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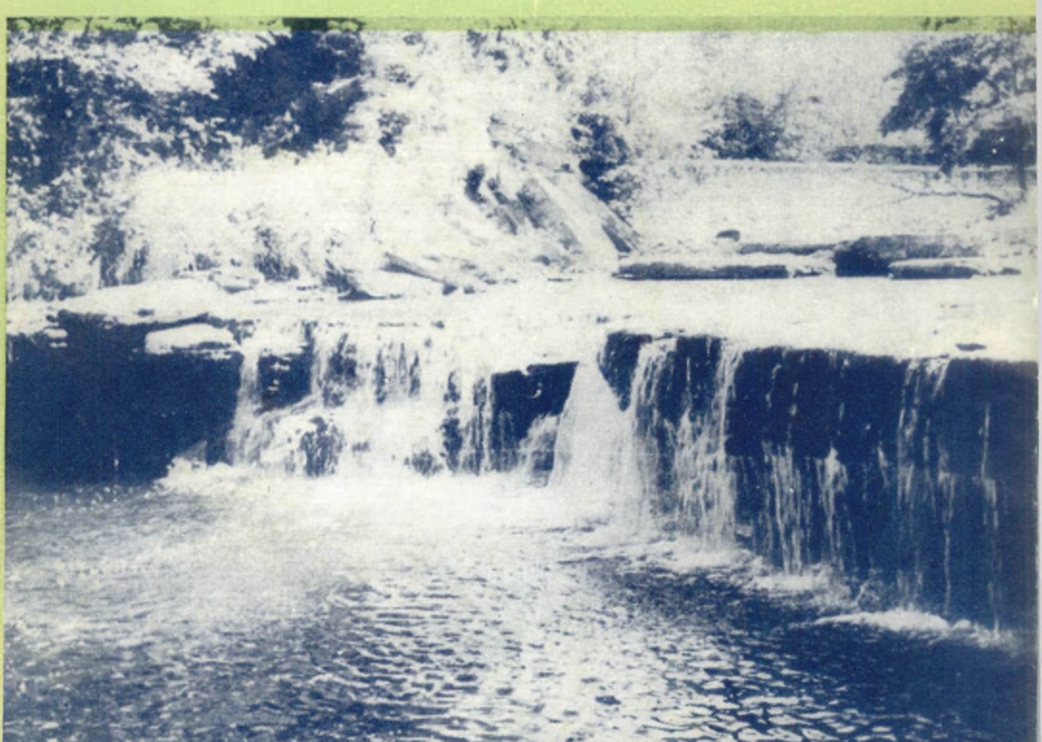
PUBLICATIONS ON GEOGRAPHY
GEOGRAAFIA-ALASEID TÖID
ТРУДЫ ПО ГЕОГРАФИИ

XIII



TARTU RIIKLIKU ÜLIKOOLI TOIMETISED
УЧЕНЫЕ ЗАПИСКИ
ТАРТУСКОГО ГОСУДАРСТВЕННОГО УНИВЕРСИТЕТА
ACTA ET COMMENTATIONES UNIVERSITATIS TARTUENSIS
ALUSTATUD 1893. a. VIHIK 393 ВЫПУСК ОСНОВАНЫ в 1893 г.

GEOGRAAFIA-ALASEID TÕID

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XIII

ТАРТУ 1976

TRANSACTIONS OF THE TARTU STATE UNIVERSITY
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ON THE OCCASION OF THE XXIII INTERNATIONAL GEOGRAPHICAL CONGRESS

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Editorial board:

L.-P. Kullus (editor), O. Kurs (editor), S. Nõmmik, E. Varep and L. Vassilyev.

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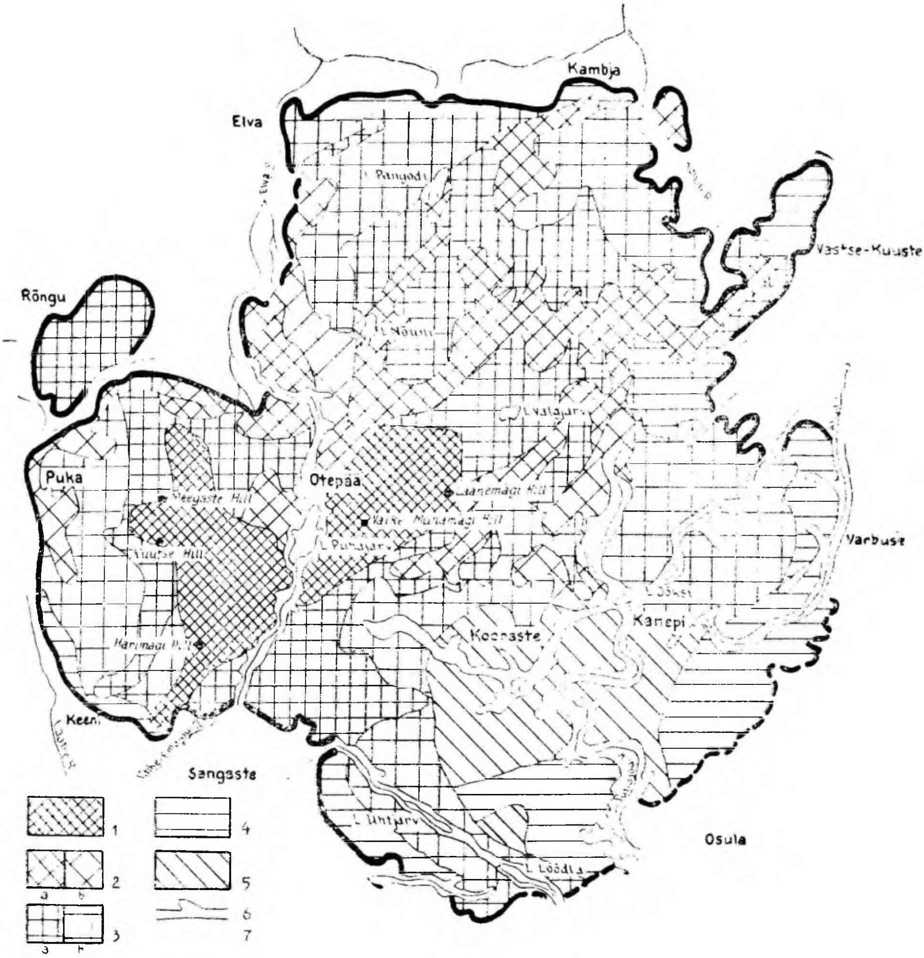
SURFACE RELIEF AND GEOLOGICAL STRUCTURE AS CAUSES OF THE LANDSCAPE PECULIARITIES OF THE OTEPÄÄ UPLAND

E. Hang

The Otepää Upland is situated in the south-eastern part of the Estonian S.S.R., between lakes Peipsi and Võrtsjärv. In the central part of the upland lies the town of Otepää. Near its boundaries the following settlements are to be found: Elva and Kambja in the north, Vastse-Kuuste and Varbuse in the east, Osula and Sangaste in the south, and Puka and Rõngu in the west. The total area of the upland is approximately 1.200 sq. km, its longest range from both north to south and east to west being 40 km.

The Otepää Upland is one of the main forms of the surface relief of the Estonian S.S.R. Already K. Rathlef regarded it as a separate orographic unit, which he called Otepää Plateau in his survey of the hypsometry and hydrography of Livonia, Estonia and Courland published in 1852. Besides the greater height of the upland in comparison with the areas surrounding it he also pointed out its varied hilly relief as one of its characteristic features. The investigations carried out since last century have contributed a wealth of material that has helped us to form a more accurate picture of the peculiarities of the geological structure and morphology of the landforms of the upland as well as of other distinctive features and differences in its nature. As a result the Otepää Upland has come to be regarded as a separate unit on many maps representing the nature of Estonia (e.g. the landforms, climate, soils, mires etc.).

J. G. Granö (1922) and A. Tammekann (1931) distinguished the Otepää Upland as one of the Estonian landscape units. In view of the whole complex of its natural conditions it is also regarded as such on the most recent schematic maps of the physico-geographical (landscape) regions of the Estonian S.S.R., which are based on the results of more detailed investigations (Варен, 1961; Varep, 1964, 1968; Kildema, 1966). In those treatments the boundaries of the Otepää Upland as a landscape region



F i g. 1. Landforms of the Otepää Upland.

1 — large moraine hills and kames with complicated structure, 2 — fluvioglacial and limnoglacial kames of medium (a) and small size (b), 3 — moraine hills and till-covered kames of medium (a) and small size (b), 4 — moraine plains and limnoglacial abrasion plains, 5 — outwash and limnoglacial accumulation plains, 6 — primeval valleys, 7 — the highest points in the upland.

do not exactly coincide with those that mark it as an orographic unit. That is due to the fact that in determining the boundaries of the landscape region the main consideration has been the hilly relief characteristic of the central part of the upland, whereas its marginal areas, which have a more even surface relief, especially in the south-east, have been regarded as forming part of the plain areas (the South-East Estonian Plateau), which lie outside the boundaries marking the upland as an orographic unit. The present article will give a short physico-geographical survey of the Otepää Upland within its orographic boundaries.

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The Otepää Upland is a typical insular height with a hilly moraine relief which is surrounded by lower and more even areas. As is well known, such elevations are fairly numerous in the north-western part of the East-European Plain. Their most remarkable representative on the territory of the Estonian S.S.R. is the Haanja Upland, the highest part of the republic, which rises to a height of 317.6 metres above sea-level. The highest points of the Otepää Upland reach a little over 200 metres above sea-level.

In the north, east and south-east the Otepää Upland borders on the South-East Estonian Plateau, which lies 40—100 metres above sea-level. In the west it is contiguous to the depression of Lake Võrtsjärv. In those marginal areas moraine, outwash, limnoglacial accumulative and abrasional plains prevail. It is only in the south-west that the Otepää Upland borders on a similar more elevated area — the Karula Upland — which, however, is considerably smaller and lower in comparison.

The boundaries of the Otepää Upland are comparatively easy to distinguish along its foot at a height of 90—100 metres above sea-level. Only in the south-east is the borderline more difficult to determine for here the upland has no clear-cut foot. In several places the boundaries of the upland are marked by valleys running along or parallel to it in its immediate vicinity. Such are the Laatre, Rõngu and Elva valleys in the west, the Aarike-Tõravere valley in the north, and the Reola (Konsu) valley and partly also the Ahja valley in the east.

In broad outline the Otepää Upland can be divided into two more elevated parts — the western and the eastern one. These are separated by a lower area round Lake Pühajärv trending from north to south. This area lies at a height of 120—130 metres above sea-level, the water level of Lake Pühajärv reaching 115 metres above sea-level.

The western part of the upland is smaller in area, more compact in configuration, and in general higher than the eastern part. The western part has a more elevated axis running from north-west to south-east. Within its boundaries there are several large round and elongated hills attaining a height of over 200 metres above sea-level. Among these mention should be made of Kuutse Hill (217 metres), the highest point of the Otepää Upland, the hills of Kõrgemägi (214 metres), Tsiatrahvimägi (213 metres), Karjamägi (207 metres) and some others lying farther to the north, and Harimägi Hill (212 metres) in the south. In the vicinity of Kuutse Hill and north of it the landforms have a noticeable trend from north-west to south-east and from north to south. In the vicinity of Harimägi Hill the hills converge to form a belt running from north-east to south-west. In the north-east (south of Lake Pühajärv) it forms a link between the two higher parts of the upland, and in the south-west (in the direction of Sangaste) it continues even outside the boundaries of the upland.

Much more complicated is the orography of the eastern part of the upland, which is more extensive in area but generally has a less varied surface relief. Lower areas resembling the depression of Lake Pühajärv and numerous primeval valleys divide this part of the upland into several separate hilly areas and plateaus with an undulating or hilly moraine relief. Here, too, the highest is the central part, where, just as in the western part of the upland, round and elongated hills rise higher than 200 metres. The most remarkable of these are Laanemägi Hill (211 metres), Tõikamägi Hill (210 metres), Väike Munamägi Hill (207.5 metres), and several landforms in the vicinity of Lake Valgjärv. The larger hills in this area run from north-east to south-west or from north-west to south-east. The trend from north-east to south-west is especially clearly noticeable in the belt of landforms between Lake Valgjärv and Väike Munamägi Hill. This belt continues south-west of Väike Munamägi Hill, where it joins the above-mentioned belt of landforms running in the same direction in the vicinity of Harimägi Hill.

In the south-eastern part of the upland, which generally has a more even relief, primeval valleys of 30—40 metres in depth, such as the valleys of Kooraste (Truuta), Sirvaste, Jõksi-Piigandi, Erastvere-Ahja, Urvaste and that of the River Pühajõgi, constitute a remarkable feature. They are also rich in lakes.

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The Otepää Upland is an outcrop area of Devonian sandstones. In the northern and central parts of the upland outcrops of the Aruküla and Burtniek stages of Middle Devonian sandstones are revealed respectively, while in the extreme southern part of the area the sandstones of the Gauja stage of Upper Devon appear. The Aruküla stage mainly consists of red, the Burtniek and Gauja stages of light-coloured (white, pinkish, yellowish and bright red) obliquely laminated sandstones. Outcrops of the bedrock occur only in the outlying parts of the upland, mainly in the deeper valleys. In the central part of the upland it is everywhere hidden under a thick cover of Quaternary deposits.

Eearlier there were few direct data on the height of the upper surface and the nature of the surface relief of the Devonian sandstones. On the analogy of the Otepää Upland to other uplands in the Estonian S.S.R. and the hilly moraine uplands in the neighbouring areas it was merely supposed that the surface of Devonian sandstones might reach higher here than in the surrounding areas. Recent geological research (Каяк, 1963, 1965) has proved that this supposition is valid first and foremost for the eastern part of the upland, where the absolute height of the surface of the sandstones is 90—115 metres, which is 20—50 metres more than in the area lying east of it. In the western part of the upland the upper surface of the bedrock reaches 50—70 metres above sea-level, i.e. approximately the same height as it attains in the area bordering on the upland in the west. At the same time it has been found out that the surface relief of the sandstones under the upland is cut by deep valleys, the bottom of several of which reaches below sea-level. These constitute a complicated maze of buried valleys filled with Quaternary deposits. The direction and depth of all of these valleys have not been investigated in detail yet. Some of these valleys are directly reflected in the present-day relief in the form of river valleys, whereas others are perceptible as rows of separate depressions.

Special mention should be made of the Tartu—Otepää—Valga buried valley, the bottom of which lies up to 60 metres below sea-level. This valley is noticeable in the present-day relief of the Otepää Upland as the lower area round Lake Pühajärv. North of the latter it is observable as a succession of depressions (those of lakes Nõuni and Pangodi), and outside the boundaries of the upland it continues in the form of the Aardla primeval valley almost up to the outskirts of the town of Tartu. In the south it runs along the upper reaches of the valley of the Väike-Emajõgi River and the valley of the Pedeli River in the direction of the town of Valga (Каяк, 1965; Каяк, Лийвранд, 1967).

The total thickness of the Quaternary deposits covering the Devonian sandstones is 50—200 metres in the buried valleys and the more elevated parts of the Otepää Upland. Thus the existence of the Otepää Upland is not so much due to the greater height of the surface of the Devonian sandstones in comparison with the surrounding areas as to the great thickness of the Quaternary deposits. This thick cover is mostly made up of Pleistocene deposits, i.e. tills and various sands and gravels accumulated by the meltwaters of the Continental Ice. Among the Holocene deposits the thickest are the lacustrine and paludal deposits in the depressions between the hills (their total thickness reaching 7—8 metres, in some cases up to 15 metres).

The results of recent research have confirmed an earlier conjecture, which has partly also been proved by a find of interglacial deposits at Rõngu (Orviku, 1939), claiming that the Pleistocene deposits forming the Otepää Upland date back not only to the latest glaciation, but also to the preceding glaciations and the interglacials between them. According to K. Kajak (Каяк, 1965) four horizons of tills and meltwater sediments can be distinguished among the Pleistocene deposits. In several localities both in the upland and in its immediate vicinity boring data have proved the existence of fluvioglacial and limnoglacial deposits between the tills as well as the occurrence of lacustrine and paludal deposits with pollen and spores of plants. This has made it possible to carry out a palynological investigation with a view to determining the stratigraphic age of the tills, though no final conclusions have been drawn as yet. The upper horizon (the reddish brown, more rarely the grey till) corresponds to the Valday glaciation, the next (the grey till rich in carbonate boulders) to the Moscow glaciation, the third one (the brown till rich in crystalline boulders) to the Dniepr glaciation. The thickness of these till horizons ranges from a few metres to 20—40 or even more metres. The fourth and lowest till horizon consisting of grey, more rarely brown, till with a greenish shade rich in carbonate boulders occurs especially in buried valleys and presumably dates back to the Lower Pleistocene (Каяк, Лийвранд, 1967).

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Today's landforms of the Otepää Upland have chiefly been shaped by the latest Continental Ice Sheet and its meltwaters (Fig. 1). During the Post-Glacial period the positive landforms have been denudated to a certain extent, the depressions between them have been filled with lacustrine and paludal deposits and some smaller erosional forms have also appeared. The whole complex of landforms here, which bears the generalised name of hilly moraine relief, is characterised by a great heterogeneity as regards the morphology, geological structure and genesis of its landforms, and the distribution of their different types (Hang, Lepasepp, 1961; Каяк, 1963; Raukas, 1972).

The positive landforms of a hilly relief are usually divided into small, middle-sized and large forms, the relative height of which is respectively up to 10 metres, 10—25 metres and 25 and more metres. Among the landforms of all three size groups there are forms with oval, elongated and irregular bases. Very often the separate landforms are linked side to side or end to end to make up morphologically very complicated compound forms. It is quite usual for several small forms to rise from one common base. The incline of the slopes of the positive landforms differs very widely. Between the positive landforms there are depressions of different size and shape, constituting an element that is just as characteristic of the relief type in question as the positive landforms themselves. It must be admitted that so far no systematic study has been made of the specific morphological peculiarities of landforms of different geological structure and genesis. Little attention has been paid to the investigation of depressions.

As far as the geological composition of the landforms is concerned moraine hills (i.e. elevations wholly consisting of till) occur sporadically in all parts of the upland, but their role is not dominating. Mostly they belong to the group of small or middle-sized landforms, have irregular contours and gentle slopes. In the lower outlying parts of the upland, where they are more frequent and occur together with moraine-covered kames they constitute a hilly undulating relief in which it is often rather difficult to distinguish the separate landforms. The dominating landforms in the Otepää Upland are kames of different types. The most numerous are kames consisting of various sands and gravels of fluvioglacial origin (fluvioglacial kames), less frequent are kames consisting of limnoglacial deposits of sandy loam (limnoglacial kames). Often both types of kames are covered either wholly or partly with a thin layer of till, probably ablation moraine. In the higher central part of the upland middle-sized or large round and elongated hills frequently occur. They have a complicated structure and should also be regarded as belonging to kame-type landforms. Among them there are hills the lower part of which consists of till whereas the upper part is made up of either fluvioglacial or limnoglacial deposits, or even both of them. There are also numerous landforms the basic part of which consists of fluvioglacial and the upper part of limnoglacial deposits. The characteristic morphological peculiarities of those landforms whose upper part consists of limnoglacial deposits are an even surface and steep slopes. The covering limnoglacial deposits include both varved and unlaminated clays. The layer of clay is not thick, 2—3 metres on an average. It should be added that round and elongated hills covered with similar limnoglacial clays can be found among landforms of various size and at different absolute heights also in other parts of the Otepää Upland (Saarse, 1969).

In the northern and north-western parts, i.e. in the proximal parts, of the Otepää Upland, among others we can find landforms, which evidently have been formed under the pressure of the Inland Ice. Besides deposits of the latest glaciation, the components of such landforms often include older tills and fluvioglacial and limnoglacial deposits. Morphologically more clear-cut marginal forms are to be found in the vicinity of Kambja, Luke and Tamsa on the northern edge of the upland.

The south-eastern (distal) part of the upland is regarded as an outwash and limnoglacial abrasion and accumulation plain, which is intersected by primeval valleys of glacial meltwaters. This part of the upland stands in need of a more detailed geomorphological investigation than has been carried out so far.

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In comparison with the surrounding areas the climate of the Otepää Upland has certain specific features. These result from the greater absolute height of the upland, which exceeds that of the neighbouring areas by 100—150 metres, from the hilly relief of the area under discussion and from the highly varied nature of its surface structure (Raik, 1967).

According to P. Karing (1974) the total radiation in the Otepää Upland, both in summer time and throughout the year, is somewhat smaller than it is in the neighbouring plains. The greater height and variable surface relief favour the performance of convection currents in this area. This causes greater cloudiness above the upland, which reduces the influx of radiation. Together with greater cloudiness there is more precipitation (the average annual rainfall exceeding 650 mm) as well as a greater number of rainy days (the annual average being 270 rainy days). The Otepää Upland is one of those regions in Estonia that receive the greatest rate of rainfall. Showers are more frequent here than in the surrounding plains.

Air temperature is somewhat lower in the upland than in the neighbouring lower-lying areas. The joint effect of this circumstance and the greater rate of precipitation is especially evident in winter. In the upland thaws are less frequent and much slighter, the snow cover is deeper and lasts longer. The average depth of the snow cover is 40 cm, and the average period with persistent snow cover lasts for 110 days (from Dec. 10 to March 31). In some years on the wooded slopes with a northern exposure the snow will not melt till the beginning of May. The total of the active temperatures (the average diurnal temperatures rising above 10° C) in the upland ranges between 1780° and 1850° C, being nearly 100° C smaller than the respective total for the surrounding areas. The period of active plant growth (125—130 days) is 5 days shorter than it is in the plains (Eesti NSV agroklimaatiline teatmik, 1962).

The upland is characterised by a great variety of microclimatic conditions. Very few direct microclimatic investigations have been carried out in the upland so far. The observations that have been made have shown that in summer time on hills of medium size the soil temperature is on an average 2—3° C higher on the southern slopes than it is on the northern ones. During the period of night frosts the difference between the temperatures at the bottom of closed depressions and the tops of hills may be as great as 8 degrees. In closed depressions night frosts may occur as late as June and even July. In the hilly landscape the distribution of the snow cover is uneven. The microclimatic peculiarities of the upland are well reflected by many phenomena in the seasonal development of the nature. In the same way these peculiarities appreciably affect the course of land cultivation work (e.g. by the difference in the dates by which separate fields are ready for tilling and harvesting).

The microclimatic peculiarities differ in separate parts of the upland, mainly depending on the local characteristic features of the surface relief. These peculiarities are the most striking and the microclimatic conditions are the most varied in the distribution area of big hills.

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Owing to its general orographic features (the existence of several more elevated areas), its hilly surface relief and the occurrence of primeval valleys, the Otepää Upland is divided into a great number of small drainage areas. The brooks and little streams that draw their water from the upland mostly join to form rivers only outside its boundaries. The rivers that take their origin in the upland in this way are the Väike-Emajõgi, Elva, Ahja and Pühajõgi. The most important watershed area is the group of high hills in the western part of the upland and a belt of similar landforms between Väike Munamägi Hill and Lake Valgjärv in its eastern part. Owing to the peculiarities of the climate and surface relief the runoff has a somewhat higher average in the upland than it has in the surrounding areas. However, since the runoff is divided between numerous brooks and streams, their discharge within the limits of the upland is small. In spite of the fact that the numerous lakes have a certain regulating effect on the regime of the streams and brooks, there still is a considerable fluctuation in the runoff during the different seasons. It attains its maximum in spring when the snow is melting.

A great part of the rivers in the upland take their origin in the lakes and mires situated in the depressions between the hills. They wind their course through these depressions and primeval valleys towards the outlying areas. In the peatlands their beds are narrow, low and winding, but they have often been straightened and converted into ditches. Only in places where the river has broken through a saddle linking two neighbouring hills, have there been formed short stretches of V-shaped or U-shaped valleys. Within these the streams have a remarkable fall and swift current. The same is the case in places where brooks and streams fall into primeval valleys or onto the plains surrounding the upland. Another part of the rivers take their origin in the lakes situated in large primeval valleys. These are like relics of the powerful streams of glacial meltwaters that used to flow through these valleys at the end of the latest glaciation. In the outlying parts of the upland outcrops of Devonian sandstones are revealed on the banks of some rivers (e.g. those of the Ahja and Pühajõgi rivers). There are also terraces in many primeval valleys, which testify to their gradual deepening during the Late-Glacial period as the water level of the large periglacial lakes, which covered the less elevated areas surrounding the upland and constituted the erosion basis for rivers, gradually became lower (Hang, Liblik, Linkrus, 1964).

Thus the present brooks and streams in the Otepää Upland have adapted themselves, on the one hand, to the glacial surface relief without transforming it to any appreciable extent, and, on the other hand, to the primeval valleys, the morphology of which they have also changed but slightly.

In comparison with the brooks and streams the lakes have a much more important role in the landscape of the Otepää Upland (Varep, 1962). This is one of the regions richest in lakes in the Estonian S.S.R. Their number is as many as 130, there being an average of one lake per every 9 sq. km. As the total surface area of the lakes amounts only to 14.3 sq. km, it is clear that small lakes are predominant here (Eesti järvede nimestik, 1964). The great number of lakes can be explained by the humid climate and the abundance of depressions in the young glacial relief, which has hardly been changed by water erosion. The original number of lakes was much larger. This is proved by the fact that most of the mires in the depressions between the moraine hills and kames have resulted from the overgrowing of former lakes.

On the basis of the morphology of the lakes as well as the genesis of their beds we can distinguish three types of lakes in the Otepää Upland: those lying between the moraine hills and kames; those situated in primeval valleys; and an intermediate type of lakes which are connected with buried valleys of the Otepää Upland.

The lakes situated between moraine hills and kames may be either round or oval in shape and commonly have a simple bottom relief. Some of them have a well-indented shoreline, rich in peninsulas, inlets and islets, and a varied bottom relief (such as Lake Valgjärv, which has a surface area of 64.4 hectares and a maximum depth of 5.5 metres). Most of these lakes are small and not very deep, although some of them stand out for their great depth in comparison with their small surface area (e.g. Lake Tornijärv in the western part of the upland, with an area of 13.3 hectares and a depth of 15.2 metres). Such lakes often form groups (e.g. the Päidla group of lakes in the north-western part of the upland).

An important part in the formation of the depressions of these lakes has been played by dead ice.

The lakes situated in primeval valleys are long and narrow in shape, have high shores and attain a great depth. The greatest depth of Lake Uhtjärv (with a surface area of 43.5 hectares) in the Urvaste Valley is 26.5 metres (the fifth deepest lake in the Estonian S.S.R.), the depth of Lake Piigandi (43.4 hectares) and Lake Jõksi (64.9 hectares), both situated in the Jõksi—Piigandi valley, is 25.3 and 23.9 metres respectively. In the Kooraste valley there is a chain of eleven small lakes, of which Lake Uiakatsi (17.3 hectares) has a depth of 18.6 metres.

The largest lakes in the Upland are Lake Pühajärv (285.9 hectares), Lake Pangodi (115 hectares), and Lake Nõuni (78.8 hectares). Lying over the buried valley of Otepää, they are oblong in shape like the valley lakes, but shallower (8.5, 11.1 and 14.7 metres respectively) and have a well-indented shoreline like the lakes in hilly localities. Lake Pühajärv has the most indented shoreline of all the lakes of the Estonian S.S.R. Varved clays and terraces are to be found on the shores of these lakes. This is proof of their complicated development in the Late-Glacial period and in the Holocene.

It is worth mentioning that in those lakes that are enclosed between hills or lie in deep valleys, where they are sheltered from the winds, clearly-marked vertical stratification of the temperatures is observable all through the summer. While on the surface of the water the temperature reaches up to 22° C, at a depth of 8—10 metres it is barely 7—8° C. In some lakes such differences in the water temperatures are also caused by the existence of springs.

From the hydrobiological point of view most lakes in the upland are eutrophic lakes rich in nutrients, which are characterised by copious flora and fauna (Mäemets, 1965, 1974).

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The rugged surface relief and the variety of the Quaternary deposits constituting the parent rock of the soils, are the main factors that directly or indirectly together with man's land cultivating activities, have influenced the development of a highly mosaic complex of soils in the greater part of the Otepää Upland. The soil cover is made up of a great number of soil varieties with different genesis, composition, and structure, which are distributed as elementary areas of highly complicated configuration.

On the schematic soil map of the Estonian S.S.R. the principal part of the Otepää Upland is included in the region of eroded soils covering the uplands of South-East Estonia (Lillema, 1963). Owing to the hilly relief soil erosion is wide spread; as a result eroded soils predominate in the upland. In this hilly area within the limits of one relief form, and consequently within the limits of one unit of cultivable land, we can find a great many varieties of soils, which widely differ (or even contrast) in their qualities. Large-scale soil maps show that different varieties of more or less eroded soils are common on the elevations of the hilly area, whereas a complex of deluvial soils and mires is spread on the negative elements of the relief.[1] Soils untouched by erosion are more wide spread in the south-eastern part of the upland, which has a more even surface relief and which (as was mentioned earlier on in this article) is usually not regarded as a part of the Otepää Upland, but is included in the South-East Estonian Plateau (which constitutes the district of South-Estonian pseudopodzolic soils).

On approximately 80 per cent of the surface area of the Otepää Upland, i.e. the part that is in the possession of the state and collective farms, large-scale soil maps were compiled by the State Designing Institute "Estonian Agricultural Project" ("Eesti Põllumajandusprojekt") in 1956—1967. The remaining 20 per cent of the territory is in the possession of other owners (mostly belonging to the state-owned forest fund) and so far its soils have not been thoroughly investigated yet. Calculations based on the general and detailed soil maps of the agricultural enterprises in the region under discussion[1] show that the most wide-spread soil types here are the closely connected eroded and deluvial soils, pseudopodzolic soils and mires. These soils account for 43% (eroded soils making up over 31%, and deluvial soils over 11%), 22% and 17% respectively, thus all in all for over 80% of the mapped area. Figures very close to these — 45 (33 and 12), 21 and 17 per cent respectively — are also given in the most recent data about the soils of the Estonian S.S.R. (Kokk, Rooma, 1974, Table 2). In the group of mineral soils in the Otepää Upland loamy sand prevails (covering 49% of the mapped area), less wide spread are sandy loam (17%) and sand (16%), and very scarce are loam and clay (1%).

For the sake of comparison it should be pointed out that in the neighbouring plains the dominant varieties are pseudopodzolic soils (covering 35—45% of the mapped area) and also gley-podzols (10—20%). An appreciable percentage here is made up of different varieties of gley soils (10—12%), which are very scarce in the upland. The area of mires is nearly the same (14—15%) as it is in the upland, whereas eroded and deluvial soils account for only 3—4%.

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[1] See also the article "Soil map of the Estonian S.S.R." by L. Reintam and I. Rooma in the present collection.

[1] E. Mäeks. The composition of the soil cover of the Otepää Upland and its local peculiarities. Diploma thesis. Tartu 1967. 33 p. The manuscript (in Estonian) is preserved at the Chair of Physical Geography of Tartu State University.

Among the eroded soils in the Otepää Upland the most wide spread are eroded pseudopodzolic soils (covering 67% of the area of eroded soils). According to the degree of erodedness, weakly (44%) and moderately (41%) eroded soils prevail, which are mostly found on slopes with a gradient of 3—5° and 5—10° respectively. The fertility of eroded soils is very low. The average yields of crops from weakly eroded soils are about three quarters, from moderately eroded soils from three quarters to a half, and from strongly eroded soils from a half to one quarter of those gathered from fields with the same variety of uneroded soil (Kask, 1964). Eroded soils often prove nonresistant to drought.

Among deluvial soils moderately moist and moist varieties prevail (covering nearly 90% of the area under deluvial soils). In the group of pseudopodzolic soils and podzols weakly and moderately podzolized varieties cover 95%, and among mires lowland swamps account for 90% of the distribution area respectively. The mires of the hilly area are not easily drainable owing to their scattered nature and the fact that they are fed by groundwaters. Their amelioration is often accompanied by the sinking of the water level in the lakes, which in its turn has undesirable results (the overgrowing of lakes etc.).

The soil cover is not uniform throughout the territory of the upland. The changes in it are a clear reflection of the geomorphological differences of its various parts. R. Kokk and I. Rooma (1974) divide the Otepää Upland into three agricultural microdistricts of soils. In the Otepää microdistrict, which embraces the largest and geomorphologically most remarkable part of the upland, the proportion of eroded and deluvial soils amounts on an average to 63 per cent, that of mires to 22 per cent, and that of pseudopodzolic soils and podzols only to 7 per cent of its mapped area. There are localities here where there are practically no mineral soils unaffected by erosion. In this microdistrict the proportion of strongly eroded soils is also larger than it is elsewhere. In the Kambja—Keeni microdistrict (the northern and western marginal areas of the upland), and especially in the Kanepi microdistrict (the south-eastern and southern parts of the upland), the proportion of eroded and deluvial soils is, owing to the more even surface relief, considerably smaller, accounting for 44 and 29 per cent of the mapped area respectively. The proportion of mires is also smaller here (17 and 13 per cent), for the number of depressions enclosed between the hills is smaller in the outlying parts of the upland and they are smaller in area, whereas the network of valleys favouring drainage is more developed than in the central part of the upland. On the other hand, the percentage of pseudopodzolic soils is higher (25% and 30% respectively). A local difference between the Kambja—Keeni and Kanepi microdistricts, which also reflects the differences between the geomorphology of the proximal and distal parts of the upland, lies in the presence of carbonate soils in the former and the remarkable proportion of podzol-gley soils (over 17%) in the latter. In comparison with other microdistricts the Kanepi microdistrict is remarkable for the greater percentage of soils of lighter composition (sand and loamy sand). It should be pointed out that in the south-east the boundaries of the Otepää Upland, as they have been treated in this paper, reach somewhat farther beyond those of the Kanepi microdistrict, including also some areas with a prevalently even surface relief. In these parts of the upland the specific features characterising the soils of the Kanepi microdistrict are even more noticeable (the higher proportion of pseudopodzolic soils, etc.).

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Before the beginning of extensive human activity that brought about changes in the natural environment, the Otepää Upland, except the lakes and mires, had been covered with forests. It was only in the first centuries of our era that the central part of the upland was settled, the population gradually moving in from its marginal areas and the surrounding lower districts, which were already inhabited by that time (Eesti NSV ajalugu, 1955). In all probability most of the old villages in the upland that have been preserved up to the present day had been founded by at least the beginning of the 13th century (Varep, 1966). During the following centuries the network of settlements grew ever thicker.

Here, too, as in other parts of Estonia, the forests had undergone a long and complicated development during the Post-glacial period. Palynological investigation has shown that at the time when the first settlements were founded in the upland area it was chiefly covered with various spruce or spruce and pine forests. Besides those there were forests of small-leaved trees, in which the birch dominated (Laasimer, 1965; Valk, 1974). The expansion of settlements and the development of land cultivation and cattle-raising resulted in a decrease in the area remaining under forest. Spruce forests, especially those on fertile soils, suffered the greatest decline. The slash-and-burn agriculture prevailing in land cultivation during the early centuries of settlement caused frequent forest fires and thus contributed to the replacement of spruce forests by pine woods and mixed spruce and pine forests. Later on, after transition to the permanent fields new arable land was mostly gained by clearing spruce forests, which were preferred because of their more fertile, clayey soils. If cultivation of such fields was discontinued they were soon overgrown with shrubs and were subsequently covered with secondary deciduous forests of birch, aspen and alder.

At the present time 28 per cent of the area of the upland is under forest, which is a few per cent less than the average for the Estonian S.S.R. Meagre spruce forests and spruce and pine forests are prevailing here, accounting for up to 66 per cent of the whole forested area in most parts of the upland. The relatively high rate of such forests is a feature that makes the Otepää Upland stand out among all the other regions in the Estonian S.S.R. (Laasimer, 1965). Spruce forests rich in species are very few. In the central part of the upland they make up 10—15 per cent, and in the south-eastern and southern marginal areas only 3—5 per cent of all the forests growing there. Pine forests are most wide spread in the south-eastern part of the upland. By the present time all the above-mentioned forests have been strongly affected by human activity. Secondary woods of birch, aspen and alder are also comparatively frequent here.

Besides the paleogeographic and historical factors an important role in determining the distribution of the forests, fields and settlements in the Otepää Upland has been played by the surface relief. The area taken up by forests, fields and meadows varies in accordance with the character of the landforms in different parts of the upland. Owing to the hilly surface relief and the mosaic pattern of the soils in most places the fields are scattered about on the gentler slopes and flat tops of the round and elongated hills, where soil erosion is less pronounced. On round tops and steep slopes the forests, too are scattered about and grow in small groves. In the area of the large round and elongated hills of the central part of the upland, where the number of relief elements liable to erosion is bigger, more land has been left under forests, which account for up to 40 per cent of the area here. The case is almost the same in the area of fluvioglacial kames, which are not covered with till and have a sandy soil of poor fertility. The outwash plains in the south-eastern part of the upland are conspicuous for their high percentage of forested areas (reaching up to 50 per cent). At the same time the forests there are also more extensive. On the other hand, in the area of medium-sized and small moraine hills and kames covered with till, especially in the outlying parts of the upland, where the surface constitutes a hilly undulating plain, only about 20 per cent of the territory is under forest. In places there are large expanses of cultivated fields here.

Nowadays a start has been made with planting under forest lands that have been owergrown with shrubs. In the same way forests are planted instead of former small infertile plots of fields on steep slopes where there is a danger of erosion and where it is difficult and unprofitable to use modern agricultural machinery.

Besides forests there are various types of meadows and bushland. Large areas were overgrown with shrubs during World War II and the years immediately following it, when it was not possible to continue regular cultivation of all the fields that had been under crops in the preceding years. In general in the upland meadows are less common than they are in most other regions of the Estonian S.S.R. They are represented mainly by marshes and swamps, which lie in depressions and river valleys and are difficult to drain. Dry meadows are scattered all over the area. They are not numerous, since drier localities that did not have to be left under forest for fear of erosion have mostly been brought into cultivation.

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The prevailing type of settlement in the Otepää Upland is farming villages, the distribution of which primarily depends on the existence of suitable arable lands. In hilly landscape the fields and settlements are scattered among the hills, the most widespread type of settlement being the dispersed village. Most of the villages are small. A common feature is the occurence of single farmsteads and groups consisting of 2—5 farms. Only in marginal areas of the upland where the fields are larger some more compact villages constituting clusters of irregularly situated farms can be found.

The network of settlements is also undergoing great changes at the present time to make it meet the requirements of our socialist economy. Great progress has been made in building up central settlements for collective and state farms, as a result of which the present dispersion of settlements will gradually disappear. As the upland abounds in localities suitable for recreation centres, numerous holiday resorts, sports bases, etc. have been founded and are being built up here.

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OTEPÄÄ KÕRGUSTIKU RELJEEF JA GEOLOOGILINE EHITUS TEMA MAASTIKULISE ERIPÄRA PÕHJUSTAJANA

E. Hang

Resümee

Oetpää kõrgustik on tüüpiline künkliku reljeefiga saarkõrgustik. 217 meetrini küündiva absoluutse kõrguse juures ulatub ta 100 kuni paiguti 150 m võrra kõrgemale ümbritsevatest tasase pinnamoega aladest. Kõrgustiku olemasolu on seotud keskdevoni liivakivide pealispinna mõnevõrra suurema absoluutse kõrgusega (idaosas kuni 115 m) kui ümbritsevatel aladel, põhiliselt aga neid katvate pleistotseeni setete suure paksusega (mattunud orgudes kohati kuni 200 m). Viimaste seas eristub neli moreeni ja moreeniga seotud jääsulamisveesetete horisonti. Nendest kõige vanemat on loetud pärinevaks alampleistotseenist, nooremaid vastavalt dnepri, moskva ja valdai jääajast. Kõrgustiku mitmesuguse kuju ja suurusega positiivsete pinnavormide hulgas on esindatud moreenkõrgendikud, fluvio- ja limnoglatsiaalsed mõhnad (nende seas sellised, milledel esineb õhuke moreenist kate) ning keeruka ehitusega mõhna-tüüpi vormid, millede alus koosneb moreenist, ülaosa aga kas fluvioglatsiaalsetest või limnoglatsiaalsetest või koguni mõlemat nimetatud tüüpi setetest. Kõrgustiku proksimaalses osas leidub mandrijää surve läbi kuhjatud ja segi paisatud setetest koosnevaid pinnavorme. Tema distaalset osa käsitletakse sandur- ning jääpaisjärve akumulatsiooni- ja abrasioonitasandikuna, mida liigestavad jääsulamisvee äravooluorud.

