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EFFECTS OF RELIEF CONFIGURATION AND HUMAN INTERVENTION ON THE NATURE OF THE KARST PROCESS

DR. LÁSZLÓ JAKUCS

My observations have completely convinced me that the distributions of the components of karst erosioninclu de certain features that are unexplained either by differences in lithology, by concrete differences in climatic factors representing the situation of the karst region in a climatic zone, by structural pre- or postformation, or by the relationship of the karst to its not karsted surroundings.

When it is recalled, for instance, that most of the dolines on a karst surface have a ground plan that is not circular but elongated in some direction, as a result of which one of the doline flanks is almost invariably much steeper than the others, one is already in possession of a relationship with a bearing on the causal relations of this problem. Mapping of the asymmetries of a variety of dolines revealed that the factors determining the ground plan of the depression in the course of its evolution are not the relationships studied and published by early authors (J. CVIJIC A. GRUND, J. CHOLNOKY, etc.), notably the dip of the strata and thelines of structurally preferred orientation, but rather some other factors influencing the dynamism of corrosion that the authors mentioned were not aware of; these factors overcome the preferred orientation due to the dip and strike of the strata, to impress upon these forms an orientation depending on the points of the compass. In other words, *independently of* whether the strata dip north, south, east or west, *the doline flanks with by far the highest relief energy*, for instance in the Bükk Hills and on the North Borsod Karst, *are invariably the flanks of easterly or north-easterly exposure.*

However, from the recognition of this phenomenon it is still a far cry to the drawing of general conclusions, which requires the analysis of a number of further examples.

It is known that the karsts of our planet are in various stages of erosion and of geographic relief evolution. The present-day aspect of the landscape provides us with the resultant of all the forms from previous episodes of relief evolution. *The actual (temporal) cross-section of the succession of events, reflected in the set of relief forms, is not merely the complex upshot of all the preceding episodes of relief evolution, however, but is itself a dynamism-controlling factor affecting relief formation in the present and in the future through its qualitative and quantitative driving factors.*

This rather general statement, intentionally formulated rather broadly, expresses an important feature of the evolution of any relief, and not just of the karsted ones; however, in adducing proof for it we shall remain within the confines of karst science.

Given a leaching solution of fixed quantity, temperature and chemical composition, karst corrosion on the surface is the more efficient, the more extensive the rock surface in contact with unit volume of the solution during unit time. *The extent* *of the surface is relative, however, and a function of palaeographic events.* At the beginning of the process of erosion, a limestone plateau not yet provided with a karst relief offers to erosion precisely one square kilometre of surface per square kilometre of map area (disregarding, of course, the internal fissures and joints). However, owing to the intense dissection of the relief by advanced doline sculpture on a limestone plateau of advanced karstification, one square kilometre of map area may actually correspond to 1.5 square kilometres or more of actual rock surface. The rates of erosion of a young and an old karst relief differ purely for this reason, if for no other.

There are other reasons too, however. Karstification widens part of the fissure grid draining surface waters into the rock mass. The widened fissures with their reduced wall drag attract a substantial proportion of the water pulled down by gravity. Hence, whereas early in the process of karst evolution, when all the fissures were still narrow and *the three-dimensional karstification of the young karst mass was still homogeneous,* even the narrowest fissures could contribute to the drainage of the descending waters, the advancing maturity of karst evolution gradually resulted in *a linearization of vertical drainage,* thereby reducing the total area of the surface in contact with the leaching solution in the interior of the karst mass.

As a consequence of all these factors, *as erosion advances the efficiency of surface corrosion increases, while the efficiency of corrosion within the karst mass gradually becomes linear.*

This set of examples may be followed still further. The partial increase in slope angles resulting from the formation of dolines promotes not only a faster surface run-off of precipitation, but also soil erosion and hence the natural baring of the karst rock. This process may reduce the efficiency of karst corrosion in the areas of steep doline and valley *flanks,* whereas it may increase it on the doline and valley *floors* characterized by the confluence of waters and the deposition of sediments; in contrast, beyond a given limit (that of the critical impermeability of the deposits), it may eliminate the process altogether.

In order to present a wider proof of our theorem, some back-acting channels of a different nature should be pointed out.

In numerous karst regions, including Yugoslavia, Italy, Austria, Cuba, South China, etc., it is obvious that *the size of the karst mass* itself may result in qualitative differences in karst erosion. For instance, in the authigenic karst mountains of Slovenia, Croatia, Albania, etc., several hundreed square kilometres in extent, even the A-type lenticular zones exhibit a B-type motivation, purely *because of the volumes of water* involved in their sculpture.

To consider another example of a different type, snow accumulated in the hollows of well-developed, deep dolines on karst plateaux, fallen in the winter and swept together by the wind, may persist well beyond the general snow-melting characteristic of the region as a whole. Masses of snow in striking contrast to the blossoming countryside can be encountered quite frequently in May and June in hte peculiar microclimatic spaces of temperate-zone dolines. Beneath these snow-covered spots the karst process is, so to speak, put into a deep freeze; that is, it will be many times less efficient than in the snowless surroundings: even though the gradual melting of this long-lived snow ensures a continuous supply of infiltrating cold water, this cannot vie with the high corrosive potential of the soil solutions, due to the vegetative production of CO_2 in the rhizospheres of the verdant surfaces close by.

Many similar examples could be enumerated, as the number of back-acting channels by which a set of karst forms, once developed, may and does react upon the complex of morphogenetic processes controlling the further course of evolution is very large. These back-acting channels have all been included under the heading of *geomorphological variance in karstification,* as they express the highly manifold and significant influence, also highly variable in both space and time, of the *geomorphological features* of the present-day landscape, developed during the prior evolution history of the karst. In a concise formulation, probably unusual on a first hearing, but certainly expressing the essence of the matter, we might say that *geomorphological variance in karstification means the influence of the karst topography upon karstification.*

Karst forms and, of course, the relief forms typical of any other type of landscape as well, are *not* in this sense mere *passive* products of erosion, etc., but undeniably active, *indirect relief-forming, process-controlling factors.*

I am therefore of the opinion that a systematic, analytical study of the above effects, and of a number of other effects not touched upon here, may be one of the primary tasks of morphogenetics in the future, since a full and realistic genetic understanding of a landscape on today's exacting level of sophistication in our science makes indispensable an analysis of the manifold *interactions* initiated by earlier erosion in the qualitative and quantitative parameters of subsequent erosion.

I am convinced that a profound understanding of cause-to-effect relationships in morphogenetics will be impossible on an up-to-date level without studies of the sort outlined above.

Further, any natural region and the human society living there will indisputably interact on many levels, just as there are similar, variable interactions between endogenous and exogenous dynamics, and the actual state of the relief at any instant. The problems that arise are to decide what agencies are enhanced, and where, at any given instant in the interaction of region and society, and in what measure these enhanced agencies affect the tendencies of continuing evolution of the human community and of the landspace itself.

The influence upon the evolution of society of the orographic, hydrographic, climatologic, petrographic, etc. features of a geographic environment has been studied in the last few decades with a great deal of care, and discussed from many aspects by modern geographical science. As a result, it has been possible to reject most of the one-sided, distorted approcahes: geographic determinism as one extreme, and the total negation of the importance of all these effects as another, or the exaggeration of the role of society to the point of a geographic biologism.

Present-day geographical science tends to attribute importance to these problems in keeping with their real weight, and devotes a great deal of painstaking effort to the study of the effective relationships; by learning the laws of their spontaneous manifestation, it is hoped to find reasonably practicable ways of applying these laws to a positive control of nature, most appropriate to the requirements of the society. The final aim and the *raison d'etre* of the scientific research is concretized in these studies; of the numerous relevant volumes that have been published, many have contributed viewpoints of inestimable value to concrete, national economic planning.

Under the conditions of a karst region, its interactions with the human communities living in and off it are perhaps even stronger than in regions of a different nature. The almost total lack of available water on extensive karst plateaux, most often coupled with a practically complete absence of agricultural land are highly unfavourable to the settling and evolution of cultures, even the minimum requirements barely being supplied. This is the main reason why, in the largely karsted state of Crna Gora (Montenegro) in Yugoslavia, the population density is only 33 per sq. km, whereas in the adjacent state of Serbia it is 86 per sq. km, with corresponding significant differences in the ways of life, the living standards and the cultural demands of the two peoples.

In keeping with the morphogenetic aims of the present work, however, I do not intend to highlight this aspect of karst regions and the social communities embedded in them, but rather the modes of expression of anthropogenic effects in the qualitative and quantitative evolution of karstification, and which may be included under the heading of the *anthropovariance* of karst evolution.

It may be stated as a general preamble that these effects usually influence the karst process very intensely, even though their reflection in land forms may as yet be unmeasurable, *the duration of their action having been too short* on a geological time scale. They may fundamentally and recognizably alter the *tendencies* of surface evolution, however, by initiating a completely new "cultural denudation", giving rise to a landscape altogether different from a landscape subject to its own laws of spontaneous evolution.

All this will now be illustrated by the presentation of certain important anthropovariantal modifiers of erosion. The topic discussed will be *modifications in erosion due to changes in the natural plant cover of a karst region.*

It is common knowledge that the huge demands in industrial timber required for the building of Venice, and for the construction of the Adriatic fishing fleets and the men-of-war and trading vessels of more recent times were tantamount to a death sentence for the forests in near-shore areas of the Croatian and Dalmatian karst. Complete deforestation was naturally followed by large-scale soil erosion, and the karst-type ablation of the steep hillsides soon resulted in the total and irreversible denudation of the region.

In Albania and especially in Greece, on the other hand, it was the tremendous multiplication of goats some centuries ago that was responsible for deforestation and denudation; feeding on buds and young shoots, and thereby killing off replacement growths, goats caused the ageing, senility and decay of woods and forests, thus opening up the way for the total ablation of the soil deprived of its reinforcing network of roots.

Soil erosion was also promoted and accelerated by the mechanical effect of trampling by the herds. In a short while, the multiplication of stray goats and the undesirable consequences of this reached such a degree that the animals could not find sufficient food, while the little agricultural land that did remain could not provide even the minimum sustenance to a population living even at the best of times on the meagre agricultural produce. Thoughtless interference with nature therefore resulted not only in the upsetting of the biological equilibria, but also in a profound change in the character of the land, in a reduction of its agricultural productivity and naturally also in qualitatively new features of erosion.

Based on the comparative analysis of wide-ranging phytogeographical data, P. JAKUCS (1956) first demonstrated consistent connexions between the form types of limestone lapies and the plant associations thriving in the karst region. One consequence of these connexions is that, whereas the *primary lapies reliefs* (Fig. 1) of karst areas bearing a sufficient soil and plant cover are places of intense subcutaneous lapies formation, resulting as a rule in *rounded microforms and root holes of irregular pattern,* these forms have been altered by subsequent denudation and exposure on the surface, giving rise to the *typical furrow and rain-rill set of karst forms typical of high mountains,* as a result of these secondary processes (Fig. 2).

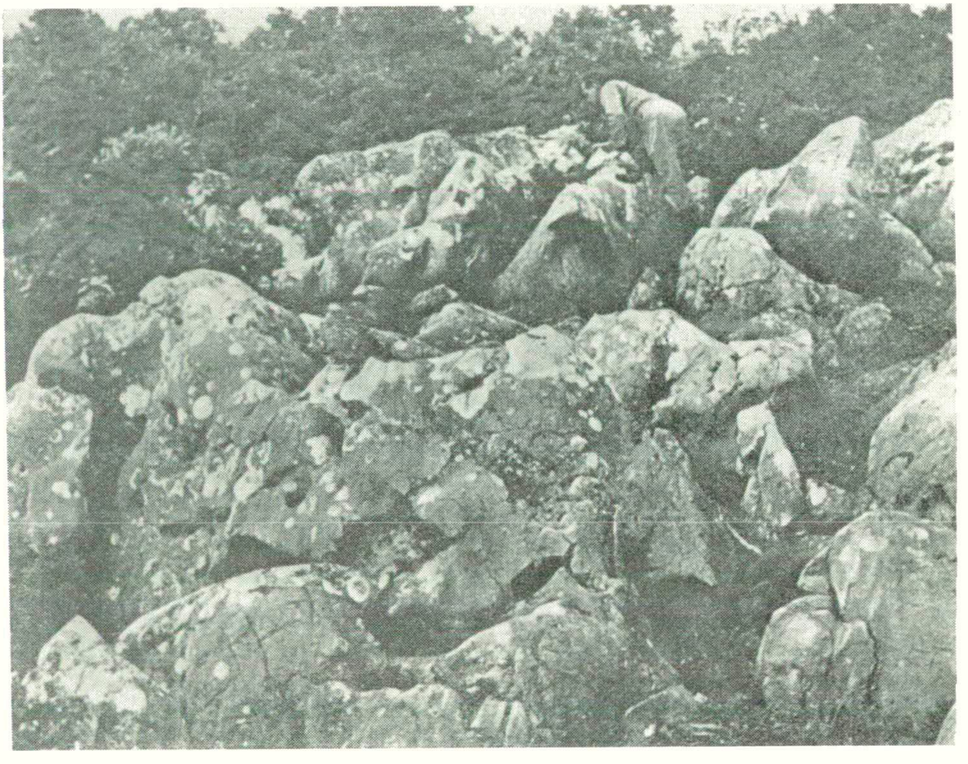

Figure 1. Rounded limestone lapies with root holes, the typical result of evolution under a soil cover, on a flank of Baradla-tető at Aggtelek (photo by HOLLENZER)

This effective "metamorphism" of lapies forms is so regular, even quantitywise, that, for instance in the various areas of the Dalmatian Karst, *the state of advancement of this reshaping* (via comparative morphoanalysis) permits a good approximate estimate of the *time elapsed* since the baring of the rock in any particular locality. Figures 3 and 4 give a concrete illustration of this.

The removal of the plant and soil cover also has other consequences, of course, resulting in a distortion of the karstifying process.

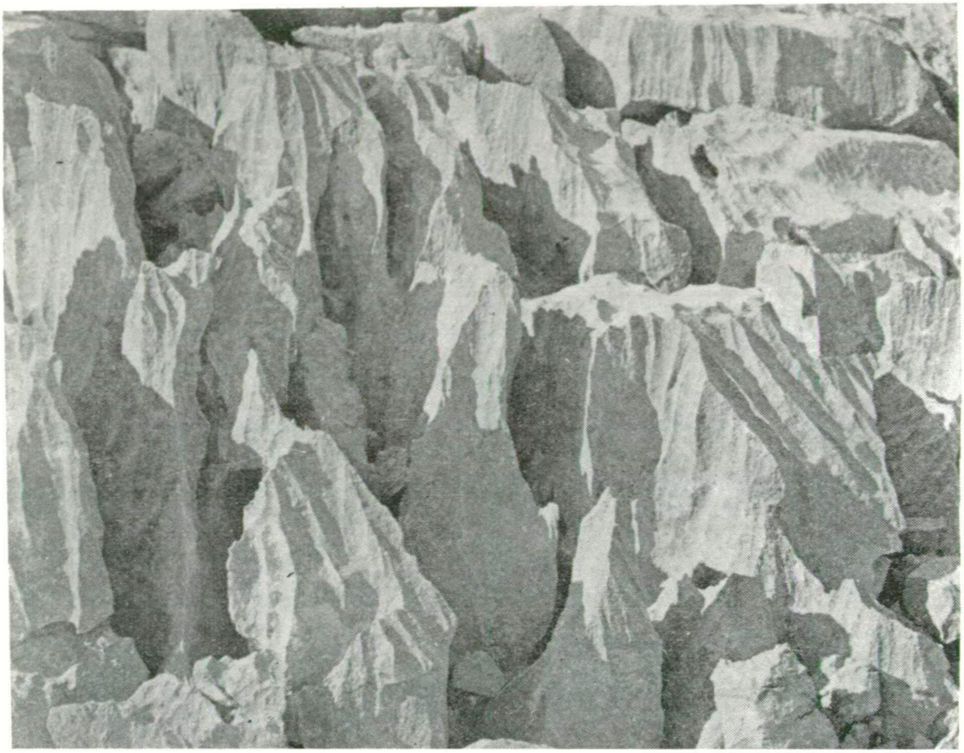

Figure 2. Secondary dissection of barren lapies of the Dalmatian Karst by parallel runoff furrows: the lack of a preferred orientation among the blocks of rock clearly indicates the subcutaneous sculpture of the basic forms

Prior to degradation, karst soils covered with forest, and even those supporting only a lawn association, supply an evened-out flow of ground water to the underlying limestone. This is a consequence of the natural water storage capacity of the soil, which enables it occasionally to take in and transitorily store quite substantial amounts of precipitation. In the process, a large proportion of the pores between the soil particles become filled with water; some soils swell considerably as a result.

On the other hand, rain immediately runs off barren karst surfaces, being partly absorbed into the fissure system of the karst rock, and so even a few hours after a summer shower the limestone surface is again completely dry. This is why *drippings of comparatively uniform discharge, active the year round, invariably occur in any dripstone cavern beneath wooded karst surfaces, whereas stalactites with markedly variable dripping rates occur almost without exception in cavern sections underlying barren karst surfaces.* These latter dripstones frequently include some for which there may be periodic cessation of the water discharge.

This is borne out convincingly by my recordings of the water discharge rates of some stalactites in the Baradla and Béke caverns at Aggtelek (Fig. 5).

My Slovenian observations in the nineteen-sixties convinced me that there are also other, sensitive relationships between the plant-cover pattern of the ground surface and the resulting state of the soil, and also the nature of the karst process. First and foremost, there are at times considerable differences in the dynamics of dripstone formation in cavern sections lying beneath covered and barren karst surfaces. *Dripstone formation rates greater by several orders of magnitude were found beneath forest-covered reliefs than beneath degraded planinas.* Especially in short-range comparisons, dynamisms differing by a factor of 10^3 were observed. This is understandable since some drippings of water dry up entirely from time to time under barren karsts.

Via the above factors, any significant deterioration in the original water-storage capacity of the soil and in the infiltration-evening role of the surface cover in eroded karsts will also lessen *the reliability of the yields of karst springs* surging in the karst area considered. In a karst in the process of degradation, spring discharges tend to become *irregular;* the advance of degradation entails increasing *extremes* in the yield and even in the water composition of the springs. Whereas the peak discharge prior to general soil degradation is likely to exceed the minimum by a factor of ten

Figure 3. A lapies field laid bare by total soil erosion subsequent to deforestation, near Hercegnovi, Yugoslavia. The lapies still reflect the influence of the subcutaneous process; the evolution of runoff furrows is quite embryonal. Deforestation took place about 80 to 100 years ago. (See also Fig. 4.)

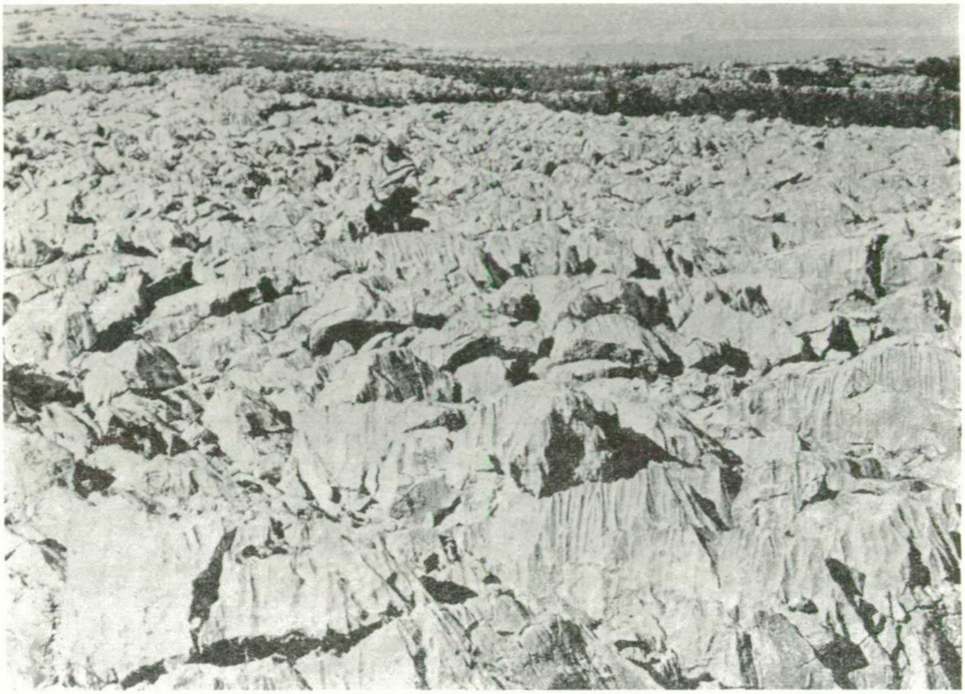

Figure 4. A lapies field laid bare by total soil erosion subsequent to deforestation, near Hercegnovi (about 2 km from the site shown in Fig 3). The lapies shows hardly any remains of the primary forms due to the subcutaneous process; the well-developed runoff furrows are indicative of an advenced stage of barren-karst corrosion. The time elapsed sinci deforestation is at least 400 to 600 years.

at most, after degradation the peak discharge may exceed the low-water discharge by as much as a factor of one hundred (KESSLER 1954, 1956). This also has a deleterious influence of course on the purity, the natural filtration, the possible bacterial contamination, etc. of the water, even in the case of A-type springs.

