4	0.1	0.1	1.3	—	—	—	6.7
Skarżysko-Kam.	32.7	9.0	58.3	18.4	2.5	6.2	0.5	1.4	0.3	2.4	—	0.1	0.9	30.9
Staszów	28.6	15.8	55.4	15.0	—	1.5	9.8	1.1	—	0.4	—	0.2	—	5.1
Strzelin	31.7	9.9	58.4	18.0	1.4	2.2	2.5	1.7	3.0	0.9	—	0.4	1.6	7.7
Trzebinia	37.5	7.7	54.8	20.5	0.5	2.8	0.5	0.3	0.2	1.0	—	0.6	11.1	6.1
Zduńska Wola	33.0	12.2	54.8	21.9	0.2	1.8	1.1	0.9	1.1	1.8	—	0.2	4.0	22.9
Żary	39.9	10.0	50.1	20.4	2.2	1.7	1.9	1.7	4.7	4.7	—	2.3	0.3	19.9
Żyrardów	42.5	11.7	45.8	28.0	0.7	0.8	1.6	1.3	0.3	0.4	—	0.4	9.0	27.2
						b) satellites								
Błonie	35.0	9.0	56.0	6.3	1.8	0.6	1.6	—	0.2	1.6	—	0.7	22.2	9.1
Koluszki	36.5	6.2	57.3	0.5	—	8.2	2.0	0.3	0.1	3.6	—	0.5	21.3	6.7
Milanówek	40.3	9.1	50.6	5.5	0.2	—	0.1	1.0	0.0	5.0	—	0.8	27.7	14.4
Pruszków	35.9	9.3	54.8	12.0	0.7	1.4	0.2	1.9	1.6	1.0	—	0.3	16.8	34.4
						c) satellitic-industrial								
Iłża	34.6	7.5	57.9	9.2	—	—	2.9	2.3	—	8.7	—	—	11.5	3.3
Szydłowiec	37.0	13.0	50.0	13.5	—	—	2.5	8.2	0.8	•	—	—	12.0	4.9
Tarnowskie Góry	31.5	9.1	59.4	8.4	0.2	7.9	1.1	1.2	2.6	1.8	—	0.5	8.2	26.2
						d) various								
Ciechocinek	32.5	12.4	55.1	0.1	0.7	0.6	0.7	1.3	—	5.6	18.4*	0.1	5.0	5.9
Zakopane	29.2	23.1	47.7	4.5	1.7	1.5	1.6	2.1	1.9	2.8	11.2*	0.7	1.3	23.6
Kudowa	45.9	10.5	43.6	24.1	—	1.7	1.3	1.0	0.3	—	14.5*	1.7	1.3	5.5
Otwock	33.7	8.0	58.3	—	—	0.6	0.7	1.7	0.1	4.7	8.6*	1.6	15.7	31.1

Table 12 cont'd (III)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Myszyniec	20.5	10.5	69.0	2.6	—	12.2	2.2	1.1	1.2	—	—	1.2	—	1.9
Chojnice	26.3	15.3	58.4	4.0	1.6	7.0	4.4	2.5	2.7	1.9	—	0.3	1.9	17.7
Iława	26.2	11.0	62.8	7.8	0.3	9.1	2.1	0.6	2.2	1.1	1.8**	0.8	0.5	9.5
Darłowo	28.8	13.9	57.3	5.9	1.1	3.9	8.1	1.3	0.2	3.2	4.2**	0.6	0.3	6.7
Świnoujście	35.2	12.4	52.4	3.0	7.5	4.8	1.2	0.6	3.6	1.5	3.0**	3.7	6.3	9.3
Medium towns Multifunctional towns														
Przemyśl	23.5	17.1	59.4	2.6	1.4	2.4	1.7	1.0	2.6	7.1	—	1.6	3.1	41.9
Słupsk	27.1	17.2	55.7	8.3	0.9	4.4	2.4	1.0	3.3	3.5	—	2.5	0.8	44.2
Tarnów	26.4	15.7	57.9	2.8	2.5	4.4	2.0	1.0	3.0	7.0	—	0.3	3.4	58.8
Toruń	32.3	13.8	53.9	9.6	1.1	3.6	2.4	2.0	2.5	7.6	—	0.8	2.7	92.5
Białystok	32.5	9.8	57.7	6.9	4.7	5.1		13.4		1.3***	—	—	0.1	97.2
Towns specialised industrial														
Dzierżoniów-Bielawa	40.0	13.4	46.6	30.8	0.4	0.7	2.0	0.6	1.6	2.9	—	0.3	0.7	50.9
Elbląg	30.6	13.6	55.8	14.8	1.8	1.4	1.6	1.1	1.9	5.0	—	1.7	1.3	65.9
Kalisz	29.9	14.4	55.7	18.1	1.6	1,1	2.5	0.4	2.2	2.6	—	0.7	0.7	66.1
Radom	30.4	13.4	56.2	16.0	1.6	2.3	2.2	0.7	2.2	4.2	—	0.6	0.6	118.1
Big towns														
Wałbrzych	36.6	11.6	52.0	26.4	1.0	1.8	1.3	0.6	1.1	2.6	—	0.6	1.0	110.3
Częstochowa	33.6	14.0	52.0	21.9	2.4	1.6	1.2	1.1	0.5	4.4	—	0.2	0.3	149.7
Lublin	31.7	17.7	50.6	7.5	0.8	2.8	3.6	2.4	4.2	8.9	—	1.3	0.2	132.2
Chorzów	33.8	9.1	57.1	21.8	1.6	0.4	0.9	0.3	0.4	0.8	—	0.2	7.4	141.4
Zabrze	32.0	5.2	62.8	25.4	0.5	0.4	0.5	0.5	0.1	3.1	—	—	1.5	182.8
Bydgoszcz	35.5	12.1	52.4	13.9	2.1	6.0	3.2	1.9	3.5	3.6	—	0.9	0.4	202.0

* Resorts services.
** Fishing.
*** This group comprises university students only.

render impossible a definition of their specific characteristics consisting in the existence of large numbers of commuters employed out of town. Use could be made here also of data concerning commutation of inhabitants [39], besides occupational and social structures, but, in existing Polish conditions, this would be impossible because of the absence of appropriate data. Whole urban complexes could also be treated as units [40], but this would only make possible an ommission of the problem of satellites but not its solution.

The main difficulty encountered in Poland when conducting an investigation of this type is constituted by the absence of sufficiently detailed and up-to-date material. The data of the 1950 census have been published relatively late. Even those are treated according to counties and thus give separate data for towns constituting counties, where the professional structure is given in a form insufficient for distinguishing separate functional groups. All material besides census data obtained from the administrative authorities or collected during field investigations can equal census data in accuracy only in the instance of small towns.

To sum up we must state that, although an analysis of functional structure permits of a more thorough study of the functions of towns — which constitutes one of the key problems contemporarily investigated by the urban geography — yet the difficulties created by the absence of data and the excessive play allowed to a subjective approach of the investigator makes the application of this method rather difficult, particularly to investigations on a wider scale.

Translated by Zofia Wrzeszcz

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39 This metod has been applied by German investigations — L i n d e H. or L e h m a n n H., op. cit.

40 This procedure is followed by investigators of American conditions, N e l-s o n H. J. or A l e x a n d e r s s o n G. op. cit.

LUDWIK STRASZEWICZ

The Łódź Industrial District as a Subject of Investigations of Economic Geography

The Łódź Industrial District is situated in an area known as the Łódź Upland [1]. It is the most northerly section of a belt of uplands in southern Poland, penetrating as a peninsula into the wide decline of the Polish Lowland. A fairly diversified surface is the characteristic trait of that area. Particularly its eastern part, known as the Łódź Upland, is characterized by a highly developed relief, and the hills occurring here reach an altitude of almost 300 m. above sea level, with relative heights of up to 100 m. The incline of the slopes, which sometimes exceeds 3°, creates a typically hilly landscape. The town of Łódź itself, lying on the edge of the upland, has differences in levels amounting up to 100 m.

The area discussed is situated on a first order watershed dividing the Odra Basin from that of the Vistula. The watershed divides the area of the Łódź industrial district into two almost equal parts, the western being drained by the tributaries of the Warta river, and the eastern, by the rivers: Bzura, Pilica and their tributaries. The territory covered by the town of Łódź and its immediate environs located on the watershed is, by the very nature of things, deprived of major water streams, but constitutes an area of springs, where a great number of small rivers take their origin, flowing over the widest slope of the upland in a westerly, as well as in a northerly and southerly direction, and to some extent also in an easterly direction. This radial hydrographic pattern is one of the characteristic traits of the area.

The Łódź Industrial District is an area suffering from a considerable water dificiency. Surface waters are quite incapable of meeting the needs of an important industrial centre: those of the several hundred thousand inhabitants of Łódź and of the neighbouring industrial towns as well as those of the textile industry requiring an abundant water supply. It is difficult to assess with any accuracy the deficiency in water supply since the majority of industrial plants have no equipment for measuring the quantity of water used, while an important section of the population are provided with water from local sources having no water-meters. Only half of the inhabitants of Łódź draw their water supply from the municipal water system.

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[1] P i e t k i e w i c z S. *The morphological divisions of northern and middle Poland.* (Polish with English summary). „Czasopismo Geograficzne" I, 4, Wrocław 1947, pp. 123—169.

The concept of the Łódź Industrial District is mostly based on convention. The term refers to the area of the town of Łódź and its immediate hinterland whose predominant characteristic, playing a direct or indirect role in local economics, is industry — in the first place textile industry. The Łódź Industrial District covers the town of Łódź and the neighbouring industrial towns of Pabianice, Zgierz, Aleksandrów, Konstantynów and Ozorków, as well as territories in some way connected with the economic problems of Łódź and of the adjacent towns in respect of existing industrial plants, communication facilities, summer resorts, and suburban recreation grounds, as well as grounds devoted to farming of the suburban type [2].

The Łódź Industrial District covers territories belonging administraively to two voivodeships: the city of Łódź as a separate urban voivodeship, and the Łódź voivodeship. The districts covers a total area of some 2.000 square kilometres, this amounting to ca. 12% of the total area of Łódź voivodeship and to 0.7% of the total area of the Polish State. The Łódź Industrial District which counts near on one million inhabitants (approximately 4% of Poland's total population) constitutes an enormous accumulation of inhabitants, the third in size in Poland, next to Warsaw and the Upper-Silesian Industrial District. This accumulation, whose growth has not been dictated by local raw material resources, is not suitably located within the country's entire spatial settlement system. Its short distance from Warsaw, amounting to merely 130 km, is responsible for an undesirable density of population in this part of the country. The phenomenon of drawing near and even of a mutual interpenetration of the suburban zones of Warsaw and Łódź may be observed.

In spite of its central situation in Poland and its nearness to Warsaw Łódź has inadequate communication facilities with the remaining sections of the country. It lies in what may be described as a „communication triangle" between the main railway lines: Warsaw—Katowice, formerly known as the Warsaw—Vienna railway line, running at a distance of 25 km from Łódź, Warsaw—Poznań, passing Łódź at a distance of 67 km and the Katowice—Gdynia so-called „coal-railway line", passing Łódź at a distance of 40 km.

The Łódź Industrial District emerged in the eighteen twenties in result of the economic policy pursued by the government of the Kingdom of Poland. The main objective of this policy, characterised by far-reaching realism, was to raise the country industrially through the introduction of the then new, improved capitalistic economic patterns. Minister Lubecki was the author of this economic programme; he placed an ambitious plan of industrialisation before the country then exhausted by many years of war and economically backward [3]. The Kingdom of Poland created at the Congress of Vienna was politically united with the Russian Empire. This political union, although so abhorrent to the Polish people who value

[2] Straszewicz L. *The Lodz Industrial District as discussed in the project of the regional plan* (Polish only). „Łódzkie Czasopismo Gospodarcze", No. 1, Łódź 1958, pp. 25—48.

[3] Zdzitowiecki J. *The Duke — Minister F. X. Drucki-Lubecki 1778—1846* (Polish only). Warszawa 1948.

independence above everything else, provided nevertheless important economic advantages resulting from the existence of a high protective customs tariff dividing Poland and Russia from other countries and protecting their industries from the emulation of the West, particularly of Prussia. Lubecki decided to utilise the expansive eastern markets in favour in Polish industry. It was his main objective to take advantage of the specific economic situation in which the newly created Kingdom of Poland found itself. He held the view that the Kingdom of Poland could profit considerably from that situation until the time when the industrial revolution proceeding from the West should reach Russia.

The government programme for the country's industrialisation envisaged as a basic measure the recruitment to the Kingdom of Poland of skilled foreign artificers from the more highly industrialised western countries and their settlement in specified factory towns. The recruitment campaign was actually limited to German lands, but not always to German nationals. New settlers coming to Poland comprised Poles from Greater Poland, Czechs and Silesians. Besides immigrants from Prussia and Saxony, there were also arrivals from France and England.

The western lands of the then voivodeship of Masovia and the adjacent territories of the voivodeship of Kalisz were considered by the government to be the most suitable areas for new industrial settlements. Some of these settlements emerged as completely new towns, established by private owners, others as government towns in the vinicity of those already in existence and even within their very area. This was the manner in which the „new towns" of Pabianice, Zgierz and Łódź emerged. Łódź was set up as a modern town in the eighteen twenties. It received a municipal character as early as the 14th century, but for almost five centuries of its existence it continued as a small, destitute and mean town situated in the midst of a vast forest, far from the then existing economic and social centres. Towards the close of the 18th century Łódź was more like a village than a town as regards the number of inhabitants and type of buildings: it had short of 50 houses with thatched roofs, inhabited by not quite 200 people, mostly farmers [4].

The Polish textile industry was initiated by the government of the Kingdom of Poland, whose activity in this respect was later assessed as „a brilliant page of the history of planning in Poland" [5]. This statement is of importance to us, making it possible to understand many seemingly obscure circumstances and alleged contraditions in the initial phase of the Polish textile industry and the growth of Łódź as the principal centre of that industry.

Germany's economic situation at the time favoured the immigration of artificers to the Kingdom of Poland. The industrial revolution which introduced machines to the English industries already towards the close of the 18th century reached German lands only some decades later, and

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[4] Stebelski A. *Lodz and environs at the end of XVIII age* (Polish only). „Rocznik Polskiego Towarzystwa Historycznego w Łodzi" 1929—1930, Łódź 1935.

[5] Ostrowski W. *A brilliant page of the history of planning in Poland* (Polish only). Warszawa 1947.

the cheap machine-made products of the English industry constituted dangerous competition for the local manufactures. The impact of this difficult economic situation in Germany was strongest upon poor artificers. The instance of German immigrants, who left their country to flee from progress not being able to hold their own is very significant. What is already obsolete in one country and must give way to more progressive and modern techniques and organizational patterns, still continues for a long time to be a manifestation of progress and modernity in another.

It often seems unintelligible why Łódź and the entire Łódź region played such an important part in the government's industrialisation plan. The reason were manifold. Undoubtedly geographical location at a small distance from the then frontier, favourable to the settlement of immigrants, as well as a certain tradition in the manufacture of textile goods which, though weak, still lingered in western Masovia, favourable location in relation to the seat of the voivodeship authorities, as well as many other factors constituted some of these reasons. The fact was also of great significance that the voivodeship authorities were then headed by Rajmund Rembieliński, whose role in the implementation of the government programme was later discussed in literature on many occasions [6]. The fact that Łódź rather than any other town became the great centre of the Polish textile industry, that a whole industrial district grew up on the Łódź Upland — is largely credited to this outstanding figure.

Łódź itself offered many advantages resulting from its geographical location. As already mentioned at the beginning, it lies in the elevated, most northerly section of the uplands of southern Poland, and its environs differ considerably from the neighbouring lowlands of Greater Poland and Masovia. In seeking connections between geographic environment and the economic development of Łódź, we must place much emphasis on this distinct geomorphological character and the geographical peculiarities of the country around Łódź. The vast lowlands lying on the outskirts of the Łódź Industrial District of to-day were the site of a lively settlement campaign already in the initial stages of Poland's existence as a state, while in the neighbourhood of Łódź, on the watershed between the Vistula and the Odra, there stretched existence forests, which, even in the 19th century, had an important influence over the fate of these parts and contributed indirectly to the emergence here of an industrial district [7].

The territory around Łódź was then State property thus obviating difficulties connected with land grants to new arrivals of the type experienced in other towns in view of complicated property titles, characteristic of the towns of the period. The authorities had here at their

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[6] This problem was discussed by Flatt O. in *Description of Lodz as regards its history, statistics and industry,* Warszawa 1853. Lorentz Z. *Reports of R. Rembieliński,* „Rocznik PTH w Łodzi" 1929—1930, Łódź 1935. — *Rajmund Rembieliński — builder of industrial Lodz,* Rocznik Łódzki III, Łódź 1953, pp. 39—45 and others.

[7] Cf. the works of Dylik J.: *Unites morphographiques des environs de Lodz,* Łódź 1948 and *The development of settlement in the Lodz-region,* Łódź 1948. (Polish with French and English summary).

disposal building sites and timber as constructional material. Water was also one of the assets resulting from geographical location. It is probably the greatest paradox connected with Łódź that favourable water conditions were the very factor which contributed to the development of the town. The spring areas of the watershed were then the origin of numerous streams, whose significance lay in the cleanliness of their water — an important factor in the fabric finishing process — as well as in the energy which they provided. Undoubtedly these favourable conditions as far as water supply is concerned stood in some connection with the existence of the neighbouring forest, whose role in this respect was very significant.

The first period in the history of the growth of the Łódź Industrial District closed in 1831 when the fall of the November Insurrection against Russia and the political defeat of the Kingdom of Poland unleashed a serious crisis in the young textile industry then only ten years old. During this original period of its existence Łódź was but a small town, although with an extensive layout. Before the Insurrection it counted not quite 5.000 inhabitants. The neighbouring town of Zgierz was almost twice its size, being a centre of the woollen industry and central town of the district. Zgierz suffered most heavily by the fall of the Insurrection, since the crisis which followed upon it hit hardest the woolen industry — the most important buyer of cloth — the Polish army — having gone out of existence. But the crisis had a favourable effect upon Łódź, where the cotton industry was already developed and which won primacy over all manufacturing towns of the Kingdom of Poland [8].

The whole history of Łódź is inalienably bound up with the growth of the textile industry — is, to some extent, — a function of this growth. But Łódź, while expanding into a big settlement through a great accumulation of inhabitants, failed to develop the characteristics of a town notably those of a cultural and social centre, a centre providing services for a specific territory and so on. While increasing the number of its inhabitants and its houses, Łódź remained for a long time a large factory settlement.

Already in the initial period of the town's growth an important change occurred in the Łódź industry as a result of the changing structure of the textile industry and of a shift of the centre of gravity to cotton manufacturing. A more rapid development of capitalistic forms of production was the outcome. The cloth industry was, in large measure, based on the work of artificers, while small craftsmen were out of place in cotton manufacturing processes. The rapid growth of cotton mills, and later of cotton factories, brought about a fundamental change in the manufacturing situation.

It should also be noted that the weavers arriving in the Łódź district were poor and constituted a semi-proletariat. These small producers, who were economically weak, easily lost their independence falling under the sway of merchants and go-betweens. This was one of the causes of the emergence in the Łódź District of plants engaging in diverse operations

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[8] Cf. Ostrowski W., op. cit.

with a far-reaching vertical concentration, unknown anywhere else in the world outside of Japan.

The system of home industries showed the strongest development particularly in the thirties and forties of the past century. This system was one of the chief means of accumulating capital by the financially stronger entrepreneurs by means of unlimited exploitation and expropriation of weaker competitors. Merchants belonged to the first type, and small handicraft workshops to the second. It is a highly characteristic fact that the later proprietors of great spinning and weaving plants in Łódź were overwhelmingly recruited from among merchant-entrepreneurs.

The new manufacturing technique consisting in the application of machinery began to develop in Łódź after the year 1850. Łódź was then still a small town of under 20.000 inhabitants. Twenty years later it already counted 50.000 inhabitants, being one of the biggest industrial centres in Poland and the main centre of the Polish textile industry. The extention in 1866 of the railway line linking Warsaw with Vienna finally consolidated the primacy of Łódź over the industrial towns of the district. The fact that the railway was owned by a private company was responsible for the typically capitalistic chaos then introduced into the spatial distribution of the Łódź textile industry. During the period when economic life was controlled by the government of the Kingdom of Poland the textile centres developed at a uniform pace, but the railway company found it most convenient to build a railway to Łódź only. At this period, when transport costs already played an important role in the economics of a textile mill — a railway connection for Łódź and its absence in other towns of the district had a degenerating influence on these smaller centres and widened the disproportion between Łódź and the towns neighbouring upon it. Zgierz, counting 12.000 inhabitants at the time, and Pabianice with some 10.000 inhabitants, were definitely outstripped and reduced to the role of quasi-satellites [9].

During the last thirty years of the 19th century the growth of the Łódź industry assumed a lightening pace. During the period between 1860 and 1897 the value of the industrial output of the town increased 25-fold and there was a parallel growth of the town itself. It was so rapid that no analogy for it can be found in Europe. During the decade between 1870 and 1880 the town's population increased more than twofold — from 50.000 to 112.000, and in the two decades that followed this number increased threefold: in 1897 Łódź counted 315.000 inhabitants. According to St. K o s z u t s k i's computation the population of Łódź increased 1361% during the forty-year period between 1857 and 1897 [10]. Hobson made the statement that, during the whole century, Leeds was the only town in Europe which showed a more rapid rate of growth (1,500%) [11].

A tendency towards spatial and economic concentration is one of the

[9] Cf. S t r a s z e w i c z L. *The suburban zone of Lodz.* (Polish with English summary). „Przegląd Geograficzny" XXVI, 4, Warszawa 1954, pp. 182—197.

[10] K o s z u t s k i S. *The development of the great industry in the Kingdom of Poland* (Polish only). Warszawa 1901).

[11] *The evolution of modern capitalism, a study of machine production* by John A. H o b s o n M. A., London 1894 (Polish translation, Warszawa 1898).

basic traits of the growth of modern industries. This becomes evident with particular clearness in the instance of the cotton industry. The Polish cotton industry went through a concentration process at the close of the past century. Geographically it concentrated in the Łódź District, particularly in Łódź itself. Economically it concentrated into large enterprises characteristic of the cotton industry the world over. The average number of workers employed by cotton factories amounted to 34 in 1870, 95 in 1884, 161 in 1891, and 570 in 1897. It was this period that the type of cotton factories engaging in diverse manufacturing processes, so characteristic of Łódź, took final form. They combined three basic production processes: spinning, weaving and finishing. This phenomenon was the outcome of a relatively brief but extraordinarily rapid growth of the Łódź industry. It differed in this from the English industry where, in spite of progressing concentration, the type of smaller enterprises engaging in one branch of manufacturing with a higher degree of specialisation was maintained.

At the turn of the 19th into the 20th century Łódź was already a very big industrial city not merely on a national, but also on a world scale. The textile industry in Łódź and in its suburban zone provided employment for some 80.000 workers, 45.000 of which were employed in the cotton industry. These figures placed Łódź in the foremost rank of the world cotton industry. Since the very beginning of its existence, a one-sided structure as regards branches of industry was its main characteristic, one not met with in agglomerations of such a size. The share of the textile industry in overall industrial employment in Łódź amounted to as much as 93%. A significant characteristic of the Łódź industry should here be emphasized, notably, the fact that it worked largely for export. At the beginning of the present century, the Łódź textile industry exported over half of its output.

The factor of location, which played a decisive role in the growth of Łódź in the twenties, very soon lost its significance and already in the latter half of the 19th century had no influence whatever on the development of the town or its industry. On the contrary, after the lapse of a dozen years or so these factors had even an inhibiting effect on the development of industry, although — judging by facts — this was not very effectual.

The geographic environment did not favour the growth of a big factory industry and a big accumulation of inhabitants. The abundant water supply which the region once enjoyed diminished steadily in consequence of the clearance of forests on the watershed, and the rapidly increasing demand on the part of the textile industry could not be adequately met. The small rivulets that were drying up and that constituted natural outlets of factory waste and also partly of sewers, soon became transformed into stinking channels incompatible with the most primitive principles of urban hygiene. The big Łódź industry had from the very beginning to overcome great difficulties connected with water supply. In the absence of surface water new springs were sought down below by drilling ever deeper wells.

A city of several hundred thousand inhabitants had to rely on the initiative of its inhabitants so far as water supply was concerned. Primitive wells, largely shallow, often periodically drying up, yielding more or less contaminated water, presented a characteristic picture of the squalor and backwardness of this „Polish Manchester". Water — that great asset of Łódź at the time of the Kingdom of Poland — has for the last hundred years been its main drawback.

The other factors which played such an important role in the period when Łódź was growing up — also lost all their significance for the big factory industry which developed in the latter half of the 19th century.

The adoption of modern manufacturing techniques placed before Łódź problems of transport, especially of coal transport. For this reason the construction in 1866 of a railway line linking the town with Koluszki was of great importance to Łódź, although it did not solve all the transport difficulties of this big town. This investment initiated the third phase of development of the Łódź industry.

The growth of a big factory industry proceeded in spite of the natural factors of geographic environment and in an unfavourable geographic situation. The Łódź industry imported its raw materials from distant continents in order to export its manufactured goods to often equally distant eastern markets. The British Lancashire industry worked in similar conditions, with the difference, however, that it had a good local supply of water and cheap coal, while Łódź struggled with a deficiency of water, hauled its coal from a considerable distance and its situation as regards transport was not of the best. Thus, the powerful development of Łódź towards the end of the 19th century and at the beginning of the 20th is, to economists, an astounding phenomenon.

We must state plainly that the set of favourable economic circumstances which provided the Polish industry with practically unlimites export possibilities constituted the foundation of the growth of the Łódź industry which was able to compete successfully with Russian industries. But available markets would not by themselves have produced such an effect in the absence of other factors to which Łódź owes her development.

Besides the advantages flowing out of a concentration of industrial plants, only one other factor exercised an influence; notably — cheap labour. Labour is often a decisive factor in locating production plants, usually in combination with local manufacturing traditions resulting in an adequate local supply of skilled workers. It sometimes also consists in the availability of large reserves of unskilled and very cheap labour. Łódź owes its growth largely to the labour factor in its latter form. In consequence of the Uprising of January 1863, and of the functioning of a secret National Government — serfdom was abolished in the territory of the former Kingdom of Poland in 1864 and peasants were awarded land grants. Łódź became at that time the goal of migration of destitute inhabitant of rural districts who moved in great numbers into the town. Until that time foreign nationals predominated not only among entrepreneurs, but also among workers. A mass influx to peasants into the town decided the Polish character of the Łódź proletariat.

Foreign entrepreneurs found it profitable to build factories in Łódź and in the adjacent towns, to haul cotton, wool and coal from great distances, to export their wares to distant eastern markets, since low wages and the low standard of consumers' requirements guaranteed high profits, in spite of high transportation costs. The Łódź proletariat of peasant origin formed the basic group of the town's population. Low wages and the low standard of living of Łódź workers was a fundamental condition of the city's rapid growth. The inflowing population had no requirements whatever as to housing, cultural services or health services and did not ask for municipal facilities of any kind. Coming from rural districts where conditions were still more primitive at the time, these new arrivals remained unaware of the odious character of conditions in Łódź. The colonial character of the town formed the basis of the growth of big industries in Łódź [12]. The local working proletariat payed by its squalor for all the deficiences of location of this big industrial centre and created the necessary conditions for its further development.

The rapidly growing city owed everything to the textile industry, i. e. the violent increase of its population, as well as its faulty outlay, violating all the rules of town-planning. Łódź was a foreign element among its surroundings, a parasitic creature draining of their supply of labour.

The Łódź industry developed without intermittance up to the outbreak of the world war in 1914, occasioning a growth of the city which reached a population of 506.000.

The world war and the drastic political changes which followed upon it in the years 1914 to 1919 had a most adverse effect upon the Łódź industries. The textile industry incurred heavy losses as a result of war requisitioning, of protracted stoppage of manufacturing processes and particularly through the forfeiture of its assets in Russia.

In 1919 the Łódź industry found itself in a completely novel economic situation. On the one hand it felt very keenly the loss of the Russian market, which had been the mainstay of its existence. On the other hand, is was now faced by a completely different domestic market comprising, instead of the 12 million inhabitants of the former Kingdom of Poland, the 28 million inhabitants of restituted Poland. In relation to the new domestic market, which increased during the interwar period to 35 million inhabitants, the production potential of the Polish textile industry was none too big. Nevertheless, in spite of its size, the domestic market did not provide a sufficient outlet for Polish textile goods. This was a consequence of the specific range of goods produced before the war, adapted to the requirements of eastern markets, and of the low level of domestic consumption [13].

The unfavourable market conditions resulting from political and economic changes were fairly soon overcome by the Łódź industry, but nevertheless throughout the entire interwar period it had to struggle continously to secure markets.

During the interwar period, an overwhelming majority of the Polish textile factories were concentrated in Łódź district. The Łódź voivodeship accounted for 90% of total production capacity of the Polish cotton industry, and for ca. 50% of that of the woollen industry; the town of

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[12] Koszutski wrote on this subject, op. cit., also Szczepański J., *The general characteristics of Lodz* (typescript), Łódź 1947.

[13] Krasuski E. *The cotton industry in the post-war Poland* (Polish only). Łódź 1935.

Łódź — for 80% of the production capacity of the Polish cotton industry and ca. 40% of that of the woollen industry [14].

The sudden change in the economic situation in the twenties and the economic crisis in the thirties were the causes of great fluctuations in employment within a range of 50 to 100.000 workers.

The end of the First World War constituted for Łódź the beginning of a new stage in its history. Until that time, in spite of having attained a population of half a million, Łódź still remained by character only a big industrial settlement. From now on it became a big city with various functions, although these were not greatly developed. In independent Poland it became the seat of voivodeship authorities and of all kinds of other authorities and official agencies of second order of importance (military, ecclesiastical and so on), whose number increased steadily. In spite of this however, in the year 1929, to 600.000 inhabitants of the city — 125.000 or 21% of the total were industrially employed — of this 106.000 in the textile industry. During the entire interwar period the textile industry, and particularly the cotton industry, had a decisive influence on the town's character. As far as town-planning goes, the outward appearance of Łódź took shape as early as the beginning of the present century as a chaotic complex of dwellings and industrial plants forming a mosaic on a canvas of streets ill-adapted to the functions assigned to them.

The Second World War together, with the social and economic changes which occurred in Poland after its termination, opened the latest stage of the development of Łódź.

The town lived through the period of German occupation in difficult conditions. The German authorities were not interested in its development or even in sustaining the Łódź textile industry which constituted an important competitor to German manufactures. The plants that were most valuable from a technical point of view were dismounted and removed to the Reich, while those that remained were subjected throughhout the period of occupation to the predatory methods of a war economy.

After the war the Łódź industry quickly resumed its operations. In consequence of the changes effected in Poland's social and economic system textile enterprises were nationalised and reorganized, generally into big manufacturing units. The number of workers employed in the textile industry of the Łódź district increased considerably. This was brought about by a better utilisation of machinery through the introduction of the multiple-shift system. The overall volume of goods produced was thus materially increased, but at the same time the existing machinery and equipment began to wear out more quickly lowering in consequence the technical efficiency of the local factories, which was already low. A shortage of adequate funds for new investments as well as for indispensable overhauls caused the value of the Łódź industry to decline still further in the last decade or so.

From this brief outline of the economic development of the Łódź Industrial District the role of the textile industry is clearly visible. It was rather like that usually played by heavy industry and differed considera-

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[14] Bajer K. *The outline of industrialization of Lodz voivodeship* (Polish only). Łódź 1928.

bly from the part habitually played by light industries, whose location is, as a rule. dictated by the existence of large accumulations of population or of large industrial centres. In this connection the economic pattern of the Łódź district is similar to that of industrial districts based on the extraction of local raw materials. For instance, both Polish great industrial agglomerations, i. e. the Upper Silesian Coal Basin and the Łódź Industrial District emerged and developed exclusively due to industry, without any participation whatsoever of other basic factors. Nevertheless, unlike the Upper Silesian Basin, which developed in a consistent and logical way, the Łódź Industrial District is an instance of a great production centre the only argument in favour of whose existence consists at present in its technical investments, great accumulation of inhabitants and a vital — although weak — manufacturing tradition. The fact that the Łódź textile industry reached the peak of its growth before 1914, and that the growth of Łódź as a great urban organism dates from the year 1919 makes it possible to classify the Łódź Industrial District as an industrial accumulation of the type termed by J. Chardonnet as industrial complex [15].

As has been shown above, the textile industry has so far been the basic town building factor in Łódź and the Łódź region. That industry, until recently practically the only basic town building factor, is apalingly obsolete from the technical standpoint, this finding its reflection in employment figures. Of the 240.000 people employed by industry in the Łódź Industrial District almost 170.000 or 72% are employed by the textile industry. These figures witness to the role of the Łódź district as a great textile manufacturing centre on a world scale [16]. They also witness to the size of the textile industry and the underdevelopment of other branches of production. In the vast area of this district almost 40% of all Poland's textile workers are employed, and somewhat more than in the entire Czechoslovakia's textile industry.

The cotton mills constitute the basic branch of the Łódź textile industry, being adapted to the manufacture of cheap articles on a mass scale. These mills handle all three phases of cotton goods manufacture. The Łódź spinning mills have a total of ca. one million spindles, that is over one half of the overall number of spindles in Poland and ca. 1% of the word's spindles. The spinneries use as raw material imported cotton in about 80% and synthetic fibre supplied by a local Łódź factory and by factories in the neighbouring towns of Tomaszów Mazowiecki and Chodaków in 20%.

The weaving mills of the Łódź district dispose of near on 20.000 looms. As a rule, they process yarn produced by the local plants, but by reason of the imperfect coordination of manufacturing equipment, certain amounts of yarn from other cotton spinning centres are brought to Łódź, primarily from that of Lower Silesia.

Finishing plants constitute a serious problem of the Łódź industry.

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[15] Chardonnet J. *Les grands types des complexes industriels,* Paris 1953, and Straszewicz L., *The Lodz industrial complex* (Polish with English summary), „Przegląd Geograficzny" XXIX, Warszawa 1957, pp. 741—777.

[16] Allix A. and Gibert A., *Geographie des Textiles,* Paris 1956.

These are plants handling the last stage of the process of manufacturing tissues and require a plentiful supply of water for their operations. This fact is the reason why their location in Łódź and in the neighbouring towns situated near the watershed is very unfavourable both for them and for the local towns. For this reason a removal of the finishing plants from Łódź to localities possessing favourable water conditions and situated as close to the town as possible is now envisaged. Such a solution is practicable in view of the poor technical condition of the majority of finishing plants as well as in view of the fact that costs of transportation between the weaving and the finishing plants will not affect the economics of production, considering the high value of the goods thus carried.