Suurema kõrguse, rahutu reljeefi ja vaheldusrikka aluspinna mõjul on Otepää kõrgustikul pilvisus, sademete hulk ja sajupäevade arv suurem, summaarne päikesekiirgus suvel ja aasta lõikes pisut väiksem, õhutemperatuur mõnevõrra madalam, lumikate sügavam ja püsivam, aktiivsete temperatuuride summa väiksem ja aktiivse taimekasvu periood lühem kui ümbritsevatel tasandikel. Iseloomulik on mikroklimaatiliste tingimuste mitmekülgsus.

Saarelisest iseloomust ning mitme kõrgema keskuse ja vanade orgude olemasolust tingitult jaotub Otepää kõrgustik paljudeks väikesteks valgaladeks. Nendelt vett koguvad ojad ja väikesed jõed on kas kohastunud künkliku reljeefiga, jälgides küngaste vahelisi nõgusid, või kasutavad vanu orge. Kõrgustikul võib eristada moreenküngaste ja mõhnade vahelisi järvi (enamasti väikesed ja madalad, osalt ümara kuju ja lihtsa põhjareljeefiga, osalt käärulise kaldajoonega, saarterikkad ja vahelduva põhjareljeefiga; sageli paiknevad rühmiti), orujärvi (pikad, kitsad, kõrgete kallastega, sügavad; moodustavad aheljärvestikke) ja Otepää mattunud oru kohal paiknevaid suuri järvi (Pühajärv, Nõuni ja Pangodi järv), mis on orujärvedele sarnaselt piklikud, kuid madalamad, liigestunud kaldajoone ja põhjareljeefiga ning keeruka arengulooga.

Peamiselt liigestatud reljeefi ja lähtekivimiks olevate kvaternaari setete mitmekesisuse mõjul koosneb suuremal osal Otepää kõrgustikust mullastik suurest hulgast mullaliikidest, mis on levinud väikeste keeruka konfiguratsiooniga elementaarareaalidena. Põllumajanduslikele ettevõtetele kuuluvatel maadel mullastikuliselt kaardistatud alast, mis moodustab 80% kõrgustiku pindalast, hõlmavad 43% erodeeritud ja nendega seotud deluviaalmullad, 21% leetmullad ja 17% soomullad. Nimetatud domineerivate muldade vahekord on kõrgustiku geomorfoloogiliselt erinevates osades erinev. Teravamalt erinevad teistest kõrgustiku keskosa suurte pinnavormide levikuala (erodeeritud muldade ja soomuldade osatähtsus suurem) ja kõrgustiku kaguosa (leetmuldade levik tunduvalt ulatuslikum).

Enne inimasustuse kujunemist valitses Otepää kõrgustikul metsamaastik. Praegusel ajal ulatub metsasus keskmiselt 28%-ni. Künklikus maastikus on metsad (põhiliselt liigivaesed kuusikud ja kuuse-männimetsad) levinud katkendlikult kõrgendikkude tugevasti kumeratel lagedel ja järskudel nõlvadel. Rohkem kui kõrgustikul keskmiselt on metsa (40% pindalast) kõrgustiku keskosa suurte pinnavormide levikualal ning fluvio- ja limnoglatsiaalsete mõhnade levikualadel. Suure metsasusega (50%) paistavad silma kaguosa sandur- ja jääpaisjärvetasandikud. Seevastu väikeste moreenkattega mõhnade ja moreenküngaste levikualad on suuremalt jaolt põllustatud. Keerukast pinnaehitusest tingitud põldude killustatuse tõttu domineerib kõrgustikul hajaasustus.

РЕЛЬЕФ И ГЕОЛОГИЧЕСКОЕ СТРОЕНИЕ ОТЕПЯСКОЙ ВОЗВЫШЕННОСТИ КАК ОСНОВАНИЕ ЕЕ ЛАНДШАФТНЫХ ОСОБЕННОСТЕЙ

Э. Ханг

Резюме

Отепяская возвышенность представляет собой типичную островную возвышенность с холмистым рельефом. Абсолютная высота возвышенности, достигающая 217 метров, на 100—150 м превышает абсолютную высоту окружающих ее равнинных территорий. В пределах возвышенности поверхность коренных пород (среднедевонских песчаников) имеет несколько большую высоту (до 115 м над уровнем моря), чем на окружающих равнинах, но в основном наличие возвышенности связано с большой мощностью (местами в погребенных долинах до 200 м) плейстоценовых отложений, покрывающих коренные породы. Среди плейстоценовых отложений прослеживаются четыре горизонта морен и связанных с ними водно-ледниковых отложений. По данным спорово-пыльцевых анализов можно предположить, что самый нижний горизонт имеет нижнеплейстоценовый возраст, а остальные три горизонта по возрасту коррелируются соответственно с днепровским, московским и валдайским оледенениями.

Среди холмистых форм рельефа на возвышенности встречаются моренные холмы, флювиогляциальные и лимногляциальные камы (в том числе камы с чехлом из морены) и холмы (преимущественно более крупные по сравнению с другими), моренное ядро которых покрыто озерно-ледниковыми или флювиогляциальными отложениями или же отложениями обоих названных типов. В проксимальной части возвышенности отмечены напорные ледниковые образования. В дистальной части ее преобладают зандровые равнины и озерно-ледниковые аккумулятивные и абразионные равнины, расчлененные долинами стока талых ледниковых вод.

Большая высота, наличие холмистого рельефа и разнообразие подстилающей поверхности вызывают заметные изменения климата возвышенности по сравнению с климатом окружающих равнин. Климат возвышенности характеризуется бо̀льшей облачностью, бо̀льшим числом дней с осадками и бо̀льшим годовым количеством осадков, несколько более низкими показателями суммарной радиации за летний период и в среднем за год, более низкими температурами воздуха, более мощным, устойчивым и продолжительным снежним покровом. На возвышенности сумма активных температур несколько меньше и период активной вегетации менее длительный чем на прилегающих равнинах. Для холмистого ландшафта возвышенности характерна разнородность

микроклиматических условий, в особенности в центральной части возвышенности, где распространены наиболее крупные формы рельефа.

Общим островным характером Отепяской возвышенности, которая, кроме того, образуется из нескольких более высоких водораздельных частей, а также наличием в ее пределах ряда древних долин, обусловлено разделение ее на многочисленные небольшие бассейны стока. Приспособившиеся к рельефу ручьи и малые реки проложили себе путь по впадинам между холмами в виде слаборазвитых молодых долин, или же протекают в древних долинах. На возвышенности можно выделить озера, находящиеся между моренными и камовыми холмами, долинные озера и озера, расположенные по линии погребенной долины Валга—Отепя—Тарту (озера Пюхаярв, Ныуни и Пангоди). Первые — преимущественно небольшие и неглубокие. Некоторые из них имеют округленную или овальную форму и несложный рельеф дна; у других береговая линия извилистая, а рельеф дна сильно расчленен. Озера этого типа часто расположены группами. Долинные озера по форме продолговатые и узкие. Они отличаются значительной глубиной и имеют высокие берега. В юго-восточной части возвышенности такие водоемы образуют цепи озер в древних долинах. Озера Пюхаярв, Ныуни и Пангоди — самые крупные озера Отепяской возвышенности. Они продолговаты, как и озера предыдущего типа, но имеют меньшую глубину. Береговая линия у них извилистая, рельеф дна расчленен. Они прошли сложную историю развития.

Из-за сложного строения поверхности и большого разнообразия четвертичных отложений, которые являются почвообразующими породами, почвенный покров возвышенности очень мозаичный. Он состоит из многочисленных видов почв, которые распространены в виде мелких элементарных ареалов со сложными контурами. По данным почвенной съемки земель сельскохозяйственных предприятий в почвенном покрове преобладают эрозионные и связанные с ними делювиальные, подзолистые и болотные почвы. Площади распространения названных почв составляют соответственно 43%, 21% и 17% от общей площади, охваченной почвенной съемкой. По сравнению с другими частями возвышеносити ее центральная часть бросается в глаза большей распространенностью эродированных и болотных почв, а юго-восточная часть отличается большим значением подзолистых почв.

До заселения Отепяской возвышенности человеком здесь полностью господствовали леса. В настоящее время лесистость не превышает 28%. Преобладают ельники с бедным видовым составом и елово-сосновые леса. В крупно-холмистом ландшафте раздробленные леса сохранились на выпуклых вершинах и крутых склонах холмов, непригодных для сельскохозяйственного пользования ввиду эрозионной опасности. Но лесистость достигает здесь все-таки 40%. Такова же лесистость тех частей возвышенности, где преобладают флювио- и лимногляциальные камы, состоящие из песчано-гравийных отложений. Значительно большим распространением лесов (лесистость около 50%) отличаются зандровые и озерно-ледниковые равнины юго-восточной части возвышенности. Зато в районах распространения мелких моренных холмов и камов с моренным чехлом преобладают пахотные земли. В холмистом ландшафте из-за раздробленности полей до сих пор характерны деревни рассредоточенного типа.

THE GLINT HEADLANDS AND GLINT BAYS IN THE LAHEMAA NATIONAL PARK

E. Linkrus

The North-Estonian limestone escarpment, which forms part of the extensive Baltic Glint, has attracted the attention of scientists for many centuries. In the first half of the present century Professor A. Tammekann set himself the aim of writing a comprehensive monograph on the Baltic Glint. However, only the first part, the one dealing with the morphology of the Glint, appeared in print (Tammekann, 1940).

During the post-war period, as a result of different investigations, additional data have also been obtained about the Glint. Articles adding further details and revising earlier views about the origin of the limestone escarpment have been published (Orviku, 1958a; Künnapuu, 1959; Гембель, Нильсон, 1959). Most scientists have come to the conclusion that the North-Estonian Glint in broad outline represents a denudation form, having first come into being as the steep southern slope of a huge river valley that occupied the place of the present Gulf of Finland during the Preglacial period (Tammekann, 1949; Orviku 1958a; Raukas, Rähni, 1974). The southern slope became steeper owing to the occurrence of layers with varying denudation resistance in the bedrock, which has a slight southern incline of 3 — 4 metres in 1 km. The deep buried valleys in the bedrock which chiefly trend from the south to the north or from the south-east to the north-west, divide the edge of the limestone plateau into joints. These valleys were probably formed by subsequent streams of a primordial river — the Primeval Baltic or the Primeval Neva which flowed in the denudation area mentioned above. The formation of the Glint continued as a result of the exaration of the Continental Ice Sheet during the Ice Age, under the influence of running water and abrasion of the sea and great lakes in the depression of the Baltic Sea during the interglacial periods, and owing to the denuding effect of the waves during the Postglacial Period. At all stages denudation has been aided by tectonic processes.

The author of the present article has explored the geomorphology of the North-Estonian Coastal Plain on the territory of the Lahemaa National Park over a number of years. In the course of the investigation certain data have been amassed about the relief forms in the region of the North-Estonian Glint in the Lahemaa area. These will be the subject of the following discussion.

SOME GENERAL DATA

From the geomorphological point of view the Glint constitutes a boundary between the Limestone Plateau of North Estonia and the denudation zone in the outcrop area of Cambrian sediments (Орвику, 1960). As has been pointed out above, the edge of the plateau is well jointed. After A. Tammekann (1926, 1935, 1936, 1940) the parts of the edge of the plateau reaching out towards the sea are called Glint headlands and the depressions between them Glint bays.

In the Lahemaa area the North-Estonian Glint occurs everywhere as an inland scarp. It constitutes a natural boundary between the landscape regions of the North-Estonian Coastal Plain and the North-Estonian and North-Eeast Estonian plateaus and the Kõrvemaa area wedged between them (Вареп, 1961; Varep, 1964; Вареп, Тармисто, 1967). As the Glint does not form an uninterrupted line various landscape units alternate on the borderline of the coastal plain and the plateau, which dovetail with each other here.

In the Lahemaa area the coastal plain lying between the Glint and the sea attains its greatest width in Estonia. On the peninsulas it may be as much as 16 — 17 km, and between them 4 — 5 km (at Palmse almost 6 km). At Tsitre, on the other hand, it is barely 1 km. At a distance ranging from a score of metres to 3.5 km from the edge of the limestone plateau, running along the line of Kolga — Oandu — Pajuveski, there is a scarp denuded in the Cambrian sandstones and clays. Buried under limnoglacial and fluvioglacial sediments of the Palivere Stage of the Continental Ice Sheet, it can be traced in the present surface relief as an ice-contact slope, which has been somewhat changed by the action of great lakes and the sea in the Late- and Post-Glacial periods. The slope mentioned above has determined the formation of two distinctly different locality types within the boundaries of the coastal plain (Линкрус, 1974).

The lower part of the North-Estonian Glint is made up of Lower-Ordovician sandstones and clay slates (the Pakerort and Latorp stages). Upon those are deposited Lower- and Middle-Ordovician limestones (the stages of Volkhov, Kunda, Aseri and

Fig. 1. The North-Estonian Glint in the Lahemaa National Park.

1 — the North-Estonian Glint (when buried, marked with an interrupted line); 2 — the ice-contact slope of the Palivere Stage (the scarp in the Cambrian sediments buried under Pleistocene deposits).

Lasnamägi).[1] Geological survey has proved that in the west (reaching as far as Palmse) the Kunda Stage occurs along the edge of the escarpment; at Sagadi and east of it the outcrop of the Volkhov Stage occurs in the upper part of the Glint.

In the western part of the Lahemaa area the edge of the plateau is especially well jointed. The area covered by the Glint headlands is smaller than that under the Glint bays. Both are easily traceable in the present surface relief. The headlands end, especially on the north and north-western side, in a high (up to 30—32 metres) and steep (50—70° and even more) scarp, the upper, limestone part of which juts out like the eaves of a roof in some places. The steep scarp of the Glint gradually grows more gentle and lower in the direction of the end of the Glint bays till it finally disappears under the surface cover. The vegetation peculiar to the Glint occurs in its most characteristic form on the steep slopes of the headlands (Lippmaa, 1935; Laasimer, 1965).

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[1] The boring data cited both here and later on have been taken from reports of the Board of Geology of the Estonian S.S.R.

The Glint bays between the headlands have a sandy surface layer and their present-day relief is characterised by fluvioglacial deltas and accumulative coastal formations, most commonly by barrier beaches reaching from one headland to another. Behind the coastal formations there may stretch strips of peatbog. The Glint bays serve as beds for rivers and brooks. Flowing over the brink of the plateau they fall in picturesque cascades, which together with those remaining outside the boundaries of Lahemaa area make up a whole fall line along the edge of the tableland (Orviku, 1935; 1958b; Kaasik, 1972). Several Glint bays are characterised by deep buried valleys.

The picture somewhat changes in the eastern part of the national park, beginning with the River Loobu. In comparison with the western part big denudation depressions are fewer here and the parts of the plateau separated by them are larger. The Glint occurs here as a slanting simple or compound slope overgrown with grass and in most cases barely 10 — 11 metres in height. On the other hand, the edge of the eastern part of the tableland is more indented than the western one with secondary Glint promontories and inlets of 100 — 200 metres, less commonly of 300 — 400 metres in length. In the eastern part of the national park outcrops of the limestone bedrock are less frequent than in the western part.

Although the relative height of the Glint is greater in the west, the absolute height of its foot and edge increases from the west to the east. In the west the foot of the Glint is nowhere higher than 20 metres (at Tsitre and Muuksi only 15 — 17 metres) and the edge of the Glint is not higher than 45 — 50 metres. In the eastern part of the national park, on the other hand, the foot of the Glint towers 45 — 50 metres and its edge 55 — 65 metres above sea-level.

A highly characteristic feature of the North-Estonian Glint is the abundance of springs. In some places they have given rise to a zone of swamps fed by springs along the foot of the escarpment.

THE LOO GLINT HEADLAND

The limestone plateau extending in the western part of the national park was called the Tsitre Glint peninsula by A. Tammekann (1940). Actually the peninsula consists of three parts — the headlands of Tülivere or Sõitme, Loo or Tsitre, and Muuksi—Uuri, which are separated by two depressions. Through the western one of these the River Loo (Liiva) flows to the sea; the other stretches north of Lake Kahala as the Muuksi Glint bay. The Tülivere — Sõitme region remains outside the boundaries of the national park (the western boundary of the park following the River Loo). It has been ascertained that under the Loo Glint bay, near the present shore there is a buried valley reaching over 100 metres below sea-

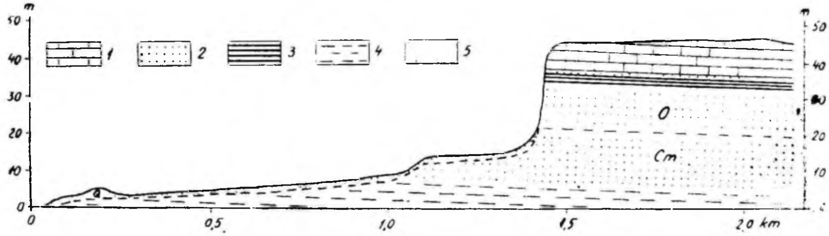

Fig. 2. The profile of the coastal plain and the Loo Glint headland.
Conventional signs used in Figures 2—5:
1 — limestones; 2 — sandstones and aleurolites; 3 — *Dictyonema*-slate; 4 — clays of the bedrock; 5 — Quaternary deposits.

level. In the valley-like denudation depression of the Muuksi Glint bay separating the Loo and Muuksi—Uuri Glint headlands the denudation of the bedrock has not reached the Cambrian sediments.

Geological investigations have proved that the Loo or Tsitre and Muuksi—Uuri Glint headlands represent two relic islands of the limstone plateau which are separated from each other by a denudation area. This area is made up of the Muuksi depression, up to 1 km in width, and the depression of Lake Kahala, both of which lie in the outcrop area of the Pakerort Stage. In the area of Loo and Muuksi—Uuri Glint headlands limestones of the Kunda Stage are exposed.

The scarp of the Loo headland attains its greatest height of 28 — 30 metres in the north-west where its foot rises 15 — 17 metres and its brink 45 metres above sea-level. Both the scarp and the talus are overgrown with broad-leaved forest characteristic of the vegetation of the Glint (Lippmaa, 1935; Laasimer, 1965). A striking feature here is the abundance of *Lunaria rediviva* L. In front of the scarp there is a strip of spring fens. The northern slope of the headland is intersected by a hanging valley about a hundred metres long. Below it there is a cave known as the Turje cellar. It is approximately 20 metres wide at the mouth and 4 — 4,5 metres high. It has been formed in Pakerortian sandstone, which displays an outcrop of 6 — 7 metres in thickness. Attention was drawn to this outcrop of *Obolus*-sandstone at Tsitre by A. Öpik already in 1929. The height of the Glint at the Turje cellar is 17 — 19 metres, reaching up to 20 metres east of it. In the north-eastern part of the headland the scarp rises to a maximum of 16 — 18 metres.

The Loo Glint headland is characterised by a well-developed scarp in the south-east bordering on the depression of Lake Kahala, which clearly shows that it is a Glint island. Actually, it is made up of a scarp of 4—5 metres with an incline of up to 30 degrees. Lower down there is a slope of 200 metres in length and 7 metres in height. The scarp is separated from the slope by a 50-metre-wide terrace. At the edge of the scarp stones abound.

Farther away from the brink the absolute height of the Loo Glint headland reaches 47 metres. The limestone bedrock is covered with calcareous loamy moraine, often only 10—20 centimetres deep. Thus a large part of the Glint headland constitutes an alvar locality with an extremely peculiar water regime, soil and vegetation (Vilberg, 1927; Laasimer, 1965, 1973; Rooma, Sepp, 1972). The settlement of Loo at the south-western edge of the headland has got its name from the word *lood* (Gen. *loo*), which is the Estonian equivalent for 'alvar'. In the eastern half of the Glint headland juniper-covered alvars prevail. In the west there are marshy spots covered with a peat layer of up to 25 centimetres. On other Glint headlands in the Lahemaa area peatlands do not occur so near to the brink of the limestone plateau. The alvars are mostly used as pastureland. A peculiar feature here is the occurrence of stone-kist barrows dating back to the second half of the first millennium B. C. They can be met with also elsewhere in the Lahemaa area, but they are especially abundant in the vicinity of Lake Kahala (Moora, 1972).

The Muuksi depression between the Loo and Muuksi—Uuri Glint headlands connects the depression of Lake Kahala with the coastal plain. In the present-day relief the Muuksi Glint bay is especially well discernible at the village of Muuksi. Through the middle of the depression passes the barrier beach that begins on the Glint headlands of Loo and Muuksi—Uuri. As has been mentioned above, the Pakerort Stage is exposed in the Muuksi depression and in the depression of Lake Kahala, whereas outcrops of the Kunda Stage occur on the Glint headlands. This fact points to the conclusion that the depression of Lake Kahala should evidently be regarded as a preglacial denudation basin.

Lake Kahala in the depression mentioned above was once connected with the Gulf of Finland through the Glint bays of Loo and Muuksi. Judging by the height of the coastal formations surrounding the lake, it may be concluded that a lake had existed here already before the stage of the Ancylus Lake. The foot of the barrier beach in the Muuksi depression lies 38—38.5 metres above sea-level. The height of the foot of the spit bordering the lake in the west is about 34 metres. The spit arose behind the south-western side of the Glint headland of Loo. Below it, at the mouth of the Loo Glint bay, there is another belt of coastal formations, a barrier beach covered with dunes, which came into being during the stage of the Ancylus Lake.

The present water level in Lake Kahala is about 33 metres above sea-level. A great part of the depression has become a peat-land which lies 33.5—34 metres above sea-level. In addition the lake is to a great extent filled with mud. According to K. Veber (1964) the average thickness of the sapropel layer in the lake is 2.0 metres, the maximum thickness being 4.25 metres. According to A. Määr (1931) in places the thickness of the mud layer may even reach 7.5 metres.

THE MUUKSI — UURI GLINT HEADLAND

The Muuksi—Uuri Glint headland is conspicuous for its steep (often inclined over 70°) and high north-eastern slope. Here the Glint reaches its maximum relative height in the Lahemaa area, rising 30—32 metres, while its foot lies 16—18 metres above sea-level. The scarp reveals outcrops of sandstones and *Dictyonema*-slate of the Pakerort Stage, glauconitic sandstone of the Latorp Stage and deposits of limestone attaining a thickness of 5 metres. In places Pakerortian sandstone forms a wall of up to 4 metres high in the lower part of which abrasional caves occur. In cases where there is a sandstone scarp in the middle of the Glint the scree is made up of two parts — one lying between the limestone and the sandstone wall and the other below the latter. The upper, limestone part of the scarp, which is intersected by crevices, juts out like the eaves of a roof. The scarp is overgrown with shady deciduous forest characteristic of the Glint.

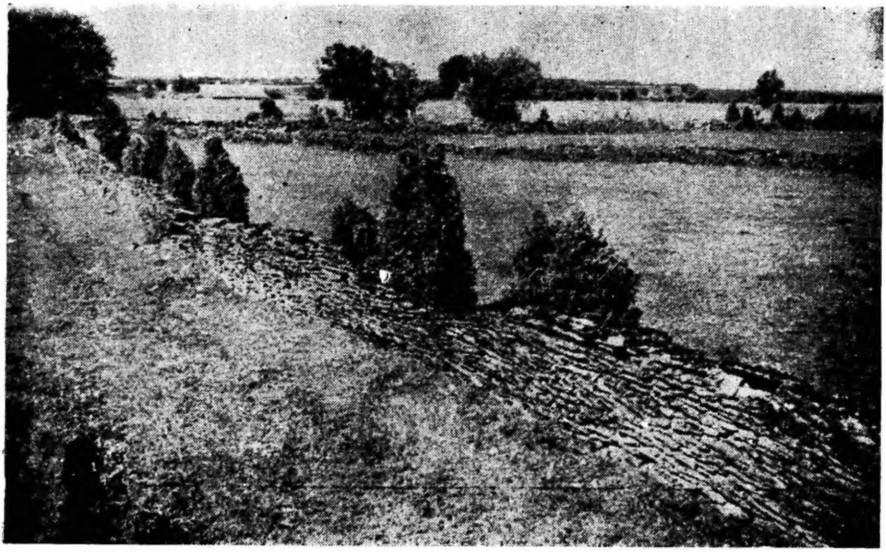

Photo 1. Alvar on the Muuksi Glint headland. In the background the Loo Glint headland.

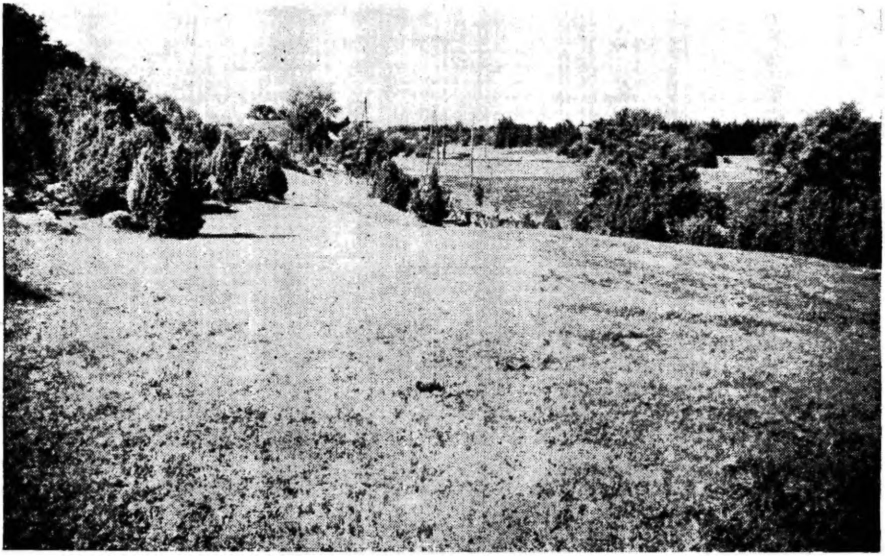

Photo 2. The border of the coastal plain and the limestone plateau at the village of Uuri.

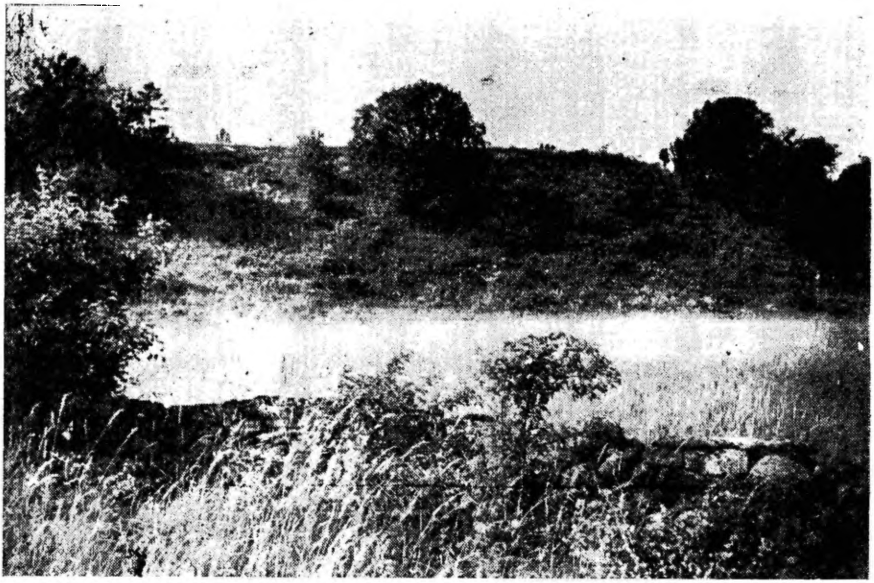

Photo 3. North-eastern edge of the Loo Glint headland.

Photo 4. Northern end of the Muuksi Glint headland.

At the village of Uuri the steep north-eastern side of the Muuksi—Uuri Glint headland gradually changes into a compound slope 200—300 metres in length, which becomes more and more gentle and lower till it imperceptibly disappears under the Quaternary deposits. There is no outcrop of the bedrock even in the valley of the River Kolga. But judging by the river's longitudinal profile and the appearance of pieces of limestone in the river bed, the Glint line should run not far from the Kolga forestry centre.

Compared with its north-eastern side, the south-western slope of the Muuksi—Uuri headland is lower and gentler. Here the surface of the limestone plateau sinks towards the Muuksi depression and in the direction of Lake Kahala in the form of two or three slopes. At the end of the headland, at the so-called Linnamägi ('Stronghold Hill'), there is a scarp, which has a height of 8—10 metres and an incline of 45 degrees. The name of the hill is connected with the fact that about the beginning of our era an ancient Estonian stronghold stood here (Moora, 1955).

The surface of the Glint headland is flat, most of it being covered with a 30-centimetre layer of calcareous local moraine. The absolute height of the plateau reaches up to 53 metres. As the surface is completely or almost completely made up by the limestone bedrock, alvars are wide spread here. The surface layer is thicker only on the slope sinking towards the depression of Lake Kahala. A great part of the headland is overgrown with junipers. Stone-kist barrows are found in abundance here.

The width of the Kolga Glint bay, which lies between the Muuksi—Uuri and Kolga Glint headlands, is a little under 3 km at its mouth. Bay-way the Kolga or Männiku River winds its course. Geological investigations have proved the existence of a buried valley in the Kolga Glint bay. In terms of its present relief and its natural complexes the Kolga Glint bay is a typical one.

THE KOLGA GLINT HEADLAND

The Kolga Glint headland bordering the Kolga Glint bay in the east has a more northern trend than the Loo and Muuksi—Uuri headlands. The headland is 2.5 km long and about 1 km wide. It is escarped only at the end. Here the height of the Glint attains 20 metres, its foot rising 27 metres and the brink 47 metres above sea-level. For about 3 metres it assumes the form of a vertical limestone cliff. The lower part of the glint is covered with scree, which is overgrown with a forest of broad-leaved trees, mostly limes (*Tilia cordata* Mill.). The upper part of the escarpment is abrupt and bare of vegetation.

The eastern side of the headland sinks in the direction of the Glint bay either in the form of three slopes separated by narrow terraces or as a 100—200-metre-long compound slope consisting of three parts. In the west the plateau sinks towards the coastal plain in the shape of a single slope or scarp. At the foot of the Glint there is a terrace of Cambrian sandstones; it lies 28—28.5 metres above sea-level. On the plateau as well as on the denudation slopes on the eastern side the limestone is almost exposed, being covered with a thin layer of calcareous moraine or sand, which often is no thicker than 10 — 20 centimetres. In the alvars, especially in their higher parts, erratic blocks abound. In comparison with the other headlands there is more forest here. The dominant tree species is the spruce, besides which the pine and in places the birch and aspen grow; the hazel is also common here.

The Pudisoo or Leedikõrve Glint bay lying between the Kolga and Kolgaküla Glint headlands is besides the Valgejõgi — Loobu Glint bay one of the largest in the Lahemaa area. Its breadth and length are more or less equal, both attaining about 4 km. A characteristic feature of both the Pudisoo (or Leedikõrve) and Valgejõgi — Loobu Glint bay is the same width throughout their length. The smaller Glint bays are usually funnel-shaped, narrowing fast in the direction of the end of the bay. The south-eastern part of the Pudisoo Glint bay is filled with a fluvioglacial delta of the

Palivere Stage which borders on an ice-contact slope running along the Ulliallika — Kolgaküla line. Near the mouth of the Glint bay there is a belt of coastal formations running from Tagavälja to Suurekõrve; its seaward foot lies at a height of 26 — 28 metres.

Limestone appears again at the village of Kalme, where an outcrop of 1.5 metres in thickness can be seen in the lower part of the flank of the Pudisoo river valley and another is found at the bottom of the river bed at an absolute height of 43 — 45 metres. Limestone outcrops occur here for a stretch of 200 metres along the river bank and end in a 30—40-centimetre-high step in the bed of the river. Thanks to the abundance of springs along the Glint the valley is overgrown with calciphilious vegetation. The dominant tree species are the spruce, lime and elm; among the bushes it is the hazel that prevails.

THE KOLGAKÜLA GLINT HEADLAND

At Kolgaküla, as at Muuksi and Uuri, the Glint headland is conspicuous for its steep north-eastern slope, which stretches for 3 km. It is 16 metres high (the foot rising 35 metres and the brink 51 metres above sea-level). Outcrops of the bedrock can be seen on the slope only in spots and their height nowhere exceeds 1 — 2 metres. Unlike the western headlands, beginning from the Kolgaküla Glint headland the edge of the plateau is mostly under fields.

At Kolgaküla the lower, sandstone scarp is easier to distinguish than in other parts of the national park. After the limestone slope swings westward, the sandstone scarp continues for another 1.5 km in a north-westerly direction. The height of the scarp is 10 metres (the foot rising 28.5 — 29 metres and the brink 39 metres above sea-level). The brink of the scarp is intersected by V-shaped

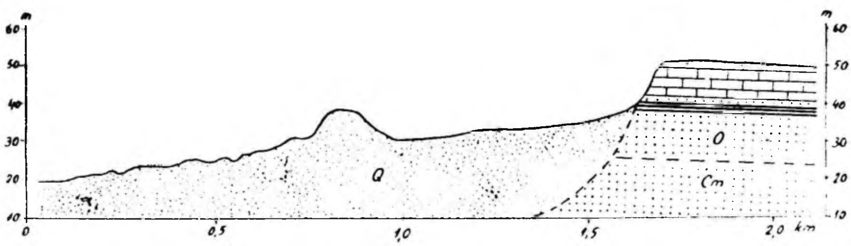

Fig. 3. Profile of the Valgejõgi—Loobu Glint bay and the Kolgaküla Glint headland. For conventional signs see Fig. 2.

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Photo 5. The Nõmmeveski waterfall.

gaps. The scarp has been abraded mostly in Pakerortian sandstones, which are covered with a surface layer of about one metre in thickness. In front of this scarp above Lake Lohja there are three other lower scarps abraded in the bedrock. In sections where the limestone and sandstone scarps have joined, the relative height of the Glint at Kolgaküla reaches 20 metres. In this case the length of the slope may attain up to 300 metres.

A. Tammekann has treated the Kolga and Kolgaküla Glint headlands together, regarding them as a single Kolga peninsula. He also includes in the limestone plateau the area lying south-west of Lake Lohja on the slope of the sandstone scarp (Tammekann, 1940, Fig. 30). The Glint bay bordering the headland in the west is referred to as the Pudisoo Glint bay (the Kolga Glint bay in the present treatment). The denudation area between the Glint headlands where the former Kolga manor and the Kolgaküla village are situated (the Kolga and Kolgaküla headlands) is referred to as the Liidikõrve Glint bay by A. Tammekann (in the present paper it is called the Pudisoo or Leedikõrve Glint bay). The latter is regarded by him as a bay of secondary significance although he was aware that it reached up to the Kalme village.

Between the Kolgaküla and Vatku villages lies the Valgejõgi — Loobu Glint bay through which rivers of the same name wind their way in their lower reaches, in broad outline following

Photo 6. Cascade on the Loobu River at Joaveski.

the course of buried valleys. Near its mouth the width of the Valgejõgi — Loobu Glint bay is 5 — 6 km, which is more than its span from the north-west to the south-east (3 — 3.5 km). At the mouth of the bay there is a barrier beach covered with sand dunes, the foot of which rises 28 — 30 metres above sea-level, and which marks the maximum reach of the Ancylus Lake. Like the Pudisoo Glint bay, the south-eastern part of the Glint bay in question is filled with a fluvioglacial delta of the Palivere Stage. The contour of the Glint bay can be traced along the outcrops of the bedrock occurring in the valleys of the Valgejõgi and Loobu rivers. In the valley of the River Valgejõgi limestone outcrops can be seen at Nõmmeveski and 1 — 2 km to the north-west in the tributary valleys on the left-hand side. In the valley of the River Loobu outcrops appear at the Joaveski settlement. At Joaveski, Nõmmeveski and Vasaristi (in one of the tributary valleys to the left) small waterfalls occur at the frontline of the Glint. On the right-hand slope of the Nõmmeveski Canyon 20-metre-high outcrops of Ordovician sediments (limestones, glauconitic sandstone, *Dictyonema*-slate, and *Obolus*-sandstone) can be seen. This is the most representative outcrop of the bedrock on the territory of the national park. The Nõmmeveski Canyon is overgrown with deciduous forest characteristic of the Glint locality type. Under the forest *Lunaria rediviva* L. is also present. The direction of the Glint line between the villages of Joaveski and Vatku can be approximately traced on the basis of the springs and other landscape characteristics occurring in the area.

THE GLINT FROM VATKU TO PALMSE

Extending east of the Vatku village the Glint continues as an uninterrupted escarpment for over 5 km, running a little north of the highway. At Vatku the height of the Glint is 10 — 11 metres (the foot rising 44 metres and the brink 54.5 metres above sea-level). The edge of the limestone plateau is indented with several promontories and inlets of 100 — 300 metres in length. Just as in case of headlands, the ends of the promontories are abrupt, whereas in the inlets between them the slope of the plateau is gentler as a result of denudation. A somewhat larger inlet is to be found at the western edge of the Tõugu village, where the Tammispea Brook, the upper reaches of which also bear the name of Tõugu Brook, descends from the limestone plateau. East of Tõugu the plateau forms a small arc-like promontory descending in two terraces. The brink of the plateau is 53 — 54 metres high (the foot rising 43.5 metres above sea-level), thus the relative height of the scarp seldom exceeds 10 metres. Farther away from the edge the absolute height reaches 58 metres. The surface layer is thicker here than in the more westerly areas. Alvars occur in small patches here among abraded moraine plains on the limestone bedrock.

In the Võhma — Ilumäe section the Glint escarpment is somewhat steeper near the Hiiepärn ('Sacred Limetree') in the village of Ilumäe. Here the scarp is over 16 metres high (the foot being 44 metres, and the brink 60 — 60.5 metres above sea-level). At the Muike village there is a 300 — 400-metre-wide and 4—5-metre-deep smooth-sloped depression joining the forest-covered sandy areas in front of the Glint and on the edge of the plateau.

As a result of the action of the springs issuing from the limestone cliff a great many V-shaped valleys of 10 and more metres in depth have come into being at the foot of the Glint at Muike and Palmse. In places they cut the ground after every 20 — 30 metres. On the edge of the Glint alvars occur here and there.

From Võsupere to Sagadi the Glint is not visible in the surface relief. A. Tammekann (1940) and some other authors have expressed the opinion that a Glint bay several kilometres wide extends between Palmse and Sagadi. However, there is limestone on the Kone farmsteads by the side of the Palmse — Sagadi road (Orviku, 1940). Evidently the bedrock has been denuded to form a Glint bay where the Revoja and Sillaoru brooks flow. According to the data available at the Board of Geology the depth of the buried valley at Palmse is 50 — 100 metres.

THE GLINT FROM SAGADI TO KARULA

The Glint reappears in the surface relief at the village of Sagadi. Its height here is nearly 11 metres (the foot rising 50 metres and the brink 61 metres above sea-level). At the former Sagadi manor the edge of the limestone plateau forms a slope, the upper part of which consists of limestones, and the lower part of glauconitic sandstone of the Latorp Stage and *Dictyonema*-slate of the Pakerort Stage. The glauconitic sandstone and *Dictyonema*-slate are so near to the surface here that they come to light when the soil is turned up in ploughing the fields near the former manor of Sagadi. The lower Glint terrace is known as Savimägi ('Clay Hill') owing to the clayey Latorp Stage. In some places at the Sagadi village the Glint is buried under glacial accumulations and is not visible in the present surface relief.

At the Lauli village the height of the Glint, which occurs here as a slope consisting of two parts, is still 10—11 metres (the foot being 52—53 metres and the brink 62—63 metres above sea-level). On the verge of the Glint there is a ridge, which is 3 — 4 metres high and 70 — 80 metres wide, and the crest of which rises up to 66.5 metres above sea-level. Its northern part merges into the edge of the Glint, but its southern slope is clearly visible. The proximal part of the ridge consists mostly of limestone pebble and shingle. The southern slope is made up of finer materials. Such a formation runs along or near the brink of the Glint for many kilometres becoming lower or being interrupted only in a few places. In some places the breadth of the ridge grows to 400 — 500 metres, whereas its height does not generally exceed 5 — 6 metres. On the basis of its structure and position the ridge might be regarded as a marginal esker.