In a general way it seems that although the degradation of the karsted drainage area increases the total yield of the area on a year-round average, by increasing the proportion of durably infiltrated water, at the same time the accompanying extreme fluctuations of the discharge and the deterioration of the water quality are very unfavourable changes wherever it is intended to use the spring to *supply* some settlement, for example. Consequently, the afforestation of karst surfaces within the drainage areas of one or several karst springs ensuring the water supply of a town is a high-priority task for the society. Hungarian examples of such towns are Miskolc, Pécs and Borsodnádasd. Neglect of this task, or even allowing the processes of degradation to continue, will inevitably result in the deterioration of the reliability and quality parameters of the spring.

Anthropogenic influences deflect the evolution of the natural plant cover over a karst region almost invariably in the direction of degradation; there are also some other sensitive intensity indicators of the connected karst processes, however. One of these is *the changing colour of dripstones in caverns,* perhaps the most sensitive record of rates of degradation in the past as well as in the present.

Reference can be made in this context to my examinations concerning the colour, structure, chemical and mineralogical composition, locality of occurrence and abundance of dripstones in the caverns of the North Borsod Karst in Hungary (L. JÁKUCS 1960, 1962), which clearly led to the following inferences:

1. The abundance of non-carbonatic contaminations is least in the dripstones of those cavern sections under a relief with an uninterrupted forest cover and a natural soil profile.

2. The dripstones under barren karsts are often inactive, dull of surface, and usually yellow, brown, ochre or a clayey-grey in colour.

3. Where the plant cover has died off recently, the surfaces of stalactites and stalagmites show a marked change in colour, usually towards a red tint. Areal erosion on the surface and the increased infiltration into the karst of the eroded clays and iron compounds results in a lower calcium carbonate content in recent dripstone formations; such layers tend to be friable and rich in non-carbonatic contaminating substances.

4. If the forest on the karst is renewed after a brief period of barrenness, the dripstones grow lighter once more, and the most recent layers are then clear again. In this way it is possible to infer the phases of surface degradation from the cross-sections of inhomogeneous dripstones in caverns; such phases may reflect either an anthropgenic influence, or a natural destruction of the forest, for example by fire. Not only do the interiors of such dripstones exhibit concentric shells of dripstone

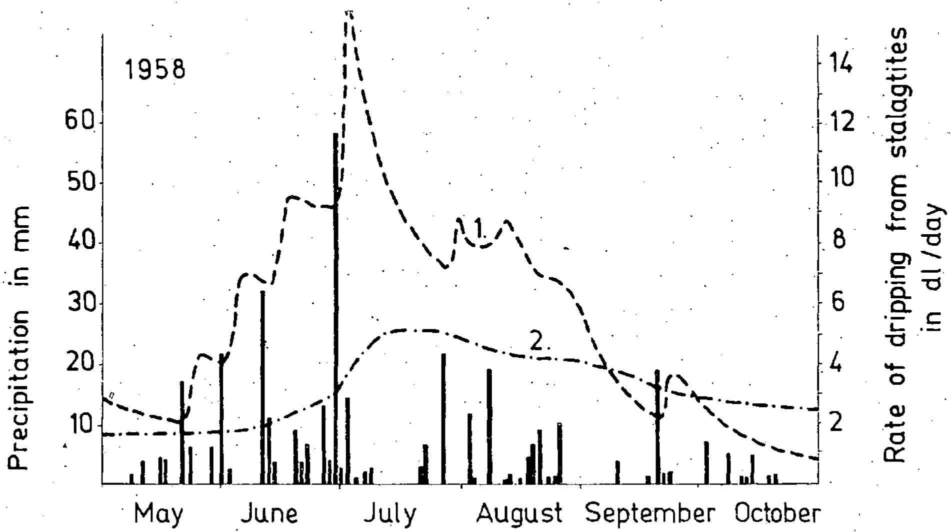

Figure 5. Typical differences in water yield of stalactites underlying a fully degraded, barren karst (graph 1) and a karst covered with a thickish humus soil under a forest (graph 2). The histograph shows the rainfall in the region under study during six months of 1958
1 = stalactite 3 in the „Hall of Columns" of the Baradla;
2 = stalactite 4 in the Béke Cavern

differing in colour and composition, but some of the calcium carbonate layers even wear a coating of clay. The calcium carbonate content of this intrastalactic clay may be as low as 1%. The clay coating is in turn surrounded by a calcium carbonate shell, this pattern possibly being repeated 5 or 6 times. This may occasionally reach such a degree that a broken-off stalactite can be drawn out telescope-fashion by deforming the plastic layers of clay contained in it (Fig. 6).

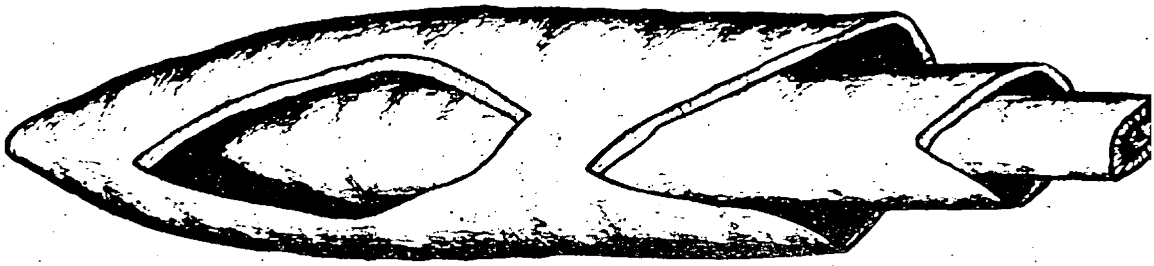

Figure 6. Structure of a telescoping stalactite indicative of ancient forest fires or other episodes of surface degradation. The soft clay intercalated between the calcite shells, deposited at times of degradation, can be washed out subsequently, in which case the broken-off stalactite readily slides apart (original)

In caverns underlying limestone planinas, where the terra rossa-type soil is rich in ferric oxide, the degradation of the soil and of the plant cover is clearly indicated by the redness of large masses of wall linings and dripstones, as in karst areas where the forest cover was destroyed the upsetting of the long-standing equilibrium of the soil cover permitted the waters to wash the degraded soil through the fissures of the limestone into the caverns. Comparison of cavern and surface maps reveals (L. JAKUCS 1960, 1962) that in the vicinity of the "Red Hall" or of the "Stone Toadstool Gate" in the Béke cavern of Aggtelek, for instance, where the red lining on the cavern formations is especially conspicuous and ubiquitous, a denudation caused by total deforestation has taken place over the last hundred years or so.

The washing of clay into the barren karst may occur locally at so high a rate that even over a few centuries it may result in a significant, and locally even complete *silting-up* of inactive cavern sections. Sedimentological and pollen-analytical methods applied to the muddy fillings in the "Fairytale Land" and the "Golden Street" of the Aggtelek cavern, and in the upper passage of the "Radish branch", as well as in numerous upper-level syphon bypasses in the Béke Cavern, etc. have demonstrated that silting-up over the last few centuries (during a period of general surface denudation in the neighbourhood) has deposited a bed of clay thicker than the aggregate deposits of the previous three or four millennia.

Such a fast process of silting-up and clogging of underground cavities therefore justifies the statement that *any anthropogenic interference with the natural plant cover of a karst region will initiate a period of intense changes and decay in earlier-formed karst features both on the surface and underground.*

Of course, the above considerations do not at all imply that it is altogether unfeasible to displace the process in the opposite sense, that is, to put a stop to degradation already under way, and even to reverse the trend. There are many examples to show how successful a timely and well-chosen method of reafforestation may be. According to P. JAKUCS, (1954, 1955, 1956), however, the task is far from simple. "Reafforestation must always start from the shrub-covered spots left over in the place of the former forest; it must employ everywhere the tree species of the ancient, natural plant cover that may be found still thriving on similar slopes of adjacent hillsides. The work of reafforestation must proceld gradually, with due respect to the natural succession of the plant associations. For instance, a lawn-covered spot should at first be planted with shrubs, and only after these have gained a foothold may one think of planting trees (in Hungary primarily hairy oak (Quercus pubescens)).

Any change in the natural plant and soil cover of a limestone planina will, as a matter of course, affect the intensity of every karst process connected with corrosion, including e. g. doline sculpture, or calcareous tufa deposition next to a spring. I have nevertheless picked out above only the formation of lapies and the phenomena of hydrology and sedimentation in caverns; the slowing of doline formation on the advance of degradation, as well as the reduction or cessation of calcareous tufa deposition from a karst spring whose waters are gradually softening, are processes whose *short-term morphological consequences* are not conspicuous, or not recordable at all with the tools available today, and this makes their discussion very largely theoretical.

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MORPHOGENETICS AND PALAEOGEOGRAPHIC CONDITIONS OF ALKALI LAKES ON THE HUNGARIAN PLAIN

DR. MIHÁLY ANDÓ

A considerable number of alkali lakes and periodically waterlogged areas are to be found on the alluvial plain deposited by the rivers Danube and Tisza and their tributaries in Hungary. On the calcium-rich sediment of the Danube talus system, one finds limy, sodic, alkali lakes and alkali deposits, while on the Tisza alluvium (originating in the main from eruptions) acid solonetz and solodj types are observed. (VÁMOS R.—ANDÓ M.: 1969.)

The alkali waters and *alkali lakes form one of the characteristic types of surface waters.* As a result of the extreme climate of the Hungarian Plain, they posses characteristic hydrographic conditions. On account of their high dissolved salt content (604.5—7,124.2 mg/l), they can be classified as salt waters; the typical features are primarily richness in Na^+ and HCO_3^- ions, a high pH (7.5—10.5) and an alkaline character (MEGYERI J., 1972).

The alkali waters are extreme sites for life, populated by a particular living world different from those of other surface waters, and from those of salt waters found in other countries.

The alkali lakes on the Hungarian Plain generally formed where the morphological conditions of the surface were favourable. The beds of the lakes consist of old river-valley reaches, bends backwaters, depressions with no outlets, basins and deflation wind-furrows. *At the turn of the century* (before the regulation of the inland waters and rivers), *the alkali lakes were much more numerous and extensive than nowadays.* They are still not rare, but they are not standing waters of a uniform nature. A considerable number of them are shallow, and are in the swamp stage. These are completely covered by the aquatic vegetation. The water of another group of the *alkali waters* is already constant, and their hydrographic character is that of a lake. These latter *comprise three regional taxonomic groups on the Hungarian Plain* (Figure 1):

I. Deflation-type lakes on the sandy table-land between the rivers Danube and Tisza;
II. Polygenetic-type lakes of the Tisza valley;
III. Fresh-water erosion bed lakes of the Békés-Csanádi loess table-land.

The alkali lakes of the table-land between the rivers Danube and Tisza *mainly originated as a result of deflation,* for here the sandy material from near the surface of the talus between the Danube and the Tisza accumulated and was denuded by aeolian means (ANDÓ M., 1964; MIHÁLTZ I., 1953; MIHÁLTZ I.—FARAGÓ M., 1944—45; MIHÁLTZ I.—UNGÁR T., 1954; KRIVÁN P., 1953; MUCSI M., 1963; SÜMEGHY J., 1953). The sand and loess formations extend horizontally and can be followed for considerable distances (50—80 km); together with their

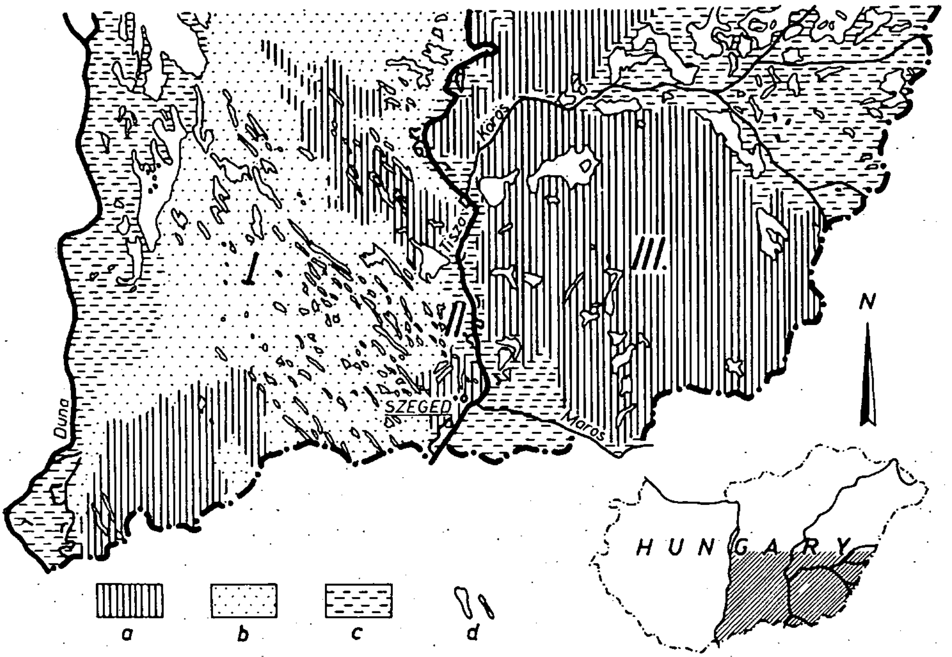

Figure 1. Surface geological picture of the lakes of the South Hungarian Plain and their environment
I. The sandy table-land between the Danube and the Tisza. II. Alluvium of the Tisza valley. III. The Békés—Csanádi loess table-land. (a) loess and infusion loess formations; (b) drift-sand; c) flow-mud and meadow clay; (d) alkali depressions.

particle-distributions (coarse-grain sand and gravel, and absence of clay formations), these prove the deflation origin. This picture is particularly characteristic in the central part of the table-land, where the wind-borne origin is indicated not only by the particle form and the abrasion value, but also by the terrestrial (Ubiquista) mollusc fauna (ANDÓ M.—MUCSI M., 1967). In the course of the complex investigations it was established that the sand found here did not exhibit signs of having undergone aeolian transportation over great distance, i. e. the sand was originally transported to the area between the Danube and Tisza by flowing water. This sand was then repeatedly re-piled and transformed by the wind, and deflation depressions developed in it.

On the lower ground of the table-land, falling away to the two river valleys, the amount of sand and mud deposits of fresh-water origin increases. Large numbers of fresh-water Mollusca are found in these deposits. The sand grains here are somewhat splintery (weakly blunted at the edge) and semitransparently coloured. This structural and genetic difference appears sharply in the hydrogeographic features of the alkali lakes.

The difference in the deposit facies may be observed strongly particularly within the types of alkali waters, when in addition to the Na^+ and HCO_3^- ions determining the type, the amounts of the other chemical components (CO_3^{2-}, Cl^-, SO_4^{2-}, K^+,

Ca^{2+} and Mg^{2+}) and other hydrographic properties, such as, for example, the variation in the mass of water (permanent and periodic alkali waters), the transparency of the water, etc., may be very different in each alkali water. *In this region, therefore the varied development of the deposits during the end of the Pleistocene period and throughout the Holocene period resulted in different hydrological conditions even within the individual regional taxonomic unit.*

The accumulation of loess and the drift sands between the Danube and the Tisza can not be regarded as a continunos accumulation of sediment, since in the hotter climatic periods with higher precipitation there was also an appreciable soil formation together with a certain degree of surface denudation. Accordingly, this explains why (as a result of the denudation of the surface) the "Würm III" loess layer on the tableland sloping toward the Danube appears in patches only, while at the same time it can be found everywhere in the centrall and eastern (Tisza valley) parts of the tableland. In general, a drift-sand layer of variable thickness accumulated on the "Würm II" and "Würm III" loess layers in the Holocene period; on the action of the wind, this sand layer was shaped into dunes. On the regions between the sand dunes, however, i. e. on the regions of the lakes and periodically waterlogged ground, the deposits which accumulated largely developed from standing water.

The substratum of the Holocene formation under the lakes lying in the western part of the region between the Danube and the Tisza consists of loess from the "Würm II" period. This structure is very rich in fauna; particularly in the lower parts there is a strikingly high number (exceeding 80%) of wet-terrain (Ubiquista) molluscs, and it contains relatively few of the dry-terrain variant inhabiting groves and woods. *The "Würm II" loess layer accumulated in its staidal, initial stage. Paleocelimatologically, it is assumed that the climate at the time of the accumulation was moderately cold and not too wet,* although the quantity of cold-resistant molluscs increases compared to other groups in the central structure of the loess layer; in our view, however, the stadial maximum of the "Würm II" here did not result in a climate modification of such a nature as completely to exclude the species requiring moisture from among those enduring drought. The cover of the loess layer is in places composed of vegetable remains and humus, and with its weakly developed adobe zone can be distinguished in two parts. The thermophilic fauna present in the adobe zone confirm the climatic improvement.

The loess layer is covered by a sharply-defined layer of Pleistocene drift-sand, which accumulated in the "Würm II—III" interstadial, mild subtropical period. On the centrals and eastern parts of the table-land, this drift-sand layer is again covered by loess ("Würm III), but on the western part of the table-land this loess developed only discontinuosly. Where it does exist, it is characteristic that there is a thin inclusion of clay, varying in strata, in the upper part of the loess. Above this layer there follows a further sand deposit, which extends generally over the region between the Danube and the Tisza; this newer sandy layer is the covering stucture of this area, and in it have formed deflation depressions (lakes). It originates from the end of the Pleistocene period and the beginning of the Holocene period. *Stratographically, the separation of the Pleistocene and Holocene sand levels is possible only where the sand was deposited on a loess terrain, or perhaps where the two levels are separated from one another by sandy loess.* Where this is not the case, however, distincion between the drift-sands formed in the two different periods is very dubious. As a result of the eroding effect of the water collecting in the wind-furrogs formed on the surface of the

Early Holcene drift-sand, the wind-furrows proceeded to deepen, and in them were deposited the very characteristic formations from the Early Holocene period: lacustrian lime mud and meadow limestone.

Numerous data from test borings have provided the evidence that the substratum of the Early Hoiocene sand is fine-sandy, unassorted rock flour, with fauna of a mixed nature. As regards these latter, both thermophilic and cold-enduring types are found. Their water-requirements are variable: those of a mainly periodic aquatic nature amount to about 40%, and the other groups to 60%. On the basis of the fauna composition and the results obtained from pollen investigations, the period of accumulation of the deposit can be denoted as the fir-birch phase of the Early Holocene period.

There was also an intensive movement and accumulation of drift-sand on the Hungarian Plain in the hazel-nut phase of the Early Holocene. At that time there was a considerable transformation of the previous surface appearance. In this region, for instance, the individual lakes became deeper, but in addition a large number of new depressions too were formed. Faunistically, this period is much more difficult to follow, since the movement of the drift-sand led to the fragmentation of the skeletal remains of the molluscs and their abrasion into undeterminable forms. Where there was a possibility for their survival, e. g. deflation depressions, the microbiotope reflects a periodically wet, shady and cool microclimate, and not that generally expected regionally.

To clarify the conditions governing the development of the surface during the main phase of the Holocene period, a study was made of the potamogenous alluvial deposits of the alkali lakes and the conditions of these. In the lakes and the areas periodically covered with water, the accumulation took place of sandy mud and of mud rich in carbonate and containing unassorted detrital matter (Table 1).

TABLE 1.

Sediment-genetic processes of the lakes from the end of the Pleistocene to the present age

Period	Climate	Between Danube and Tisza (I)	Beyond Tisza (II, III)
Beech II	moderate, fairly wet (subatlantic)	drift-sand accumulation, strongly carbonate alkali sand and rock flour accumulation	intensification of alkalization, destruction of present-age accumulation woods near rivers; formation of alkali mud
Beech I	moderate wet subboreal	sand unassorted strongly carbonate rock flour accumulation, abundant vegetation, strong humification	strong soil formation, sandy mud, peaty adobe formation
Oak II	hot Atlantic	strong alkalization, slight mumous carbonate mud accumulation	running-water sand, sandy mud with rich pollen content; running-water and wild-branch type sediment variant

Period	Climate	Between Danube and Tisza (I)	Beyond Tisza (II, III)
Oak I	fairly wet Atlantic	laminated and compact fresh-water limestone formation with rich Mg content; beginning of drift-sand surface carbonate accumulation	medium-grained fresh-water sand deposit, sandy muddy clay — reaccumulated sediment formation
Hazel-nut	hot dry boreal	drift-sand accumulation, rich iron accumulation in upper part of sand intense alkalization	accumulation of gravelly coarse-sand of runn ng-water origin with formation of floodiplain swamp sediment
pine-birch	cold wet preboreal	drift-sand periodic-water lacustrian deposited unassorted rock flour	erosionperiod, river valley cutting, loess surface crumbling, running-water coarse-grain sediment formation
Yonnger tungra	cold dry $Drias_2$	drift-sand accumulation, strongly loessy fine sand formation	loess, sandy loess, clayey mud accumulation
Middle tundra	subarctic Allerőd	drift-sand	clayey mud, sand formation
Older tundra	$Drias_1$	loess, sandy loess	loess, running-water sandy mud, clay formation
Würm III	cold dry	loess formation	infusion loess and clay formation

The carbonate became concentrated as a result of the fact that the calcium-containing material in the higher terrain adjacent to the deflation depressions was dissolved up by the precipitated rain-water and was transported towards lower areas. The sodic water accumulated in the depressions precipitated out the lime from the evaporating solution in the form of minute particles, and this sediment provides the characteristic lime mud of the alkali waters. If the precipitation of the lime took place in the presence of sand grains, then the fine mud was deposited onto these sand grains, and in this way lime-mud sand was formed. At times the carbonate precipitation does not occur in the form of independent grains; instead, the sand particles are cemented together by the solid carbonate, and then limy sandstone beds are formed. In many places, however, the precipitation of the lime is so intensive that sand in it is insignificant in comparison, and meadow limestone is then formed. On the western slopes of the table-land between the Danube and the Tisza a carbonate-rich, small-frain, sandy mud was deposited with a loose colloidal structure, containing a considerable concentration of soda. This is also the form of the carbonate mud in the alkali lakes found in the central part of the table-land.