The cotton industry in the Łódź industrial District employs some 80.000 workers or over 60% of the total number of workers of the Polish cotton industry. In Łódź itself the cotton mills employ almost 60.000 people, i. e. almost half of all those employed in the textile industry of that city. These employment figures place Łódź among the world's biggest cotton manufacturing centres.

The specific historical conditions which attended the growth of the Łódź Industrial District are responsible for the fact that its equipment and machinery are to a great extent obsolete and inefficient. Most of the equipment dates from before the First World War and a considerable portion from before 1880. The large number of workers employed in manufacturing processes is a consequence of this situation.The low productivity of the Polish coton industry attracted the attention of Polish economists in the interwar period and was a cause of worry. At present it constitutes one of the basic problems of the Polish textile industry, primarily of the cotton industry. It is also a matter of fundamental importance to the demographic development of the Łódź district and primarily of the town of Łódź. The modernization of manufacturing processes in the textile industry envisaged in economic quarters will cause a considerable reduction in employment in the Łódź industry.

The organizational structure of the Łódź industry is also a consequence of historical processes, its characteristic feature being the gigantic size of its plants. The big cotton factories of the Łódź Industrial District are among the world's largest. This, in a certain measure, makes reorganization more difficult, and will complicate a future shifting of those plants to the manufacture of a different range of goods from that now produced. From the point of view of town-planning the Łódź cotton plants, such as the Mickiewicz, Kościuszko, Defenders' of Westerplatte, Defenders' of Warsaw, Marchlewski or First of May factories constitute distinct spatial units covering considerable industrial areas, in some instances intersected by railway branches and surrounded by cheap tenement houses inhabited by workers. But the majority of plants are scattered among dwelling houses all over the city. Industrial buildings are also in a poor technical condition, similarly as equipment and machinery. Factory buildings consist largely of many-tiered constructions, which do not correspond to the requirements of modern manufacturing processes.

In the area of the Łódź Industrial District cotton plants are mainly concentrated in the town of Łódź. Other important centres of this industry are Pabianice and Ozorków. The Pabianice cotton plants have a total of 90.000 spindles, almost 3.000 looms and a big finishing plants of an annual capacity of over 60 million metres of tissues. They employ near on 10.000 workers. The plants at Ozorków also have mills handling all phases of production. There is a spinning mill counting over 20.000 spindles, a weaving mill with nearly 900 looms and a finishing plant of an annual capacity amounting to 30 million metres. These plants employ ca. 3.000 workers. The cotton industry at Zgierz is on a much smaller scale. It comprises merely a spinnery with twenty odd thousand spindles employing ca. 1.000 workers.

The woollen industry plays a much less significant role in the Łódź Industrial District. Total employment in this branch of industry amounts to ca. 35.000 people, including 27.000 in Łódź. Outside of Łódź there are woollen industry factories at Zgierz, Pabianice and Konstantynów. At Zgierz — a traditional centre of the cloth industry — the woollen industry plays an important role, employing 4.000 workers. In Pabianice the woollen industry is not a match to the cotton industry. It employs not quite 3.000 workers. In the town of Konstantynów, which is a suburb of Łódź, there are woollen plants exclusively. Total industrial employment in that town amounts to ca. 1.500 people. Tomaszów Mazowiecki, situated at a 40 km distance from Łódź, is also a big centre of the woollen industry.

The woollen industry is even in a worse technical condition than the cotton industry. The majority of existing machines are of an obsolete type, comprising even several score handlooms that are still operated. But the technical backwardness of the woollen industry affects the quality of its products and its economic indices to a much smaller extent that of the cotton industry, where production is based on much cheaper raw materials. On the other hand, the woollen industry has much less favourable conditions of development in the Łódź Industrial District because of the more important role played by water in its manufacturing processes. In the manufacture of woollen goods the quality of water is of considerable significance, let alone its quantity. This goes particularly for finishing plants, whose presence in the district is still less justified than that of cotton finishing plants.

The role played by the manufacture of silk and decorative tissues is somewhat less than that of the woollen industry. This branch of industry has developed in the latest period: during the interwar years and, principally, after the Second World War. Technical conditions in the silk industry are highly unsatisfactory. In this respect it differs but slightly from the cotton and woollen industries. The machines and equipment are largely obsolete and of a great variety of types — a circumstance which makes their proper utilisation difficult. The manufacture of silk as well as of decorative tissues is mainly concentrated in Łódź. The Łódź plants belonging to these branches of industry employ over 13.000 workers. Outside of Łódź there are some plants of the manufacturing silk and decorative tissues industry — small in size — at Zgierz and Pabianice.

Łódź is also then main centre of the Polish manufacture of knitware and hosiery. This branch of production is relatively less developed in

Poland than in the industrialised countries of Europe. Its operates mainly small, primitive mills, that are merely administratively organized into larger manufacturing enterprises. Some 20.000 people are employed in the knitware and hosiery mills of Łódź. Aleksandrów is also an important centre of these manufactures. The two small manufacturing towns of Aleksandrów and Konstantynów neighbouring on Łódź are extremely specialized in this type of production. As has already been mentioned, Konstantynów has woollen factories exclusively, and Aleksandrów hosiery mills only.

Big centres of the textile industry constitute appropriate areas for the development of the clothing industry which relies on the textile industry for its supply of raw material and, as a rule, is located within large accumulations of population. The clothing industry, of whose workes higher skill is demanded, but which also pays higher wages, usually ousts the textile industry — particularly spinneries and weaving mills — from big industrial centres, taking over the role formerly played by them. This happened long ago in Manchester, where the clothing industry employs at present almost twice the number of people working in the textile industry. In Łódź the situation is entirely different. The clothing industry is relatively weak here and employs 16 times less people than the textile industry. Outside Łódź there are plants of inconsiderable size in the neighbouring Pabianice and Zgierz, as well as in Brzeziny, a small town with ancient traditions of home-tailoring.

There are also in the Łódź Industrial District industrial plants whose links with the textile industry are fairly strong by reason of the type of their production, technology and economics. The textile industry employs, as has already been said, over 70% of the total number of industrial workers in the district, and the industries „related to the textile industry" only about 20%.

Besides the textile industry, the engineering and electrical industries are at present of greater significance in the Łódź district. They employ together over 20.000 workers. The former has many ties with the textile industry, since a number of its plants, for instance, the factory of textile machinery, repair and assembling plants as well as others, work for the latter. There are, nowever, other plants in this branch of production that are not immediately connected with the textile industry, notably: factories of machine-tools, radiators, telephone apparatus, and others in Łódź, and the factory of electric bulbs at Pabianice.

As has already been said, one of the basic problems of the Łódź Industrial District consists in the faulty and one-sided structure of its industry. The envisaged reduction of employment of the textile industry in consequence of modernization of its machinery and of the possible transfer of the plants requiring a particularly abundant water supply from the water deficient area of the watershed should contribute to an improvement of that structure. The decline in textile employment should, at least in some measure, be compensated by greater employment in other branches of industry occasioned by the setting up of new plants. In view of the specific economic and social problems of the district, these newly set up plants will have to answer to a number of conditions. They will have:

1) to constitute complements of the existing textile industry;

2) to employ chiefly men, for the sake of a healthier structure of employment, the textile industry now employing chiefly women;

3) to be of a type requiring relatively little water for their manufacturing processes, as well as;

4) to be of a type employing highly skilled workers in order to create a conterbalance to the textile industry employing mainly unskilled labour.

The development of the engineering industry is of special significance to the improvement of the industrial structure of Łódź. Particularly its branches manufacturing textile machinery and precision instruments answer these requirements in full and should find favourable conditions for development in the Łódź Industrial District as an industrial centre and an important centre of technical science and thought.

The chemical industry operates three very big plants in the district — in Łódź, Zgierz and Pabianice. Thery are closely connected with the local textile industry. The Łódź works manufacture synthetic fibre, while the factories at Zgierz and Pabianice emerged as manufacturers of dyestuffs and reagents for textile production. The Pabianice plants slowly changed the type of its production and has become one of Poland's main pharmaceutical factories.

Generally speaking, conditions in the Łódź Industrial District do not favour much the development of the chemical industry, which largely calls for an abundance of water and yields much sewerage that is difficult to dispose of. In this connection regional plans for this area envisage a restriction of the growth of the factory producing synthetic fibre and the closing down of factories of the rubber industry now in existence in Łódź.

Of much smaller importance to the Łódź Industrial District are the wood, paper and leather industries, employing several thousand workers each. These do not have appropriate conditions for development in the district because of the absence of local sources of raw material (wood industry), as well as because of the large water requirements of their manufacturing processes (paper and tanning industries). The foodstuffs industry, working to meet the needs of the local population is also of smaller significance.

Of special importance to the city is the film industry. After the war, the main Polish film centre was created here having locally at its disposal studies of feature and educational films as well as plants producing cinematographic equipment.

As regards its demographic aspect, the Łódź Industrial District may be counted among exceptional accumulations, its centre being constituted by a big city, while its suburban environments remain underdeveloped. The whole complex, formed under the influence of the textile industry which developed with elemental force up to the First World War, shows glaring disproportions between its centre and its outskirts. These disproportions have had a tendency to increase within recent years. They are firmly connected with the considerable condensation of industrial plants and population in the centre of the complex. Of the total population of the district, which is but little short of one million — 700.000 or over 70 per cent live in Łódź, and less than 300.000 or ca. 30% in the remaining area [17],

[17] Straszewicz L. *Relations between places of work and places of*

this being a consequence of the already mentioned process of condensation of the textile industry in Łódź itself, proceeding in an entirely different manner from those in other agglomerations of that industry. In the latter, after the first stage of its growth, the textile industry was outsted from the centres of settlements by other industrial plants, requiring higher skill from their workers in exchange for higher wages. Manchester is an instance in point. According to H.B. Rodgers' the industrial structure of the town expanded gradually in the course of the last hundred years and, at present, not cotton spinneries, but a factory of the engineering industry is the symbol of industrial Manchester [18]. In 1934, the textile industry employed in that town merely 11 per cent of all industrial workers, and operated mainly finishing plants, closely linked with marketing organization. At the same time the clothing industry employed 19% of all industrial workers, the engineering industry — 20%, the chemical industry — 7%, the polygraphic industry — 6%, and so on. The textile industry in the world's cotton capital provided employment for merely ca. 18.000 people or under one seventh of the number of employed in Łódź. Of particularly vital significance is the fact that the textile industry (together with the clothing industry) developed in the region of Manchester which had only a restricted area as its hinterland. In 1943, only 46% of all workers of the textile industry in the region were employed in Manchester itself [19]. In the Łódź Industrial District, in consequence of different development processes, the majority of workers employed by the textile industry are concentrated in the town of Łódź. Over 75% of all textile workers of the district are employed in Łódź factories.

The town of Łódź it the centre of the Łódź Industrial District. In 1946 its administrative limits were moved beyond the actual city, to include Ruda Pabianicka, formerly a distinct town, several urbanised settlements adjacent to the city and some farmland immediately bordering on it. The city of Łódź now covers a total area of 212 sq. km. Let us recall, for the sake of comparison, that before the last war the area of the town covered only 59 sq. km., i.e. only about one fourth of its present area.

As regard population Łódź, now counting 700.000 inhabitants, ranks second in Poland next to Warsaw. It is thus a big city of a very specific character. In spite of its functions as the seat of administrative authorities of second order, and of being important political, cultural and scientific centre, as well as a centre of economic services of various kinds — Łódź is a typical manufacturing town. Two hundred thousand of its inhabitants are industrially employed this meaning that almost 30 per cent of the entire population works in industrial plants, primarily in textile factories. This latter industry employs over 130.000 persons, i.e. 70 per cent of all industrial workers and ca. 20 per cent of the total population of Łódź.

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residence in the Lodz industrial Area (Polish with English summary), „Przegląd Geograficzny" XXIX, 4, Warszawa 1957.

[18] Rodgers H. B. *Industrial Lancashire and the British cotton industry* (Polish with English summary). „Przegląd Geograficzny" XXX, Warszawa 1958, pp. 243—262.

[19] Nicholas R. *The Manchester and District Regional Planning proposals*. Norwich and London 1945.

The towns of Pabianice, Zgierz, Konstantynów and Aleksandrów, situated in the immediate neighbourhood of Łódź, form, in a sense, together with Łódź — the „Łódź Urban Complex". Pabianice and Zgierz come next to Łódź as to size in the district. Pabianice has over 50.000 and Zgierz over 30.000 inhabitants. In spite of their prominently manufacturing structure, these towns also perform certain service functions within narrow limits. Although they are not at present seats of county authorities (being urban counties), they nevertheless constitute centres of gravitation for the surrounding areas and employ in their plants the surplus labour of the neighbouring villages.

The two remaining towns neighbouring on Łódź — Aleksandrów and Konstantynów — are much smaller — falling within the 10.000 inhabitant group. These are exclusively manufacturing towns which perform no other functions.

Outside of the five towns mentioned, constituting the centre of the system in the proper sense of the term, manufacturing functions are also performed by Ozorków, located 12 km. north of Zgierz. This is a typical textile town. Ozorków counts 15.000 inhabitants but, in spite of this fairly big population, it performs no functions whatever outside of manufacturing and exercises a very small influence on the surrounding rural areas.

Brzeziny is closely connected with the textile industry; it is situated about 20 km east of Łódź. Unlike the towns mentioned before, the role of the textile industry in the growth of Brzeziny was relatively insignificant. Brzeziny which, for a long time, was the capital of a county comprising a considerable part of what is now the Łódź Industrial District, has at present, in spite of deficient transport facilities (no railway) and general economic decline — a fairly large area of gravitation. It continues to be a county seat.

The remaining town in the Łódź suburban area perform manufacturing functions only to an insignificant extent. They constitute local agricultural centres which have developed independently from the emergence and existence of Łódź. As has already been said, as Łódź grew in size and importance the remaining towns developed very slowly or even declined. Two of these, notably Lutomiersk and Rzgów, have even forfeited their town status. The only town which owes its emergence and development to Łódź is Koluszki, at a distance of 25 km from Łódź and 6 km from Brzeziny. Koluszki is the only typical satellite-town of Łódź. It was granted town status after the Second World War and owes its growth to a big railway junction serving Łódź. On the other hand, all the other towns, bigger and smaller, on the Łódź complex, do not have the characteristics of satellites in the generally accepted sense of this term, since neither their emergence nor their growth have been influenced by Łódź.

The suburban zone is inhabited by somewhat under 300.000 persons, 52 per cent of whom reside in towns and 48 per cent in villages. This small predominance of urban over rural population is clear evidence of the weak development of the Łódź suburban zone. That zone plays a very insignificant role in the economic and social sphere as compared with the city of Łódź. The growth of the population of Łódź and of its hinterland in the course of the last decades makes this perfectly clear. In the period between

1921 and 1950 the ratio between the population of Łódź and of the suburban zone underwent the following changes:

	1921	1950
Łódź	65.5	71.1
Suburban zone	34.5	28.9
Łódź Industrial District	100.0	100.0

While the population of Łódź increased during that period by about 150.000 people, in the suburban zone the increase amounted to merely 20.000 inhabitants. As regards particular towns and administrative parishes — only Pabianice showed any considerable population increase (over 50 per cent), Zgierz, Aleksandrów, Konstantynów, Tuszyn and Koluszki and six administrative parishes having shown but small increases. On the other hand, the population of Ozorków, Brzeziny and of the remaining small towns and administrative parishes declined.

The Łódź suburban zone as a whole has a population density of some 130 inhabitants per square kilometr. This density is not too high if one takes into consideration that the zone comprises ten towns, of which Pabianice accounts for 50.000 inhabitants, and Zgierz for 30.000. The population density of the rural areas of the district amounts to some 70 inhabitants per 1 square kilometer.

Near on 40 villages or somewhat over 10 per cent of all the rural settlements of the district have a population density of 40 inhabitants per 1 square kilometer. These villages are distributed throughout the region, but primarily in the compact complex west of the city reaching up to its administrative limits. Over 200 villages, or almost 60 per cent of the total number, have a population density from 40 to 80 people per 1 square kilometer. They are distributed throughout the Łódź Industrial District — more sparsely around Łódź itself — but mostly surrounding the smaller towns of the district. Of the remaining villages some 24 per cent have a population density of 80—150 people per 1 square kilometer, and about 7 per cent one of over 150 people per square kilometer.

A cartographic analysis warrants the statement that the areas with a low density of population lie immediately beyond the administrative frontiers of Łódź and that the areas with a high density of population are situated along the railway lines running from Łódź in the direction of Koluszki, Łask and Łęczyca. It is a highly characteristic circumstance that the suburban electric tramways built in the years 1907 to 1930 which have linked with Łódź in a very convenient way the neighbouring towns and settlements, have had practically no influence whatever on the emergence of new settlements or the expansion of those already in existence. This points to the specific conditions in Łódź during the capitalist period, of which mention has already been made, and to the considerable isolation of the city from its hinterland. It also stands in some connection with the fact that, in spite of the very rapid development of Łódź during the last century, the phenomenon of mass commutation to work has not been observed in this region.

In the Łódź Industrial District the locations of places of work and places of residence are remarkably well adapted, this being largely the outcome of the historical conditions already described in which the district emerged and developed in the latter half of the 19th century and the beginning of the 20th. From 1864, the inhabitants of rural settlements travelling to work in the textile factories have resided, in the vicinity of their new places of employment, in buildings that constituted the property of the factory owners, or in tenements surrounding the industrial plants. In the town of Łódź, the growing at a very rapid pace, dwelling houses were constructed in the immediate neighbourhood of industrial plants and the newly arising factories were located in the residential sections of the town. In the densely built up centre of the town, generally speaking, residenaces were distributed in harmony with the layout of places of employment.

Type of employment is not without significance here. Outside of industry, where an overwhelming majority of plants is of the basic (townbuilding) type, employment in the other functions of the basic type is insignificant, accounting in the Łódź Industrial District as a whole to about 15 per cent of the total. Outside of industry, the basic town functions primarily occur in Łódź, many authorities and institutions providing services to the voivodeship besides Łódź itself are in existence. In the other towns, the non-industrial basic town functions show weak development, Koluszki being the only exception, where the big railway junction employs a considerable number of workers.

As may be seen from the foregoing, the structure of employment in the Łódź Industrial District is distinctly one-sided and shows little diversity in its spatial distribution, this favouring to a considerable extent local employment of the population and creating no necessity of commutation on any more significant scale.

For this reason the Łódź Industrial Centre is characterised by a general harmony between place of work and place of residence. The population employed in nonagricultural vocations resides primarily in Łódź, but also in the other towns of the district. A comparison of the distribution of places of employment in percentages of their total number with the distribution of places of residence (of person vocationally active according to place of residence) shows a substantial similarity of spatial patterns. In the three largest towns of the district, notably in Łódź, Pabianice and Zgierz, there is a predominance of employment over residence, i.e. in those towns the number of employed exceeds that of the vocationally active local inhabitants. In Łódź, this preponderance amounts to some 17.000 people, this constituting a little under 6 per cent of the total number of persons employed in non-agricultural occupations within the urban area. In Pabianice and Zgierz the respective indices are 4 and 8 per cent of the total non-agriculturally employed population.

In all the remaining towns of the district the number of vocationally active inhabitants exceeds the number of those actually employed. In the rural areas constituting the hinterland of the manufacturing towns, not quite 10.000 people are vocationally employed outside of agriculture. This means that, in the rural hinterland of Łódź, there is a surplus of almost 20.000 persons working in nonagricultural professions over actual employment in these areas. Commutation to work, which constitutes one of the basic problems of every bigger accumulations of population, is a result of the spatial separation of places of employment from places of residence. In spite of the fact that the Łódź Industrial District belongs to such accumulations, commutation to work does not constitute a major problem here. The total number of commuters does not exceed 9 per cent of the total number of non-agriculturally employed persons. This relatively small number of commuters is the outcome of a favourable pattern of distribution of places of work and places of residence, of uniform employment structure in the bigger centres of the district (textile industry) and of the high percentage of women employed. For the Łódź Industrial District as a whole commutation to work is balanced i.e. departures to work from the district and arrivals from more distant areas being within the relatively small limits of 5.000 people.

Places of work and places of residence in the Łódź Industrial District (in per cent of total)

	Places of work (non-agricultural employment)	Places of residence (vocationally active population outside of agriculture)
Łódź	81.9	76.3
Pabianice	7.3	6.9
Zgierz	3.6	3.3
Ozorków	1.6	1.8
Aleksandrów	0.9	1.1
Konstantynów	0.6	0.8
Brzeziny	0.7	0.7
Stryków	0.2	0.3
Koluszki	0.6	0.8
Tuszyn	0.1	0.5
Rural areas	2.5	7.5
Łódź Industrial District	100.0	100.0

In commutation between places of residence and places of employment within the district municipal tramways play the most important role; they carry 49 per cent of all commuters. The railways come second, carrying almost 45 per cent of all commuters. Thus, these two means of rail transportation carry jointly 94 per cent of all commuters from outlying settlements, and play a decisive role in this respect. Buses are not very important, only 1 per cent of all commuters making use of them. Much more significance attaches to motor vehicles operated by individual employers. These are lorries adapted for carrying passengers; and handling jointly 5 per cent of all commuters.

Over 30.000 people commute to work daily in the Łódź Industrial District to places of employment located beyond their places of residence. Some 21.000 persons or 7 per cent of the total number of persons employed in the city travel daily from beyond its borders. Somewhat in excess of 5 per cent of all industrial workers commute from outside town, while in other branches of economy the corresponding ratio is 8 per cent in these vocational groups. Commuters from an easterly direction predominate constituting 32 per cent of the total. Twenty-three per cent travel from the north, from the direction of Zgierz, 29 per cent from the south, from the direction of Pabianice and Tuszyn, which only 16 per cent arrive from the west, from the direction of Konstantynów and Aleksandrów.

As regards the area from people commute to Łódź, the great majority of workers, 65 per cent of the total, come from a distance under 20 km. A further 15 per cent of persons employed in Łódź come from the remaining area of the Łódź Industrial District. Generally speaking, 80 per cent of all the Łódź commuters come from the city's immediate hinterland. The remaining 20 per cent are primarily made up by those arriving from the hinterland of the district, especially from the neighbourhood of Koluszki and Głowno. Our investigations have ascertained that the number of persons arriving from distances beyond 50 km is relatively inconsiderable. It has also been established that an overwhelming majority — 90 per cent — of commuters to Łódź have convenient transportation facilities carrying them within a relatively short time to work and to their homes.

Besides those commuting to Łódź, some 4000 inhabitants of Łódź leave the city daily to places of work beyond the city. The overwhelming majority of them travel by tramway and short distances only. Furthermore, a certain number of persons residing in Łódź travel regularly to work in Warsaw. In spite of the considerable distance of 130 km this is made possible by good express electric train connections, the trip one-way taking under 2 hours.

Commutation to work in the towns neighbouring of Łódź is of relatively greater significance than that to the city itself.

Of special importance to the economy of Łódź are the agricultural problems of the city's suburban area. This is primarily the case because 34 per cent of the population of the suburban Łódź region engage in farming. For the rural areas of the Łódź Industrial District the corresponding proportion is 65 per cent, 54 per cent of all settlements in that area having an overwhelming preponderance of farming population, i.e. one exceeding 80 per cent of the total number of inhabitants. The distribution of these settlements is characteristic in that, in several points, they adjoin the limits of the city and stretch in a compact belt at a distance of several km beyond these limits. As may be seen, agriculture is one of the basic branches of economy in this area, yielding a living to a considerable section of its inhabitants.

Also the special tasks imposed of farming in the suburban zone, consisting primarily in providing to the non-agricultural population of perishable basic foodstuffs that may not be transported over greater distances — such as milk, fruit and vegetables — constitute a vital problem of the industrial district.

It should be emphasized that the conditions created by the geographic environment of the Łódź suburban zone are not over favourable for farming. It is interesting to observe that the natural conditions which limit farming are, to a considerable extent, a consequence of the illconsidered economic activity of man (clearance of forests). The local soil is largely infertile, and two thirds of the whole area consist of the poorest type of soil as far as agriculture is concerned, classified as „rye-and--potato-land". These difficulties created by soil conditions are further aggravated by the unfavourable influence of climate, chiefly characterised by low precipitation.

Next to these unfavourable natural conditions, the low level of farming methods is a characteristic trait of the agriculture in the Łódź suburban zone, as well as the absence of sufficiently defined characteristics of the suburban zone. This is indicated by the manner of land utilisation and the choice of crops. Agricultural land accounts for 68 per cent of the total area of the Łódź suburban zone. Eighty-four per cent of this is arable land, while meadows and pastures account for 14 per cent. On the other hand, gardening, which normally plays an important economic role in the suburban zones of big cities, occupies merely 2 per cent of total cultivated land in the Łódź Industrial District. The main crops grown throughout the voivodeship are: grain, potatoes and fodder plants. The vicinity of a big city is thus not reflected in the type of farming.

The basic agricultural problem of the Łódź suburban zone — one common to industry, public management and agriculture — consists in the utilisation of the Łódź municipal sewage system. Łódź is at present the largest Polish centre which utilises sewerage for agricultural ends.

The Łódź sewerage — both sanitary and industrial — is channelled of to the small river Ner, running at a short distance south of the town. The sewers are drained off partly through a system of municipal conduits and through a mechanical purifying plant, and partly proceed in an unpurified condition through rivulets, tributaries of the Ner, which have now been transformed into natural sewerage collectors. True, only part of the sewerage of Łódź is drained off into the river Ner, but its volume is considerable in view of the fact that the textile industry uses up great quantities of water. Since the river Ner has a small capacity, amounting to about 2 cubic meters per second, and since it receives sewerage of a thick consistency, its water is, in actual fact, of a concentration normal sewerage in the conduits of a big city. Practically speaking the river is an open sewerage collector.

The water of the Ner is highly fertilizing. It carries large quantities of suspended solid substances, which form in the flooded areas slime that is particularly valuable for the sandy soils near Łódź. Industrial waste containing organic textile remnants plays a very important role in raising the fertilizing quality of the sewerage. Some 3.000 ha. of meadows are now thus being watered and their yields exceed 100 quintals per hectare in many places. The watering (flooding) of the meadows not only increases their yield but also improves the quality of the fodder thus increasing of the meadows bordering on the Ner, particularly in view of the considerably economic significance of scarcity of fodder in this neighbourhood.

The ensuing sanitary situation constitutes the adverse aspect of the problem of melioration of the river Ner. Not only the valley of the river, but also wide belts on both its sides are permeated with nasty exhalations, very unpleasant for the local population, and the pleasant valley of the Ner cannot be utilised as a suburban tourist area.

The problem of utilising the sewerage of Łódź is even more comprehensive than this since it affects not only the valley of the Ner. Łódź, which is situated on the watershed, has exceptionally favourable conditions for distributing its sewerage, better than those enjoyed by any other city. It can namely distribute it by shear force of gravitation, without pumping, over a distance of several score kilometres. At the same time, in view of the enormous volume of the water industrial drained off from the industrial plants, Łódź has at its disposal very great quantities of sewerage. According expert estimates, the sewerage drained off from Łódź and Pabianice is capable of watering an area of 30.000 hectares, while the impact of such watering could affect an area exceeding 120.000 hectares.

A plentiful water supply is required for intensifying suburban farming and truck gerdening near Łódź which is a real necessity.

Projects for the utilisation of the sewerage for farming also envisage the bringing of water from outside. Clean water is an absolute necessity for diluting the sewerage, as well as for a periodical irrigation of this area. This is the reason why the problem of agriculture water supply is no less important, although much less delicate, than that of providing with water the population and the industries in the towns in the Łódź district.

Translated by Zofia Wrzeszcz

RAJMUND GALON

New Investigations of Inland Dunes in Poland

I

Poland is a country showing an aboundance of inland dunes. They occupy vast areas of ice — marginal streamways, especially their basin-shaped widenings, but they have also developed on outwash plains, and are encountered too on sandy ground moraine (Fig. 1). Alongside of typical parabolic dunes with horns (or arms) extending westwards, there also appear slightly crescentic transverse dunes with a N—S trend, as well as linear or longitudinal dune ridges of a rather W—E trend. Barkhans are also met with. Very numerous, however, are dunes of irregular shape, such as dune hummocks, and reworked (destroyed) dune forms. In the vicinty of such dunes there are spread out areas of moving (drifting) sand.

Dunes occur both singly and in groups, forming compact dune fields with their shape resembling a parabolic dune. The most interesting, the largest and most classically developed Polish dune landscapes consist of the dune groups of the Warsaw Basin, of the Toruń—Bydgoszcz valley depression, the region between the Warta and Noteć rivers, the Kurpie Forest in the Narew Basin, and likewise the dunes extending between the Warta and Prosna rivers as well as the dunes found in Lower Silesia (see Fig. 1).

In contrast with dunes known from Holland and Germany, the dunes on Polish territory represent a more continental variety. Due to this, the control of processes of dune deflation is more complicated in Poland than in Western Europe.

Aeolian processes, and dunes being their principal product on Polish territory, are since long occupying Polish geographers and students of related sciences, due to the important part they play in the geographical environment of our country, and due to their being typical for all of Poland. The beginning of investigations of inland dunes dates back to the first years of this century. Alongside of Polish scientists (E. R o m e r, W. F r i e d b e r g, St. M a ł k o w s k i), the problem of dunes on Polish territory has been — in accordance with contemporaneous political conditions — studied by Russian and German geologists and geographers too (among others: P. T u t k o w s k i, P. L e h m a n n, F. S o l g e r). In the investigation of inland dunes in Poland, highest credit is due to the previously mentioned St. M a ł k o w s k i, and to St. L e n c e w i c z. Due to their value and enduring actuality, their studies referring to distribution, shape, origin and age of the inland dunes, carried out before, and immediately after, the first world war, have recently been republished by Wydawnictwa Geologiczne *(10)* in the shape of a separate volume. Many new observations and suggestions on the origin of parabolic dunes in Poland have also been presented in a most interesting paper of the Hungarian geographer L. Kadar *(5)*.

After the second world war, detailed investigations of dunes were started at almost all university centres. These studies were, principally,

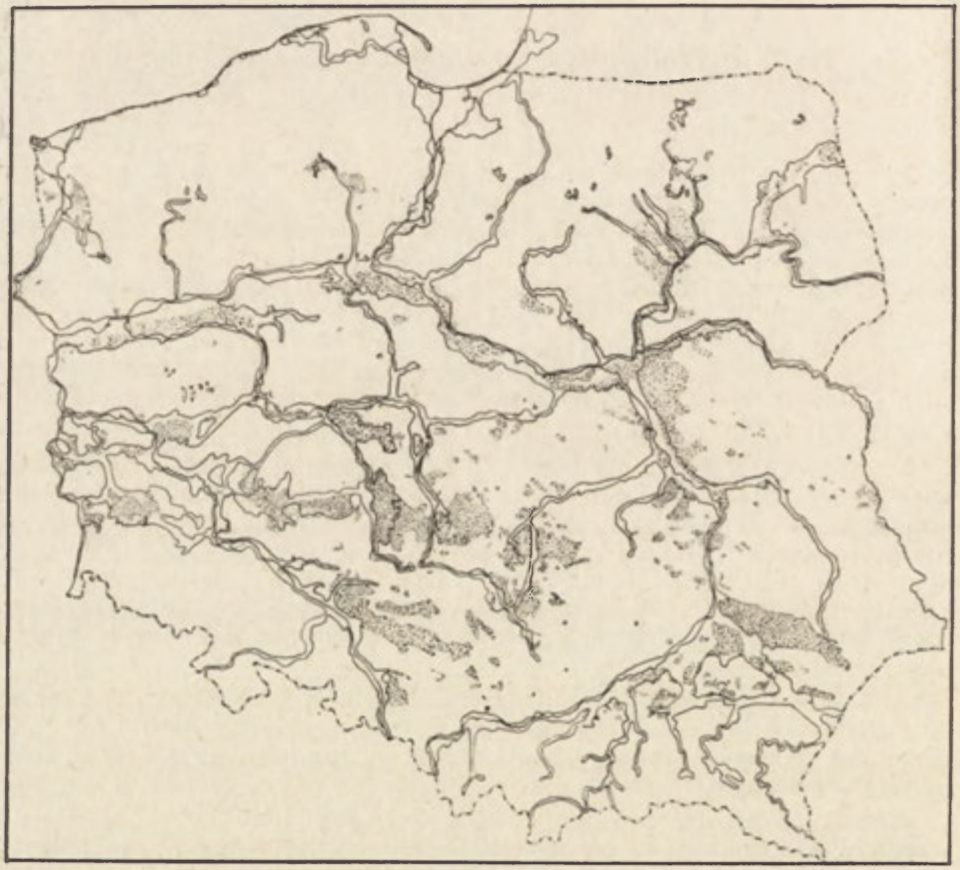

Fig. 1. Dune areas in Poland

monographs on individual dune regions, usually based on morphological methods. There also are under way observations on dunes being deftaled at present; these dunes are also being examined by petrographic methods. Worthy of special attention, especially from a methodological point of view. is a teamwork paper on the Zadroze dune situated south of Toruń; this paper has been prepared jointly by a geographer, a petrographer, a botanist, a zoologist and an ecologist *(21)*. All these results of investigations of inland dunes in Poland have been presented and discussed at a special scientific session, organized in 1954 by the Polish Geographical Society (Polskie Towarzystwo Geograficzne). The purpose of this session was to establish the actual status of dune cognizance in Poland on the basis of deposits. There also were to be discussed methods of investigating dunes, and rules for further (teamwork) examinations, carried out by the respective branches of science.

The papers read at the above session (since then they have been supplemented and brought up to date), as well as a number of further papers, prepared by the participants of the session at a later date and representing, to some extent, a continuation of the dune problems discussed at the meeting, have been published, as special publication of the Polish Geographical Society, under the title „Wydmy Śródlądowe Polski" (Polish Inland Dunes — Warszawa 1958). This book has the character of a digest on dune phenomena in Poland. The authors are representatives of several sciences interested in dunes; various methods of investigation are presented. Aside of this compendium on Polish dunes, there have been published further papers on dunes. Thus, we are in possession of a fairly universal and up-to-date picture of dune problems in Poland, — data which might interest dune students of other countries too. Below are put forth the most important problems as well as the results of their investigation, gained by means of the most recent studies.

In nearly every paper on Polish inland dunes there are principally taken into consideration two problems, namely:

1) shape and structure of dunes, as token of the prevailing dune-forming winds,

2) number of dune periods, i. e. the age of dunes, considered a palaeoclimatological problem.

These problems have been treated by various methods, i.e. by dealing with them from the point of view of geomorphology, geology, petrography, palaeoclimatology and archaeology.