At the village of Vihula the Glint forms a small promontory. Its end, which rises to a height of 7 — 8 metres and sticks out for

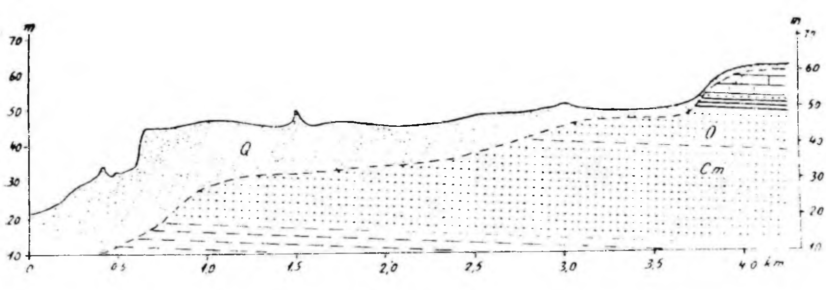

Fig. 4. Profile of the Glint and the Fore-Glint Terrace at Sagadi. For conventional signs see Fig. 2.

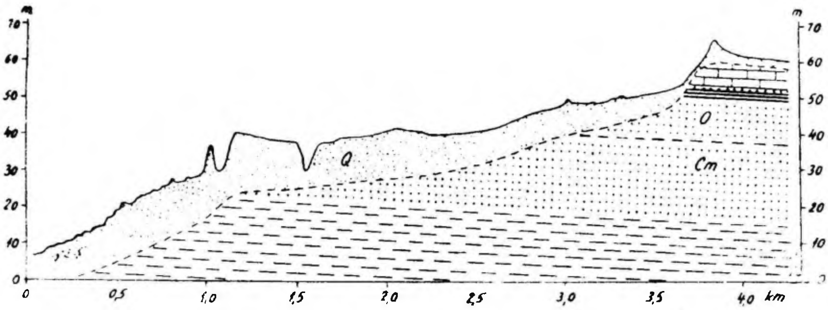

Fig. 5. Profile of the Glint and the Fore-Glint Terrace at Lauli. For conventional signs see Fig. 2.

a length of 150 metres, is known under the name of Vihula Linnamägi (the Vihula stronghold). It is situated on the lower terrace of the Glint, the absolute height of which is about 55 metres. An ancient stronghold existed here probably during the first half of the first millennium A. D. (Moora, 1955). The absolute height of the upper part of the Glint headland is prevalently 64 — 66 metres, on a small territory reaching up to 67 — 68 metres. This is the greatest height the marginal area of the limestone plateau attains. On the abrasion terrace in front of the Glint headland sandstone occurs at a depth of barely 0.5 metre in places. This area is called Tahunõmm ('Sandstone Heath') by the local people. One of the characteristic features of this area is the occurrence of pine-wood with *Myrtillus*.

A somewhat lower (59—59.5 metres above sea-level), but morphologically similar, Glint promontory is also found near the former Vihula manor. The River Vihula has cut its bed in the bedrock, and there are many outcrops of sandstone visible on the flanks of the valley. The river flows in a depression running along the wall of the cliff, where the bedrock has been abraded down to the Pakerort Stage, which is exposed as a strip of several hundred metres in front of the limestone scarp near by. The Vihula springs are also well known.

At Karula the Glint attains a height of 8 — 9 metres only, in places forming a rather steep scarp. The brink towers about 54 metres above sea-level. Here, too, along the edge of the plateau there extends a ridge, the absolute height of which is 59.5 metres. The ridge at Karula was already mentioned by A. Tammekann in 1940.

South-east of the settlement of Karula the Glint recedes into a smooth slope, swings to the south and disappears under the sur-

Photo 7. The Nõmmeveski Canyon of the Valgejõgi River.

Photo 8. The Vasaristi Brook disappears in a swallow hole

face cover, forming a Glint bay under which the Ordovician sediments have been denuded. Through the Glint bay the River Vainupea winds its way, for a short stretch constituting the eastern boundary of the Lahemaa National Park.

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LAHEMAA KLINDINEEMIKUD JA KLINDILAHED

E. Linkrus

Resümee

Põhja-Eesti paekallas esineb Lahemaal kõikjal sisemaise astanguna. Selle kaugus merest on napilt 1 km-st (Tsitres) kuni 16—17 km-ni (poolsaarte kohal). Paekallas ei ole pidev, vaid esineb lõikudena, mida eraldavad kulutusvagumused. Lavamaa serva väljaulatuvaid osi on A. Tammekannu järgi hakatud nimetama klindineemikuteks, nendevahelisi vagumusi klindilahtedeks. Klindi katkendliku esinemise tõttu on rannikumadaliku ja lavamaa piiril tekkinud omapärane maastikuline vööde, mida iseloomustab rannikumadalikule ning lavamaale omaste paigaste vaheldumine.

Lahemaa lääneosas on lavamaa serv eriti tihedalt liigestatud. Siin esinevad Loo (Tsitre), Muuksi—Uuri, Kolga ning Kolgaküla klindineemikud (joon. 1). Neemikute otsad on järsud ja kõrged. Muuksi — Uuri neemikul ulatub klindi suhteline kõrgus 30—32 m-ni. Neemikuid lahutavad Muuksi, Kolga ja Pudisoo (Leedikõrve) klindilaht. Kolgaküla klindineemikust idas asub Valgejõe —

Loobu klindilaht, mis on suurim Lahemaal (laius suudmes 5—6 km).

Klindineemikutel esineb sageli alvareid, nende järskudel nõlvadel aga laialehist metsa. Klindilahtedele on iseloomulikud fluvioglatsiaalsed deltad ning akumulatiivsed rannikuvormid. Rannikumoodustiste taga leidub ribadena soid. Valdav osa klindilahtedest on nõmme- ja palumetsa all.

Loobu jõest idas on suuri kulutusvagumusi vähem, neist lahutatud lavamaa-osad suuremad. Paekallas on üldiselt laugem, olles enamasti ainult 10—11 m kõrge. Lavamaa ääreala absoluutne kõrgus on aga idas suurem kui läänes, küündides 55—56 m-ni, Vihula külas väikesel alal isegi 67—68 m-ni. Alvareid on rahvuspargi idaosas vähem, põllustatud maa osa aga suurem kui läänes.

ГЛИНТОВЫЕ МЫСЫ И БУХТЫ ЛАХЕМАА

Э. Линкрус

Резюме

Северо-Эстонский глинт в Лахемааском национальном парке удален от берега. Его расстояние от моря колеблется в пределах от 1 км до 16—17 км. Глинт представляет собой прерывистый уступ коренных пород. Крутые участки чередуются с денудированными отрезками. Выступы известнякового плато названы А. Таммеканном глинтовыми мысами, денудированные участки — глинтовыми бухтами. Из-за расчлененности глинта на границе прибрежной низменности и известнякового плато образовалась своеобразная зона, которая характеризуется чередованием типов ландшафтов известнякового плато и прибрежной низменности.

В западной части Лахемааского национального парка край плато особенно сильно расчленен. Здесь выделяются глинтовые мысы Лоо (Тситре), Муукси — Ури, Колга и Колгакюла (рис. 1). Оконечности мысов крутые и высокие. В Муукси относительная высота глинта достигает 30—32 м. Между мысами расположены глинтовые бухты Муукси, Колга и Пудисоо (Леэдикырве). К востоку от мыса Колгакюла находится глинтовая бухта Валгейые — Лообу, самая широкая в Лахемаа (ширина в устье — 5—6 км).

На глинтовых мысах часто встречаются альвары, а на их крутых склонах — широколиственный лес. Для глинтовых бухт характерны флювиогляциальные дельты и аккумулятивные береговые образования. Бóльшая часть территории в глинтовых бухтах покрыта сосновыми лесами; за береговыми формами нередко встречаются болота.

К востоку от реки Лообу крупных глинтовых бухт меньше, а расположенные между ними участки плато больше. Глинт здесь, в общем, более пологий, его относительная высота обычно лишь 10—11 м. Абсолютная же высота края известнякового плато в этой части больше чем на западе; она достигает 55—65 м, а в окрестностях деревни Вихула на маленьком участке даже 67—68 м от уровня моря. Альваров в восточной половине национального парка значительно меньше, а процент пашни больше, чем на западе.

ON THE DIVERSITY OF MONTHLY TOTALS OF PRECIPITATION IN ESTONIA

H. Mürk

A many-sided knowledge of the precipitation regime plays a significant role in the study of the climate of a locality. When describing the rainfall regime, investigators, as a rule, confine themselves to the presentation of the mean values of monthly totals and those of rain days. Such data on precipitation are, of course, very important, but they are insufficient, because climatological means do not reflect the diversity of the precipitation regime. This, however, is a basic feature of not only rainfall, but also of all climatological elements.

Information theory, which deals with the problem of diversity, has been successfully applied in several disciplines, but so far it has been very sparingly used in the field of meteorology and climatology.

The aim of the present paper is to study the precipitation regime from the standpoint of information theory in climatic conditions obtaining in Estonia. The monthly rainfall totals of Tartu, Pärnu, Vilsandi and Narva-Jõesuu have served as observational data for those years concerning which complete rainfall data have been preserved at all the above-mentioned localities. Such data on Estonia have been preserved for the years 1892—1908, 1921—1943 and 1950—1963, altogether fifty-three years.

1. ON DIVERSITY AND THE AMOUNT OF INFORMATION

Information theory (Вентцель, 1962; Пугачев, 1968; Пузаченко, 1969; Яглом А. М. и Яглом И. М., 1973) reports that the quantitative indicator of the degree of diversity of a random quantity ξ is entropy as defined by C. Shannon by the formula

$$H(\xi) = -\sum_{i=1}^{n} p_i \log_2 p_i \qquad (1)$$

where p_i is the probability of the occurrence of a certain realization

x_i $(i=1, 2, \ldots n)$ of ξ and n is the number of all possible realizations.

Entropy is at its maximum in the case of a uniform distribution $(p_i = \frac{1}{n})$:

$$H_{max}(\xi) = \log_2 n \tag{2}$$

To express the ratio between the entropy obtaining at a factual distribution and the entropy obtaining at a uniform distribution, the following ratio is used:

$$\frac{H(\xi)}{H_{max}(\xi)} = \frac{H(\xi)}{\log_2 n} \tag{3}$$

This formula shows what part the entropy at a factual distribution constitutes of the entropy at a uniform distribution.

When monthly totals of precipitation are studied, we have to do with a system of random quantities and with the entropy of this system. A system of two random quantities (ξ, η) is such a set which is composed of the elements of any combinations of the realisations x_i $(i=1, 2, \ldots n)$ of the random quantity with all the realizations y_j $(j=1, 2, \ldots m)$ of another random quantity η, i. e. the elements of (ξ, η) are the pairs (x_i, y_j). Denoting the probability of the occurrence of (x_i, y_j) with p_{ij}, we obtain from formula (1) the following expression of the entropy of the system (ξ, η):

$$H(\xi, \eta) = -\sum_{i=1}^{n} \sum_{j=1}^{m} p_{ij} \log_2 p_{ij} \tag{4}$$

The entropy of the system (ξ, η) is expressed through the entropies of its components ξ and η by means of the formula

$$H(\xi, \eta) = H(\xi) + H(\eta|\xi) \tag{5}$$

where $H(\eta|\xi)$ is the conditional entropy of η with regard to ξ.

Since the observational data help to determine the quantities of $H(\xi)$ and of $H(\eta|\xi)$, formula (5) is used to determine conditional entropy as follows:

$$H(\eta|\xi) = H(\xi, \eta) - H(\xi) \tag{6}$$

The entropies treated above enable one to establish the amount of information which one random quantity imparts concerning another quantity. According to the information theory the imparted information is the amount which an independent random quantity ξ imparts concerning another random quantity η, which is dependent on ξ, bearing in mind the formula

$$I(\xi, \eta) = H(\eta) - H(\eta|\xi) \tag{7}$$

or formula (6)

$$I(\xi, \eta) = H(\xi) + H(\eta) - H(\xi, \eta) \tag{8}$$

It is obvious that the amount of information $I(\xi, \eta)$ imparted by a random quantity concerning another random quantity depends on how closely these random quantities are correlated.

In the case of complete independence ξ does not impart any information concerning the other quantity and consequently the amount of the imparted information is

$$I(\xi, \eta)=0 \tag{9}$$

which is the minimum value of $I(\xi, \eta)$.

In the case of complete dependence ξ imparts exactly as much information as is necessary to eliminate the diversity of η. For this purpose it is necessary for ξ to impart to η the amount of information

$$I(\xi, \eta)=H(\eta) \tag{10}$$

which represents the maximum value of the imparted information.

It follows from the above that in the case of any degree of dependence the amount of information imparted by ξ to η is

$$0 \leqslant I(\xi, \eta) \leqslant H(\eta \tag{11}$$

Dividing any term of this inequality by $H(\eta)$, one obtains the amount of relative information (Пузаченко, 1969; Mürk, 1974):

$$s(\xi, \eta)=\frac{I(\xi, \eta)}{H(\eta)} \tag{12}$$

which is a standardized quantity changing within the limits of

$$0 \leqslant s(\xi, \eta) \leqslant 1$$

It is easy to see that if ξ and η are independent, $s(\xi, \eta)=0$ and, if they are completely dependent, then $s(\xi, \eta)=1$. Thus $s(\xi, \eta)$ shows what part the information imparted by ξ to η constitutes of the information which is necessary for complete elimination of diversity; at the same time it is an indicator of the degree of dependence of two random quantities.

2. DIVERSITY OF MONTHLY TOTALS OF PRECIPITATION AND THE AMOUNTS OF INFORMATION IMPARTED IN ESTONIA

In climatic reference books the monthly totals of precipitation are given with great accuracy (Table 1). In the present paper the monthly totals have been divided into classes at intervals of 10 mm to render the calculation of the amounts of entropies and information more convenient.

When using the formulas treated above for the study of the precipitation regime, the random quantity ξ is represented by the monthly total of precipitation R_k of the month k (k is the number of the sequence of a month in a year); its particular realizations are yearly amounts of precipitation in the month under study (k) within a 53-year observational period; in the case of the observa-

Table 1

MONTHLY MEAN TOTALS OF PRECIPITATION (IN MM) IN ESTONIA

Locality	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tartu	34	31	29	31	44	67	77	82	61	48	46	40
Pärnu	30	23	24	33	41	52	67	78	66	54	47	41
Vilsandi	35	25	24	26	31	34	47	69	59	61	49	40
Narva-Jõesuu	42	35	30	32	36	52	69	82	64	55	48	45

tional material divided into classes, p_i is the relative frequency of occurrence of the monthly totals of precipitation of a given class, and the random quantity η is the amount of precipitation R_{k+1} of the month k+1 following the month of k.

Further follow entropies of the monthly totals of precipitation $H(R_k)$ (Table 2) in the 53-year period concerning Tartu, Pärnu, Vilsandi and Narva-Jõesuu calculated from the formulas (1) to (3), (8) and (12), entropies at a uniform distribution of precipitation $H_{max}(R_k)$ (Table 3), relative entropies $\frac{H(R_k)}{H_{max}(R_k)}$ at a uniform distribution of rainfall (Table 4), the amount of information

Table 2

Entropies of monthly totals of precipitation $H(R_k)$ in Estonia

Locality	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tartu	2.61	2.55	2.17	2.53	3.01	3.29	3.64	3.86	3.49	3.12	2.90	2,73
Pärnu	2.47	2.24	2.26	2.69	3.01	3.27	3.52	3.72	3.46	3.37	2.99	2.84
Vilsandi	2.60	2.24	2.30	2.32	2.79	2.71	3.22	3.50	3.33	3.48	2.77	2.75
Narva-Jõesuu	2.76	2.49	2.78	2.99	3.22	3.32	3.51	3.81	3.42	3.40	3.24	2.78

Table 3

Maximum entropies of monthly totals of precipitation $H_{max}(R_k)$ in Estonia

Locality	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tartu	3.00	2.81	3.17	3.00	3.70	3.58	4.32	4.09	4.00	3.70	3.70	3.46
Pärnu	3.32	3.17	2.81	3.17	3.81	3.70	3.91	3.91	4.32	3.58	3.91	3.58
Vilsandi	3.58	2.58	2.81	2.58	3.32	3.46	3.70	4.17	3.58	3.81	3.70	3.46
Narva-Jõesuu	3.46	3.00	3.32	3.46	3.81	3.70	4.00	4.25	4.17	4.25	3.81	3.17

Table 4

Relative entropies of monthly totals of precipitation (with regard to max.) $\frac{H(R_k)}{H_{max}(R_k)}$ in Estonia

Locality	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Tartu	0.87	0.91	0.68	0.84	0.81	0.92	0.84	0.94	0.87	0.84	0.78	0.79
Pärnu	0.74	0.71	0.80	0.85	0.79	0.88	0.90	0.95	0.80	0.94	0.76	0.79
Vilsandi	0.73	0.87	0.71	0.90	0.84	0.79	0.88	0.84	0.92	0.91	0.75	0.80
Narva-Jõesuu	0.80	0.83	0.84	0.86	0.85	0.90	0.88	0.90	0.82	0.80	0.85	0.88

imparted by the month under consideration to the following month $I(R_k, R_{k+1})$ (Table 5) and the values of the coefficients of dependence $s(R_k, R_{k+1})$ (Table 6).

It follows from the data presented in the tables:

1) The monthly totals averaged over the period studied are largest in August, smallest in March; they are slightly larger in East Estonia than in West Estonia (Table 1).

2) The diversity of the monthly totals of precipitation all over Estonia in summer is greater than in winter: maximum indeterminacy (3.5 to 3.9 bits) both in the interior and on the sea-coast occurs in August, minimum diversity (2.2 to 2.8 bits) occurs on the coast in February, in the interior in March. The range of entropy on the coastal areas varies between 1.3 and 1.5, in the interior it is 1.7 bits (Table 2).

3) Since greater entropy means greater diversity, the prognostication of precipitation in summer is more complicated than in winter.

4) There is a close positive correlation ($r>0,8$) between the entropy of the monthly totals of precipitation $H(R_k)$ and the monthly totals of precipitation averaged over a long period $\bar{R}_k$.

5) The values of actual entropy $H(R_k)$ account for 68 to 95 per cent (Table 4) of the values of entropy at a uniform distribution $H_{max}(R_k)$ (Table 3).

6) The amount of information which the month under consideration imparts to the following month ranges from 1.1 to 2.0 bits in summer and from 0.3 to 0.7 bits in winter. The amounts of the imparted information on the coast are by a few tenths of bits smaller than in the interior (Table 5).

7) The average precipitation of a given month depends on that of the preceding month more closely in summer than in winter: the amount of the imparted relative information $s(R_k, R_{k+1})$ in the summer months is approximately 0.4—0.5, in the winter months 0.2—0.3.

TRÜ Raamatukogu

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Table 5

Amounts of information imparted on monthly totals of precipitation $I(R_k, R_{k+1})$ concerning consecutive months

Locality	I/II	II/III	III/IV	IV/V	V/VI	VI/VII	VII/VIII	VIII/IX	IX/X	X/XI	XI/XII	XII/I
Tartu	0.47	0.44	0.40	0.81	1.17	1.55	2.04	1.87	1.47	1.09	0.93	0.82
Pärnu	0.37	0.34	0.38	0.95	1.38	1.70	1,75	1.70	1.40	1.03	1.10	0.76
Vilsandi	0.38	0.52	0.36	0.40	0.77	1.09	1.45	1.38	1.48	0.91	0.52	0.85
Narva-Jõesuu	0.69	0.69	0.96	1.18	1.32	1.59	1.91	1.73	1.65	1.56	0 96	0.75

Table 6

Coefficients of the dependence of monthly totals of precipitation $s(R_k, R_{k+1})$

Locality	I/II	II/III	III/IV	IV/V	V/VI	VI/VII	VII/VIII	VIII/IX	IX/X	X/XI	XI/XII	XII/I
Tartu	0.31	0.18	0.20	0.16	0.27	0.35	0.43	0.53	0.54	0.47	0.38	0.34
Pärnu	0.17	0.15	0.14	0.32	0.42	0.48	0.47	0.49	0.42	0.34	0.39	0.31
Vilsandi	0.17	0.23	0.16	0.14	0.28	0.34	0.42	0.42	0.43	0.33	0.19	0.33
Narva-Jõesuu	0 28	0.25	0.32	0.37	0.40	0.45	0.50	0.50	0.49	0.48	0.34	0.27

8) There is a rather close negative correlation between the entropies of the monthly totals of precipitation and the entropies of the average monthly temperatures (on the coast $r = -0.66$, in the interior $r = -0.83$).

SUMMARY

According to the data on a 53-year-long series of meteorological observations there is a close positive correlation between the monthly totals of precipitation and their entropies (i. e. diversities of the distribution of precipitation) in Estonia (at the localities of Tartu, Pärnu, Vilsandi and Narva-Jõesuu): the correlation coefficient varies from 0.84 to 0.96, depending on the particular locality.

The amount of information which the month under study imparts to the following month on the monthly totals of precipitation ranges between 1.1 and 2.0 bits in the summer months and between 0.3 and 0.4 bits in the winter months; under the influence of the Baltic Sea the amounts of information imparted to the next month are on the coast by a few tenths of a bit smaller than those in the interior of the country. The dependence of the monthly totals of precipitation, which is characterized by the imparted relative information $s(R_k, R_{k+1})$ between the consecutive months varies approximately from 0.4 to 0.5 in the summer months and from 0.2 to 0.3 in the winter months.

There is a negative correlation between the monthly totals of precipitation and the diversities of the mean temperatures of the same months (Shannon's entropies), the values of varying from −0.66 to −0.83.

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SADEMETE KUUSUMMADE MITMEKESISUS EESTIS

H. Mürk

Resümee

53-aastase vaatlusrea andmeil on Eestis (Tartus, Pärnus, Vilsandis ja Narva-Jõesuus) sademete kuusummade ja nende entroopiate (jaotuse määramatuse) vahel tugev positiivne korrelatiivne seos: olenevalt kohast muutub korrelatsioonikoefitsient 0,84 kuni 0,96.

Informatsiooni hulk, mida vaadeldav kuu annab järgmisele kuule sademete kuusummade kohta, on suvekuudel 1,1—2,0, talvekuudel 0,3—0,4 bitti, kusjuures mere mõjul on üleantud informatsiooni hulgad rannikul mõne kümnendiku biti võrra väiksemad kui sisemaal. Sademete kuusummade sõltuvus, mida iseloomustab üleantud relatiivne informatsiooni hulk $s(R_k, R_{k+1})$ naaberkuude vahel, on suvekuudel ligikaudu 0,4—0,5, talvekuudel 0,2—0,3 ümber.

Sademete kuusummade ja sama-kuude keskmiste temperatuuride määramatuste (Shannoni entroopiate) vahel on negatiivne korrelatsioon ($r = -0{,}66$ kuni $-0{,}83$).

О НЕОПРЕДЕЛЕННОСТИ МЕСЯЧНЫХ СУММ ОСАДКОВ В ЭСТОНИИ

Х. Мюрк

Резюме

По данным наблюдений осадков в Эстонии (Тарту, Пярну, Вильянди и Нарва-Йыэсуу) неопределенность (энтропия по Шеннону) распределения месячных сумм осадков сильно зависит от средних месячных сумм осадков: между ними имеется сильная положительная корреляция ($r = 0{,}84 \ldots 0{,}96$). Максимальное значение энтропии в августе, минимальное — в феврале-марте.

Количество информации, которое передается от одного месяца к следующему о месячных суммах осадков в летних месяцах около 1,1 . . . 2,0, в зимних месяцах 0,3 . . . 0,4 бита.

Между неопределенностями месячных сумм осадков и средних месячных температур существует сильная положительная корреляция.

INVESTIGATION INTO THE MICROCLIMATE OF THE LANDSCAPE UNITS IN THE ESTONIAN S.S.R.

J. Jõgi, P. Karing, A. Raik

INTRODUCTION

The metabolic and energy exchange processes important for the development of landscape units are closely dependent on the characteristics of the meteorological regime of the air-layer near the earth's surface. Therefore a study of the microclimatic peculiarities plays an important part in detailed investigation of the physical and geographical characteristics of a given territory.

It also has a great practical importance. The importance of such studies grows in accordance with the rise of the level of agrotechnics, more thoroughly planned amelioration work, the elaboration of plans for more varied recreational activities, a better understanding of the problems of ecology and environment protection and a deeper insight into the laws of nature in general. In actual fact, however, unduly little attention is paid to the practical application of microclimatic data which can partly probably be explained by the methodological difficulties in getting such data for more extensive areas.

The aim of the present article is to give a survey of the principles and methodology of detailed microclimatic studies in the ESSR and of the results obtained so far.

THE INITIAL CONCEPTION OF RESEARCES

Processes influencing the meteorological regime of the air layer near the earth's surface — transformation of radiation flows, evaporation, heat flow into the air and soil, etc. are formed due to the influence of the structure of the active surface, the essential components being the relief, the surface cover, the type of soil and its mechanical composition. On the earth's surface these components are systemically organized into natural-territorial complexes. The methodology for mapping and studying such complexes has been elaborated by the landscape science branch of Soviet physical geography. Facies — an area in the boundaries of which all landscape components are uniform has been considered the smallest landscape component i. e. a methodology applied at the present time in large-scale studies does not bring out such changeability in the characteristics of the components that would exceed the exactness with which they were determined.

It can logically be concluded that if the factors forming the microclimate make up a landscape complex, a certain type of microclimate is formed in the boundaries of such units, that a certain type of microclimate corresponds to a certain type of landscape unit. The meteorological regime of the air-layer hear the earth's surface within the boundaries of a facies is treated as elementary microclimate.

Microclimate can be considered on the one hand a component of the landscape and on the other hand a phenomenon conditioned by the rest of the components, by the territorial complex made up by them. We cannot deal closer with the differences of these two approaches in the present article. We only point out that in either of these approaches the microclimatic boundaries must coincide with those of the landscape.

Microclimatic studies, mapping and analysis on the basis of landscape data we call the landscape conception of microclimate. One of the methodological problems of microclimatic studies that can be solved applying the landscape conception is the spatial extrapolation of observation data. The latter is one of the most difficult problems to be solved in microclimatic mapping. According to the landscape conception the landscape structure of an area reflects its microclimatic structure, we can pass over from statistical areal landscape characteristics to microclimatic characteristics of the same type, and the dividing of the landscape into regions forms the basis for microclimatic division (Райк, 1971).

It must be pointed out that microclimatic mapping according to landscape characteristics not directly on the basis of the parametres of the meteorological fields in the air-layer near the earth's surface should not be considered an emergency way out. We speak about genetic mapping when phenomena causing microclimatic differences are taken as the basis for the delimitation of areas (Райк, 1965).

METHODOLOGY OF COMPILING LARGE-SCALE MICROCLIMATIC MAPS WITH THE HELP OF A COMPUTER

A methodology has been worked out for mapping the microclimatic components and complexes and for the analysis of such maps with the help of a computer with a view to the needs of the detailed microclimatic studies of extensive areas (Каринг, 1974, Каринг, Йыги, 1974). Computers can be used thanks to the fact that the necessary methodology has been worked out for characterizing the distribution of the basic microclimatic elements and general correction tables have been drawn up for the following components: direct solar radiation and radiation balance (Голубова, 1967) several characteristics of the thermal regime of the air (Гольцберг, 1961, Мищенко, 1962), temperature of the active surface (Мищенко, 1971), soil moisture (Романова, 1971), wind precipitation (Романова, 1967), etc.

The scheme of the study is as follows. The general climatic background, the basis for calculating the microclimatic characteristics of a period of many years, is determined by means of the distribution maps of the climate elements and the observation data of the nearest meteorological station. By means of observations in nature the influence of different landscape components on the deviation value from the general climatic background is determined. On the basis of the data obtained a classification of geocomplexes is compiled according to their influence on the microclimate. The classification is presented as a microclimatic correction table. A unit is distinguished even if it brings about the gradation cell.

A microclimatic correction table (Table 1) for the hilly landscape of the south-eastern part of the Estonian S.S.R. (Йыги, 1974, Каринг, Йыги, 1974) was compiled on the basis of the data collected since 1968 by the observation net and the expeditions (Раудсепп, 1970, Юлейые, 1973, Каринг, 1972). Table 1 gives corrections of microclimatic mapping units for the following characteristics: direct solar radiation, radiation balance, minimum temperature, soil moisture, velocity of the wind, redistribution of precipitation under the influence of the wind, precipitation-water redistribution on the slope, moisture balance. For considerations of space the values of the corrections are not given.

The study and mapping of the microclimate is hindered by the fact that landscape mapping is being carried out for small areas only. In Estonia the problem can be solved by making use of the large-scale soil maps which are being compiled for the whole arable land, and which, due the complex methodology applied, approximate analytico-synthetical landscape maps. The properties of soil as an important factor of forming the microclimate are presented multifariously and in detail on those maps. The characteristics of another decisive factor, the relief, are not presented directly, and bringing them out requires additional efforts.

A network is transferred to a large-scale landscape map which is assumed as the basis for studying the microclimate. The type of landscape is determined for each mesh by means of the above classification of the microclimatic correction table and its index

Table 1

Classification of landscape complexes according to their influence on the microclimate in conditions of hilly relief.

Relief element, exposition	Incline	Part of slope	Properties of soil
Ceiling	The slope below 3°—12° (or: over 12°)	—	sand sandy loam sandy clay
Southern (or eastern, or western, or northern) slope	3°—12° (or: over 12°)	upper	sand sandy loam sandy clay
		middle	sand sandy loam sandy clay
		lower	sand sandy loam sandy clay
		foot	sand sandy loam sandy clay
Plain between hills	—	—	sand sandy loam sandy clay peat excessively moist mineral soil

is fed into the memory of the computer, like the characteristics of the climatic background and the correction table.

The computation is typed in the form of a microclimatic cartogram, a computer map, and the numerical characteristics of the area investigated are presented as a system of characteristics based on the areas occupied by different types of the microclimate.

ON TEMPORAL AND TERRITORIAL CHANGEABILITY OF THE MICROCLIMATE OF FIELDS

Detailed investigations into the temporal and territorial changeability of the microclimate have been carried out on an about 100 hectares' area of the hilly landscape of the south-eastern part of Estonia. 27 fields have been formed on this area in the course of land cultivation. Maps of single microclimatic components and of the artifical regulation norms of the soil water regime have been compiled for the area. Both microclimatic characteristics for single fields and the temporal changeability of these characteristics have been calculated by means of computer maps.

The territorial distribution of the microclimate of the given area is characterized by the following characteristics:

— the areally weighed value of an element
— the area (in per cent) showing a similar value of an element
— the number of gradations present
— indices of the microclimatic heterogeneity of the territory; the similarity coefficient of the structure of the gradation of elements as a complex has been given according to U. Mereste (1962).

The temporal changeability of the microclimate is characterized by the calculation results in which differently guaranteed characteristics of the climatic background have been used as initial data.

We shall give some explanations below about the data of the indication tables for the territorial and temporal changeability of the field microclimate calculated by means of computer maps.

A steady increase above 10° C of the average day-and-night soil temperature at the depth of 10 cm which indicates the proper time for spring sowing, has in the average picture of the fields investigated for many years been connected with the following date limits: up to May 8, May 12, May 16, May 20 and later. It becomes evident that one field out of 27 entirely falls under one gradation, 9 fields are limited to 2 gradations, but on 3 fields even all 3 gradations are represented. It appears that the optimum sowing time for the component parts of the majority of fields fluctuates around 10 days.

In the formation of field expanses the cultivator has naturally strived to establish the most rational contours. Consequently the above figures testify to a high complexity of landscape conditions. As a matter of fact in $^2/_3$ of the fields the gradation of the temperature rise above 10° C involves $^3/_4$ or more of the area.

The average thermal characteristics of the fields are calculated applying the weighed average formula. The values of the parts weighed are proportional to the areas of similar soil temperature. It appears that the dates of the interval of the dominating soil temperature and those of the soil temperature above 10° C calculated by means of the weighed average formula do not in most caser coincide.

Productive humidity reserves of a 0—50 cm thick soil layer in the spring period on the area investigated range as follows: from 50 to 75 mm, 75—100 mm, 100—125 mm, 125—150 mm, over 150 mm. It view of humidity fields prove to be even less uniform that in view of temperature — more than half of the fields have all 5 gradations of humidity reserve mentioned above. The weighed averoge values of the humidity reserve of a field do not in most cases coincide with the values of the dominating soil humidity. There are fields in the area investigated where the average humidity reserve remains under 75 mm as well as fields where it exceedes 150 mm.

The calculation of the climatological values of the artificial regulation norms of water regime is of interest with a view to the solution of the problems of environmental change and the functioning of a number of natural complexes. The above — mentioned values are calculated by means of the following formula

$$\Delta W = E_p - W_{HO} - X_P \qquad /1/$$

ΔW — climatological norm for artificial regulation of water regime
E_p — summary evaporation in case of optimal reserve of soil moisture
X_p — precipitation taking into account the influence of the wind and water redistribution on the slope

$W_{HO} = W_H - W_K$

W_H — water reserve of a 0—50 cm thick soil layer
W_K — critical value of soil moisture

ΔW was computed for the average regime of a period of many years, as well as for the years with different radiation balance and precipitation guarantee.

The summary evaporation E_p for mineral soils has been calculated by means of the following formula

$$E_p = \alpha(R_p - B) \qquad /2/$$

R_p — radiation balance of the slopes with a certain exposition and incline
B — heat flow into soil
α — coefficient calculating the state of plant cover and turbulent heat exchange

Since a two-sided regulation of water regime takes place on the areas predominantly covered with perennial grasses the coefficient α has been determined taking into account the peculiarities of such plants. It was found out as a result of field observations in 1968—1972 that in the Estonian conditions the value of the coefficient α is approximately 0.70.

Heat flow into soil in the cross-section of a langer period is quite a small quantity in comparison with the other components of heat balance, and it is very difficult to measure it (Адаменко, 1972). Therefore in our calculations heat balance equals to 10% of the values of radiation balance. The radiation balance of the slopes was calculated on the basis of the radiation balance of level areas applying a methodology suggested by I. G. Golubova (Голубова, 1967).

Evaporation from peat mold was calculated by means of the following formula

$$E_t = \beta \cdot R \qquad /3/$$

E_t — evaporation from peat mold covered with perennial grasses in case of optimal reserves of soil moisture

R — radiation balance of a level area

β — (biological) coefficient which in the Estonian conditions equals to 1.0

The precipitation of level areas was determined on the basis of the observation data of the nearest meteorological station while the redistribution on a hilly area under the influence of the wind was calculated applying the results obtained by I. Sandsberg (1970), and the redistribution of precipitation on the slopes was calculated by means of Romanova's methodology (Романова, 1971).

Reserves of soil moisture in spring are given in E. N. Romanova's article. The critical moisture on the slopes was considered 60% of the smallest field water capacity.

ΔW gradation value was considered to be 30 mm, this quantity being the smallest watering norm in present — day agricultural practice (Тамм, 1972). The change of ΔW at the interval from -15 to $+15$ mm was considered as optimal moisture indicator. According to Formula /1/ the negative value of ΔW points to areas with excessive humidity, whereas the positive value indicates a dangerous situation of drougth.

Values of the artificial regulation norm of water regime (ΔW) have been calculated for the months of May and June. One some parts o the field ΔW values remain under -45 mm while on others they are over $+45$ mm, all 5 gradations of 30 mm being represented. In eight fields out of 27 investigated all 5 gradations are present, 9 fields have 4 gradations. Areas with excessive humidity tend to prevail on the territory investigated.

Besides the territorial heterogeneity of microclimate we can notice its temporal changeability which depends on changes in general weather conditions.

In order to characterize temporal changes of humidity condi-

Table 2

Values of the territorial characteristics of the distribution of artifical regulation norm of the soil water regime (ΔW) in accordance with precipitation guarantee of 9—10 per cent and radiation balance guarantee of 10—90 per cent in the month May

Guarantee		Areas with the same value of ΔW (per cent of the whole territory)								Weighed average values of ΔW on the territory in mm	Similarity coefficient of the structure
Precipitation	Radiation balance	+46 up to +75 mm	+16 up to 45 mm	+15 up to −15 mm	−16 up to −45 mm	−46 up to −75 mm	−76 up to −105 mm	−106 up to −135 mm	−136 up to −165 mm		
10	90	—	—	—	10.45	15.72	29.18	18.95	25.70	−76 up to −105	0.73
20	80	—	—	4.45	20.53	29.29	17.05	28.68	—	−46 up to −75	0.41
30	70	—	—	17.05	13.67	24.63	20.63	24.02	—	−46 up to −75	0.89
40	60	—	—	24.94	29.34	17.51	28.21	—	—	−16 up to −45	0.93
50	50	—	11.32	19.41	24.63	20.63	24.01	—	—	−16 up to −45	0.84
60	40	—	17.05	13.67	29.13	40.15	—	—	—	−16 up to −45	0.70
70	30	—	19.01	34.67	20.02	25.70	—	—	—	−16 up to −45	0.90
80	20	8.50	19.20	27.65	20.63	24.02	—	—	—	−15 up to −15	0.70
90	10	17.05	13.67	24.63	44.65	—	—	—	—	−15 up to −15	0.66

tions ΔW values have been calculated in case of different guarantees of radiation balance and precipitation (10, 20 ... 90%).

To show how the values of the artificial regulation norm of water regime for the given area are calculated, we shall give a variant which presupposes the change of the quarantees of radiation balance and precipitation in the reverse direction. Such a tendency is quite common in nature. As can be seen from Table 2, the total number of gradation is 8, but for every concrete variant of the general climatic background there are 4—5 gradations. It should be noted here that high radiation balance guarantee points to its low value, whereas high precipitation guarantee corresponds to scanty precipitation.

SUMMARY

The course of the analysis confirms the judgement that the system of microclimatic areal characteristics used in the article works efficiently, the characteristics sensitively react to the changes in both the physico-geographical and weather conditions.

The application of the landscape conception should be taken as a perspective scientific foundation for the mapping and analysis of the microclimate of a territory.

It is expedient to use computers in compiling microclimatic maps, characterizing the territorial distribution of the solutions of various equations, calculating areal characteristics as well as the changeability of the general climatic background through guarantees. It will create new broad prospects for microclimatic studies both theoretical and practical.

The results obtained in the work show that the variability of the characteristics of heat and water regime in the Estonian hilly landscape is so great even within one field, that it must by all means be taken into consideration in fixing the proper time for field work, designing amelioration projects and determining watering norms. The changeability of the Estonian weather causes an extensive temporal variability of microclimatic conditions.

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MAASTIKULISTE KOMPLEKSIDE MIKROKLIIMA UURIMINE EESTI NSV-s

J. Jõgi, P. Karing, A. Raik

Resümee

Maalähedase õhukihi ja mulla hüdrotermilist režiimi kujundavate faktorite (reljeef, mulla liik ja mehhaaniline koosseis, veerežiim, taimkate) süsteemsest organiseeritusest looduslik-territoriaalseteks kompleksideks tuleneb järeldus, et igale maastikulisele üksusele peab vastama kindel mikrokliima. Sellist juurdeminekut nimetavad autorid mikrokliima maastikuliseks kontseptsiooniks, mis on perspektiivne mikrokliima tunnetamisel ja uurimisel, seejuures vaatlusandmete territoriaalsel ekstrapoleerimisel, mis on mikrokliima kaardistamise aluseks. Mikrokliima uurimist maastikulisel alusel tuleb lugeda geneetiliseks uurimiseks.

Esitatakse metoodika mikrokliima üksikelementide ja komplekside kaardistamiseks ja analüüsimiseks raali abil. Raalitöötluse aluseks on kliimafooni andmed, mille määramisel tuginetakse lähimatele meteoroloogiajaamadele, maastikulised karakteristikud, mis määratakse peamiselt suuremõõtkavalise mullakaardi järgi, ning mikrokliima parandid, mis leitakse mikroklimaatilistest vaatlusandmetest lähtudes.

Viimaste alusel on välja töötatud maastikuliste komplekside klassifikatsioon nende mõju järgi mikrokliimale künkliku reljeefi tingimustes; tabelis 1 eristatud üksuste kohta on sedastatud mikrokliima karakteristikute parandid. Töötlusse hõlmatavad andmed viiakse raali mällu aluskaardile kantava võrgustiku silmade kohaselt. Raaliarvutuste tulemused trükitakse välja mikrokliima kartogrammina, raalikaardina.

Esitatakse uurimistulemused Karula kõrgustiku 100 ha suuruse, 27 väljaks jaguneva ala kohta. Soojusrežiimi iseloomustatakse mullatemperatuuri 10 cm sügavusel püsivalt üle 10° tõusu kuupäevaga, niiskust mulla kevadise produktiivse niiskuse varuga 50 cm kihis. Integraalse karakteristikuna rakendatakse veerežiimi kunstliku reguleerimise normi arvutuslikku klimatoloogilist väärtust (valemid 1, 2, 3).