In contrast, the alkali accumulation is very different in the sand depressions faling away to the Tisza valley (Figure 2).

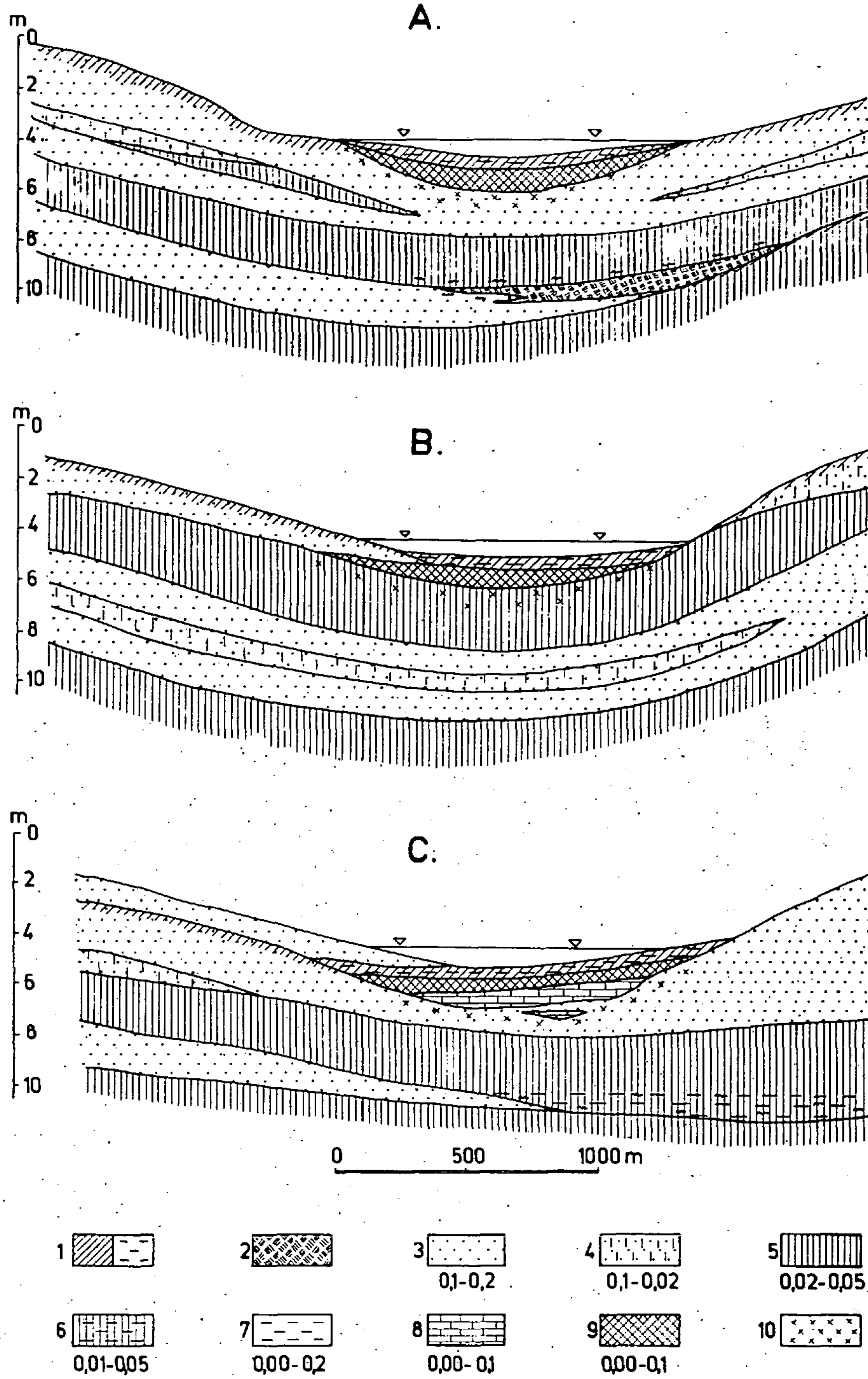

Figure 2. General geological profile of the lake types between the Danube and the Tisza

A. Lakes of the sandy table-land sloping down to the Danube valley. B. Lakes of the central part of the sandy table-land. C. Lakes of the sandy surface sloping down to the Tisza valley.

1. sediment rich in humus with plant residues;
2. peat; 3. drift-sand; 4. loessy fine sand;
5. loess; 6. muddy loess; 6. lime-muddy sand;
8. meadow limestone; 9. carbonate mud; 10. carbonate-rich sand, loess.

As in the western part of the table-land, here too the lacustrian carbonate deposited on drift-sand. *Limy sand was first deposited in intermittent patches (then higher in a coherent layer) on the uneven surface of the Pleistocene, while this was followed above by the formation of sandy limestone.* The thickness of the limestone layer varies from region to region (in general 30—70 cm), and its internal structure is not homogeneous. The lowest layer consists of loose sand grains, the central part is more compact, while the upper part contains sharply distinguished fine strata, and has a strongly porous structure. Above the limestone there follows a white, or greyish-white, loose, easily crumbled layer of the carbonate mud, and above this humous, rock-flour sand in a sharply distinct layer of variable thickness (20—50 cm). In places in this humous formation traces of peat can also be detected, pointing to a climate with more precipitation than the present one. The cross section of the Holocene accumulation was also outlined by the characterized layersequence. It was found that *a significant surface deposit on the Hungarian Plain was formed in the Holocene period only on the overflow regions of running waters and on the regions of the surface depressions (lakes).*

The rate of accumulation and the palaeoclimatic conditions are very well indicated by the limnetic deposits in the lakes of the sandy table-land between the Danube and the Tisza. The pictures of the pollen and the fauna in the individual lacustrian deposits give a good reflection of the palaegeographic situation. In the lakes in question (between the Danube and the Tisza) pollen pitures and fauna favouring a cold climate are found only in a few species and in low individual numbers in the sublayered drift-sand (Galba truncatula, Pinus silvestris). Accordingly, it is also considered possible that *the drift-sand comprising the base of the carbonate deposit may have been formed in the post-glacial pine-birch period at the end of the Pleistocene.* In the lower part of the sandy limestone structure the species enduring periodic drought predominate, and the proportion of those requiring constant water is significantly decreased (ANDÓ M.—MUCSI M., 1967). The coenosis too points to periodic wetness and a terrestrial wet terrain. On proceeding upwards in the series of fresh-water limestone layers, however, the number of individuals increases rapidly. The maximum number of individuals is found at the boundary of the lower and central layers.

The permanent and periodic aquatic, eurytherm species predominate in the composition of the fauna, but the number of those tolerating cold also increases. This population suggests that the climate on this area was wet, and colder than the preceding one. This is also confirmed by the pollen picture, for the thermophilic deciduous species (Quercus, Tilia, Ulmus, Juglans, a few Faugs) in the sandy lower level of the limestone indicate a hot, rainy climate, while the Petula, Salix and Pinus in the central, more compact limestone layers point to a temperature decrease. Both cold-resistant (eurytherm) and themophilic species occur therefore in the central, compact limestone bed. It is here that the proportion of permanent and periodic aquatic fauna is the highest. The species satisfied with periodic water occur in the greatest quantities, while the ratio of the water-side to the dry-land species favouring moisture is shifted in favour of the water-side species (ANDÓ M.—MUCSI M., 1967). The above data permit the conclusions that the climate was a wet one, that there was rich water-side vegetation in this area, and that the lakes had permanent open water surfaces.

In the thin-laminated structure of the uppermost fresh-water limestone the numbers of those species requiring permanent water is decreased, whereas the proportion of those satisfied with periodic water is unchanged. The proportion of the water-side

Succinea oblonga in the deposit is increased considerably; this means the recession of the permanent water-surface, but complete drying-out is excluded by the high number of individuals. The pollen picture indicates that the thermophilic deciduous trees again gain ground, implying a newer increase of temperature, accompanied by a certain drying-up.

In the lower part of the carbonate mud above the fresh-water limestone a decrease in the number of individuals is observed, the conditions leading to an increase in the proportion of the fauna requiring water and having wide limits of endurability (Anisus spirorbis, Succinea oblonga). In contrast, in the upper part of the carbonate mud the dry-land, thermophilic species not demanding moisture predominate over the periodic and water-side species. This stage means the enhancement of the dryness and the further increase in temperature of the climate.

Again, carbonate determinations show that the carbonate content of the underlying drift-sand is somewhat higher than that of the surface drift-sand. This is probably due to the fact that the carbonate content of the upper layer was washed out by the action of the precipitated rainfall and accumulated in the lower layers. *The carbonate content of the lacustrian deposit is considerable in the lower part of the fresh-water limestone, but low at the lower boundary of the central layer.* This decrease can generally be correlated with the local insufflation of sand, which is also proved by the lamination of the deposit. *A further increase of carbonate can be observed in the other parts of the fresh-water limestone.* The maximum is found in the lower part of the carbonate mud situated above the limestone (87%). In the structure above this layer there is at first a slow, and then a more rapid decrease in the carbonate content, so that in the upper humous layer it is only 25%.

In contrast with the deflation depressions in the aeolian deposits between the Danube and the Tisza, *the lakes in the south-east of the area beyond the Tisza (Békés—Csanádi table-land, III) are found in fresh-water erosion depressions.* As a consequence of the intensive fresh-water accumulation work, these lakes are very few in number. The considerable subsidence of this region in the Pleistocene period is compensated for by a fresh-water deposit serveral hundred metres thick. At the end of the Pleistocene the tempo of the subsidence decreased, and as a result not only the fresh-water alluvium, but also a falling-dust formation was deposited on the area in the final glaciation period (ANDÓ M., 1964; MOLNÁR B., 1966). However, the falling-dust loess formation became mixed in with the fresh-water accumulation, and accordingly several facies variants (sandy loess, clay loess) resulted in this region. A typically dry-terrain aeolian formation is not found in the region, for the falling dust either accumulated on a wet terrain, or was so transformed in structure on the action of the soil-water that it completely lost its typical loess character. *Here an infusion loess developed, and the present-day alkali lakes are also descending into this. In the infusion loess layer one finds calcium carbonate-rich clayey abobe zones, frequently washed together by the action of the soil-water and the standing-water cover of the region.* These layers have a considerable effect on the present hydrographic conditions of the lakes.

As a consequence of the flowing-water erosion work observed in the lakes, the alluviation of the river beds in the Pleistocene period was followed by an only partial similar process in the Holocene period. For this reason, the residual valleys of the old marshes and river beds are today's alkali standing-water depressions. *The alluviation of the lakes with infusion loess matter in the Holocene period occurred to a considerable* *extent, and thus only a small number of lake beds can be observed.* Where the extent of the silting-up is above the present average soil-water level the water cover of the surface is only periodic, but where it is below the present level the water cover is permanent. The lakes containing periodic water are of a very strongly alkaline character, while the lakes with permanent water are less so.

The deepest-lying formation (25—50 m depths) investigated by us is mud-clay from the Pleistocene period. On the basis of the layer sequence, it is probable that this is a Riss-Glacial formation. Its thickness and the extent of its area are variable, while from below upwards it is composed of ever finer particles. Gravelly, coarse-sand formations (Riss—Würm interglacial) were deposited on this structure, indicating a new rhythm in the deposition. This rhythm also consists of deposits which are increasingly fine in the upwards direction, the final uppermost member being a Würm falling-dust formation which marks the end of the Pleistocene. The surface formation of the Békés—Csanádi loess table-land, consisting predominantly of infusion loess material, is formed by this layer.

The Holocene represents a new rhythm in the surface development. Based on the particle composition of the transported alluvial deposit, the working capacity of the flowing waters in this rhythm were weaker than the earlier ones, and in direct relation to this the erosion activity was also less pronounced. The deposition of the fresh-waters sediment became periodic, as indicated by the fine sandy mud, and by the clay and clayey mud deposited in the standing water. The substratum of the Holocene deposit is formed by the "Würm III" infusion loess, but much more general than this is clay from the Pleistocene period. The thickness of the clay is 4—10 m, and in practice it can be regarded as impermeable. Above it, in the line of the ancient river valleys, coarse-grained sand accumulated (in a number of places gravelly coarse sand). In more rainy years there is a rapid soil-water movement in the river-valley zones filled with this porous deposit, and under the layer pressure in the lower-lying terrain the soil-water may even well up. In the upwards direction the particle composition of the coarse grained sand becomes increasingly finer, and the final layer is always a strongly unassorted sediment of varied development. It is well known that the oxbow lake state in the alluviation of the old river beds began at the beginning of the late Holocene and is still continuing today. The beds (lakes) were mainly filled in with infusion loess washed in from their environment, and have become strongly alkaline as a consequence of the environmental climate and the hydrograpic features. On the basis of the layer sequence of the alluviation rhythm in the Holocene period, a clear distinction can be made between the fresh-water deposits of coarse and medium-grained sand (early Holocene) and the always unassorted clayey mud (late Holocene) layer composition accumulating with standing and periodic water.

In the genesis of the lakes found on the direct Tisza alluvium (II) the main mechanism which can be observed is a fresh-water one. In the Holocene this terrain underwent not only intensive subsidence, but also considerable erosion. Here, surface erosion and accumulation took place to a depth of 15—20 m. The sedimentation of the covering layer can be regarded geographically as the only accumulation phase, where the granule size of the deposit becomes gradually finer in the upwards direction. At the lowest level is the loose fresh-water sediment, followed by a layer of muddy sand, clayey mud, and finally meadow clay. Since the control of the flood waters and the internal waters, this latter layer has been undergoing a process of considerable alkalization.

On natural or anthropogenic effects, all of the present standing waters of the Tisza valley are enclosed channel fragments. The water of the majority of them is not alkaline, since on flooding the water reserves of the lake are exchanged from the river Tisza. These water surfaces are subject to appreciable human intervention (storage lakes, fisch lakes). Those ox-bow lakes which are already strongly silted up are not very suitable for irrigation purposes, because of the chemical composition of their water and the high centration of salts. They are mainly utilized as inland stor age lakes, and as a result of their favourable natural features they are nature conservation areas.

To summarize; With regard to the historical aspects of the palaeogeographic development of the lakes on the Hungarian Plain, it can be stated that from the end of the "Würm III" a periodic water cover was involved in the case of certain lakes. In the hazel-nut phase of the early Holocene there was an intense movement and reaccumulation of drift-sand. In our view the channel bed of the standing water is a result of the intensive surface change in the hazel-nut phase at the end of the "Würm III" and in the early Holocene. Thus, the individual depressions have been covered by water not only from the oak phase of the early Holocene, but from the end of the "Würm III" period. In the drier hazel- nut phase there was a significant decrease of the water area and a shift of the surface, but on the Hungarian Plain this did not mean the complete cessation of the lacustrian state.

In the case of the lakes in the hazel-nut phase, generally horizontal shifts of the shores took place, with variations of form of the shores in the directions NW-W and S-SE-E. This phenomenon must also be reckoned with in the oak phase, with the difference that there were then significant layer deficiencies as a result of their lacustrian abrasion. It is probable that the extension of the lakes attained its maximum at this time, for in the beech I and beech II phases of the Holocene period the water area further decreased. At the same time, in contrast with this, the water cover of the depressions became constant because of the impermeablle effect of the earlier accumulated carbonate mud.

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CONNECTIONS OF EFFECTS OF EXPOSURE RELATIONS OF SLOPES AND DIFFERENT DENUDATIVE MICROFORMS

DR. ILONA BÁRÁNY

The conception has developed in the Department of Natural Geography in Szeged that in the future one of the fundamental tasks of geomorphology will be to provide a comprehensive regional evaluation of the state of our environment, of its spontaneous developmental tendencies, and of its regional dynamics, striving towards full complexity even in a morphogenetic sense. However, our scientific efforts can hope to achieve the approximate complexity of regional evaluation only when the form-analyzing examinations are extended to the analysis of microregional processes. As established by L. JAKUCS (1971) in a generalization of karstic features, the process of denudation of the surface in a zone can be conceived as the average of the "denudation events" of the microregions comprising the zone. The form types observed in the macroregions and the complex interactions of the natural geographical processes giving rise to these can thus be interpreted simply as the statistical sum of the characteristically manifested microregional effect-connections. For this reason the denudation events fundamentally determining the morphological aspect of a region, or a regional type, can themselves be expressed in an exact manner only on the basis of the examination and synthesis of the microregional processes.

In the present paper an account is given of a part-question of the above general topic: the results of studies aimed at revealing the relations between the slope exposures and the various microregional forms.

The substrata of the microregions, in which the denudation processes take place, are equivalent if the base rock aud the Soil Covering it are of the same quality, thickness and stratification, and if the vegetation on it is the same (as regards its formation and density too). In microregions of the same type and the same climate, the developing microforms too are the same if the exposures of the microspaces to be compared are also the same.

The most important primary factor in the bringing about of the differences in dynamism of the microregional denudation processes is the microclimate. Depending on their structures, water contents, colours and exposures, the various rocks and soils heat up and cool down in different ways. This has a direct effect on the processes of comminution, wearing-away and corrosion, but it also acts on the development and composition of the vegetation by changing the structure, and possibly the texture, of the soil covering the rock.

The temperature and moisture conditions of the soil influence the vital conditions of the microorganisms living in the soil. An important indicator of the qualitative features of soilsis the humus content. Humus is formed from organic matter as a result of the destructive activity of microorganisms. The life functions of the microorganisms involve the liberation of carbon dioxide, which, in the case of carbonate rocks, acts directly on the processes of denudation of the base rock by increasing the dissolving power of the rainwater seeping through. The vital activity of the microfauna and microflora thus has a considerable influence on the corrosion activitiy in soils.

Both earlier and more recent investigations (BECK 1968, FEHÉR 1954) indicate that, in addition to the temperature of the soil, one of the factors having a great effect on the vital activity of the soil bacteria is the moisture content of the soil. The quantity of CO_2 produced by the microorganisms differs from soil to soil depending on the moisture content. The seasonal fluctuation in the number of microorganisms too is a function of the water content and temperature level of the soil. The change of the water content is most often inversely proportional to the temperature change, and directly proportional to the amount of rainfall. The local soil moisture concentrating in the rhizosphere of the individual plant species also frequently acts on the quantitative development of bacterium populations of certain species.

On the above basis, therefore, the soil life, as a function of the microclimate of the soil, exerts a considerable influence on the rate and development of the denudation of the rock surface covered by the soil, and hence on the quality of the resulting microforms.

The differences in the micromorphological types of the microregions are thus functions of the interactions of multiple factors, the study of which requires comprehensive orientation. Of these factors, the effect of the exposure will now be examined, and the important role of this factor in the denudation processes will be pointed out.

In a study of the close disposition of the microclimates at Hosszúbérc in the Bükk Hills, WAGNER (1955) observed that the substratum in the E-exposure within the dolines represents a characteristic morphological structure. However, since the aim of his research was to differentiate microlimates of different orders of magnitude, he investigated the morphological structure only as a factor affecting the microclimate. Nevertheless, he did point out that the rapid heating-up of the slopes of E-exposure has a direct effect on the processes of comminution by insolation. Similar results were found by the present author (BÁRÁNY 1967) in a microclimate study relating to N and S-exposures. It was established that the various slopes within the closed microclimatic region of the doline exhibit extremes of heating-up in accordance with the exposure. In the period of cooling-down, the effect of the exposure diminishes.

Continuing with conclusions on the theory of microclimates, the question had be turned from the viewpoint of natural geography. What is the effect of the microclimate on the development of the various forms of the microregions?

The investigations of L. JAKUCS (1971) on the example of karstic terrains indicate that the different heating and cooling relations, and the differences in soil processes on the slopes of N and S-exposures entail changes in the soils covering the surface and in the vegetation living on them, and hence give rise to large quantitative differences, even within a small locality, in the biogenous carbonic acid and organic acid productions of the soils. Investigation of this topic with regard to the morphogenetics of the forms of non-karstic rocks has not yet been carried out, either by Hungarian or foreign research workers. Accordingly, it is definitely desirable to extend the pioneering investigations initiated by L. JAKUCS to include more distant areas of rock-morphology, taken in the broader sense, utilizing results relating to climatology (WAGNER 1956, 1960, BOROS 1971), soil science (FEHÉR 1954, BECK 1968), biology (BACSÓ—ZÓLYOMI 1934, P. JAKUCS 1956, 1962) and soil-geography (GÓCZÁN 1968).