II

1. The above investigations contain ample detailed data on the shape of inland dunes, — since the analysis of dune forms makes possible determination of the directions from which the prevailing dune-forming winds had been blowing. We observe that, as to their forms, the dunes existing on Polish territory are very much differentiated. Notwithstanding the general belief, the typical regular parabolic dune with elongated arms occurs relatively rarely. The detailed description of such a dune, developed on the Brda outwash plain, has been given by I. Nowicka *(13,* see Fig. 2). More usual is the transverse dune, of a meridional trend, slightly crescentic eastwards. An example of this dune type is presented by L. Pilarczyk *(16),* from the area between the Warta and Noteć rivers (Fig. 3). Similar dune forms describes W. Mrózek *(12)* from the dune region of the Toruń—Bydgoszcz valley depression. According to L. Kádár, both the parabolic and the transverse dune (Walldune) showing the typical asymmetry of slopes, represent successive phases of an identical process of dune development.

Alongside of transverse dunes we encounter at many localities articulated dune forms, with their arms generally turned westwards, and frequently torn apart. Upon close investigation we perceive them to be deformed parabolic dunes of various sizes (Fig. 4). Generally speaking, it is manifest that transverse dunes as well as articulated dunes resemble, by the arrangement of their group in which they usually appear, large

Fig. 2. Parabolic dune on the Brda outwash plain (near Woziwoda village), according to I. Nowicka (*13*)

parabolic dunes (Fig. 3); the profusion of forms seems to be the result of parabolic dunes of various size being produced successively, as units subordinate to each other, thus forming dune units of higher order.

A separate group of dune forms represent the linear or longitudinal dune ridges which extend rather in a aequatorial direction. They are of various origin. Usually, however, these forms were produced by the destruction of parabolic dunes (Fig. 5), and constitute the ultimate phase of development of the dune — forming process (Fig. 6). In many instances, linear dunes of this character appear in company of parabolic or transverse dunes, forming their periphery (Fig. 3), and disclosing an analogous slope asymmetry as that seem in the arms of parabolic dunes. The genetic connection between the linear dune and the parabolic dune is indicated by the fact that often the linear dune ridges constitute the collective arm of several parabolic dunes (Fig. 7).

An entirely divergent opinion on the origin of linear dunes, based on dunes of the Warsaw region as example, has recently been presented by K. Schoeneich (*19*) who questions their connection with parabolic dunes. In his opinion, the linear dunes extending W—E, or in a NW—SE direction, have been built by southern winds blowing at right angles to them, with the additional action of southwestern and, to a lesser degree, of western winds too. When two linear dunes meet at an acute angle, a pseudoparabolic form develops, i.e. (ostensible) parabolic dunes (Fig. 8). This is perhaps an interesting, yet a rather discretional notion, inconsistent with everything we know on the mechanics of dune formation and the relation of dune form to the dune-forming wind; nor is this notion in agreement with our knowledge of the postglacial atmospheric circulation.

However, it should here be remembered that, on the basis of dune forms in the Kampinos Forest, (near Warsaw) J. Kobendzina *(7)* also

Fig. 3. Transverse dunes in region between Warta and Noteć rivers, according to L. Pilarczyk (*16*)

assumes that the unaltered dune form is a linear dune; still, this dune's development depends on the position of the vegetal zone connected with the humidity of the soil. On the other hand, she considers the parabolic dune to be a secondary form, produced due to aeolian transformation of the original linear dunes under increasing soil humidity, yet before the development of a soil layer.

Somewhat differently considers W. Mrózek this problem, on the basis of his studies of dunes observed in the Toruń—Bydgoszcz valley basin. He has ascertained that alongside of linear dunes, genetically and morphometrically connected with the parabolic dunes, there also appear linear dune ridges with symmetrical slopes. They are very young, as indicated by the fact that they extend parallel with the prevailing direction of dune-forming winds, yet somewhat deflected owing to the valley's. shape. But here, too, parabolic dunes may be found (Fig. 9).

Thus, in principle, all the above described dune forms are linked up, in greater or lesser degree, with parabolic dunes with asymmetrical slopes, as characteristic forms for aeolian conditions existing, towards the end of the Pleistocene, on the previously glaciated Polish lowland. By its form, the parabolic dune corresponds most aptly with conditions of aerodynamics and environment which prevailed at those times. Therefore with particulat interest should be received the assertion of L. P e r n a r o w s k i *(15)*, that in Lower Silesia there are found, besides parabolic and analogous dunes, dunes in appearance resembling barkhans, characteristic for desert areas. Due to this, the traditional discussion on both

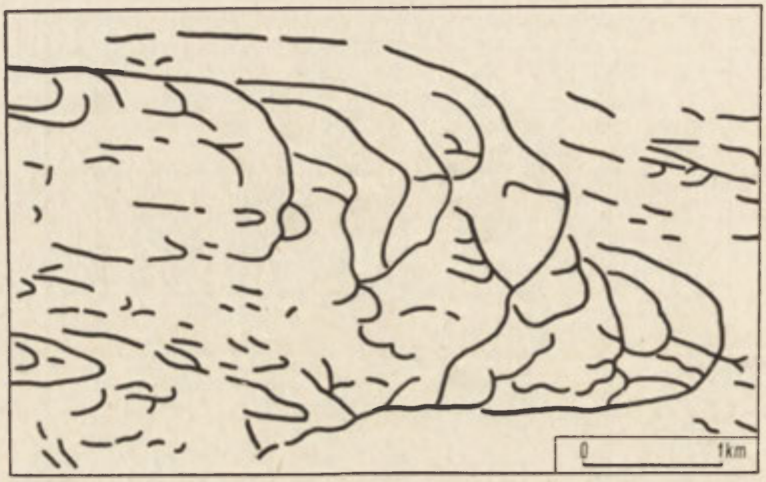

Fig. 4. Deformed and coalesced parabolic dunes in Toruń—Bydgoszcz valley depression, according to W. M r ó z e k (*12*)

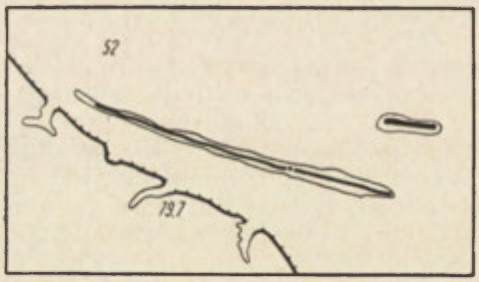

Fig. 5. Linear dune — fragment of previous southern arm of parabolic dune near Aleksandrów Kujawski, according to M r o z e k (*12*)

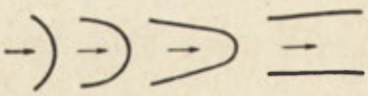

Fig. 6. Evolution of inland dune, according to L. K á d á r (*5*) and R. G a l o n (*3*)

origin of dunes and prevailing directions of dune-forming winds are passing into a novel phase. More on this subject shall be said later.

As mentioned before, alongside of regular dune forms more or less resembling parabolic dunes, there also occur irregular dune hummocks. According to I. N o w i c k a, these hummocks appear in company with typical dunes. Thus it may be suposed that the dune hummocks were produced by deflation and destruction of regular dunes. However, this same author also suggests that dunes of irregular form may have developed due to denudation, and to disturbances occurring during their formation. On areas where aerodynamic forces might be assumed to have been acting from various directions, both shape and structure of the dunes developed in a rather irregular manner. Due to these alternating directions of winds, the dunes must have been developing in the shape of flat, dome-like hillocks. Both regular and irregular dunes are accompanied by flat, previously deflated sand sheets, of chaotically scattered slight forms and spreads of wind-borne sands which, at present, are undergoing deflation.

It appears that, as to their dimensions, the dunes occurring on regions of older glaciations are not inferior to the dunes of Northern Poland; e.g.,

Fig. 7. Fragment of morphological map of Kampinos Forest, according to J. Kobendzina (7)

in the Sandomierz Lowland they reach a height of 20 meters, sometimes even more, and a length up to several kilometers. However, the density of dunes is smaller on older areas, — as already pointed out by St. Lencewicz. According to H. Maruszczak *(11),* the relatively slight density of dunes on the Lublin Plateau and on its adjoining regions should be ascribed to the fact that here the vegetative cover at the period of dune formation was better developed than in Northern Poland, i.e. on the area but recently freed of its ice sheet.

2. How then appears now, in view of recent investigations, the problem of dune-forming winds? Whence came the winds that have formed the inland dunes on Polish territory? What methods were utilized by the scientists investigating this problem?

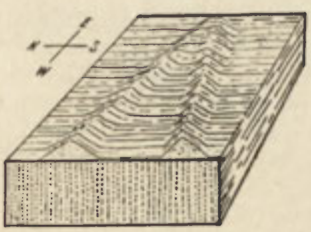

Fig. 8. Pseudoparabolic dune, according to Schoeneich (*19*)

Fig. 9. Linear dunes in Toruń — Bydgoszcz depression, west of Toruń, according to W. Mrózek (*12*)

In her examination of dunes on the Brda outwash, plain, I. Nowicka determined, on the basis of both shape and position of the parabolic dunes, three principal directions of dune-forming winds: a western, a southwestern and a northwestern direction. 91% of the area investigated by her proved to be oriented in accordance with these directions. — According to St. M a j d a n o w s k i *(9)*, a predominance of western winds in the late-glacial and post-glacial climatic phases results from the presupposed general atmospheric circulation. On the other hand, aerodynamic conditions occurring during the full glaciation in this part of Europe imply — as has been admitted by numerous scientists — a dune-forming activity of winds blowing principally from the east. Finally, during the post-glacial climatic optimum, i.e. at the period of the most intensive northward translocation of atmospheric circulation, there prevailed, for a short time, southern and southwestern winds. However, in St. M a j d a n o w s k i' s opinion, the latter winds, coinciding with a period of a fairly ample vegetative cover, failed to produce new dunes, merely transforming dunes already existing. J. K o b e n d z i n a asserts that the winds which produced the dunes of the Kampinos Forst, must have been blowing from the west.

From W. M r ó z e k's investigation of dune slopes in the Toruń—Bydgoszcz depression it appears that the main force sculpturing these dunes must have been western and, to a lesser extent, southwestern winds; this seems to be indicated by the fact that the steepest grade of interior slopes appears on the distal part of the southern dune arm. However, here also appear parabolic dunes on which the interior (western) slopes are relatively steep (11°—16° incline), whereas the outer (eastern) slopes are relatively gentle (6°—12°). M r ó z e k sees here the influence of eastern winds which remodeled both dunes devoid of vegetation, and such dunes as were situated suitably with regard to the action of these winds.

The problem of participation of eastern winds in the formation of dunes has been studied by L. P e r n a r o w s k i who investigated dunes in Lower Silesia by the morphological-statistical method. The main problem looked into by this author has been the question whether the formation of dunes was dependent on aerodynamic conditions similar to those existing to-day. He believes that dunes resembling barkhans have been produced in a drier climate than at present. At that time there existed, in Lower Silesia, vast sandy areas devoid of vegetation where, alongside of the much more numerous linear dunes, barkhans were formed. Afterwards, the climate turned humid, and vegetation appeared; western winds gradually became constant. On the sandy areas, then covered but locally by a feeble vegetation, there began the development of parabolic dunes which — sporadically — were accompanied by surviving barkhans. This opinion of L. P e r n a r o w s k i as to the formation of barkhans in Lower Silesia in a full desert environment has been collaborated by the above mentioned suggestions of St. M a j d a n o w s k i with regard to changes in atmospheric circulation occurring on the Pleistocene — Holocene boundary, and to the probable existence of prevailing eastern winds in the period of full glaciation. It should be noted, however, that H. M a r u s z c z a k, who investigated the dunes of the Lublin Plateau situated in the same morphogenetic (palaeogeographical) zone as the Lower Silesian dunes, claims to have found, on the Lublin Plateau, exclusively forms produced by western winds.

On various areas there may be ascertained dunes formed by other winds too, as shown by the incline of the dune lamination, the most sensitive criterium on this subject. In the cross-section of the Sułowo dune (north of Wrocław), the above quoted L. Pernarowski observed oblique strata deposited by northern winds in the dune's lower part, whereas the upper part contains chiefly strata laid down by southern winds. Somewhat different results obtained A. Dylikowa *(2)* while analyzing strike and dip of strata in the dunes of the Łódź region. She found, the same as did L. Pernarowski, a bipartition in the dunes' structure; here, however, the predominant lower part of the dune indicates western or northwestern winds, while the lesser, upper part shows the activity of southern or southwestern winds.

Thus, more recent investigations corroborate the opinion as to the dominant part played by winds of the western sector in the formation of inland dunes on Polish territory. This is indicated by the shape of the parabolic dunes, their arms trailing westwards or, in the case of linear dunes, extending W—E. This is also confirmed by the asymmetry of slopes which are gentle westwards and steeper eastwards, as well as by the position of deflation basins usually appearing on the western side, i.e. in the interior of the dune crescent. Finally, there is the dip of the dune strata and the frequently determined derivation of the dune material from areas situated west of the dunes, — and the penetration of dunes upon younger terraces from a west-east direction. All these arguments point to formation of the dunes by western winds.

However, at the same time we can not deny the participation of eastern winds, — especially on areas of the older glaciations — in the formation of dunes, particularly of older dunes. Some of the most recent investigations supply evidence for this theory.

We also must take into account a later transformation of the parabolic dunes, especially of the incline of their slopes, by southwestern, southern and — in special conditions — by eastern winds.

III

1. From the above contemplations we may conclude that the dune-forming processes were concentrated in certain phases, or dune periods. Are we in a position to specify how many such dune periods existed? Here we come up against the problem of the age of dunes. Analyzing the trend of atmospheric circulation in the Quaternary on the basis of world literature, St. Majdanowski came to the conclusion that in Central Europe there must have occurred at least two dune periods. The action of (eastern) winds during the older dune period appeared exclusively on the forefield of the inland ice, during the last glaciation. On the other hand, the action of late-glacial winds of the younger dune period comprised all of Poland. During this latter period there took place, in Southern and Central Poland, on the previous forefield of the inland ice, a transformation of the heretofore unstabilized dunes of the older period, brought about by western winds, whereas in Northern Poland, recently abandoned by the melting inland ice, there were wormed new dunes on sandy areas. Vegetation,

progressing from the south, interrupted the aeolian processes and stabilized the new dune forms. The change in wind direction occurring after this stabilization failed to change the main outlines of these dunes.

How far has been confirmed the theoretical argumentation, put forth by St. M a j d a n o w s k i, in our investigations on individual dune groups in Poland? In the first chapter already, treating the variableness of dune-forming winds, we have determined distinct phases in the intensity of aeolian processes. In view of structure and shape of dunes, L. P e r n a r o w s k i assumes at least a two-phase aeolian accumulation in Lower Silesia. L. P i l a r c z y k too suggests the existence of several dune-forming cycles. The oldest, probably late-glacial, period, is represented, in the area between the Warta and Noteć rivers, by transverse dunes in the central part of the dune field. A second, past-glacial, dune-forming period was perpetuated in the parabolic dunes of the eastern part of the above mentioned dune area. Finally, the forming of dunes from the sands on the lower Warta terraces is the result of modern processes of aeolian accumulation and denudation.

I. N o w i c k a formulates in a similar manner the results of her studies on the number of dune periods, established on the area of the Brda outwash plain. She counts at least three periods.

a) the period of formation of fundamental forms, i.e. of parabolic dunes,

b) the period of destruction of the parabolic forms, and the formation of linear and irregular dunes,

c) the modern period of deflation.

As a result of studies on directions and dip values of dune strata in the Łódź region, A. D y l i k o w a likewise distinguishes three dune-forming phases of similar character. That phase in which, due to western and northwestern winds, the major part of sands has been deposited, she calls the actual dune-forming phase. The higher series of dune sands, less in quantity than in the preceding phase and connected with the processes of cutting down previous forms and of renewed accumulation by the action of dune transformation. The last chapter in the history of dunes, stabilized in the upper series of dune sands, but usually structureless and comprising modern processes of intensive transformation and destruction of the previously built dunes, this author calls the phase of dune destruction.

Thus, in the light of modern studies, we may speak of two dune phases on Polish territory, existing during the late-glacial and post-glacial period, not including the modern deflation of dunes. As to the number of dune phases, there is readily seen, from the results of the discussed recent investigations, a confirmation of the opinions of some previous Polish and German scientists (such as St. M a ł k o w s k i and H. L o u i s).

Undecided remains the problem put forth by some of the authors (M a j d a n o w s k i, P e r n a r o w s k i) who suggest a further, i. e. an oldest dune prase, coinciding with period of eastern winds. Therefore, the discussion started on this subject by T u t k o w s k i, R o m e r, and S o l g e r, and others, continues to be of current interest.

2. With the number of dune phases is closely connected the problem of their a g e. What criteria should be applied for determining the age

of the inland dunes? Did, according to recent investigations, the dunes on Polish territory develop simultaneously, or are the dunes of Southern and Central Poland older than those of Northern Poland, i.e. of the area of the last glaciation? In this respect the viewpoints of scientists disagree. L. S a w i c k i *(18)* assigns the dune sands with their Palaeolithic flint articles, found on terraces of the Wisła river near Warsaw, to the interstadial, between the Poznań (Frankfurt) and the Pomeranian stadium of the last glaciation (parabolic and linear dunes), and the older Dryas (dunes situated north of Warsaw). L. P e r n a r o w s k i defines the geological age of the dunes he investigated in Lower Silesia. In his opinion, the dunes developed on the alluvial cone of the Kwisa and Bóbr rivers, of interglacial age, might have been formed, at the earliest, during the last glaciation, while the dunes of the Sułowo region, situated on the basal moraine of the last glaciation, and on the higher Holocene terraces, might exist since one of the first Holocene phases.

W. M r ó z e k studies the interrelation between dunes and other forms, such as valley terraces, dry lateral valleys, and basins due to dead ice (peat bogs), thus trying to determine their morphological and climatic age. In his opinion, the commencement of the development of aeolian processes took place in the pre-Boreal age, characterized by sparing precipitation, a scanty vegetation cover, and a preponderance of western winds. These processes lasted throughout the subsequent Boreal period[1]. The long duration of the first period of dune formation is, according to this author, attested too by the morphological uniformity of large dune complexes, irrespective of valley teraces. At that same time there also developed, independently of the dune relief, basins due to dead ice. It should be mentioned, however, that — according to palynological investigations carried out by K. K ę p c z y ń s k i *(6)* — some of the peat bogs, younger than their adjoining dunes, have been formed in the Allerod already, thus they extend back to the late glacial.

The second dune phase coincides with a more arid sub-Boreal period. This phase is preceded by the humid and warm Atlantic period, perpetuated by the laterization of sand layers and humus laminae, observed in dune sections. The humid sub-Atlantic period, following the sub-Boreal period, is perpetuated by shallow peat bogs which to-day appear amidst the dunes. Due to its higher water table, this sub-Atlantic period aided in stabilizing the dunes. Short-lived phases of a somewhat drier climate which took place in historical times and, especially, deforestation carried out by man brought about the development of the modern processes of dune accumulation and deflation.

In order to determine whether the dunes found on Polish territory were produced simultaneously or at different times, a problem treated by R. G a l o n *(3)* and St. M a j d a n o w s k i, of importance are the dune investigations carried out on the area of the older glaciations. Examining the details of the Lower Silesian dunes with regard to their substratum (see above), L. P e r n a r o w s k i admits the possibility of aeolian processes having begun in this region as early as during the

[1] Compare a similar opinion expressed by W. O k o ł o w i c z *(14)*.

last glaciation. Dune studies on the Lublin Plateau, carried out by A. J a h n *(4)*, W. P o z a r y s k i *(17)* and H. M a r u s z c z a k, showed that the lower boundary of development of existing dunes is indicated by the last glaciation; this appears from the fact that these dunes were formed on terrace sands produced by this glaciation. Upland sands from the western part of the Lublin Plateau, originating even from earlier than the last glaciation, have also undergone aeolian processes as late as the end of the last glaciation, since — as pointed out by H. M a r u s z c z a k — before the formation of dunes, the surface of these sands had been formed by periglacial processes during the last glaciation. In agreement with this author we may assume that, as to their age, the dunes appearing on the Lublin Plateau and on its neighbouring regions most probably correspond with the dunes of Northern Poland; this, incidentally, is indicated too by the freshness of these dune forms. Previously produced dunes underwent destruction and transformation by periglacial processes, presupposing they were older thant the last glaciation, — or they were formed during the interstadials of this glaciation. Thus, most probably, the dunes on the Lublin Plateau developed in the period between the younger Dryas and the postglacial climatic optimum. Besides this dune phase, there may be also distinguished a modern, anthropogenic phase of dunes on this area. In my opinion we lack sufficient evidence for assuming (as does A. J a h n) that on the Lublin Plateau there existed, succeeding the above mentioned climatic optimum, a second aeolian phase, — although its existence, analogous with other regions, seems quite probable.

Particular attention should be paid to the fact that, according to A. J a h n' s and H. M a r u s z c z a k's investigations, the dunes on the Lublin Plateau and on Roztocze appear on the surface of a typical younger loess which is limeless and clayey. Thus, the accumulation of dune sands on this area must have been, as to its time of origin, distinctly separated from the accumulation of the younger loess.

In conclusion we may claim that the assumption of a glacial aeolian phase might justified theoretically, i. e. in view of an analysis of glacial and interglacial atmospheric circulation, but that it would disavow our suppositions as to the course of periglacial processes during the period of maximum glaciation. On the other hand, we have no right to consider impossible the formation of dunes from the very moment when deglaciation began on the forefield of the ice sheet, still during the reign of eastern and northeastern winds. Later, these dunes, due to altered aerodynamic conditions, might have undergone transformation, surviving only in fragments, or locally only (e.g. in Lower Silesia). All hitherto investigated dunes on Polish territory were rather formed during the late--glacial period, — s i m u l t a n e o u s l y on the entire investigated area of Poland; it also seems probable that as aeolian material were utilized various fluvioglacial and fluvial sands as well as, partly too, sand from previously formed dunes.

3. Ultimately we may assume, on Polish territory after the last glaciation [2], the following sequence of dune processes. The formation of

[2] Compare paper by R. G a l o n (3).

dunes began immediately after recession of the inland ice from the area of Central Europe; it reached its culmination as soon as a preponderance of western winds had been established, and lasted upon the entire area until, in the Boreal period, a vegatative cover developed. Locally there continued the formation of dunes during the Boreal period. This has been the main, and morphologically the most important, dune phase during which, simultaneously all over Poland, mainly parabolic dunes were produced.

During the Atlantic period, when the level of underground waters rose and the last blocks of dead ice and sheets of winter ice melted, the dunes were „inundated", and stabilized by vegetation.

During the sub-Boreal period, when the climate turned rather dry and warm, and in peat layers the so-called boundary horizon appears, there took place a second, less intensive dune phase. During this phase the previously formed parabolic dunes underwent transformation or, partly, destruction (linear dunes), due to prevailing southwestern, and, even, southern winds; at the same time new dune complexes were formed, with less distinct forms, sometimes in the shape of irregular dune hummocks.

In the sub-Atlantic period the climate again became more humid and somewhat cooler, and peat bogs were developed; at that time the dune forms again underwent stabilization. As late as in the middle of the present millenium, the climate again became more dry. The continental dunes began to suffer processes of aeolian denudation, especially since man started to deprive the land of its forest cover. When, subsequently, the climate again turned more humid (about 1700 A.C.), there was added, to the processes of deflation, denudation and cutting apart of the dunes by flowing water. We are witnessing the deflation and destruction of the inland dunes and the formation of sheets of drift sands. This current anthropogenic dune phase is going to be terminated by the stabilization of the advancing dunes and sands, by means of afforestation.

IV

1. An interesting insight into both origin and conditions of the forming of dunes has been obtained from the results of more recent investigations on the granulometric and petrographic analysis of dune sands. They represent a valuable addition to the above discussed geomorphological and geological studies. In view of these investigations it appears that, as a rule, dune sands did not undergo any distant transportation, and that they are derived from various sediments. J. Trembaczowski (20) has pointed out that the material building the dunes on the terraces of the Wisła valley near Puławy has been drawn from sands of neighbouring moraines. A. Dylikowa asserts that the dune material of the Łódź region has been windblown from fluvial and fluvioglacial sand sheets situated further west. W. Mrózek also admits a transport of dune sands of several up to, at the most, a score kilometers from a western direction for the Toruń—Bydgoszcz valley depression. This author demonstrated that the grains of dune sands show a but feeble

rounding, similar to the sands building the upper sand layer of river terraces, and that they may be distinguished from such sands solely by their being stightly dimmed. Thus, the sands of dunes produced in the above mentioned part of the Wisła valley are predominantly of valley origin; exceptionally only were they blown over from the upland surrounding this river basin.

2. Let us now survey the data characterizing the grain size of dune cn Polish territory, and compare them with data from other dune occurrences.

Brda outwash plain (J. Nowicka): 0.2—0.4 mm,
Greater Poland (B. Krygowski): 0.25—0.5 mm,
Toruń—Bydgoszcz valley basin (W. Mrózek): 0.25 mm (54%),
0.25—0.5 mm (42%),
Region of Łódź (A. Dylikowa): 0.2—0.4 mm,
Region of Puławy (J. Trembaczowski): 0.26 mm.

In a paper devoted specially to the granulation of dune sands, B. Krygowski *(8)* obtained analogous results for seven Polish dune regions and some neighbouring regions (see also Fig. 10).

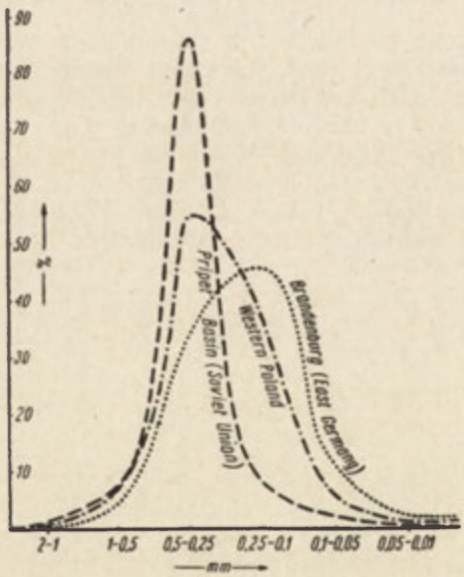

Fig. 10. Several examples of the granulation of dune sand, according to B. Krygowski (8)

B. Krygowski called attention tc the fact that, as a rule, dunes on the area of the Baltic glaciation show a smaller size grain, whereas dunes of areas of older glaciations disclose grains of larger size. The author connects this feature with a more thorough washing out, and with the deflation of the dune substratum on the area of the older glaciations. To a certain degree, a dune illustrates the screening, i. e. the mechanical composition of the sand of the substratum from which the sand is derived.

The analysis of dune sand fractions enables us also to visualize the force of dune-forming winds. Taking into account an average size of sand grain of 0.2—0.4 mm and adopting the scale suggested by the Russian scientist J. Pietrow, the prevailing velocity of dune-forming winds must have been 4—7 m. per sec. A. Dylikowa mentions a similar value (6—8 m. per sec.). Moreover, this same author states that the fraction of dune sands is larger in the lower part of the deposits forming the described dunes, than in the higher part. Therefore, during the phase of dune transformation (represented by the upper sands), the force of dune-forming winds has been less powerful than in the main phase of dune building (lower and series); this is corroborated by the forms of the dunes.

Dune areas	grain size in mm, in %			
	0.25	0.25—5.0	0.5—1.0	1.0
Sea shore	55.5	41.8	1.7	—
Toruń-Bydgoszcz valley depression	46.5	49.7	4.3	—
Region between Warta and Noteć rivers	75.5	23.1	1.4	—
Ancient Warszawa-Berlin valley	45.0	33.6	21.0	0.2
Lower Silesia (Barycz) valley	36.7	51.6	10.0	1.5
Sandomierz depression	22.5	72.0	5.5	—
Polesie (Soviet Bialorus)	14.0	73.8	10.5	1.7
Brandenburg (German Democratic Republic)	61.4	35.0	3.3	0.25

3. Undoubtedly, the shape of the sand grain reflects the background in which it originally was formed. It is well known that the grain of desert sand is rounded, whereas the grain of fluvial sand is rather of prismatic shape. G. Krygowski voices the opinion that in Polish dunes 60% of sand grains are rounded, while 30% are semirounded. The far-reaching degree of aeolization of the dune sands is confirmed by the fact that in dune sands there are frequently found grains of globular shape, thus grains transformed by aeolian processes to the highest degree. On the other hand, we encounter sands with rounded grains in aqueous deposits too. Presumably, this is dune sand on a secondary bed.

Here should be remembered A. Cailleux's *(1)* statement that differing from Tertiary material comprising but 5% of grains transformed by aeolian activity, Quaternary deposits (taking into acount all sand deposits) contain, at an average, as much as 40% aeolian material. In view of these investigations it appears that the participation of grains thus transformed decreases westwards: in Poland it is 50% of the deposits (in dunes even 80%) while in Holland it is but 40%. This is in agreement with the eastwards increasing climatic continentalism and the growing part played by sands of fluvial origin. According to granulometric examinations made by J. Trembaczowski at Puławy, on the middle course of the Wisła river, the part played by rounded grains in Quaternary deposits is greater yet. The morainic sand from the Puławy region is likewise sand transformed by wind action.

Tying up with the above discussed facts B. Krygowski reached the conclusion that on Polish territory west of the Wisła river, there is no marked difference in degree of rounding between fluvioglacial sands and dune sands. In both deposits there predominates a semirounded grain; the dune sand, however, contains slightly more sphaerical grain (26%) than do fluvioglacial sands (18%). Thus, presumably due to the more oceanic climate, the dunes of Western Poland are rather built of glacial sand which failed to be thoroughly transformed by aeolian activity.

For determining the origin of dunes in the Toruń—Bydgoszcz valley basin, W. Mrózek utilized criteria of grain rounding. He determined that here the grains of dune sands disclose but moderate rounding, frequently resembling sands which build terraces, and differing from them solely by a slightly dulled appearance. In this manner this author endorses B. Krygowski's above mentioned conclusion regarding the non-typical character of grains in Western Poland's dunes.

4. There still should be discussed the feature of dulled surfaces of sand grains, constituting an indication of the aeolian origin of a deposits, and the application of this feature in recent Polish publications. This problem, discussed fundamentally by A. Cailleux, appears to be a most interesting one. On the basis of Quaternary deposits of the Puławy region, J. Trembaczowski has revealed that frequently rounded grains prevail in both morainic and dune sands; in such instances a more marked dimming of the grain distinguishes the dune sand which has undergone aeolian processes, from sands of other origin. As shown by W. Mrózek, in cases of feebly rounded sand grains too, a higher degree of dimming is the principal feature of sands which recently have gone through a period of aeolian activity. To be sure, A. Dylikowa, after determining a marked prevalence of lusterless grains in the lower series of dune sand with large grain fractions, believes — in line with Cailleux's suggestion — that dimmed grain surfaces are a feature acquired exclusivelly by larger sand grains. However, I am of the opinion that a prevalence of lusterless grains in these lower series is connected with a greater intensity of aeolian processes during this principal dune phase, — as mentioned above.

Concluding this critical survey of dune literature I wish to point out that investigations on Polish inland dunes, by means of various methods, are being continued at several scientific centers. Near Warsaw, in the Kampinos forest, J. Kobendzina maintains steady systematical observations of current processes and of the background conditions in which these processes take place. The Toruń center examines systematically the individual dune areas of the Wisła valley and the Pleistocene valley of the Noteć river, whereas the Poznań center pays particular attention to the dunes situated in the region between the Warta and Noteć rivers, as reported in L. Pilarczyk's introductory notice.

In view of these measures there might be expected, within the next few years, the next publication of a teamwork paper on dunes in Poland.

Translated by Karol Jurasz

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JERZY KONDRACKI

Studies on the Natural Landscape of the Masurian Lake District

The trend in physical geography towards landscape studies developing especially in Germany and in the Soviet Union [1] is thus far but feebly represented in Poland. In an attempt to develop a method for full physico-geographical analyses of the natural landscape, a complex „landscape" study on a selected region of the Masurian District (in Mrągowo county) was conducted in 1956 and 1957 by part of the staff of the Physical Geography Chair at the Warsaw University and by the Climatological Section of the Institute of Geography of the Polish Academy of Sciences. The study was authorized by the Institute of Geography. The aim of this undertaking was to gain experience in preparing synthetic maps of geographical environment and in the correlation between the various component features of a landscape. The selected region shows a fairly ample differentiation of landscape, comprising all the principal features met with in the Masurian Lake District.

A team of specialists from the main branches of physical geography was organized in order to attain the desired goal. Differing from investigations previously undertaken by loosely cooperating groups of naturalists, the principal feature of this investigations was the simultaneous presence in the field of all the participants, their constant contact, frequent discussions and analyses of results obtained. This project was carried out by five groups directed by Professor J. Kondracki [2]. During about a month's work (two weeks each in 1956 and 1957), the various components of landscape for an area of 40 square kilometres were mapped (for hydrography and relief the area was larger), numerous problems were discussed

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[1] A review of Soviet literature points to A. Isachenko's book *Osnovnyje voprosy fizicheskoj geografii* (1953), whereas the German literature mentions the book by J. H. Schultze *Die naturbedingten Landschaften der Deutschen Demokratischen Republik* (1953) and a paper by E. Meynen and J. Schmithüsen, in the Introduction to *Handbuch der naturräumlichen Gliederung Deutschlands* (1953).

[2] Taking part in the geobotanical mapping were: Docent S. Jarosz and Assistant J. Stasiak, in soil mapping: Docent M. Prószyński and Assistant J. Wolaniecki, geomorphology was elaborated by Assistant K. Świerczyński, and hydrography by Lecturer H. Więckowcka. Climatological observations were made by a group of 15 persons, headed by Docent J. Paszyński.

in the field, and a synthetic treatise based on observed evidence and on analytical maps was prepared. These field maps were drawn at 1:10.000 scale. The results of these investigations comprise: maps on geomorphology, hydrography, soil conditions, geobotany, on the degree of danger of radiation frosts, and — finally — a synthetic map of types of geographical landscape. These maps, together with comments discussing the individual landscape components, are published in the „Geographical Studies" of the Institute of Geography of the Polish Academy of Sciences.

In this paper I shall briefly present our general conclusions from the correlation of component factors and from changes in geographical environment observed on the background of distinct types of terrain.

As the starting point for discerning the types of environment landscape differentiation brought about by land utilization methods has been accepted. In the Masurian Lake District, the land relief is the relic of a previous geological period and in our present climatic conditions has thus far not changed. This land relief is the basis for a general regional division and, being a relatively static factor, produces physical and chemical conditions for other processes. On the other hand, the dynamics of the contemporary landscape are principally characterized by changes in biocenoses. Since the modern landscape has lost its natural appearance, man's economy exerts a fundamental influence upon the natural environment by the forms of land utilization and management of water resources. For this reason, too, we have in our investigations distinguished arable land, forests, meadows and water basins as biotic types of landscape.