Mikrokliima territoriaalsete erisuste iseloomustamisel rakendatakse pindalalisi karakteristikuid. Ilmneb, et enamiku põldude piires erinevad nii temperatuuri- kui ka niiskuseolud suuresti, mida tuleb arvestada põllutöödel ja veerežiimi reguleerimisel.

Mikrokliima võimaliku ajalise muutlikkuse iseloomustamiseks on arvutatud mulla veerežiimi kunstliku reguleerimise normi vahemike pindalaline osatähtsus kogu uuritaval alal kliimafooni karakteristikute, kiirgusbilansi ja sademete hulga, erineva (10, 20 ... 90%) kindlustatuse korral. Tabelis 2 on toodud variant, kus kiirgusbilansi ja sademete hulga kindlustatused muutuvad vastassuunas; selline tendents esineb küllalt sageli.

ИССЛЕДОВАНИЕ МИКРОКЛИМАТА ЛАНДШАФТНЫХ КОМПЛЕКСОВ В ЭСТОНСКОЙ ССР

Я. Йыги, П. Каринг, А. Райк

Резюме

С системной организацией в природно-территориальные комплексы факторов, формирующих гидротермический режим приземного слоя воздуха и почвы (рельеф, вид и механический состав почвы, увлажненность, растительный покров), напрашивается вывод, что каждой ландшафтной единице должен соответствовать определенный микроклимат. Данный подход назван авторами ландшафтной концепцией микроклимата. Она считается перспективной при исследовании микроклимата, в частности при территориальной экстраполяции результатов наблюдений, являющейся основой микроклиматического картирования. Исследование микроклимата на ландшафтной основе следует считать исследованием генетическим.

Разработана методика картирования и анализа микроклиматических элементов и комплексов с помощью ЭВМ. Основой при этом являются показатели общеклиматического фона, при определении которых опираются на данные ближайших метеостанций, характеристики ландшафта, определяемые прежде всего по крупномасштабной почвенной карте, и микромлиматические поправки, которые устанавливаются исходя из данных микроклиматических наблюдений. На базе последних разработана классификация ландшафтных комплексов по воздействию их на микроклимат в условиях холмистого рельефа; по выделенным единицам (таблица 1) установлены поправки микроклиматических характеристик. Включаемые в обработку данные вводятся в память ЭВМ по узлам сетки, наложенной на исходную карту. Результаты произведенных на ЭВМ разработок выпечатаются в виде машинной карты.

В статье излагаются результаты исследования микроклимата территории с площадью в 100 га, разделенной на 27 полей, в холмистом рельефе юго-востока Эстонии. Термический режим характеризуется датой устойчивого перехода температуры почвы на глубине 10 см через 10°, увлажненность — весенним запасом продуктивной влаги в 50 см слое. В качестве интегрального показателя применяется расчетное климатологическое значение нормы искусственного регулирования водного режима (формулы 1, 2, 3).

Для описания территориальных различий микроклимата применяются площадные характеристики. Оказывается, что отдельные части большинства полей сильно различаются друг от друга по температуре и влажности, что нужно учитывать при земледелии и регулировании водного режима.

Для характеристики возможной временной изменчивости микроклимата расчитаны площадные значения градаций норм искусственного регулирования водного режима почвы по всей исследоваемой территории при различной обеспеченности (10, 20...90%) характеристик общеклиматического фона — количества осадков и радиационного баланса. В таблице 2 приведен вариант, при котором обеспеченности рациационного баланса и количества осадков изменяются в противоположных направлениях, что в действительности встречается нередко.

CURRENTS IN THE STRAITS OF THE VÄINAMERI

H. Mardiste

The Väinameri is a part of the Baltic Sea located between the West-Estonian Archipelago (Saaremaa, Hiiumaa) and the Estonian mainland. The area of the Väinameri is over 2,000 sq. km, its mean depth is about 5 m and the greatest depth amounts only to 22 m. The Väinameri is connected with the open sea and the Gulf of Riga through the following straits: the Voosi Strait between the mainland and Vormsi Is., the Hari Strait between the islands of Vormsi and Hiiumaa, the Soela Strait between the islands of Hiiumaa and Saaremaa and the Large Strait between Muhu Is. and the mainland; a causeway was constructed across the Small Strait between the islands of Saaremaa and Muhu in the last

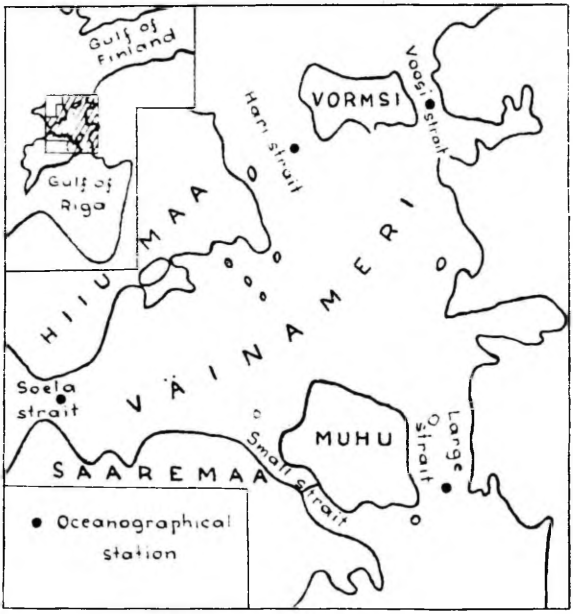

Fig. 1. The Väinameri.

decade of the 19th century. As to the natural conditions the area of the Väinameri is one of the most peculiar regions of Estonian coastal waters (Mardiste, 1971). The Väinameri has also a great importance in the economy of the Estonian S.S.R., particularly in fishery, aquaculture and recreation.

The present article is composed on the basis of the data collected by the Hydrometeorological Service of the Estonian S.S.R. in the straits by means of marine current meters in 1958—1969. The number of the stations in the straits and frequency of the observations in them varied during the above-mentioned period. It was the greatest in the central points (stations) of the straits — in the Voosi Strait 199, in the Hari Strait 292, in the Soela Strait 397 and in the Large Strait 360 observations. The registered data were divided according to the force of the wind into three groups: 1—2, 3—4 and 5—6 (Beaufort scale) and according to the direction of the wind into 8 groups. In every group the mean direction and velocity of the currents was calculated (Table 1). The mean direction of the currents was found by the geometrical method, i. e. as a sum of the vectors of single measurements. As the direction of the currents in the straits corresponds to the direction of the wind, those cases where the direction of the currents was opposite to that of most observations, were omitted from the calculations. Analysis of these cases showed that before the recordings the direction of the wind had changed, but the direction of the currents had not yet changed. In the case of those directions of the wind which are transitional with regard to the change of the direction of currents to the opposite direction, the prevailing direction of the currents is shown in the Table 1.

For the calculation of water transport the data of the current recordings in the straits in 1958—1962 were used. The number of the stations in the straits was as follows (the number of recordings in the cross section of the strait is shown in brackets): in the Hari Strait — 6 stations (14 recordings), in the Voosi Strait — 3 stations (4 recordings), in the Soela Strait — 6 stations (12 recordings) and in the Large Strait — 6 stations (20 recordings). Volume transport was calculated (altogether 364 cases) by the graphic method used in the calculation of river discharge. The changes of the cross section of the straits connected with fluctuations of water level were not taken into consideration as they are small ones. The volume transport on the basis of recordings made at the time of weak or changeable winds was not calculated.

The main force generating currents in the Väinameri, as in the whole of the Baltic, is the wind. Variability of the wind causes a great variability of currents. Directly registered currents in most cases are not only wind currents. Aside from the stream caused by the wind other components may occur in the observed current: density current, compensation current, etc. Separation of

Table 1

Mean direction (in degrees) and velocity (cm/sec) of currents

Wind (Currents) Dir.	Force	Hari Strait Dir.	Hari Strait Velocity	Hari Strait Number of rec.	Voosi Strait Dir.	Voosi Strait Velocity	Voosi Strait Number of rec.	Soela Strait Dir.	Soela Strait Velocity	Soela Strait Number of rec.	Large Strait Dir.	Large Strait Velocity	Large Strait Number of rec.
N	1—2	161	17,9	10	144	14,7	7	287	9,4	9	163	17,4	7
	3—4	161	22,6	35	147	19,1	22	275	18,2	14	167	17,9	23
	5—6	—	—	—	—	—	—	—	—	—	181	30,8	5
NE	1—2	162	18,5	4	140	11,0	1	299	15,6	7	155	9,2	6
	3—4	165	20,2	6	163	22,4	8	285	16,6	20	186	12,3	11
	5—6	158	45,0	3	—	—	—	—	—	—	269	20,0	1
E	1—2	325	12,2	6	193	7,0	2	309	10,5	8	328	17,3	3
	3—4	317	17,9	12	156	12,4	7	305	17,1	27	332	21,1	11
	5—6	—	—	—	150	22,0	1	288	30,3	3	—	—	—
SE	1—2	341	15,8	5	360	13,0	6	314	10,3	6	334	17,4	14
	3—4	333	18,2	25	341	17,7	17	314	11,6	22	332	20,7	26
	5—6	336	29,5	4	336	27,0	1	333	15,7	4	343	20,3	6
S	1—2	339	11,7	7	347	13,2	8	92	13,4	11	336	15,2	17
	3—4	350	20,4	31	349	22,8	20	92	15,4	20	346	22,9	24
	5—6	342	35,9	10	352	25,7	9	68	9,0	1	350	31,0	3
SW	1—2	63	7,0	7	—	—	—	96	13,7	9	314	12,4	17
	3—4	351	25,4	29	354	28,7	19	90	15,5	26	335	20,6	23
	5—6	347	32,9	8	343	38,7	9	97	25,3	6	327	31,6	11
W	1—2	342	6,2	6	339	16,3	3	100	12,7	12	135	16,6	3
	3—4	356	18,1	12	347	23,1	7	100	13,4	32	160	15,4	11
	5—6	345	30,3	3	341	29,0	2	118	21,0	2	—	—	—
NW	1—2	170	16,0	10	144	19,0	3	99	12,2	2	165	13,0	6
	3—4	158	25,7	36	134	16,2	15	102	13,4	28	168	20,7	21
	5—6	153	23,6	8	142	18,0	3	110	25,5	4	178	18,7	3

these components from the data obtained by the current meters, particularly in the case of narrow straits, is difficult. On this account the directly measured currents are dealt with. It is correct to designate these currents as summary currents. As only the data of summary currents are used in this article, the term "current" is used instead of the term "summary current" for the sake of brevity.

From the data presented in Table 1 it appears that the velocity of the currents depends on the direction and on the speed of the wind. As the mean speed of the wind in the region of the Väinameri is 5—6 m/sec, mainly the data of the currents observed during winds of force 3—4 as being near to the mean conditions are used to analyse the currents. The prevalent number of the observations was made in the case of such winds.

The mean velocity of the surface currents in the centre of the straits of Hari, Voosi and Large is 20—22 cm/sec. Close to this or a little greater may be the velocity of the currents in the narrowest part of the Soela Strait. According to the direct measurements made systematically in the wider eastern part of the strait (area of the cross section 14,700 m^2), the mean velocity of the currents in case of wind force 3—4 is 14.7 cm/sec (208 recordings), but reducing the mean volume transport of that section (2,000 m^3/sec) to the narrowest part of the strait (cross section 8,100 m^2) we obtain a mean velocity of the surface currents of about 25 cm/sec. Measurements made in 1951—1957 in a little wider western part of the strait corroborate the validity of the latter value. In case of winds of force 3—4 (39 measurements) the mean velocity of the currents was 21.4 cm/sec. The greatest mean velocities of the currents of the Väinameri occur in the Large Strait between the islands of Muhu and Kesselaid. Somewhat to the north from the narrowest part of the strait the mean velocity of 30 recordings at wind force 3—4 is 27.3 cm/sec.

In the open part of the Väinameri the currents are about three times weaker than in the straits in case of the same speed of the wind. Very weak is the movement of the water in the Kassari Bay, where the mean velocity is only 5—6 cm/sec.

The maximum mean velocities of the currents at force 3—4 are as follows: the Hari Strait — 26 cm/sec (NW wind), the Voosi Strait — 29 cm/sec (SW wind), southern part of the Large Strait — 23 cm/sec (S wind) and between the islands of Muhu and Kesselaid — 31 cm/sec (S wind). The appearance of greater streams in case of these winds can be explained by the configuration of the coastline — the winds press the water masses into the straits like into a funnel.

Heavy winds produce very strong currents in the straits. Maximum registered velocities during the study period are the following: in the Hari Strait — 75 cm/sec, in the Voosi Strait —

58 cm/sec, in the Soela Strait — 54 cm/sec and in the Large Strait between the islands of Muhu and Kesselaid — 75 cm/sec. The wind force was 5—6 and besides comparatively few measurements have been made during such heavy winds. With more heavy winds the velocity of the currents may exceed 100 cm/sec. In November 1906, J. Mey (1924) recorded the strongest known stream of the Väinameri — 206 cm/sec in the Soela Strait. The wind conditions at the time of the recording are unknown. According to the same author the highest velocities were in the Hari Strait — 77 cm/sec, in the Large Strait — 103 cm/sec and in the Voosi Strait — 154 cm/sec.

With depth the velocity of the currents decreases. Due to the shallowness of the straits the currents measured at 0.5—1 m from bottom are still considerable. So the bottom currents of the Hari Strait (in the depth of 10 m) are 9 cm/sec, of the Voosi Strait (5 m) 8 cm/sec and of the Soela Strait (8 m) 3 cm/sec weaker than the surface one. Bigger differences of these values occur in the case of wind directions that induce the strongest surface currents. At wind force 3—4 the bottom currents are 8—9 cm/sec weaker than the surface currents. At the time of the strong surface currents the stream is strong within the whole profile. For example, in November 25, 1969 in the Hari Strait the velocities were: 75 cm/sec at the surface, 62 cm/sec at 5 m and 57 cm/sec at 10 m.

The direction of the currents depends upon the direction of the wind and orientation of the straits (Fig. 2). The currents of every strait have two general directions: into the Väinameri or out from the Väinameri. Only at low winds and weak currents the direction of the currents is indistinct. In the case of winds of the same direction but transitional concerning the change of the direction of the currents, the latter may have either direction. Such are NE and W winds in the Hari Strait, ESE and NE winds in the Voosi Strait, ENE winds in the Large Strait and N and S winds in the Soela Strait.

We have few data on the time necessary for the change of the direction of the currents and for obtaining the velocities corresponding to the speed of the winds. On the ground of these data we may assert that after a rapid and considerable change (90—180°) of the direction of the wind as well as in the cases when the wind has a force of 4—5, the direction of the currents changes to the opposite during 3—4 hours and the velocity acquires a permanent value after 5—6 hours respectively. In the cases of the slow veering of the direction and also on the occasion of slow winds the direction of the currents changes only 6—10 hours after the change of the direction of the wind and the velocity acquires a permanent value 10—12 hours later. According to the literature currents in the open Baltic need 10—12 hours (Бетин, Пантелеев, 1970)

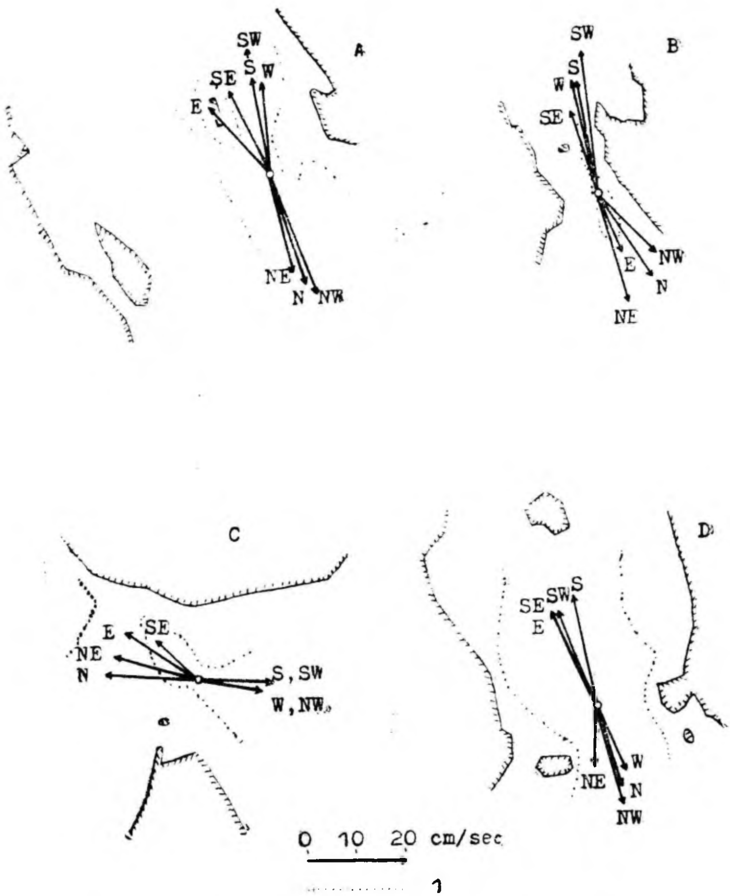

Fig. 2. The mean direction and velocity of the surface currents depending on the direction of the wind at force 3—4 in the centre of the straits of Hari (A), Voosi (B), Soela (C) and Large (D). 1 — isobath of 5 m.

and the currents in the gulfs of Finland and Riga about 12 hours (Соскин, 1964) to acquire a permanent value.

Because of limited data the frequent occurrence of opposite directions of the surface and bottom currents, particularly in the line of the straits of Large and Hari, was previously emphasized. Numerous later measurements do not confirm this. In the relatively deep Large Strait the directions of the surface and bottom currents have been opposite in 4—5 per cent of the recordings, in the straits of Hari and Soela this has been the case in only 2 per cent of observations. In most such cases the velocities of the currents have been weak — below 10 cm/sec. The currents of opposite directions are mostly caused by a change of the direction of the wind before observations: the influence of the new wind does not reach the deep layers of the water.

As continuous recordings of the currents are lacking, we may judge the frequency of the direction of the currents on the ground of frequency of wind directions. The mean month frequency of the latter on the basis of the observations of five coastal hydrometeorological stations of the Väinameri according to M. Mardiste (Мардисте, 1967) is presented in Table 2.

Table 2

Frequency of wind direction in the Väinameri in per cent

Month / Direction	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
N	8	8	9	12	16	12	12	10	12	9	8	6	10
NE	9	10	9	10	13	7	10	9	7	7	6	6	9
E	11	12	12	8	8	6	9	7	7	9	13	13	10
SE	13	14	13	15	9	9	8	11	11	11	19	17	12
S	19	17	15	17	11	13	12	13	16	18	20	21	16
SW	19	15	15	15	15	22	18	22	21	22	17	20	18
W	12	11	13	9	9	14	14	14	12	13	9	10	12
NW	9	13	14	14	19	17	17	14	14	11	8	7	13

In the case of most directions of the wind the schemes of the currents in the Väinameri as compiled by us are well connected with schemes of the currents of the neighbouring parts of the sea compiled by other authors (Баранов, 1970; Бетин, Пантелеев, 1967, 1970; Соскин, 1961).

Water exchange through the straits lying between the Väinameri and the Baltic proper and the Gulf of Riga is an essential factor forming the hydrological and hydrochemical regime of the Väinameri. The intensiveness of the water exchange is characterized by the transport in the straits.

In mean wind conditions the mean transport through the straits is as follows: Large Strait — 8,000 m³/sec, Hari Strait — 7,000 m³/sec, Soela Strait — 1,500 m³/sec and Voosi Strait — 800 m³/sec (Table 3). The maximum calculated transport is three time greater than the mean one. As no measurements have been made during storms, the possible maximum transport is unknown. If the velocity of the surface current in the centre of the strait is about 100 cm/sec, the mean transport through the Hari Strait may amount to 27,000—33,000 m³/sec and through the Large Strait to 33,000—37,000 m³/sec; in other straits it might be less.

Table 3

Mean transport (m^3/sec) through the straits at wind force 3—4

Strait	Inflow		Outflow	
	m^3/sec	Number of recordings	m^3/sec	Number of recordings
Hari Strait	6,840	37	7,330	36
Voosi Strait	770	30	870	69
Soela Strait	1,510	57	1,460	61
Large Strait	8,610	49	7,120	25

The data given in Table 3 show that the main water exchange takes place meridionally, i. e. through the Large and Hari straits. The share of other straits is small.

In order to establish the authenticity of the mean transport on the basis of frequency of the directions of the wind the preliminary annual water balance of the Väinameri was calculated. In doing this the water exchange through the straits was taken as the only component of the water balance. Other components of the water balance — river inflow, precipitation and evaporation compared with water exchange, are very small. The frequency of the directions of the currents (positive and negative transport) was ascertained on the basis of the data of the hydrometeorological station nearest to the strait (Справочник по климату СССР, вып. 4, часть III). The use of the data of the coastal stations is well-founded, because, as shown by M. Mardiste (Мардисте, 1967) the directions of the wind between the single parts of the Väinameri differ very little. Calculations show that the sum of the inflowing and outflowing transport of all straits differs only by 2 per cent.

The collecting of data and calculation of the water transport in every case is labour-consuming. To simplify the calculations and to limit the number of observations the connexion between the velocity, v (cm/sec) of the surface current in the centre of the strait, and the transport, Q (m^3/sec), was found. For this the data of the currents with velocities up to 50 cm/sec were used. The following regression equations show the empiric connexions obtained for the straits:

Hari Strait	inflow	$Q = 270v + 360$	$r = 0{,}92$
	outflow	$Q = 330v + 400$	$r = 0{,}94$
Voosi Strait	inflow	$Q = 40v + 10$	$r = 0{,}96$
	outflow	$Q = 60v - 390$	$r = 0{,}91$

Soela Strait	inflow	$Q=100v+110$	$r=0{,}93$
	outflow	$Q=100v-40$	$r=0{,}81$
Large Strait	inflow	$Q=310v+2100$	$r=0{,}81$
	outflow	$Q=360v+1000$	$r=0{,}91$

One can use these connexions to calculate the water balance of the Väinameri. To do this correctly in every respect, data on the variability and maximum velocities of the currents are needed. They may be obtained by means of self recording current meters, as it was made in the Irben Strait by A. Pastors (Пасторс, 1974).

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VÄINAMERE HOOVUSED

H. Mardiste

Resümee

Töös analüüsitakse summaarseid hoovusi väinade keskel. Mõõdetud hoovused on jaotatud tuule tugevuse järgi kolme gruppi: 1—2, 3—4 ja 5—6 palli ja tuule suuna järgi 8 gruppi. Iga grupi kohta on leitud hoovuste keskmine suund ja kiirus (tabel 1). Hoo-

vuste kiirus sõltub tuule tugevusest ja suunast. Keskmine hoovuste kiirus väinade keskel on 20—22 cm/s, maksimaalne kiirus kuni 6-palliste tuultega ulatub 75 cm/s. Hoovuste suund sõltub tuule suunast ja väinade orientatsioonist (joon. 2). Peale järsku tuule suuna muutumist (90—180°) ja selle tugevnemist 4—5 pallini muutub hoovus endisele vastupidiseks 3—4 tunni jooksul ja selle kiirus püsivaks 5—6 tundi peale tuule muutumist.

Väinades mõõdetud hoovuste andmete põhjal on leitud keskmised vooluhulgad igas väinas (tabel 3), millest nähtub, et Väinamere põhiline veevahetus leiab aset läbi Hari kurgu ja Suure väina. Arvutuste lihtsustamiseks ja ekspeditsiooniliste tööde vähendamiseks on leitud seos vooluhulkade ja väina keskel mõõdetava pinnahoovuse vahel.

ТЕЧЕНИЯ В ПРОЛИВАХ ВЯЙНАМЕРИ

Х. Мардисте

Резюме

В работе анализируются суммарные течения в проливах Вяйнамери (Муху). Измеренные течения были подразделены в зависимости от силы ветра на 3 группы: 1—2, 3—4 и 5—6 баллов, а по направлению ветра на 8 румбов, и в каждой группе были найдены средние значения скорости и направления течений (табл. 1). Сопоставление средних величин показывает, что скорость течения зависит от скорости и направления ветра. Средняя скорость течений в проливах характеризуется величиной 20—22 см/сек, а максимальная (при ветрах до 6 баллов) достигает 75 см/сек. Направление течений зависит от направления ветра и ориентации проливов (рис. 2). После резкого изменения направления ветра (на 90—180°) и его усиления до 4—5 баллов, направление течения в проливах становится противоположным предыдущему в течение 3—4 часов, а скорость течения устанавливается через 5—6 часов после смены ветров.

На основании измерений течений, выполненных во время рейдовых наблюдений, вычислен средний расход воды в каждом проливе (табл. 3). Сопоставление этих данных показывает, что основной водообмен. Вяйнамери происходит в меридиональном направлении.

Для упрощения вычислений и уменьшения объема необходимых экспедиционных работ найдена связь между скоростью поверхностного течения и расходом воды.

SOIL MAP OF THE ESTONIAN S.S.R.

I. Rooma and L. Reintam

The first comprehensive schematic soil map of Estonia was compiled 50 years ago by A. Nõmmik (1925). Later up to 1938, complementary variants of this map were published on several occasions. Based on the data of route investigations, first of all, the occurrence of automorphic soil types and subtypes was described there. A more detailed survey of Estonian soils was provided by A. Lillema (1946) on a medium-scale soil map compiled on the basis of different regional materials (soil maps of counties, topographical lists, etc.) and soil estimation data. This soil map was already differentiated according to the occurrence of soil subtypes and even some kinds and varieties. Later as the result of the generalization of this map a new small-scale (1 : 1 500 000) soil map was published by A. Lillema (1960).

Compared with the earlier comprehensive soil maps the present schematic one is compiled on the basis of somewhat other principles. So in any contours of earlier maps the predominant soil formation (automorphic being favoured) was represented whereas its area sometimes could be less than 50% of the total contour. But the contours of the present map contain one or several soil types (subtypes) whose territorial share is over than 70% (90% for mires) of the contour area. At that the soil formations of complex contours are arranged in the order of importance of their occurrence beginning with the predominant ones. The texture indices must include at least 50% of the contour area. The contours of soil combinations are grouped according to the prevalent soils.

The following materials have been used for the present soil map: (1) the map of soil microdistricts with respective numerical data (Kokk, Rooma, 1974); (2) the soil maps of administrative districts compiled on the basis of large-scale cartographical studies; (3) the soil map of the Estonian S.S.R. compiled by A. Lillema (1946). The soils distinguished in the present map may be characterized as follows.

Rendzinas occur on ordinary and dolomitized limestones, but also on strongly calcareous pebble (ryhk*) moraine and fluvio-glacial coarse materials. The presence of carbonates (more than 10%) already in the humus horizon rich in total organic matter (11...18% and 8...12% in limestone and pebble rendzinas respectively under virgin vegetation) and insoluble fractions in that (70...80% of organic carbon), slightly differentiated (*A1—C*) short sceletal profile, loamy texture of fine earth, slow weathering and calcic turnover of substances in the arid hydrothermal conditions are characteristic of them. Due to their high calcareousness the rendzinas are base saturated and neutral or slightly alkaline. As a result of cultivation the humus content decreases, but the Ch : Cf ratio increases in renzinas, being in their arable variants 3...5% and up to 1.8 respectively. Larger expanses of rendzinas occur in North and North-West Estonia as well as in the island of Saaremaa. Usually they form different combinations with gley-rendzinas and/or gley-brown soils, but also with gleyed formations of rendzina and brown forest types. In the northern part of the Pandivere Uplands also complexes of rendzinas and brown forest soils may be described.

Brown forest soils (cambisols in FAO/UNESCO terminology) are being formed on calcareous yellow-grey and red-brown moraine and/or on noncalcareous loamy deposits underlain with calcareous moraine (all rich in alumosilicates) under favourable hydrothermal, redox and biological relationships. The argillization of total solum or separate horizons and the absolute and relative accumulation of the nonsiliceous hydrates of sesquioxides in soil profile and topsoil respectively are their main diagnostic indices. Brown forest soils contain 3.4...4.7% of humus, which decreases up to 2.4...2.8% in their arable variants. The fulvic or humic-fulvic origin (Ch : Cf=0.5...0.9) of humus is characteristic of them. Though a slight translocation of clay may be found in typical (leached) brown soils the metamorphic argillic character without the morphologically distinguished lessivage is typical of their profile. Only a more intensive lessivage on two-membered deposits and/or on red-brown sandy loamy moraine results in the formation of a argillic-textural lessive profile which retains all the brunification features.

Large expanses of typical and lessivaged brown soils are characteristic of Central Estonia, but their combinations with rendzinas and gley formations also occur in the northern and western parts of the Republic. The complexes of brown and pseudopodzolic types have been described in South Estonia. All the brown forest soils are neutral or slightly acid in topsoil, but neutral or slightly alkaline beginning from the argillic zone in the subsoil. They are

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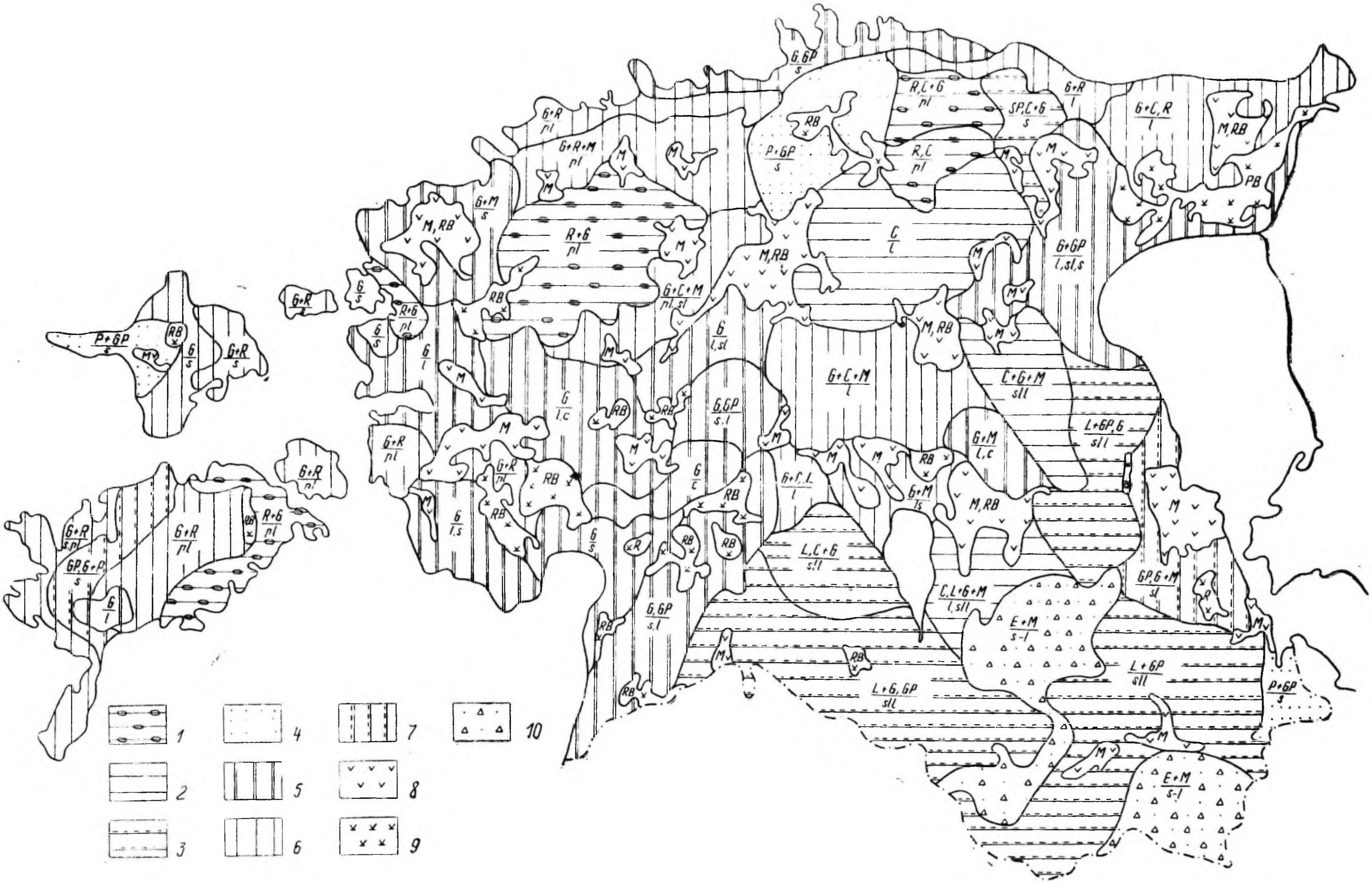
[1] Ryhk — limestone debris with a diameter of 1...10 cm.



Schematic soil map of the Estonian S.S.R.

1 : 2 500 000

By I. Rooma

1 — rendzinas (R), 2 — brown forest soils or cambisols (C), 3 — pseudopodzolic soils or luvisols (L), 4 — sod-podzolic soils (SP and podzolis (P), 5 — bley soils or gleysols (G), 6 — gleysols in combination with different automorphic soils, 7 — gley-podzols (GP), 8 — flood-plain marshes (M), 9 — transitional mires and raised bogs (RB), 10 — different eroded and talus soils (E); s — sand, sl — sandy loam and loamy sand, l — loam, c — clay, sll — silty and loamy sand on loam, s-l — sand, loamy sand, sandy loam, loam and clay, pl — peble loam.

$\frac{R+G+M}{l}$, etc. $\frac{\text{soil genetic indices}}{\text{soil texture}}$

R+G+M, etc. — the complexes of the soils of different water relationships beginning with the prevailing ones;

R, C, etc. — soils with identical water relationships medium or highly base saturated and characterized by high quality indices.

Pseudopodzolic (degraded) soils (glossic and albic luvisols by FAO/UNESCO) are being formed previously on two-membered deposits (silty or sandy materials on loamy moraine), but also on clayey sediments under the seasonal stagnation of top and/or leakage water at the juncture of layers of different texture. As a result of degradation (autoaluminization and hydrolytic desaturation of weathering complex), deferritization and lessivage representing the origin of pseudopodzolization, the white-coloured pseudopodzolic horizon rich in concretions is formed in the zone of seasonal overmoistening. Simultaneously the significant accumulation of nonsiliceous sesquioxides may be found in the topsoil. The acidity of pseudopodzolic soils is intrinsic in origin as well as their low base saturation in upper horizons. Pseudopodzolic profile is two-membered not only by textural, but also by chemical and hydrothermal differentiation.

The brown pseudopodzolic soils prevail in this type and they have large expanses in South Estonia. The presence of two accumulative horizons is typical of the brown pseudopodzolic profile formed on two-membered deposits: the first below the humus and above the white-coloured pseudopodzolic horizon is yellow-brown and rich in amorphous iron of biogenic and lithogenic origin, the second below the pseudopodzolic horizon in the upper part of the underlying moraine — rich in crystalline iron and some illuviated clay. The light pseudopodzolic soils formed on clays are characterized by the presence of a white-coloured horizon rich in amorphous iron and ferric concretions immediately below the humus ones. A more significant textural argillization of the *B*-horizon is also characteristic of them. Compared with brown pseudopodzolic soils they have somewhat rarer in South Estonia. Pseudopodzolic soils are highly qualified for forestry and grassland husbandry, but deep subsoil loosening in combination with drainage is necessary for their improvement in arable lands. They usually contain 2...4% of humus, the Ch:Cf ratio being 0.5...0.7. Pseudopodzolic soils often occur in combination with different gley and podzol-gley formations as well as with brown lessive and sod-podzolic soils.

Sod-podzolic soils occur on noncalcareous sandy and loamy sandy sediments, a flowing regime, good filtration, low-intensive ash-deficient biological turnover and aggressive mobile humus being characteristic of them. They are acid, base unsaturated and impoverished in topsoil in clay, sesquioxides and bases, but also poor in humus (1.5...3%) and rich in fulvic acids (Ch : Cf = $= 0.55 \pm 0.06$). Eluvial-illuvial differentiation of nonsiliceous sesquioxides is typical of the sod-podzolic profile. Soils of this type usually occur on microrelief hillocks in combinations with podzol-gley as well as with pseudopodzolic, etc. formations.

Podzols are being formed on sands of different genetic categories under the types of pine forests without a herb layer, but with dwarf shrubs, mosses and lichens in the ground vegetation. They are strongly acid, base unsaturated and extremely poor in clay and sesquioxides in topsoil. The podzol profile usually has a humus-illuvial or iron-illuvial character. More large expanses of podzols occur in the Peipsi Lowlands, but also on the western edge of the Pandivere Uplands and on the islands of Saaremaa and Hiiumaa. Usually they are in combination with humus-illuvial podzol-gley formations as well as with raised bogs of atmospheric nutrition. Podzols are unsuitable for agriculture.

Gley soils (gleysols) include different hydromorphic types of ground and/or combined surface-ground nutrition whereas gley-rendzinas and gley-brown soils are being formed on calcareous moraines occurring in North and Central Estonia, but sod-(humus)gley soils — on graded deposits of the Baltic transgressions in the western and northern depression of Estonia. At that large expanses of gley-rendzinas being characterized by the presence of carbonates in the topsoil, slightly differentiated short sceletal profile, highly variable water regime and base saturation, as well as of gley-brown soils being formed as a result of the complicated combination of brunification, lessivage, pseudopodzolization and ground-gleyzation in the conditions of neutral reaction and intensive biological turnover are absent.

They usually occur in a transitional position between rendzinas, brown forest soils and mires. But sod-gley soils on aqueous deposits of different texture and chemism occupy large territories in West-Estonian depression. A short groundgley profile and highly variable reaction, base saturation and content of organic matter are characteristic of them. Often on different aqueous sediments the base-saturated sod- and humus-gley soils on flat territories or on microlowlands alternate within a short distance with the acid podzol-gley formations on microrelief heights showing a space variance of hydromorphic soils depending upon water nutrition as well as upon chemism of water and sediments. Also the complexes of gley soils and mires have a wide occurrence.

The gley soils of different categories are the main objects of amelioration in the Estonian S.S.R.

Podzol-gley soils (gley-podzols) are being formed on different noncalcareous deposits as the result of podzolization and gleyzation. Raw fulvic humus, strong acidity, base unsaturation, poverty in the clay and sesquioxides of the topsoil and low-intensive ash-deficient biological turnover are characteristic of them whereas the podzolic profile is rich in the indices of overmoistening. The humus-illuvial profile is typical of sandy gley-podzol which predominate in this type. More large expanses of gley-podzols occur in the Peipsi Lowlands, but their combinations with pseudopodzolic (South Estonia), gleysol (West Estonia) and podzol formations occupy a significant territory.

Mires are being formed under the continual surplus of water and a peat horizon more than 30 cm deep is their main diagnostic index. They occupy nearly 20% of the Estonian territory and their large expanses occur mainly in the West-Estonian and Peipsi depressions. Flood-plain marshes (lowland swamps) prevail in the limits of mire type. They are covered with meadow or swampy forest vegetation and are characterized by a groundwater or flooding regime as well as favourable ash, nitrogen, calcium, peat texture and bulk density indices. Flood-plain marshes may be cultivated with agricultural aims. Transitional mires and raised bogs are characterized by atmospheric nutrition, sphagna and dwarf shrub vegetation and poor indices of ash, nitrogen and calcium content as well as of peat texture. These subtypes of mires are unsuitable for agricultural management.

Different eroded and talus (deluvial) soils occur in recessional hilly landscapes in South-East Estonia (the Haanja and Otepää—Karula Heights). Eroded soils on the slopes and/or crests of morainic, fluvioglacial, etc. hills are highly variable not only as to the initial genetic types, but also in texture and profile structure. Each of the automorphic soil types (rendzinas, brown forest, pseudopodzolic, sod-podzolic soils and podzols) may be eroded when they occupy the positive elements of the relief of this landscape. Therefore very complicated combinations of the eroded variants of these soils may be described whereas their calcareous varieties have a wide occurrence. The soils in neighbouring microdepressions may be covered with deluvial sediments and classified as individual talus soils of different hydromorphism and genetic categories. In these conditions mires in the deep hollows and valleys are of essential importance.

Due to the small scale of the present map it was impossible to distinguish and characterize both **alluvial** and **saline littoral soils** which occur on valley plains and coastal territories of the Baltic Sea respectively.