However, the length of the present paper does not permit a detailed account to be given of every topic now under examination in order to attain the above aim. For a start, therefore, and as an introduction of the methodology, let us analyze as an example the characteristic features of a karst doline in the Bükk Hills, where a study was made of the daily fluctuations in the moisture and in the air-temperature in a 10 cm air-layer above the surface. This 10 cm layer represents the air-layer approximately in contact with the surface in various association types on mountain meadows. Since the short waves of the solar rays change into thermal energy on the surface of the soil, this layer plays an important part in the regulation of the thermal changes in the soil and the higher air-layers. The course of the temperature is different on overcast, cloudy and bright days, and the various exposures result in further differences within this. In general the data for the bright days are suitable for the deducing of regularities in the microclimate, but as regards the surface development the overcast and cloudy days can not be left out of consideration either. In the Bükk Hills, for instance, the sky is 55% overcast on a yearly average. The number of overcast days is 100, and ef bright days 70. In the menth ef August the sky is 40% overcast. The total annual precipitation is 750—800 mm. May and June are very raintymonths. At any event, therefore, it is justified to investigate the climatic features of the exposures on cloudy and evercast dyas too.

On a bright day the maximum and minimum values of the air-temperature are higher on the E and S-exposures on every slope section. The exposure difference is also marked on a cloudy day, between both the E-W and the S-N exposures. However, while 80% cloud-cover does not cause a significant temperature decline in the S-N and W-exposures, the E-exposure reacts rapidly to a fall in temperature. This is due to the extreme heating -up compared to the lother slopes.

The temperature difference of nearly 5°C occurring in a short time (during about 1 hour) with the large daily amplitude accelerates the comminution processes in the fibrous rock (see Fig. 1.)

The slope culmination on the E-exposure occurs at about 10 a. m., while up to this time the radiation arrives on the W and N-exposures at a low angle. On the cloudy days too high temperatures (25—27°C) promote the establishment of the xerothermous vegetation. The favourable situation of the E-exposure is related with the fact that both in the air and in the soil the temperature maxima can be observed earlier, in the morning, while on the other slopes the maxima are attained only in the early afternoon hours. On bright, cloudy and overcast days the maximum is higher on the E and S-exposures. On the other hand, the minimum attains the lowest value on the W-exposure. As a consequence of the early self-shading in the case of the E-exposure, with decreasing temperature the humidity saturation value of the air is reached sooner; this leads to precipitation, and this results in a heat excess here compared with the W-exposure.

In the intensive heating-up and cooling-down stages the W-exposure comes into a more favourable situation. This arises from the fact that a considerable amount of heat is used in the early-morning hours on the E-exposure for the drying-up of the dew, and only at around 8—9 a. m. does the air temperature exceed the temperature values on the other exposures, where the dew is dried up only later, when the sun is higher. All this also plays an important role in the development of the soil temperature.

In the afternoon the E-exposure gradually comes into the shade, and the air temperatures are again higher on the W-exposure. At night the E and S-exposures are in

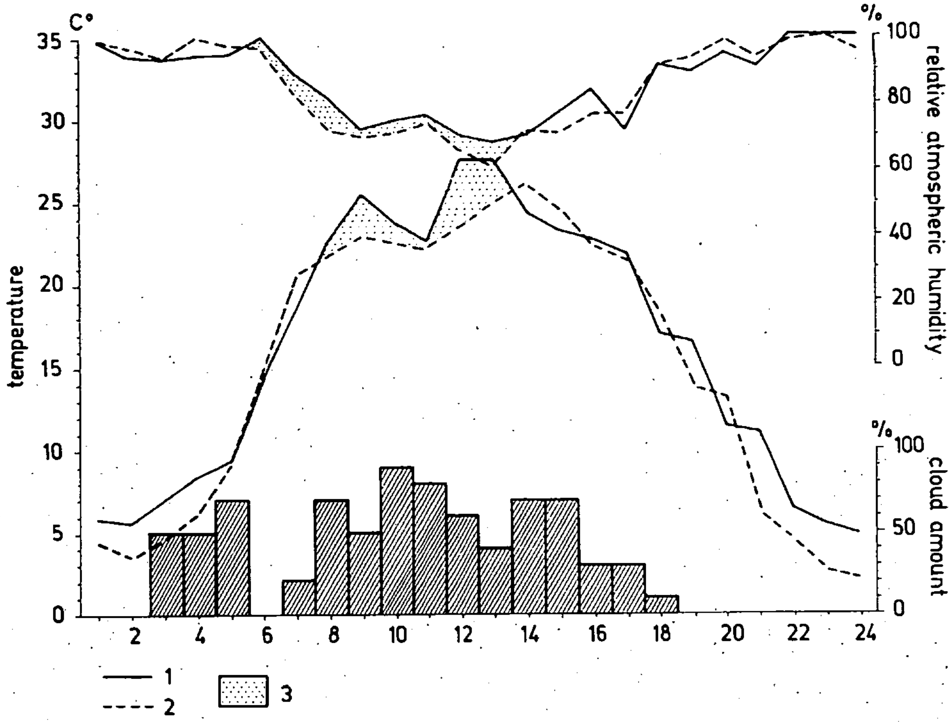

Figure 1. Daily course of the air temperature and humidity 10 cm above the soil in a Bükk doline on a typically cloudy day (2 August 1960). 1 = E-exposure; 2 = W-exposure; 3 = temperature and humidity eycess of E-exposure

more favourable situations in all types of weather, for these two cool slopes down more slowly in the eradiation period because of the strong heating-up in the daytime. In the intensive heating-up and cooling-down stages on the N and S-exposures an almost isothermal air state results, and the features of these stages according to exposure can be recognized only with difficulty.

In the case of the fibrous rock the strong heating in the daytime has a direct effect on the comminution of the rock, but in the main on the evaporation from the soil covering the rock, on the transpiration of the vegetation, and on the multiplication of the soil microorganisms and the acceleration of their vital rhytms.

The connection between the exposure and the air temperature can thus be demonstrated unambiguously. However, only few research workers have dealt with the question of how the humidity of air above the soil varies (P. JAKUCS—MAROSI—SZILÁRD, 1967). On the basis of the humidity of the air, information can be derived on the transpiration ability of the vegetation and indirectly on the change with time of the soil moisture too.

On bright, cloudy and overcast days the relative humidity of the air layers above the soil in the S, N and W-exposures (in the sense of the macroclimate regularity) decreases on the rise of temperature, and vice versa. On the E-exposure, however, clearly as a result of the strong irradiation, from 6 a. m. until 11—12 a. m. the relative humidity values do not vary in accordance with this regularity. The temperature here is higher, and thus the relative humidity values should be lower than on the W-exposure. Examinations for several days, however, show the relative humidity in the morning hours to be higher in the E-exposure than in the W-exposure (see Fig. 2). The strong irradiation following the period of calm at night accelerates the processes of metabolism of the vegetation, and hence the amount of humidlty resulting from the transpiration is higher here. On the E-exposure, therefore, the state of the soil and the vegetation is related with the characteristic course of the humidity.

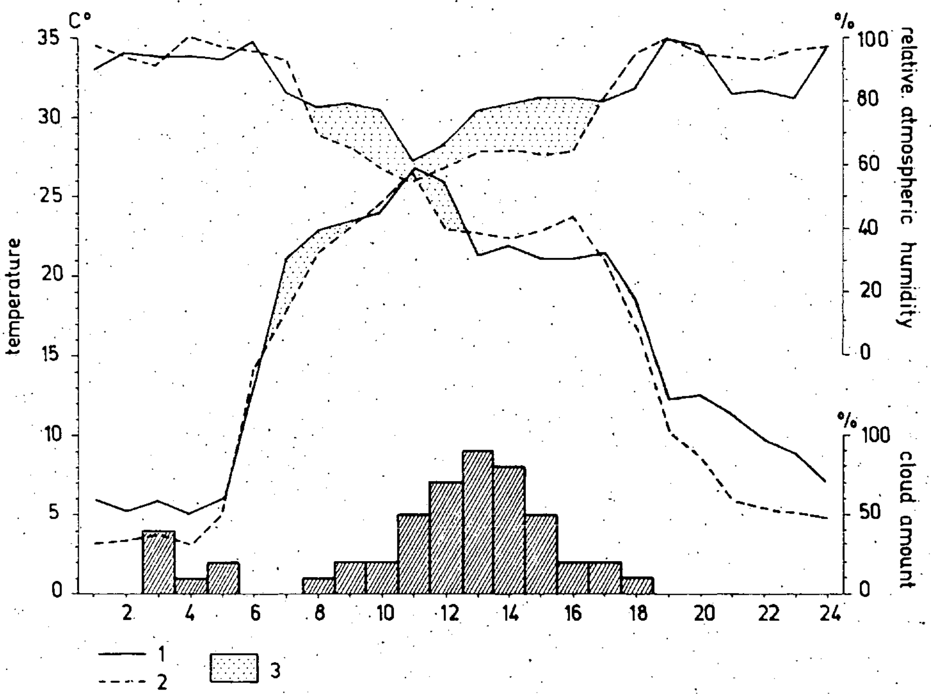

Figure 2. Daily course of the air temperature and humidity 10 cm above the soil in a Bükk doline on an overcast day (1 August 1960).
1 = E-exposure; 2 = W-exposure; 3 = temperature and humidity excess of E-exposure

To summarize, it may be stated that the temperature and humidity conditions of the air-layer just above and in contact with the soil indicate that of the four exposures the E-exposure distinguishes itself by strong heating-up in the morning and by intensive evaporation in the afternoon. This fact results in the creation of local differences in denudation dynamisn, leading to peculiarities of the micromorphological picture, primarily by acceleration of comminution by insolation, variation of the soil moisture, and hence enhancement of the biogenous carbonic acid production.

The microclimatic characteristics depending on the exposures are naturally only part-factors in the extremely complex problem. The above account was intended merely to indicate the tendencies of the investigations now under way. In the future it is hoped to extend these primarily to the temperature changes and moisture conditions of the soil, to the composition of the vegetation, and to the effects of these factors in the regulation of denudation.

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ОТРИЦАТЕЛЬНОЕ ВЛИЯНИЕ АТМОСФЕРНЫХ ЗАГРЯЗНЕНИЙ НА УРОЖАЙНОСТЬ СЕЛЬСКОХОЗЯЙСТВЕННЫХ КУЛЬТУР

Г. Круглова – Вл. Фролов

На рост сельскохозяйственных культур оказывают неблагоприятное влияние твердые выбросы в атмосферу. Отрицательное влияние состоит в том, что сокращается количество солнечной энергии, которую получает поверхность листа, что ведет к замедлению ассимиляции и создания органического вещества. Наблюдается существенное уменьшение урожайности всех сельскохозяйственных культур. Влияние выбросов твердых веществ в атмосферу проявляется на культурные растения и через почву.

В литературе не встречается подробное рассмотрение этой проблемы. В большинстве статей речь идет лишь о примерах влияния твердых эмиссий на урожайность некоторых культур в ряде местностей в непосредственной близости от промышленных предприятий. Но и эти исследования свидетельствуют об отрицательном влиянии промышленных выбросов на сельскохозяйственные культуры.

Область, где проводились исследования, включает 5 райнов: Карвина, Новый Йичин, Орава, Острава и фридек-Мистек, с общей площадью сельскохозяйственных угодий 210 тыс. га, из этого 50 тыс. га подвергается загрязнению промышленными выбросами. Этот район находится преимущественно в Остравском бассейне, где располжены самые крупные источники загрязнения: металургические комбинаты Витковитский, Новая Гуть им. Клемента Готтвальда и другие. На остальной герритории исследуемой области влияние промышленных выбросов на сельскохозяйственное производство носит местный характер. Проведенные исследования позволили выявить отрицательное влияние выбросов в отдельных хозяйствах вблизи цементных заводов, вблизи каменоломен и карьеров.

Загрязнение пор пылью и снижение поглотительной способности проявляется в большей степени у пропашных культур, кукурузы и кормовых, в несколько меньшей у сахарной свеклы, фруктовых и зерновых культур. В непосредственной близости от источников загрязнения потери у некоторых культур достигают 30% и выше. Газообразные выбросы (особенно металлургических комбинатов и Вратимовского целлюлозно-бумажного комбината) оказывают сильное воздействие на плодовые деревья, картофель, овощи, сахарную свеклу и зерновые, потери в урожае достигают 30% и выше.

Чтобы получить возможность сравнить и проверить результаты исследования, проведенного в отдельных хозяйствах, была сделана попытка определить характер и степень зависимости между загрязнением воздуха и сельскохозяйственным производством. В исследуюмую область было включено 25 хозяйств, расположенных в Остравском бассейне и его окресностях, где наблюдалось выпадение твердых осадков в размере от 75 до 1200 т на км^2. Для выяснения потерь исследовались статистические данные об урожайности отдельных видов зерновых за 1971. г. и осаждение пыли в т/км² за тот же год по измерениям областной санитарно-эпидемиологической станции (оценка за целый год, а не за вегетационный период).

Для выяснения степени и характера зависимости между загрязнением воздуха и сельским хозяйством была прежде всего установлена зависимость урожайности (в ц/га) зерновых в целом, а также отдельных видов зерновых от количества выбрасываемой в атмосферу пыли в том же пункте (в т/км²). Эта зависимость была установлена с помощью коэфициента парной корреляции Пирсона.

$$k = \frac{n \cdot \sum_{i=1}^{n} x_i y_i - \sum_{i=1}^{n} x_i \sum_{i=1}^{n} y_i}{\sqrt{\left[n \cdot \sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x\right)^2\right]\left[n \cdot \sum_{i=1}^{n} y_i^2 - \left(\sum_{i=1}^{n} y\right)^2\right]}}$$

где x_i —количество выпадаемой пыли на данном участке

y_i —урожайность зерновых в целом или отдельной культуры на том же участке i

n —число участков $i = 1, 2, \ldots n$,

Для зерновых, пшеницы, ячменя и овса подсчет произ одился по 25 хозяйствам, для ржи только по 17 (разное количество объясняется отсутствием статистических данных).

Были получены следующие коэфивенты корреляции

1. Загрязнение воздуха—урожайность зерновых	$k_1 = -0{,}333$
2. Загрязнение воздуха—урожайность пшеницы	$k_2 = -0{,}240$
3. Загрязнение воздуха—урожайность ячменя	$k_3 = -0{,}328$
4. Загрязнения воздуха—урожайность овса	$k_4 = -0{,}513$
5. Загрязнения воздуха—урожайность ржи	$k_5 = -0{,}497$

Исходя из полученных данных можно сделать следующие выводы:

1. Зависимость между загрязнением воздуха и урожайностью зерновых отрицательная, на что указывает знак „минус" у всех коэфициентов.
2. Зависимость между загрязнением воздуха и урожайностью отдельных видов зерновых различна. Меньше она у ячменя и пшеницы и в 2 раза больше у овса и ржи. (Для ржи эта зависимость может быть несколько завышена из-за меньшего, чем для других культур, объема наблюдений.)
3. Несмотря на то, что пункты наблюдения имеют различный микроклимат, почвы, режим увлажнения, в разной степени используются удобрения, все же четко прослеживается снижение урожайности при увеличении концентрации пыли, *а* для овса и ржи загрязнение воздуха является уже одним из отрицательных факторов роста.

Для установления зависимости между урожайностью зерновых и степенью загрязнения тамосферы был использован метод наименьших квадратов

$$y = a_0 + a_1 x$$

где y—урожайность зерновых в ц/га

x—колич *е* ство выбрасываемой в тамосферу пыли в т/км²

a_0 и a_1 постоянные коэфициенты

причем a_0 показывает, какой могла бы быть средняя урожайность, если бы загрязнение атмосферы не оказывало на нее влияние

a_1 характеризует непосредственное влияние загрязнения воздуха на урожайность и показывает на сколько уменьшается урожайность при увеличении концентрации пыли в атмосфере. Уравнение $= \frac{a_1}{a_0} 100\%$ дает представление о том, на сколько процентов уменъшается урожайность зерновых при увеличении концентрации пыли на

1 т/км² и фактически характеризует степень влияния загрязнения атмосферы на урожайность.

Расчеты дали следующие коэфициенты уравнений

1. Зависимость урожайности зерновых от концентрации пыли в атмосфере

$$y_1 = -0{,}00373x_1 + 29{,}4$$

2. Зависимость урожайности ячменя от концентрации пыли

$$y_2 = -0{,}00315x_2 + 29{,}8$$

3. Зависимость урожайности пшеницы от концентрации пыли

$$y_3 = -0{,}00461x_3 + 31{,}45$$

4. Зависимость урожайности овса от концентрации пыли

$$y_4 = -0{,}00456x_4 + 26{,}2$$

5. Зевисимость урожайности ржи от концентрации пыли в атмосфере

$$y_5 = -0{,}00308x_5 + 22{,}8$$

Сравним, сколько же процентов от расчитанной теоретической средней урожайности составляет действительная урожайность

	зерновые	ячмень	пшеница	овес	рожь
теоретическая урожайность	29,4	29,8	31,5	26,2	22,8
действительная урожайность	27,4	28,0	29,0	24,0	21,0
%	93,2	94,6	92,2	91,6	92,1

Следующая таблица показывает, на сколько процентов уменъшается урожайность при загрязнении атмосферы на 1 т/км².

культуры	зерновые	ячмень	пшеница	овес	рожь
культуры	12,7%	10,6%	14,7%	17,4%	13,5%

Интересно, что зависимость между показателями первой и второй таблицы почти полная (меняются местами пшеница и рожь).

И наконец, сравним степень зависимости между загрязнением воздуха и урожайностью (коэфициент корреляции) и степенью влияния загрязнения на урожайность (% снижения урожайности).

	зерновые	ячмень	пшеница	овес	рожь
коэфициент корреляции	−0,333	−0,328	−0,240	−0,513	−0,497
% снижения урожайности	12,7%	10,6%	14,7%	17,4%	13,5%

Можно констатировать, что загрязнение атмосферы больше всего влияет на урожайность овса, его урожайность в свою очередь теснее всего связана с концентрацией пыли в атмосфере. Менее всего загрязнение воздуха влияет на урожайность ячменя, у которого в то же время один из наименьших коэфициентов связи. Остальные кульуры находятся между этими крайними точками.

В заключении была сделана попытка вычислить приблительные потери урожая в 25 хозяйствах исследуемой области в 1971. году. Общие потери составили у пшеницы 13,8%, у ячменя 8,6%, у овса 16,6%, у ржи 9,4%, что составляет около 1 млн. крон.

Полученные результаты имеют, главным образом, методическое значение. На них в значетельной мере повлияло отсутсвие точных данных о концентрации пыли в атмосфере в отдельных хозяйствах. Однако потери за счет снижения урожайности зерновых под влиянием загрязнения атмосферы бесспорно значительны. Одной из мер, направленных на уменьшение потерь, является внедрение на исследуемой территории севооборотов, где бы было ограничено высевание культур, особенно чувствительных на воздействие твердых выбросов, прежде всего пропашных, кормовых, а из зерновых, лгавным образом, овса.

ASSESSMENT OF THE LEVEL OF DEVELOPMENT

F. Móricz, Gy. Krajkó, Mrs. Abonyi

Part. I.

Economic development is a central problem of our age. Problems or sets of problems connected with the level of economic development of the territorial differences of the rate of development often arise. Representatives of many branches of science, economists, statisticians and geographers try to solve them. Analyzing of the problems connected with economic development is especially popular among theoreticians. The national and the international literature of the subject is very rich. The theoretical and methodological problems of the research of the subject is the theme of scientific programs and international conferences.

Economic development is such a complex process that one researcher or research group or even one discipline cannot undertake an all-round analysis of it. Our study is also confined to only a relatively narrow field of it, the assessment of the level of development of individual economic regions.

The foreign literature of the subject is very extensive. Among its cultivators are BRADISTILOV, JAN KAZIMOUR, M. K. BANNETT, and H. H. HARMAN.

As a consequence of the dynamic economic development following our liberation the subject has attracted increased interest of the researchers. It has become a social requirement, — especially since the second half of the 1960' s — to relieve or research the structural imbalance in certain areas. (Especially outstanding in this field is the work of M. BARABÁS, GY. BARTA, I. BARTKE, GY. BORA, K. NAGY Mrs. DUX, T. GERŐ, M. VISSI Mrs. HALMI, I. HUSZÁR, L. LACKÓ, L. KLONKAI, J. KÓRÓDI, L. KŐSZEGI, Mrs. L' KŐSZEGI, V. KULCSÁR, G. MÁRTON. J. RIMLER, GY. SZILÁGYI, GY. WIRTH, and Mrs. ZALAI.