The relic postglacial relief (together with its characteristic geological material) and the actual moderately humid climate bear decisively upon water conditions in the area. On elevated regions, built of permeable material, rain waters penetrate into the ground, causing a leaching on the surface strata and, subsequently, the formation of podsolized soils. In flat lands with high ground-water level there develop bog soils with a high content of organic substances, and turfs. On the slopes of the numerous hills, especially on boulder clay, the calcium carbonate has failed to be displaced downwards; thus vegetation is more abundant here, the earth belonging to the type of brown forest soils.

It appears that soil development has proceeded in one cycle — from a tundra type to podsolized brown soils. Locally this process may have varied, depending on the character of the relief, on the permeability of the substratum and on existing water conditions; due to this the soil map is actually a mosaic of different types, i. e. of brown and degraded brown soils, of podsolized soils and bog soils. At the same time there is no full correlation between types of soils and vegetation, although a genetic mutual relation undoubtedly exists between these factors. This may be explained chiefly by the fact that vegetation undergoes changes much more rapidly than soils. On arable land areas the soil is more or less altered by man's agricultural technique; however, in these changes we can perceive the evolutionary stage of the natural environment by the introduction of agriculture. In the investigated areas the latter event took place scarcely a few hundres years ago (this area belonging to the medieval Masurian colonization undertaken in ancient primeval forests).

On forested areas the evolutionary stage of environment is chiefly indicated by the vegetation, even when changed by human economy. This is less a matter of association of presentday wood cover than of the composition of the forest floor, a much more reliable index. Ascertainment of conformity or nonconformity of both plant cover and soil type makes possible further conclusions as to proceeding changes as well as to the rationality of the undertaken economy. In general, we have divided the existing forest associations into three large classes: *Alnetea glutinosae, Querceto-Fagetea* and *Vaccinio-Piceetea,* corresponding to conditions of soil moisture (combined with land relief and permeability of substratum) and in turn exerting their influence upon the type of soil. This interrelation may be shown graphically in the shape of a circular diagram (Fig. 1).

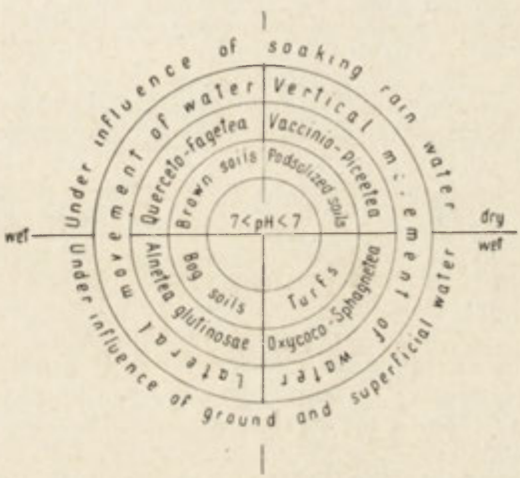

Fig. 1. Scheme of correlations in the landscape of Northern Poland

The upper part of the cycle presents an environment shaped by rainfall; on the left is shown a substratum of basic reaction, on the right — of acid reaction. To the former correspondent deciduous forests of the *Querceto-Fagetea* class and brown forest soils, to the latter coniferous forests of the *Vaccinio-Piceetea* class and podsolized soils; in the middle appear transition types of both soil and vegetation. The lower part of the circular diagram illustrates an environment shaped by grounds waters. Here again, the diagram's left side shows an environment of basic or neutral reaction, the right — an acid reaction. In cases of excess moisture there occurs an accumulation of organic substances; bogs and peat soils are formed there. In an alkaline environment, humid deciduous forests of *Alnetea glutinosae* grow here, whereas in an acid environment we observe accumulations of high moors *(Oxycocco-Sphagnetea).* Of course, everywhere at the boundaries of the vegetation formations and the soil types there exist transition categories not shown in our general diagram for reasons of clarity.

Changes of environment are brought about by changes in water conditions which, in turn, are connected with changes of climate. Assuming as the starting point a substratum rich in mineral salts on the area of the Northern Polish Lake District we may conclude that the development of vegetation and soils proceeded from the left side of our circular diagram towards the right (both in the upper and lower part); and, depending on water conditions, the ultimate links of this process — assuming constant conditions of precipitation and a constant level of ground waters — would be represented by either a dry pine forest or a high moor. However, due to the fact that during the Holocene, water conditions have not been constant, there might have occurred — within certain limits — changes in a reverse direction too.

Most difficult is to determine the stage of the landscape evolution on meadow areas; here man has powerfully interfered with the natural processes of development, by regulating water conditions and by changes in vegetation. Man's activity, to be true, did not create entirely altered formations as is the case on arable land; still, conditions at present are very much different from those existing with forest floor (even in cultivated forests). As a rule, meadows were created by cutting down forests, and can therefore be subordinated to corresponding classes of forest vegetation.

In a water environment the well known division is the oligotrophic, eutrophic and distrophic types. These three types are also correlated within certain stages of evolution. The original waters in postglacial lakes, assigned to the oligotrophic type, contained very little organic substances, whereas they abounded in mineral salts, among them in *calcium carbonate*.

In conditions of an intensive development of organic substances, the oligotrophic lakes, passing througt various stages of mezotrophy, reach the eutrophic stage (which, on stable land, corresponds to the *Alnetea glutinosae* formation).

In acid conditions the oligotrophic as well as the eutrophic lake may pass into the distrophic type; this type, however, is relatively rare in Poland due to the fact that the exchange of material between lake and surroundings and the connection between lake and underground waters make difficult an evolution in this direction. An intermediate link between the coniferous forest and distrophic lake constitutes the high moor.

On areas of arable land when natural or seminatural plant groups are lacking, the type of natural landscape is determined only by the soils. Within the four principal physiognomic types, the evolutionary stages conditioned by the character of vegetations and of the soil have been distinguished in this manner.

The relief of the land is shown with contour lines each 5 m. Among concave forms are marked depressions exposed to a maximum degree by radiation freezing (climatological criterion). Alongside of these physical components of the environment we have taken into account surface waters.

A map prepared on these principles is, in some measure, the sum of elements chosen from individual analytical maps; it makes it possible to estimate the stage of changes as to the principal types of environment, and to draw conclusions as to the processes taking place there. The full hydrographic conditions are shown separatly on the second map (see the both tables).

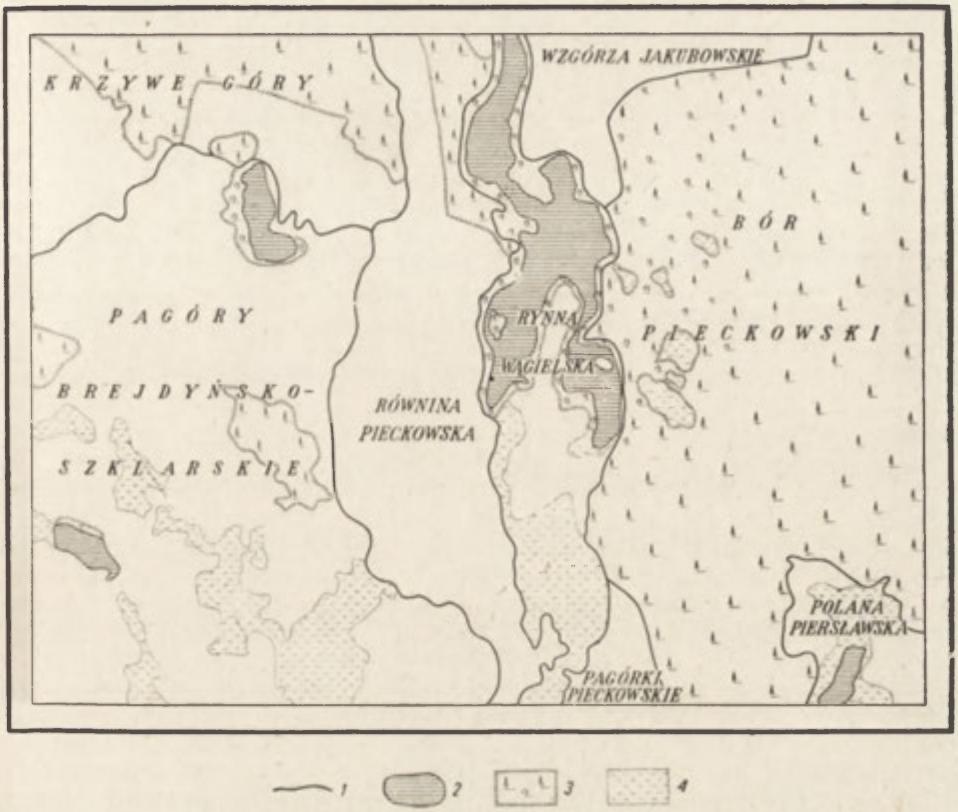

Fig. 2. Division into microregions
1 — Limits of microregions, *2* — lakes, *3* — forests, *4* — meadows and swamps

On the basis of the above discussed types of landscape and in due consideration of relief we have distinguished the following microregions:

I. The forest sandy hills of Krzywe Góry in the northern part of the area, west of Wągiel lake.

II. The forestless loamy hills near Jakubowo, east of Wągiel lake.

III. The loamy hill site under cultivation in the western part of the area near the villages Brejdyny and Szklarnia.

IV. The cultivated sandy plain along the Piecki—Mrągowo highway (Równina Pieckowska).

V. The through of Wągiel lake with its southern extension, covered by meadows (Rynna Wągielska).

VI. The sandy forest region east of Wągiel lake.

VII. The cultivated sandy and gravel hills east of Piecki (Pagórki Pieckowskie).

VIII. The midd-forest clearing near Pierslawek village, with a shallov lake of the same name.

Within each one of these units there in turn appears a number of spots of specific physical and geographical feature; however, owing to their purely local significance no description is given.

A further result of our field investigations, tending towards their practical utilization, ought to be an evaluation of the environment, i. e. some kind of estimate of its value. This is, however, rather a subject for economic geography. This type of estimate can only be made from the point of view of the means of utilizing the environment. Different evaluations are required respectively regarding town planning, agriculture, forestry, irrigations, etc. Physical geography can supply but a very general evaluation. Thus it might be pointed out that the microregions of Krzywe Gory, the plains and hillocks of Piecki, the hills of Jakubowo and the clearings of Piersławek each constitute natural sites of mixed forests and, partly, of deciduous forests, and that the man has changed the forest vegetations in an unfavourable manner, i. e., into a monoculture of pine and spruce, causing a gradual deterioration and podsolization of the soil. Less fertile regions adjoining forests became mostly fallow during the post-war period; in many localities there may be observed the invasion of the forest upon formerly cultivated fields. On the other hand, the Brejdyny-Szklarnia hills represent a region of fertile soils and are suitable for intensive agricultural utilization. The investigated area contains a great expanse of meadow land, too; however, here we observe the adverse symptom of transformation of prolific meadows into deteriorated acid meadows.

Investigations of this type continue to be made in the Masurian Lake District and elsewhere. On the one hand they lead towards a further detailed analysis of an area limited to one or several spots while, on the other hand, they take in the smallest economic units, such as individual communes. On the basis of the above described experiences we here aim at applying the method of one-man mapping, without the cooperation of representatives trained in analyzing individual component features of the landscape. It must be stressed too that the lakes represent an environment differing from biotic land types to such an extent that they cannot be investigated simultaneously by the same group; notwithstanding certain analogies of development they comprise separate problems which had to be omitted in our investigations.

Translated by Karol Jurasz

EXPLANATION TO THE SEPARATE MAPS *

Tablica VI — Map VI. Jerzy Kondracki: *Typy środowiska geograficznego — Types of the natural landscape (geographical environment)*

Typ biotyczny — Biotic type

A. LASY – FORESTS

Grąd — *Querceto-Carpinetum* (class of *Querceto-Fagetea*).
Bór mieszany — *Querceto-Piceto-Pinetum*. }
Bór typowy — *Piceto-Pinetum* } (*Vaccinio-Piceetea*).
Bór bagienny — *Pinetum turfosum*. }
Łęg — *Alnetum glutinosae* (class of *Alnetea glutinosae*).

B. ŁĄKI I FORMACJE BAGIENNE – MEADOWS AND MOOR FORMATIONS

Łąka grądowa — Alcaline meadow.
Łąka kwaśna — Acid meadow.
Torfowisko wysokie — High moor.
Torfowisko przejściowe — Transitional moor.
Torfowisko niskie — Low moor.

C. POLA UPRAWNE – ARABLE LANDS

Na glebach brunatnych — On the brown forest soils.
Na glebach brunatnych zdegradowanych — On the degraded brown soils.
Na glebach bielicowych — On the podsolized soils.
Na czarnych ziemiach — On the black soils.
Na rędzinach (na marglach) — On the carbonate soils (on marls).

Rzeźba — Relief

Izohipsy co 5 m — Contour lines each 5 m.

Wody — Waters

Jeziora (ze strefą roślinności przybrzeżnej) — Lakes (with the zone of littoral vegetation).
Rowy melioracyjne — Meliorative ditches.

Mikroklimat — Microclimate

Zagłębienia zagrożone przymrozkami radiacyjnymi — Depressions exposed to a maximum degree by radiation freezing.

* The maps are taken from the 19 copy of the „Geographical Studies" (Prace Geograficzne), edited by the Institute of Geography of the Polish Academy of Sciences (Warszawa 1959).

Typy kwasowości — Types of acidity	*Typy nawilgocenia — Types of wetness*
Alkaliczny — Alcalic	Wilgotny — Wet
Obojętny — Neutral	Względnie wilgotny — Relatively wet
Kwaśny — Acid	Względnie suchy — Relatively dry

Tablica II — Map II. Helena Werner-Więckowska: *Wody — Waters*

A. TEREN Z ODPŁYWEM POWIERZCHNIOWYM – AREA WITH SUPERFICIAL DRAINAGE

Linijny dział wodny główny (wód Wisły i Pregoły) i działy niższych rzędów — Linear main watershed (Vistula and Pregel rivers) and watershed of lower order.

Rowy melioracyjne we wkopie i na mokradle — Drainage ditches in cutting and on the swamp.

Miejsce pomiarów przepływu i jego numer — Points of measurement of water discharge and its number.

Niektóre linie dren i studzienki drenarskie — Some lines of drainpipes and drain-wells.

Dawne mokradła osuszone pod uprawę — Previous swamp drained off for arable land.

B. OBSZARY BEZODPŁYWOWE – AREA WITHOUT SUPERFICIAL DRAINAGE

Obszary zespołów zlewni bezodpływowych i otaczające je działy wód powierzchniowych — Group of catchments without superficial drainage and surrounding them watersheds.

Obszary bezodpływowe łatwoprzepuszczalne, chłonące wodę opadową (dla odpływu podziemnego dolnym poziomem) przez: — Highly permeable areas without superficial drainage absorbing rain water by the way of:

Suche zagłębienia zamknięte — Dry closed hollows.

„Ponory” w żwirach — „Pot holes” in gravels.

Obszary bezodpływowe trudnoprzepuszczalne o skąpym odpływie podziemnym, o przewadze parowania bezpośredniego przez: — Nearly impermeable areas without superficial drainage of low value of underground discharge with superiority of direct evaporation by the way of:

Oczka stałe lub okresowe — Little hollows with water (perennial and periodical).

Oczka, źródła, wodopoje — Little hollows with water or springs used by the farmers.

Jeziora (izobaty w metrach) — Lakes (izobaths in metres).

Zagłębienia zalewane (w sierpniu 1956) — Flooded depressions (August 1956).

Obszary bezodpływowe trudnoprzepuszczalne o skąpym odpływie podziemnym o przewadze parowania pośredniego przez ewapotranspirację — Nearly impermeable areas without superficial drainage of low value of underground discharge with superiority of indirect evapotranspiration by the way of:

Przybrzeżne zarastanie jezior — Littoral overgrowing of lakes.

Trzęsawiska — Quagmire.

Mokradła stałe — Perennial swamps.

Mokradła okresowe górnego poziomu wodonośnego — Periodical swamps of upper underground water table.

Mokradła okresowe dolnego poziomu wodonośnego — Periodical swamps of lowe underground water table.

C. GÓRNY POZIOM WÓD PODZIEMNYCH NIEJEDNOLITY I NIEOBFITY W GLINACH ZWAŁOWYCH – DISCONTINUOUS AND POOR-ABUNDANT UPPER UNDERGROUND WATER TABLE IN BOULDER CLAY

Studnie przeważnie w glinie (2—8 m głębokie) — Wells mostly in boulder clay 2—8 m. deep.

Przybliżony zasięg poziomu od strony zasilania — Probable limit of underground water level from alimentation side.

Przybliżony zasięg poziomu od strony tracenia wód — Probable limit of underground water level from losing side.

Strefa działu wód — Zone of watershed.

D. DOLNY POZIOM WODONOŚNY JEDNOSTAJNY I OBFITY W PIASKACH I ŻWIRACH NIEPOKRYTYCH LUB PODGLINOWYCH – CONTINUOUS AND ABUNDANT LOWER UNDERGROUND WATER LEVEL IN SANDS AND GRAVELS UNCOVERED OR UNDER THE CLAY

Studnie głębokie 6—24 m — Wells 6—24 m. deep.

Strefa działu wód — Zone of watershed.

Studnie dwupoziomowe o dużych (do 18 m) wahaniach poziomu.

Wells in two aquiferous layers with high (up to 18 m.) oscilation of water lewel.

LESZEK STARKEL

Development of the Relief of the Polish Carpathians in the Holocene

Characteristic of the problem, and method of investigation

Thus far, in our geomorphological literature, we lack a full opinion of the part played by the most recent geological era, the Holocene, in the transformation of older relief forms. Within the recent several score years the profound attention devoted to the periglacial morphogeny postponed studies on contemporaneous processes and on forms being produced in a temperate climate. Everywhere efforts were made to discern periglacial forms and covers. On the basis of material collected from various regions of Germany, J. Büdel *(3)* assumes that the freshness of glacial forms in the development of the full (podsolized) soil profile, and the appearance of peat bogs on the periglacial covers contradict a more distinct alteration of older forms by contemporaneous processes.

On the other hand, investigations carried out by many scientists, especially soil expertes, agronomists specializing in drainage, geologists (S. Sobolew, *34,* Bennett, *2,* A. Reniger, *28,* Keil, *15*) and, more rarely, by geomorphologists, call particular attention to the extent of contemporaneously occurring morphogenetic processes embraced by the common term: soil erosion. The development of new forms of erosion and denudation is chiefly connected with deforestation O. Schmid, *32,* L. Hempel, *10,* M. Dorywalski, *4,* J. Dylik, *5*). Proof of intensified soil denudation are the covers *(Auelehmdecke)* of quicksand deposited during flood times on valley floors, as described from many European countries (L. Hempel, *9,* H. Mensching, *22,* Ambrož, *1,* M. Lukniš, E. Mazur, *20*). From the floors of Carpathian valleys they are known by papers published by W. Friedberg *(7),* M. Łomnicki *(21),* M. Klimaszewski *(17),* A. Środoń *(41)* and A. Jahn *(13).*

On the other hand, less papers exist discussing processes and forms which took place during the postglacial, without being connected with deforestation. The subject of particularly numerous publications have been Holocene landslides known on the area of the Flysch Carpathians and of other regions *(31, 43, 45, 24).* On the basis of their relation to periglacial or glacial deposits there have been classified as being of Holocene origin: small erosive valleys commonly appearing in forests *(19, 44, 35, 8, 16, 12, 26, 38),* shallow slides, and creeping rock debris *(38);* to modern slope wash in forests is also being ascribed the formation of new rock debris (Harz, *11*). In river valleys there have been determined erosive channels incised into the periglacial covers, subsequently filled in by quicksand layers as well as by late glacial and Old Holocene deposits *(23, 46, 35, 36)*. The above mentioned papers indicate that the Holocene is not a period of a lifeless landscape and of stoppage of processes, but rather a period hitherto but scantily investigated.

Towards cognizance of the part played by the Holocene morphology, the Geographic Institute of the Polish Academy of Sciences, Department of Geomorphology and Hydrography at Kraków is carrying out, during recent years, studies on this subject in the Carpathians. The present paper discusses the results obtained from investigations undertaken in 1956 and 1957 on the Holocene morphogeny in the Flysch Carpathians.

The northern part of the Carpathian chain, split up by deep valleys, is built of Flysch formations Cretaceous — Palaeogene age. On Polish territory they occupy an area of approximately 22.000 sq. km. Morphologically this area consists of a number of compact mountain groups, of isolated zones or in isolated mountains with culminations reaching from 800 to 1.725 m. above sea level. In the north there extends, in a continuous belt, the elevated area of the Carpathian Upland (Pogórze); along the numerous valleys it penetrates bay-like the Beskid Mountains. Its difference in altitude oscillates between 100 and 250 meters, its individual ridges from 300 up to about 700 meters. Within the range of both these units, hill scarps and valleys are differentiated as to their inclination as well as their lengths and relief features (concave or convex slopes, concave--convex slopes, escarpments). This variety in slope relief is distinctly dependent on the geological structure. The mountain groups are built of more compact complexes, chiefly of sandstones, whereas the valley depressions are incised into formations of feeble resistance, chiefly clays, shales or mixed sandstone-shale series. On top of the rock lie cover deposits of a thickness up to 15 m. Depending on geological structure and slope shape these periglacial covers disclose with differing mechanical composition and physical features. In the Holocene these deposits are directly exposed to denudation. The Carpathians show an equally intense differentiation as to conditions of climate, hydrology and vegetation. It may suffice to mention that in the Carpathians the snow cover lasts from 70 days on the foreland to 200 days on the slopes of Babia Góra; depending on altitude and exposition, rainfall precipitation ranges between 700 and 1500 mm. In regions with argillaceous shales there predominates water flow along the surfaces, whereas in fissured sandstone complexes the water penetrates into the interior. Almost all of the Flysch Carpathians is situated in the forested stage of the area, the forest's upper boundary lying at 1.400 m. above sea level. However, the Carpathian Upland and the lower parts of the Beskids (e. g. to about 800 m. above sea level) have undergone deforestation to about 80%.

In the present paper I have aimed at describing the part played by the Holocene morphogeny in the alteration of the relief of the Flysch Carpathians. My efforts have been directed towards qualitatively recognizing the phenomena and ascertaining their different processes and forms, as well as towards quantitatively determining the extent of denudation and the degree of alteration of the slopes, and towards investigating the phases of diverse intensity of erosion and denudation during the late glacial and the Holocene. I propose to establish the part played by the Holocene morphogeny by studying Holocene forms and deposits as well as the contemporaneously occurring processes. I have concentrated by investigations upon two areas: destructive forms and processes I investigated within the range of the Flysch Carpathians, whereas alluvial deposits I studied chiefly in the Holocene cones in the Sandomierz—Basin on the foreland of the Carpathians.

The cognizance of Holocene forms appearing on the entire area of the Flysch Carpathians would require studies of many years' duration. Due to this, I selected in various regions of the Carpathians moderate size areas representing larger morphological regions, similar in relief, geological structure, climate, water conditions and vegetative cover. Together the chosen areas disclose all the principal rock complexes of the Flysch (the Krosno, Magura, Submagura, Inoceramus beds, and others), all types of relief (upland, mountain massifs, mountain chains, intramountain depressions), and various altitude zones of climate and vegetation (from 200 to 1725 m. above sea level). Thus, the selected representative areas combined constitute a full picture of the differentiation of Holocene processes and forms of the area of the Carpathians.

On each one of the seven representative areas (each of a surface of less than 10 sq. kilometers) I have carried out a detailed geomorphological survey in 1 : 10 000 scale. This investigation comprised the mapping of all existing forms, with particular attention paid to Holocene forms, and the study of both Holocene and periglacial cover deposits. The age of the Holocene forms I managed to determine on the basis of their relation to the periglacial cover and to other Holocene forms and deposits, and on the basis of shape and degree of freshness and activity revealed by these forms. In order to have the advantage of a more extensive comparative material I also utilized material and 1 : 25 000 maps prepared for further 8 areas. In this manner I obtained a total of 15 representative areas situated in the Carpathian Upland and in the Beskids (Fig. 1). On the basis of this geomorphological mapping I prepared a review of all Holocene forms, distinguishing 6 types of slope shapes formed in the postglacial. Aside on this geomorphological mapping I undertook field observations at various periods of the year, especially during snow-melt and torrential summer showers, investigating both extent and intensity of modern morphogenic processes. My purpose in collecting this field material was to gain konwledge of the variability of processes during the year, and to determine the extent of denuding activities in the Holocene. The comparison between these processes taking place within forests and on deforested areas made it possible to distinguish forms developing in natural conditions from forms which are produced, or intensively remodeled, by man's deforesting activity; thus to determine the extent of alterations occurring before man started to interfere with nature. On the basis of both my mapping and my field observations of processes I subsequently computed the masses of material washed down Holocene valleys, and the masses translocated within the individual representative areas. The computation of material from the valleys was based on multiplying the mean cross-

-section of various types of Holocene valleys with the length of these valleys. The sum of volumes obtained for the various types of valleys gave the total amount of material removed from the entire representative area.

However, my investigation of processes and forms within the Carpathians failed to elucidate the successive evolutionary stages of the Carpathians' relief in the Holocene, and to establish the amount of material swept down on the area of the entire Carpathians. In order to find the answer to this query I investigated the deposits forming the huge alluvial cones at the outlets of the wide Carpathian valleys, especially those of the Wisłoka, the Wisłok and the San rivers.

I took it for granted that any changes in intensity of erosion and denudation taking place in the Carpathians ought to disclose their correlation in processes occurring within the range of alluvial cones. This supposition of mine has been fully corroborated by an analysis of both the mechanical composition and the position of deposits, made with regard to about 50 exposures and more thatn 500 bore hole profiles, as well as by an analysis of plant remains aboundantly discovered in these deposits[1]; this investigation made it possible too to distinguish series of different age showing various types of alluvial material. In this manner, on the basis of the character of deposits and the phases of erosion determined within the cones, we are in a position to portray the course of processes which were taking plase in the Carpathians througout the Holocene, and even to correlate specific forms appearing in the Beskid Mountains and in the Highland with deposits investigated on the Carpathian foreland, In order to indicate the extent of removal of material from the entire Carpathians I have compared the volume of Holocene alluvia contained in the alluvial cones with my computations of the material carried away from the range of representative areas. Besides Holocene covers, I also have analyzed the late glacial covers, owing to the fact that in the Carpathians the late glacial period is connected with the Holocene morphogeny. During the Alleröd there started in the Carpathians the denudation of the accumulated periglacial cover deposits, introducing the postglacial period *(35)*. The cause of this change was an increase of precipitation and temperature, as indicated by investigations carried out by W. Szafer and his school *(39, 40, 41)*.

Differentiation of Holocene forms and processes in the Carpathians

On the basis of material obtained from the geomorphological mapping of the representative areas (Fig. 2) there may be distinguished several groups of forms related with Holocene alterations in a varying degree. The first among these groups are old forms which failed to be altered during the Holocene and, at best, were sculptured by denudation. To them belong, in the first place, slopes covered by permeable covers, and periglacial valleys overlain by sheets consisting mostly of rubble and,

[1] Palynological and macroscopic analyses of the plant remains have been made by Dr. M. Sobolewska and K. Mamakowa M. Sc., from the Botanical Institute of the Polish Academy of Sciences at Kraków.

due to this, not rejuvenated. A second group comprises forms which are still developing, similarly as in a periglacial climate. These are, principally, various stone streams, as well as talus cones discovered above the upper forest rim (see representative area XV). To the third group I am assigning valleys of ancient origin, covered by periglacial covers, where the valley floors have been dissected and rejuvenated or, inversely, have been filled in by deluvial covers. Most numerous, however, is group four. It comprises forms developed in the Holocene within the range of valley slopes and floors sculptured by periglacial processes. In these forms are incised or (sometimes, especially where accumulative forms are concerned) laid down on top of them (Plate 1—8):

a) denudation forms: mobile block-fields, scars of slides, land slumps and rock falls, slide tongues, weathered rock creep, earth creep scopes, creep zones, bowl-shaped depressions due to creep, slide or slope wash, monadnock-type intervalley ridges, plains of deluvial accumulation, etc.

b) forms of fluvial erosion: river beds, rock steps in the river bed, erosive edges, valleys with modern erosive incision (gullies, ravines), permanent flow-shaped valleys, erosive valleys of box section, valleys of modern sculpturing due to denuding processes (dales with accumulative floors, „tielke", glens, trough-shaped hollows),

c) suffosive forms: suffosive kettles (sink holes), suffosive. blind valleys, ravines and bowl-shaped small valleys of suffosive origin.

d) forms of fluvial accumulation: gravel banks, inundation terraces and terraces above flood levels, alluvial cones,

e) sporadic forms of organic origin, such as peat bogs,

f) anthropogenic forms.

The above enumerated forms are by no means evenly distributed all over the area of the Carpathians, nor do they occur in identical frequency everywhere. Alongside of the above mentioned forms, being in the Carpathians the result of current linear erosion, of slopewash, slumps, slides, creep, suffosion and of the activity of organic matter and of man, there also appear minor forms which, however, frequently are very common, such as erosive gullies, rock blocks perched on ice needles, etc., indicating the widespread occurrence of denudation and of translocation due to ground ice, solifluxion and deflation. Observations of forms and processes appearing in forests, on meadows and on arable fields enable us to determine the part played by the individual processes in the sculpturing of slopes, and to distinguish the group of natural processes, typical for the Holocene, from processes whose intensity is connected with man's economy. Amongst natural processes, first place takes linear erosion, gravity movements of landslide type and underground washing (suffosion). After deforestation, on the other hand, there is an enormous increase of surface washing down, and of earth creep.

Young erosive valleys are characteristic for the entire area of the Flysch Carpathians. Best proof for this assertion is the almost universely observed lengthening of valleys during the Holocene; in some of the representative areas it exceeds 100% (Table 1). The most common natural erosive forms are — shaped valleys which in the Carpathians reach depths up to 20 meters. Such shaped valleys originate

Table 1

Greatness of alteration of slopes and of denudation in the Carpathians in the postglacial

Area for representative areas number has been added	Surface in sq. kilometers	Type of shaping *	Length of valley in kilometers		% of surface altered during the postglacial	Cubic content of masses carried away from Holocene valleys
			pre-Holocene	Holo-cene		
Wieliczka I	4.5	A, D, B	length increase about 50%		> 20	(abt. 50 cu. m./sq. km/year) **
Dębica-Flysch II	abt. 5—10	C/D, D, A	length increase 50—150%		10—40	
Dębica-Miocene III	about 5—10	A, B	no length increase		< 5	
Grabownica IV	6.0	A, C/D	3.9	5.5	about 20	150 000 cu.m./sq. km
Rabka-Skaliste VIII	3.5	B, D, C/D	2.7	6.0	> 20	280 000 cu.m./sq. km
Rzyki-Leskowiec IX	7.2	C, B,	2.5	3.3 (2.7) ***	< 10	130 000 cu.m./sq. km
Luboń Wielki (part) X	1.7	B, C/D	3.0	3.5	< 10	380 000 cu.m./sq. km
Gruszowiec XI	6.5	B, D, C	2.2	3.4	about 10	135 000 cu.m./sq. km
Bukowiec Korbania XII	8.0	B	3.1	4.4	< 10	140 000 cu.m./sq. km
Czarna-Żołobek (part) XIV	4.0	A, E, C	2.8	5.6	< 10	
Lukawica basin (acc. to Reniger 30)	9.5	(B, C)				(122.5 cu. m./sq. km/year) **
Stasikowski creek basin (acc. to Pietruszewski *27*)						(41 cu. m./sq. km/year) **
Świdnik basin (acc. to Pietruszewski *27*)						(122.2 cu. m./sq. km/year) **
Mleczka basin (acc. to Reniger, Jarocki *14*)						
Locality Bystrowice 80 sq. km.						abt. 70 t/sq. km/year ****
Locality Kańczuga 138 sq. km.						abt. 93 t/sq. km/year ****

* Most important types of shaping. The letters indicate the various types according to Fig. 1.
** Amount of material displaced during one year according to measurements made in storage basins.
*** In brackets is given length of valleys active in the Holocene.
**** Amount of suspended material according to measurements made at bathometric stations.

from various (not always Holocene) forms, such as: slight depressions, of ablation, stone zones or streams, creep streaks, trough-like creep-valleys and „tielke", grooved slides on undercut slopes, suffosive channels and sink-holes, — finally also gullies, notches and channels of streamlets caused by the direct action of water flowing down on the surface. When such V-shaped valleys become deforested or when their outlets are supported by accumulated alluvia in the main valley, they are transformed into ravines with accumulative floors. Due to this aggraded, ravines constitute the most habitual group of small valleys in the Carpathian Highland. On cultivated slopes, aggraded, ravines frequently are changed into trough-like forms. In this manner, many Holocene valley forms have in a fairly short time passed their entire cycle of development. In the Carpathians many shaped valleys started in the Alleröd already and underwent deepening in the Holocene. Evidence of this are late glacial and Holocene alluvial cones which at the outlets of small valleys were deposited on top of solifluxion covers *(41, 37)*.

L a n d s l i d e s are forms particularly typical for the Flysch Carpathians. They are grouped: in regions built of mixed shale-sandstone complexes (Inoceramus beds in area III, Submagura beds in area VIII and XI), in valleys rejuvenated during the Holocene, with their floors covered by pervious covers deposited on an argillaceous substratum, — and on escarpment slopes built of sandstones with sales at their bottom. The Carpathian landslides show a manifold morphology and origin. Alongside of small or large consequent, rarely asequent, slides of plastic masses of earth or rock, there also appear slides and slumps of big, compact rock masses. — In a fundamental manner landslides modify the form of a slope and by producing concave forms they give rise to new valleys. The majority of big landslides are motionless today, frequently covered by vegetation and showing mature forms. Most probably they originated during the late glacial when basins of ground water were formed. Deforestation speeded up both the development of earth slides and the frequency of occurrence of minor slides and slumps of earth masses.