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EESTI NSV MULLASTIKU KAART

I. Rooma, L. Reintam

Resümee

Eesti NSV mullastiku mikrorajoneerimise, administratiivsete rajoonide mullastiku kaartide ja teiste andmete alusel on koostatud Eesti NSV mullastiku kaart mõõtkavas 1 : 2 500 000. Kaardil on igas kontuuris tähistatud üks või mitu mullatüüpi arvestusega, et nende üldine osatähtsus oleks vähemalt 70% kontuuri pindalast.

Kaardil eraldati järgmised mullatüübid või alltüübid: 1) rendsiinad, 2) pruunmullad, 3) pseudoleetunud mullad, 4) leetunud mullad, 5) leedemullad, 6) gleimullad, 7) leet-gleimullad. 8) madalsoomullad ja 9) siirdesoo- ning rabamullad. Kõigi loetletud ühikute kohta on antud lühike iseloomustus.

ПОЧВЕННАЯ КАРТА ЭСТОНСКОЙ ССР

И. Роома, Л. Рейнтам

Резюме

На основании микрорайонирования почвенного покрова республики, почвенных карт административных районов и других данных составлена почвенная карта Эстонской ССР в масштабе 1 : 2 500 000. На карте в каждом контуре обозначены один или несколько типов почв с расчетом, чтобы их доля от общей площади контура составляла не менее 70%.

На карте выделены следующие типы или подтипы почв: 1) рендзины, 2) буроземы, 3) псевдоподзолистые почвы, 4) дерново-подзолистые почвы, 5) подзолы, 6) глеевые почвы, 7) подзолисто-глеевые почвы, 8) болотные низинные почвы и 9) болотные переходные и верховые почвы. Для всех перечисленных в легенде единиц приведена их краткая характеристика.

SPATIAL CONCENTRATION OF PRODUCTIVE FORCES AND SOCIAL-ECONOMIC SPATIAL SYSTEMS

S. Nõmmik

The development of society has already been investigated for many centuries. The different ways of its cognition by different scientific schools are generally well-known. But the research work of the regularities of spatial existence of society has begun only recently. There are some viewpoints of philosophers on this field of science, but there is not yet any complete theory of the spatial existence of society. Extensive information about the spatial regularities of nature, population and economic life has been accumulated during many centuries by geographers. But this information has a very heterogeneous character, being different in spatial extent of objects of investigation as well as the degree of generalization, in methodological principles and also in concrete methods, with the help of which the information has been obtained. To go through and generalize such material is a global task, which because of its normous extent must still wait for the collaboration of world science. In the present paper we confine ourselves only to the hypothetical treatment of the problem. Below, an attempt is made to throw some light on the most general aspects of the spatial existence of society — the spatial concentration of productive forces, the nature of this process and the formation and typology of its social-economic spatial systems.

1. SPATIAL CONCENTRATION OF PRODUCTIVE FORCES

The spatial concentration of productive forces must be understood as the accumulation of population and already invested labour (ground funds) on a certain territory, first of all into settlements — into villages, towns and regions, etc. This process may be approximately measured by the growth of the specific weight of urban population in the structure of population, with the growth of population of large towns and their number. Thus in Russia in

1913, the rural population embraces 82% and the urban 18%; in U.S.S.R. in 1940 this ration was 67% and 33% and in 1974 — 40% and 60%. From 1939 to 1974 in the U.S.S.R. the number of million-towns increased from 4 to 13; these numbers for the whole world for the period from 1900 to 1972 were 16 and 152. But that is not all. The concentration of population takes place continously from lower hierarchical stages of settlements to the higher hierarchical stages. This process takes place not only in the urban settlements, but also in rural ones. However, the urban and rural settlements are not abruptly separated from each other, but constitute one progressing successive unity of settlement as a whole. At the same time with the spatial concentration of population there takes place a spatial concentration of basic funds (ground funds).

The spatial concentration of productive forces is brought about by the change of the structure of activities of the population. Taking into account the connectedness of them with land the activities of society may in a very general way be grouped into rural and nonrural activities. The beginning of the development of society was characterized by rural activities (agriculture, cattle-breeding, etc.), which have areal territorial localisation and corresponding dispersed rural settlement. Gradually there revealed themselves nonrural activities (handicraft, trade, communal economy), the specific weight of which in the structure of social activities has gradually increased and is increasing today. An objective premise for their coming into being was the spatial concentration of the population as the producer and the consumer. Thus them revealing of nonrural activities took place in dialectic unity with the spatial concentration of productive forces as a whole. This way the growth of specific weight of nonrural activities turned into a motive power of spatial concentration of productive forces. Showing already in their essence a tendency of co-existence, the nonrural activities reveal themselves first of all in those points of territory which have some kind of favourable economic conditions and there they develop into the foundation of towns and industrial regions.

Investigating the structure of social activities in time and space, we can observe a general regularity: the specific weight of rural activities decreases and that of nonrural activities increases. Even more. The tempo of the increase of the role of nonrural activities and the intensity of the spatial concentration of productive forces are correlative processes: the more speedy the growth of nonrural activities in the structure of social-economic activities, the faster the spatial concentration of productive forces.

Leaving out the taking into use of new territories, natural and war catastrophes, the spatial concentration of productive forces reveals a certain sequence in time and space. It takes place in all social-economic formations and in all countries of the world with greather or lesser speed. Besides it is modified in everyone of them accordingly to the basic economic laws of the formation. In every historically consecutive social-economic formation the intensity of this process is greater than that of the preceding one.

In the primitive community the territorial organization of economic life was characterized by disperse localisation of small groups of people which obtained their livelihood out of the nature surrounding them or by primitive tillage or cattle-breeding. In the slave-owning social-economic formation the development of nonrural activities and with it the process of spatial concentration of productive forces began. It continued also in feudal society in the form of developing feudal towns as centres of handicraft and trade. But as rural human activities were prevailing, spatial concentration remained inextensive and slow as before.

The next social-economic formation — capitalism — is mainly supported by semi- and nonrural forms of social activities, branches of economic basis and renewal of productive superstructure belonging to them. Capitalism with its manufacturing industry caused a sudden spatial concentration of productive forces. The essence of it was the accumulation of population in certan regions and places of the world, rich in some natural resources and other economically favourable preconditions. These places were the slopes of the Pennines, the Ruhr basin, Donbass, Pennsylvania, etc. Where industrial regions came into being there conurbations and cities appeared. These processes are typical of all countries where capitalism has developed and is developing.

In the conditions of socialism and planned economy the spatial concentration of productive forces grows even more. This is the result of the concentration of production. The growth of very large productional and nonproductional enterprises causes spatial concentration of population as the producer and consumer. On the other hand, democratic centralism and the territorial-hierarchical division of labour of the state organs necessitates accumulation of people into urban centres. Towns become places of localisation not only for production enterprises, but also for servicing institutions. It is natural that in connection with all this the basic funds of towns are growing too.

Spatial concentration of productive forces is also favoured by the mechanization of agriculture which releases manpower from rural activities for work in nonrural ones. Even in the country places people and basic funds are concentrating into large rural settlements. Thus the spatial concentration of productive forces is a total regularity of the development of society, that is revealing itself as a quality of spatial existence. Evidently the regularity of the spatial concentration of social production must be the starting point of a geographical comprehension of social-economic phenomena and processes.

2. FORMATION AND DEVELOPMENT OF SOCIAL-ECONOMIC SPATIAL SYSTEMS

As it by the author already in an earlier paper was discussed, in the process of the spatial concentration of productive forces there reveal themselves various spatial complexes of human activities that differ in structure and territorial extent. In the course of the spatial concentration of productive forces first of all settlement, social-economic territorial complexes and social economic regions came into being.

In the following we shall endeavour to cognize causes and regularities of forming the social-economic spatial systems and subsystems.

The formation of settlements may be considered as the initial stage of the spatial concentration of productive forces. The cognition of this process is feasible if we comprehend the period when the spatial concentration of productive forces has just begun at the highest stage of primitive communal system. On the basis of preliminary rural activities settlement with rural functions came into being, using the land of the zone of gravitation of the same settlement. In modern times rural settlements develop too mainly on the basis of rural activities, but in conditions of the far-going division of labour in rural settlements there appear functions that are not directly connected with the land belonging to the village.

Yet, let us cast a retrospective glance at the development of settlement. The development of handicraft, trade and later on of manufacturing industry, communal economy, caused the development of transport and building, etc., i. e. the appearance of nonrural activities, for which, as we have already pointed out above, the spatial concentration of productive forces is an objective prerequisite. Thus one part of rural settlements acquired nonrural functions and passed into the category of urban settlements with nonrural functions prevailing. Thus against the background of rural settlements there rise urban ones. Surely this is not the only way for the appearance of urban settlements, but only the most typical one in those places where natural catastrophes and wars did not spoil this general regularity. Urban settlements may also arise without passing the rural stage of development, as fortresses, university towns, etc. In the present time, first of all, manufacturing industry is the town-forming activity and forms the main function of urban settlements.

A young urban settlement, which has recently been transformed into the category of urban settlement, still has rural functions in its functional structure.

The higher the level of the development of the urban settlement, the less is the specific weight of the rural functions in its functional structure and the more different functions the settlement fulfils with regard to its hinterland. The transition from rural settlements to urban ones is not abrupt, despite the currently widespread opinion due to the influence of the juridical status of settlements. In the transition from rural to urban settlements there is a group of rural settlements in which only recently nonrural functions have become preponderant and on the other hand there exist urban settlements in which the role of rural functions is still large. In a well-developed settlement system there are all stages of the genetic series represented from the village up to giant cities.

In conditions of well-developed distribution of labour no one settlement can advance separately, but always together with other settlements. As the result of social-economic intercommunication with the largest settlement on a certain territory and other settlements remaining on its area of gravitation, there arises a regional settlement system. The latter possesses all the qualities of systems, but posses specificic qualities peculiar only to geographical systems. Settlement systems consist of a unity of relatively independent components, which are connected with one other with functional system-forming ties. The interior organisation of settlement systems is characterized by structureness, hierarchy, territorial discreteness, wholeness and finally — relative autonomy.

From the above-said we may conclude that the settlement represents a spatial form for social reproduction. A settlement arises on the basis of the economic activities of people and these activities are the content of the settlement.

The most typical attributes of the settlement are its functional structure and the extent of its hinterland. The functions of the settlement depend on the activities which the active population of the settlement engages in with regard to the settlement itself and its zone of gravitation. The hinterland of the settlement is an economic territory with which the settlement is dealing economically and culturally. This intercommunication serves as the basis for the development of production forces for both the central settlement and its hinterland as well.

On the basis of the functional structure and the extent of hinterland the settlement system may be divided into functional-hierarchical stages and into regional systems. In the settlement of the U.S.S.R. we may find the following regional and functional-hierarchical systems (Ныммик, Марксоо, 1974).

The first stage — a village, the initial stage of the settlement system with the most simple rural functional structure, mainly a dwelling village, with some single agricultural institutions (stockfarm, drying-room, etc.). The zone of gravitation of the villages embraces its own agricultural land.

The second stage — the centre of an agricultural enterprise (a collective farm or a state farm), usually a large rural settlement (alevik). At this stage of settlement with the prevailing rural functions there are associated some servicing functions (shops, school, kindergarten, etc.). Specific for this stage is the economic-organizational function. The hinterland of the centre of the agricultural enterprises embraces its corresponding territory with villages on it.

The third stage — a local centre, a larger rural or a small urban settlement, in the structure of which besides prevailing urban functions there are rural ones which still occupy a significant place. Local centres have also administrative, everyday and periodical servicing functions. Its hinterland embraces two or three agricultural enterprises.

The fourth stage — a district centre, usually a town with administrative and more wide production and servicing functions; to the everyday servicing functions there are added periodical and some kinds of episodical servicing functions. The hinterland of the settlement at this stage embraces usually the territory of the corresponding district, but in case there is an industrial enterprise with far-reaching economic ties in the district centre the economic connections of the centre may extend even into other republics of the U.S.S.R.

The fifth stage — a regional centre, a large town with a notable industrial potential of republican and all-union importance. The regional centre fulfils economic-organizational and cultural functions (trade bases, administration of roads and building, theatre, secondary technical school, etc.), in some two or more districts that form the hinterland of the regional centre.

The sixth stage — the capital of a small Union Republic or of a province of the Russian Federation — a large town, which contains a production potential of republican and allunion importance and also all present-day servicing enterprises, especially the episodic and unique ones (higher government institutions, those of art and literature, etc.). The hinterland of the capital is all the territory of the small Union Republic or of a province of Russian Federation.

The seventh stage — an interrepublican or interprovincial centre — a very large town, with a powerful production and servicing potential that gravitates a large part of the U.S.S.R. (Leningrad, Kiiev, Sverdlovsk etc.).

The eighth stage — the capital of the U.S.S.R. — Moscow, with a mighty productional and servicing potential, the head of the regional system of settlements of the Soviet Union.

The settlement represents systems in which the social material production and servicing spheres co-exist.

But social economic activities do not confine themselves only to the settlement itself. Everyone of the functions of the settlement has its own scope. Yet in the nearest hinterland of the settlement all functions coincide in space. Thus a core appears which differs from the far hinterland in intensity and diversity of social economic life.

The extent of the hinterland of the settlement is proportional to the social-economic potential of the settlement and reciprocal to the square of the distance from the settlement. Functioning mutually the productive forces in a settlement of a certain hierarchical stage and these of its hinterland form a certain unity — a social-economic territorial complex, the framework of which is the corresponding settlement system. The author of this paper regards social-economic territorial complexes as node systems, which have their centre of concentration in the form of a central settlement and their structure has a functional-hierarhical character.

The appearance of social-economic territorial complexes is caused by various natural-historical, social-economic and geographical factors. The character of social-economic territorial complexes and their structure is conditioned by the inevitable necessities of society and the objective possibilities of meeting these needs. The latter depend on the one hand from the quantity of the already invested human labour, i. e. from the level of development of productive forces on the corresponding territory, and on the other hand, on the potential of the natural-historical basic of the social-economic territorial complex. The latter contains the potential of natural conditions and natural resources and the economic geographical situation. The influence of them on the corresponding social-economic territorial complexes is realized by the social production.

The structure and territorial scope of the social-territorial complex are greatly conditioned by the potential of the natural-historical basis. A certain social-economic territorial complex with a certain structure and special scope may arise only on a certain complex of natural prerequisites. In the North-East of the Estonian S.S.R. there is developing a territorial-production complex of oil-shale chemistry-electric-energetics and of building materials. The possible extent of this complex is confined by the location of the oil-shale deposits. On the basis of the development of the above named material production sphere a social-economic territorial complex is being formed.

As it was said above, the social-economic territorial complex is formed on the basis of the settlement system. In connection with this the character of the social-economic territorial complex results from the structure and functional-hierarchical stage of the settlement system. If formed only on the basis of the first and second stages of the settlement system, the village and the centre of a rural enterprise are social-economic territorial complexes which have intrinsically mostly rural economic ties and whose complexness is in the first stage of development. Real social-economic complexes are formed already on the basis of local centres, which have their special functions in the form of processing local raw material and which service their own and the population of their hinterland. With these social-economic ties the local centre and its hinterland are joined into a social-economic unity.

A district social-economic territorial complex already contains a production and servicing potential, which connects all the territory of the administrative district with manysided social-economic ties into a unity of social-economic territorial complex. In case of an economically strong district centre, there is one whole concentric social-economic territorial complex that corresponds to it (Viljandi, Võru, Paide districts). But if there is an economically weak district centre, several equivalent social-economic territorial complexes on the level of local complexes are formed on the territory of the district.

In case the district centre possesses a powerful social-economic potential and it gravitates not only the territory of one but several districts, it fulfils the functions of a regional centre. A typical regional centre in the Estonian S.S.R. is Tartu and conventionally we may regard Kohtla-Järve and Pärnu as regional centres too. In the North-West of Estonia the role of a regional centre is fulfilled by Tallinn. On the basis of regional centres regional social-economic territorial complexes have been formed. In case of a mighty concentric regional centre (Tartu in the South-East) the corresponding social-economic territorial complex forms a complete unity. If there is no such centre, the zone of its gravitation embraces several social-economic complexes on the level of district centres.

The gravitation area of the capital — Tallinn, embraces the whole of the territory of the Republic. At the same time it also fulfils the functions of regional and district centres and corresponding social-economic complexes.

The above said asserts the dialectic unity of settlement systems and social-economic territorial complexes. Yet as a rule the settlement systems and social production are comprehended apart both in the theory and in practice of the national economy. Actually settlement may be regarded as a spatial form of social production and productive forces as the content of this form. There are no settlements without social reproduction and the latter does not exist without a settlement.

Spatial concentration does not confine itself to the forming of settlements and social-economic territorial complexes. One of its expressions is the formation of social economic regions. N. Kolossovsky already demonstrated in his works that the basis of the rise of economic regions is the formation at the same time of productional-territorial complexes. Wholly accepting this, we cannot help stating that in objective reality not only economic regions are formed but also social-economic regions which comprise all the links of social life on the corresponding territory.

As it was said above, a social-economic territorial complex can be discussed as such only on the level of local centres. The same must be said about social-economic regions. The social-economic territorial complex becomes the core of the formation of a social-economic region (Ныммик, 1970) which associates with the neighbouring territory into a spatial unity. On the basis of a local social-economic territorial complex there arises a social-economic microregion, on the basis of a social-economic complex of a district — a lowstage social-economic region, consisting of one or two districts. On the basis of a regional social-economic territorial complex — an intrinsical republican or an intrinsical provincial social-economic region is formed.

An essential prerequisite of the formation of states is the formation of a general social-economic unity, which in spite of various reasons leads to the rise of a political unity — a state. The latter is the most determined social economic spatial system. At present in the conditions of far-reaching distribution of labour no state can exist apart from others, but is joined to them and thus systems of states are formed.

All the above examined spatial complexes of productive forces belong to the content of the most generalized theoretical concept — social-economic spatial system. The process of spatial concentration of productive forces continues. In the course of it every one of the above observed social economic spatial systems develops and improves, becoming more and more complicated. The scientific and technical revolution serves as an important lever of spatial concentration of productive forces. On the one hand, it liberates a part of the people from rural activities and, the other hand it brings forth new nonrural activities, which can all together exist only in the conditions of high spatial concentration of social life.

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TOOTLIKE JÕUDUDE RUUMILINE KONTSENTRATSIOON JA SOTSIAAL-MAJANDUSLIKUD RUUMSÜSTEEMID

S. Nõmmik

Resümee

Käesolevas artiklis esitatakse katse valgustada ühiskonna ruumilise olemise üht kõige üldisemat aspekti — tootlike jõudude ruumilise kontsentratsiooni protsessi olemust, tema arengus kujunevate sotsiaal-majanduslike ruumsüsteemide formeerumist ja nende vahekorda. Tootlike jõudude ruumilise kontsentratsiooni protsessina mõistetakse rahvastiku ja juba asjastatud töö (põhifondid, tootmisvõimsused) ruumilist koondumist teatud piiratud territooriumidele, esmajoones asulatesse, nende aglomeratsioonidesse ja rajoonidesse. Ühiskonna ruumilise kontsentratsiooni peamiseks põhjuseks on areaalse lokalisatsiooniga ruraalsete tegevusharude vähenemine ja diskreetse lokalisatsiooniga mitteruraalsete tegevusharude erikaalu kasv ühiskonna tegevuste struktuuris, aga ka ühiskondliku tootmise kontsentratsioon. Ruumilise kontsentratsiooni protsessis formeeruvad tootlike jõudude mitmesugused ruumilised kooslused: asulad, sotsiaal-majanduslikud territoriaalsed kompleksid, sotsiaal-majanduslikud rajoonid, riigid. Kõik need on oma iseloomult sotsiaal-majanduslikud ruumsüsteemid. Asustust vaadeldakse kui tootlike jõudude ruumilise kontsentratsiooni algastet ja kõigi teiste sotsiaal-majanduslike ruumsüsteemide karkassi. Artiklis antakse kõigi sotsiaal-majanduslike ruumsüsteemide formeerumiskäik ja nende omavahelise suhte käsitlus.

ПРОСТРАНСТВЕННАЯ КОНЦЕНТРАЦИЯ ПРОИЗВОДИТЕЛЬНЫХ СИЛ И СОЦИАЛЬНО-ЭКОНОМИЧЕСКИЕ ПРОСТРАНСТВЕННЫЕ СИСТЕМЫ

С. Ныммик

Резюме

В настоящем представляется опыт изучения одного из наиболее общих аспектов пространственного бытия общества — сущности пространственной концентрации производительных сил, формирования в этом процесс социально-экономических пространственных систем и их соотношений.

Процесс пространственной концентрации понимается как аккумуляции населения и овеществленного труда (основные фонды и производственные мощности) на определенной ограниченной территории, прежде всего в поселениях, в агломерациях и некоторых районах.

В качестве основной движущей силы этого процесса принимается, с одной стороны, уменьшение в структуре деятельности общества руральных отраслей, которые имеют ареальную локализацию, и с другой стороны увеличение неруральных отраслей имеющих дискретную территориальную организацию. В процессе пространственной концентрации формируются различные сочетания производительных сил: поселения, социально-экономические территориальные комплексы, социально-экономические районы, государства (страны). Все они по своему характеру являются социально-экономическими пространственными системами.

Расселение рассматриваются как первая ступень пространственной концентрации производительных сил и каркас всех других вышеназванных систем. В статье дается характеристика формирования и соотношение всех этих социально-экономических пространственных систем.

ON THE REGULARITIES OF THE CONCENTRATION PROCESS IN THE SETTLEMENT SYSTEM OF THE ESTONIAN S.S.R.

Ann Marksoo

The scientific-technical revolution is accompanied by an ever-increasing concentration of production. At first this tendency revealed itself in industry, but at the present time it shows itself ever more clearly in the field of rural production, agriculture, forest management and fishery which so far had had a scattered distribution. The progress of transport and of other means of communication likewise furthers the continuous concentration of the social infrastructure — administrative management, education, science, public health, cultural servicing, the carrying out of everyday repairs and other services. All this produces direct changes also in the settlement system as a form of the territorial organisation of productive forces. Nearly all tendencies in the development of the functional and territorial structure of the settlement system, above all urbanisation, reveal the concentration process as proceeding here synchronously. This process ist most distinctly expressed by an increase in the role of the principal centres of the settlement system (which could be agglomerations in case of higher-order systems). The population is an active and at the same time the most mobile component of productive forces. Hence an analysis of population dynamics (linked with changes in the material basis of settlement) is an effective means of determining the regularities of the concrentration process taking place in the settlement system.

The aim of the present paper is to establish the regularities of the concentration process in the settlement system of the Estonian S.S.R., relying on an analysis of the demographic characteristics on the basis of the data for years 1959—1974. Starting from the peculiarities of the internal structure of settlement systems — hierarchical and territorial division, the analysis was carried out from two aspects. F i r s t, it was performed within the republican settlement system as a whole according to individual levels of hierarchy with the aim of finding out under the action of which factors and to what extent the redistribution of the population proceeds from the lower, more dispersed levels to the higher levels consisting of a smaller number of larger centres. Secondly, the same phenomenon was studied according to territorial subsystems where the mutual relations between the centres and their subordinated settlements (i. e. the interrelations between different hierarchical levels) are most direct. It is this research aspect that enables the investigator to best assess the effect of the system-shaping ties of the centres on the concentration process.

It must be emphasized that by the redistribution of the population is meant here not only migration of the population from one individual settlement or settlement group to another (i. e. movement of the population from one level to another), but also changes in the share of settlements under study in the population of the whole system, which depends also on the peculiarities of natural movement. Any increase or decrease in the role is a relative index. This may proceed under the action of an active or of a passive factor. An increase in the role of a settlement is active if this is the result of an increase of its own population. An increase in the role of a settlement is passive when the increase proceeds as a result of decrease in the population of other comparable settlements of the same system.

Since the object of research is a system, a closely interrelated community, one cannot confine oneself only to the establishment of the size of the migration gain or loss of settlements; it is also necessary to determine at the expense of which other settlements this gain or loss takes place. When studying the concentration process, chief attention is paid to the centres of the territorial settlement system of all hierachical ranks. It is above all necessary to ascertain of what kind are these migrational links between centre and other settlements of the same system and if the centre has any reserves of growth outside the particular settlement system.

1. ON THE SETTLEMENT SYSTEM OF THE ESTONIAN S.S.R.

To understand the phenomena of the concentration process taking place in the settlement system, it is necessary to take into account the peculiarities of the general dynamics of growth as well as those of the hierarchical and territorial structure. In the case of the settlement system of the Estonian S.S.R. the following circumstances must be pointed out.

The settlement of Estonia as a union republic constitutes one of the basic subdivisions of the settlement system of the Soviet Union, which is rather autonomous, but at the same time inseparably linked with the settlement systems of the other union republics. The present investigation includes a section which discusses the settlement of the Estonian S.S.R. as a basic system (which is a part of the settlement of the Soviet Union as a super-system), which itself is divided into hierarchical and territorial subunits.

The Estonian S.S.R. belongs to those union republics which steadly has had a migration gain from the other parts of the Soviet Union. At the same time the growth factor inside the system — natural gain — is low. For this reason the general growth rate of the population is moderate. During the period under consideration the population of the republic increased by 18.5 per cent. 57 per cent of the total gain was due to migration gain and 43 per cent — to natural gain. The moderate increase of the population slows down changes on the one hand and increases the need for a redistribution of the population inside the system on the other.

The settlement system of the Estonian S.S.R. is markedly characterized by a powerful basic centre Tallinn, — the capital, which alone concentrates 28 per cent of the population of the republic and which of all the Estonian towns has the most many-sided functions. At the same time the lower hierarchical levels of the republican settlement system are highly dispersed: here are a great number of small urban settlements, and extremely large number of rural settlements, particularly small villages. Relying on the research results obtained by several members of the staff of the Chair of Economic Geography of Tartu State University (S. Nõmmik, V. Murel, E. Tsopp, etc.) and adapting them to the aims of the present paper, the author distinguishes 7 hierarchical levels in the settlement system of the republic: 1. the capital as head of the republican settlement system, 2. polyfunctional regional centres. 3. industrial centres of republican importance, i. e. basic nuclei of the agglomeration of NE Estonia, 4. district centres, 5. local centres, 6. central settlements of collective and state farms, and 7. the remaining rural settlements — villages without any system-shaping functions. Of the groups listed, the third, fifth and sixth need some explanation.

The third group of settlements includes a couple of towns — Kohtla-Järve and Narva — which occupy a special position among the other towns of the republic. They are equivalent of the poly-functional regional centres in population size and even surpass them in their industrial potential; however, they have not got a large zone of influence within the framework of the republic which characterizes other regional centres. This circumstance results from the specific peculiarity of their position — on the one hand, the district of Kohtla-Järve is surrounded by natural bodies of water in the north and in the south, on the other, this district lies between the zones of direct influence of two large centres — Leningrad in the east and Tallinn in the west. For this reason Kohtla-Järve and Narva have basically only the administrative district of Kohtla-Järve for their close hinterland within the republic. This characteristic feature brings these towns closer to the remaining district centres. Hence they occupy an intermediate position among the regional and district centres, and this is why they have been set aside as a separate hierarchical subgroup (or intermediate level).

The group of local centres is rather heterogeneous in its composition, consisting of small urban settlements having various functions as well as of larger rural settlements. Their common characteristic is that they have a certain compact zone of influence, which has taken shape on the basis of links of production or of servicing (in part of them mainly on the basis of links of servicing). Here one has to add that starting from this characteristic, not all small urban centres of the republic have been included in the group under study. Due to the peculiarities of their position (proximity to a larger centre, location among forests and bogs) or some other factors, several small urban settlements do not posses a distinct close hinterland of their own, on account of which they have not been treated in this paper as local centres but as satellites of the capital, of the regional and industrial centres of republican importance. In this paper the group of farm centres comprises not only those settlements in which the office of a collective or state farm is directly situated, but also other large rural settlements with manifold production and servicing functions involving in their sphere of influence the territory of the same farm as a whole or only a part of it.

Starting from the territorial aspect, the following, hierarchically overlapping subsystems can be distinguished in the republican settlement system: 3 regional, 15 district, 52 local and 370 farm or lower-rank subsystems (for brevity they will be called regional, district, local and farm systems below). The majority of the farm systems consist only of the territory of one collective or state farm. The boundaries of some farm have been extended at the expense of the forestry settlements situated on the territory of the state land reserve, likewise at the expense of fishing, recreational and some other settlements lying along the sea-coast. Most of the territorial systems have a distinct management centre, which in some cases is the nucleus of an agglomeration. The republic as a whole has such an agglomerational centre in the form of the capital and its closer satellites. Part of the systems are polycentric, having two or more roughly equal centres sharing their functions. The greatest number of polycentric systems are found among the lower-rank systems; however, there also exist two district systems with double principal centres. Of them, Kohtla-Järve and Narva concentrate a number of local centres around them, constituting the largest industrial agglomeration of the republic where the close hinterlands of individual centres overlap.

It has to be recalled that part of the centres are polyhierarchical, i. e. they simultaneously perform the functions of two or more centres of settlements systems of different hierarchical rank. Thus, the capital is the head of the settlement system of the entire republic, but at the same time it is also the regional centre of NW Estonia, the administrative centre of Harju District and local centre of its immediate surroundings. Likewise all district centres are the local centres of their nearest surroundings and part of the local centres are at the same time farm centres. This leads to the division of the territorial settlements systems into two groups — systems of so-called "pure type" with centres corresponding to their hierarchical level, and systems with centres of higher rank. The latter group comprises altogether 36 systems (18 farm systems, 14 local systems, 3 district systems and 1 regional system). Below we shall see that the hierarchical rank of a centre exercises an influence on the population dynamics of the settlements of its surroundings which is not to be ignored.

2. ON CHANGES IN THE HIERARCHICAL STRUCTURE OF THE SETTLEMENT SYSTEM

Table 1 presents a survey of the changes that have taken place in the respective role of the individual hierarchical subdivisions of the settlement system of the republic as a whole over the 15 years under review. When undertaking an analysis one has undoubtedly to consider that the period under study is short; no cardinal changes could therefore take place during that period. Nevertheless, the time interval is sufficiently long to enable one to ascertain the trends of the process under consideration.

From the table presented below one can see that the most essential shift which has taken place in the settlement of the republic is the exchange of the places taken by the capital and the villages — two extreme hierarchical levels with the largest number of inhabitants. While in 1959 the villages concentrated the majority of the population and the capital occupied the second place, in 1974 the situation was reversed. Clearly one may expect a further decrease in the share of the villages in the near future, because this is the only group of settlements in the settlement system of the republic in which the number of inhabitants is also diminishing in absolute figures.

Both natural and migration gain in the villages is in the aggregate negative, migration gain being the decisive factor in the decrease. At the present stage in the group of villages there is

Table 1

Changes in the share of the more important hierarchical ranks in the settlement system of the Estonian S.S.R. in 1959—1974

	Number of inhabitants in % compared with 1959	Share in the population of the republic in %		Share in total gain of population in %	Share in migration gain outside the republic in %**
		1959	1974		
The capital *	142	24.2	29.0	55.5	44.6
Regional centres *	132	9.6	10.7	16.7	10.9
Industrial centres of republican importance *	160	10.9	12.3	29.6	29.3
District centres	139	8.1	9.4	17.2	6.0
Local centres	126	6.5	6.9	8.1	0.0
Farm centres	126	9.3	9.9	14.8	} 9.2
Villages	73	30.3	21.8	−41.9	
Total	119	100.0	100.0	100.0	100.0

* Together with near satellite settlements.
** During the period of 1971—73.

proceeding even an apparent rise in fragmentation since the number of small villages (below a hundred inhabitants) is increasing and so is the total population living in these villages and their share in the total population of the republic. Due to the rapid decrease in the number of inhabitants many villages which previously boasted large populations have now moved into the group of small villages. It is obvious that the rise in the share of small villages is a temporary phenomenon, peculiar to the transitional period which is preparing a new stage — a decrease in the number of villages and above all the disappearance of small villages.

In the remaining hierarchical groups the total population is growing, the growth rate being noticeably higher in settlements with a higher hierarchical position. One must point out that the extraordinarily rapid growth of the industrial centres of republican importance is chiefly due to the town of Narva, which over the whole period under review has been in the forefront of industrial and constructional activities in the republic. Altogether 85 per cent of the total population gain is concentrated in two principal agglomerations — the capital and the industrial region of Kohtla-Järve—Narva.

Differences inside the group of the population dynamics of the hierarchical levels under study are increasing towards lower ranks i. e. in parallel to the increase of the number of settlements and to the decrease of the total growth rate. On higher levels, from the capital down to the district centres, all settlements are growing, although at a different rate (the limiting values ranging between 18 and 177 per cent). Among the local centres and on the levels below the local centres, diminishing settlements are found beside the growing ones; the share of the diminishing ones is increasing towards the lower ranks. Thus, the number of inhabitants is diminishing in 10 per cent of local centres and in 30 per cent of farm centres and in the overwhelming majority of villages.

3. PHENOMENA OF THE CONCENTRATION PROCESS IN THE TERRITORIAL SUBSYSTEMS OF SETTLEMENT

When we analyze the population dynamics according to the territorial subsystems of republican settlement, we see a regularity similar to the previous one — the number of subsystems with a diminishing total population is increasing towards lower ranks. The population has increased in the republican settlement system as a whole as well as in all regional systems, whereas the population has diminished in one-third of district systems, in one half of local systems and in four-fifths of lower-rank systems.

The concentration of the population at the centres has increased on all the hierarchical levels of the territorial subsystems of the settlement system irrespective of the fact that part of the local and farm centres themselves have a diminishing population. As a rule, the decrease of the population in villages situated near such dying out centres is still more rapid. For this reason the share of a centre in the total population is growing or remains at least on the previous level. In summary, the role of centres in the population of the corresponding territorial system has increased in lower-rank systems even more rapidly than in higher-rank ones. Thus the share of the capital and of its closer satellites in the total population of the republic has increased by 5 per cent, the role of the local centres in the respective systems has risen by 9 per cent and the proportion of the central settlements in farms has gone up by 11 per cent. This depends on the relationship of the active and the passive factor in the increase of the concentration discussed above. The share of the capital in the total settlement system has increased only due to the influence of the active factor (i. e. increase of its own population) while the whole population of the remaining settlements of the republic has increased. The share of the centres of the different territorial subsystems has increased also due to the influence of the passive factor (decrease in the population of the other settlements of the same system). The role of the passive factor grows rather regularly towards lower ranks. For example, the relationship between the active and the passive factor in the increase of the role of regional centres is 1:0.5, in the case of the district centres this relationship is 1 : 1, in the case of local centres 1 : 2, and in the case of farm centres 1 : 3 (each of the centres mentioned within the limits of the subsystem of the corresponding rank).

The components of the active growth of the population — natural and migration gain — vary considerably in the centres of different type, while differences in migration gain can be expected to be greater. At the same time there manifests itself a regularity in the circumstance that the area of migration gain within the republican system basically corresponds to the hierarchical rank of the respective centre: the capital grows at the expense of the whole republic, the district centres grow at the expense of the same districts, the local centres grow at the expense of their own subsystems, etc. The control ties in administration, production and servicing step up the exchange of information with the other settlements of the same system, which, as a rule, stimulates the migration to centres (foreseen by plan as well as undertaken on personal initiative). Approximately 70 per cent of the transference of the population from a lower hierarchical level to a higher one (calculated from migration gain) proceeds within the boundaries of district subsystems, i. e. under the influence of direct contacts with the nearest centres. Nine-tenths of the positive balance of the migration country $\rightarrow$ town in favour of towns takes place as a result of migration within the district. Migration outside the republic proceeding between higher-rank settlement systems promotes the concentration of the population on the higher hierarchical levels (see Table 1).

The hierarchical rank of the urban centres and the functional type greatly affect the dynamics of their close farm systems as well as the concentration in their central settlements.

This statement is confirmed by an analysis of the population dynamics and the role of the central settlements according to the local settlement systems of the republic by grouping them in accordance with the hierarchical rank of its centre, i. e. we separate the local subsystems of a pure type from the remaining ones whose centre is a district centre or another centre of a higher rank. The results of this analysis are presented in Table 2.

It is evident from the table referred to that depending on the differences in the population gain of the centres themselves the population dynamics of the local systems of a different type is not uniform. The total population of the local systems of a pure type has decreased because there are among them also such where the number of inhabitants of the basic centre of the sybsystem itself has gone down. In the local systems whose centre happens to be a district centre, the total population has remained more or less stable due to the growth of the centres themselves, whereas

Table 2

Population dynamics and the role of centres in the local settlement systems of the republic in 1959—1974.

Hierarchical rank of centre	Population gain or loss in the local systems in %	Share of centres in the population of the systems in %		Farms belonging to the respective local systems				
				Population gain or loss in %	Among these		Share of central settlements in total farm population in %	
		1959	1974		in central settlements	in villages	1959	1974
Local centre	– 6	24,3	35,4	–18	+15	–27	21,6	30,5
District centre	+ 4	33,3	44,5	–13	+33	–26	22,1	33,9
Industrial centre of republican importance	+48	84,2	91,1	–16	+34	–34	25,3	41,0
Regional centre	+19	68,7	76,2	– 9	+30	–21	23,2	33,0
The capital	+42	93,5	94,1	+32	+130	– 9	24,4	42,6
Total	18,5	60,4	68,3	–15	+26	–27	22,1	32,8

in the subsystems whose centre happens to be a centre of a higher rank the total population has grown considerably.

Further, we see that this general dynamics is influenced not only by the growth rate of the basic centres of the local systems, but that it also depends on the rate of decrease in the population of the farms belonging to the respective local systems. The population dynamics of the farms in its turn is affected by the growth rate of their central settlements.

On the farms situated close to the capital the total population has been increasing, the increase being due to the rapid growth of their central settlements. Many of them enjoy the additional function of a satellite, since they serve as dwellings for the workers of the capital. In the remaining local systems the total farm population has been diminishing, the decrease being the most rapid on the farms which are situated close to the local centres and to the industrial centres of republican importance. On the farms bordering on the local centres the growth of the central settlements is slow because part of the local centres have taken upon themselves the functions of the farm centres. In the neighbourhood of the industrial centres of NE Estonia the growth of farm centres is comparatively rapid and the concentration of the population in them is nearly as high as in the neighbourhood of the capital, but there the population of the villages is diminishing even faster than on an average in the sphere of influence of the local centres.

Table 2 gives a very general idea of the phenomena discussed here. Figs. 1 and 2 present a somewhat more concrete regional survey of the population dynamics of the farm settlement systems, also the population growth in their central settlements as well as the degree of concentration in the central settlements. They demonstrate once more that although there exist some differences according to districts, the majority of farms with a growing total population or at least with growing central settlements in all the districts are in the sphere of influence of district centres (incl. the capital and regional centres). The trend towards the development of stronger central concentration nuclei likewise manifests itself in the fact that the greatest number of farms with a diminishing population, including farms with diminishing central settlements, are situated on the outskirts of districts as well as in the outlying parts of the republic.

At the present time several farm and a few local settlement systems are polycentral. In the majority of such centres one may observe the priority development of one major centre, thus a tendency towards becoming monocentral. Other investigators (e. g. Alayev & Khorev, 1974) have also pointed out the same phenomenon.

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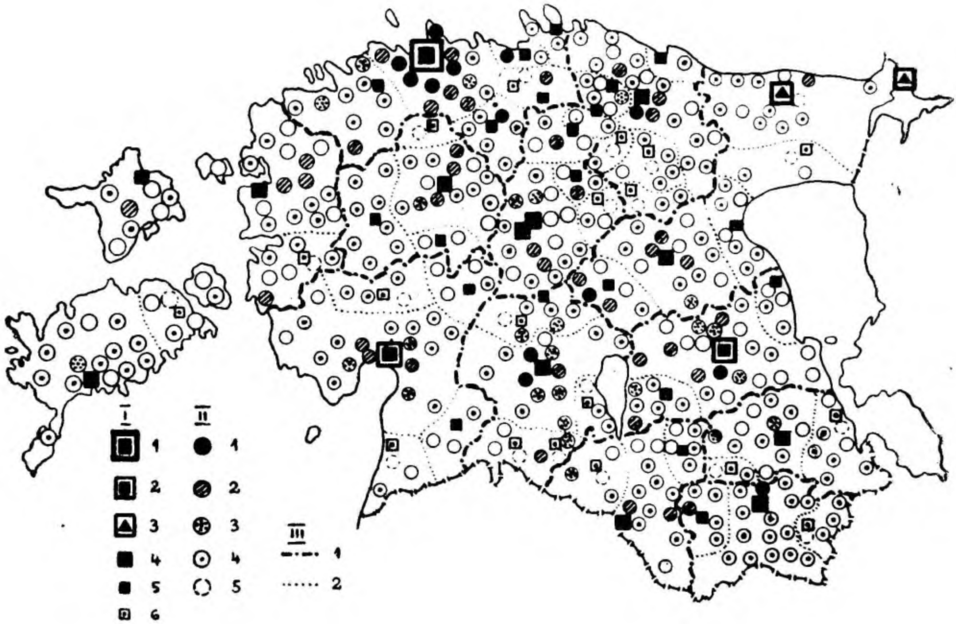

Fig. 1. The dynamics in the population of the farm settlement systems in 1959—1974.