The different authors worked out, modified, or applied methods to certain areal units. According to these areal units, however, countries, administrative units (counties, districts, towns, villages) and regions representing different levels (macro-, meso-, sub- and microregions) require differentiated methods. Each method gives reliable results only when applied to an areal unit of a certain level. E. g. an accepted indicator in comparisons between countries is the national income calculated for a single inhabitant. Although the result obtained in this way must be received with caution (because it may be distorted by calculation into the currency of different countries, by different interpretations of the concepts, etc.), on account of its simplicity it is doubtless the best indicator among those used. There are attempts at a comparison of the levels of economic development of the different countries based on a system consisting of natural indicators (e. g. the method of Jánossy employing 16+8 indicators); however, these are complicated and are gaining popularity only with difficulty.

Determination of the state of development of the parts of a country is an even more difficult task than the comparison between countries.

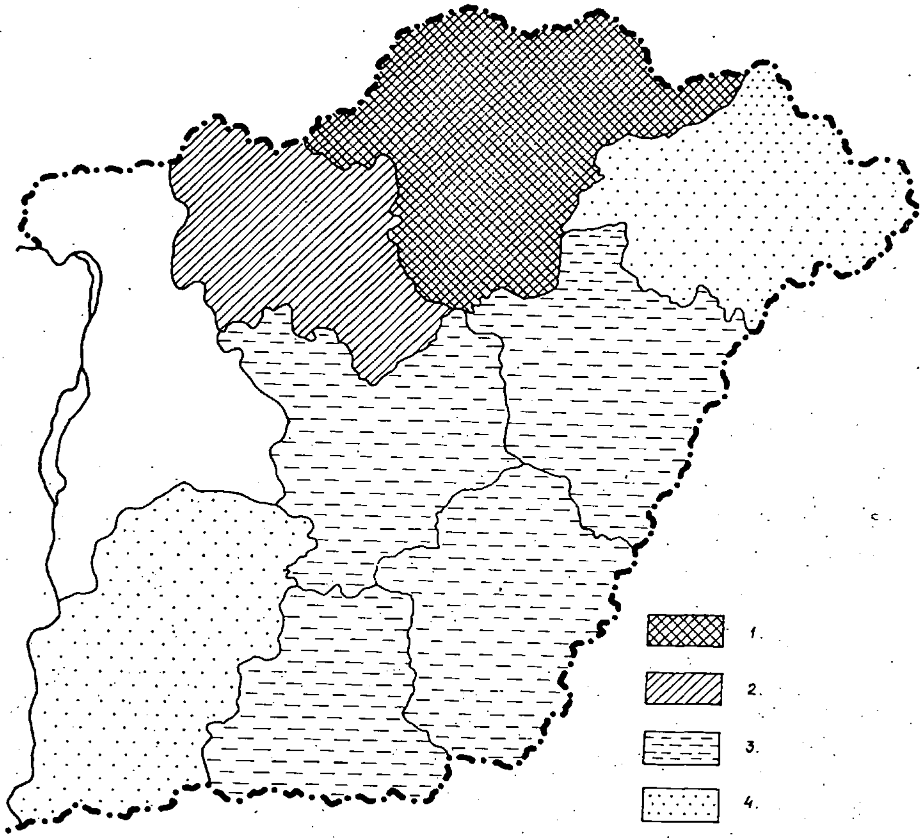


Figure 1. Industrial development of subregions of East Hungary
1. developed
2. medium developed
3. underdeveloped
4. very poorly developed

The problem of areal units

In our work we tried to elaborate a method that would reflect the state of development of the economy and would not only classify the areal units but also express their quality quantitatively. (By subregions we understand the third level from above of the hypothetical classification of regions worked out by the Department of Economic Geography of JATE and published in the Geographical Communications in 1969.)

We consider the areas chosen by us for basic units as suitable to give distortion-free indicators and true pictures. Areas of such size (on the average 5000 km^2 in East Hungary) may be regarded as "homogeneous" in respect of social production; in respect of the spatial distribution of the forces of production they form areal production complexes.

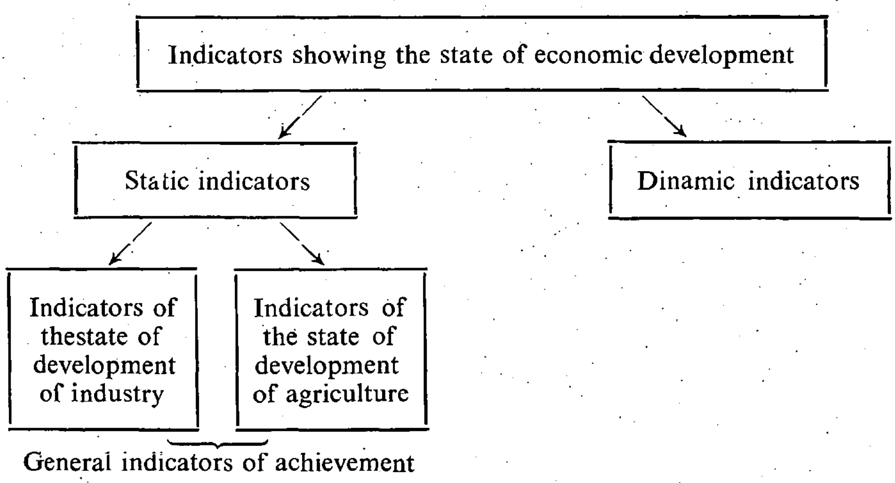
The requirements of the indicators

In the course of the analysis of the different areas there arises the need for a complex indicator that in itself, as if by summary, would express the level of development of a given areal unit. In our work we used the method employed also by many other researchers which was that with suitable grouping a system of indicators was constructed from the various natural indicators reflecting the different degrees of economic development. We think that the synthetic index thus formed approximates reality sufficiently.

A very important and difficult task is the proper selection of the economic indicators. The indicators must be connected with the economic development as closely as possible. At different stages of development different indicators express the level of development; therefore the system of indicators must also change in time and space. At the present stage of development of our economy the most highly industrialized areas are also the most highly developed ones. However, because any production complex of the branches of economy can, in principle, develop an economically advanced area, we think that the areal units established by us must be examined both from the point of view of industry and from the point of view of agriculture. We endeavored to form groups of indicators composed of approximately identical numbers of indicators. The indicators showing the state of development of industry and agriculture are without exception of static character. Therefore we have formed another, dynamic group of indicators from which the territorial differences of the rate of development appears. With the help of this the trends of development and the dynamism of our areas can be clearly seen and on the basis of these the perspectives of our areas can be clearly seen and on the basis of these the perspectives of our areas can be outlined.

Finally — as if by control — we introduced a group of indicators named general indicators of achievement. In this group we have collected indicators which with more or less distortion express the state of development of a given area.

Survey of the system of indicators



I

Indicators of the state of development of industry

1. The corrected national income per inhabitant (Ft per head).
2. Fixed assets of industry: The gross value of fixed assets per inhabitant (Ft per head).
3. The value of current assets per unit of current assets in industry (Ft/Ft).
4. The propelling power supply of industry: The capacity of power machines and electric motors per head in industry (kW per head).
5. Electric energy consumption per worker (kW per head).
6. Mechanization of industrial production:
   The number of places of work beside machines in industry (places per piece).
7. The ratio of those employed in industry. The number of industrial wage earners per 1000 people employed (wage earners per head).
8. The concentration of industry: The number of workers working at industrial establishments employing more than 500 persons per 10 000 inhabitants (persons employed per head).

II

Indicators of the state of development of agriculture

1. The corrected national income from agriculture per inhabitant.
2. The fixed assets of agriculture:
   The value of fixed assets per inhabitant in the agricultural large-scale cooperatives.
3. Total traction power per 100 ha of agricultural area in traction units (tractors per ha).
4. The utilization of artificial fertilizers per ha of plowland (kg per ha).
5. The importance of livestock farming:
   Number of animals per inhabitant (number per inhabitant).
6. The importance of livestock farming; Milk production per inhabitant (l per head)
7. The ratio of intensive plant cultivation:
   The garden, orchard, vinyard, and vegetable-growing plowland area per active agricultural wage earner (ha per head).
8. The ratio of irrigated area in % of the total agricultural area.
9. Buying up per inhabitant in agriculture (Ft per head).

III

General indicators of achievement

1. The national income per active wage earner (Ft per head).
2. Consumption of the national income per inhabitant (Ft per head).
3. The total value of fixed assets and current assets per inhabitant (Ft per head).
4. The number of those employed per 1000 persons in the population constituting the manpower resource (persons employed per head).
5. The number of city dwellers per 1000 inhabitants.

IV

The indicators of dynamic development

1. The total investments per inhabitant in the last five years (Ft per head).
2. The ratio of machine stocks younger than five years to the total machine stocks (%).
3. Intensive plant cultivation and the size of irrigated areas as compared to the level five years earlier (%).
4. The number of new diploma holders per 1000 inhabitants (in 5 years) (heads per head).
5. The number of flats built per 1000 inhabitants in the last 5 years (flats per head).

The method of investigation

The mathematical method of investigation is the factor analysis. The factor analysis is a branch of statistical analyses with several variables which is a very widely applicable mathematical statistical method. The aim of the factor analysis is to produce simple hypothetical variables, factors strating from the set of variables observed which reproduce the data observed fairly accurately and explain them in a sense. Whille the statistical methods with several variables generally examine essentially given hypotheses, the aim of the factor analysis is just the search for a hypothesis or she making of it. The factor analysis tries to set up a model which is as simple as possible, with well interpretable values and real correspondences.

The factor analysis model

Let a number m of random variables $Y_1, Y_2, \ldots, Y_m$ be given. It is suitable to work with standardized variables. That is instead of the original variables Y_i we work with the standardized variables

$$Z_i = \frac{Y_i - M(Y_i)}{D(Y_i)} \qquad (i = 1, 2, \ldots, m),$$

where $M(Y_i)$ is the expectation of Y_i, and $D(Y_i)$ is its standard deviation. Therefore

$$M(Z_i) = 0, \quad D(Z_i) = 1 \qquad (i = 1, 2, \ldots, m).$$

The factor analysis starts from the hypothesis that the Z_i variables are the functions of further hypothetical variables; they can be ritten as the linear function of the so-called factors;

$$Z_1 = a_{11}K_1 + a_{12}K_2 + \ldots + a_{1r}K_r + b_1U_1$$
$$Z_2 = a_{21}K_1 + a_{22}K_2 + \ldots + a_{2r}K_r + b_2U_2$$
$$Z_m = a_{m1}K_1 + a_{m2}K_2 + \ldots + a_{mr}K_r + b_mU_m,$$

where $K_1, K_2, \ldots, K_r, U_2, \ldots, U_m$ are the so-called *factors*, and $a_{11}, a_{12}, \ldots, a_{mr}; b_1, b_2, \ldots$ $\ldots b_m$ are the *factor loadings*.

If the loading of a factor differs essentially from O in the case of at least two variables, it is called *common factor*. It this condition is satisfied for all variables, then we have a *general factor*. If the factor loading differs from O only for one variable, it is called *unique factor*. In our notation $K_1, K_2, \ldots, K_r$ are common factors, $U_1, U_2, \ldots, U_m$ are unique factors, and r is the number of common factors.

The factors analysis model in matrix form can be expressed as follows:

$$Z = A \cdot f$$

where

$$z = (z_1, z_2, \ldots, z_m)^*$$

is the column vector of the standardized variables,

$$A = \begin{pmatrix} a_{11} & a_{12} & a_{1r} & b_1 & 0 \ldots 0 \\ a_{21} & a_{22} & a_{2r} & 0 & b_2 \ldots 0 \\ a_{m1} & a_{m2} & a_{mr} & 0 & 0 \ldots b_m \end{pmatrix}$$

the matrix of the factor loadingd, and

$$f = (K_1, K_2, \ldots, K_r, u_1, u_2, \ldots, u_m)^*$$

the column vector of the factors.

The factor analysis model showing the common and the unique factors can be written in this form:

$$z = A_k f_k + A_u f_u,$$

where

$$A_k = \begin{pmatrix} a_{11} & a_{12} \ldots a_{1r} \\ a_{21} & a_{22} \ldots a_{2r} \\ \vdots & \\ a_{m1} & a_{m2} \ldots a_{mr} \end{pmatrix}$$

is the matrix of the factor loadings of the common factors,

$$A_u = \begin{pmatrix} b_1 & 0 \ldots 0 \\ 0 & b_2 \ldots 0 \\ 0 & 0 \ldots b_m \end{pmatrix}$$

is the diagonal matrix of the factor loadings of the unique factors,

$$f_k = (K_1, K_2, \ldots, K_r)^*$$

is the column vector of the common factors.

Summarizing:

$$A = [A_k, A_u] \quad \text{and} \quad f = [f_k, f_u].^*$$

The matrix A is also called *factor pattern*.

In the following we always suppose that the factors are standardized random variables:

$$M(K_i) = 0, \quad D(K_i) = 1 \quad (i = 1, 2, \ldots, r),$$

$$M(U_j) = 0, \quad D(U_j) = 1 \quad (j = 1, 2, \ldots, m),$$

furthermore, that the unique factors are always uncorrelated with each other and with the common factors:

$$R(U_j,\ U_l) = 0 \quad \text{if} \quad j \neq l\,(j, l=1, 2, \ldots, m),$$

$$R(K_i,\ U_j) = 0 \quad (i=1, 2, \ldots, r;\ j=1, 2, \ldots, m),$$

where $R(K,\ U)$ denote the correlation coefficient of the variables K and U.

From these assumtions it follows that the $(r+m)\times(r+m)$ correlation matrix of the factors is the following:

$$C = \begin{pmatrix} c_{11} & c_{12} & c_{1r} & 0 & 0 & 0 \\ c_{21} & c_{22} & c_{2r} & 0 & 0 & 0 \\ c_{r1} & c_{r2} & c_{rr} & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ \vdots & & & & & \\ 0 & 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

where $c_{ij} = R(K_i, K_j) \qquad (i,\ j=1, 2, \ldots, r)$.

A simple calculation shows that

$$1 = D^2(Z_i) = M(Z_i^2) = M\left[\left(\sum_{p=1}^{r} a_{ip}K_p + b_iU_i\right)^2\right] = \sum_{p=1}^{r}\sum_{q=1}^{r} a_{ip}a_{iq}M(K_pK_q) + b_i^2 =$$

$$= \sum_{p=1}^{r}\sum_{q=1}^{r} a_{ip}c_{pq}a_{iq} + b_i^2,$$

where $c_{pq} = R(K_p,\ K_q) = M(K_p \cdot K_q)$. Thus we get

$$1 = a_i^* C a_i$$

where

$$a_i^* = (a_{i1}, a_{i2}, \ldots, a_{ir}, 0, 0, \ldots, \underbrace{b_i}_{r+1}, \ldots 0)$$

is the i' th row vector of the matrix A, while a_i is the same written in the form of a column vector $(i=1, 2, \ldots, m)$.

Separating lhe common and the unipue factors, the above formula may also be written:

$$1 = a_{k,i}^* C_k a_{k,i} + b_i^2,$$

where

$$C_k = \begin{pmatrix} c_{11} & c_{12} \ldots c_{1r} \\ c_{21} & c_{22} \ldots c_{2r} \\ c_{r1} & c_{r2} \ldots c_{rr} \end{pmatrix}$$

is the correlation matrix of the common factors,

$$a_{k,i}^* = (a_{i1}, a_{i2}, \ldots, a_{ir})$$

the i'th row vector of the matrix A_k, while $a_{k,i}$ is the same in the form of column vector $(i=1, 2, \ldots, m)$. Written in a short form:

$$C = \begin{bmatrix} C_k & O \\ O & E_m \end{bmatrix};$$

where E_m is the mxm indentity matrix and O is the zero matrix.

If the pairs of common factors are uncorrelated among themselves, then

$$C_k = E_r \quad \text{and} \quad C = E_{r+m}.$$

Then the above formula obtained for the variance $D^2(Z_i)$ of the variable Z_i becomes essentially simpler:

$$1 = a_i^* a_i = a_{k,i}^* a_{k,i} + b_i^2 = a_{i1}^2 + a_{i2}^2 + \ldots + a_{ir}^2 + b_i^2 = h_i^2 + b_i^2 \quad (i = 1, 2, \ldots, m),$$

where the *communality*

$$h_i^2 = a_{i1}^2 + a_{i2}^2 + \ldots + a_{ir}^2$$

can be interpreted as that part of the variance of the variable Z_i which can be explained by the common factors together, while b_i^2 is that part of the variance of the variable Z_i which can be explained by the unique factor and which is generally termed the *uniqueness* of the given variable $(i = 1,2, \ldots, m)$.

On the basis of the equality

$$h_i^2 + b_i^2 = 1 \qquad (i = 1, 2, \ldots, m),$$

it is enough to determine the common factor loadings in the course of the solution.

In some cases the *factors structure*

$$S = \begin{pmatrix} s_{11} & s_{12} & s_{1r} & b_1 & 0 \ldots 0 \\ s_{21} & s_{22} & s_{2r} & 0 & b_2 \ldots 0 \\ \vdots & & & & \\ s_{m1} & s_{m2} & s_{mr} & 0 & 0 \ldots b_m \end{pmatrix}$$

which contains the correlation coefficients of each Z_i variables with the common K_j and unique U_k factors $(i=1,2,\ldots,m;\ j=1,2,\ldots,r,\ k=1,2,\ldots,m)$ plays an important role.

Otherwise

$$S = [S_k,\ S_u],$$

where

$$S_k = \begin{pmatrix} s_{11} & s_{12} \ldots s_{1r} \\ s_{21} & s_{22} \ldots s_{2r} \\ \vdots & \\ s_{m1} & s_{m2} \ldots s_{mr} \end{pmatrix}, \qquad S_u = A_u.$$

Here s_{ij} is the correlation coefficient among the variable Z_i and the common factor K_j. $(i=1,2,\ldots,m \quad j=1,2,\ldots,r)$ These correlation coefficients can be determined on the basis of the model in the following way:

$$s_{ij} = R(Z_i, K_j) = M(Z_i K_j) = M\left[\left(\sum_{p=1}^{r} a_{ip} K_p + b_i U_i\right) K_j\right] =$$

$$= \sum_{p=1}^{r} a_{ip} M(K_p \cdot K_j) = \sum_{p=1}^{r} a_{ip} c_{pj} \qquad (i = 1, 2, \ldots, m;\ j = 1, 2, \ldots, r).$$

Thus the following connection exists between the factor structure and the factor pattern:

$$S = A \cdot C,$$

or what is equivalent to this,

$$S_k = A_k \cdot C_k \quad \text{and} \quad S_u = A_u.$$

Hence it can easily be seen that in the case of uncorrelated pairs of common factors

$$S = A,$$

because in this case $C = E_{r+m}$. Therefore, in the case when the solution consists of pairs of uncorrelated common factors, it is sufficient to determine only the factor pattern A. However, when correlated common factors are also allowed in the model, then the solution must contain both the factor pattern and the factor structure.

On the basis of the model of factor analysis there is an opportunity not only for the composition of the variance of the different variables, but it is also possible to determine the correlation coefficients among the variables. Thus the fidelity of the model of factor analysis can also be determined.

Let

$$R = \begin{pmatrix} r_{11} & r_{12} \dots r_m \\ r_{21} & r_{22} \dots r_{2m} \\ \vdots & \\ r_{m1} & r_{m2} \dots r_{mm} \end{pmatrix}$$

be the correlation matrix of the variables $Z_1, Z_2, \dots, Zm$, where $r_{ik} = R(Z_i, Z_j)$ $(i, j = 1, 2, \dots, m)$. A simple calculation shows that

$$\begin{aligned} r_{ij} &= R(Z_i, Z_j) = M(Z_i \cdot Z_j) = \\ &= M\left[\left(\sum_{p=1}^{r} a_{ip} K_p + b_i U_i\right)\left(\sum_{q=1}^{r} a_{jq} K_q + b_j U_j\right)\right] = \\ &= \sum_{p=1}^{r} \sum_{q=1}^{r} a_{ip} a_{jq} M(K_p \cdot K_q) + b_i b_j M(U_i \cdot U_j) = \\ &= \sum_{p=1}^{r} \sum_{q=1}^{r} a_{ip} c_{pq} a_{jq} + \delta_{ij} b_i^2, \end{aligned}$$

where $\delta_{ij} = 1$ if $i = j$, and $\delta_{ij} = 0$ if $i \neq j$ $(i, j = 1, 2, \dots, m)$.

Writing this in matrix form we get

$$R = A_k C_k A_k^* + A_u A_u^* = ACA^*,$$

where A^* is the transpose of the matrix A.

If the pairs of common factors are uncorrelated among themselves then $C = E_{r+m}$. Therefore in this case

$$R = AA^* = A_k A_k^* + A_u A_u^* = A_k A_k^* + A_u^2.$$

We call the matrix $R_h = R - A_u^2$ *reduced correlation matrix*. The reduced correlation matrix R_h differs from R in that just the h_i^2 communalities stand in its diagonal.

Of course, when the factors are uncorrelated, the above formula simplifies to the following expression for the reduced correlation matrix:

$$R_h = A_k A_k^*.$$

This equation has been called "the fundamental factor theorem" by Thurstone.