S u f f o s i v e f o r m s or, at the very least, traces of subterranean erosion I have observed on almost all representative areas. However, particularly frequent is suffosion in two instances: a) when the steep Beskid slopes are covered by permeable rubble covers, and b) when slopes of an average dip of 8 to 20°, built of impermeable or poorly permeable rock, are overlain by silty or sandy covers (Plate 1). In the latter instance only there is possible a more rapid widening of the subterranean suffosive channels and the formation of sink holes which later, after joining, produce young valley forms upon the slopes. At a particularly large scale suffosion takes place within the range of boulder clays deposited on Krosno beds (see Fig. 1, — representative areas XII, XIII, VI, VII, and others) where new forms are being produced up to the present day. Suffosive sink holes appear most frequently in spring hollows of existing valleys. Due to this I believe that suffosion has played an important part in the formation of the system of Holocene valleys. Sinks and valleys of suffosive origin were formed in the postglacial, after the cessation of cold climate and of eternal ice. In periglacial conditions the entire melted ice layer was

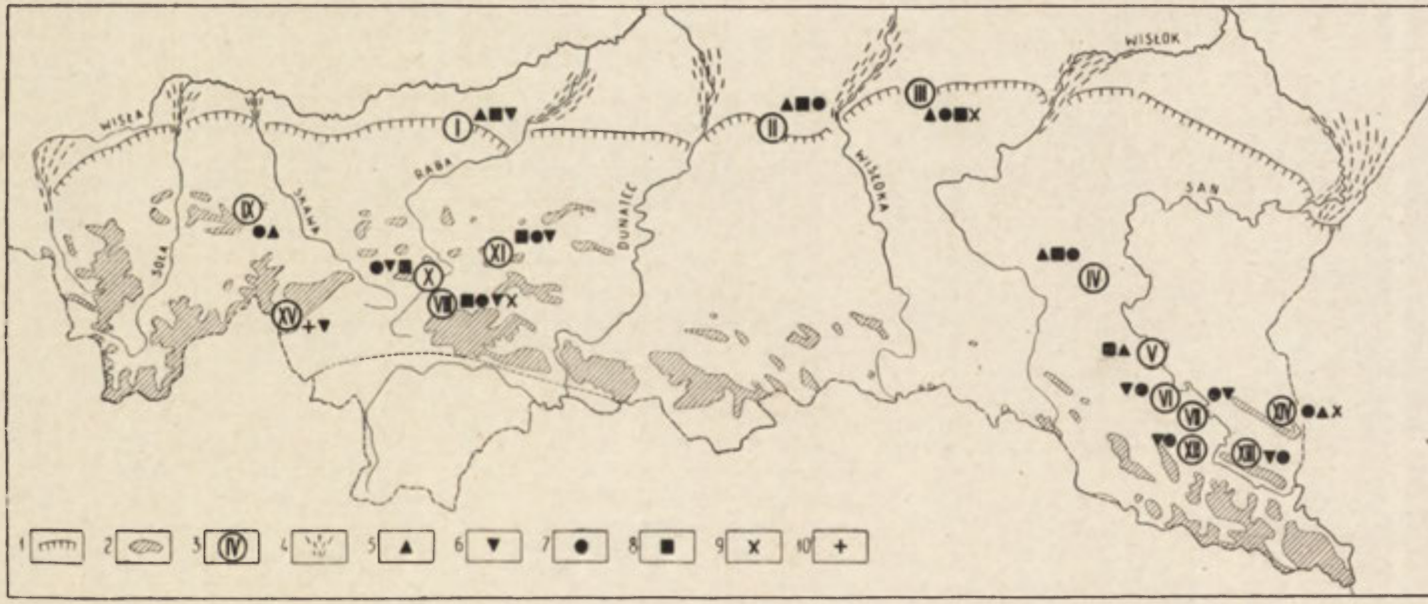

Fig. 1. Areas of investigations of Holocene forms in the Carpathians.
Explanation of symbols: *1* — northern boundary of Flysch Carpathians, *2* — areas belonging to climatic and morphogenetic mountain zone (elevations exceeding 700 m. above sea level), *3* — successive numbers of representative areas, *4* — Holocene alluvial cones on Carpathian foreland
On representative areas, their principal type of slope shape has been marker as follows: *5* — slope out-wash type (A), *6* — slope out-wash — suffosive type (B), *7* — erosive type (C), *8* — slide type (D), *9* — creep type (E), *10* — rubble creep type (F)

Fig. 2. Geomorphological map of representative area XI „Gruszowiec" Explanation of symbols applying to all areas mapped at 1:10 000 scale (areas I, IV, VIII, IX, X, XI, XII).

I. Older forms, of Pliocene and Pleistocene age;

A. Forms produced by the destructive action of flowing water and denudative factors: *1* — Fragments of denudation peneplains, *2* — Valley sides and slopes of Pliocene and Pleistocene forms, *3* — Denudation (structural) break of slope, *4* — Forms of ridges or humps: a) narrow, sharp-edged, b) narrow, rounded, c) wide, rounded, *5* — Dome-shaped summits, *6* — Deforested block-fields, in situ or slightly translocated on slope, *7* — Denudation rock forms, *8* — Slide scars: a) well preserved, b) poorly preserved, *9* — Steps of slides and slumps, *10* — Trough-shaped valleys paved by periglacial covers, *11* — Deep trough-shaped valleys cut into rock formation, *12* — Pleistocene (corrasive) V-shaped valleys, *13* — Erosive well preserved: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *14* — Erosive edges poorly preserved: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceding 12 m.

B. Forms produced by the constructive action of denudative factors: *15* — Slopes covered by talus sheets, *16* — Ridges and summits caused by slides and slumps, *17* — Depressions within range of slide tongues and slump treads, *18* — Denuded surfaces of slide tongues, *19* — Plains of solifluxion accumulation from the period of the Baltic glaciation

C. Forms produced by the constructive action of flowing water: *20* — Plains of fluvial accumulation from the period of the Kraków glaciation, *21* — Plains of fluvial accumulation from the period of the Middle Polish glaciation, *22* — Plains of fluvial accumulation from the period of the Baltic glaciation, *23* — Plains of aluvial cones from the period of the Baltic glaciation, *24* — Plains of alluvial cones from the late glacial period

II. Older forms, of Pliocene and Pleistocene age, reshaped during the Holocene:

A. Forms sculptured by the destructive action of flowing water and denudative factors: *25* — Drained being formed in the Holocene, *28* — Rejuvenated (dis of their periglacial covers, *27* — V-shaped valleys stone streams, *26* — Older V-shaped valleys deprivedsected) V-shaped valleys, *29* — Trough-shaped rejuvenated valleys, *30* — Erosive undercutting continued in the Holocene

B. Forms sculptured by the constructive action of flowing water and denudative factors: *31* — Trough-shaped valleys with accumulative floors

III. Holocene forms, formed and sculptured in the Holocene:

A. Forms produced by the destructive action of denudative factors: *32* — Mobile deforested block fields, creeping along slope, *33* — Valley sides and slopes of Holocene forms, *34* — Monadnock-type intervalley ridges, *35* — Gulies incised into rock, *36* — Scars of rock slides, well preserved, often rejuvenated: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *37* — Scars of rock slides, poorly preserved, immobile: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *38* — Scars of earth slides, well preserved, often rejuvenated: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *39* — Scars of earth slides made more gentle, immobile: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *40* — Scars of slumps and falls (subdivision as for scars), *41* — Smalls slumps and falls: a) immobile, b) mobile, fresh, *42* — Weathered rock creeps: a) immobile, b) mobile, fresh, *43* — Slope creep, *44* — Creep streams, *45* — Small trough-shaped creep valleys, *46* — Small trough-shaped slide valleys, *47* — Small trough-shaped slope wash valleys

B. Forms produced by the constructive action of denudative factors: *48* — Acumulated talus sheets, *49* — Slide tongues: a) immobile, b) mobile, fresh, *50* — Large slide ridges, *51* — Axes of slide ridges, *52* — Flattening of slide treads, *53* — Intraslide depressions, *54* — Plains of deluvial accumulation

C. Forms produced by the destructive action of flowing water, combined with denuding processes: *56* — River beds: a) incised into rock, b) incised into accumulated material, *57* — Steps in channel (rapids, falls), *58* — Steps at otulets of hanging valleys, *59* —Gap like valley stratenings in rock, *60* — Erosive edges, undercut in modern times: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *61* — Erosive edges well preserved: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m. height, d) of height exceeding 12 m., *62* — Erosive edges, poorly preserved: a) of height up to 3 m., b) of 3—6 m. height, c) of 6—12 m.height, d) of height exceeding 12 m., *63* — Small erosive valleys, deepened by present-day erosion: a) slope gullies, b) V-shaped valleys with permanent flow, water incised into compact rock, c) V-shaped valleys with permanent flow water, incised into covers, d) V-shaped valleys sporadically drained (ravines), e) canyons, f) small, shallow ravines and other V-shaped valleys, *64* — Small, usually erosive valleys, of present-day sculpture: by the denudative factors or accumulated: a) V-shaped valleys with gravel covered floors, b) ripe valleys with accumulative floors, c) „tielke", d) small, e) — type-like valleys, produced by accumulative raising of banks on the boundary of arable fields in old trough-like valleys

D. Forms produced by the constructive action of flowing water: *65* — Gravel banks in river-bed, *66* — Plains of low flood terraces and valley floors, *67* — Plains of terraces above flood level

E. Forms produced by the destructive action of subcuta neously flowing water: *69* — Suffosive sink holes, *70* — Blind suffosive gorges, *71* — Ripe valleys with suffosive sinks in floor, *72* — Small trough-shaped valleys with suffosive sinks in floor

F. Anthropogenic forms: *73* — Road cuts: a) utilized, b) erosively altered, *74* — Walls of quarries, clay pits, etc., *75* — Artificial steps in flow channels, *76* — Earth fills and mine dumps saturated with water, while underground escape of water was impossible. Although the discussed depressions are frequently formed in forests, still deforestation and a compacted turf cover aided in developing suffosive forms.

D o w n - w a s h is in the Carpathians a common process: of particular intensity it occurs in deforested areas of the Carpathian Upland with its silty, often loess-like soils. This proces leads to degradation of mouldered horizons and to accumulation of deluvia on the floors of small valleys and on the lower parts of concave slopes. On the marginal parts of the Upland the deluvial covers frequently disclose a thickness of 2—3 m. (representative areas I—III); in the larger valleys of the Upland the cover of quicksand strata, developed form slope wash during the entire Holocene, reaches thicknesses up to 10 meters.

S o i l c r e e p in the Carpathians occurs, in natural conditions, on slopes with an inclination exceeding 8°, in cases when clayey covers, superimposed most frequently on argillaceous sales, have been thoroughly saturated with water. Owing to deforestation, this process occurs commonly in regions built of argillaceous shales, but sporadically only during humid spring and summer periods. This process is aided by a continuous turf cover which — as established by S c h m i d t *(32)* — absorbs water easily and retains it. Unhomogeneous creep of waste layers leads to the formation of such valley forms as slide hollows and — „tielke". (Plate 7, 8).

On the area of the Carpathians, Holocene forms appear chiefly in certain strictly defined groups indicating that landscape sculpturing during the Holocene proceeds differently in different regions. Thus there are regions where, e.g., landslides occur plentifully; in others there prevail soil creeping slopes and „tielke", or various other suffosive forms. In none of the representative areas, however, have there been ascertained any large territories where but on type of process takes place. There is always a group of processes; this seems justified by the variableness of seasons and atmospheric conditions. With regard to the fundamental process which influences the manner of alteration of the individual slope, I have distinguished in the Flysch Carpathians six principal types of slope sculpture which today frequently happen to be in varying stages of development: the slope wash type, the slope wash-suffosive type (most common in the Carpathians), the erosive type (dissection of slopes by a network of valleys), the slide type, and (much rarer) the earth creep type and rubble creep type (Fig. 1). This differentiation depends principally on the permeability of the covers deposited on slopes of various inclination.

Tread-like array of Holocene morphological and climatic regions

In the Carpathians we may clearly discern three zones, one on top of the other, which differ as to assemblage of processes and intensity of these processes, as well as to their different degree of alteration of relief during the postglacial.

The lowest, Carpathian Upland („Pogórze") - zone comprises the area of the hilly foreland and the lower part of the Beskid Mountain slopes, up to the altitude of 700—800 m. above sea level. Here we note a great variety of processes, — actually all types of slope sculpturing appear. Very distinctly in evidence is the phase of processes taking place in winter and during snow-melt. Of particular intensity in this zone are forms of slope wash and sliding of earth masses, as pointed out by M. Klimaszewski *(17);* this is mainly due to a preponderance of silty and clayey cover strata, and to deforestation. The material flushed down from the slopes has frequently been deposited at the slope bases and on valley floors; the small valley forms are, as a rule, mature. Some parts of the foreland and of the intramountain depressions show convex slopes, split up by fissures.

The mountain zone extends upwards to almost the upper timber line, i.e. to about 1400 m. above sea level. This zone comprises the steep slopes (15—35°) of the Beskid summits, built of more resistant rock series and covered by talus and sand strata. Underground drainage and flow along valley floors predominates; processes are less differentiated. Among them most important are linear erosion, suffosion and surface out-wash. The forest cover, the long, almost lifeless winter period combined with plentiful summer rainfall is the cause why the chief season of erosion and earth movement on the steep slopes is the period of heavy summer showers. The flushed-down material is carried beyond the range of the slopes. Here the degree of alteration of periglacial forms is but limited; frequently there are preserved channels cut into the river shingle, even non-rejuvenated gorges, with their floors covered by periglacial covers.

The reason for this contrast between both these zones with regard to the degree of alteration of the older relief is not only a difference in orology and lithology, but likewise the shorter period of duration of the Holocene morphogeny within the mountain zone, and its shorter vegetative season which bears upon the extent of chemical weathering. Here erosion is restricted, being usually confined to the river beds of old valleys.

The third, forestless highmountainous zone comprises but a limited area on Babia Gora and on Pilsko. Climate, steep slopes and absence of forests have led here to the development of processes characteristic for the periglacial morphogeny, such as frost weathering and the crumbling off and creeping down of talus. Still, owing to the long duration of winter snow, the absence of an ground-ice layer and the short period of warm summer, combined with ample summer precipitation during which intensive denudation takes place, this entire assembly of processes can not be looked upon as typically periglacial.

Fundamental tendencies of alteration of slopes and valley floors during the Holocene

Whereas the shaping of slopes in the Flysch Carpathians has been going forth in various manner, during the Holocene the alteration of slopes consisted mainly of uncovering its rock surface from under their periglacial covers. However, this process of alteration discloses differences in its course. In the upper part of the valleys this uncovering starts at the slope bottoms near the valley's axis; at the upland's margin, near the Sandomierz-Basin on the other hand, we observe on the lower part of a slope an accumulation and a covering up of the old form, whereas the upper and middle part of the slope is degraded. Convex and convex-concave slopes, as well as the scarp slopes of the Beskid Mountains and of higher parts of the Upland are, in general, uncovered upon their entire length. In upper slope sections, the talus covers are gradually denuded and dissected; on scarp slopes we observe rock slumps and slides. Flowing down from upper slope sections, water increases the condition of saturation in the lower sections which are, as a rule, overlain by feebly resistant solifluxion and deluvium covers of a thickness of up to 15 m. *(19)*. This denudation starts from the slope bottom and is connected with the dissecting of periglacial covers in the valley axis, frequently with an undercutting of slopes too. Thicker and more earthy covers are being dissected (areas IX, X XI), are sliding down (area XI), show creep features (area VIII), or are being destroyed by suffosion (areas XII, XIII, XIV). In this manner the first (and usually still continuing) phase of climatically effected degradation of slopes leads to their becoming more gentle, either by rejuvenation or by a linear dissection by means of a network of valleys. The contrasts of both forms and differences in altitude steadily grow, the slopes are gradually cleared of periglacial covers. Although up to the present time periglacial covers still shroud the majority of the Carpathian slopes, yet destruction distinctly proceeds, accelerated by increased intensity of denudation due to deforestation.

A different course of slope denudation I observed in various areas of the Carpathian Upland (areas I, III, IV, VI respectively), in intramountain depressions (areas II, XIV), and on the Carpathian foreland built of Miocene deposits (areas I, III). On the upper and, particularly so, the middle section of the slope, degradation takes place while on the lower section, accumulation occurs, i.e. a covering up of the slopes simultaneously with aggradation on the valley floors. Along these lines are being altered the convex-concave and concave slopes, overlain by fine-grained covers but not undercut; they are sculptured in this manner not only by slope wash but likewise by slides and creep, and at times too by being dissected by ravines in their middle and upper sections.

At the floors of the Carpathian valleys I also am perceiving a distinct difference between slope sections: the upper, erosive sections and the lower, accumulative sections (Fig. 3). In all the upper valley stretches the periglacial covers from the last glacial have been dissected to an average depth of 3—8 m. This dissecting has been proceeding gradually, interrupted by periods of accumulation. This is indicated by the existence of two, at times even three, lower terraces cut from, or inserted into, the covers of periglacial accumulation. On the other hand, in the lower valley stretches within the northern part of the Upland, in the Sandomierz-Basin foreland and in intramountain depressions (e.g. the Jasło — Sanok basins), the periglacial covers are deeply buried underneath Holocene covers of a thickness of up to 10 m.; these covers form the widespread plain of a bottom terraces of 6 to 12 m. height *(35, 36)*. Between the upper valley stretches which have been rejuvenated, and the zone in which the Holocene acumulation is superimposed on alluvial deposits of the latest glacial, there extends an intermediate zone. In this latter, zone which in the San valley clearly appears between Rajskie and Sanok, the periglacial zone gradually dips beneath the Holocene cover. In the morphology of the valley floor this may be distinguished either by the existence of two terraces of different structure, separated by a ridge of about 2 m. height, or the floor is covered by a single plain built of periglacial solifluxion and fluvial deposits overlain by Holocene haugh-loam.

Areas revealing different courses of denudation of slopes during the Holocene show mostly, a distinct conformity with such areas in which the valley floors are deepened by erosion or raised by aggradation of alluvial material. Whereever the floors of main and lateral valleys have been dissected and deepened during the Holocene, and where frequently the slopes are undercut, we observe a lowering of the base of denudation and a gradual uncovering of slopes. On the other hand, whereever in the

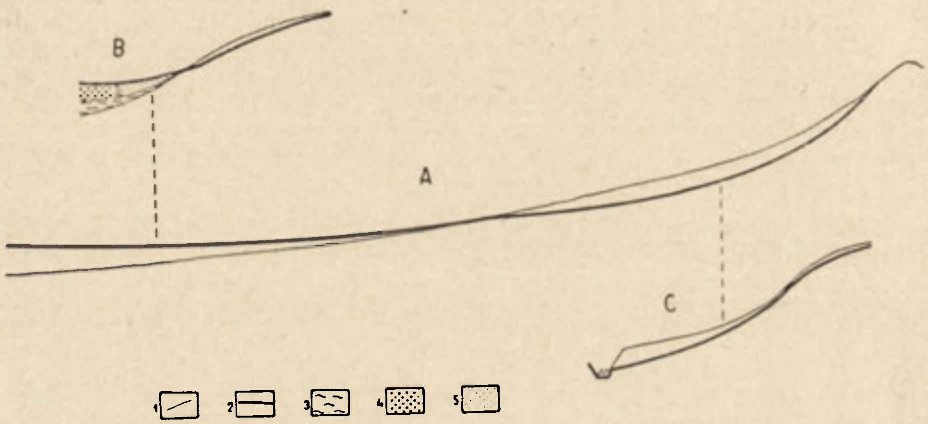

Fig. 3. Interrelation between Holocene valley processes and slope processes
A — (Diagrammatical) long profile of Carpathian valley in last glacial and Holocene. *B* — Alteration of slope profile in marginal part of Carpathian Upland: in upper and middle part — denudation, in lower — accumulation frequently superimposed upon covers from last glacial. *C* — Alteration of slope profile in the Beskid Mountains: deepening of valley floors and slope uncovering proceeding from the bottom.
Explanation of symbols: *1* — profile of floor or slope during last glacial, *2* — present-day profile of floor or slope, *3* — periglacial covers, *4* — Holocene fluvial covers, *5* — covers of Holocene slope accumulation

Holocene the accumulative valley floors appear to have been raised, we note — simultaneously with the raising of the base of denudation — an incipient accumulation at the foot of the slopes, i.e. there the slope bottoms are supported by cones and rendered more gentle (Fig 3). This process continues rapidly, due to the fact that the deforested marginal zone of the highland is covered by fain silty soils.

Both the origin and the changes in the process of sculpturing of slopes and of forming a new erosive long profile of rivers I ascribe to the Holocene morphology succeeding upon the periglacial morphology. In the peri-

Plate 1. Suffosive sink holes in axis of bowl-shaped valley tarrier. Area of basin of upper San river

Plate 2. V-shaped valley cut into feebly resistant shales. Region of Rabka (representative area VIII)

Plate 3. Ripe ravine dissecting slope of larger flat-bottom valley, where the opposite slope had been undercut in the Holocene. Region of Grabownica (representative area IV)

Plate 4. Fresh alluvial cone at outlet of gorge, piled up after a shower in June 1956. Sieniawa near Rabka

Plate 5. Deforested valley slopes, affected by slides after a shower in July 1953. Phase of transformation of former ravines into „tielke". Postołów (representative area V)

Plate 6. Snout of slide tongue filling main valley and supporting lateral valley (in background). Kruhel near Przemyśl

Plate 7. Creep slope dissected by furrow of a young „tielke" (corrasional valley). Silesian Beskid, region of Wisła

Plate 8. Clayey material saturated with water creeps on slope, and fills in a creek channel. Region of Rabka (representative area VIII)

glacial climate there predominated a transversal slope transport over the longitudinal fluvial transport, and due to this the grade of valley floors was steeper. In the Holocene fluvial transport prevails over slope transport — i.e. the transporting power of the rivers has increased whereas slope transport has been reduced. However, the deepening of valleys disturbed the balance between the material deposited on slopes and the denudation proceeding from the slope bottoms. In these altered conditions the rivers tend to reach a long profile of equilibrium, portrayed by erosion in the upper course of valleys and by aggradation on the valley floors of the lower stretches of rivers. In the deforested upland regions, with their washed-down soils in the cone-supported valleys, there ultimately starts to prevail a slope transport. This indeed is a secondary phenomenon; while it is not connected with the periglacial morphogeny, still it produces similar morphological effects on the deforested slopes.

Attempt at quantitative determination of extent of Holocene erosion and denudation in the Carpathians

During the investigation of Holocene forms and processes there always has been raised the question: what is the extent of alterations which took place int he Carpathians during the Holocene, and what might be the cubical content of masses which during the Holocene were swept down from the Carpathians?

To start with, it should be noted that in the Carpathians there took place an increase in density and in length of the system of valleys. The density of the pre-Holocene valley system was 2—4 km. per 1 sq. km. of surface. The increase, however, has not been homogeneous. In the intramountain depressions showing a difference of altitude of up to 50 meters and more, we frequently observe no new forms; there the old valleys have not been rejuvenated. In regions situated within the mountain area and built of sandstones, the length of valleys has not increased either by as much as 20%. However, in regions built of mixed complexes and apt to be denuded, the increase often amounts to from 100 to 150% (Table 1). In particular it is the spring funnels which have been densely dissected by valleys. The percentage of surfaces completely altered during the Holocene, thus affected by Holocene forms such as smaller valleys and landslides, oscillates in the Carpathians between several percent in some sandstone zones, and in depressions up to 20%, — even to 50% in regions built of plastic rocks. — In order to determine the amount of material removed from valley slopes and floors I have approximately computed the cubical content of all the Holocene erosive forms occurring in several of the representative areas. I obtained values from 130.000 to 380.000 cu.m. per sq. km., indicating the amount of material removed from a surface of one square kilometer.

More difficult, however, is the cognition of the part played by other processes, such as slope wash which, at present, moves on the upland material at the yearly rate of a score of cubic meters from a surface of 1 sq. km. Still, the amount of removed material fails to exhibit the total extent of alterations, because in the case of a flushed-down or a slid-down form of sculpture the material itself, in spite of a change in slope shape, remains within the slope's range. The absence of distinct traces of out-wash and a scarcity of mass movements on some forest--covered mountain slopes (e.g. the representative area IX) would imply that the extent of surface degradation is but small. Almost all the material carried away from this representative area has been removed by water flowing linearly from those erosive forms whose cubical content I managed to compute. Thus I am taking for granted that the minimum amount of translocated material upon an area of 1 sq. km. in the Carpathians should be assumed to be about 150.000 cu. meters. On the other hand, the volumes of translocation are many times larger in areas of landslides. The computation of the volume of the large slides at Duszatyn *(33)* and Szymbark *(31)* which happened in the present century, imply that the maximum amount of Holocene material displaced on the area of one square kilometer often exceeds one million cubic meters.

Striving to determine the approximate amount of Holocene material translocated in the entire Carpathians I have compared the volume of the material removed from the area of larger river basins, with the volume of Holocene alluvia accumulated within the range of widespread alluvial cones upon the immediate foreland of the Carpathians and on the floors of the highland stretches of valleys. There are, however, areas at the bases of the Carpathian margin where almost the entire material removed from a basin has been deposited. Thus, for instance, in the axis of the Subcarpathian Furrow there flows westwards, towards the Wisłoka river, the Wielopolka, a small river whose narrow bed, as well as the beds of its tributaries, has been cut into the alluvial plain to a depth of 2 to 6 meters. The Wielopolka river drains an area of about 400 sq. km. of the highland, and it deposits the washed-down material on this alluvial plain. Several score of bore holes perforating deposits with Holocene vegetal remnants *(35)* show the volume of deposited material to be about 175.000.000 cubic meters. This means that from one square kilometer of drainage area of the Wielopolka river, about 440.000 cu. m. of soil has been carried off. On the basis of this figure we may assume that on the Carpathian Upland the extent of postglacial denudation fluctuates between 400.000 and 500.000 cubic meters. In the Beskid Mountains whose soils are of a more rigid structure and where 30—70% of the area is covered by forests, the amount of denudation is less. Often, however, we note that erosion, concentrated in creek channels, leads to the removal of even greater volumes of material than on the Upland.

If we take as basis the above data from the Wielopolka basin, i.e. a mean value of denudation per sq. km. to be 500.000 cu. m., we must conclude that from the basin of the Wisłoka river, of about 3000 sq. km. area within the Carpathian Upland, a total of 1.500.000.000 cu. m. of material has been displaced. — On the basis of investigations carried out by M. Klimaszewski *(17)* and myself *(35)* in the Wisłoka valley, it is possible to determine the volume of alluvial material laid down in this valley. In the highland stretch of this river and on the immediate Carpathian foreland, i.e. common on a 55 km. stretch of this valley, the floor is covered by Holocene deposits occupying about 135 sq. kilometers;

the mean thickness of Holocene alluvia is 6 meters. Thus the volume of material deposited in the Wisłoka valley is approximately 810.000.000 cubic meters, equalling only about 55% of the above computed volume of material. The balance, about 45%, has been carried off further. At the junction of the San with the Wisła river there is yearly being carried off about 20 cubic meters of material per 1 sq. km. of basin *(14)*. Another proof of thist distant transport are the Young Holocene covers of haugh-loam, several meters deep, which have been discovered in the Wisła valley by W. Pożaryski *(28)*.

Summarizing the above we may assume that during the postglacial there has been displaced, from the area of the Polish part of the Flysch Carpathians comprising the area of 22.000 square kilometers, material of a volume of approximately 10 thousand millions of cubic meters.

The intensity of Holocene denudation has particularly increased during the period of man's activity. It suffices to compare the volume of material swept away from the mountains. Measurements of earth masses accumulated in storage reservoirs, as reported by Pietruszewski *(27)*, A. Reniger *(30)* and W. Jarocki *(14)*, and confirmed by my own measurements made in a small valley lake, tend to show that in modern times there is carried off, from the Carpathians, from the area of 1 square kilometer, an amount of 50 to 150 cubic meters of soil and rock rubble per year. Had, in natural conditions, the intensity of denuding processes not been less than this figure, there would have been removed, within the 10 000 years of duration of the Holocene, about 1 000 000 cubic meters of material per square kilometer surface. However, in view of our analysis of representative areas, this latter figure appears to be inacceptable as average for the Flysch Carpathians (Table 1). Before man's deforestation started, the extent of denudation must have been several times less.

Phase of development of the relief of the Flysch Carpathians in the late glacial and the Holocene

Alternately the climate of the late glacial and the Holocene has been cooler or warmer, more continental or more oceanic *(25, 6, 39, 40)*. These climatic fluctuations have been distinctly portrayed by changes of intensity, even of types, of morphogenetic processes. A. Środoń *(41)* has determined a distinct humid phase at the commencement of the Sub-Atlantic period. It would be difficult to distinguish on the fifteen representative areas of the Flysch Carpathians individual phases of development of erosive and denuding forms. Only in the Beskid Mountains the late glacial phase of denudation of mountain slopes *(37)* may be clearly distinguished. Several steps in the lower terraces indicate changes in the transporting power of rivers and in the volume of carried material; however, owing to the absence of plant remnants, it proved difficult to link them with climatic periods. At the escarpment of the Carpathians there appear extensive alluvial cones, at present dissected by river beds to the depth of 8—12 meters. They are built of late glacial and Holocene covers (Fig. 4, horizons C—I), up to 15 meters thick, frequently covering at their base alluvial material from earlier phases of the last glacial (horizons A—B). On the enclosed figure I have presented a synthetical cross section of these cones, based principally on profiles made in the valleys of the Wisłoka, Wisłok and San rivers. This section illustrates the existence of phases of both erosion and accumulation, picturing periods of lessened and increased denudation in the Carpathians. The deposits appear in two distinct facies: in a river-bed facies and a terrace (flood) facies. During the period of erosive deepening of river channels there went forth, during flood times, accumulation in a terrace facies. But simultaneously, with increased accumulation in the river bed, there also takes place accumulation on the surface of the existing flood terrace. Synchronizing the covers building the discussed cones with forms and deposits existing in the interior of the Carpathians we may, in the late glacial and the Holocene, distinguish the following morphogenic periods:

A. Transition phase

1. The declining period of periglacial morphogeny (Oldest Dryas), during which a gradual increase of temperature took place, together with penetration of vegetation into the highland valleys. Higher up in the mountains there continued to exist periglacial processes of weathering and solifluxion, as indicated by solifluxion horizons in the top strata of the periglacial accumulative series in the valleys of Łososina (*19*) and Solinka creeks· Only the floors of the lower stretches of larger valleys were gradually cut up by gullies, as evidenced by the deposition of Allerod material at the floor of these gullies. Erosion was made possible by the rather scanty supply of material from slopes covered by vegetation, and by the dry, continental climate (loess accumulation in Southern Poland — (*12*).

2. The Allerö d period *(sensu lato* — Szafer, *39).* Simultaneously with the increase of precipitation and the invasion, during the Alleröd optimum, of the lower Carpathian parts by forests (upper forest boundary at about 1050 m. above sea level — *40, 42),* there began in the Carpathians a spell of increased erosion. Evidence are, on the Carpathian foreland, covers of coarse gravels and sands (horizon C), about 5 m, thick, with trunks of trees like *Larix, Pinus silvestris, Betula,* and *Salix* and *Picea* too (*35*), laid down in the erosive gullies which had been deepened and widened at the commencement of this period.

The recession of permafrost aided the development of mass movements, suffosion and linear erosion. Presumably during this period were formed the alluvial cones superimposed upon solifluxion covers and dissected by Holocene ravines. They are found at the outlets of small valleys of the Highland there accumulated sheets of silty alluvia (Wielo- erosive deepening of these valleys.

3. The Younger Dryas period is characterized by a decrease of incisive erosion in the mountaines. This finds its expression in the dissection of covers (Fig. 4) and deposition of fine material of the flood facies (bottom part of horizon D) on the accumulated gravel sheet formed in the Alleröd *(36).* Above an altitude of about 500 m. above sea

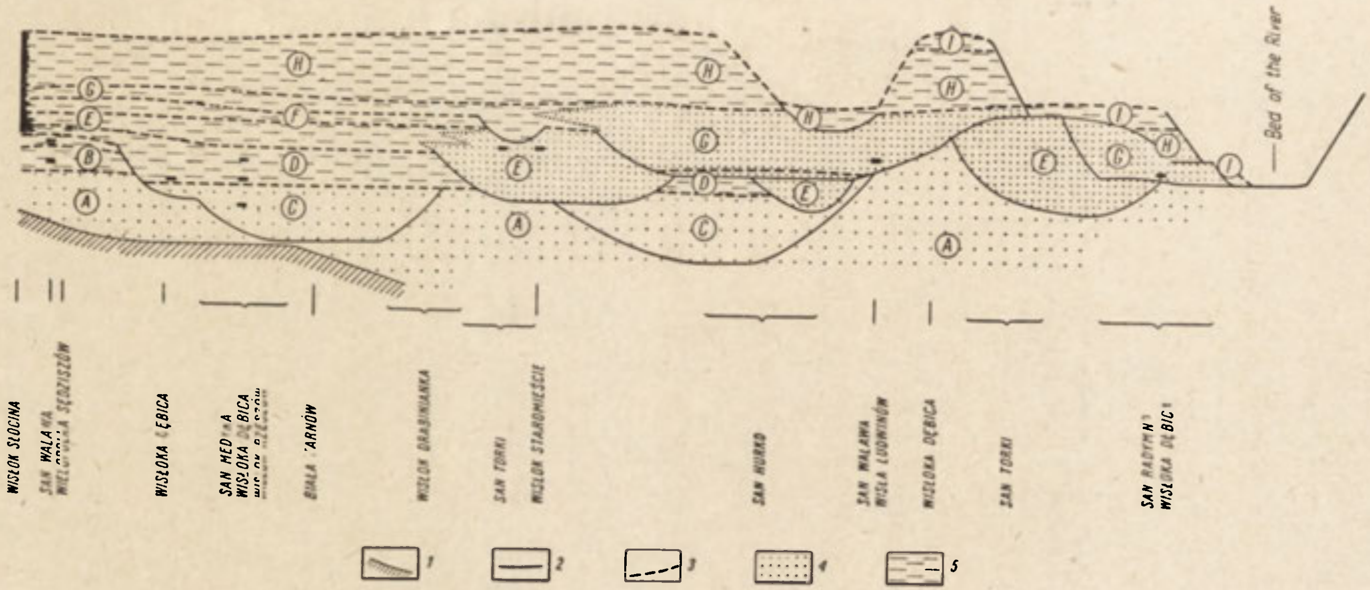

Fig. 4. Diagram of phases of erosion and accumulation, as portrayed in covers building the cones on the Carpathian foreland

Explanation of symbols: *1* — older substratum, *2* — erosive surfaces, *3* — accumulative contact planes of strata, *4* — deposits of river-bed facies, *5* — deposits of terrace (flood) facies. Horizons *A* — *I* indicate alluvial beds of equal age, discussed in text. Underneath are given names of fluvial valleys and of localities where the individual sections of the profile have been identified (black surfaces indicate discovered fossil vegetal remnants) level *(39)* there took place a recurrence of periglacial conditions, — and for this reason probably many forms found on the slopes of Beskid Wyspowy and Mały Beskid show distinctly periglacial features.