I Hierarchical type of the basic centres 1. — the capital 2. — regional centre 3. — industrial centre of republican importance 4. — district centre 5. — local centre 6. — local centre in which the farm office is situated. II The dynamics in farm population. 1. — the total population has increased both in central settlements and in villages. 2. — With an increase in the total population at the expense of the central settlements 3. — the total population has stabilized (growth ±5 per cent) 4. — the total population has decreased at the expense of the village, the population of the central settlements has increased or stabilized 5. — the population has decreased both in village and in central settlements. III Boundaries 1. — of the district settlement system 2. — of the local settlement systems.

To sum up, the concentration manifesting itself in the settlement system, is a complicated process, vertical in its principal direction, but proceeding by stages. Here find simultaneous expression both development (i. e. appearance of new elements) and an attempt intrinsic to systems to preserve their basic structure by adapting themselves to new conditions. At the present time the concentration process is more intensive on the lower levels of the settlement system where the trend of a decline in the number of settlements (including systems of lower rank) is very distinctly noticeable, in other words this is an attempt to perform the func-

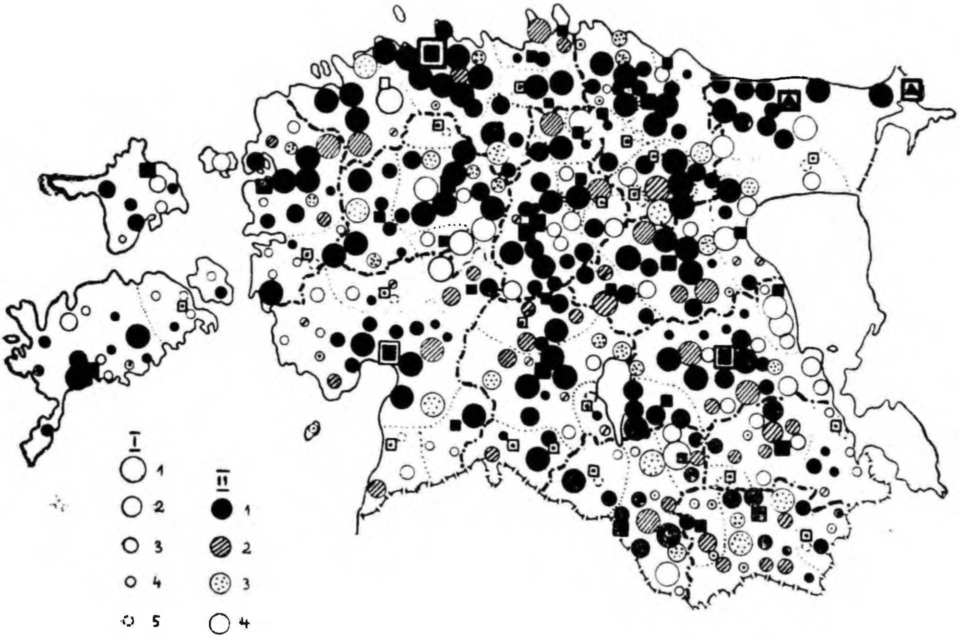

Fig. 2. The role of the central settlements in the farm population and the rate of their growth in 1959—1974.

I The role in the farm population 1. — below 20%, 2. — 20—29%, 3. — 30—39%, 4. — above 40%. 5. — a farm. the office of which is situated in the local centre. II The growth rate 1. — with a rapid growth rate (20 or more %). 2. — with a moderate growth rate (5—20%) 3. — with a stable population (±5%) 4. — with a decreasing population (more than — 5%).

tions inherent in a corresponding hierarchical level through a smaller number of settlements.

First of all, the number of villages is diminishing, particularly the number of those villages that serve as homes for the farm population. In connection with continuous concentration of animal husbandry the number of villages that primarily perform the function of agricultural production is also decreasing. The decrease of the number of farms and the increase of their territory leads to a decline in the number of farm centres. Part of them continue to exist as villages, but the smaller and less developed of them may cease to exist. The process of differentiation also affects the group of local centres — the strong ones develop further, the weak ones are reduced to the level of farm centres. As district centres become stronger, their close hinterland widens and evidently "swallows up" some weaker and less developed local systems. It is not excluded that in the future the number of district centres will diminish — some district centres of recent date and not so firmly established which are situated in the neighbourhood of regional centres may in all probability be relegated to the level of local centres.

The chief circumstance which at present slows down the concentration of the population in the centres of subsystems is the dwelling function. The dispersion of dwellings in the rural settlements of the republic is still very high and this cannot be eliminated overnight. On the other hand, the concentration of the population in centres is in addition to the direct functions of production and servicing promoted by the administrative and organizational control ties mentioned earlier. Migration studies confirm convincingly that those hierarchical groups that possess a certain official hinterland also have stronger and more permanent local growth reserves in the form of migration gain (steady positive migration gain as a rule also raises natural gain). In conditions obtaining in the Estonian S.S.R. the farm and district centres as well as the capital represent such groups. The farm centres are above all the centres which control production on the territory of their farms. The district centres and the capital have in addition the function of organizing administration and servicing. The local and regional centres do not possess administrative power with respect to its entire hinterland and this circumstance somewhat weakens their local ties and growth reserves. Regional centres, like other centres occupying a higher hierarchical position, have a remarkable source of growth in the form of migration gain from outside the republic, but in general its extent is noticeably less stable, fluctuating from year to year.

All that has been said above points to symptoms suggesting that in future development a decrease in the number of the hierarchical levels of the settlement system is likely, which will signify a further and more profound stage in the process of concentration.

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KONTSENTRATSIOONIPROTSESSI SEADUSPÄRASUSTEST EESTI NSV ASUSTUSSÜSTEEMIS

Ann Marksoo

Resümee

Teaduslik-tehnilise revolutsiooniga kaasneb tootmise ja sotsiaalse infrastruktuuri kontsentratsioon. See kutsub esile muutused ka asustussüsteemis kui tootlike jõudude territoriaalse organisatsiooni vormis. Peaaegu kõik asustussüsteemide struktuuris toimuvad muutused, eesotsas urbaniseerumisega, väljendavad samaaegselt siin toimuvat kontsentratsiooniprotsessi. Viimase kõige selgemaks avaldusvormiks on asustussüsteemi kui terviku ja selle erinevat hierarhilist järku territoriaalsete allsüsteemide keskuste (mõnedes kõrgemat järku süsteemides aglomeratsioonide) osatähtsuse kasv.

Käesolevas artiklis analüüsitakse kontsentratsiooniprotsessi seaduspärasusi Eesti NSV asustussüsteemis demogeograafiliste karakteristikute alusel aastail 1959—1974. Lähtudes asustussüsteemide sisemise ehituse iseärasustest — hierarhilisusest ja territoriaalsest liigestatusest — uuriti kontsentratsiooni kahes aspektis. **Esiteks** selgitati kontsentratsiooni vabariigi asustussüsteemis kui tervikus üksikute hierarhia astmete kaupa, selgitamaks, milliste faktorite mõjul toimub rahvastiku ümberjaotumine ühelt astmelt teisele. Kontsentratsioon väljendub siin seaduspärasuses, et rahvastiku arv väheneb kas absoluutselt ja suhteliselt või ainult suhteliselt asustuse hierarhia alumistel, enam killustatud astmetel ja suureneb ülemistel astmetel, mis koosnevad vähema-arvulistest suurematest keskustest. **Teiseks** uuriti sama nähtust asustuse territoriaalsete allsüsteemide kaupa, pöörates peatähelepanu süsteemide keskasulate osatähtsuse kasvule vastavate süsteemide rahvastiku üldarvus.

Töö tulemused näitavad, et absoluutne rahvastiku juurdekasv on suurim asustuse hierarhia ülemistel tippudel, s. o. juba väljakujunenud peamistes kontsentratsioonikeskmetes — pealinnas, regionaalsetes ja vabariikliku tähtsusega tööstuskeskustes. Uuritava protsessi intensiivsus on aga tugevam asustuse hierarhia alumistel astmetel, kus esineb tendents nii asulate kui ka alam-astme asustussüsteemide arvu vähenemiseks. Vastav arengusuund valmistab ette kontsentratsiooniprotsessi teist, süvenenud etappi, mil algab ka hierarhia astmete arvu vähenemine.

ЗАКОНОМЕРНОСТИ ПРОЦЕССА КОНЦЕНТРАЦИИ В СИСТЕМЕ РАССЕЛЕНИЯ ЭСТОНСКОЙ ССР

А. Марксоо

Резюме

Научно-техническая революция сопровождается все углубляющейся концентрацией производства и социальной инфраструктурой. Это вызывает непосредственные изменения и в системе расселения, являющейся формой территориальной организации производительных сил. Почти все изменения в структуре системы расселения, в первую очередь в урбанизации, выражают в то же время и процесс концентрации. Самой явной формой проявления последнего является рост удельного веса главного центра (или центров) в системах расселения разного иерархического ранга.

В данной работе анализируются закономерности процесса концентрации в системе расселения Эстонской ССР на основании изменения демогеографических показателей в периоде 1959—1974 гг. Исходя из особенностей внутреннего строения системы расселения — иерархичности и разделения на территориальные подсистемы — процесс концентрации был исследован в двух аспектах. Во-первых концентрация изучалась по иерархическим ступеням республиканской системы расселения в целом, чтобы установить факторы, вызывающие перемещение населения с одних иерархических ступеней на другие. Концентрация выражается при этом в закономерности, что численность населения уменьшается как абсолютно так и относительно (или только относительно) на низких более раздробленных ступенях и увеличивается на высших тсупенях, состоящих из немногих крупных центров. Во-вторых, то же явление было проанализировано по территориальным подсистемам расселения, обращая главное внимание на прирост удельного веса центров в общей численности населения соответствующих подсистем.

Результаты исследования показывают, что наибольший абсолютный прирост населения наблюдается на высших ступенях иерархии расселения, т. е. в уже сформировавшихся главных ядрах концентрации — в столице, региональных и промышленных центрах республиканского значения. Однако в настоящее время интенсивность исследуемого процесса сильнее отражается на низших ступенях иерархии расселения, где проявляется тенденция к уменьшению численности отдельных поселений, а также территориальных подсистем нижнего ранга. Данное направление развития подготовляет другой, углубленный этап процесса концентрации, когда начинает уменьшаться и число ступеней иерархии расселения.

LOCAL CENTRES IN SETTLEMENT SYSTEMS

E. Tsopp

It is a prominent feature in modern settlement geography that, in accordance with the modern systemic approach to objects of study, the mutually related settlement communities are treated and investigated as systems. In a broad sense, system implies unity of individual parts in a uniform distinctly articulated whole, in which each component part has its strictly fixed place and function. In the theory of geography, which generally considers its object of research as a component of a complex whole devoting particular attention to the relations holding between the phenomena, the systemic theory is, in principle, not a new approach.

The 'rational core' of the concept of the 'local centres' which dates back to the 1930's, and is so popular in the literature on the settlement problems abroad, consists in treating the settlements not in isolation but as a definite networke, i. e. as a system. In Soviet economic geography elements of systemic research made their first appearance as early as around the middle of the 20th century (Баранский, 1946; Колосовский, 1947), although without the terminology employed in the systemic theory.

Well known is the division of settlements into urban and rural ones, and on that account they are kept apart in traditional treatment. However, the development of human settlement is a uniform steady process of change in the size, character and extent of the functions and relations whose nature and regularities are revealed only when the whole of the phenomenen is investigated as a system.

In geographical settlement studies, townships have always received more attention. The first attempts at the systemic study of the settlement problems were made in the treatments of systems of towns, which were followed by a systemic-structural analysis of the rural settlements. Several investigators of settlements have realized the need for a unified treatment of townlike and rural settlements, which has ked to the study of integral territorial systems (Nõmmik, Murel, 1971; Nõmmik, Marksoo, 1974).

An integral system of settlement is a whole made up of parts or components. These components are individual settlements (towns, rural settlements) or subsystems hierarchically depending on the higher stage, the main system. The structure of a settlement system viewed as an articulated whole is determined by the links and relations between its elements. The structure of the system can variously be described through the dimensional relations, the character of its functions, the extent of the links of the settlements, etc. A peculiar feature of a settlement is the existence of a certain territory, which, in addition to the area containing its material elements (buildings and lay-outs, etc.) includes also the hinterlands (the attraction area) around it. On the process of communication between the settlement and its hinterlands is based the functional unity of their territory and their socio-economic complexity.

What N. Baranski has said about towns also applies to the nature of the whole of settlement. Towns, like the armed forces, have a hierarchical arrangement. With in each economic region of a country, the towns are subordinated and co-ordinated in a certain fashion. Each has its peculiar functions and a more or less defined area of activity, its radius of influence and attractions (Баранский, 1946). The hierarchy of the settlements is not determined by their spacing, i. e. by their "geographical situation" (Kristaller-Lösch), but by their functions and mutual intercourse. The basic functions of a settlement are those of production, all other functions being supplementary.

The above features characteristic of settlements allow us to treat settlement as a functional-territorial hierachical system or a functional-hierarchical spatial system. By 'system of settlement' on the analogy of the system of towns is meant the integral dynamic community of both townlike and rural settlements, which are mutually interrelated and linked by a common economic basis and undivided territory. Ranking as systems of economic geography, settlement systems possess the following specific features: 1) unity of natural conditions, production and population, 2) links with the territorial organization of the productive forces, 3) fixed territory, 4) temporal and spatial dynamism.

Description of the settlement of various territoral units (states, large economic areas, member states of federations (sister republics), their parts, etc.) as systems of different stages is currently the basic trend in the geographical study of settlements. The task of investigating the settlement systems rises as a dual problem involving 1) elucidation of the functions and hierarchical ranking of the settlements, 2) consideration of the territorial settlement systems. The methodology, and also the outcome of the study of the problem is a functional-hierarchical classification of the settlements with the specification of the territorial settlement systems of different ranks. Although there exist numerous researches of various regional settlement systems (territories, areas, sister republics), there are as yet few investigators in the Soviet Union who regard the settlement systems as a unique whole.

The settlement of the whole of the Soviet Union is viewed as a unique system by the settlement investigator of the Department of Economic Geography of Tartu State University. To determine the position of a settlement in a hierarchical system and to define the territorial systems of settlements, one has to determine the community of the enterprises belonging to both productive and nonproductive spheres of the settlement concerned and the extent and nature of its socio-economic links. Accordingly, in broad outline, one can distinguish in the settlement system of the U.S.S.R. the following components: village, farming centre, local centre, regional centre, capital — centre of a Union Republic or region, intraterritorial (intrarepublican) centre, Capital of the Soviet Union (Ныммик, Марксоо, 1974). Within the framework of this supersystem, these settlements, in their turn, build a number of territorial subsystems with similar structures, but differing in the extent of their hierarchical scale. Such structural isomorphism permits of the application of analogous methods to the study of different settlement systems. This is borne out by the delineation of the structure of the settlement systems in the Estonian S.S.R., as a result of concrete investigations (Table 1.).

In this classification, the place between the district centres and the interfarm centres is occupied by the so-called local centres. This hierarchical type is one of the most heterogeneous components of the settlement systems as regards their functional, economic and other potentiality. The need to study the nature, development and perspectives of these settlements has prompted us to examine about 70 local centres in the Estonian S.S.R. So far, R. Ehrlich has carried out an investigation of the towns and townships functioning as local centres, rural local centres have been studied by V. Murel. U. Pragi was guided by the principle of functional unity in his choice of target settlements when he studied towns and rural settlements with urban functions. Without a strict formal delimitation of our object of research (according to the administrative adherence, number of population, etc.), and without taking into account the genetic-functional unity of settlement, we propose to deal with settlements which are at a transitional stage from rural to urban. In doing so, our aim is to elucidate the nature of the local centres, to throw light on the basis of their social and economic development and, accordingly, their role in the settlement system concerned.

Table 1

Settlement System of the Estonian S.S.R.
(Nõmmik, Murel, 1974)

Hierarchical type	Functional type			Territorial system
	Polyfunctional	Polyfunctional, with one prevailing function	Narrowly specialized	
1. Capital	Tallinn	—	—	Republican
2. Regional centres	Tartu, Pärnu	Kohtla-Järve	—	Regional
3. District centres	Rakvere, Paide, Võru, Haapsalu, Valga, Viljandi	—	Narva	District
4. Local centres	18 small townlike and 39 larger rural settlements	10 small townlike and 29 larger rural settlements	15 small townlike and 18 larger rural settlements	Local
5. Farm centres	ca 170 villages	65 villages	145 villages	Interfarm
6. Villages	—	ca 1450 villages	ca 2200 villages +2900 dwelling villages	

1. LOCAL CENTRES. NATURE AND NOTION

There are two main approaches to the nature of local centres as settlement types. All settlements, polyfunctional as well as the narrowly specialized ones, from district centres to collective and state farm centres are broadly regarded as local or local economic centres (S. Kovalyov, V. Yershova, K. Krasnova, V. Drushkova, N. Schevtsova, et al.). Specific types of local centres include district centres, additional local centres, economic centres with different variations (basecentres, specialized centres, etc.). Such a treatment can be considered to be partly justified, as all the above mentioned settlements exercise a certain power of attraction on the settlements of the lower stage. Yet, as a rule, a local centre can be distinguished as a settlement in its own rights only when considered as part of a larger territorial unit. B. Khorev has rightly pointed out that not all settlements that at all possess the required "central functions" can be classified as local centres, but only those in which the above mentioned functions are in overwhelming majority (Хорев, 1968). Hence, it is not correct to view the local centres as embracing also the district centres which are characterized by the administrative, political, economic and other specific functions within the boundaries of one administrative unit. In the other, narrower approach, only part of the settlements mentioned above, namely the polyfunctional local centres are considered as local centres proper. Also K. Šešelgis, V. Maldžiunas and most of the authorities in settlement planning (in Estonia, Latvia, Lithuania, the Ukraine, etc.) regard such intermediate stages between the district and interfarm centres as local centres. In this paper we propose to deal with the local centres in the latter, narrower sense.

Unlike many authors who regard non-productive functions (servicing of the population) as the primary or sole characteristic feature of the local centres, we consider the functions of production as the basic factor in their development. The specific features of the local centres are first and foremost determined by the socio-economic division of labour within the administrative unit. Depending on that division of labour, this type of settlement has to fulfil various functions in the sphere of production and servicing, catering for a definite area in the district. In a way, the local centres serve to assist the district centres in the fulfilment of certain decentralized functions.

A local centre is a polyfunctional intrafarm centre whose basic task is to satisfy the various requirements of the economy and population of its attraction area. The specific functions of a local centre include 1) processing of the mineral resources (oil shale, peat, clay, etc.), timber and agricultural raw materials (wood, milk, meat), 2) economic and organizational servicing of the area (the "Agricultural Implements Repairs and Maintenance" (Põllumajandustehnika), housing construction, road building and transport organizations, communication systems); 3) catering for the various, mostly periodical cultural and communal needs of the population of the attraction area.

2. SOCIO-ECONOMIC BASIS OF THE DEVELOPMENT OF LOCAL CENTRES AND ITS INVESTIGATION

The socio-economic basis of the development of a settlement is an integral problem and admits of various interpretations. In principle, the development of any settlement depends on all the natural, economic, demographic, historical, etc. conditions present. Acknowledging the decisive role of the productive forces in the evolution of a settlement, we cannot overlook the impact of the settlement itself on the development of its economic branches. "Towns (settlements), whatever their function, constitute a kind of capital which cannot remain unproductive", J. Beaujeu-Garnier and J. Chabot (1967) have observed. This "Capital" (people and labour invested in things) finds its application, is synthesized and reveals itself in the function of the settlement. On account of this we can study the socio-economic basis of a settlement through the various spheres of activities or functions of its population.

What is generally meant by the functional structure of a settlement is the whole of its national-economic substructure, although some authors are of a different opinion, claiming that its economic base and functions only comprise such branches of economy as turn out export goods and are thus placed in the service of the inhabitants of the other settlements as well. The evolution of the functional structure of a settlement is best viewed as a chain reaction in which the primary functions contributing to the making of a settlement are inevitably accompanied by such activities as are concerned with its servicing. Each function or field of activity has its "ceiling", that is to say, its individual need for co-functions and, accordingly, its characteristic potentiality in the making of the settlement concerned. It is the above objective factors that give rise to the functional variety in the settlements and determine the individual character of every local settlement.

The development of a settlement ranking as a local centre is not confined to the specific functions it fulfils in its attraction area. It has a broader national-economic basis. Apart from the local inter-settlement factors there are also remote links at work in the making of each local centre. Life has shown that settlements with plants of merely local importance very soon tend to reach their ceiling and their growth stops. This is caused by the peculiarities of the functions and the territories that gave rise to the development of these settlements. The rise and development of the settlements have to be regarded as depending on the territory with which they are in close contact.

Investigating the development of the socio-economic basis of the local centres one has to describe several aspects of the functions of the settlements — their structure, links and dynamism. Owing to the fact that there is no integral quotient to characterize the functional structure of a settlement one has to resort to the data concerning the basic funds, or output, or, most frequently, the figures showing the rate of engagement of the population in different branches of national economy. In the present discussion we shall employ a combined method based on the degree of engagement of the local population and the total number of workers. We presume that 1) the functional nature of a settlement is determined, first and foremost, by the functional character of the establishments and the plants located in it. Here we take into account only the workers employed locally, including also the commuters who live elsewhere, and excluding the workers of the shops and departments situated outside the settlement. 2) In addition to the above, the functions of a settlement are also attributed to what may be termed as regional fields of activity engaging the population of a settlement and often constituting the economic and organizational basis for the settlement. Owing to the areal dispersion of the objects of work (in farming, forestry, land amelioration) or its itinerant character (construction work, transport, road repairs), such arrangement of work is inevitable. Moreover, the the working place is usually in the nearest vicinity of the settlement, therefore such regional engagement cannot be regarded as regular commutation; 3) the functions of a settlement do not include the data characterizing the engagement of those inhabitants whose place of occupation is at a distance considerably exceeding the radius of the regional activities. The latter, the so-called commuters proper are mostly employed in larger towns, and the settlements we are concerned with only serve them as dwelling places. The function of a dwelling place, however, is characteristic of all settlements and we do not see any justification for singling it out as a specific separate function in some of them. Very marked outwardly directed commutation is a sign of scarcity of the national-economic functions or a complete lack of a basis for development on the spot.

Below we shall consider the possibilities and ways of determination of the peculiarities of the functional structure of the local centres employed in our Republic. The development of the settlements was found to depend on six branches of the national economy: 1) industry, 2) transport, building, servicing of roads and communications systems, 3) "Farm Implements Repairs and Maintenance", 4) farming, forestry, fisheries, 5) communal services, 6) various other branches including administrative, safety services and special functions, science and the administrative organization of the district centre. A comparison of the relative importance of these groups will best bring out the prevailing, basic functions in the local centres. Yet we cannot confine ourselves to that, for a mere analysis of the co-existing functions and the structural relations within a settlement fails to identify it as a local centre. Here we have to resort to the examination of the territorial aspect of its functions, that is to say, we have to define the extent of the area over which these functions are revealed. This is one of the basic problems in the study of the functions, and also the most difficult one as it requires an analysis of the productive and non-productive relations within the settlement. In the given situation we are first and foremost concerned with the horizontal aspect of the relations, i. e. with the area of their distribution in order to determine the role and structure of the specific functions based on local relations in the settlements under investigation. For this purpose we distinguish between three groups of territorial links with their corresponding functions: 1) predominantly intersettlement, 2) comprising part of the administrative district — settlement and its vicinity together with several farms, i. e. local links characteristic of local centres; 3) links with the whole of the district and those reaching outside its boundaries. According to Z. Dzenis (1973), the local centres are chiefly characterized by polyfunctional areal close or local links. These are primarily based on the industry processing the local raw materials, regional fields of activity and servicing of the population. The longrange connections of some few enterprises are mono-functional and narrowly oriented to a few target and starting points. Such links are mostly peculiar to large independent industrial enterprises connected with local economy only through the use of its labour power and infrastructure. As a rule, we only make a distinction between the functions contributing to the making of a setlement and those of the servicing of the latter. The former group is made up by local and long-range functions, the latter, by those of a predominantly intersettlement scope.

It would be natural to presume that the role of a settlement in the capacity of a local centre is determined in the first place by local factors. In local centres, the local functions are the basic ones, and those based on the long-range links serve to supplement them. Prevailing intersettlement links show that functionally the settlement has not yet reached such a stage in its development as might enable it to participate in the intrasettlement exchange. Such treatment will result in summing up what functions combine to form the attraction area of a local centre, and what functions belong to the intradistrict level. Of particular significance is the dynamism of the functions, especially in the prognosis of the future of the settlement concerned. Yet it is hard to define the nature of the individual functions without their corresponding temporal characteristics. Against the general background of the development of national economy, we can still divide the functions of a settlement into dynamic and stable ones. It is upon their relations and nature that the future, i. e. the further growth or stagnation of the settlement depends.

3. DISTRICT-FORMING ROLE OF THE LOCAL CENTRES

Elucidating the role of a settlement in organizing a district[1] we regard it as a framework filled in by the district. The role of towns as attraction centres or organizers of districts is widely acknowledged. In fact, both urban and rural centres are found to generate districts of lower stages around them. The very notion of local centre presumes the existence of a certain local territory with the given settlement in its centre. This territory constitutes its hinterlands. The hinterlands or the attraction area of a settlement is the territory with a definite system of economic links in the centre of which is the given settlement developing at its expense. This area with which the settlement is in immediate contact is also called the area of its economic attraction (Konstantinov), its suburban zone (Knobelsdorf), the area of economic impact (Pomus), etc.

Settlements, especially those resembling the local centres, owe their district-forming role in the first place to their economic attraction. A settlement without an area of attraction fails to exercise an organizing influence over its surroundings. Therefore, in the opinion of E. Knobelsdorf and J. Leizerovich, it is more correct to speak of attraction to the settlements, which is essentially their principal district-forming role (Кнобельсдорф, 1967; Лейзерович, 1972).

The attraction of the smaller settlements within the impact area of a local centre to central settlements is due to the greater socio-economic potentiality of the latter. In a local centre there co-exist various plants and servicing enterprises, many of them being unique for the whole of the vicinity. The variety of occupations in a polyfunctional settlement like a local centre creates extremely varied links (see pp. 10—11). Of these, only the local links with predominantly areal distribution possess a district-organizing role. The system of local relations between the local centres and their surroundings, which also serves as their district-forming mechanism, reflects the specific functions of those local centres. The latter include both productive and non-productive occupations. Therefore, in order to determine the district-forming role of a centre one has to study all the local links, which can be

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[1] B. Khorev suggests the term 'district-organizing role' of a settlement instead of 'district-forming role'. The former is also preferred by N. Baranski.

broadly classified as productive and servicing. The links in the sphere of labour supply are also important. These links can further be differentiated as covering the spheres of 1) industry, 2) infrastructure, 3) commerce, 4) culture, 5) communal services, 6) education, 7) health services.

Special attention is devoted to the links originating in the migration of the population (both for occupational and servicing purposes) and the infrastructure. Their local character is dependent on financial-temporal restrictions (in case of the migration of the population) and technological-economic conditions (in case of the infrastructure). In the study of the links within the servicing sphere on can bring out areas which are concerned with free and paid services, that is to say, areas that are either controlled or uncontrollable. Such areas can be planned with great accuracy (schools, hospitals) or smaller probability (commerce, communal services, establishments of culture and entertainment). This has proved to be an important methodological device in bringing out cases of discordance between the existing state of affairs and the imposed system.

The hinterlands of a local centre thus develop on the basis of the variously linked branches of economy whose corresponding areas seldom coincide. Every sphere of activity has its own definite operation territory or territories which all combine to form a uniform attraction area of the settlement. In the process of manysided and intensive intercourse, the local centre and its hinterlands get inseparably linked, so that they can be treated as a territorial system. This system is characterized by 1) articulation into components or elements; 2) a relatively constant linkage of the elements, which is expressed in its structure; 3) existence as a unique separate whole at the extrasystemic level. The basic components of the system are, on the one hand, the local centre, and, on the other hand, the attraction area with its numerous components (establishments, enterprises, etc.) These are mutually bound by intrasettlement links expressed in the regular migration of the people, circulation of goods and information, etc. The systems that are heterogeneous by nature, but are joined together into a whole by such links are termed junction districts by B. Rodoman (1971). According to him there may prevail relations of distribution, attraction and exchange in them. Owing to its links of various nature with other smaller settlements, the local centre with its hinterlands constitutes a junction district based on relations of mutual exchange. It is composed of two functional parts, the servicing district and the serviced one. If these are unequal in area, we have a district consisting of a servicing central core and the serviced periphery. Such a smaller governing servicing core in a micro-district is the local centre, and the larger dependent territory serviced by the former is its attraction area. As a junction district, a micro-district constitutes a taxonomical unit, a special kind of economic region which results form the division of a territory with different centres in it according to their respective spheres of impact. Here one can perceive orientation to the basic elements in the territorial structure of the economy of the district, which, as a rule, are the local centre as the largest settlement, and one or two more important roads. This is expressed in the power of attraction a centre possesses in the centralization of the socio-economic links and the concentration of the population and economy in the centre, near the main roads, etc.

To sum up, the role of the local centres in the formation of districts manifests itself in their economic attraction. The centre governs, organizes, supplies, caters for its hinterlands, primarily owing to the specific production and servicing functions of the local centres.

Most of the works on settlement planning, however, regard local centres merely as servicing centres of a definite size category, and see their task in the determination of the optimal community of servicing establishments and the fixing of their proper servicing radius. This is based on the presumption that the district-organizing role of the local centres is confined solely to their servicing functions, which, however, will lead to the incorrect conclusions of the notorious theory of "central places". One cannot agree with the statement of K. Šešelgis that the micro-districts are predominantly social in content (Шэшельгис, 1968), and, hence, are to be regarded as hinterlands with an optimal radius surrounding their servicing centres.

Our investigation of the settlements in the Estonian S.S.R. has shown that local centres play a district-forming role both in the field of production and servicing.

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KOHALIKUD KESKUSED ASUSTUSSÜSTEEMIS

E. Tsopp

Resümee

Asustuse geograafia päevaprobleemiks on asustussüsteemide uurimine. Vastastikku mõju avaldavaid ja funktsionaalselt seotud linnalisi ja maa-asulaid, mida seob majandusliku aluse ühtsus ja ühendab territooriumi terviklikkus, käsitleme asustussüsteemina. Integraalne asustussüsteem on osadest koosnev tervik, mille komponentideks on üksikasulad (linnad, maa-asulad) või nendest koosnevad alamsüsteemid.

Kohalikud keskused paiknevad asustussüsteemis rajoonikeskuste ja põllumajanduslike ettevõtete keskuste vahel. Need maalistelt linnalistele üleminekutüüpi asulad on heterogeensemaid asustussüsteemi koostisosi nii funktsioonide kui ka demograafilise, majandusliku jm. potentsiaali poolest. Nende keskuste funktsioone selgitati Eesti NSV 70 kohaliku keskuse uurimise põhjal.

Kohaliku keskuse all mõistame polüfunktsionaalset majanditevahelist keskust, mille põhiülesandeks on tagamaa majanduse ja rahvastiku mitmekesiste vajaduste rahuldamine. Kohaliku keskuse spetsiifilisteks funktsioonideks on 1) tagamaal leiduvate maavarade ning põllu- ja metsamajandussaaduste töötlemine; 2) tagamaa majanduslik-organisatoorne teenindamine; 3) tagamaa rahvastiku valdavalt perioodilise iseloomuga kultuur-elukondlike vajaduste rahuldamine.

Asula areng kohaliku keskusena ei piirdu üksnes nimetatud spetsiifiliste funktsioonidega, vaid toimub hoopis laiemal sotsiaalmajanduslikul alusel. Asulate arengut uurides tuleb nende funktsioone iseloomustada struktuuri, sidemete ja dünaamika seisukohalt. Kohalike keskuste rajooni organiseeriv osa väljendub majandusliku tõmbuvuse kaudu. Keskus juhib, organiseerib, varustab, teenindab jne. oma tagamaad eelkõige kohalike keskuste spetsiifiliste, nii tootmis- kui teenindusalaste funktsioonide baasil.

МЕСТНЫЕ ЦЕНТРЫ В СИСТЕМЕ РАССЕЛЕНИЯ

Э. Тсопп

Резюме

Актуальной проблемой географии расселения является изучение систем расселения. Последние представляют собой целостные динамические совокупности функционально взаимосвязанных и взаимодействующих поселений, объединенных единством хозяйственной основы и общностью территории. Составными компонентами интегральных систем расселения являются городские и сельские поселения или составляющие их подсистемы.

Промежуточное место между районными центрами и производственными центрами сельскохозяйственных предприятий занимают местные центры. Как переходные поселения от сельских к городским, они являются гетерогенной частью системы расселения как функционально так и в отношении демографического, экономического и др. потенциалов.

Исходным материалом для предлагаемого сообщения являются результаты исследования 70 местных центров Эстонской ССР.

Местные центры в нашем понимании представляют собой полифункциональные межхозяйственные центры, основной задачей которых является многостороннее обслуживание нужд хинтерланда. Специфическими функциями местных центров являются: 1) обработка местных полезных ископаемых, сельскохозяйственной продукции и лесного сырья; 2) производственно-организационное обслуживание экономики хинтерланда; 3) удовлетворение периодических культурно-бытовых нужд населения хинтерланда.

Развитие поселений в качестве местных центров не ограничивается их специфическими функциями, а происходит на более широкой социально-экономической основе. При изучении основ развития поселений их функции нужно рассматривать в отношении структуры, связей и динамики функций. Районоорганизующая роль местных центров состоит в хозяйственном тяготении к ним центров низшего ранга. Местные центры руководят, организуют, снабжают, обслуживают свой хинтерланд на базе производственных и обслуживающих, преимущественно специфических для местных центров функций.

MEASURING SHAPE IN GEOGRAPHY

U. Pragi

It appears that the shape of areas does mean something to a geographer. Consequently, it is worthwhile to give some thought to the investigation of shapes.

In the literature there are three ways of approaching the problem: coding shapes, measuring shapes and classifying them on the ground of some measures.*

Coding means fixing a different code number to different shapes. The problem here is to ascertain the existence of a difference between two shapes, the fixing of code numbers is easy while optional. So far the authors have concentrated on code numbers and little has been done to ascertain differences. (Бунге, 1967, Taylor, 1971). We shall not linger long on that approach.

Passing over to measuring, we must first of all state that shape as such is a quality and can not be measured fully. But, as any quality, shape has quantitative aspects which can be measured. These measures are partial and even in there sum they do not make up the shape, as the sum of quantities never quite explains the entire quality. But they do explain some aspects of quality, provide insights into the shapes and hence are useful.

One of the quantities of a shape is its compactness. Geometry asserts that compactness means to have the minimum perimeter provided a fixed area or to have the maximum area provided a fixed perimeter. Thus compactness is relationship between perimeter L and area S. So it was defined by Nagel (1835):

$$\gamma_N = k \frac{L}{\sqrt{S}}$$

But this formula has been used so far either with the indefinite coefficient k or the coefficient is conventionally fixed to unity (Ю. С. Фролов, 1974). The last convention is not proved or explained anyway.

* We do not touch upon indices of population, production etc. distribution inside the shapes.

To specify the value of k, we must graduate compactness measure γ, which means that we must choose at least two standard shapes and fix some values of compactness to these standards. It is useful to choose a circle for the first standard, as the circle is the most compact shape, and fix the value of γ in case of a circle to unity. The second standard should then be the shape of minimum compactness. Such a shape is a straight line, that is a limit of real shapes in case the perimeter approaches ∞ and area to 0. As compactness cannot be negative (both perimeter and area are non-negative), the value of γ in case of a straight line should be fixed to 0. Thus $0 \leqslant \gamma \leqslant 1$ and measuring any real shape we always are provided with a scale to judge the results.

If the area of the shape to be measured is S and the perimeter L, then an equiareal circle also has an area $S = \pi R^2$ and the perimeter $P = 2\pi R = 2\sqrt{\pi S}$. The relation between perimeters of our shape and an equiareal circle is hence

$$\gamma' = \frac{2\sqrt{\pi S}}{L} = 2\sqrt{\pi}\frac{\sqrt{S}}{L}. \, *$$

Consequently, if $k = {}^1/_2\sqrt{\pi} \neq 1$, then

$$\gamma' = \frac{1}{\gamma_N}.$$

The dimension of this equiareal compactness is $\sqrt{m^2} : m = \varnothing$, which means that the values of compactness do not depend on the sizes of measured shapes. For example, all squares with any size have the same value of γ' (approximately 0.89).

The twofold definition of compactness permits an alternative deduction of γ by way of equal perimeters. If $L = P$, that is the perimeters of the shape to be measured and a standard circle are equal, then the area of the standard circle is $L^2 : 4\pi$ and equiperimetral compactness

$$\gamma'' = \frac{4\pi S}{L^2}$$

with dimension $m^2 : m^2 = \varnothing$: equiperimetral compactness also does not depend on the size of shape (V. C. Miller, 1953).

Thus we have two measures of compactness. But this produces no confusion. Note that $\gamma'' = \gamma'^2$ and as always $\gamma \geqslant 0$, there is a fully definite relation between the two measures, they are fully equivalent and give always concordant results. The only difference is in scale. Judging from dimensions, the equiareal compactness has a linear, the equiperimetral — a parabolic scale. For example, the equiareal compactness of shape, equally different from both stan-

* This index has been widely known for a long time. As far as we know, the first use of it in literature is by Muraveiski (С. Д. Муравейский, 1948).

dards, must be 0.5, equiperimetral — 0.25. As we see, in case of relatively compact shapes the equiperimetral compactness γ'' has a greater discerning capacity and vice versa.

Although the described compactness index has been known for a long time, it is not universally admitted by geographers. For example, Yu. S. Frolov (Ю. С. Фролов, 1974, p. 282) argues that, first, it does not measure all the quantitative aspects of a shape, and second, it does not measure compactness at all. We shall show that the first argument is inaccurate and that second one is founded on a misunderstanding. Let us begin with the second argument.

It appears that Yu. S. Frolov uses a different definition of compactness. He says that compactness means some measure of nearness between the points of the shape and is opposed to alienation of these points (Ю. С. Фролов, 1974, p. 282). We prefer to call such nearness measure massiveness, while we think that it contains some relations with the size of the shapes. But personal preferences count for little, if at all in science *. The matter is that the definition given by Cu. S. Frolov is intuitive, not operationalized, unable to produce a measure without further specifications. The definition used by us is an operational one and contains a formula of shape measure. And that difference between two definitions should settle the matter, at least, preliminarily.

An intuitive definition, besides not permitting immediate transformation into a formula, is usually indefinite. Proceeding from such a defnition if we ever come to some measure, the last is usually somehow deficient: it measures more or less than requested and measures it sometimes in one way, sometimes in another way. Such a measure could be useful in situations where no high precision, adequateness or reliability are needed, it could function as a provisional solution of a problem or as a step to a more adequate solution, but not any more. Let us convince ourselves of that on the basis of some examples.

The Rohrbach index is defined as the mean distance of the shape (figure) points to its outline (C. Rohrbach, 1890, С. Д. Муравейский, 1948, p. 88):

$$\gamma_R = \frac{\iint\limits_F \varphi dxdy}{\iint\limits_F dxdy},$$

where F is the figure in question, φ — the distance to the outline. First we shall note that practical calculations can be done only for a sample, a finite subset from the infinite number of points.

* Sufficient to say that L. Ya. Nutenko explicitly requires that a compactness index must measure size. See Л. Я. Нутенко, 1971, p. 127.

Thus in practice (almost always) the Rohrbach index is a sample one with certain limits of confidence. These limits seem to be unestimable at present. Thus we do not know whether our sample is correct or not.

Moreover, using the theoretical formula, one can show that squares of various size acquire different values of the Rohrbach index although their shapes are absolutely identical. Further one can show that the Rohrbach index sometimes measures size with the shape and sometimes not, that is, the manner of measuring shape or size by this index is obscure.