Finally we mention H. H. Harman' s excellent book, Modern Factor Analysis, The University of Chicago Press, 1960, which deals in exhaustive detail with the method of factor analysis. Besides this, the description of the method of factor analysis, together with economic applications can be found in Judit Rimler' s paper "Investigation of economic development and the factors' analysis, Közgazdasági Szemle, 1970, pp. 913—926 and László Vita's paper "The possibilities of the economic application of factor analysis, Szigma, 1970, pp. 127—152.

V.

Determination of the state of industrial development of subregions by the method of factor analysis

In our days the economic political endeavor to reduce the differences in state of economic development of different areal units (economic regions of different levels) and in the standard of living of their popolation is becoming ever stronger. The literature of the subject has now made it reasonably clear that the state of economic development of an area is determined by the whole of its production sphere. However, we have already mentioned in the above that in the present state of the development of our economy industry plays the decisive role among the branches of production. Therefore our investigation covered first of all industry.

In the introductory part (in the chapter on principles and methods) we could ronsider only the following five of the above-described eight indicators chosen for assessing the level of development of industry:

1. The gross value of fixed assets in industry per inhabitant.
2. The power machine and electric motor capacity in industry per inhabitant.
3. The consumption of electric energy per worker.
4. The number of industrial wage arners per 1000 persons employed.
5. The number of workers in industrial establishments employing more than 500 perssons per 10 000 inhabitants.

The following eight subregions were considered in the investigation: the areas of Bács, Békés, Borsod, Csongrád, Hajdú, Heves, Szabolcs and Szolnok counties.

Table 1 shows the values of the different indicators concerning the different subregions:

Table 1

subregions / indicators	Bács	Békés	Borsod	Csongrád
Indicator 1	10.230	15.840	54.560	21.730
Indicator 2	0.160	0.220	1.550	0.340
Indicator 3	2.690	3.640	20.520	3.970
Indicator 4	0.250	0.390	0.520	0.330
Indicator 5	27.010	27.370	102.680	53.770

subregions / indicators	Hajdú	Heves	Szabolcs	Szolnok
Indicator 1	15.080	44.630	8.130	17.690
Indicator 2	0.180	0.930	0.090	0.320
Indicator 3	4.160	7.470	2.680	4.530
Indicator 4	0.370	0.320	0.240	0.290
Indicator 5	32.670	61.470	21.920	37.000

If we consider the different indicators as random variables, then each row of Table 1 is an eight-element sample for the variable concerned. After standardization Table 2 contains the matrix of the standardized values.

Table 2

subregions / indicators	Bács	Békés	Borsod	Csongrád
Indicator 1	−0.786	−0.453	1.842	−0.104
Indicator 2	−0.617	−0.499	2.119	−0.263
Indicator 3	−0.588	−0.429	2.395	−0.374
Indicator 4	−0.984	+0.568	2.010	−0.097
Indicator 5	−0.687	−0.674	2.128	+0.308

subregions / indicators	Hajdú	Heves	Szabolcs	Szolnok
Indicator 1	−0.498	1.254	−0.910	−0.343
Indicator 2	−0.578	0.898	−0.755	−0.302
Indicator 3	−0.342	0.211	−0.590	−0.280
Indicator 4	+0.346	−0.207	−1.095	−0.540
Indicator 5	−0.476	0.594	−0.876	−0.315

The majority of indicators (variables) considered are characterized by strong interdependence. In the correlation matrix the value of the smallest correlation coefficient is +0,711, which means that stronger than average positive correlation exists among any two indicators examined by us. The correlation matrix of the indicators is as follows:

Indicator 1	1.000				
Indicator 2	0.979	1.000			
Indicator 3	0.883	0.953	1.000		
Indicator 4	0.711	0.745	0.832	1.000	
Indicator 5	0.946	0.965	0.938	0.769	1.000

On the basis of the correlation matrix the following values were found for the communalities:

indicators	communalities
Indicator 1	0.9966
Indicator 2	0.9985
Indicator 3	0.9951
Indicator 4	0.9158
Indicator 5	0.9489

The communality belonging to the different indicators can be interpreted as that part of the variance of the variable concerned which can be explained by the common factors together.

Replacing the units in the diagonal of the correlation matrix with communalities we obtain the so-called reduced correlation matrix:

Indicator 1	0.996				
Indicator 2	0.979	0.998			
Indicator 3	0.883	0.953	0.995		
Indi ator 4	0.711	0.745	0.832	0.915	
Indicator 5	0.946	0.965	0.938	0.769	0.948

Starting from the reduced correlation matrix we determined the factor pattern using the method of factor analysis. We found four common factors the matrix of whose factor loadings are shown in Table 3.

Table 3

factors / indicators	K_1	K_2	K_3	K_4
Indicator 1	0.985	0.230	0.155	0.009
Indicator 2	0.983	0.162	−0.031	0.037
Indicator 3	0.937	−0.084	−0.198	0.007
Indicator 4	0.388	—0.455	0.102	0.005
Indicator 5	0.966	0.083	−0.010	−0.059

The factor loading at the crossing of the K_1 column and the first row shows for example the degree of the correlation among the first factor and indicator 1. The value of the correlation coefficient in question is 0.958 which is indicative of a strong positive correlation. In case the sign of the factor loading is negative, the correlation among the factor and the variable is negative.

Table 4 shows the part of the variance of the five standardized variables considered and explained by the different factors.

Table 4.

Serial numbers of factors	The variance explained by the factor in percentage of the combined variance of all variables	
	The value of the factors	Cumulated sums
1	89.6	89.6
2	6.0	95.6
3	1.5	97.1
4	1.0	98.1

As the first factor explains 89.6% of the combined variance of all the variables the first factor K_1 can rightly be regarded as a synthetic indicator of the state of development of industry which comprises a considerable part of the information represented by the five indicators considered in the investigation. In the present study we did not deal with the analysis of the remaining three factors.

Table 5 shows in what measure the first factor, K_1, contributes to the variance of the variables (indicators).

Table 5

Indicator	Communality	Uniqueness
	%	
Indicator 1	91.8	8.2
Indicator 2	96.8	3.2
Indicator 3	94.7	5.3
Indicator 4	69.4	30.5
Indicator 5	93.5	6.5

According to Table 5, with the exception of the fourth indicator, at least 91.8% of the variance of the other indicators is explained already by the first factor, which justifies again our dealing only with the first factor.

After this we determined the value of the first factor for each area unit considered and on the basis of this classified our subregions according to their state of industrial development. The results are summarized in Table 6.

Table 6

Subregion	Value of K_1	$K_1+1{,}826$
Bács	−0.826	1.000
Szabolcs	−0.783	1.043
Békés	−0.416	1.410
Szolnok	−0.336	1.490
Hajdú	−0.260	1.566
Csongrád	−0.240	1.586
Heves	+0.663	2.489
Borsod	+2.200	4.026

It should be noted that we shifted the values the K_1 factor by 1.826 to bring the level of the industrially least developed subregion of Bács to +1.000 and to make thereby comparison easier.

Finally, on the basis of the factors analysis we counted back the correlation coefficients among the different variables and obtained the so-called reproduced reduced correlation matrix:

Indicator 1	0.995				
Indicator 2	0.975	0.996			
Indicator 3	0.882	0.950	0.993		
Indicator 4	0.709	0.742	0.829	0.913	
Indicator 5	0.943	0.962	0.935	0.766	0.945

On this basis the fidelity of the factor analysis can also be assessed, because the difference between the reduced correlation matrix and the reproduced reduced correlation matrix obtained on the basis of the model is practically the zero matrix:

Indicator 1	0.000				
Indicator 2	0.003	0.001			
Indicator 3	0.000	0.003	0.001		
Indicator 4	0.002	0.002	0.002	0.002	
Indicator 5	0.002	0.002	0.003	0.002	0.003

The above table shows that the factors explain well the correlation of the different variables (indicators) among themselves. At the same time this proves the correctness of the basis hypothesis of the factor analysis model and its applicability in our study of the state of development of industry.

Finally we attempted to classify our subregions according to categories of levels of development. Establishing four grades we obtained the following results:

Borsod-Abaúj-Zemplén county	developed
Heves county	medium developed
Csongrád county Hajdú-Bihar county Szolnok county Békés county	underdeveloped
Szabolcs-Szatmár county Bács-Kiskun county	very poorly developed

THE CHIEF CHARACTERISTIC OF THE TRANSPORT CONDITIONS OF THE SOUTHERN PART OF THE GREAT HUNGARIAN PLAIN

DR. GY. KRAJKÓ—DR. R. MÉSZÁROS

The transport relations of the southern part of the Great Plain

It is nearly impossible, but for the determination of the chief characteristics it is not even necessary to assess fully for all productavs the trade relations of the southern part of the Great Plain on the basis of the data vailable ("analysis of the aver average transportation distances of the supplying and consuming areas of the more important products demanding care in transportation"). NIM publication of the Institute of Industrial Economy and Factory Management. The commodity composition of the road and rail haulage, the direction of the flow of the most important goods, and the transport structure of the region can be determined.

It is valid for all levels of regions that it is the role of the region in the national division of labor that determines the structure and main direction of the trade in goods; consequently the transportation relations must reflect the production profiles of the regions. In the case of the southern part of the Great Plain the production profile, as is known, is composed mainly of the branches of the processing industry and agriculture. Thus it is understandable that largest lost of impoted goods are mining products: coal, stones, pebbles (40%); basic material industrial products: cement and steel (10%); and industrial products for the agriculture: artificial fertilizers (7%) and wood products (4%). Conversely, among the goods exported from the region orude oil and its products (15%), cereals and other agricultural products, milling products, sugar, etc. and characteristically bricks and tiles figure in considerable amounts. It will be seen from this list that the amount of goods imported into the region exceeds the amount of goods sent out of it.

The changes that have taken place in the profile of the region in the last decade are exactly reflected in the changes in the trade relations of the southern part of the Great Plain and in the composition of trade. Grude oil and natural gas figure as important items not only in the export but the increase of production has reduced, and in the future will further reduce, the import of energy supplies. The development of machine industry and agriculture has increased the use of steel and artificial fertilizers. It is unlikely that in the 1970' s changes of similar scale as in the preceding decade will take place; the minor changes that are taking place even now do not affect essentially the structure of trade in good.

The directions of the transporteon of the abovementioned items charateristic of the southern part of the Great Plain are, similarly to their composition, usually given in consequence of the national division of labor and its main directions can be considered stable.

The southern part of the Great Plain has developed the firmest trade ties with Budapest. The bulk of industrial goods comes from that town and the crude oil and gas as well as the larger part of the food industrial and agricultural products flow there. From Borsod county the region receives mainly coal, stones, cement, steel, and artificial fertilizers; from central Dunántúl (Transdanubia) similar products arrive with the exception of steel, only in smaller quantities, and the other way round mainly food and smaller amounts of industrial ready made products flow back into both regions. It is first of all the textile industry that has cooperative connections with Kisalföld ("Small Plain"). The trade relations of the southers part of the Great Plain with the two, neighboring regions, southern Dunántúl (Transdanubia) and northern Tiszántúl (Transtheissia or Easttheissia or lowland region east of the Tisza) are rather weak.

Thus owing to the trade relations between the regions, the southern part of the Great Plain is part of a nationwide, highly centralized, trade in goods, the centralized character of which is reinforced by the circumstance that the bulk of the trade with Kisalföld (the "Small Plain"), central Dunántúl and Borsod county goes through Budapest because of the greatly centralized system of roads and railrozds.

The traffic connections of the southern part of the Great Plain correspond to the flow of goods in trade, but it cannot be said that they are in agreement in every respect.

As it appears from the foregoing, considerable amounts of industrial and agricultural products reach their place of destination, especially Dunántúl, only by detour. The railroad connections of the southern part of the Great Plain with the regions of Dunántúl are very weak (road connections being slightly better) because even the use) of the only direct line, the Baja line, involves great loss of time owing to the detour. It is somewhat easier to send shipments to northern Tiszántúl on the Szolnok—Debrecen line, although it is not free from detours either, but the goods can be transported on it faster than on the other lines. It is interesting that the eastern part of the region, Békés county, is not in a better position; its nearness means no great advantage because it is not easier to reach from here the eastern counties of the country by rail.

It is characteristic of the transport geographic position of the southern part of the Great Plain that for centuries there have been important international roads crossing it. This role is played in our days by two railroads, a highway, and the Danube) Of course the same roads or ways play an important part in the internal trade of goods. Consequently the achievement of the road network of the region depends also on the international connections of the country, especially with Yugoslavia and Roumania. In this respect there have been important changes in all branches of transportation in the past decade. The greatest problem is the sudden increase in internal and transit trade; e. g. the transit traffic of goods has risen tenfold in the last ten years. The E5 road will soon be unable, even in its modernized form, to satisfy the requirements of traffic. With the completion of the superhighway the transportation geographic position of the region will be far better, for it will be crossed by one of the most important roads of Europe. A radical change can be expected also in the water traffic of the region in the following ten years with the construction of the canals between the Danube, Rhine and Maine, the Danube and Oder and the Danube and the Tisza, and the building of barrages on the Tisza.

Although there will be no sudder changes in railroad traffic, a considerable increase in the transit trade of the region can be expected.

It is difficult to determine exactly the ratios of achievement of the branches of transportacion for the territory of the southern part of the Great Plain because neither the rail nor the road transport data are calculated for the region, and there are no data whatsoever of the terrirorial distribution of water transport. The two most important branches of transportation, road and railroad transport, can be compared because the data can be calculated for the territory of the southern part of the Great Plain.

The achievement of the railroad in 1970 was 2268 million tons (km which is 11.4% as compared to the national value. The figures for road transport are lower: 201 million tons/km, that is 7,2%. From this it appears that the achievement of the railroad as compared with the roads represents a higher ratio in the southern Part of the Great Plain than in other territories of the country.

We get essentially the same results if we compare the amounts of goods exported from the region. The amount of goods carried on the railroad lines of the region was 10 281 000 tons, i. e. 8.2% of the national value. Though the absolute value of road haulage is higher than this (11 237 000 tons), its ratio in the road tranport of goods of the whole country was lower than that of the railroad (7.4%). That is to say the amount of goods transported by road was larger here (as als in the whole country) than that transported by rail, but in a somewhat smaller measure than on the national level.

If we take the achievement of the two branches of transportation as 100%, the ratio of rail transport in 1970 was 43.6% in the whole country, and 47.7% in the region The achievement expressed in tons/km was in the same order 87.4% and 918 respectively.

While the southern part of the Great Plain has nearly 20% of the railroad network of the country and 17% of its network of highways, the ratio of the region in the goods traffic of the country in 1970 was only 10.9%, in tons/km 8%. This means that the loading of both networks was much less than (about half as much as) the national average.

Rail transport

The density of the railroad network of the railroad network of the southern part of the Great Plain (10.3 km per 100 km) can be said to be satisfactory and it is essentially the same as the national average (10.2 km per 100 km); in fact, its index referred to the population is even somewhat more favorable. (In the southern part of the Great Plain there is a railroad stretch of 12.9 km for 1000 persons, while in the whole of the country the stretch for the whole population is 9.1 km). In spite of this — as has been mentioned earlier its achievement is poorer than the national average and thus the favorable density of the railroad network is not the reflection of an aconomically developed area but the result of other factors. The ratio of less economic lines is highest here. This appears among other things also from the fact that half of the network consists of sidetracks and the ratio of narrow-gauge railroads is very high, about 15% (i. e. more than 60% of the narrow-gauge railroads of the country). This is the explanation of the fact that in the last 10 years the length of the railroads has decreased more than in other areas of the country: the ratio of the little used, less economic lines is highest here and their closure consequently affected more this part of the Great Plain. This process has not stopped yet; therefore a further reduction in the length of the railroad network can expected in the future.

The bulk of railroad transportation of goods is concentrated on a few main lines, first of all on the transit traffic lines between Budapest—Szolnok—Békéscsaba—Lőkösháza and Budapest—Kiskőrös—Halas—Kelebia. Also important are the lines connecting the towns of Szeged—Kecskemét—Budapest and Békéscsaba—Szeged—

—Kiskunfélegyháza—Halas—Baja (Fig. 1). If we compare the transportation data of 1959 and those of 1970 it appears that the decade-long development brought no essential changes in the territorial ratios of goods traffic; in fact the concentration increased owing to the fact that while the total transport of goods rose twofold, the increase on the lines mentioned here was much larger. At the same time traffic hardly changed on many sidetracks, and in places it even decreased (Figs. 2 and 3).

The increase of the goods traffic of the southern part of the Great Plain was greater than the national average. The tons of goods per person per km in the country between 1960 and 1970 rose from 1336 tons (km to 1922 tons/km, at the same time it rose in the region from 452 tons/km to 1552 tons/km, which no doubt is connected with the rapid development of industry, mining, and considerable investments.

The railroad is the most important means for handling goods traffic between the regions; consequently the structure of goods traffic reflects the profile of the region not only at the level of macro but also of microregions. Among the items of consignment mining products are dominant and thus the bulk of this kind of goods determines the ratio of the incoming and outgoing commodities (Table 1). Sending out goods is dominant only in the mining areas (not counting transit traffic); elsewhere the amount of goods delivered is larger. The amount of mining products (coal, stone, pebbles, sand, crude oil) delivered is in direct proportion with the state of development of industry in each microregion or even settlement. Only the case of Orosháza is different because large amounts of sand are brought here for glass production. On the other hand, there are very great differences; e. g. pebbles and sand are sent from the regions of Baja and Szeged and a very large part of the crude oil also comes from the region of Szeged. These products constitute 30% of the transported goods. The situation is similar in the case of the other products, too. In the transportation of bricks and tiles the region of Békés, in the case of sugar the regions of Békés and Orosháza, in the case of potatoes the region of Szeged stand out and conversely; in respect of the sending of bread and fodder grains, as well as living and slaughtered animals the regions of Kecskemét and Halas fall behind the others. Similar is the situation in the transport of milling products. The order is changed again in the case of the transport of veget tables and fruits because here the vegetable and fruit growing areas are prominen (Table 2). From the above enumeration it follows logically that while the ratio of the goods sent out indicates the structure of production only in some places (e. g. in the case of sugar beet or sand) but shows roughly its scale, the structure of goods sent reflects the production profile fairly well.

It is work while to compare the structure map of the railroad traffic of goods in the individual microregions in relation to the population with the picture of the industrial structure made by a similar method. There is no need to prove the similarity between the two pictures, but there are many differences, too. This is due to the fact that on the one hand the list of articles of the railroad statistics is not detailed enough and does not mention particularly a number of light industrial products, e. g textiles, shoes, etc., on the other hand the largest part of just the goods mentioned is transported on trucks. Thus the structure of the goods sent by rail can indicate the profile of production of the region in question but it cannot be identified with it because it comprises only part of the goods transported.

The scale of railroad traffic shows important differences in the different microregions. The order of the regions in respect of the scale of goods traffic agrees essentially with the order of industrial state of development (Table 3).

TABLE 1.

Structure of rail goods traffic in the microregions (1000 tons)

OUTGOING	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Baja	0,2	—	—	—	769,7	—	0,1	17,6	0,1	0,5	0,1	0,7	23,7	7,3	1,6
Kecskemét	1,7	—	1,0	1,3	0,5	11,2	14,5	0,1	—	2,5	0,1	0,4	21,5	25,8	6,7
Kkhalas	—	—	—	—	—	161,2	—	—	—	0,5	0,2	0,3	1,9	9,7	1,6
Szeged	0,6	—	—	0,2	765,7	1122,4	7,3	15,7	0,1	1,3	0,4	3,6	21,7	36,5	9,2
Szentes	—	—	—	0,1	—	94,7	1,0	—	—	49,2	—	—	3,9	41,5	7,5
Békéscsaba	9,4	—	—	0,33	1,2	—	6,1	0,7	—	265,7	0,8	1,8	1,1	59,9	18,6
Orosháza	0,5	—	—	0,1	—	116,1	4,3	—	1,6	18,3	—	0,1	—	32,2	27,6
Togather	12,4	—	1,0	2,0	1537,1	1505,6	33,3	34,1	1,8	338,0	1,6	6,9	73,8	212,9	72,8

	16	17	18	19	20	21	22	23	24	25	26	27	28
Baja	51,5	9,2	61,5	20,4	0,8	25,4	9,4	5,0	114,6	12,4	1,4	—	1133,1
Kecskemét	18,2	7,0	31,9	77,9	22,5	48,8	0,3	4,6	493,9	24,6	61,1	—	878,1
Kkhalas	15,7	3,2	21,2	38,5	—	17,1	1,5	7,5	218,4	9,9	40,0	863,4	1411,8
Szeged	89,1	107,4	145,4	109,4	46,7	91,5	11,7	17,3	615,3	57,6	57,9	872,1	4206,1
Szentes	77,1	5,8	185,8	11,4	1,5	32,1	8,0	26,8	365,1	18,3	20,3	—	950,1
Békéscsaba	73,0	1,8	147,0	42,9	—	35,1	7,0	26,2	271,0	22,7	29,5	713,8	1735,8
Orosháza	51,5	11,5	71,0	2,6	27,1	6,2	5,2	12,3	258,3	8,9	22,2	—	677,6
Togather	376,0	145,9	663,8	303,1	98,6	256,2	43,1	99,7	2336,6	154,4	232,4	2449,3	10992,4

1 = coal, briquette; 2 = iron ore, manganese ore; 3 = bauxite; 4 = strone; 5 = pebble; 6 = oil, oil product; 7 = iron and metal (steel) ware, 8 = artificial; 9 = coke, coke briquette; 10 = brick, tile; 11 = lime; 12 = cement, 13 = cement-ware; 14 = milling-product; 15 = sugar; 16 = corn, maise; 17 = potato; 18 = sugar-beet; 19 = wood, timber; 20 = earth, sand; 21 = fruit, greens; 22 = hay, straw; 23 = animals; 24 = other goods; 25 = piece-goods; 26 = raily coal, stone, other; 27 = import, transit; 28 = rail goods togather

TABLE 2.