B. „Full” Holocene phase

This phase is of fundamental significance for stabilizing and emphasizing forms occurring in the mountain zone. Processes which are going forth today in forests, such as the development of erosive valleys, landslides, suffosive forms, traces of slope wash and, even, of limnoglacial deposits are proof that similar processes have been taking place throughout the Holocene. In a like manner are gravel-sand alluvia from the Atlantic and from the beginning of the Subatlantic period a clear proof that indeed this has not been a phase of inactivity of processes. Within this phase I am distinguishing 4 periods of varying intensity of processes:

4. The Preboreal and Boreal period. All over the Carpathians erosion and denudation of normal type sets in as indicated, i.a., by dated landslides from the beginning of this period *(42)*. Simultaneously with the stabilization of these conditions and the relatively small precipitation the intensity of erosion and denudation decreased; evidence is the absence of thick gravels within the cones. Inversely, here erosion predominated, peat bogs developed on the terraces, in the side valleys of the Highland there accumulated sheets of silty alluvia (Wielopolka valley, et alia). A. Jahn's *(12)* opinion as to an increase of denudation during the less humid periods fails to be confirmed on the area of the Carpathians.

5. The Atlantic period is featured by an increase of rainfall, by erosion and denudation in the mountain zone and by accumulation on the Carpathian foreland. Here, sand and gravel deposits containing tree remnants *(Pinus, Tilia, Picea, Corylus, Ulmus, Alnus, Betula, Quercus)* fill the erosive channels and reach a thickness of up to 4 m. (horizon E). These deposits were laid down on older, late glacial as well as periglacial deposits (A—D).

6. The Subboreal period reveals a slightly cooler spell and a decrease in precipitation. A lessened denudation in the Carpathians is indicated by the absence, on the foreland, of deposits of the river bed facies, and by a thin layer of clays (horizon F), laid down on the surface which cuts across older deposits. The finding, in the bottom of a haugh-loam bed in the Wisłok valley near Rzeszów, of pottery fragments from 4000 years ago *(36)*, and other archeological findings within the Carpathians *(47)* seem to indicate that during this period there developed on the Highland the first larger human settlements, and that locally deforestation and subsequently soil erosion started then.

7. The Older Subatlantic period was an epoch of floods and of powerful erosion. From this period are known many alluvial cones laid down by torrential streams at the mouths of lateral valleys *(41)*. In the highland stretches of the larger valleys and upon the Carpathian foreland the plains of cone terraces were overlain by gravels and sands (horizon G), containing numerous tree trunks which illustrate the age of this deposit *(Fagus, Abies)*.

C. The „anthropogenic" phase

8. The Younger Subalantic period. After a particularly humid period there commenced, together with a reduction of transporting power, the dissecting of covers accumulated in the valleys, combined with a superimposition of haugh-loam series (horizon H) on top of the cones. These beds have a thickness of from 3—6 meters. This abrupt change in granulation of deposits and the considerable thickness of the beds must be ascribed to deforestation, beginning about 2500 years ago in the vicinity of settlements of the period of Łużyce (Lausitz) culture *(47, 48)*. Within the recent 1000 years man started a mass invasion into the mountains. This appears to be a period of an enormous increase of denudation on slopes deprived of the unbroken vegetation cover. Shallow earth movements were revived, such as slope wash, suffosion, and linear erosion; during the winter, conditions were produced apt to cause earth translocation due to ground ice, and even solifluxion creep. In the wide valleys there was enhanced, in their upper stretches, lateral erosion and accumulation of big boulders in the river beds, while in the lower stretches there took place a deepening of river channels, incised into the floor built during the beginning of the Subatlantic period. There also developed a lower moor terrace (horizon I). The cone plains at the Carpathian fringe are frequently not reached any more by flood waters, thus accumulation continues to proceed on the less powerful terraces in the interior of the Carpathians. In lateral valleys the deepening of river channels progresses in a similar manner, accelerated by river bed straightening; during floods accumulation takes place on the wide valley floors. By increased fluvial erosion and by landslides, the processes taking place today illustrate distinctly features of the Holocene morphogeny; on the other hand, by abrupt increase and unrestricted spread of denudation on the deforested slopes, these processes remind us of the effects exerted by the periglacial morphogeny.

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ALFRED JAHN

The Raised Shore Lines and Beaches in Hornsund and the Problem of Postglacial Vertical Movements of Spitsbergen

1. Introduction

In 1957 and 1958, there stayed at Spitsbergen, at Hornsund fiord, the Polish Spitsbergen Expedition of the International Geophysical Year. Within the scope of the Expedition's geophysical program, I carried out periglacial-morphological investigations, chiefly on the question of periglacial processes, i. e., on their dynamics and on the quantitative effect of these processes within that year. I also collected some material on the problem of late-glacial and postglacial vertical movements of the land, and on the phases of transgression and recession of glaciers in the Hornsund region. I prepared a morphological map of the investigated area, paying special attention to littoral terraces, raised beaches, and cliffs. All these forms, evidence of young movements of Spitsbergen, were accurately measured using a tachymeter; these measurements comprised numerous sections. In all these surveys I enjoyed the faithful assistance of my coworkars, members of the group of the periglacial expedition: Docent St. Szczepankiewicz, Z. Czeppe D. Sc. and H. Piasecki M. Sc.; in this place I wish to express my sincere gratitude for their untiring efforts.

The main area of our investigations extended north of Hornsund fiord, as far as the Werenskjöld glacier (Wedel Jarlsberg Land) (Fig. 1). Comparative studies were also undertaken south of Hornsund fiord (Sörkapp). Here the majority of glaciers extends to the sea shore (see map), i. e. the Horn, Mühlbacher, Paierl and Hans glaciers. Separating them are mountain ridges; at their bases, towards the shore, treads of terraces and of old cliffs have been preserved (Fig. 2). A large area of land, situated between the Hans and the Werenskjöld glaciers, discloses most distinct traces of raised marine shores, especially in the region of the Rev valley (Revdalen) which once had been a marine bay. At the mouth of this valley was situated the Expedition's main base; this fact very much faciliteted the detailed morphological investigations of this stretch of land.

2. Hanging valleys and traces of old morphological levels

Almost the entire area embraced by our investigations is built of palaeozoic formations Hecla Hoek, i. e. of limestones, dolomites, argillaceous shales, phyllites and quartzites. They are vehemently folded, presenting no conditions for developing horizontal structural forms.

Fof this reason interesting are here level morphological surfaces which cut across the inclined rock strata in the region of the Rev valley (Map I).

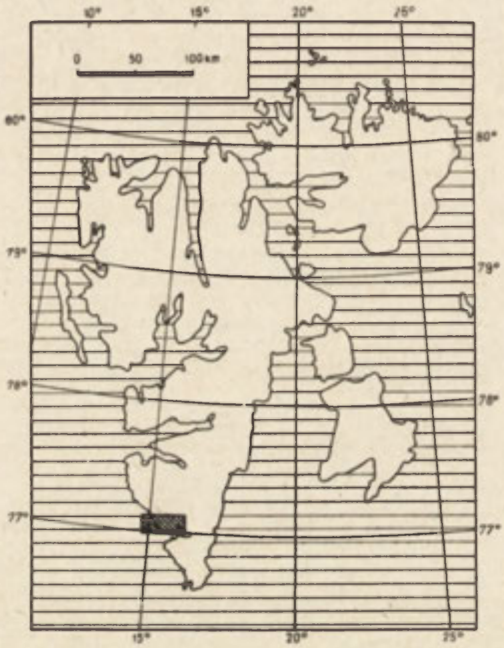


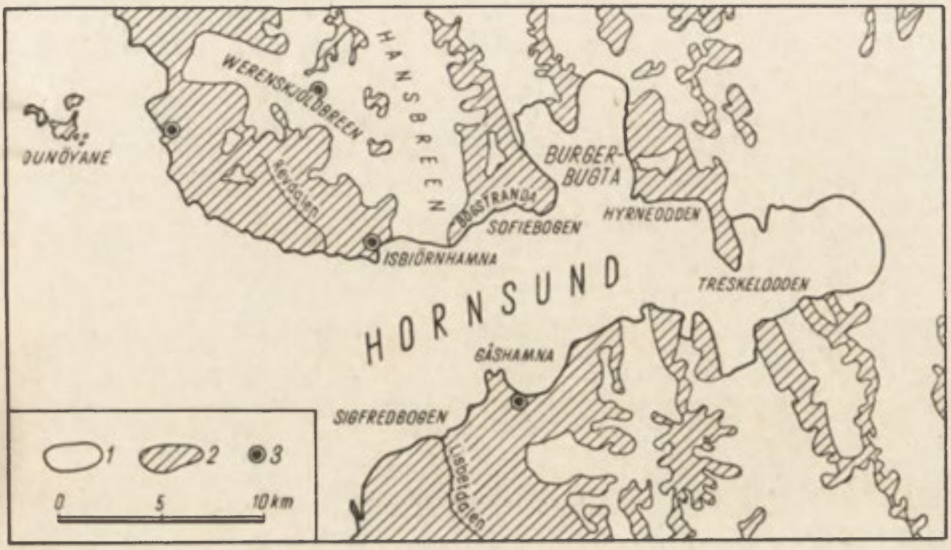
Fig. 1. General sketch map of Spitsbergen. Shaded part — area of investigations

Worthy of attention are these forms found on the eastern side of the valley, on the slopes of Skoddefjellet and Skalfjellet, — at a height of 350—400 m.

A more regular development and a wider range show forms of a lower morphological horizon, situated at a height of 200 m. These forms consist of cirque floors and of hanging valleys, with wide and very level bottoms. Here should be mentioned the Skalfjell valley and the Rotjesfjellet cirque, both of them forms suspended above Revdalen. Furthermore, wide ledges in the Torbjörsenfjellet kar and in Steinwikdalen, and wide valley plains in Bratteggdalen. The absolute altitude of these forms oscillates within very narrow limits, between 200 and 215 m. The position of the hanging valleys is not a matter of chance. At that same elevation there extend, on the mountain slopes and in large valleys, ledges of terraces, — proving that the bottoms of the hanging valleys have once been conformable with broad morphological plateaus.

Finally, a third morphological horizon occurs at the level of 110 m.; it appears most distinctly in the hanging valley of Arie (Ariedalen), and in cirque of Torbjörsenfjellet.

It would be a difficult task to define the origin of these forms; their mere height, of course, can not serve as basis for appropriate conclusions on this subject. Undoubtedly, these are traces of hitherto unknown pre-



Fi? 2. Hornsund fiord: *1* — surface of glaciers, *2* — land not covered by ise, *3* — base and camps of Polish Expedition of 1957—58

glacial forms, of probably abrasive or denudative origin. The glaciers failed to obliterate the typical features of these forms or to destory the continuity of their surfaces.

The postglacial or, to be exact, the late-glacial shore lines of this part of Spitsbergen extend above the 200 m. level; at one locality (Steinwikdalen), a gravel beach of this age covers the bottom of a suspended valley. Still, I do not imagine that processes of postglacial abrasion might have sculptured these forms. The location of the shore line at this altitude must have been of too short a duration; besides it is clearly visible that the high terraces are closely connected with forms of glacier activity, i. e. outlets of valleys and kars.

3. Raised Gravel Beaches, Terraces, Wave-cut Abrasion Platforms and Cliffs

a) *Gravels of hanging valleys and high cliff lines on slopes*

The highest position of pebbles of raised marine beaches has been found in the Steinwik hanging valley. Single pebbles are being observed in this

WERENSKIOLDBREEN
HANSBREEN
TUVBREEN
KVARTSITT-SLETTA
Brattegdalen
552
Steinvika
SKIERSTRANDA
RÅLSTRANDA
TORBJÖRNSENFJ.
Revdalen
Skålfjeldalen
Revvatnet
SKODDEFJ.
ROTJESFJELLET
395
511
ARIEKAMMEN
FUGLEBERGSLETTA
ISBJÖRNHAMNA
WILCZEKODDEN
VESLEBOGEN
1
2
3
4
5
6
7
0
1
2 km

valley at a maximum altitude of 275 m., whereas their main accumulation lies somewhat lower, at 230 and 205 meters (Fig. 3, 4, Plate 1). At the latter altitude we find a broad level plain, almost 0.5 km. wide, covered by clay and rock debris, amidst which pebbles appear abundantly. There prevails local material, quartzites and gabbro rock, derived from the Gulliksen-fjellet ridge extending north of, and in close proximity of Steinwikdalen. Shaly sandstone and granite pebbles are found there too. The shape of the pebbles is the typical beach form: very well smoothed, discoidal in most cases, or globose. Their dimensions vary greatly, from the size of a human fist to blocks of 1 m. diameter.

Pebbles appear exclusively on the above mentioned ledge, on the left (southern) side of the valley. This is a fragment of a raised beach which might have been developed upon an ancient preglacial surface. At that period, Steinwikdalen must have been a small marine bay. At the same altitude of 200 m. there may be observed, on both sides of the mouth of the hanging valley, a feebly marked line of a suspended cliff extending on the mountain slopes. This is a small shelf, cut into the compact rock, covered up by slope talus. It appears from these facts that we can not look upon the entire length of slope, where undoubtedly the effect of wave abrasion. If this were the case, the wave-cut terrace would have to extend upon the entire length of slope, where undoubtedly the effect of wave action would have been more powerful than within the small bay. During the younger postglacial, at the time when the intensity of vertical movements of land had markedly decreased, there developed on that same stretch of the shore a typical abrasion terrace (altitude 10 to 30 meters), in the shape of a wide ledge, running parallel with the shore line. Thus the 200 m. horizon as described above is the older, preglacial level.

It might seem puzzling why, in one locality only, marine gravels were preserved upon the 200 m. terrace, although this level is so common along Hornsund. However, this is easily explained. After formation of this raised beach, the Spitsbergen glaciers moved forward far into the forefield, carrying away any marine deposits lying in their way. Evidence is the presence of marine pebbles in almost every moraine. The favourable situation in Steinwikdalen was brought about by the fact that the small glacier in this short valley failed to fill the entire valley during transgression; instead, the glacier travelled towards the coast line within a low furrow along the right side of the valley. The gravel plain along the left valley slope was not covered by the moving glacier.

We observe marine gravels on the terraces of Bratteggdalen, where their highest position was found at an altitude of 132 m. At the mouth of this valley there is an entire system of terraces with gravels; among them we distinguish a terrace at 113—115 m. altitude. The level of the hanging valley (its threshold) lies at 75 m. altitude; numerous quartzite gravels appear on this level.

High gravels have also been found on the slopes of Ariekammen, at an altitude of 120—135 m., — thus they correspond with the gravels of

Fig. 3. Morphological map of area between the Hans and Werenskjöld glaciers: *1* — glaciers, *2* — mountain ridges, *3* — younger morainic ridges, *4* — older morainic ridges, *5* — high deposited marine gravels, *6* — high cliffs, *7* — abrasion and accumulation platform (margins of terraces of the same altitudes)

Table 1

	Raised beaches and wave-cut terraces										High Cliffs and Residual Gravels
Dunöyane	2—3_w	7_w	11								
Werenskjöld-Bratteggdalen	4		11	16	24		41				75, 112, 132, 145, 200
Kwartsittsletta	3_w	7_w	12	17	24	32	40_w				97, 139, 206, 230, 275
Skjerstranda	3.9_w	6.7_w	13	16.8	25	32					95, 104
Ralstoranda-Lakpynten	4_w	8_w	11	15							
Ralstoranda-Worcesterpynten	5.6_w	8.5_w	12.8_w								
Veslebogen-Revdalen	2.7—4.7_w	7.5	10	17	24	32	40	46		65	
Ibsjörnhamna	3.7—4.0_w	8.3_w	10.2_w	17	25	32		45		62	75, 135
Fannypynten	2			17							
Sofiebogen-Bogstranda	2			16.7	24.7	32	39		52.5	65.8	72
Hyrneodden	2	9.5		18	24		38				100
Treskelodden	2.5—5.0	8.8—13.5		15—19			38 ?				
Sigfredbogen (Sörkapp)	2			17	24	31_w	41_w				75, 81

w — storm ridge

Bratteggdalen. Along the slopes of Ariekammen may be observed several hanging cliffs, at the altitudes 135, 115 and 75 m. Everywhere at the base of these cliffs there may be observed fragments of gravel banks. Marine gravels have also been lying at the bottom of Arie valley; their traces have been found at the altitude of 115 m. upon the spit forming the extension of Ariekammen.

b) *Wave-cut terraces and raised gravel beaches on the shore*

This type of raised shores appears at the altitude of 65 m., or lower. They differ considerably from the fragmentary terraces and cliffs appearing on higher parts of the slopes. They consist of broad abrasion and accumulation-plains, extending in a belt, beginning at the Werenskjöld glacier as far as the Hans glacier. On the Norvegian map these plain surfaces are called: Kvartsittsletta, Skjerstranda, Ralstoranda, Fuglebergsletta (Plates 3, 5, 11, 13, 14). Terraces we find further east too, near Sofie-

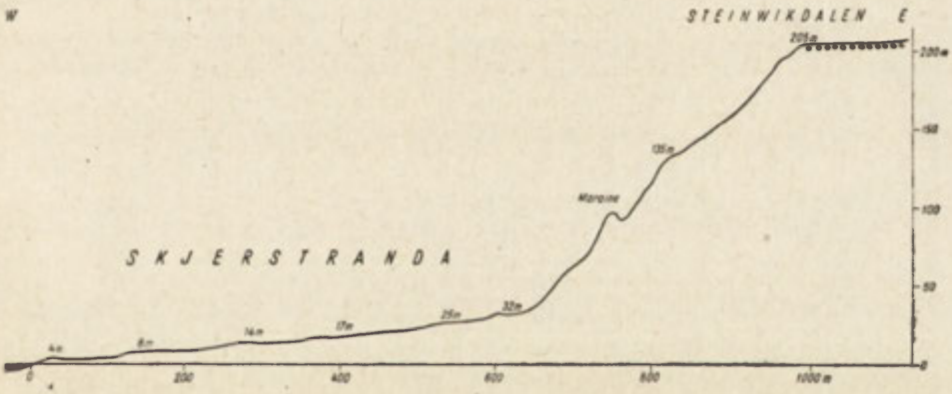


Fig. 4. Profile of terraces on Skjerstranda. Position of high gravel beds in Steinwikdalen

kammen (Bogstranda), and surrounding Burgerbukta and Adriebukta (Plates 6, 7, 8, 9). The width of this belt is, at an average, 0.5—1.0 km.; in the Rev valley only it extends deep into land, as far as 4 km. from the present-day shore line (Table I).

This belt consists of numerous terraces which — notwithstanding different altitudes — disclose a common feature. All of them are forms of degradation and accumulation. Evidence of abrasive action are wide areas of wave-cut platform, from which hillocks of abrasion-monadnocks (stacks) jut out. Whenever these hillocks rise from the lower terrace, there may be observed traces of upper terraces on the surface of the hill tops (Fig. 5). It seems that this type of abrasion and accumulation plain developed owing to the same processes which today are shaping the sea shore of Spitsbergen. The tidal wave cuts off peninsulae and capes, whereas in bays there is being deposited material of littoral rubble, forming gravel-built storm ridges and surfaces of accumulation. Exactly in this same manner have been built the terraces existing between altitudes 0 and 65 m.; gravel banks extend between the stacks.

The individual terraces are separated by treads, more or les distinctly marked; these treads had previously been marine cliffs. For this reason too the margin of the terraces is mostly formed by a belt of stacks, shorewards undercut by a steep wall. Alongside of these former cliffs there appear big, rounded blocks (up to several meters' diameter) of rocks of erratic origin, remnants of a washed-down moraine. Similar blocks, everywhere in the wash of tidal waves, we find along the modern cliff too.

Let us now scrutinize these terraces, beginning with the point situated farthest westwards upon the Dunöya Islande („Isles of Down"), and moving towards the interior of the fiord as far as the Horn glacier: everywhere we see a clear conformity of altitude of their surfaces (see Table I).

The lowermost element of sculpture is a recent storm ridge and, connected with it, a gravel-rubble beach. The height of the ridge oscillates within wide limits, between 2.0 and 5.5 meters. This ridge is higher at the outer shore, beyond the fiord's range. In the fiord's interior, where storm waves are feeble, the ridge disappears completely (eastwards, beginning from Sofiebogen). Highest located is the storm ridge at such points where the ocean breakers rise, in their attack upon the shore, between the stacks (at Ralstoranda, 5.7 m.). On top of the storm ridge driftwood is piled up in considerable quantities (Plate 16).

The storm ridge shuts off and separates from the sea the lowest terrace, formed by filling — in of lagoons (coves) by continental and marine material (Plate 13, 14). The altitude of this terrace varies from 1.5 to 4.0 m. The next higher terrace has an altitude from 7 to 10 m. Here we note an increase of height toward the fiord's interior, perhaps caused by an irregularity of land uplift. However, the amplitude of height variations is limited to 3 m. On the western shore of Treskel peninsula, directly underneath the Horn glacier, the surface of this terrace rises even to 13.5 m. altitude; this feature, however, has its particular cause. The peninsula extends at right angle to the fiord, and here the peninsula's shore must have blocked the tidal waves and breaker swells entering the fiord's interior. This caused a rise of water level, connected with a far-reaching pushing-up of gravels; this in turn led to a strongly tilted terrace surface. From Dunöyane as far as Isbjörnhamma this terrace discloses distinctly a storm ridge, appearing in particularly spectacular form on a littoral plain called Fuglebergsletta (between Revelva and the Hans glacier). This storm ridge runs parallel with the shore, — behind it are blocked small valleys and kettle holes (being lakelets today).

Similar conditions exist at the next terrace, of 10 to 13 m. altitude. The outer boundary of the terrace is marked by a ridge, and inside this ridge lie small lakes.

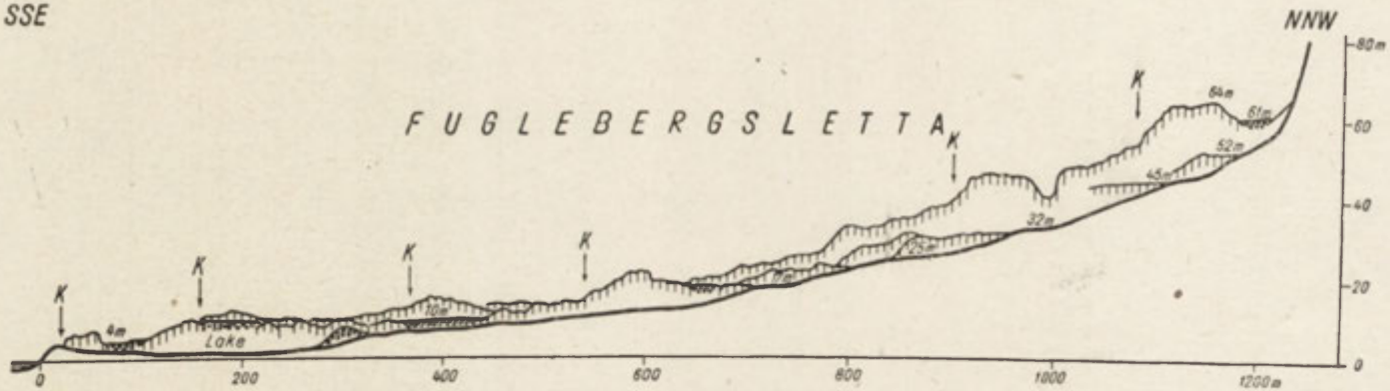


Fig. 5. Profils of abrasion and accumulation terraces of Fuglebergsletta, as far as Ariekammen. Accumulation terraces — lower line (valley bottom) and sections indicated by circles. Higher up — remnants of abrasion terraces with abrasion monadnocks and cliffs (K)

Beginning with the contemporaneous storm ridge and blocked-off lagoons as far as the 11 m. ridge, we thus have a group of lowest terraces which, in view of their many common features, might be considered forms of identical type and similar origin. In the formation of these terraces an important role has been played by the storm ridge, i. e. an element of rapid littoral sedimentation. In many instances, the surface of the terrace proper was formed secondarily by the filling-in blocked-off lagoons and coves. Storm ridges developed at shore stretches where strong littoral currents and heavy wave action existed (at the mouth of the fiord and on the outside shore).

A second condition for the formation of storm ridges was the presence of klippen (stacks) of littoral islands (skjors) which partly supplied material for the littoral rubble and formed a kind of shield too, indispens-

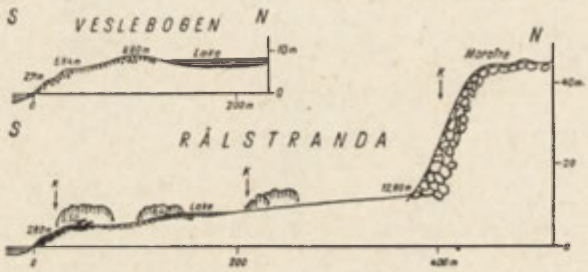


Fig. 6. Profile of Fuglebergsletta terraces at Veslebogen (*1*) and Rålstoranda terraces (*2*). Lower and higher storm ridges, lakes and morainic cliff

ible for the development of processes of sedimentation. Frequently such klippen constitute the cores of the storm ridges. — A third condition for the development of storm ridges was the presence of ground and terminal moraines which to a large extent supplied the material for the littoral rubble.

Most frequently the outer boundaries of terraces under discussion disclose the shape of arches, curving landwards. Both ends of these arches consist of one, or of a group of, klippen jutting seawards. At such points the ridges use to be highest, whereas on the landwards recessed sections of the arch their height is much less. I wish to stress the point that these remarks refer to terraces situated at the fiord's mouth, i. e. west of the Hans glacier. In the fiord's interior, where littoral shoals are lacking and where the abrasive and accumulating activity of the sea has been feeble, the lower terraces are of but minor importance.

A second group consists of terraces of an altitude of 15 to 65 meters (Figs. 5, 7, 8). It might be stated generally that these terraces are less closely connected with the storm ridges than are the terraces of the previous group; however, on some of these terraces we also observe the presence of storm ridges (the 32 and 40 m. terraces). These forms are rather of lesser height, flattened; in the terraces' development these ridges failed to be as important as was the case with the terraces of the first group.

A further difference between both groups of terraces results from their relative position. Whereas the lower terraces occur almost exclusively in the outer skjor section of the shore, the higher terraces are seen in both parts of the fiord (see Table I, p. 148). Incidentally, this fact is linked with the origin of both groups of terraces. The higher terraces are primarily forms of wave-cut action; in their development the accu-

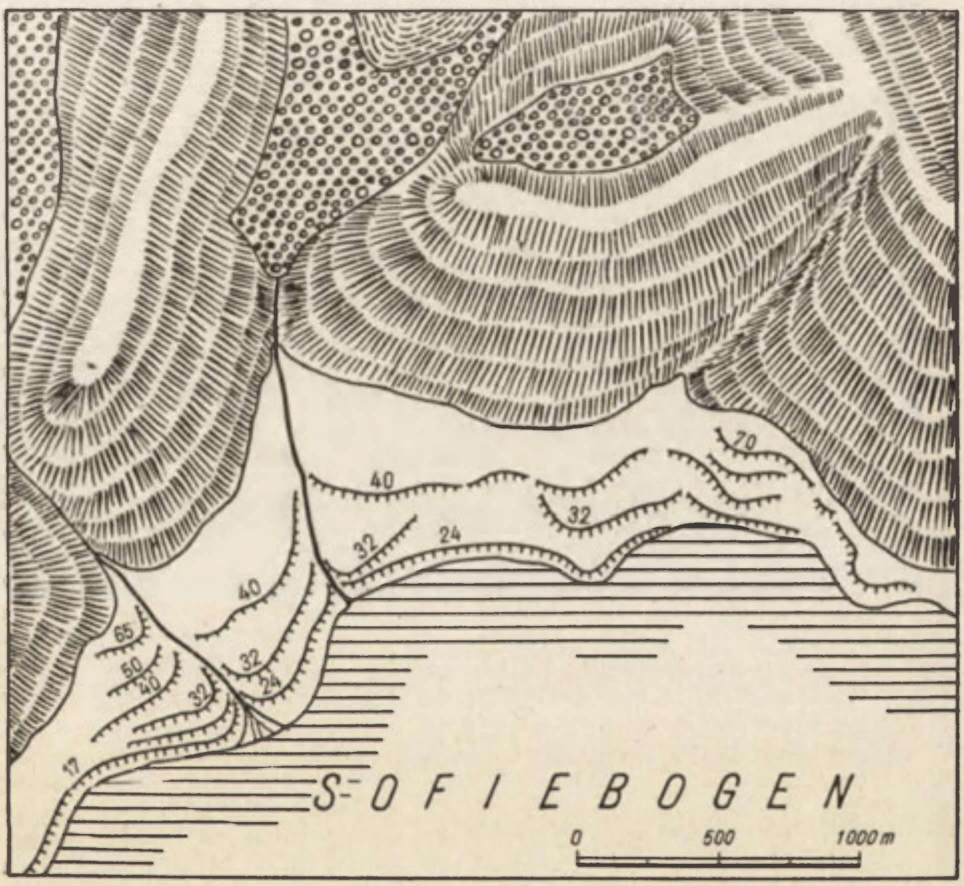


Fig. 7. Sketch map of Bogstranda terraces at Sofiebogen

mulating activity of the sea played a but secondary part. These terraces are built up on evenly sculpture rock footings, covered up by rubble and debris.

I managed to distinguish the following treads in these terraces: 15—18 m., 24—25 m., 32 m., 38—41 m., 45—46 m., 52 m., 65 m. Most astonishing is the enormous hypsometric sameness of this system of terraces: along the entire length of the fiord, oscillations in altitude within the individual terraces do not exceed 2—3 m. An identical system of terraces exists on the southern side of the fiord, on the Sörkapp shores.

Between the Werenskjöld glacier and Revelva, terraces of this group appear at the bases of mountain slopes, forming the inner ledge of the wave-cut platform of Skjerstrand and Ralstorand. In the Rev valley, the terraces penetrate fairly deep into the land, as far as the northern margin of a large lake (Revvatnet) (plate 2). At the period when the 40 and 45 m. terraces were formed, the Rev valley was still a bay. Marine

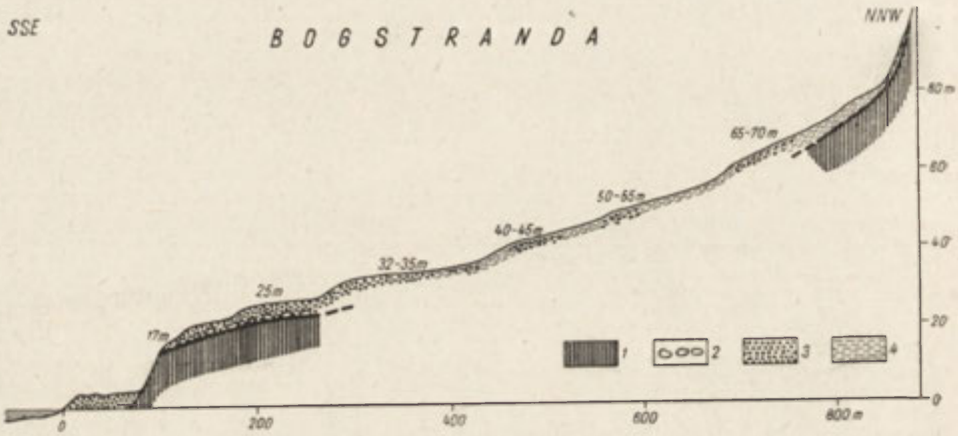


Fig. 8. Section of Bogstranda terraces: *1* — bedrock, *2* — residuals blocks, *3* — gravels. *4*— solifluction rubble and clay

gravels extend on the bottom of the valley at the level of the two above mentioned terraces. Between Revelva and Isbjörnhamma, ledges of the 24, 32, 46 and 62 m. (Fig. 5) terraces extend at the bottom of the Ariekammen slopes. Towards the fiord's interior, east of Fannypynten, terraces of this group form regular treads at Sofiebogen and Burgerbugta (Figs. 7, 8; Plates 5, 6, 7).

Within the discussed group of terraces special attention should be given to the terrace of 38—41 m. altitude. It is distinguished by being a general wave-cut platform appearing along the entire shore of the fiord; this terrace occupies a larger surface too than any other terrace of this group. On many stretches of the fiord's shore this terrace is the highest one; even at places where higher terraces occur, they usually extend over small areas only. Thus the 40 m. terrace is of exceptional significance.

The principal investigations were made on the fiord's northern shore. Additionally, several sections were carried out on the southern shore of the fiord; these revealed the complete concordance of heights of the terraces in this region with the terraces situated on the northern shore. Here predominate the 17 m. and the 24 m. terraces. At the mouth of the large Lisbet valley (Lisbetdalen), especially along the Sigfred bay (plate 12), there lie, widely spread out, the 31 and the 41 m. terraces. Both of them show large storm ridges. The 41 m. terrace is the highest surface at the base of an old cliff. The Lisbet valley is suspended at the altitude of 75 and 81 meters. Here, from under the moraine, old marine gravel beds may be perceived.

In the arrangement of terraces on the southern shore of the fiord there prevails the same order as in the northern terraces. The system of low terraces extends upwards to the height of about 40 m. The succeeding terrace system, very much destroyed and covered by a moraine, extends beyond the 75 m. height.

4. Gravel Material and Fauna of Raised Beaches

The recent gravel beaches and storm ridges of Hornsund, contain fist-sizes pebbles, thorough rounded. Characteristic is the thorough mixing of the material, i. e. the great uniformity of its petrographical composition on an extensive stretch of shore line. Even the gravel beach of the Dunöyane Islands, 5 km. from the shore, show at an average the same composition of gravels as the shore of the mainland. This uniformity of gravel banks is connected — as correctly pointed out by K. Birkenmajer *(4)* — with the fact that they were formed mostly (although not exclusively) by the washing down of moraines, that they thus consist of allochthonous material thoroughly mixed by glacier action. Of course, autochthonous rocks from nearly cliffs are likewise represented in the shore rubble, mainly in the shape of sharp-edged talus or of feebly-rounded gravels.

The material found in the raised beaches and storm ridges is slightly different from the material of the recent shore rubble; it discloses a greater contrast in composition. Thus, alongside of a large amount of local debris (produced by solifluction), there also appear many perfectly rounded „exotic" sandstone and quartzite pebbles (Plate 4).. On the entire stretch of shore line from Burgerbugta almost as far as the Werenskjöld glacier (chiefly on Fuglebergsletta and Ralstoranda), these gravels are an element very typical for all terraces of the middle group, i. e. beginning with the ridge on the 7 m. terrace as high as the 40 m. terrace. They are featured by a bright, at times white, colour and thus are easily distinguished on the terrace surface. Near the Werenskjöld glacier or, to be exact, beginning with the shore section called Kwartsittsletta, there markedly prevail authochtnous pebbles of white or light-green quartzite.