Consider a square with a side length a, situated with the left lower corner A in the beginning of Descartes' coordinates so that two sides of the square coincide with the axes (Fig. 1). The area

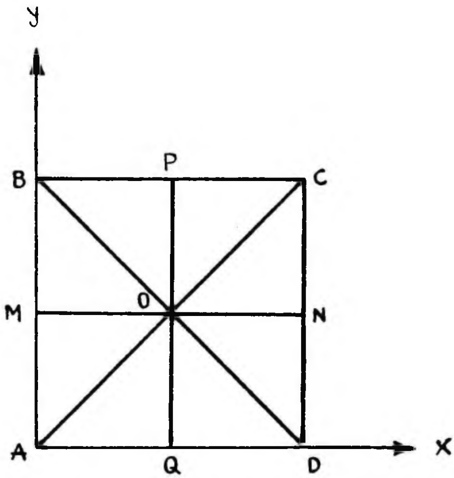

Fig. 1.

of such a figure is a^2. For to calculate the sum of distances, it is useful to draw square diagonals AC and BD and symmetry axes MN and PQ. Eight triangles formed thus are congruent and the sum of distances to the square outline is equal in each of them. (The reader could easily prove this assertion, we do not present the proof as it is rather lengthy.) Consequently, it is sufficient to consider only one of these triangles, e. g. ABO. The distance to the square outline is x in this triangle and the sum of all distances

$$\int_0^{a/2} \int_0^{y} x dy dx = \frac{a^3}{48}.$$

Thus the sum of distances in the whole square is $a^3/6$ and the Rohrbach index equals a/6. This means that squares of various size have different Rohrbach indices, q.e.d. at first. But one can demonstrate, using polar coordinates, that all circles of any size have the same value of the Rohrbach index. Accordingly, in case of squares the Rohrbach index measures size, among other things, in case of circles — it does not. How could we know which quantities are measured and which not in case of a more complex figure? The measuring results may be interesting and perhaps even correct, but they are never reliable, which greatly lowers the usefulness of the Rohrbach index.

The Blair and Biss centrality index (D. J. Blair, T. H. Biss, 1967, also Ю. С. Фролов, 1974, p. 290)

$$\gamma_{BB} = \frac{S}{2\pi \int\limits_S \varrho^2 dS}$$

(where S is the area of the shape and ϱ — distance of a point from the centre) is a size measure in case of circles. Let us consider a circle with a radius R, centered in the beginning of polar coordinates. Then

$$\int\limits_0^{2\pi} \int\limits_0^{R} r^2 d\varphi dr = \frac{2\pi R^3}{3}$$

and

$$\gamma_{BB} = \frac{\sqrt{3}}{2} \sqrt{R}.$$

But using Descartes' coordinates one can prove, that the Blair and Biss index does not depend on the size of the square, centred in the intersection of diagonals. Thus the circumstances are the same as in the case of the Rohrbach index: the measurement results are unreliable.

The cause of such unreliability is in the empirical nature of both indices, which are based on intuitive (at least partly) definitions of "compactness" and centrality, and employ trial-and-error procedures for fixing the values of coefficients.

Always when we are limited to indefinite, obscure, ill-structured knowledge about a study object, we cannot and should not avoid the use of empirical measures and models as a first step to a more adequate solution. The question is: what we know about the shapes and are we able to make a second step? The author hopes so.

A rather promising avenue of study opens when we consider all possible shapes as distortions of some initial shape in some geographic process. Given the process we may restore the initial shape and vice versa, given the initial shape we may understand something about the process. The relation between compactness of actual and "restored" shape may serve as a measure of shape distortion: indentation of contours, elongation, twisting, etc. There are many kinds of distortion. We may hold that each process is lawful not only in its essence but also in form, that is, each process is characterized by a certain kind and degree of shape distortion.

Unfortunately, geographical processes are almost uninvestigated in respect of their spatial shapes. We must proceed in the opposite direction: beginning from the actual shape, try to restore the initial shape, "smooth down" the distortions. This approach is quite popular in the literature (С. Д. Муравейский, 1948, Л. Я. Нутенко, 1971, Ю. С. Фролов, 1974). But not knowing the process of distortion, we cannot choose a correct smoothed shape, where a certain kind of distortion and only that kind is eliminated. The matter is that most shapes are in some degree indefinite. The only fully definite shape is a circle. A regular polygon is indefinite in its orientation and number of its sides, an ellipse — in orientation and elongation, a rectangle — in orientation and elongation, a parallelogram — in orientation, elongation and obliqueness, etc. The most we can do is to follow a certain arbitrary convention. For example, if we choose to smooth all shapes to a rectangle, we may agree that the rectangle is always oriented in a north-south direction, touches an actual shape with all four sides and completely includes the actual shape. Then we could calculate the elongation of the actual shape as the relation of length and width of a smoothing rectangle, as is often done (see К. К. Марков, О. П. Добродеев, Ю. Г. Симонов, И. А. Суетова, 1973, p. 158—159). But this procedure obviously does not work in the case of Japan's territory. Moreover, does the elongation of the Somali Republic's territory make any sense whatever?

There is a procedure for discerning indentation by way of smoothing the shape (S. Günther, 1874, 1882, С. Д. Муравейский, 1948). One has to draw tangents to the shape in some points. A polygon formed by segments of the tangents between intersection points makes up the smoothing figure. Then the indentation equals the relation between compactnesses of the actual shape and the polygon. We would advise the use of equiperimetral compactness as in that case the relation of compactnesses is reduced to the relation of the length of the border lines and the measure is applicable not only to figures, but also to curves (С. А. Лукьянова, Н. А. Холодилин, 1975, p. 51).

This smoothing procedure has a great practical value and just for that reason we must point out the theoretical deficiency of the measure. Namely, a smoothed-down convex polygon results not automatically, by itself, using a floating along the border-line tangent (as is asserted by Yu. S. Frolov, Ю. С. Фролов, 1974, p. 287), but only by using a certain sample of contact points where tangents are drawn. The floating tangent only re-draws the original shape. The selection of the contact points is fully arbitrary. If a researcher possesses extensive experience and takes into account his unformalized knowledge of matter, this sample may be adequate and the results usable. But we never can formalize the rules of such a procedure and therefore it will always be to some some extent art and not science with all the resulting consequences.

Thus we are forced to give up the exact distinguishing of different kinds of distortion and to concentrate on the measuring of the distortion degree as a whole. Evidently the fully smoothed-down shape is the circle. As the compactness of the last is unity, the compactness of the actual shape turns out to be a total measure of distortion of any kind, though in a backward direction.

Now we are able to correct the argument of Yu. S. Frolov referred to above (on p. 124). It appears that compactness does measure all aspects of shape, but in total, jointly, not distinguishing various kinds of shape distortion. And as exactly such distinguishing is most interesting to a geographer, since it provides an insight into the nature of processes, Yu. S. Frolov is right in asserting the insufficiency of compactness as a shape measure.

We can discern some degrees of distortion although we cannot relate them with certain processes. Namely, all regular shapes have a constant compactness, independent of their size and orientation, which could be calculated and compared to the compactness of the actual shape. So we can ascertain whether the degree of distortion of some shape is greater, equal or lesser than, e. g. the degree of the distortion of a square. Unfortunately, the great majority of shapes are more distorted than even the most distorted regular shape — a triangle. Only in few cases we get results when applying this approach.

Let us also say some words on the classification of shapes. Here the following procedure is applied (D. R. Lee, S. G. Thomas, 1970, W. A. V. Clark, G. L. Gaile, 1973). Some standard shapes are chosen and some of there quantities measured. Then the same quantities of the shapes to be classified are measured and the results compared to the values of that measure in case of a standard shape. An actual shape is classified to that standard one, where the difference is the smallest. As we can see, the procedure realizes a qualitative classification of shapes.

The goodness of results depends first of all on the adequate sample of standard shapes. They must be representative of numerous actual shapes and be well discernible. Their differences should be approximately even. And there should not be too many standard shapes. Nothing to say about the awkwardness of a classification with too many classes, the measures used are more often than not empirical, that is rough, approximate, not fully reliable. If there are few well-discernible classes, the deficiency of measures most likely does not exerts an influence on results. If classes are numerous and similar to each other, serious errors are probable.

As we see, the classification of shapes is in some degree independent of the measuring problemes. But only in some degree. The improvement of measures makes possible more detailed classifications, distinguishing between more similar shapes and therefore improves even the coding of shapes. Exactly as shape links inseparably together quality and quantities, so are all three approaches to shape investigation related.

CONCLUSION.

There are three interdependent approaches to shape research: coding, classifying and measuring shapes. Shape is a quality, only its quantitative aspects can be measured. Compactness measures the total distortion of shape in all possible processes causing that distortion, among them ungeographic ones. The distortion degree can be calculated also in relation to regular polygons. All other shape indices are empirical, theoretically deficient, and may cause confusion. But some of them may be very useful if used reasonably, allowing for their limited reliability and taking into account unformalized knowledge of the matter.

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VORMI MÕÕTMISEST GEOGRAAFIAS

U. Pragi

Resümee

Eksisteerib kolm omavahel seotud lähenemist geograafiliste objektide vormide uurimisele: kodeerimine, mõõtmine ja klassifitseerimine. Vorm on kvaliteet, mõõta saab ainult selle kvantitatiivseid aspekte. Vormi kompaktsus on täpne ja ühene mõõt, mis kirjeldab antud vormi summaarset moonutatust kõikvõimalikes (sealhulgas ka mittegeograafilistes) protsessides, võrreldes ringiga — kõige määratletuma vormiga. Kõik teised vormi indeksid on empiirilised, teoreetiliste puudujääkidega, võivad tekitada vasturääkivusi. Ent mõned neist (näiteks kontuuri tasandamisel põhinevad) võivad osutuda vägagi kasulikeks, kui ei unustata nende piiratud usaldusväärsust ja võetakse arvesse mitteformaliseeritud teadmisi uurimisobjektist. Neile mõõtudele tuginev vormide klassifitseerimine peab siiski jääma võrdlemisi vähedetailseks.

ОБ ИЗМЕРЕНИИ ФОРМЫ В ГЕОГРАФИИ

У. Праги

Резюме

Существует три взаимосвязанных подхода к изучению формы географических объектов: кодирование, измерение и классификация. Форма является качественной стороной объекта и измерить можно только ее количественные аспекты. Компактность формы — точная и однозначная мера, описывающая суммарную искаженность данной формы по сравнению с кругом — наиболее определенной геометрической фигурой в результате всевозможных, в том числе и негеографических процессов. Остальные индексы формы являются эмпирическими, которым свойственно теоретическое несовершенство, и их использование может привести к противоречию. Но некоторые из них (например, исполь-

зующие сглаживание контура) могут оказаться полезными, если не забывать об их ограниченной доверительности и учесть неформализованные знания об объекте изучения. Все же классификация форм, опирающаяся на эти меры, должна остаться сравнительно малодетальной.

PRACTICAL APPLICATION OF THE BASIC PRINCIPLES OF NATURE STUDY PATHS IN RECREATION AND NATURE CONSERVATION AREAS OF THE ESTONIAN S.S.R.

J. Eilart

The practical application of the basic principles of nature study paths has become an important means for regulating the load of visitors to the recreational and nature conservation areas in the Estonian S.S.R. The same principle is also being widely and successfully used in many other countries (Eilart, 1964; Grosser, 1965; Komarkova, 1967; Bauer, Weinitschke, 1967; Pacanovsky a kolektiv, 1967; Information for Visitors to the Krkonoše National Park, 1967; Yellowstone National Park, 1967; Flynn, 1969; National Parks in Japan, 1969; Haapanen, Mikola, Tenovuo, 1971, etc.). The huge capacity for visitors in the National Parks of Japan, for example, results directly from the extensive practical application of the prerequisites of walking on nature study paths. In the Tatra and Krkonoše National Parks of Czechoslovakia, nature study paths have been laid out very methodically and thoroughly. The same principles are successfully applied in John Muir's sequoia stand, in the marshes of Canada, the Algonquin Provincial Park and other places.

In the Estonian S.S.R. several nature study paths have been projected and some even partially laid out for the first (1962) under the general guidance of the Chair of Physical Geography of Tartu State University and the Nature Conservation Society of Estonia (Eilart, 1972; Эйларт, 1973, 1975), where detailed general ground rules for this field have been elaborated not only on the basis of experience gained in the field in other countries, but also on the basis of local prerequisites. The Tartu Students' Nature Conservation Circle has greatly aided the actual setting-up of several nature study paths. The Alatskivi nature study path was actually laid out on the Nature Conservation Day of Tartu State University.

The length of the planned paths or their systems varies from 4.2 km (Käsmu) to 43 km (Komi National Park), this being dependent upon the nature of the landscape and the possibilities of traversing the path. The longest path-systems have been projected by our explorers in unpopulated territories (Komi A.S.S.R.) where the very distance between the path's starting and termination points dictates the necessity of planning numerous observation points. It is assumed that in future there will be still longer path-systems (e. g. Lahemaa National Park), as a result of combining already existing systems (e. g. Käsmu—Viitna, Muuksi—Pudisoo—Pärlijõe, Nõmmeveski—Joaveski—Palmse, etc.). Of course, in such a situation it would be essential to preserve the autonomy of paths that acquaint one concisely with the features of the entire territory, i. e. the so-called minimum paths. Contingent on the period and the hindrances faced in transversing it, this minimum path should be fully representative of the existing possibilities of recreation or conserved species. The Paganamaa path, which was drafted at to republican meeting of the Estonian Nature Conservation Society, can, in this light, be considered a typical path and a model for the projects of the majority of later pahts. There exist a 5.7 km path variant and a 10 km path variant. One of these, an account of points of interest, etc. is simply a "must" for nature-fans, whereas the other would be considered optional. A special Raadi observation tower enhances its value.

Let us examine the following methodological and basic principles for paths.

1. On the one hand, nature study paths guarantes preservation of the laid-down system and regulate the extent of use of the given areas, whereas on the other hand, they are a means of introduction to the dierse features of the nature of the area.

2. The nature study paths are meant first of all to be covered on foot. They should also be well-suited to the landscape and should consist of trails suitably marked to facilitate hikes. It should also be easy to cross-check these trails.

3. The paths do not only consist of sights worth seeing, but should also acquaint one and provide information about the general sights of the natural habitat, the species of the flora and fauna and associations of the given area.

4. The paths should form a suitable unit having a uniform numbering system for all points, different variations of each being differing lengths, difficulties in traversing them, and a varying total number of observation points on each.

5. The shortest part should acquaint one with, logically and in proper sequence, the most characteristic spets of the entire area.

6. A general map of the various tracks, where all observation points of the habitat are indicated number-wise, and particulars about the length of each individual part given, should be provided at the starting-point.

7. The shown tracks should be easily visible, at the same time they should be laid out in harmony with the surrounding nature. Besides numbered points about which accurate information is available, guiding marks and indicators are utilized. Their colours are different for alternative paths.

8. Study path routes should be not noly informative, but also such as to offer emotional stimulation. Attention should perticularly be directed towards lovely views. The views should be improved, if necessary, by felling parts of the forest.

9. The study path routes should desirably lead back to the starting-points. In case of availability of general transport routes the paths could be planned in such a manner that they begin and end at different points.

10. In addition to durable indicators and weatherproof explanatory boards, it is also desirable to use seasonal signa, depending upon the process of phenological growth in the area.

11. The study paths should not be constructed very fundamentally from the point of view of the materials used for their construction, but in such a way as to preserve their natural appearance in spite of the fat that it might be essential to improve the paths partially (log-tracks in bogs, tree-trunks across streams, stones in watery hollows, etc.). Materials and means which preclude pollution and spoilage of the environment should be used (marked sites for littercans gathering or taking away of objects prohibited, etc.).

12. Permanent resting sites, camping, parking and camp-fire sites should normally be located away from the track system, advisably in the vicinity of their starting-points, where depending upon needs and available possibilities, additional services could be provided and check-points arranged.

13. Plans of nature study paths should make provisions for reserve trails, so that whenever necessay, some portions of the regular tracks could be given a "rest", also so as to facilitate the maintenance and restoration of the regular tracks.

Different types of nature study paths have been methodically developed and laid out on these principles. Besides the common type of paths special-purpose paths (ornithological and paths exploring marshes in the Lahemaa National Park) have made their debut. Although ideally the paths should be traversible in both directions (increasing and decreasing numner-wise) a major difficulty in planning a path is due to the very fact that the information to be obtained on the path should be available in the right sequence. The study path should not lead one to a point, comprehension of which presupposes a knowledge of other (later) points. The general information about soil structure, relation between different elevations, history, etc. should precede detailed scientific explanations. From this standpoint, the main sequence of points on the Pühajärve—Munamäe track is not a success. The Kõrvemaa—Tammsaare track and the track passing through the Kõrvemaa marshes has been inadequately set up, etc. On some paths information provided for observation of nature is insufficient. So also the information concerning the seasonal changes in nature is rather inadequate.

In summing up the methodology of the nature study paths we should once again like to draw attention to various experiences of landscape conservation, of scrupulously abiding by the precedures set up. and of regulation of the volume of visitors. Being aware of the fact that excessive trampling could lead to the degradation of species may continuous full loads even to their destruction, different researches have attempted, in the first place, to formulate standards about the total number of persons who may simultaneously visit a landscape with a given type of association. Such investigations are highly essential in order to obtain a proper perspective of the anthropogenic dynamics of the landscape; however, they are of less assistance in the actual work of landscape conservation, in guaranteeing the proper implementation of the set procedures and in the regulations of the extent of use.

The very principle of the creation of nature study path is to enable proper direction of visitors. Hence the most visited areas can be made use of only with the aid of nature study paths. By accurately planning the capacity of the parking lots at the starting points, camping sites, etc. and by instituting a system of souvenir-passes for visitors, it might be relatively easy to regulate the general volume of visitors. And this really is the only means of preserving the landscape, preventing the spoilage of nature, and facilitating relatively undisturbed enjoyment of nature and learning to understand it. The hills also provide favourable conditions for rope-ways which enable a higher frequency of visitors.

The system of the paths should be planned in such a manner that there would be a minimum of damage to nature. The possibility to block off any given portion of the path should exist so as to facilitate restoration. For example, for keeping out of sight unique relics or consciously planning the paths for species which can easily tolerate interference from various exterior factors (for example eagles, *Margaritana margaritifera*, *Pteromys volans*, *Ursus arctos*, etc.), the security of the most ecologically sensitive species of the ecosystem is guaranteed. At the same time the visitors assume that well-marked paths containing a large volume of information are meant to enable everyone to visit the most exciting objects in nature. It is generally known that restricting signs cause unpleasant reactions, in fact, even special curiosity amongst those who regard themselves as having the right to go everywhere in nature. Nature study paths solve these complications in a psychologically admissible manner. The extent of the damage caused through the paths depends in a certain measure on the surface, which should be, so to say, artificially strengthened (log-tracks in the bogs, stones on the slopes, etc.). This should, as far as possible, be done in a manner, that is in harmony with nature.

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LOODUSE ÕPPERADADE PÕHIPRINTSIIPIDE RAKENDAMINE EESTI NSV PUHKE- JA KAITSEALADEL

J. Eilart

Resümee

Artiklis käsitletakse looduse õpperadasid kui üht võimalust külastajate koormuse reguleerimiseks puhke- ja kaitsealadel. Formuleeritakse looduse õpperadade rajamise põhilised printsiibid ning näidatakse nende rakendamise võimalusi. Tutvustatakse Eesti NSV puhke- ja kaitsealadel looduse õpperadade rajamisel senini tehtud tööd ning eelseisvaid ülesandeid.

ПРАКТИЧЕСКОЕ ПРИМЕНЕНИЕ ОСНОВНЫХ ПРИНЦИПОВ ПРИРОДНО-УЧЕБНЫХ ТРОП НА РЕКРЕАЦИОННЫХ У ОХРАНЯЕМЫХ ТЕРРИТОРИЯХ ЭСТОНСКОЙ ССР

Я. Эйларт

Резюме

В статье рассматриваются природно-учебные тропы, как одна из возможностей регулирования посещаемости рекреационных и охраняемых территорий. Даются основные принципы организации систем природно-учебных троп, а также возможности их применения. Характеризуются проделанная работа и предстоящие задачи по организации природно-учебных троп на рекреационных и охраняемых территориях Эстонской ССР.

PUPILS' ATTITUDES TO DIFFERENT METHODS OF TEACHING AND FORMS OF WORK USED IN LEARNING GEOGRAPHY

A. Benno

Teaching in itself is a joint activity of both the teacher and the pupils. The greater the mutual understanding that exists in it, the better are the results. The material to be taught is provided for in the syllabus. How well the pupils acquire it depends greatly on their previous knowledge, skills, habits and attitude to work. The last factor plays a particularly important part in the success achieved in instruction. A contented and interested attitude to learning creates a positive emotional background that influences the results of work. In the Soviet Union the pupils' attitudes have become an object of research only recently. J. Ots (1972), for example, has studied the pupils' preferences for the different types of exercises in teaching Russian. V. Ennulo (1975) has been interested in the factors having an effect on the children's attitude to their school. K. Tarro (1975) has dealt with the pupils' attitude to different activites. U. Kala and H. Liimets (1974) have studied the pupils' attitudes to several objects connected with the activities in learning. The discussion of the problem in the present paper has been influenced by all the studies mentioned above.

1) What kind of methods and organizational forms of interaction are preferred by pupils and teachers respectively in acquiring different knowledge of and skills in geography.

2) What connection is there between the methods and forms of interaction most frequently used by the teacher and the preference of the pupils for some of these methods? The pupils' positive attitude towards the use of a certain teaching method or form of work most likely contributes favourably to the acquisition of knowledge. Their negative attitude, however, brings about a distaste for the subject which, no doubt, has its effect on the result of work. That is why the teacher should know his pupils' opinion of their attitudes to the subject so that he could better organize his own activities.

In order to limit the extensive material the present paper is confined only to the work at lessons. From the methods' point of view it is based on questionnaires. The latter were drawn up after some survey was obtained of the classification of teaching methods and forms of work employed in class.

TEACHING METHODS AND FORMS OF INSTRUCTION

All teaching is connected with the use of one or another teaching method. Different scientists have proceeded from different aspects of teaching in defining teaching methods N. M. Verzilin (Верзилин, 1957) and V. F. Shalayev (Шалаев, 1954) consider the teaching method as a device or way by means of which the pupils are given knowledge and the acquisition of it as a whole by the pupils. N. N. Kuzmina (Кузмина, 1970) and T. A. Ilyina (Ильина, 1969) in their turn regard teaching methods to be devices used by the teacher in his activity. In the opinion of I. T. Ogorodnikov (Огородников, 1968) and B. P. Yessipov (Ессипов, 1968) teaching methods are the devices of both the teacher's and pupils' activities and they are aimed at the solution of tasks given during tuition.

The Soviet "Pedagogical Encyclopedia" characterizes teaching methods as the ways of work used by both the teacher and the pupil, which help to acquire knowledge, skills and experience to form the pupils' world outlook, to develop their abilities (1965, p. 813). The same idea is expressed by A. V. Darinsky (Даринский, 1966) in his book dealing with the teaching methods of geography.

So far there is no consensus of opinion as to the classification of teaching methods either in pedagogical literature or in publications on methods. A many-sided review of different trends is given by Z. S. Kharkovsky and R. G. Tchurakova (Харковский, Чуракова, 1973). E. J. Golant and N. N. Kuzmina (Педагогика, 1966; Кузмина, 1970) think that the basis of the classification is the source from which the pupils get their knowledge. The word, audio-visual aids and the practical activity of the pupils make up that source and according to these component 3arts they differentiate three types of methods:

1. Verbal methods: the teacher's narration, explanation, work with the book, lecture.

2. Visual methods: demonstration, independent observation, excursion, demonstration of tables and the analysis of them by the pupils, demonstration of slides, models and other visual aids.

3. Practical methods: oral exercises, exercises on teaching machines, written papers, drawings, cartographic and laboratory work, solution of problems.

Teaching methods have been grouped in a similar way also in the literature on the methods of teaching geography (Даринский, 1966, с. 68; Методика обучения географии в средней школе, 1968 с. 222).

Such a division is evidently rather conventional. It is based not on the manner of work but on the sources of knowledge. The demonstration is always accompanied by the teacher's narration or explanation; independent observation, however, is purely the pupil's activity firmly linked with laboratory work.

T. A. Ilyina (Ильина, 1969) is of the opinion that the guidance of pupils' cognition by the teacher forms the basis of the classification. Proceeding from that the author distinguishes five groups of methods:

1) methods of the preliminary acquisition and consolidation of new knowledge: dialogue, work with the text-book and book, demonstration, laboratory work and experiment, methods of drill and revision;

2) methods for providing new information: explanation, narration, school lecture;

3) methods for working with technical aids;

4) methods for checking;

5) methods of programmed teaching.

But here, too, one can find contradictions. Technical aids and programmed teaching are used both for the acquisition and imparting of knowledge. Through the dialogue the pupils do not only acquire new information but the teacher also imparts it to them, etc.

M. M. Levina divides the methods of teaching into two groups: a) informative methods by means of which the teacher gives the pupils some new knowledge, b) organizational methods to guide the pupils' cognitive activity (Левина, 1974, с. 60).

In the syllabus of pedagogy for the Tartu State University the following classification of teaching methods can be found: 1) methods of the teacher's presentation (oral presentation, demonstration); 2) dialogue; 3) methods used by the pupils in their work (work with a book, exercises, observations, experiments, practical and laboratory work (1972, p. 8). The activities of both the teacher and the pupils and their mutual integration are taken as the basis of the classification. One part of them is the methods used by the teacher. They are usually accompanied by the pupils' active work. The other half of them deals only with the pupils' activities which the teacher in most cases does not directly participate in. During the dialogue the activity of the teacher and that of the pupils constantly alternate.

The choice of methods for the lesson depends first and foremost on the didactic aims and the educational pursuits of the school. N. K. Krupskaya writes that the choice of methods depends on what is being aimed at — whether to bring up a slave of capitalism or a conscious, independent member of socialist society. In the latter case all scientific achievements should be used to teach children to think independently, to act collectively and in an organized way (1969, p. 70). The choice of methods is largely due to the contents of the material to be taught. It would be useful to teach some parts of school geography employing narration or school lecture, another part by using maps, etc.

The pupils' age, their level of development, their former experience and several other factors must be taken into consideration as well. Usually it is not only a single method that is used in class but their various combinations. That helps to make the pupils more active and retain their attention.

The contents of instruction, its didactic tasks and teaching mehtods are realized in its organizational form which in our schools is mainly the lesson. Proceeding from the pupils' activities, H. Liimets (1970, 1972) groups the forms of instruction used in class as follows: 1) work with the whole class, 2) individual work, 3) group work (universal and differentiated), 4) collective work. When educationalists are mostly of the same opinion how to define individual work and work with the whole class, then the characterization of collective, especially group work, has often caused misunderstandings. The most frequently occurring mistake is that group work is considered as individual teaching within the class (Golant, Yessipov, 1970). Defining group work H. Liimets points out that it is such a form of instruction in which the class is divided into groups of 3—8 members to fulfil one or another task. The task is given to the group and not to any individual pupil. The work is planned by the group as a whole, consequently the intercommunication of the members of the group can be taken for granted (1970, p. 839; 1972, p. 5).

Different forms of work have different didactic and educational possibilities. The use of various forms of work in class creates conditions for making learning more interesting and the acquisition of knowledge more collective. Such tuition enables us better to take into account the individual peculiarities and abilities of the pupils and to carry out the educational tasks of the school.

I. M. Tcheredov (Чередов, 1970, 1973) has given examples of how various forms of work can be combined at the lesson considering the individual differences of the pupils.

E. Sepa (1972, 1975) has described the combination of different forms of work in teaching mathematics.

The part of group work played in the formation of an integral process of study is characterized by H. Liimets in the following way: "Group work seems to occupy a specific place in the interrelation of the forms of work. But it cannot exist alone, without other forms of work. In any case it presupposes their existence. It appears to have an integrating effect on the whole complex of work forms" (1972, p. 8).

PUPILS' PREFERENCE FOR DIFFERENT FORMS OF WORK AND TEACHING METHODS

On the basis of the classification of teaching methods and principal forms of work, simple and understandable questionnaires were drawn up in order to find out what kind of teaching methods and forms of work were preferred by the pupils of different classes at geography lessons.

Pupils of the 6th, 7th and 8th classes of Tartu Secondary Schools Nos. 3, 5 and 10 and Viljandi 8-year School No. 4 were questioned. The number of those who answered amounted to 294 (in the 6th class — 41; in the 7th — 122; in the 8th class — 131). The questioning was carried out in the school-year of 1973—74 and in the second and third quarters of the 1974—75 academic year. The questionnaires had to be provided with the pupils' names and the conditions for carrying them out were the same in all schools.

The questions could be divided into four groups which included from the pupils' point of view the chief aspects of teaching geography: 1) How do you like to learn the subject best of all? 2) How can you easily memorize geographic notions? 3) What is the most convenient way to learn themes of greater difficulty? 4) How to learn map reading? Out of the possibilities given in the questionnaire 1—2 could be chosen by the pupil in case he considered them equal. A survey of the results for all the classes is given in Table 1. To facilitate the comparison of the results the data are presented in percentages.

As we can see geography is considered a narrational subject by the pupils as well. In all the classes the teacher's narration and explanation made up nearly half of the possible choices (in the 6th class — 54%, in the 7th — 41%, in the 8th — 48%). These methods are particularly preferred by the pupils in learning geography in general (geography is the favourite subject) and in the acquisition of the more difficult parts of the subject. The former shows clearly the pupils' attitude to geography as a subject. Quite understandable is that the teacher's help and explanations are needed in order to comprehend the more complicated problems. Pupils in the 6th class prefer the teacher's narration and the dialogue even in learning geographic notions and map reading. The same methods used for the same aims are considerably less preferred in the 7th and 8th classes.

Computation shows that the difference between preferences is statistically essential only when it amounts to 18—20% ($t>2$). Taking that into account, it becomes clear that the pupils of the 7th class attach remarkably less value to the teacher's narration and explanation in learning geographical notions than those of the 6th classes. In the 8th class the difference is smaller but

Table 1

Pupils' Assessment of Different Teaching Methods and Forms of Work

Part of geography course and its contents	Teacher narrates and explains the material			Dialogue			Independent work			Work in groups of 2—3 pupils			Film watching and questions answered		
	Classes														
	6	7	8	6	7	8	6	7	8	6	7	8	6	7	8
	(in percentages)														
Geography is the favourite subject	42	51	54	2	10	17	4	11	11	—	12	10	52	16	8
More difficult parts are better understood	57	60	53	10	15	12	10	8	13	12	11	6	14	6	6
Geographic notions are more easily memorized	51	29	37	8	12	0	13	17	48	2	24	12	26	6	3
A better way for map reading	66	24	—	9	3	—	21	5	—	4	68	—	—	—	—
	54	41	48	7.2	10	9.6	12	10.2	27.3	4.5	28.8	9.3	23	7	5.7

approaches reliability (t=1.6). Pupils of the 7th class choose the teacher's narration considerably less frequently in learning map reading, preferring work in groups of 2—3 pupils. The question about map reading was left out of the questionnaire for the 8th-class pupils.

Independent work ranks second in the pupils' preferences. The olny exception is the 7th class which is more interested in group work. Quite according to expectations the importance of independent work showed an increase hand in hand with that of the pupils' age. The difference is not statistically significant between any of the classes. The pupils of the 8th class, in particular, like independent work in learning geographic notions. The percentage of preferences is noticeably above the mean of the class (difference 21%). In the 8th class a new part of the geography course begins — economic geography of the Soviet Union. In connection with the new syllabus and text-book the number of notions is abnormally large in this class and that their acquisition requires serious work has been evidently grasped by the 8th-class pupils.

Independent work was preferred by the 6th-form pupils most of all in learning map reading. That is understandable because the acquisition of geographic nomenclature and its association with the map requires quite definitely more individual or joint training. From the statistic point of view the 7th-class pupils have regarded work in 2—3 member groups while learning map reading as essentially more appropriate.

Differences between schools likewise offered some interest. The answers of the 7th-class pupils were studied just from that standpoint because the number of pupils was larger there and they were from different schools. Results according to schools are given in Table 2.

It turns out that differences between schools are big enough. As before, the teacher's narration and explanation have been preferred most of all. The school in Viljandi, however, is the only one where preference for these methods shows an overwhelming prevalence. The pupils of Tartu Secondary School No. 3 have been in favour of independent work. The difference between the teacher's narration and the preference of independent work, however, is not great (t=0.7). Tartu Secondary School No. 10 is conspicuous for its extremely even (similar) preferences. In comparison with other classes, pupils in that school prefer working in groups of 2—3 members on all the parts of the geography course pointed out in Table 1. The reason may be in the fact that pupils know group work because this form of work was used experimentally in that class during the previous school-year when teaching a new theme. It is interesting to note that the dialogue plays only a modest part in all the classes, although it is rather often used in teaching geography.

Table 2

Assessment of Different Teaching Methods and Forms of Work by the 7 th-Class Pupils of Different Schools

Data given in percentages

Part of geography course and its contents	Teacher narrates and explains the material			Dialogue			Independent work			Working in groups of 2—3 pupils		
	Schools											
	V	T.3	T.10	V	T.3	T.10	V	T.3	T.10	V	T.3	T.10
What kind of geography lessons are liked most of all?	56	48	59	3	16	13	5	20	7	7	16	21
What way of learning helps better to understand the more complicated parts of the subject?	76	47	38	5	10	15	12	34	12	3	9	35
Geographic notions are better memorized	29	31	16	9	12	13	33	50	37	24	7	34
Total:	47	35	31	7	11	17	16	46	25	16	8	27

V — Viljandi 8-year School No. 4.
T.3 — Tartu Secondary School No. 3.
T.10 — Tartu Secondary School No. 10.

In order to make possible a comparison of actual tuition in schools with the pupils' wishes, 23 geography teachers were asked to fill in the questionnaire. Results in percentages are presented in Table 3. In teaching geography teachers make most use of narration and explanation. The pupils are evidently accustomed to these methods because the majority of them consider them to be the best way of learning geography. On the other hand, the predominating use of these methods by the teachers may have influenced the pupils' preferences. The dealogue occupies the second place among the methods enumerated by the teachers. Pupils, however, show little interest in it. As a rule, the dialogue in class is onesided — the teacher asks questions and the pupils answer them. In case of a big class, it is obvious that the role of a single pupil remains modest and he does not gain much profit from it. Group work is used by the teachers very seldom, but the pupils' assessment of it is high enough. In teaching different parts of the subject the biggest difference appears to lie between learning and teaching geographic notions. According to the teachers, the best suited methods are narration and explanation, the pupils, however, do not prefer them to the other methods. The pupils of the 7th and 8th classes think altogether that the most fruitful way to learn geographic notions is to do it either independently or in 2—3 member groups.

Table 3

Teachers' Assessment of Different Teaching Methods and Forms of Work (in percentages)

Part of the subject and its contents	Narration and explanation	Dialogue	Independent work	Group work
Most often used methods in teaching geography	44	34	20	2
Methods used in teaching more difficult themes	44	28	28	0
Methods preferred in teaching notions	64	18	18	0
Teaching map reading	18	39	36	7.2
Total:	42	30	25	2.4

To sum up all the above said one can conclude that geography is considered to be a narrational subject by both the teacher and the pupil. Besides the teacher's narration and explanation the pupils think highly of both independent work and work in groups of 2—3 people. The teachers in their turn like the dialogue better. In the pupils' preferences the dialogue stands at the end of the list. In the conditions of big classes this method most likely gives very little to a single pupil. The number of people who participated in the experiment is too small to draw more definite conclusions. Nevertheless, certain tendencies can be seen even in the obtained results. The dialogue should be employed rather modestly, especially in senior forms. More attention ought to be paid to group work because so far it has been neglected. The pupils, however, want to work together.

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ÕPILASTE HINNANGUD ERINEVATE ÕPPEMEETODITE JA TÖÖVORMIDE KOHTA GEOGRAAFIA ÕPPIMISEL

A. Benno

Resümee

Õpetamine koolis on õpilaste ja õpetaja ühine tegevus. Üksteise parem mõistmine avaldab seetõttu kahtlemata mõju ka õppetöö tulemustele. Seepärast on viimasel ajal hakatud uurima õpilaste suhtumist mitmetesse õppetööga seotud küsimustesse.

Artikli esimeses osas antakse ülevaade õpetamise meetodite ja õppetöö vormide klassifikatsioonist. Teine osa käsitleb ankeetküsitlusel saadud andmeid õpilaste suhtumise kohta mõningatesse õppemeetoditesse ja töö vormidesse geograafia õpetamisel. Neid võrreldakse õpetajate küsitlemisel saadud andmetega selle kohta, milliseid meetodeid ja töövorme nad enam kasutavad.

Ilmneb, et geograafiat hinnatakse koolis nii õpetaja kui õpilaste poolt jutustavaks õppeaineks. Õpetaja jutustuse ja seletuse järele asetavad õpilased individuaalse iseseisva töö ja töö koos 2—3 kaaslasega, õpetajad aga vestluse. Õpilaste valikutes jääb vestlus viimasele kohale. Kindlamate järelduste tegemiseks on küsitlusega haaratud isikute hulk liialt väike, võib aga arvata, et see siiski näitab kindlate aspektide kujunemist.

ОТНОШЕНИЕ УЧЕНИКОВ К РАЗЛИЧНЫМ МЕТОДАМ И ФОРМАМ РАБОТЫ ПРИ ОБУЧЕНИИ ГЕОГРАФИИ

А. Бенно

Резюме

Школьное обучение — это совместное занятие учащхися и учителя. Поэтому хорошее взаимопонимание несомненно оказывает положительное влияние на результаты обучения. Исходя из этого в последнее время все шире производится исследование отношения учащихся к вопросам обучения.

В первом разделе статьи даётся классификация методов и форм обучения. Второй раздел посвящен изучению отношения учащихся к некоторым методам и формам преподавания географии по ответам на анкету. Полученные ответы учащихся сопоставляются с ответами учителей на вопрос о том, каким методам и формам преподавания они отдают предпочтение в своей работе.

Оказывается, что как учащиеся, так и преподаватели относят географию к повествовательным дисциплинам. На второе место по привлекательности после рассказа и объяснения преподавателя учащиеся выдвигают индивидуальную самостоятельную работу, а также совестную работу с одноклассниками в группах по 2—3 человека: учителя же считают вторым по эффективности собеседование с учеником. В ответах учащихся беседа стоит на последнем месте.

Проведенный опрос охватывает слишком малочисленное количество учащихся и преподавателей для достаточно достоверных выводов, но можно полагать, что он показывает наличие определенных аспектов общественного мнения.

GEOGRAPHY OLYMPIADS OF GENERAL-EDUCATIONAL SCHOOLS IN THE ESTONIAN S.S.R.

A. Benno

Geography as a study subject of a very wide range provides vast possibilities of extracurricular activities. As a rule, extracurricular work on geography takes place within the school itself. The final contests of the Olympiad, however, are republican events, involving the participation of general-educational schools throughout the Republic. The term "Olympiad" itself alludes to the contest-like nature of the event, constituting one of the typical features of the schoolchildren's extracurricular activities.

In our republic, the Geography Olympiads are jointly organized by the Ministry of Education of the Estonian S.S.R., the Estonian Geographical Society, the Pedagogical Scientific Research Institute, and the Geography Department of Tartu State University. The stable instruction of the Olympiad was elaborated in 1966. Its compilers proceeded from two basic principles: 1) extracurricular work on geography must differ in form from curricular studies, particularly from those done in class; 2) participation in Olympiads must be voluntary. The aim has been to launch extracurricular geographical work upon a profoundly scientific basis, rouse the pupils' interest in the subject, raise the level of their geographical knowledge as well as their socio-political consciousness, contributing to a materialistic life-outlook. With the aim of improving the knowledge of the surrounding environment, pupils are encouraged to carry out independent observations and, collect materials, and on that basis make plausible conclusions and generalizations. The Olympiads have become events of importance for all schoolchildren who are interested in geography and wish to improve their konwledge of that subject.