Structure of rail goods traffic in the microregions (1000 tons)

INCOMING	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Baja	192,6	0,1	—	88,5	20,7	35,0	12,7	110,5	5,8	34,9	16,1	52,4	12,7	8,4	1,5
Kecskemét	214,7	—	—	124,6	149,4	73,0	33,1	94,5	9,5	44,2	22,0	45,9	46,7	1,0	3,1
Kkhalas	145,2	0,3	—	70,3	81,7	28'2	22,2	81,3	2,2	39,9	17,9	44,0	18,3	15,8	6,6
Szeged	606,6	1,9	1,1	346,4	734,9	169,8	103,3	316,6	10,7	78,3	60,2	233,4	149,6	35,1	11,0
Szentes	99,0	—	—	38,8	198,1	30,4	14,7	29,4	2,3	15,2	9,2	32,9	18,0	6,2	2,4
Békéscsaba	374,4	16,6	—	402,4	220,0	80,2	48,2	122,7	4,4	8,5	18,7	100,6	32,3	18,1	2,6
Orosháza	192,6	—	0,4	239,2	153,4	56,9	14,9	67,6	—	7,2	9,3	34,5	10,4	9,3	5,3
Togather	1780,4	18,9	1,5	1310,2	1558,2	473,5	249,1	822,6	34,9	228,2	153,4	543,7	288,0	93,9	32,5

	16	17	18	19	20	21	22	23	24	25	26	27	28
Baja	3,5	0,7	—	28,8	19,7	1,2	0,3	2,8	243,6	16,9	16,8	—	926,1
Kecskemét	11,0	7,5	1;8	44,6	19,1	11,8	—	10,8	165,2	22,6	63,9	—	1 220,0
Kkhalas	18,6	1,1	—	44,0	4,4	5,4	0,2	1,3	176,4	9,9	175,8	0,7	1 011,7
Szeged	45,9	4,1	4,3	237,4	73,9	77,2	8,1	3,2	740,2	63,4	317,9	3,4	4 437,9
Szentes	25,8	0,8	—	31,3	27,1	12,5	—	—	100,6	5,7	18,6	—	719,0
Békéscsaba	69,3	8,3	162,8	116,0	47,4	0,3	—	4,9	232,9	20,3	186,0	1462,0	3 769,9
Orosháza	19,1	1,2	120,0	38,4	167,7	1,0	—	0,2	183,2	6,4	25,2	—	1 318,7
Togather	193,2	23,7	288,9	540,4	359,3	109,4	8,6	23,2	1842,1	155,2	804,2	1466,1	13 403,3

1=coal, briquette; 2=iron ore, manganese ore; 3=bauxite; 4=stone; 5=pebble; 6=oil, oil product; 7=iron and metal (steel) ware; 8=artificial; 9=coke, coke briquette; 10=brick, tile; 11=lime; 12=cement; 13=cement-ware; 14=milling-product; 15=sugar; 16=corn, maise; 17=potato; 18=sugar-beet; 19=wood, timber; 20=earth, sand; 21=fruit, greens; 22=hay, straw; 23=animals; 24=other goods; 25=piece-goods; 26=raily coal, stone, other; 27=import, transit; 28=rail goods togather

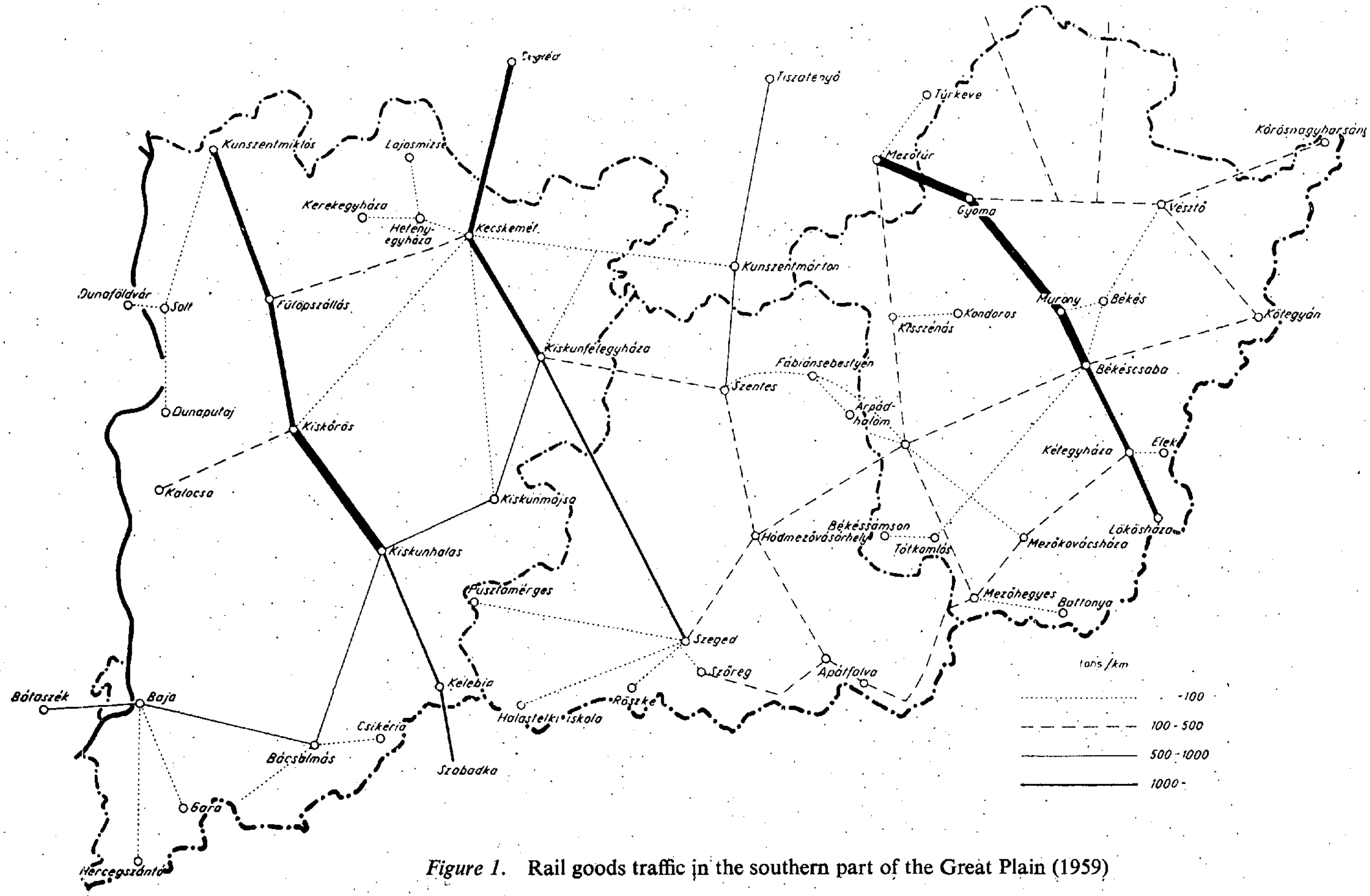


Figure 1. Rail goods traffic in the southern part of the Great Plain (1959)

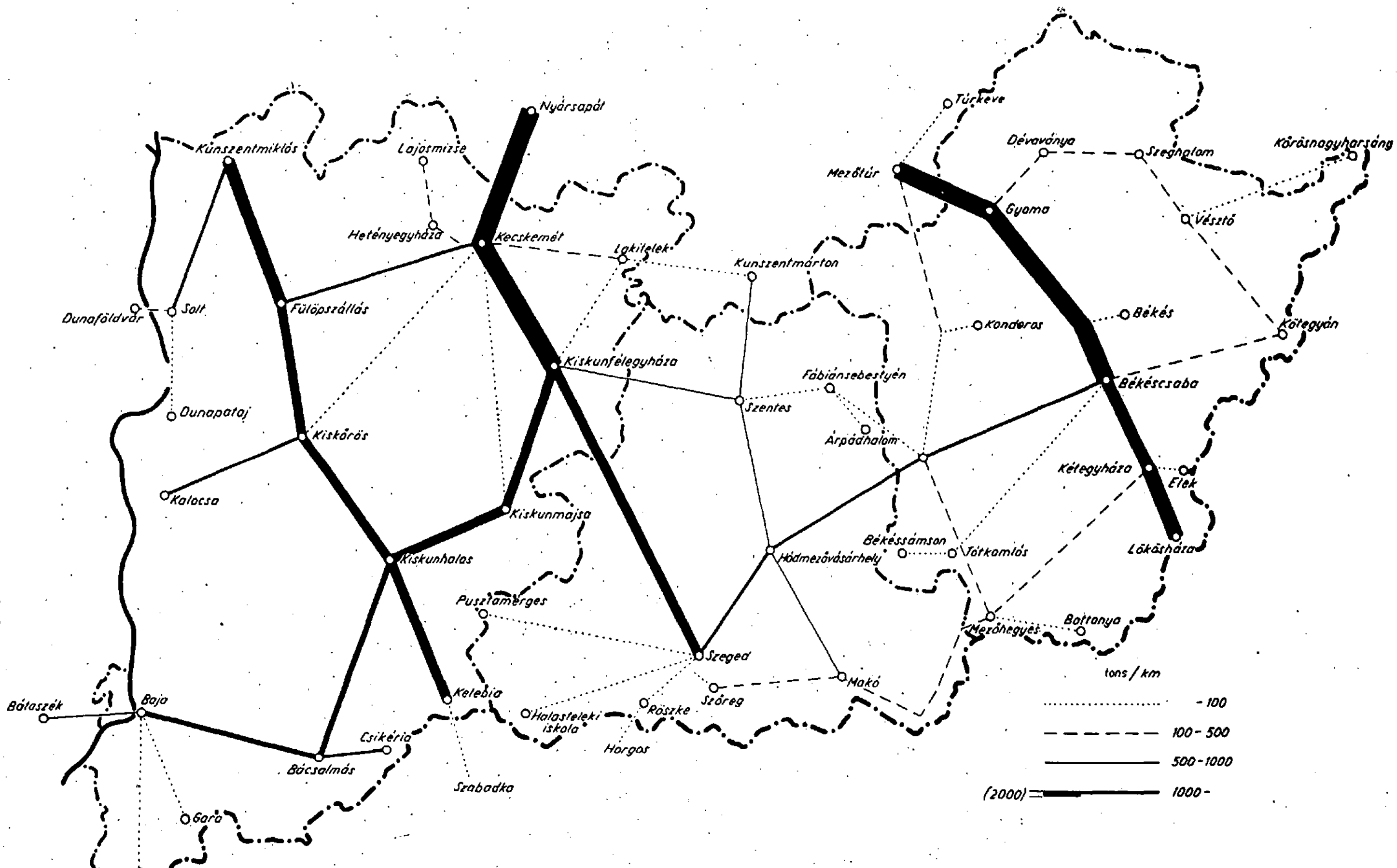


Figure 2. Rail goods traffic in the southern part of the Great Plain (1970)

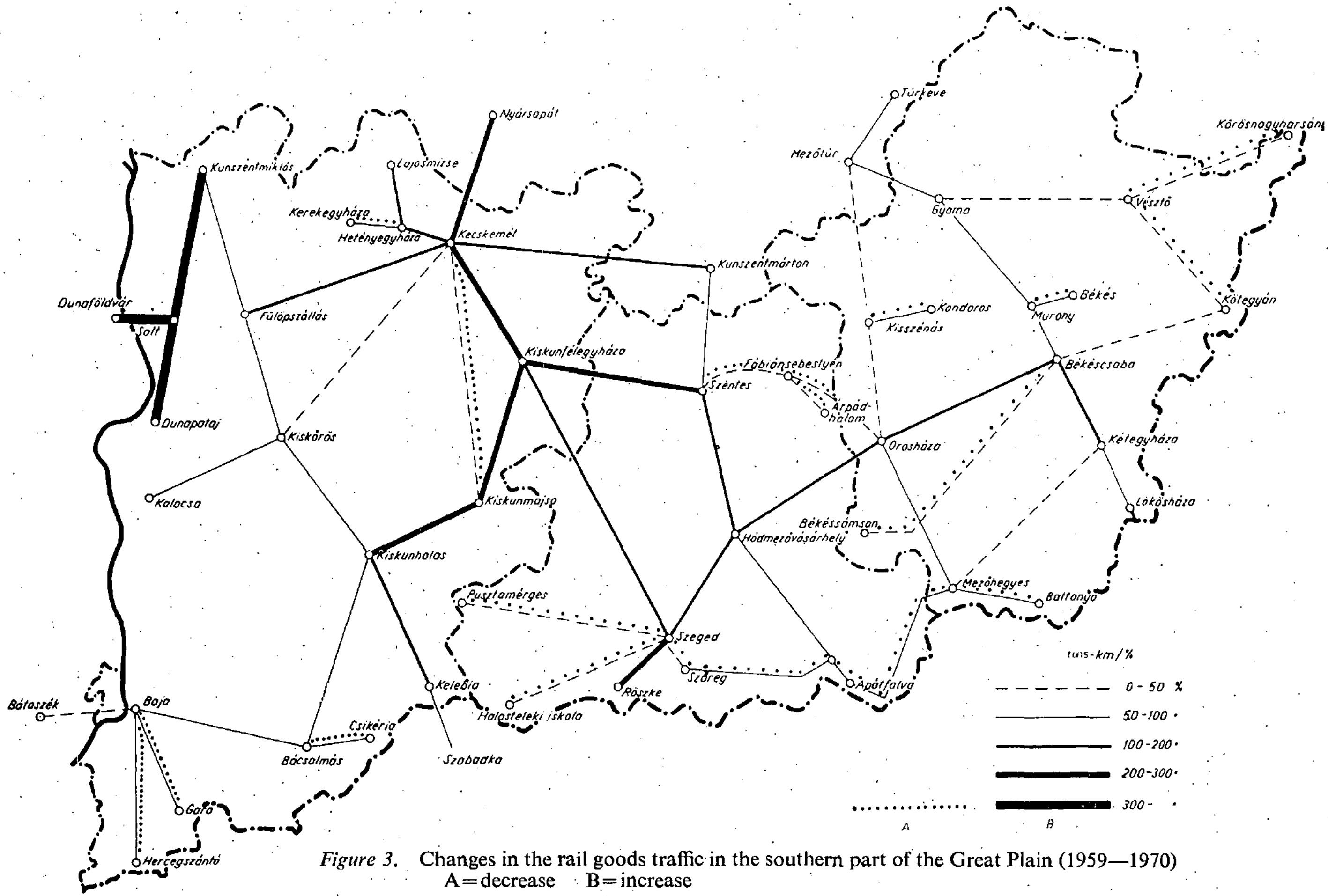


Figure 3. Changes in the rail goods traffic in the southern part of the Great Plain (1959—1970)
A = decrease B = increase

TABLE 3.

Rail traffc in goods in individual microregions

Region	sending of goods in 1000 tons	transit	Region	delivery of goods	Region	Total
1. Szeged	3334	4206	1. Szeged	4559	1. Szeged	7893
2. Baja	1133		2. Békés	2211	2. Békés	3234
3. Békéscsaba	1023	1736	3. Orosh.	1396	3. Kecskemét	2093
4. Szentes	950		4. Kecskemét	1251	4. Orosháza	2074
5. Kecskemét	878		5. Kkhalas	979	5. Baja	2012
6. Orosháza	679		6. Baja	879	6. Szentes	1657
7. Kiskunhalas	548		7. Szentes	707	7. Kkhalas	1527

Szeged holds a prominent place in every respect. In goods traffic (without transit) the region of Békés is second, coming before the region of Kecskemét which can be explained mainly by the higher ratio of bulk goods (coal, stones, pebbles, sugar beet, grains, etc.) Between the reception and sending of goods in the different regions there are great differences of order and amount. The region along the Danube is secons in regard of the amount of goods sent out, while it is sixth as regards the reception of goods. The very great difference is due to the rail transport of sand from the Danube and pebbles. A similar difference can be seen in the region of Orosháza, only the other way round: here the sand arriving from outside adds to the amount of goods received. On the other hand, if we count also the transit traffic, it comes to the third place.

Railroad transport

Transport by road as we have mentioned earlier is slighly more efficient than transport by rail but it does not follow from this that it is the more important branch of transport and even the posing of the question in this way is not correct because both branches of transport have their own spheres of function that must not be left out of consideration in the case of a comparison between them. As is well known it is the task of road transport to handle short distance traffic and the more valuable long distance traffic especially as a means of the internal traffic of goods in the mesoregion.

The density of the road network of the southern part of the Great Plain (100 km 29.1 km) is somewhat lower than the national average (100 km^2 31.8). Not even the relatively better developed road network of Csongrád county reaches the national level. Nearly 17% of the public roads of the country are in the region. The length of the roads has only slightly increased in the last ten years but the road network has undergone a very important qualitative change which is reflected also by the decrease of waterbound macadam roads (45%) and the increase of dust-free roads (19%) (Table 4). Besides this the lenght of not well built roads has considerably decreased. In spite of the development the ratio and breadth of up-to-date roads does not reach the national average; at the same time the ratio of poorly built roads, by-roads, and approach roads is far higher. The quality of the road network of the region meets less and less the requirements of the rapidly developing industry and the fast growing loading due to home and international traffic.

TABLE 4.

Pavement of the roads

(km)

County	Pavement of the roads	1965	%	percent of change	1970	%	percent of change
Bács-Kiskun	A dustless	1941			2031		+4,6
	A macadam road	61			—		−100,0
	A unbuilding road	187			186		−0,5
	Togather	2189	43,8		2217	43,9	+1,3
Békés	A dustless	582			767		+31,8
	A macadam road	836			659		−21,2
	A unbuilding road	88			88		—
	Togather	1506	30,1		1514	30,0	+0,5
Csongrád	A dustless	842			1206		+43,2
	A macadam road	400			52		−87,0
	A unbuilding road	66			62		−6,1
	Togather	1308	26,1		1320	26,1	+26,9
Regions togather	A dustless	3356			4004		+19,0
	A macadam road	1297			711		−45,2
	A unbuilding road	431			336		−1,5
	Togather	5003	100,0		5051	100,0	+0,9

The average traffic load of the road network of the southern part of the Great Plain is below the national value; e. g. while there is 5030 tons of loading for 1 km of stretch in the country, the same index in the region is not half this value: 2240 tons for 1 km. The traffic values compared with the population show roughly the same ratio. Thus in the whole country 14.7 tons fall to 1 person (277 tons/km) while in the region 7.7 tons/137 tons/km).

In the past 5 years road traffic in the region grew nearly 30% (in tons of goods per km 7.2%), i. e. more than the national value. The rate of growth was highest in Csongrád county. In Bács county the change can be considered only very moderate. Thus the national imbalance has decreased as a result of the development of the last years, but the territorial differences have increased in the region (Table 5).

At present 9% of the bus stations, 13% of the truck stock, and 20% of the traction engines are to be found in the region. Considering further the kinds of vehicles we find that the number of automobiles in 1970 was 31 327 (i. e. 13% of the automobiles of the country) and the number of motorcycles of 125 cm² capacity is 59 000. The number of automobiles per 10 000 inhabitants is here 214, that is slightly less than the national average. (In fact the number of automobiles in Csongrád and Bács-Kiskun counties is higher than the national average, being lower only in Békés county). The ratio of the number of motorcycles to the population is much higher than the national average. The rate of growth of the automobile park in the last 5 years has been faster in the region than in the other regions of the country, and in consequence of it now surpasses the average of the regions. This fact reflects in part dynamic economic development of the region. The economic growth will continue in the future and therefore it can be expected that the stock of road vehicles will frow similarly. In addition we must reckon the sudden increase in international traffic mentioned earlier, and then it is easy to see that the road network must be modernized and the service establishement must be developed if we are to keep up with this growth.

Earlier we have referred to the fact that the structure of the goods sent by rail reflects in part the production profile of the microregion. The same cannot be said of the structure of the road traffic in goods in spite of the fact that it is just as closely connected with the economic life because the structure of road taffic in goods depends on the production profile only in a small degree. The transportation of mining products (stones, pebbles, sand, earth, etc.) is of such dimensions that the amount of transported industrial materials agricultural products and especially the amount of industrial finished products is quite small in comparison (Table 6).