According to the kind information supplied by K. Birkenmajer, the geologist of the Polish Expedition, these „white" pebbles are derived from Carboniferous, Cretaceous and Triassic rocks occurring in the fiord's interior. Some of these pebbles are from conglomerates and from metamorphosed conglomerates, known within the Hecla Hoek formation (e. g., from Fannypynten cape near the Hans glacier). Thus, to a large extent, the „white" pebbles are allochtonous material, transported by glaciers. They underwent perfect rounding by surf action. Most frequently they disclose a discoidal, strongly flattened shape, often of elliptical outlines. They are typically abrasion pebbles.

For purposes of morphometrical analyses, a large number of pebble samples were collected from all the terraces. These analyses were carried out by Maria Jahn, using A. Cailleux's method. The complete record of these investigations is going to appear in a separate publication. Here but a few results are presented:

From exact measurements there were computed the indices of flattening and rounding of gravels of identical resistance to abrasion (quartzitic sandstones). They distinctly show different values for gravels of the different terraces (Fig. 10, see p. 169). The greatest indices of flattening

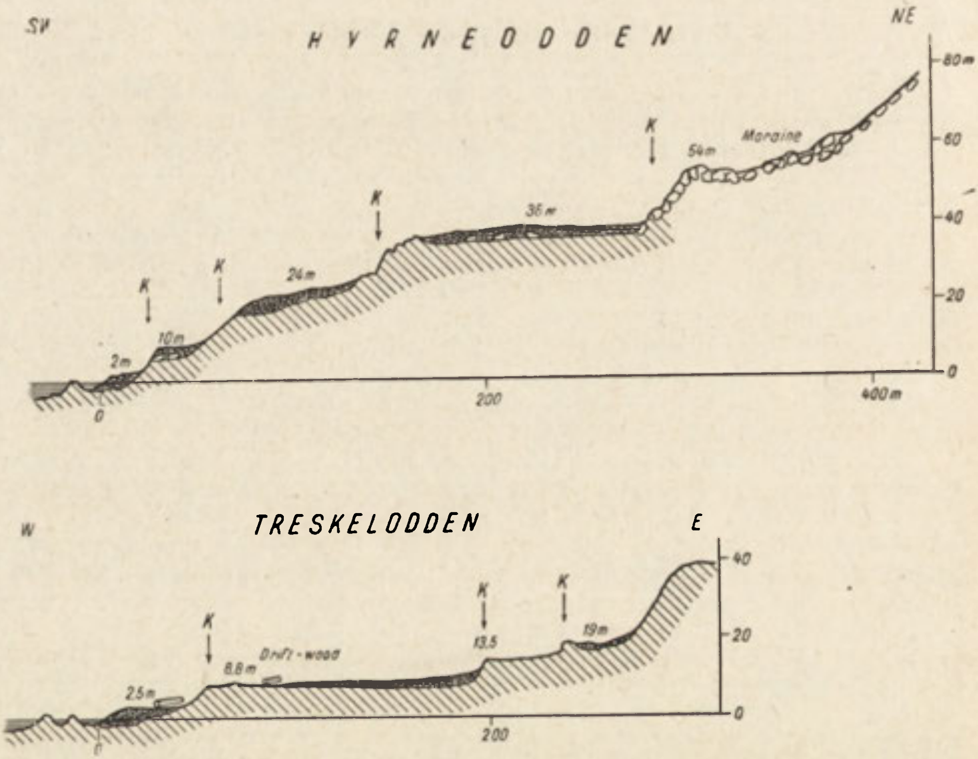


Fig. 9. Abrasion accumulation terraces at Hyrneodden (*1*) and Treskelodden (*2*). *K* — line of cliffs

show pebbles from storm ridges situated at the height from 7 to 13 m. above sea level. Here the discoidal elements are most numerous (index of flattening above 2.0). These same storm ridges also show the highest index of rounding of pebbles (exceeding 400). This refers to both the allochthonous „white" Fuglebergsletta gravels and the autochthonous quartzitic Kwartsittsletta gravels [1].

[1] The discoidal shape of the gravels is not the original form, but has been caused by marine action. On Fuglebergsletta we find flattened pebbles of metamorphosed conglomerates. However, I doubt that this type of rock is the principal cause of this commonly occurring pebble shape. This seems to be collaborated by the Kwartsittsletta occurrence where no metamorphosed rock has been found; yet the gravels of the 7—13 m. terraces are of very flat shape.

The degree of rounding and flattening of the pebbless is evidence of the intensity of their having been worked over, thus of the intensity and force of shore processes. Flat, discoidal pebbles are produced on the slope of storm ridges due to the action of shore breakers. In hitting the shore each wave changes the position of the pebbles, moves and overturns them. Due to this, all elements of shore rubble undergo abrasion on their entire surface, resulting in their rounding. On the other hand, the water flowing down from both the inclined beach and the ridge side moves the pebbles progressively; in this manner they are ground down on their bottom side only, gradually becoming flattened. Thus there is a connection between flat pebbles and the shape of the ridge, because only in conditions of a strong compensating current the one-sided grinding down of pebbles takes place. These facts have been ascertained on the Hornsund shores. The terraces with storm ridges disclose pebbles with the highest index of flattening.

However, the degree of flattening and rounding of pebbles is more than an index of the power of wave action. It also illustrates the stability of the shore line. The longer the shore line remains in place, the more thorough is the working over of the shore rubble.

As mentioned above, the highest indices of flattening and rounding of the gravel appear on the terraces and storm ridges extending at the heights from 7 to 13 m. above sea level. It must be assumed that at the time when shore line coincided with the level of the terraces, the arctic waters must have been particularly turbulent, more so than the sea is today. At those times the highest storm ridges were formed, and their material is distinguished by the most perfect grinding down. Thus both the morphology of the surfaces and the morphoscopic features of the gravels point to the same causes.

I would also suggest that the high degree of gravel abrasion is proof of a certain stability of shore line during the period of formation of the beaches raised today to 7—13 m. above sea level. The other, higher terraces are distinctly tilted seawards; they may be assigned to the category of „slope-terraces", an indication of a fairly rapid change of shore line. This agrees with the fact that on these terraces the flattening and rounding of pebbles is distinctly less in evidence than in the storm ridges of the 7 to 13 m. terraces. It might therefore be concluded that with increasing altitude of terraces the stability of the shore line is descreased. These particular conditions commenced at the time when land was submerged about 13 m. below its present-day level.

The dating of terraces is a difficult problem, due to the absence of fauna in their deposits. For this reason too it is impossible to determine the climatic conditions in which these terraces were formed. K. Birkenmajer *(4)* pointed out this fact; in spite of patient investigations he found but few species. On the higher terraces no fauna was discovered at all; only on the 8 to 10 m. terrace shells of a few *Mollusca* were found in the sands, rarely in the gravels. Birkenmajer *(4)* reports the occurrence of *Saxicava arctica* and *Mya truncata* from the 7.5—8.5 m. terraces, and of *Mya truncata* only, from the 6.5—7.0 m. terrace. In the 2.5—5.4 m. terrace are *Balanus* plates.

In the 8 m. terrace of the Isbjorn bay (at the Polish Expedition's base)

I have found well preserved *Mya truncata* shells and crushed remnants of booth *Saxicava* and *Balanus*.

Professor A. Kosiba, the glaciologist of the Polish Expedition, discovered an ample fauna in morainic cones on the surface of the Werenskjold glacier. This moraine appears almost in the middle of a glacier tongue at the altitude of 80 m. above sea level; its material is deposited from glacier fissures. A. Kosiba *(21)* is of the opinion that in this glacier's substratum there is hidden an entire system of marine terraces, and that the discovered fauna is to be ascribed to the terrace whose absolute altitude is similar to the altitude of fauna appearing on the glacier's surface (80 m.). This once has been a tranquil marine bay, filled with clays. These clays with their fauna have at present come to light on the surface of the glacier. This situation partly reminds us of the abundant fauna in the marine moraine of the Treskelodden peninsula described by A. Heinz *(15)* and by K. Birkenmajer *(4)*.

The discussed fauna from the Werenskjold glacier has been identified in Oslo by Dr. W. Feyling-Hanssen. According to information supplied through Professor A. Kosiba, here the following species appear: *Mya truncata, Saxicava arctica, Balanus balanus, Strongylocentrotus.*

All these species found in the Hornsund region belong to the assemblage of arctic or boreal fauna. Among them there is no clearly warm fauna originating from the climatic optimum. Nor is anything known regarding the vertical range of this fauna, owing to our lack of knowledge regarding the altitude of terraces covered by the Werenskjöld glacier. Particularly baffling is the absence of that fauna which abundantly appears in Isfiord, downwards from the 40 m. terrace (Feyling-Hanssen's (10) „Astarte terraces" and „Mytilus terraces"). This fauna has not been found at Hornsund neither on uncovered terraces nor in the marine moraines of the Horn and Werenskjöld glaciers. In accordance with K. Birkenmajer *(4)* we might assume that during the entire postglacial as well as until today, the Hornsund region has been distinctly cooler than the Isfiord region. If this be correct, a comparison of terraces of both these regions is controversial. Thus the scantiness of fauna on the Hornsund terraces precludes conclusions as to consequences, time of duration, and climate, of individual postglacial periods of this area.

5. Relation between Terraces and Moraines

On Hornsund there may be distiguished:

a) residual blocks and morainic rubble,
b) older morainic ridges,
c) younger morainic ridges.

Residual blocks and morainic rubble are remmants of the oldest glacier deposits which originated at the time when glaciers covered the entire littoral belt and everywhere extended as far as thea sea. Both blocks and washed down rubble are the principal elements of this moraine which has since been destroyed by the action of the sea and by solifluction; on the other hand, but rarely (most frequently in depressions), may be found patches of sandy boulder clay which have survived this destructive action. These morainis remnants, both boulders and blocks, disclose distinctly a typically „erratic" character, since to a considerable extent they are derived from rocks appearing far inland. The entire littoral zone north of Hornsund is built of rocks of the Hecla Hoek formation, whereas in the interior of the fiord there appear Triassic, Carboniferous and Devonian rocks; further east along the shore line, we find the Cretaceous and the Tertiary. The red sandstones and conglomerates, so common amongst erratics, are derived from Devonian sediments; other blocks, such as white or grey quartzitic sandstones, have been picked up by the glaciers from outcrops of Mesozoic or Tertiary rocks. These rocks we observe not on the terrace surfaces, but chiefly at the base of raised cliffs, laid down in very different position and altitude. Thus the grinding and transporting activity of the sea managed to eliminate the minor morainic material, grinding it down into gravel of the littoral rubble beds. Along the cliffs there were left blocks, washed and rounded by wave action. This is the picture along the present-day cliff and storm ridge, and identical conditions we observe on the raised beaches and cliffs. Therefore, this actually represents morainic material secondarily worked up by the action of littoral processes. This explains its smooth surfaces too.

From the arrangement of the erratic boulders it may concluded that the glacier which has been covering the discussed littoral belt, must have originated from the junction of two great glaciers, the Horn and the Torell glaciers. Only these two glaciers were capable of transporting towards the sea shore Devonian material from the interior, because these glaciers start out there. At those times, smaller glaciers like the Werenskjold or the Revdalen glacier whose firn fields were situated within the range of the Hecla Hoek formations, were of minor significance. On the Dun-Islands (Dunöyane), 5 km. from the shore, there are scattered Devonian erratic blocks (of diameters up to 4 m.), undoubtedly brought here by the Torell glacier. Here no quartzitic rocks from Gulliksenfjellet are being found, — proof that no glaciers of nearest vicinity, such as the Werenskjold or the Bratteggdalen glaciers, have reached as far as this. The moraines of Fuglebergsletta and Rolstoranda, also consisting of erratic material, should rather be connected with the range of the Horn glacier.

The relation of the terraces and the raised marine beaches to this glaciation is manifest, — on all these forms of marine abrasion washed down morainic remnants appear. The terraces are younger than this phase of glaciation.

The second type of moraines on Hornsund represent ridges of the terminal and lateral moraine, called „older" moraines (plate 2 and 11). These we know principally from Revdalen where they appear in two horizons. The lower ridge extends almost continuously along the right hand valley slope, slightly above its bottom, almost as far as the Rotjesfjellet headland. Relicts of this ridges appear too on the valley's left side, at the base of the Skoddefjellet slopes. — The second, upper ridge may be observed on the right hand slope, above Revvatnet lake, at an elevation of 100 m. a.s.l., 90 m. above valley bottom (above the bottom of Revvatnet lake).

Moraines of this kind appear at the outlet of all cirques appearing on the mountain slopes along the shore, beginning with Torbjörnsenfjellet as far as Gulliksenfjellet (Kvartsittsletta) (Fig. 3). They also occur at the mouth of Ariedalen, on the slopes of Fannytoppen next to the Hans glacier, and on Hyrneodden cape in the interior of Hornsund (Fig. 9). These moraines are built of large blocks of local rocks, most frequently torn from the nearest mountain side. This is that type of marginal moraine where an important part in its origin has been played by material from talus cones dropping onto the glacier's surface. In this respect these moraines markedly differ from the previously described remnants of ground moraines in which an intermixing of material and the presence of far--travelled rock elements is the most characteristic feature.

It is difficult to specify the relation between morainic forms and raised gravel beaches,. since the glaciers on whose rims these moraines were formed, usually came to their end in the sea. Therefore we commonly observe, between the flat gravel surface of terraces and the morainic ridges, the characteristic „morenic cliffs". The rubble of a moraine used to be undercut by the surf action of the sea and by sliding rock blocks the steep (40°) cliff slope was produced. With this type of cliffs end all morainic ridges on Ralstoranda and on Kvartsittsletta (Fig. 5). They have a very fresh appearance, — exactly as if the sea but recently had receded from the base of these moraines.

Detailed investigations undertaken in Revdalen threw light upon the mutual relation of ridges of lateral moraines and terraces. The moraine covers the marine gravels of the 65 m. terrace (below the slopes of Skoddefjellet), thus is younger than these gravels; all the terraces of lower height, starting with the 45 m. terrace, form a line of cliffs, in the moraine debris. Thus, with regard to these latter terraces, the moraine is either a contemporaneous or an older form. In this manner we are able to establish the age of the transgression of the glaciers (the second one in the sequence distinguished in this region), at the time when the morainic ridges were formed. This coincided with period in which land was submerged to a depth of at least 45 m. below the level of the sea. This transgression is younger not only than the 65 m. terrace, but younger too than the high cliffs and gravel beaches whose remnants we have distinguished on the entire mountain slope between the Hans and the Werenskjold glaciers.

Before this trangsression, the sea was intruding deeply into valleys, thus also into the Rev valley and the valley of the Werenskjold glacier. The majority of ice tongues succeeding the transgression ended in the sea. The glacier of the Rev valley reached beyond Worcesterpynten cape and had connection with all the glaciers which ran down from littoral cirques and smaller valleys. We might assume too that, at that time, the Horn glacier filled almost the entire fiord, linking up with tributary glaciers which today extend only to the shore line of the fiord.

Many of these glaciers deposited moraines at the bottom, or on the shore of the sea. The Rev glacier had a thickness of about 100 meters, whereas the depth of the bay, then existing in place of the recent valley, was but 30 to 50 meters. Thus, even during its widest range, the glacier rested on the bottom of the bay. When this glacier receded, the waves submerged its moraine, destroying almost completely the ground moraine and reaching the higher placed ridges of marginal moraines. This was a quite common occurrence and therefore some morainic features along the shore line disclose material leached by water. When later, owing to the uplifting of land, the morainic ridges became the shore of the sea, it continued to be subject to the destructive action of the breakers; on the boundary between gravel beach and ridges there developed the steep rise of the well known morainic cliff.

The third type of moraines are the „younger" arcuate ridges of the end-moraines, formed in connection with oscillations of the Spitsbergen glaciers occurring during the latest 200 years (Plate 14). They indicate the range of the glaciers before the recent phase of a climatically warmer period, which period started here towards the beginning of this century. Upon the forefield of the Horn glacier we know them from the Treskel peninsula, at a distance of about 7 km. from the present-day front of the glacier. The retreat of other glaciers, although less than that of the Horn glacier, is very noticeable too.

The possition of these terminal moraines with regard to the terraces might be illustrated by the following fact: none of the terraces is undercutting any of the morainic ridges, and it is only the recent gravel beach which, lying within the range of tides and flood breakers, forms the cliff line, in the moraine. Thus it may be concluded that, since the formation of the younger end-moraines, the shore line has not undergone any marked vertical changes; therefore too, these moraines have not taken part in the uplifting of land, nor are they connected with the system of raised marine beaches.

The advance of glaciers, during which these moraines were formed, took place on the surface of existing terraces or, even, on the bottom of bays and fiords. Evidence are gravels, driftwood, marine clays and fauna found within the moraines. Thus, discoidal, typical beach pebbles are commonly found in the moraines of the Hans glacier where they reach an altitude of 70 m., in the moraines of the Werenskjold glacier (up to 128 m. altitude), in the glaciers of Burger bay (up to 100 m.). Such pebbles are known too from older morainic ridges (e.g., in the Steinwik valley), but in younger moraines they appear much more frequently. A particular example of a moraine containing an abundant marine material is the moraine of the Horn glacier on Treskel peninsula. This deposit has been described in detail by H. Heinz *(15)* and K. Birkenmajer *(4)*; i.a., these authors have identified the rich marine fauna that appears in these moraines as a secondary deposit. In it there also are found fragments of driftwood and — although rarely — pebbles. Heinz *(15)* suggested, the transgressing glacier might have amassed this material mainly from the bottom of the fiord, thus clay with fauna. It seems probable that the glacier also tore up the shores, and that in this manner pebbles and driftwood got into the moraine.

It seems to tally with this character of the moraines that up to the present day the big glaciers rest upon the surfaces of raised marine beaches and terraces. Underneath the Hans glacier there is a 17 m. and a 24 m.

terrace, underneath the Werenskjold glacier, as established by K o s i b a (*21*), a 25 m. and 40 m. terrace (perhaps higher terraces too). At the front of the Hans glacier the shore breakers disclose a number of banks of beach gravels on which this glacier lies.

It is evident from the above data that the younger glacier advance (i. e. the one during whith the younger end-moraines were formed) was preceded by a powerful regression. It is an open question whether this is not that recession of glaciers which took place before the formation of the older moraines.

In view of the above problem, the age of the raised marine beaches on the slopes of Treskel peninsula becomes enigmatical; according to P i l- l e w i z e r *(23)* and H e i n z *(15)*, in 1900 this peninsula was still covered by the Horn glacier. Both of the authors base their opinion upon W a s s i l i e f f' s *(29)* map, drawn in 1899 - 1900 during the Russian Expedition. On this map, Treskel peninsula is not shown at all; this may indicate that, at that time, the Horn glacier extended west of this peninsula.

However, these conculsions disagree with morphological evidence. On the western slopes of the Treskel ridge there appear gravel beaches raised to a height of almost 20 m. Similar beaches exist at the base of Hyrnefjellet (Adriabugta), whereto the Horn glacier is likewise reported to have extended. These terraces are not covered by any kind of moraine. This would mean that the beach came into existence after the Horn glacier had retreated; thus within the recent 50 years, Treskel peninsula would have had to rise 20 meters. Of course, this conclusion is fallacious and therefore, in 1900, the rim of the Horn glacier could not have extended as shown on W a s s i l i e w' s map. I have been able to ascertain that the end-moraines extending farthest westwards, transsect diagonally the western slopes of Treskel peninsula. They penetrate upon all the terraces, and it is clearly visible that underneath the moraine there spread gravels of a raised 9 m. beach. In my opinion, this moraine indicates the extreme range of the Horn glacier, not only in 1910 (H e i n z, *15)*, but in 1900 too. The line which on Wassiliew's map marks the western shore line of the fiord, is most probably not the rim of the glacier, but the boundary of snow patches spreading before the glacier's front. I suppose that such snow patches once surrounded the shores of the entire Adria bay, — the same as this is here the case today, even in late summer. The eastern winds predominating here in winter blow the snow across easily, and accumulate it on the western slopes of the tranquil Adria bay. 50 years ago, these snow patches have been a more lasting phenomenon and they extended much farther at that time, when the climatic snow-line reached lower and the adjacent front of the glacier exerted its cooling influence. It must have been under these immobile snow patches, not underneath the moving glacier that the terraces of Treskel peninsula were situated.

Thus, conditions upon Treskel peninsula do not differ in the least from facts established elsewhere. There exist no raised marine beaches younger than the latest advance of glaciers.

Summarizing all the above presented data, i.e. the relation between moraines and littoral terraces, we might distinguish in the vicinity of Hornsund fiord the following three stages of glaciation:

1. The stage of oldest moraines which preceded the formation of the highest beaches and cliffs. The submergence of land underneath the surface of the sea was more than 200 m.

2. The stage of older morainic ridges, when the land was flooded by about 45 meters of sea.

3. The stage of younger morainic ridges, beginning with the period when the shore line corresponded more or less to its present-day position.

6. Oscillations of glaciers and vertical land movements

The discovery of three moraines above Hornsund suggests conclusions which should be correlated with the results of other Spitsbergen investigations, especially with Feyling — Hanssen's *(10)* well known scheme. This refers mainly to disclosing a climatic correlation which undoubtedly should exist between the glaciation of land and its isostatic uplift.

In the Pleistocene, the entire archipelago has been covered by a thick ice cover. Gravels and marine cliffs which at Hornsund reach heights up to 275 m., indicate the phase of the late-glacial submergence of land. Marine beaches raised to such heights are rather rare in Spitsbergen. In the north, they reach up to merely 150 m. (Sandford, *26*, Kulling and Ahlmann, *19)*, in the central part of the island, at Isfiord, up to 96 m. (Feyling — Hanssen, *10)*. According to Werenskjöld *(30)*, the highest raised terraces appear in the southern part of Spitsbergen. In the central part of Sörkapp (Hilmarsfjeld) there are found abrasion terraces with shore rubble and rounded rock boulders at an altitude of 338 m.

My own Hornsund observations confirm Werenskjöld's conclusions. On this basis we may take into consideration a general tendency of postglacial uplifting of the entire archipelago. In the south, the amplitude of this movement was largest. Thus Romanowsky *(24)* was at fault assuming that this uplift increased eastwards and that its center coincided beyond Spitsbergen with King Charles Land (on this island shore terraces lie at the height of 273 m.). There exists a discrepancy too between the above established tendency and Birkenmajer's *(4)* conslusions; comparing the fauna from the raised beaches at Isfiord and Hornsund this author suggests rather a southward subsidence of the lower group of terraces.

From the position of the late-glacial terraces it might be concluded that during that period the regression of glaciers has been very vigorous. The glaciers retreated from the whole shore zone and, maybe, survived solely in the interior of the island. At any rate, their range at that time has been lesser than it is today, as indicated, by the presence of marine gravels in the moraines (e.g. in the moraine of the Werenskjöld glacier). These are situated high and therefore might have originated only from the highest raised gravel beaches, such as have survived in the Steinwik valley. Since, towards the end of the glacial, land has been submerged almost 300 m., the late-glacial warmer climate must have had a more thorough and a quicker effect than it did at its later phase, when due to the isostatic uplift of land there took place a relative lowering of the snow-line. Hitherto, this aspect has not been taken into consideration when discussing late-glacial and post-glacial changes in the Spitsbergen glaciation. The amplitude of this uplift, reaching 300 m. in some parts of the island, must indeed have played a significant part, irrespective of general climatic changes.

It has been an important phase when land had been uplifted about 200 m., and the shore line extended approximately along today's 65 m. terrace. At this period we observe a new advance of the glaciers, extending even farther than do the present-day glaciers. Proof are the so-called older morainic ridges in the Rev valley and along the entire shore, extending between this valley and the Werenskjold glacier. The Rev valley is an independent morphological unit, separated from the island's interior by mountain ridges. Thus, if this valley had, at those times, its own large glacier, the firn-line must have run below the lowest mountain ridges and passes surrounding this valley. Therefore this boundary must have equalled the level of the bottom of the large cirques which pass into this valley. It thus appears that the lower firn-line has been no more than 250 m. It extended at lesser altitude than today's snow-line which, in this part of Spitsbergen, runs at the height of about 400 meters. I doubt whether this transgression of glaciers caused the formation of an ice cap reaching higher than the valley watershed — as undoubtedly happened in the Pleistocene. There only developed individual glacier tongues, i.e. valley and fiord glaciers which, here or there, may have combined forming piedmont glaciers, such as on the shore between Revdalen and the Werenskjold glacier.

The rapid isostatic uplift of Spitsbergen, hitherto undisturbed, underwent a noticeable interruption. This phase took place somewhat later than the phase of glacier development; we might consider this a feature of retardation, commonly observed in this kind of isostatic movements. Evidence of this disturbance in the movement of land is the formation of a system of great abrasion terraces at 38 to 45 m. altitude. Above I have mentioned already that, in the morphology of the Hornsund shore, these terraces are of particular significance. Incidentally, not only at Hornsund, but all over Spitsbergen; thus in the Isfiord and Kingsbay too, the 40 m. to 45 m. terraces are very well developed. Feyling — Hanssen *(10)* has determined that at the level of this terrace an important change in marine fauna has taken place; on this basis he is of the opinion that, at the period of submergence by about 40 m. in relation to the present-day sea level, the post-glacial climatic optimum must have set in. This author mentions a positive movement of the shore line at the beginning of this period, made evident by the formation of this extensive littoral platform. I believe that the cause of the positive movement of the shore line has not only been the eustatic uplift of the sea level (connected with the powerful melting of glaciers), but the above discussed transgression of glaciers too, preceding the eustatic marine transgression. Thus, in the 40 m. terrace I perceive the isostatic influence of this transgression. It has been before the postglacial climatic optimum, i. e. at the decline of the period which Feyling — Hanssen *(10)* calls the „Post-Glacial Temperate Period".

We may assume that the cause of this new transgression of glaciers might have been either the uplift of Spitsbergen, or a change in climate, of a combination of both these factors. The former factor I have discussed already. The deglaciation of Spitsbergen during the period of the early postglacial happened at a very much lesser altitude than at present. The rapid emergence of islands, especially in the south, might have created conditions favourable to a new transgression of glaciers.

On the other hand it seems probable that this phenomenon was of wider spread. Unfortunately we know but little of this transgression on Spitsbergen. It therefore seems worth remembering that Sandford *(26)* mentions kames and a moraine on the 45 m. terrace in the Wahlenberg fiord (North-East Land). On this subject he reaches the following conclusion: „The glacial covering did not disappear during the oscillation, since kames and boulder clay are associated with the greater heights of the raised beaches" (Sandford, *26*, p. 552). Here may be observed a marked similarity with conditions which I have described from Hornsund. The new moraine, proof of the postglacial transgression of glaciers, has been laid down on the 45—65 m. terraces.

Presumably a connection exists between this transgression and some kind of general cooling of the climate. This period of cooling seem to be indicated by the curve of postglacial changes in the Scandinavian glaciers (according to Bergstrom and Liestol, as reported by Ahlmann, *(3)*, and Charlesworth, *(6)*. Shortly before the postglacial climatic optimum a distinct cooling period took place in Scandinavia occurring, according to the quoted authors, at about 5 to 6 thousand years B. C. The shore line of Isfjord ran, according to Feyling — Hanssen's *(10)* opinion, at the height of 40—60 m. (Post-Glacial Temperate Period). Here the climatic optimum (the so-called Post-Glacial Warm Period) commences with the 40 m. terrace. I suppose that the „older morainic ridges" in Hornsund area, connected exactly with the 40—65 m. terraces, correspond with the phase of Scandinavian cooling.

Beginning with the 40 m. terrace there starts a gradual protracted climatic period of increasing temperatures, undisturbed by greater phases of cooling. A climatic change takes place until historical times when the Spitsbergen shores were at a level almost corresponding to today's position. This cooling period brought about a trangression of glaciers; they penetrated an almost all the terraces, even the lowermost ones. The maximum range of the glaciers occurred at about 1600—1700 A. D. This, by the way, was a common phenomenon and similar conditions were found in Greenland. In almost all the terminal moraines we observe marine gravels, picked up by the glaciers on raised beaches; in some of these moraines a marine fauna has been discovered.

It is generally assumed that in the Quaternary deposits of the Spitsbergen coast there are discernible but two phases of glacier transgression. One of them is the Pleistocene glaciation, the other — the advance of glaciers in historical times. Among others, this sequence of glaciation is reported by Donner & West *(8)* too.

I would like to stress the point that facts established on the Hornsund area indicate three transgressions of glaciers:

1) the Pleistocene transgression,

2) the post-glacial transgression of the „older morainic ridges", preceding the climatic optimum, and

3) the transgression of historical times, occurring after the climatic optimum.

7. Present-day Littoral Processes at Hornsund

Connected with the postglacial uplifting of Spitsbergen is the simultaneous smoothing, or rectification of its shore line. Feyling-Hanssen *(10)* called attention to this fact, describing the evolution of Johnson's „truncated cuspate forelands" in Billefiord. Analyzing from this point of view the Hornsund shore we observe in the postglacial history of this area two phenomena proving the progressing rectification of the shore line. Simultaneously with the receding movement of the shore line there occurs:

1) a filling in of bays and a cutting back of headlands and peninsulas,

2) a growth, both as to number and size, of littoral storm ridges.

These ridges already appear on the 40 m. terrace, but they were formed mainly on the surface of the 10 m. terrace. The lower these ledges are in bays, the wider-spread are their curved outlines, — proof of their tendency of smoothing the general course of the shore line.

In order to visualize the essence of shore processes during the formation of the postglacial raised beaches, it seems necessary to describe the results of the present-day activity of the sea.

The shore outline depends here, as well as everywhere in the world, of the force of wave action, of shore currents and of the prevalent tendency of shore line changes. Here must also be taken into account specific, typically polar conditions, such as the action of frost, snow and marine ice. Long ago they have been described by Nansen *(22)* and Ahlmann *(1)* in their classic publications on shore problem of the polar and subpolar zone; regarding Spitsbergen, important data have recently been supplied by K. S. Sandford *(26)* and S. Z. Różycki *(25)*.

As mentioned above, storm ridges appear only at the mouths of fiords, in the zone of the outer shore. This is readily understood in view of the fact that this shore formation depends primarily of the force of the shore breakers. Floating ice, i.e. small icebergs developing due to the constant melting of glaciers, play a very important role in shaping the shore. This, however, is rather a protective role. Due to the action of easterly winds blowing so frequently in Hornsund, this floating ice accumulates in the bays and by blocking up the shore reduces the vehemence of littoral waves (Plate 10). The floating ice might be pushed up or thrown by wind pressure onto the shore and, brought within the range of beach gravels, it might have its effect upon microrelief forms. The floating ice causes characteristic melting pits, formed on the slopes of a storm ridge without, however, markedly altering height or extent of the ridge.

Winter snow and the sheet of winter ice exert an indirect influence only, — they facilitate the transfer of the gravels upon sides and top of

Photo by A. Jahn

Plate 1. High terrace of Steinwikdalen (205 m.), visible from the sea

Photo by Wł. Puchalski

Plate 2. System of terraces in Rev valley (Revdalen). Cone-shaped mountain of left side is Rotjesfjellet. At this mountain's base, above the terraces, ridges of lateral moraine („older morainic ridges")

Photo by A. Jahn

Plate 3. Wall of cliff at Veslebogen. This is the stretch of shore line which retreats at the rate of about 5 cm. per year. On top of cliff, stratified deposits of 10 m. terrace. In foreground, modern gravel beach

Photo by A. Jahn

Plate 4 Stratified deposits of debris and gravel of the 10 m. terrace at Veslebogen. These deposits rest on an abrasion surface. In the rear, cape Wilczek and Hornsund fiord

Photo by A. Jahn

Plate 5. 17 m. and 25 m. terraces at Fannypynten. Upon these terraces encroaches the Hans glacier. Noticeable are fresh morainic ridges

Photo by A. Jahn

Plate 6. Sofiebogen and terrace system on the shore of this bay (Bogstranda). Lowest is the 25 m. terrace, succeeded by the 32 m. terrace. In the rear the powerful Sofiekammen ridge (763 m.)

Photo by H. Piaseck:

Plate 7. Bogstranda. Sloping surfaces of terraces higher than 50 m., covered with solifluction debris. In the rear, firn fields of Sofie glacier (Sofiebreen) and highest peak of entire Sofie ridge, Wienertinden (925 m.)