In the Estonian S.S.R., an obligatory 11-year secondary shcool education is in force. The participants of Geography Olympiads are divided into two age-groups: Group A, including the 9th—11th-formers, and Group B, including the 6th—8th-formers. The Olympiad is carried out in two rounds. In the first round, the pupils may write a paper based either on personal observations and collected data and materials, or on a theme chosen by themselves, with the helb of relevant literature. The papers are presented to the geography teacher of the school who forwards the best ones to the district or town Committee of the Olympiad. That committee, in turn, selects the best papers and sends them on to the Republican Olympiad Committee. When marking the papers, the committee considers the correspondence of the content to the theme, the expediency of the structure of the paper, the thoroughness and groundedness of the material, the skill in using the sources, the correctness of style and the exterior form of the paper. Ever since the very first Olympiad, the "research work" of the schoolchildren has been of a remarkably high standard. Participation in the first round is also possible by way of presenting written answers to the questions or tasks published by the Olympiad Committee in periodicals for teachers and pupils. As a rule, the tasks are publicated in March, with the consideration that the pupils can work on them in their leisure time during the spring holidays. Contrary to the traditional quiss questions, the Olympiad's tasks require longer answers and the making use of various handbooks, observations of a short duration, and an analysis of results. Thus, for example, one of the tasks, for several years, consisted in meteorological observations (in the course of 10 days, as a rule) and in conveying them in graphical form, with subsequent analysis. When the tasks are fulfilled, the pupils may send their work to the Republican Committee, directly. This has been made possible so as to enlist the participation of pupils of such schools where geography teachers are rather inert and do not always encourage the children to enroll in the contests of the Olympiad.

The first Geography Olympiad took place in the schoolyear 1965/1966 (in 1965), with a total of 56 pupils participating. The Republican Committee received 217 papers, on the basis of which 47 pupils were invited to the final contest. The second round took place in Tartu, at the State University, during the spring holidays. The contestants had to write answers to questions compiled on the basis of the geography course at schools as well as according to relevant publications in popular-scientific books and youth periodicals of recent years. Further, the contestants had to show their skill in reading the map, using the compass, and in the knowledge of the minerals occurring in the Republic. Since geography is a natural science, above all, it was decided to arrange the final rounds of the next Olympiads as near to the nature as possible. In the following years those events were organized in the first week of July in different picturesque natural sites of the Republic, which also represented a definite landscape type of interest.

Thus, every year the Olympiad has taken place in a different region of Soviet Estonia. Since the participants have to be accommodated in tents and most of the practical work is done in

Fig. 1. What is the bias of this slope? (Photo by A. Marksoo).

field, one has to choose a site suitable for camping and bathing, and having a varied landscape. Some final rounds have been organized at the seaside or on the banks of the major lakes. The programme, in that case, also included a baot-trip that was immensely enjoyed by the children. One of the considerations at the selection of the site was also the presence of historical, natural or cultural relics.

Traditionally, the final contest is held for three days. At the opening, every participant is presented with an emblem of the Olympiad and a brochure concerning the corresponding region, since the main thing here is not the winning of the contest, but the participation in it, and getting new knowledge and experience. The authors of the best papers in the first round as well as those

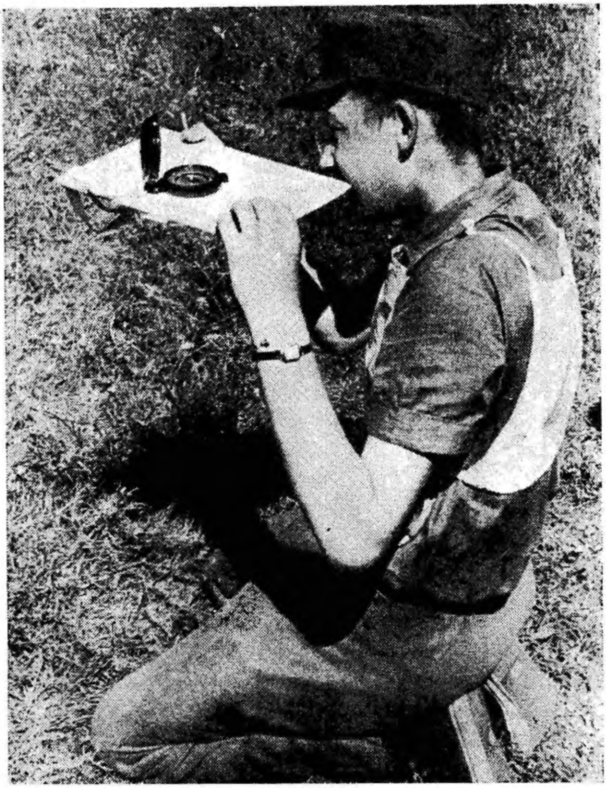

Fig. 2. Is this the right direction? (Photo by A. Marksoo).

who have given the best answeres to the published questions are awarded with diplomas and souvenirs. Those are given to the three best pupils in either age group.

The first day of the contest is reserved for written work. There are separate questions for either age group: theoretical questions, for checking the knowledge of general — geographical concepts and regularities and of relations between man and his environment. Some questions concern the geography of the Soviet Union and foreign countries, but most are connected with the native republic and the region where the Olympiad is taking place. There have also been questions about the history of geography, topical problems of geography, and environment protection. Several tasks are of a practical nature, i. e. work connected with the knowledge of the map: filling in the contour map, drawing the profile after a physical map from the atlas, compiling diagrammes on the basis

Fig. 3. How do you mark a well in a plan? And a pile of stones? (Photo by J. Lankots).

of climatic maps, or a complex description of a country or region on the basis of special maps, etc. For a change, some tasks have been given on a perphorated cassette, or slides have been shown to let the children recognize the geographically typical sites. The lastmentioned mode, by the way, has always evoked lively response and was of great interest for the participants.

The second day has been reserved for an excursion, so as to acquaint the children with the particular district. During the excursion, the participants have to keep diaries which are marked later; both the content of the notes as well as the exterior form is considered.

The third day is devoted to contests in practical skills. The bias

Fig. 4. An outcrop has to be described in a gravel pit. (Photo by A. Marksoo).

and height of a slope are measured (Fig. 1), the direction (Fig. 2) and distance of an object in steps, the distance and height of a singly growing tree, a simple plan is drawn by the eye (Fig. 3), an outcrop is described (Fig. 4). All of those tasks require corresponding skills, a good eye and a firm hand. And it is in the know-how that even the best ones are lacking. As a rule, the best results have been shown by those pupils who have been participating in the contest for some years running, and thus have acquired corresponding experience.

The second half of the day includes contests in orienting in the landscape. Thus, geography is combined here with sports. The contest begins with an orienting race, with the checking-times being chosen so as not to exceed the abilities of all the participants.

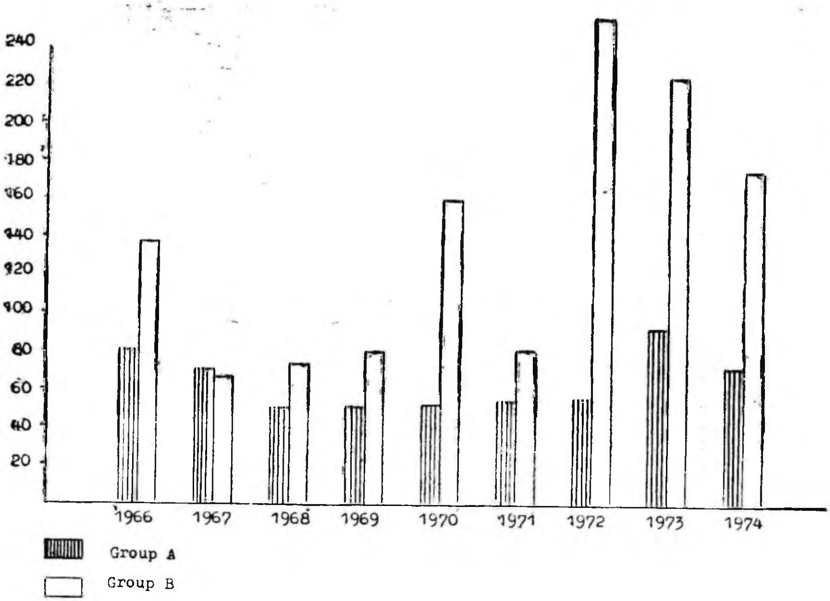

Fig. 5. The number of the papers presented in the Republican Olympiad Committee in 1966—1974.

Thus, the main thing in the contest is the skill in orienting, i. e. in finding the checking points in the landscape.

The Olypiad ends with a camp-fire, at which the winners of single events and of the total contest are awarded with diplomas and souvenirs.

Beginning with the first Geography Olympiad, the results and surveys of the contest have been published, in brief or in detail, in the press. The articles have contained descriptions of the contest, the names of the best participants, and analyses of shortcomings.

In recent years, participation in the Olympiad has been growing. The dynamics of participation are reflected in Fig. 5.

It is also a gratifying fact that participation of the older pupils has been increasing. This is of particular importance in the aspect of geography, since the course of that subject in Estonian secondary schools is completed in the 9th form. Thus, further work on geography for highar-formers is made possible by extra-curricularly, only. There have been participiants from all regions of the Estonian S.S.R. Participation in the final contest has often inspired pupils to try a hand at the next contests, as well. Several "veterans" have taken part in the final contests in 4—5 years running. A number of them have taken up university studies after graduation. Thus, during the last 9 years, 26 Olympiad participants were enrolled in the Geography Department of Tartu State University. A number of them are the best scholars of the department, and winners of personal scholarships.

The Geography Olympiads have helped to raise the pupils' interest in the subject. The compilation of an independent work has provided them with skills in using reference books, presenting results, and making generalizations. Practical field work has brought the pupils nearer to nature and contributed to improving their knowledge of the native country.

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GEOGRAAFIAOLÜMPIAADID EESTI NSV ÜLDHARIDUSLIKES KOOLIDES

A. Benno

Resümee

1975. aastal toimus kümnes vabariiklik üldhariduslike koolide geograafiaolümpiaad. Alates 1966. aastast on igal aastal juulikuu alguses viidud läbi olümpiaadi lõppvoor Eesti NSV erinevates, looduslikult huvipakkuvamates kohtades. Olümpiaadist saab osa võtta iseseisva uurimusliku töö koostamisega. Sellised tööd on enamasti kodu-uurimusliku suunaga. Samuti võib lõppvooru pääseda koostades vastused märtsi koolivaheajaks vabariiklikus ajalehes avaldatud küsimustikule. Aastast aastasse on suurenenud osavõtjate arv.

Olümpiaadi lõppvoor toimub tavaliselt traditsioonilise kava järgi. Esiteks on kirjalik töö geograafiliste teadmiste kontrollimiseks. Sellele järgneb ekskursioon ja ekskursioonipäeviku koostamine. Lõpuks kontrollitakse välitööde käigus mitmesuguseid praktilisi oskusi ja toimub orienteerumisjooks. Olümpiaadide eesmärgiks on õpilaste huvi tõstmine geograafia õppimise vastu koolis.

ГЕОГРАФИЧЕСКИЕ ОЛИМПИАДЫ ОБЩЕОБРАЗОВАТЕЛЬНЫХ ШКОЛ В ЭСТОНСКОЙ ССР

А. Бенно

Резуме

В 1975 году состоялась десятая республиканская географическая олимпиада общеобразовательных школ. Начиная с 1966 года в начале июля ежегодно проводился заключительный тур олимпиады в различных примечательных в природном отношении местах Эстонской ССР. Нраво на участие в заключительном туре олимпиады предоставляется лучшим авторам самостоятельной исследовательской работы. В большинстве случаев такие работы носяткраеведческий характер. На заключительный тур могут быть приглашены также учащиеся, которые давали лучшие ответы на вопросы, опубликованные в республиканских газетах во время мартовских каникул. Число участников в олимпиаде растет из года в год. Заключительный тур олимпиады проводится обычно по традиционной программе: 1) проверка знаний по географии (в письменной форме), 2) экскурсия с составлением дневника экскурсии, 3) проверка практических умений в ходе полевых работ, 4) ориентирование на местности.

Цель олимпиады — повышение у учащихся интереса к географии.

THE LIGHTHOUSE OF KÕPU (FORMERLY DAGERORT)

L. Tiik

The Kõpu lighthouse attracts one's attention in many respects. It is not situated on the seaside, but in the centre of the Kõpu headland, on its high moraine deposits — on Tornimägi hill. The massive four-sided (4×4 fathoms) and 34 metres high tower, the whitewashed upper part of which rises well above the dark-green forest background can be seen already from a score of kilometres out at sea. The volume of the tower is about 2,500 cubic metres and approximately 6,000 tons of stones and lime were needed to build it, but in comparison the modern equipment on the top of the tower does not weigh even a ton. We can be sure that the building of such an irrational tower is out of the question nowadays. But why was it built by merchants who always calculate and think in an economical way? When and in which conditions and for what purpose was it built?

In order to find an answer to these questions we must turn back some centuries and take a look at the requirements and possibilities of those times. First of all, it must be mentioned that viking ships with their draught of up to a metre could be pushed off any shallow by their crews as long as the vessels were still seaworthy. When on the second half of the 12th century the first cogs began to sail on the Baltic Sea floating them off shallows became considerably more difficult. Subsequently cogs grew larger and in the middle of the 15th century already three-masted and square-rigged vessels appeared on the Baltic. The reefs and coastal shallows were usually a mortal danger for them.

The compass was already in use and according to manuscripts or written navigation directions it was possible to sail without losing one's way from one point to another in case of favourable wind. But if because of the changing wind the course had to be changed frequently and at last an island, headland or a bit of coast became visible a skipper could make a mistake in determining his location and steer the ship onto a shallow. To avoid such dangerous situations mariners tried to remember coastal silhouettes and surely also to make some sketches of them, but some outstanding and exceptional natural objects or structures formed even better marks for orientation. The latter were at first called in Low German "kenninge" and "landes kenninge", later on also "piler" and "bake" or "baken". The Kõpu tower, the original name of which was also "kenninge" (German *kennen* = recognize) is likewise built as such an orientation mark or landmark.

The coastal waters of Hiiumaa Island are rich in shallows. Näckmangrund (Neckman's Ground) stretches 11 miles to the north of the Kõpu headland and Mardihansu inlet (Hundswiek) to the south is full of small shallows. Evidently the increasingly frequent shipwrecks in the 15th century were one of the reasons why the official manor of the Bishop of Saaremaa Island was established where the present Vanamõisa village now stands and the foundation of Lauka Manor can also be connected with shipwrecks. When shipwrecks that took place off the west coast of Hiiumaa Island became a source of profit for the bishop, then the Hanseatic merchants interested in reducing the perils of navigation could hardly do more than draw up and hand in applications. Bishop (1471—1491) Petrus Wetberg did not probably even reply to the Hansa, but in 1499 the Hanseatic Assembly (Hansetag) charged Tallinn with the building of the Kõpu tower. When Tallinn applied officially for permission to do this, Bishop Johannes Orgies granted it on April 20, 1500. The tower was allowed to be built only as a massive and solid one, without any openings in it. Tallinn had to bear the costs and direct the building of the tower and the armorial bearings of the bishop had to be attached to it. This was meant to underline the fact that the tower did not belong to the town but to the bishop as did the land around it.

Some letters and account-books in the archives of Tallinn enable us to follow the construction work of the tower. Although the site had been selected by a representative of Tallinn already in 1499, the work of construction was postponed till the summer of 1504 because of war. In the autumn of that year Hiiumaa Island was stricken by the plague and construction was interrupted for ten years. In the spring of 1514 work began again and was continued every summer up to 1519, the supervisor Clawes Duker, servant of the town council, being usually present for 15—17 weeks. Stone-cutters, masons and smiths were hired from Tallinn, the other auxiliary workers were probably local ones. The wages of the latter were brought by town councillors and merchants, who also were authorised by the council to solve various other problems connected with the work of construction, etc. In 1517 the Hiiumaa bailiff (German lantknecht) on one occasion provided 105 lasts (= 1,260 barrels) of lime on credit and judging by the sum of money involved, even more on another occasion (about

1,600 barrels). Salt and repeatedly grain as well as bread, however, had to be sent from Tallinn.

During 1520—1525 no expenditures were made on the tower, but in the spring of 1526, Clawes Duker was sent to complete its construction. In the correspondence of 1529, the town council applied for permission to make the tower higher, but construction work evidently did not follow. In connection with the tower, accounts were nevertheless finally settled with Clawes Duker in November, 1530 (on account of 1528) and in August, 1532. Civil war in the diocese for some years interrupted the realization of the plans to make the tower higher, and it was only in January, 1538 that the town council came to an agreement with Bishop Reinhold Buxhövden according to which the town council acquired the right to repair the tower (kennynge des landes Dageden) and to add to its height in case of need. In return the bishop received the privilege to buy every year 16 lasts of salt duty-free directly from the ships which arrived in Tallinn. It must also be mentioned that the bishops had repeatedly tried to secure for themselves a solid compensation in salt trade and in some cases their efforts had been successful, but it was not until after 38 years of bargaining that this special right was acquired in perpetuity.

As we have no account-book covering those years, we do not know whether the height of the Kõpu tower was finally increased in 1538 or the next year. But it can certainly be realized that no piece of land or dwellings around the tower belonged to the town. Neither are there any notes about intentions of burning to light at the top of the tower. There is no record of any service personnel or even a watchman. We can conclude that the Kõpu tower was intended and built as a landmark (kenninge!) of the headland. As there were as yet neither spy-glasses nor field-glasses in those days, the tower was made so massive that even the unaided eye could notice it from a score of miles in clear weather. According to our modern terminology it was a "beacon" but not a lighthouse. The maintenance of such a tower was not very troublesome for the Tallinn town council and therefore one cannot find any corresponding entries in later ledgers either.

The beacon on the Kõpu Tornimägi Hill was changed into a lighthouse not before the 17th century. According to C. Rußwurm and the wellknown historian A. Soom, the old lighthouse was again put in order at that time. This, however, is a mistake as it becomes evident from the above-mentioned and the quotation cited by A. Soom (a proposal to the Tallinn town council on May 10, 1639, which suggests that the town council should hire a person to light a fire on the top of old beacon (auf dem Pfeiler auf Dagdön) on autumn nights to show the way for passing ships. The town council was of the opinion that some other towns (Porvoo, Helsinki, Viipuri, Nyen and Narva) should share the expenses involved and turned to them but without any results.

Ten years later, the governor of the Estonian province (1646—1653) Erik Oxenstierna decided to set up lighthouses on the Islands of Hiiumaa, Osmussaar and Naissaar. In a letter to Jacob de la Gardie (May 9, 1649) he writes that Queen Christina wishes to build a lighthouse and a small dwelling on Hiiumaa Island to promote commerce. We can supplement the sources used by A. Soom with some letters from the archives of De la Gardie family (in the library of Tartu State University) and thus obtain a small survey of events. The governor sends Eberhard Dellinghausen, a merchant from Tallinn to Hiiumaa to inspect the old tower, to adapt it into a lighthouse and at the same time to ascertain the possibilities of buying firewood for it. The postal service was very slow at the time, especially by sea, and therefore the orders of Jacob de la Gardie arrived in Hiiumaa Island with great delay. The governor had wished the lighting period to begin on August 1, and to end at the close of the year, but the construction work had not begun even at the end of August. In September a wooden staircase was built on the outside of the tower and the upper part of the tower was levelled, an iron fire-grate and a winch were installed. Coal ordered from the Netherlands was late in arriving, but at the beginning of October, E. Dellinghausen announced that he had got six lasts of coal from the store of the Sõrve lighthouse. In this way the lighting period could nevertheless begin in October.

The first inspector of the lighthouse was E. Dellinghausen, but he died already in the summer of 1651, and the next inspector was Thimen Corneliszen Turlau, who came form the Netherlands. He began to buy firewood from local peasants and no longer from the steward in the nearest manor. The forest-guard engaged by the manor could not entirely prevent this and the steward called the attention of the young Axel-Julius de la Gardie to the fact that T. C. Turlau had to buy firewood from the manor or restrict himself to the use of coal; the profit of the manor would increase considerably if the count could maintain and supply the lighthouse with fuel for fixed payment. As a result of the count's application, the Kõpu lighthouse was enfeoffed (in Stockholm on June 30, 1659) to Axel-Julius de la Gardie and 800 state thalers per year were assigned from the public exchequer for the maintenance of lighthouse.

The next inspector of the lighthouse (1659—1664) was Cordt Lang, the steward of Kõrgessaare Manor, but after that these posts were separated, so that an inspector of the lighthouse (usually called Baakmeister) permanently lived there. The manor of Kõrgessaare supplied the lighthouse with labour and currently needed materials and therefore it remained an accessory of the estate up to the beginning of the 19th century.

The new situation was very favourable for the manor owner as the sum of money annually paid him from the state formed almost a net profit since very little was bought from elsewhere and outside artisans were only rarely hired (e. g. in 1662 for the building of new staircase). The peasants cut firewood in the forests of the manor, transported it to the lighthouse and took care of the light on the top of the tower and all this involved no expenses for the manor.

According to C. Rußwurm it was not before 1810 that the Kõpu lighthouse passed into the possession of the state and its modernization began. A room for six men was made in the lower part of the tower and an inner staircase was built. A larger opening was also made in the upper part of the tower and it was formed into two rooms one on top of the other and a room for lamps was built on top of them. Mirrors of polished brass were installed and 25 oil lamps were placed in front of them in such a way that light was directed to the sea from three sides and was visible up to 55 versts (over 30 miles) out at sea. About 200 poods of lighting oil (= 3.28 tons) was needed per year. The personnel of the lighthouse consisted of a petty officer and six men.

Because of a crack in the upper part of the tower some ten metres were broken off and then built up in the spring of 1845. And apparently this was the only major reconstruction of the tower during the 450 years of its existence. The system of lighting, however, has frequently been innovated in accordance with advances in technology since 1810.

Nowadays it is difficult to imagine that the Kõpu lighthouse could meet the requirements of navigators also without any light for more than a hundred years and that in the second half of the 17th century and in the 18th century the lighthouse was on holiday during the busiest period of navigation, i. e. from the beginning of May until the middle of August, and was lit only from March 16 till April 30, and from August 16 till December 31. From time to time these dates were shifted, but the summer interval remained.

If we thus consider the changes in the requirements of seafarers and the development of engineering possibilities to meet their needs, it also becomes evident that the lighthouse of Kõpu with all its peculiarities is a logical product of the development of society. It then becomes comprehensible why in 1499 Hans Scherer, a citizen of Tallinn, decided to build the tower just on that elevation and why it was built in this manner during 1504—1526.

Nowadays the Kõpu lighthouse is an exception among other lighthouses as it has gone through all the stages from a medieval "kenninge" up to a modern electric lighthouse. By way of comparison it might be mentioned that in 1532 the merchants of Riga were allowed to build a "kenninge" on the strait of Irben on the northwestern tip of the present Latvian S.S.R., but that tower and the next one are things of the past, and in the last quarter of the 19th century, as needs and possibilities had altered, a third lighthouse was already established there (former Domesnäs, present Kolka). On the other hand, the lighthouse of Kõpu (former name Dagerort) has been able to keep up with the times for about 450 years and will continue servicing navigators since its site has proved to be well chosen.

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KÕPU TULETORNIST

L. Tiik

Resümee

Kõpu tuletorn asub Tornimäel, Kõpu poolsaare kõrgel moreenkuhjatisel. Massiivne neljatahuline torn, mille ülemine valgeks lubjatud osa kõrgub tumerohelise okasmetsa kohal, on selge ilmaga merele nähtav juba mitmekümne kilomeetri kauguselt.

Tallinna Linnaarhiivis ja TRÜ Teadusliku Raamatukogu käsikirjade fondis säilitatud dokumentidest selgub, et selle torni ehitamine toimus vaheaegadega aastail 1504—1526. Kõpu poolsaar ja terve läänepoolne Hiiumaa kuulus tol ajal Saaremaa piiskopile, kellelt ettevõtjana tegutsenud Tallinna raad oli sunnitud hankima lubasid nii torni ehitamiseks kui ka hilisemaks kõrgendamiseks.

Üle saja aasta oli torn ilma valgusallikata, nii et meresõitjad said selle järgi orienteeruda ainult päeva ajal. Meresõidust ja kaubandusest huvitatud ringkondade taotlused andsid lõpuks tulemusi ning 1649. aastal toimunud ümberehitusega muudeti Kõpu torn tuletorniks. Esialgu põletati öösiti torni otsas asuvas lõkkes küttepuid koos kivisöega, hiljem kasutati ainult puitkütust.

1659. aastal andis Rootsi valitsus Kõpu tuletorni koos 800 riigitaalrise aastamaksuga selle ülalpidamiseks Axel Julius de la Gardie'le, kellele kuulus suurem osa Hiiumaast ning ka Kõrgessaare mõis, mis hakkas torni varustama põletispuudega. Alles 1810. aastal võeti Kõpu tuletorn kroonu valdusse ning sellest peale on korduvalt muudetud valgustussüsteemi, kuni nüüd on jõutud elektrivalgustuseni. Ehituslikult on suuremaks muutuseks see, et umbsena ehitatud torni sisemusse rajati sisetrepp ning kolm ruumi, üks torni alumisse ja kaks torni ülemisse ossa. Nii on torn juba üle 450 aasta olnud meresõitjate teenistuses ja suutnud sammu pidada tehnika arenguga, kuigi oma tüseduse tõttu ta näib mõnevõrra vanamoodsana.

МАЯК КЫПУ (БЫВВШИЙ ДАГЕРОРТ)

Л. Тийк

Резюме

Маяк Кыпу установлен на холме Торнимяги, расположенном в средней части полуострова Кыпу. Мощная четырехгранная каменная башня белого цвета с контрафорсами поднимается высоко над окружающим хвойным лесом.

По архивным данным, которые находятся в Таллинском городском архиве и в Научной библиотеке Тартуского госуниверситета, выясняется, что башня построена с 1504 по 1526 гг. магистратом города Таллина на земле, принадлежавшей епископу острова Сааремаа.

Более ста лет башня служила мореплавателям как неосвещаемый знак, по которому можно было ориентироваться только в дневное время. По требованию заинтересованных кругов в 1649 году были предприняты некоторые перестройки башни и в октябре этого года она стала работать как маяк. Источником света являлся костер на вершине башни. Топливом служили дрова с добавлением каменного угля, позже только дрова заготовляемые в местных лесах.

В 1659 году маяк был передан шведским правительством во владение местного помещика А.-Ю. де ла Гарди с ежегодной доплатой в сумме 800 талеров и только с 1810 года маяк был передан морскому ведомству. С того времени несколько раз основательно обновлялась система освещения, но башня верно служит мореплавателям уже более 450 хотя по сравнению новыми маяками она выглядит грузным и устаревшим сооружением.

150 YEARS SINCE THE BIRTH OF RICHARD MAACK

E. Varep

Estonia is the birthplace of many a famous seafarer and explorer, whose courageous expeditions have considerably enriched our knowledge of distant regions of the world. In this connection mention should be made of A. J. Krusenstern, F. G. Bellingshausen, K. E. Baer, A. Th. Middendorff, Ed. Toll and many others, whose names are well known from the history of geographical discoveries and explorations. We are fully justified in adding to this list the name of Richard Maack, who has made a great contribution to the exploration of Siberia and the Far East and the 150th anniversary of whose birth was marked in 1975.

Richard Otto Maack was born in the town of Kuressaare (Arensburg, the present Kingissepa) in Saaremaa Island on September 4, (all dates are given according to the Gregorian calendar), 1825. He first attended the local district school, and after his parents had moved over to St. Petersburg he continued his education at one of the gymnasiums (secondary schools) there. In 1852 he graduated from the faculty of natural sciences of St. Petersburg University and was sent to work in East Siberia, where he became senior teacher of natural sciences at the gymnasium of Irkutsk. Here he joined the Siberian Department of the Russian Geographic Society.

Irkutsk, which had been a small town mainly inhabited by traders and exiles, was having a considerable economic and cultural boom about the middle of the last century. As gold had been found in the adjacent regions, enterprising merchants who were interested in the exploitation of the enormous natural resources of East Siberia moved in from other parts of the country and settled down here. The inhabitants of Irkutsk included a large number of government officials among whom there were also representatives of progressive scientists. Now the necessity arose to explore the nature of East Siberia in greater detail than had been done hitherto. The task of organising the research was entrusted to the Siberian Department of the Russian Geographic Society, whose activities were promoted by the energetic support of N. N. Mu-

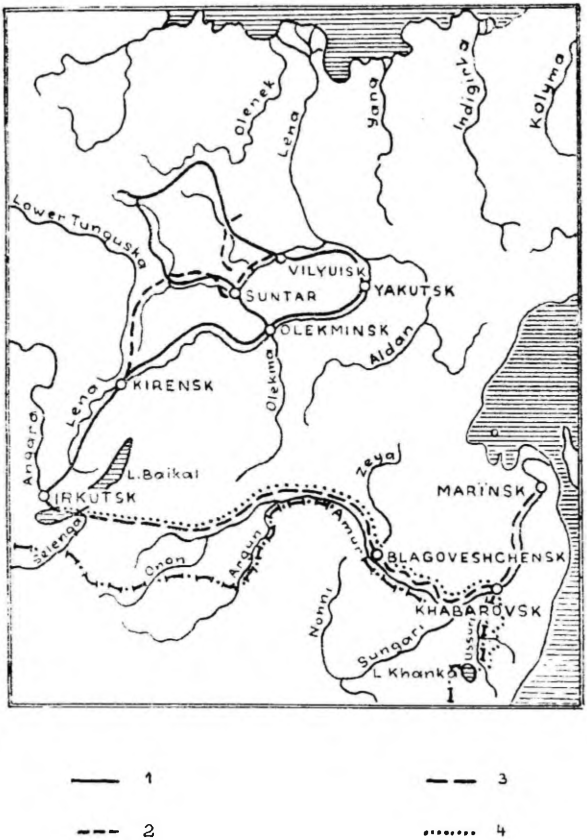

Fig. 1. R. Maack's expeditions.

1 — Maack's itinerary in 1854—1855. 2 — The itinerary of Maack's companion in 1853—1855. 3 — Maack's itinerary in 1855—1856. 4 — Maack's itinerary in 1859.

ravyov, Governor-General of East Siberia. This made it possible for the Department to set out organising a great expedition to explore the region of Vilyui, which was very little known at the time. The leadership of the expedition was entrusted to Richard Maack.

The expedition to Vilyui. Maack's first scientific expedition to North Siberia took place in 1853—1855. The first to leave Irkutsk was the topographer Alexander Sandhagen and Mihkel Fuhrmann, who set out for the river Lena in May 1853.

Mihkel Fuhrmann, an Estonian, had accompanied A. Th. Middendorff as a field assistant on his famous journey through Siberia. Having sailed down the Lena as far as Kirensk, they proceeded to the Lower Tunguska and from there moved on to the Chona and Vilyui rivers. On April 12, 1854 they were followed by Richard Maack and Alexander Pavlovski, a local explorer interested in ethnography. Maack and Pavlovski first went to Yakutsk, where they gathered additional data on the region they were going to explore. In Yakutsk they met Sandhagen and Fuhrmann, who by this time had completed mapping the Vilyui region. Together they sailed down the Lena up to the mouth of Vilyui where they began their investigations.

Now Maack's expedition proceeded on horses up the valley of Vilyui to the region of the Markha, a tributary of the Vilyui. Here the surface relief and geological structure were investigated, meteorological observations were made, and the local flora and fauna were described. On the Markha river Pavlovski and Fuhrmann left Maack's party and headed south-west for the settlement of Suntar where they began to carry out observations. They were to wait for Maack at the place where the Chona flows into the Vilyui. Maack himself and Sandhagen moved northward, crossed the upland lying between the Vilyui and the Olenek and in the month of August they reached the bank of the latter at 68°15′ northern latitude. Here they on September 10 turned back and were once again at the upper reaches of the Vilyui.

The next stage of the expedition passed under very hard conditions. The season of frost set in catching Maack's party in their summer equipment. They hoped to meet some Evenks from whom they could buy winter clothes and yurts, but their hopes were in vain. They were compelled to continue their journey through the uninhabited taiga defying the severe frost, which made their progress very laborious. Their provisions were also running out. It was only on December 30 that Maack finally reached the appointed place at the mouth of the Chona. He and his party had been awaited there for over two months. They were all thought to have perished.

In January 1855, the expedition gathered at the settlement of Suntar and from there headed for Olekminsk on the Lena. On February 21, 1855, Maack returned to Irkutsk having covered over 8,000 kilometres in the course of thirteen months.

The scientific results of the Vilyui expedition were significant. A comprehensive map of the region explored was drawn up and a description of its surface relief and geological structure was given. It was established that maritime sediments of the Jurassic period ocurred over wide areas in the central part of the Yakut country, and several deposits of rock salt and coal were dicovered. Copious data were collected on climatic conditions as well as on the flora and fauna of this hitherto almost unexplored region. In addition to that, Maack compiled very detailed descriptions of the Yakut's ways of subsistence and living conditions and drew up lists of plant and animal names in the Yakut and Evenk languages. Also some historical facts were discovered regarding the activities of Russian explorers in the Yakut country. Research work on the copious materials collected by the expedition lasted for a very long time. It was only thirty-two years later, when Maack was already dead, that the third and last volume of the scientific results of the expedition was published.

The expedition to the Amur. Maack's second great journey of exploration was the expedition to the Amur in 1855. It was a great topographic expedition for military purposes organised by Governor-General Muravyov, which was joined by a small party of naturalists from the Siberian Department of the Russian Geographic Society. Besides others, Maack was here again accompanied by Sandhagen and Fuhrmann, who had been his companions on his preceding journey. The explorers set out on April 18, thus soon after their return from the difficult expedition to the Vilyui. The explorations were started on the 4th of June from Ust Strelki, the confluence of the rivers Shilka and Argun. From Ust Strelki the party sailed on barges down the Amur. After having reached Marïnsk in the lower reaches of the Amur on August 20, the expedition started on their way back. Maack accomplished most of the journey on foot, moving along the bank of the Amur to gather the necessary scientific materials. On October 11 the expedition reached Aigun on the right bank of the river from where they only on November 24 continued the journey on horses. They arrived at Ust Strelki on January 11 and at Irkutsk on January 28, 1856, with rich collections of various materials. Thus the expedition from Ust Strelki to Marïnsk and back to Ust Strelki had lasted for 222 days during which about 5,200 kilometres had been covered along the Amur (268 km by raft, 1228 km on barges, 2863 km by boat, and 830 km on sledges).

At the beginning of 1856, Maack and Fuhrmann travelled to St. Petersburg with the materials collected during the expeditions to the Vilyui and the Amur. There Maack started research on them. Several well-known scientists (Vesselovski, Ruprecht, Maximowicz, Brandt, Regel and others) participated in this work. The materials that had been gathered were so copious that work on them lasted for three years. The scientific results of the expedition to the Amur were published in a book entitled "A Journey to the Amur", which appeared already in 1859. It was the first comprehensive study of the Amur region and was later followed by investigations by L. Schrenck, K. J. Maximowicz and other scientists.

Maack's contribution to the exploration of Siberia was highly appreciated by the Russian Geographic Society. At their proposal Maack was awarded the Order of Vladimir in 1857, Sandhagen was promoted (to the next rank), and Fuhrmann was awarded a silver medal. The correspondence with the authorities to this effect has been preserved in the archives of the Geographic Society of the U.S.S.R. in Leningrad (Stock 1, Series 1, item 22).

The expedition to the Ussuri. Maack's third journey of exploration — the expedition to the Ussuri — took place in 1859. The initiative came from the Russian Geographic Society, the money for it was raised by means of a collection. In February 1859, Maack returned from St. Petersburg to Irkutsk and on May 9, together with Dr. Brylkin, he started his voyage to the east along the rivers of Shilka and Amur. On June 17 they reached the mouth of the Ussuri. Having reached Lake Khanka on the September 9, Maack was taken ill, and was compelled to turn back. On October 8 he arrived at Khabarovsk and in March 1860 he was back in St. Petersburg again. The scientific results of the expedition to the Ussuri region were published in 1861.

The expedition to the Ussuri had great importance in gathering information about this region. At that time the first Russian colonists were appearing in the Far East and Maack's investigations made an essential contribution to opening up these regions.

After returning from the Far East, Maack worked a few years at the Central Committee of Statistics in St. Petersburg, where he supervised the processing of the data concerning Siberia. He participated in the work of the Governmental Committee for the Far East and took part in the compilation of a geographic dictionary under the supervision of P. P. Semyonov. Then he returned to Irkutsk, where in 1865 he was made director of the educational establishments of the gubernia of Irkutsk, and in 1868 he was appointed chief inspector of the schools in East Siberia. In 1879 he left Siberia for good and settled down in St. Petersburg. In the same year he was made a member of the Council of the Ministry of Education. Richard Maack died in St. Petersburg on November 25, 1886.

R. Mack's expeditions contributed much new information on extensive regions in Siberia and the Far East. He was a naturalist in the best sense of the word. He gathered a wealth of material about the geological structure, surface relief, climate, network of rivers and lakes, flora and fauna of the areas he travelled through. A proof of the great significance of Maack's explorations is the fact that the materials he collected during his expedition to the Amur region included 31 plant species hitherto unknown to science, such as the Amur corkwood (*Phellodendron amurense* Rupr.), the

Amur grape (*Vitis amurensis* Rupr.), the Manchurian basswood (*Tilia manshurica* Rupr. et Max.), the Manchurian walnut (*Juglans manshurica* Max.), the Korean pine (*Pinus koraiensis* Sieb. et Zucc.), the ginnala maple (*Acer ginnala* Max.), Maack's birdcherry tree (*Padus Maackii* Rupr.), etc. About the same number of new animal apecies were discovered by him, a new tortoise species (*Trionyx Maackii* Brandt) among them. Maack's contribution was highly appreciated by contemporary naturalists. His name has been given to 18 plant species, such as Maack's burning-bush (*Evonymus Maackii* Rupr.), Maack's honeysuckle (*Lonicera Maackii* Rupr.), Maack's bird-cherry tree (*Padus Maackii* Rupr.) etc., and to four animal apecies, such as Maack's tortoise (*Trionyx Maackii* Brandt), etc. A family of small papilionaceous trees and bushes has been named *Maackia* after him.

Maack also made an essential contribution to investigation into the ethnography of the natives of Siberia and the Far East. His observations in this field have not lost their importance to this day. A creditable feature was Richard Maack's humane attitude to the natives, with whom he managed to establish friendly relations in all contingencies.

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150 AASTAT RICHARD MAACKI SÜNNIST

E. Varep

Resümee

Richard Maack, silmapaistev Siberi ja Kaug-Ida uurija, sündis Eestis, Saaremaal Kuressaare (nüüd Kingissepa) linnas 4. septembril 1825. a. Ta lõpetas Peterburi ülikooli loodusteaduste alal ning asus 1852. aastal tööle loodusteaduste vanemõpetajana Irkutski gümnaasiumis. Vene Geograafia Seltsi Siberi osakonna ülesandel teostas ta kolm suurt teaduslikku ekspeditsiooni — Viljui piirkonda (1853—1855), Amuuri jõele (1855) ja Ussuuri jõele (1859). Tema poolt kogutud rikkalik materjal kõnesolevate piirkondade geoloogilise ehituse, reljeefi, kliima, vetevõrgu, floora ja fauna kohta oli oluliseks lisaks nende varem väga vähe tuntud maa-alade tundmaõppimisel. Maack avastas teadusele paljud uued taime- ja loomaliigid; tema nimi on antud taimeperekonnale *Maackia* ning 18 taime- ja neljale loomaliigile. Kõrgelt tuleb hinnata ka Maacki etnograafilisi uurimisi. R. Maacki saatjaks tema kahel esimesel ekspeditsioonil oli esimesi eesti päritoluga looduseuurijaid preparaator Mihkel Fuhrmann.

150 ЛЕТ С РОЖДЕНИЯ Р. К. МААКА

Э. Вареп

Резюме

Ричард Карлович Маак, видный исследователь Сибири и Дальнего Востока родился 4 сентября 1825 г. в Эстонии в г. Курессааре (Аренсбург, ныне г. Кингисепп) на о. Сааремаа (Эзель). Окончив Петербургский университет в качестве естествоведа, Р. К. Маак в 1852 г. приступил к работе старшим преподавателем естествознания в Иркутской гимназии. По заданию Сибирского отделения Русского географического общества Р. К. Маак совершил обширные экспедиции в окрестностях Вилюя (1853—1855), на р. Амур (1855) и р. Уссури (1859). Собранный в этих экспедициях богатый научный материал о геологическом строении, рельефе, климате, гидрографической сети, флоре и фауне был значительным вкладом в изучение Сибири. Р. К. Маак открыл для науки многие виды растений и животных; его именем названы род древесных пород *Maackia*, а также 18 видов растений и 4 вида животных. Высокой оценки заслуживают также этнографические исследования Р. К. Маака. В первые две экспедиции Р. К. Маака сопровождал препаратор Михкель Фурман — один из первых эстонских естествоиспытателей.

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