Photo by A. Jahn

Plate 8. System of terraces on Hyrneodden; successively 10 m., 24 m. and 38 m. Along old cliffs, patches of winter snow

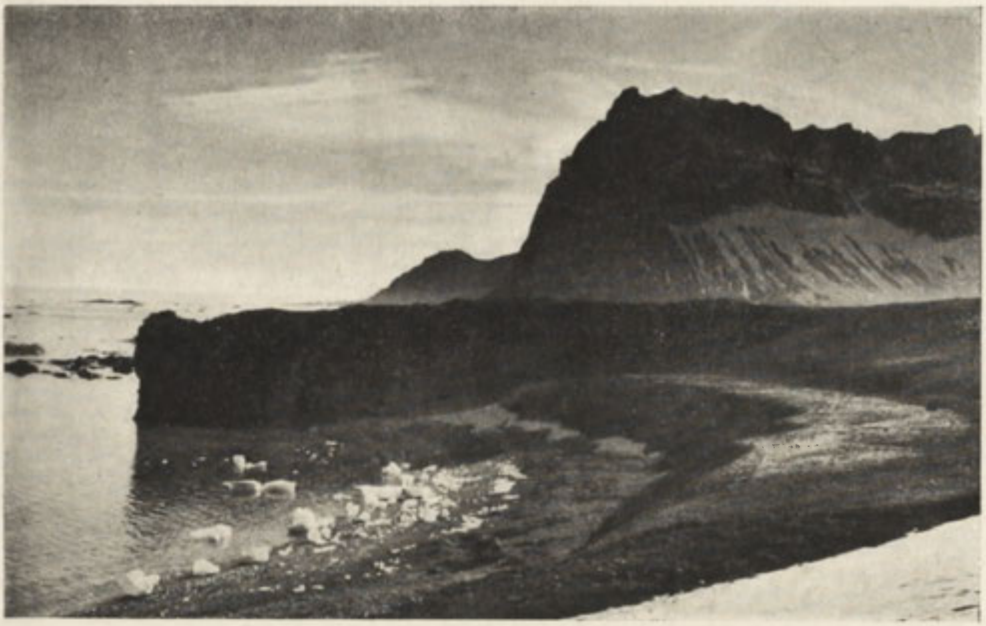


Photo by A. Jahn

Plate 9. Hyrneodden. 10 m. and 24 m. terraces. In rear, Sofiekammen

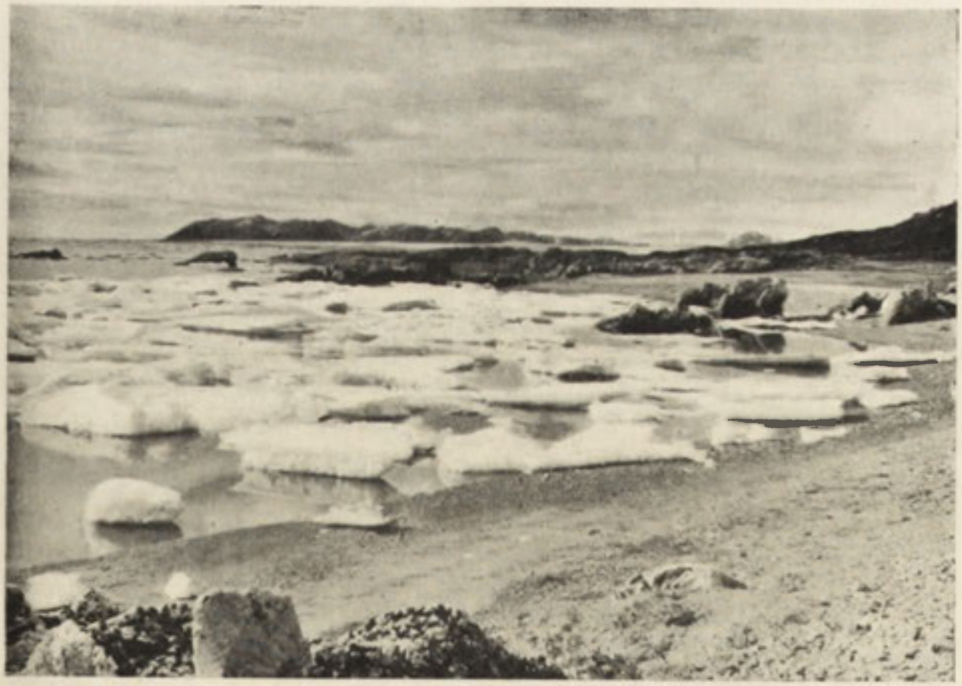


Photo by A. Jahn

Plate 10. Hytte bay (Hyttevika) filled with drift ice (Pakis), and Kwartsittsletta peninsula with full system of terraces

Photo by A. Jahn

Plate 11. Older morainic ridges on Kwartsittsletta. In foreground 6 m. terrace and trapper's hut (Hus), a subbase of the Polish Expedition

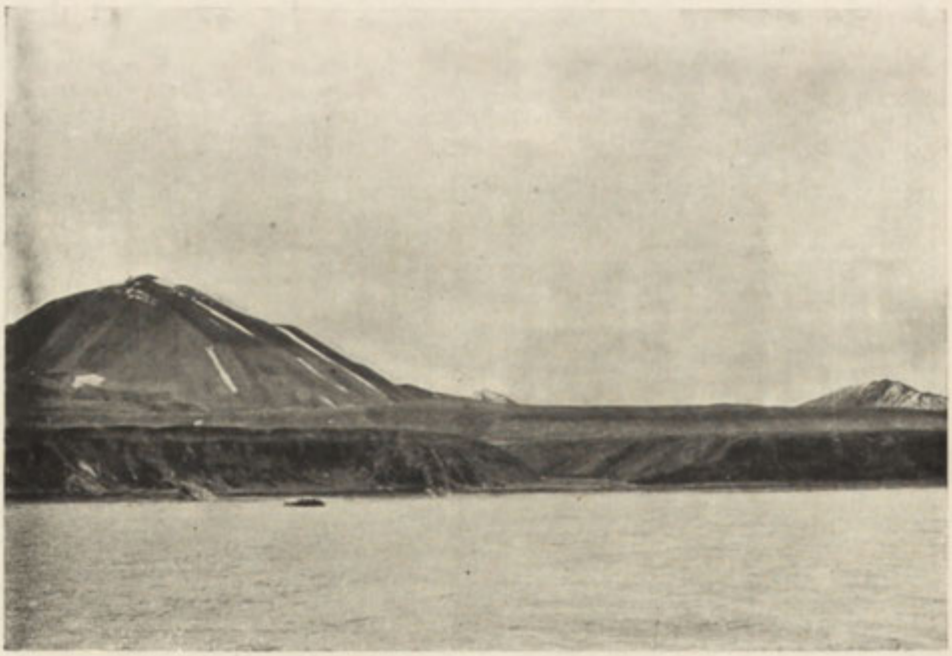


Photo by A. Jahn

Plate 12. Terraces at mouth of Lisbetdalen (Sorkapp). In front, 25 m. terrace. Gravels cover the abrasion surface. In distance (light coloured zone), cliff forming inner boundary of 40 m terrace

Photo by A. Jahn

Plate 13. Shores of Fuglebergsletta. Storm ridge with remnants of winter snow

Photo by A. Jahn

Plate 14. Isbjornhamna. Gravels of ridge of 4 m. terrace. At rear, Hans glacier and its terminal moraine

Photo by A. Jahn

Plate 15. Whale bones within range of lagoonal terrace of Fuglebergsletta

Photo by A. Jahn

Plate 16. Drift wood on the gravels of storm ridge and of 4 m. terrace. Ralstoranda

ridges (Plate 13). This takes place in spring when the entire fiord is free of ice, leaving along the shore only a narrow belt of ice and snow which fills the notch between the base of the slope and the beach surface. But, even in this instance, the actual agent determining the site of the ridge is the force of wave action.

The height of the ridge depends of the angle of the breaker's fall, thus of the height of the waves' uplift at the shore. Near shore cliffs, a ridge grows higher than at a distance from them. The height of ridge is greater in the vicinity of rocky headlands embracing a sheltered bay, and gradually decreases towards the bay's interior. The largest size attain storm-built ridges situated in narrow coves or bays, fully exposed to the attack of oceanic breakers; here occurs the highest rise of the water. On the other hand, the lowest ridges we observed in the depth of a fiord where, aside of the usually feebler wave action, the shore is protected by a barrier of floating ice [2].

As mentioned before, storm ridges are mostly built of allochthonic material, characteristic for this very mobile and variegated littoral rubble. Still, in each one of these ridges we observe a large admixture of debris rock-waste derived from local cliffs (Plate 3, 4). The amount of debris increases with the nearness of the cliffs, — thus in this direction increases the ridge's height too. Undoubtedly this symptom should be ascribed to very intensive weathering to which the cliff rocks are exposed. This is especially the case at such points where snow, accumulated during winter at the base of the cliffs, survives during spring and sumer in the shape of snow patches.

In sumer 1958 we observed such patches near the base of the Polish Expedition at Veslebogen, forced into cliff recesses (Plate 3). These patches adhered closely to the rock and were undercut by waves. Above them there extended a 10 m. wall, built of strongly fractured brittle limestone. On the surface of these patches we noticed an enormous pile of fresh debris. This loose material was the product of one year's weathering of the cliff (in autumn 1957 there were no snow patches underneath the cliff wall). The rate of retreat of the cliff wall, computed on the basis of collected material, is astonishing, — amounting to 5 cm. per year. This debris was gradually being removed by tidal waves; during autumn 1958, when the last snow patches disappeared, it had been completely swallowed up by the rubble of the beach.

In the Fuglebergsletta and Ralstoranda bays I noticed that every ridge, built of material of the littoral gravel sheet, discloses on its crest a layer of rock-waste derived from cliffs visible within the ridge. These layers have the appearance of lengthy streaks of debris, extending both sides of the cliff and growing thinner with increasing distance from the cliff. They can not be considered a normal solifluction product due to the fact that this debris is partly altered by water and has rounded edges. It must be

[2] It should be mentioned here that the latter remark does not apply to limited shore stretches situated near „calving" glaciers. Here, locally, high waves are produced owing to the pressure exerted by newly formed icebergs. This also creates, near the face of the glacier, so-called „surge" ridges of, however, but moderate extent.

assumed that this debris is produced by weathering and that in spring it slid down on the snow cover of the ridge. The direction of slide was conformable with the action of waves which, during heavy storms, reached up to the crest of the ridge.

From these examples it may be concluded that the development of storm ridges proceeds in both directions of the shore line, towards right and left from the protruding headlands and klippen. Into both directions we observe the lateral pushing on of the debris and beach material, and any change in these directions depends of changes occurring in the direction of wind or wave action. Here, the closing up of bays by the development of ridges and spits proceeds quite rapidly, owing to the fact that these ridges develop concentrically, simultaneously from both flanks of the bay. Only in such places where an easier access of marine currents exists towards the shore, such as at the Dunöyane Islands, there is formed an entire chain of unidirectional ridges, extending concordant with the current's action (northwards, in this instance).

It should be added here that the height of the shore ridges likewise depends of the thickness (diameter) of the gravels. The storm ridge is not merely a form of accumulation; its existence or, to be exact, its survival depends of the extent to which it is going to resist the action of breakers. Each storm of greater power is liable to destroy the ridge's shape left by the preceding storm. For this reason there is but a feeble chance of survival of sandy ridges, whereas of long duration are ridges built of coarse-grained gravels. The waves may even increase the height of such ridges, throwing onto their top gravels of lesses density as well as driftwood.

It may well be that I discussed in excessive detail the characteristic of storm ridges and their development; but this seemed expedient in order to explain the fairly large differences in height of the youngest beaches and terraces of Hornsund. Not always should their height be considered sufficiently convincing proof of a change in the shore line that might have been caused by a change in the level of either sea of land. A change in the wave's activity, both in space (i. e. along various stretches of the shore) and in time, might bring about results similar to those which accompany a change in level of sea or land.

The bars with storm ridges exert a decisive influence upon the formation of lagoons. After having been cut off along half its width, a bay is gradually filled up by marine material, whereas a completely cut-off bay undergoes desolation and is filled in by continental material. In this latter instance, the height of the lowest littoral terrace of accumulation depends of the height of the bar and of the rate of progress of continental processes (such as, e.g., sedimentation in the water course leaving the lagoon).

In the present climatic phase, littoral processes distinctly prevail over effects of land erosion. Smaller creeks fail to maintain their passage across the littoral ridge; their mouths are being filled in by shore rubble, and inside the ridge line small lakes are formed, subsequently promptly eradicated by continental sedimentation. As example may serve, e.g., the small lake next to Wilczek Odden, on Fuglebergsletta. On the other hand, a larger river, the Revelva, has maintained to this day its outflow into the sea; however, during winter and in early spring, this river mouth uses to be barricaded too by littoral rubble for a short space of time [3].

Thus the height of the lowest terrace is conditioned by the degree to which the lagoon, after being cut off by the storm ridge, has been filled in. This height varies from 1.5 to 4.0 meters a.m.l. in instances when the lagoon has been completely filled up to the top of the ridge. Since, in particular instances, the ridge may, during its contemporaneous formation,

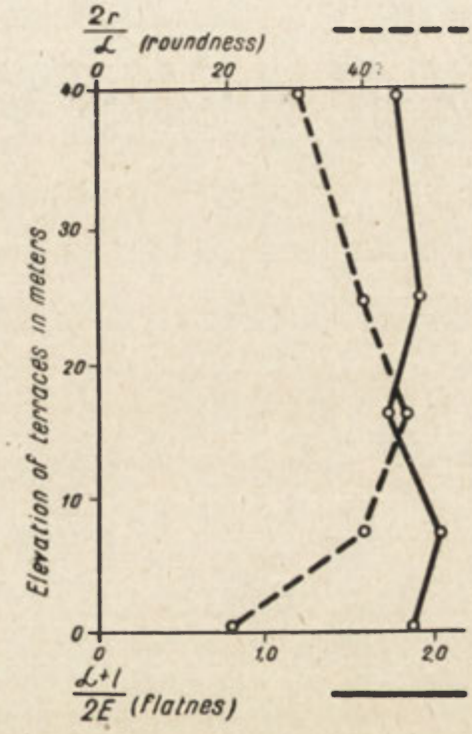


Fig. 10. Curve of indices of flattening and rounding of gravels on the Kwartsittsletta terraces. Full line — index of flattening $\left(\frac{L + l}{2E}\right)$, dashed line — index of rounding $\left(\frac{2r}{L}\right)$

reach a height of close to 6 meters a.m.l., the littoral terrace of accumulation may also attain this height. On the storm-battered shores of Scotland there are known storm ridges of 12 m. height. Thus, if storm violence should increase in the Spitsbergen waters, we might expect a higher littoral terrace to develop, — without any previous changes in the level of the sea.

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3 This information I owe to Z. Czeppe who spent the 1957/58 winter at the base of the Polish Spitsbergen Expedition, at Hornsund.

However, there exist facts indicating that, simultaneously with the formation of a lagoonal terrace, land has been uplifted, i.e. that a negative change of shore line has been taking place. The principal proof for this claim is the presence of marine sands with fauna within the range of a 3—4 m. terrace, — an observation made already by K. Birkenmajer *(4)*. Another proof might be seen in the appearance, within the area of some of the filled-in lagoons, of whale bones; they are being found in such large accumulations that this seems to exclude the assumption they might have been transported here by man or beast. They are scattered at various heights, — similarly as the bottom of the lagoons lie at various altitudes.

In one of the filled-in lagoons on Ralstoranda I found whale bones at the height of 3 m a.m.l. at a locality which is illustrated on the enclosed section (Fig. 11). Here the bottom of the lagoon is built of local rubble and of sand, derived from neighbouring klippen. The storm ridge of 4 m. height consists of well rounded gravels and represents a typical rubble of far-carried littoral transportation; the petrographical composition of this material is entirely different from the material bottom of the lagoon. The

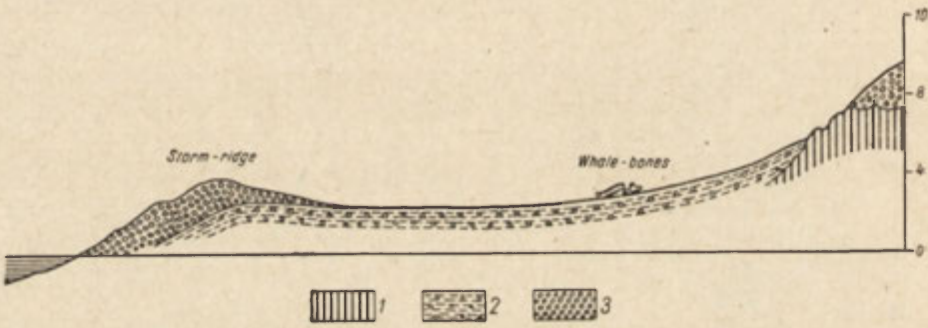

Fig. 11. Position of whale bones within range of lagoon on Ralstoranda: *1* — Klippen covered by gravels of 8 m. terrace, *2* — material of filled-in lagoon consisting of debris and sand, *3* — gravels of recent storm ridge

presence of bones indicates that they were laid down in the lagoon when still open and connected with the sea, i.e. at the period when the present-day bottom was at an altitude lower by at least 3 meters. Hence it should be concluded that the storm ridge was formed simultaneously with the uplifting of land. The rate of growth of the ridge was greater than the rate of land uplift, therefore the gravels of the ridge enter upon the surface of the filled-in lagoon.

In this manner we come up against the fundamental problem of the youngest changes of the shore line in this part of Spitsbergen, — a problem which is going to be contemplated in the next chapter of this paper. This change of shore line must have been brought about by changes of both factors which bear upon location and character of the shore, — thus upon the change in the levels of land and sea, and the change in the shore processes. Simultaneously, I see here changes of isostatic movements of land, and of climatic conditions. Incidentally, both the latter values are often interrelated.

In the fiord's interior where changes in the activity of the sea appear less distinctly, the effects of isostatic uplifting are clearly visible. Below the 10 m. terrace there appears a beach of 2 m. height, with a uniformly established surface (Plate 9). There can not be any doubt about it that this beach is an element of the contemporaneous shore, yet it would be difficult to decide how far backwards this „contemporaneousness" extends. F e y l i n g - H a n s s e n *(10)* found in the interior part of Isfiord (Bille-fiord) similar altitude conditions of its lowest terrace. However, this form he calls „Sub-Recent" in view of the fairly considerable change in fauna which already took place at that horizon, and which afterwards led to the period of contemporaneousness („Recent").

Simultaneously with the uplifting of land there went forth, on the inner shore of Hornsund, a marked increase of wave amplitude. The upward movement of the land has not been rapid enough to prevent the formation of ridges. On the contrary, the increasing intensity of wave action outweighed the lifting movement of the land; due to this, gravels of the storm ridges invaded upon the raised terraces. I am inclined to ascribe this to the fact that simultaneously with increased wave action of the sea the uplifting movement of the land was slowed down.

8. The Problem of the Youngest Vertical Movements of Spitsbergen

As mentioned elsewhere, the problem of these movements presents itself with the question of the origin of the presentday storm ridge and the lagoonal terrace. K. B i r k e n m a j e r *(4, 5)*, has touched upon this problem too. Having collected much interesting material from the Hornsund region he is attempting to determine the rate of the present-day uplifting of this part of Spitsbergen. Contemplating both the methods and the results of these investigations I wish to formulate the following critical remarks.

Firstly — the proposed method. On the basis of historical and archaeological evidence, studies of the changes in the Spitsbergen shore line are under way since considerable time. Of particular interest are here the traces of the great whaling expeditions of the beginning of the 17th century. After these expeditions there were left, on the Spitsbergen shore, the ruins of whale-oil cookeries, houses and graves of the whale-hunters and, finally, whale bones. The essence of the problem consists in the correct interpretation of the traces of these expeditions of the 17th century, and in accurate determination of the altitude of both the ancient and the modern shore line. However, this method of investigation might prove misleading or outright faulty, unless it will be possible to establish the accurate age of these ruins and whale bones, and to correctly determine the course of the ancient shore line.

My criticism applies also to K. B i r k e n m a j e r's *(4)* so-called „whale method"; this is one of the methods previously employed for estimating the uplifting of Spitsbergen on the basis of the position of these traces of former whaling expeditions. For this reason, there should be mentioned the papers published by Vogt *(28)*, Feyling-Hanssen *(10)*, Donner and West *(8)*; all of these authors attempted to determine the present tendency and the rate of movement in the uplifting of Spitsbergen.

Whale bones occur in large quantities along Hornsund where they have been found in a twofold positions (Plate 15): in a lower one, within the range of a lagoonal terrace (up to 4.0 m high), and on the gravel and rubble banks of higher terraces and ridges. K. Birkenmajer relates the highest position of these bones as being elevated 6 to 8 meters above the present-day level of the sea.

Both manners of occurrence of these bones fail to define their age; the second, higher position does not enable us to define accurately the former shore line.

Part of the whale bones happened to be laid down on the shore in a natural manner, without man's participation. This refers to the remains of those whales which were driven into shoals and lagoons by attacking dolphins; they failed to escape from here and perished [4]. This might have happened at very different periods, at the level of almost all postglacial terraces. Therefore, too, whale remnants have sometimes been found at very high places, up to 36 m. above sea level as reported by Dineley *(7)* from Jonsfiord, or even to 75 m. in North-East Land (Sandford, *26*).

To the period of large scale whaling must be ascribed bones showing traces of man's implements. However, this is not easy to determine when the bones are old and decomposed; in my opinion, many errors in judgment happen here. Distinct sings of human handling disclose only bones of the near past. It should be remembered that still in the past century a whaling station existed at Hornsund (at Gashamna). The majority of bones of marked freshness date back to these times, especially an enormous accumulation found on the shore of this bay, on the forefield of the Gas glacier. In the 17th century, whaling was concentrated mainly in the northwestern part of Spitsbergen; the country's southern part, and Hornsund with it, was barely accessible. It was seldom visited by whalers and if at all, only after the period of the great whaling expeditions.

I consider Method C_{14} the only one by which it would be possible to determine the age of some of the bones found on the shore; as far as I know, hitherto this method has not been utilized for this purpose, although recently G. Kulling *(20)* advocated it. On the other hand, I thus far fail to consider justified K. Birkenmajer's *(4)* theory that the bones raised to terraces of 6—8 m. height are derived exclusively from the beginning of the 17th century. Upon this markedly simplified determination of the age of the whale bones are based important conclusions with regard to the rate of isostatic movements of Spitsbergen; hense the accuracy of results compiled by this method (rate of movement equalling 2.3 cm. per year) is open to doubt.

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[4] In this manner, e. g., is being explained the derivation of whale bones found on the terraces of the Soviet Arctic islands (this information I owe to the kindness of W. D. Dibner, the explorer of Franz Joseph Land).

In this computation of the youngest movements of Spitsbergen the indispensible caution seems to be lacking, as far as determination of the altitude of the former shore line is concerned. I consider it inadmissible to look upon the position of the bones as the line of the shore, and as the index of the former level of the sea. If these bones are lying within the range of storm ridges there seems to be no doubt that due to various reasons they might have undergone secondary moving. Throwing over by storm waves, pushing up by the pressure of ice sheets in the spring [5], such are the causes which might bring about the uplifting of bones by several meters above sea level. But where lighter substances are concerned, like driftwood of pumice, storm breakers might easily throw them up high above the shore line. D o n n e r and W e s t *(8)* determine the former sea level in northern Spitsbergen (Hinlopen) on the basis of occurrence of fragments of drifting pumice. This indeed is a very risky method, in view of our present-day knowledge that pumice fragments, similarly as floats of fishing nets, might be thrown far beyond the shore line, oven over and beyond storm ridges. The same aplies to driftwood; from my own observations in Hornsund it appears that even today logs of this kind of wood may be found at a height of 2 to 6 m. above mean sea level.

In the previous chapter I have pointed out how variable is the action of the sea on Spitsbergen's shores, even on short stretches of the shore of Hornsund. This is manifested by the formation of storm ridges, different both in shape and height; their amplitude in height exceeds 4 meters.

In discussing the position of bones, driftwood and pumice I mentioned the littoral marine element which contributes to uplifting these ridge components. In some instances there also should be taken into account the continental, periglacial factor which might cause a downward shifting of shore objects, i. e. solifluction. In the vicinity of the base of the Polish Expedition I established the highest position of whale bones to be at an altitude of 5.60 m. above sea level. They are deposited on a gently inclined surface of a higher storm ridge (of 10 m. height). The possible influence of solifluction should not be left out of consideration within the range of this shore surface. F e y l i n g - H a n s s e n *(9)* assumes, solifluction might have shifted the position of some ruins of oil-cookeries, built in the 17th century.

Reconstructing the shore line of Spitsbergen as it might have existed 300 years ago (at the period of the great whaling expeditions), K. B i r k e n m a j e r bases his opinion on the position of objects lying, at an average, at 4 to 8 m. above sea level. The possibility of error, caused by secondary shifting of these objects, might embrace 4 meters at least; in this manner the error amounts to 50—100% of the value of computations. To some extent, this error might be eliminated by computing a correction coefficient, — presupposing, of course, that the value of secondary shifting of objects has everywhere been constant. However, this is not the case: the elements coming here into play are subject to changes even on short stretches of the shore line in a quite indeterminable manner.

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[5] S. Zb. R o z y c k i (*25*) reports (from Van Keulen fiord) that translocations of this kind, caused by raised icesheets, may reach up to 4 m. above sea level.

Taking into account these arguments I am of the opinion that objects carried by drifts, or whale bones, should not be used for accurately establishing the recent movements of Spitsbergen, such as, e. e., the changes in shore line within the latest several hundred years. Better results might be obtained by this method of investigation only in the case of movements extending over a much longer period, such as the post-glacial. In this instance, the amplitude of movements alone amounts to several score meters, and an error caused by conceivable secondary movements would be restricted to reasonable limits. Of course, presupposition for thos estimate would have to be Method C_{14} for establishing the age of driftwood or bones deposited upon the high terraces. On the other hand, both the factual tendencies of movement of the land, and the rate of this movement could be better determined on the basis of a description of the position of such objects as are not subject to secondary moving, such as the ruins of dwellings, or tombs (e. g., the Viking burial grounds on Greenland submerged under the level of the sea).

I am coming back to the problem of the recent Spitsbergen shore line upon the Hornsund sector. The young lagoonal terrace and the contemporaneously forming storm ridge are undeniable evidence of a recent negative change of the shore line, probably brought about by the uplifting of land. However, it is my opinion that this movement was by no means as rapid as would appear from B i r k e n m a j e r's estimates, — and at present this movement might have ceased altogether. At any rate, within the recent 50 years there have not been any marked changes.

The terminal moraines, piled up by glaciers during their maximum reach at the beginning of this century, are constantly exposed to wave action. This is shown by cliffs formed within these moraines in the Burger bay and on Treskel peninsula, thus in the fiord's interior part where an increase of wave amplitude need not be taken into account.

On the fiord's southern shore, in the Gas bay, there has been built in 1899—1900 the base of a Russian Expedition for measuring its geographical degree, called Konstantynowka. The topographical position of the region of this base, according to a map (in 1:200.000 scale) made by the Russians in 1900, has been compared with the position existing in 1938 (map made by W. P i l l e w i z e r *(23)* in 1:25.000 scale), and with the situation existing in 1958. The diffirence in scale in which these topographic data were recorded, makes it impossible, to reach accurate conclusions from these comparisons. However, it seems that the differences are rather insignificant. Today this Russian base is situated at an altitude of 3.11 m. above sea level.

We now shall enquire into the problem of the recent movements of Spitsbergen on other littoral stretches, besides Hornsund. H o e l *(14)* and de G e e r *(12)* too have once voiced the opinion that, since a long period, the Spitsbergen shore line does not show any changes. V o g t *(28)* (who investigated the old 17th century whaling stations in the region of the former Smeerenburg in the northwestern part of Spitsbergen) claims distinctly a subsidence of land during the latest 300 years at least. F e y l i n g - H a n s s e n *(9)* mentions 5 whaling stations of the years 1617—1636 which today lie within the range of waves. This author suggests, the wave action combined with weathering might have led to a serious destruction and dislocation of the shore [6]. From other papers published by Feyling-Hanssen *(11)* it appears that the shore of the interior part of Isfiord (Billefiord, Dicksonfiord) shows distinct signs of a subsiding tendency (positive movement of shore line). This is indicated by shore ridges which landwards grow lower, and by the position of the ruin of an old Russian hunting station on the Wijk cape.

Altogether different are the conclusions reached by Donner and West *(8)* and by Birkenmajer *(4, 5)*. They assert that the land rises rapidly, and that the rate of uplifting for the recent 350 years might be illustrated by the following figures, computed for 100 years: Inside of the Hinlopen straights (NE Spitsbergen) — 3 meters, according to Donner and West *(8)*, Hornsund — 2.3 m., according to Birkenmajer (4), Edge island situated in the eastern part of the archipelago — 4 m. according to Birkenmajer, *(5)*, on the basis of dubitable data taken from a paper published by J. Lamont in 1860.

It seems worth investigating whether the difference of opinions on movements of Spitsbergen's shore line during the recent centuries (positive or negative movements) does not spring from the difference in methods of investigation, and from differences in the source material on which these opinions were based. The positive shifting of the shore line (the movement of land surmergence) has been established by determination of altitudes of fixed objects (ruins) and of the general morphology of the shore (storm ridges). The negative shifting of the shore line (the uplifting of land) follows from the description of mobile objects (bones, driftwood, pumice); by the way, the age of these objects is unknown too. I have pointed out here the deficiencies of this method, and I am in doubt whether the conclusions reached by this method are trustworthy.

There exist other causes too which might bring about a positive movement of the shore line and a progradation of beaches; I have in mind an eustatic change in the level of the sea. According to records kept by mareographists (Thorarinsson *(27)*, Gutenberg *(37)*) the contemporaneous eustatic uplifting on the sea level amounts to 1 mm. per year. This phenomenon is connected with the gradual rise of the Arctic's temperature which, according to Ahlmann *(2)*, persists since 200 years and which considerably increased within the recent 50 years. Thus, if Spitsbergen has been rising at the rate of 10 cm. per 100 years, this movement would, by now, have been counterbalanced by the rise of the sea level. Even in this instance, i. e. assuming an isostatic movement, there would exist an isokinetic equilibrium (Wright *(31)*), wich actually would mean stability of the position of land.

A powerful and rapid isostatic movement has once been caused by the melting of ice masses, owing to the postglacial temperature increase in

[6] In 1928 Vogt *(28)* noticed at Smeerenburg the ruins of 8 oil-cookers (a whale-oil distillery) built in 1700. In 1952, investigations made by Feyling-Hanssen *(9)* there were but 7 cookers left; of these the one nearest the shore, was exposed to wave action. Thus, within 24 years, there has taken place here a change (recession) of the shore line by several score meters, due to which one of the oil-cookers disappeared while another stands now in the line of the storms ridge.

the Arctic's climate. For Spitsbergen, Feyling-Hanssen *(10)* has very clearly explained this problem, and I believe that the very energetic emergence of islands lasted here as long as the formation of the 40 m. terrace (commencement of the postglacial climatic optimum). Beginning with this period, when the climatic clearness found its expression in an abrupt change of fauna, the isostatic movement of land became irregular, as indicated by reduced intervals between terraces. There frequently occurred short periods of isokinetic equilibrium. At the same time there increased the tendency towards storms, as shown by the appearance of storm ridges at nearly every one of the terraces. Thus, present conditions are by no means exceptional. The fading isostatic movements of land, abrupt eustatic changes, and a high degree of turbulence of littoral waters, — these are the factors which shape the Spitsbergen shore line and which, since a considerable time, affect changes (positive or negative movements) of the shore line's course.

9. Conclusions

1. On the Hornsund area, situated in the southern part of Spitsbergen, there have been discovered old preglacial levels to which correspond glacial cirques.

2. Here an entire system of postglacial, high raised cliffs and gravel beaches have been identified. The highest range of the marine gravels is 275 m. These gravel beaches and cliffs appear mainly at the following heights: 230 m., 200 m., 130 m., 100 m., 65 m., 45 m., 38—40 m., 32 m., 25 m., 7—13 m., 2—5 m.

3. In the non-glaciated area at Hornsund there are found traces of three successive glacier transgressions: one during the Pleistocene, the next a postglacial one, preceding the climatic optimum and, finally, a postglacial one succeeding the climatic optimum (the latter already during historical time). The Pleistocene glaciers covered the entire shore area; when they receded, land was submerged about 300 m. below its present level. The postglacial glacier transgression occurred at the time when the shore line extended at the position of the 40 to 60 m. terraces, whereas during the youngest transgression the shore line approximatelly equalled its present-day level.

4. Hitherto, the recent changes in Spitsbergen's shore line have not always been investigated with the appropriate accuracy. This refers to those methods in which the position of whale bones, pumice fragments and drift wood is being taken into account. The possibility of error in this kind of methods almost equals the amplitude of land movement. The conclusions put forth by Donner & West *(8)* and by Birkenmajer *(4, 5)* asserting a very rapid uplift of land during recent centuries, seem to be open to doubt.

5. The shore morphology at Hornsund discloses a great variety of shore processes dependent of local conditions. These have a decisive influence on the size of storm ridges and on the character of beaches and terraces. The youngest terrace is partly a lagoonal form, produced by the filling-in of lagoons out off by bars and storm ridges.

6. The analysis of shore forms and deposits at Hornsund leads to the conclusion that the isostatic or eustatic movement of the shore line might be considerably complicated by changes in the dynamic features of the climate. Evidence of such changes is the greater or lesser turbidity of the sea and, due to it, changes in shore processes.

7. In the last postglacial phase (7 to 13 m. terraces) there may be observed a reduction in the rate of isostatic and eustatic movements, with a simultaneously increased intensity of wave action (formation of high storm ridges). It seems probable that since the last transgression of glaciers (younger morainic ridges) the changes in the shore line's position and its change of form are principally caused by shore processes, and in a but minor degree by vertical land movements.

Translated by Karol Jurasz

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CONTENTS

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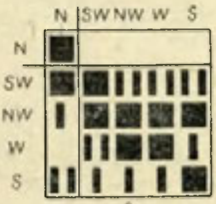
Supplement 1958

Article of L. Pernarowski.

In place of erroneously printed diagrams nos. 3-11 on pages 59, 63 and 64 the readers are requested to insert the following diagrams, printed in the right order:

page 59



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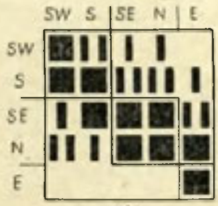

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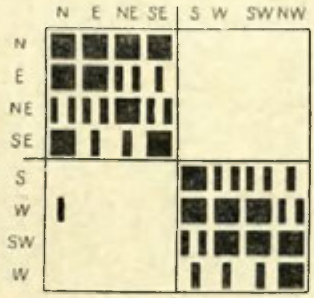
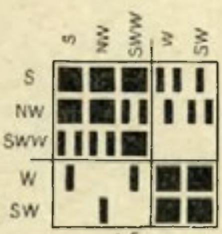


5

Fig. 3. Diagram showing similarity of dune groups for region of Leszno Górne
Fig. 4. Diagram showing similarity of dune groups for region of Sułów
Fig. 5. Diagram showing similarity of dune groups for region of Turawa

page 63



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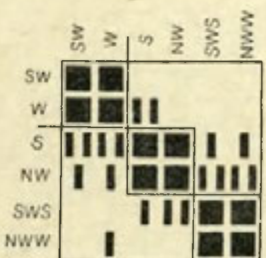
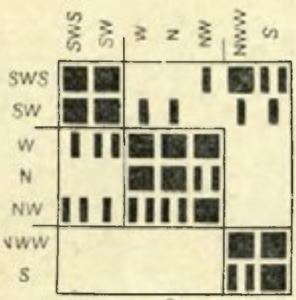


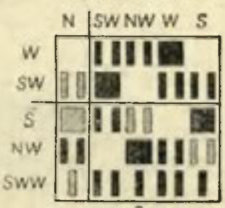
7



8

Fig. 6. Diagram showing similarity of winds for region of Leszno Górne
Fig. 7. Diagram showing similarity of winds for region of Sułów
Fig. 8. Diagram showing similarity of winds for region of Turawa

page 64



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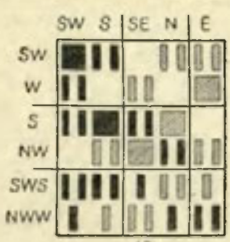

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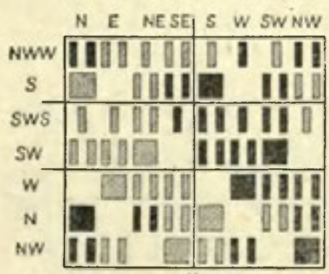

11

Fig. 9. Diagram showing influence of prevalent winds on dunes of region of Leszno Górne

Fig. 10. Diagram showing influence of prevalent winds on dunes of region of Sułów

Fig. 11. Diagram showing influence of prevalent winds on dunes of region of Turawa