It is difficult to judge the road traffic relations between the microregions for want of more recent data concerning traffic. In the nearly 10 years since the last collection of data (in 1963) the regions themselves and of course also their relations have changed considerably. The figures shown here permit the drawing of well-founded conclusions only through comparison with the present situation. This unfortunately can be done only later (Figs. 4, 5, 6).

The road traffic of goods and passengers is very closely connected with the internal economic and social processes of the microregions. We will deal with this later in detail.

The network of energy transmission lines influences the relations of the microregions to a lesser degree; therefore we do not want to deal with this in detail and mention only that the length of the high tension (120—220 Kw) electric long-distance

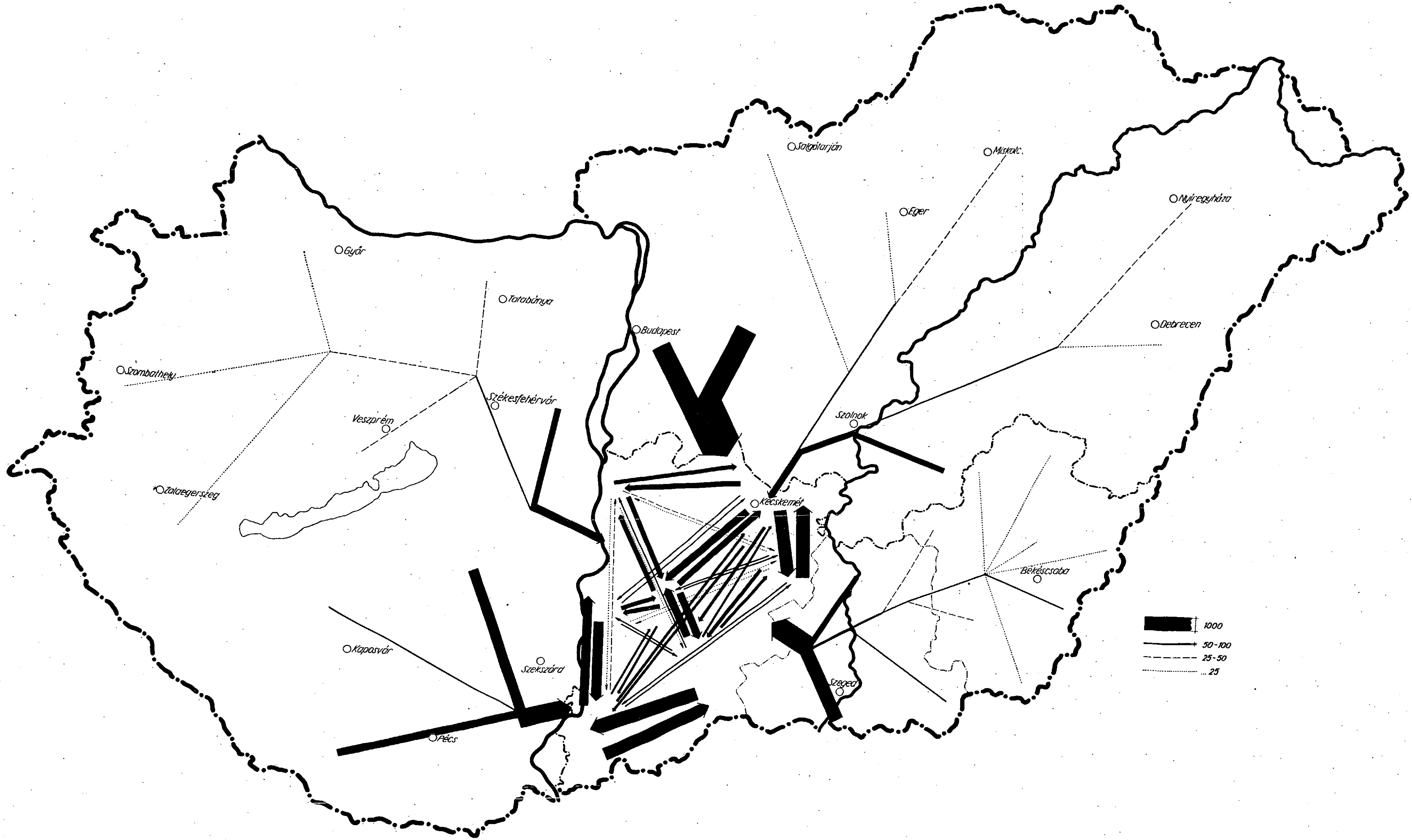


Figure 6. Vehicle traffic in the districts of Bács county (1963)

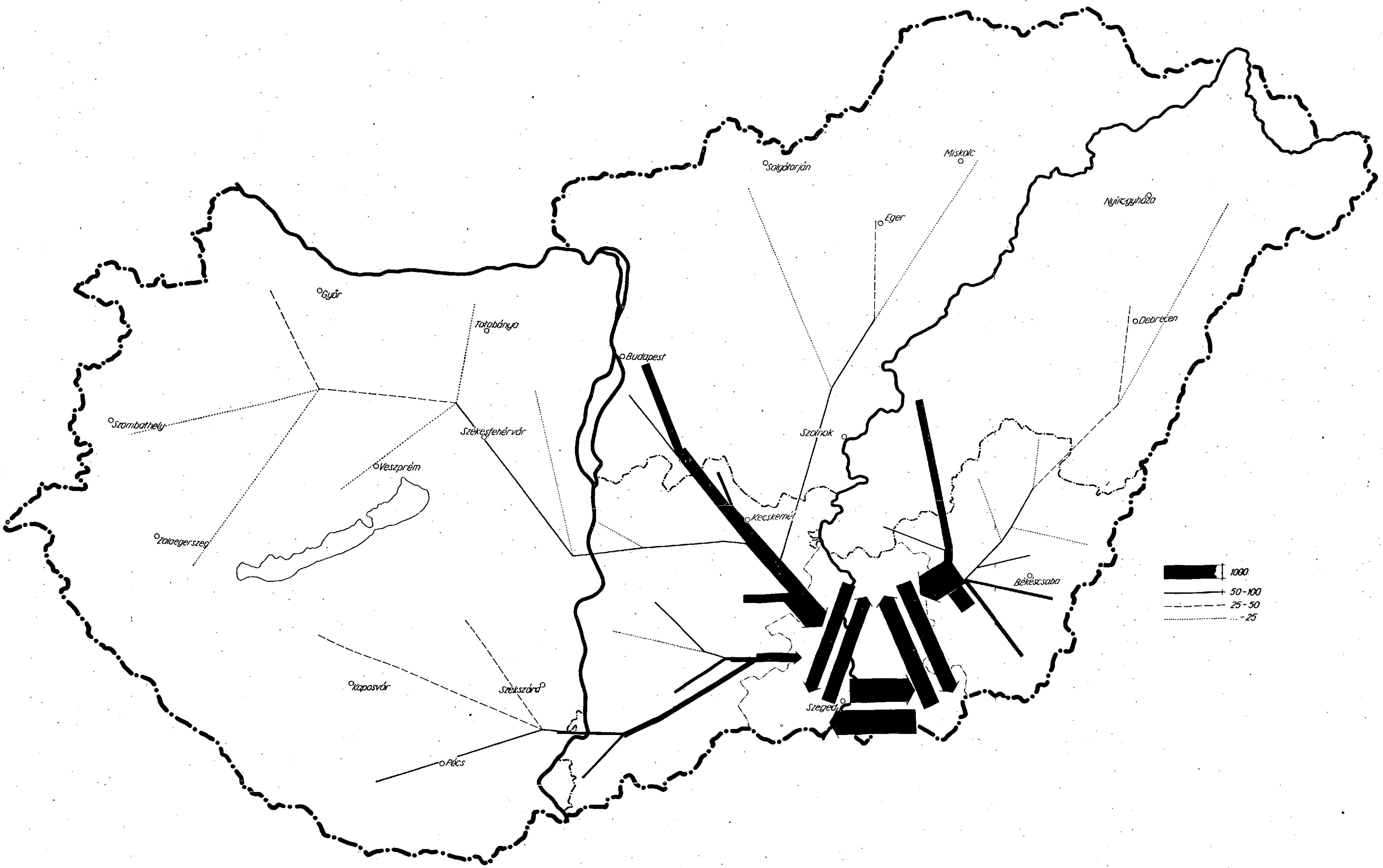


Figure 5. Vehicle traffic in the districts of Csongrád county (1963)

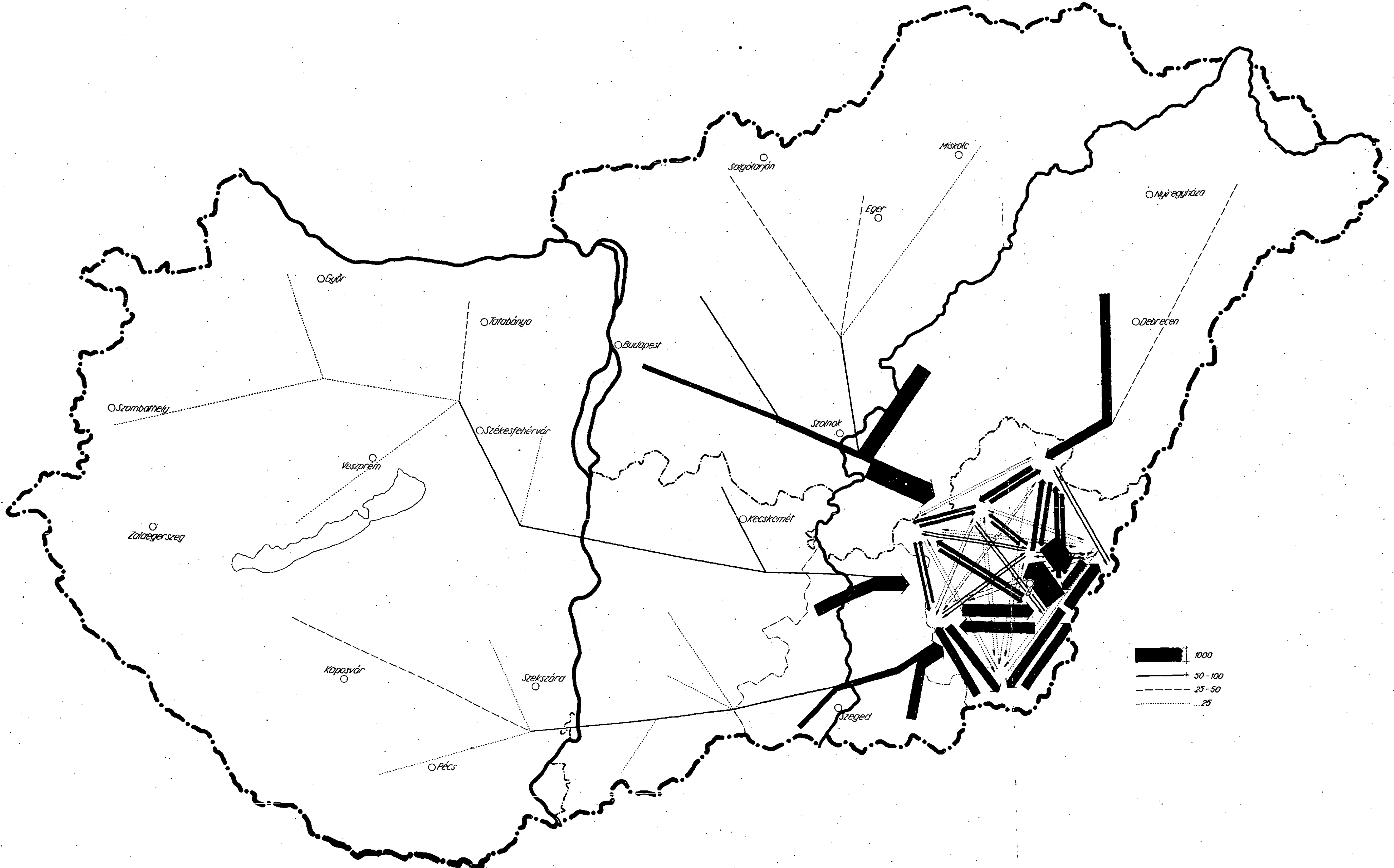


Figure 4. Vehicle traffic in the districts of Békés county (1963)

TABLE 5.

The most important fact of the heavy traffic

County	Naming	1965	%	Percent of change	1970	%	Percent of change
Bács-Kiskun	Weight of the transporting goods 1000 t.	3 264	37,6		3 479	31,0	+ 6,6
	goodstons/km	45 685	38,9		60 099	29,8	+31,6
Békés	Weight of the transporting goods 1000 t.	2 243	26,0		2 912	25,9	+29,2
	goodstons/km	27 821	23,7		55 737	27,6	+100,4
Csongrád	Weight of the transporting goods 1000 t.	3 156	36,4		4 846	43,1	+43,5
	goodstons/km	43 848	37,4		85 763	42,6	+95,6
Regions togather	Weight of the transporting goods 1000 t.	8 673	100,0		11 237	100,0	+29,6
	goodstons/km	117 344	100,0		201 599	100,0	+71,8

TABLE 6.

Transport of goods of the carriing (VOLÁN) in the southern part of the Great Plain
(sort of goods)

Naming	1970 tons	Division %
1. Coal, briquette, coke	620 331	5,5
2. Iron ore, manganese ore, bauxite	53 536	—
3. Stone	1 077 778	9,6
4. Pebble	1 771 272	15,8
5. Sand, earth, clinkers	2 526 142	22,6
6. Lime, cemuet	919 065	8,2
7. Brick, tile	331 916	3,1
8. Wood, timber	193 084	1,7
9. Milling-product	119 572	1,1
10. Sugar-beet, sugar, potato	177 299	1,6
11. Fruit, greens	307 305	2,7
12. Other food-products	995 817	8,9
13. Other goods	1 411 137	12,6
14. Iron and metal (steel) ware	364 748	3,3
15. Chemical product	361 282	3,3
Togather	11 177 284	100,0

transmission line for the southern part of the Great Plain is 5.1 km, i. e. 11% of teh national network.

The length of the natural gas pipelines is 491 km. The region yields 42% of the natural gas gained in the country. Thus it is understandable that it has a large share (24%) of the pipeline network.

Determination of the transport geographic situation of the settlements

The transport geographic situation of a given point is a relative concept. The judgment of it depends on what it is related to. Several settlements on main roads and railroad lines have excellent transport facilities and yet their situation far away from the center of their region is less favorable than that of some settlements near to the center which are connected with the center only by an approach road. It follows from the internal life rhythm of the microregion that the economic, social, and cultural life, production and consumption (in the agriculture in large part also selling) are connected with the centers. Thus the accessability of the centers is indicative of a certain kind of transport geographic situation that is in several respects important in the research of microregions.

For the research of economic microregions and the delineation of their boundaries it is expedient to consider particularly the following elements of land transport:

a) the size of road vehicle traffic,

b) the frequency of buses,

c) the ratio of the public traveling with railway and bus season tickets to the population,

d) the time needed for reaching the center by the most suitable of the regularly running vehicles.

The other aspects of transport, such as the structure of the goods transport, its territorial distribution and the direction of transport yield complementary data concerning the economic structure and external relations of the regions. The analysis of these factors, as we have seen earlier, is necessary for the judgment of another set of problems.

a) The road traffic map prepared on the basis of the vehicles passing through shows well the centers, that is the traffic nodes, the rate of the gradually increasing traffic streaming toward them, and the road stretches with little traffic usually on the border of the microregion. Unfortunately the data of the last KPM survey have not yet been summarized and so we can only count with the road traffic data of 1963. The difference between the two dates is no doubt considerable but the main ratios we need have not changed basically. In order to facilitate further analysis of the roads crossing the settlements it is convenient to class them into categories.

Traffic is
— slight, if the transit traffic is below 500 tons per day,
— medium, if is between 500—1000 tons per day,
— heavy, if it is 1000—2000 tons per day,
— very heavy, if it is above 2000 tons per day.

According to the traffic of the roads the settlements can be classified into categories, and if these are mapped the territorial differences express certain transport geographic situations. This is natural since depending on the size of the center the settlements with short-distance or heavier transit or local traffic are distinct from the others. However, the figure is only partly suitable for drawing far-reaching conclusions for in itself it does not reflect the situation of the settlements, but shows the traffic nodes of different size, the lines with heavier traffic and the areas with little traffic, and thereby indicates the boundaries of the microregions. Road traffic is absolutely necessary for analyzing the internal economic dynamism of the microregions since it expresses the relations of the centers and the areas under their influence. Yet we will disregard this here and deal with the territorial ration and differences (Fig 7).

b) For the analysis of the frequency of bus runs the freshest statistical data are available and thus they reflect the present situation. The inclusion of the frequency of bus runs is justified by the fact that the mapping of it reflects both the ratio and the direction of road travel. Accordingly the number of bus lines shows the transport geographic situation of each settlement, the place where it belongs and its traffic attraction. Similarly to the scale of traffic the map gives a zonal picture corresponding to the situation of the settlements and at the same time shows the boundaries of the attraction zones of the traffic nodes. The use of the cartogram so constructed is manifold: its zonal character is suitable for categorizing the settlements under consideration of the other factors of transportation, while the directions of traffic are necessary for delineation of the microregions (Fig. 8.).

It is convenient to classify the settlements on the basis of the frequency of bus runs as follows:
— their frequency is low, if the number of daily runs is less than 6,
— medium, if the number of daily runs is 6—15,

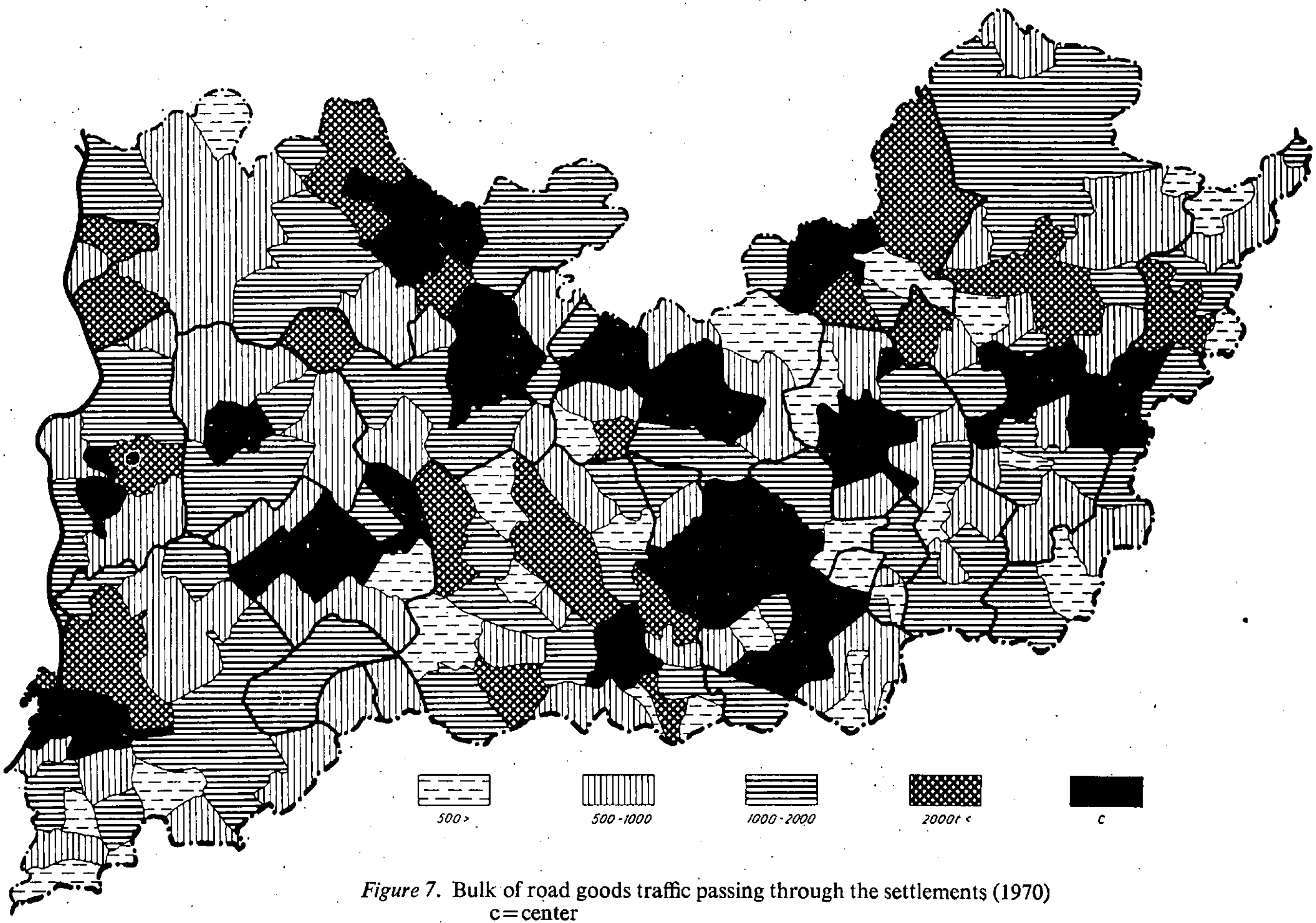


Figure 7. Bulk of road goods traffic passing through the settlements (1970)
c=center

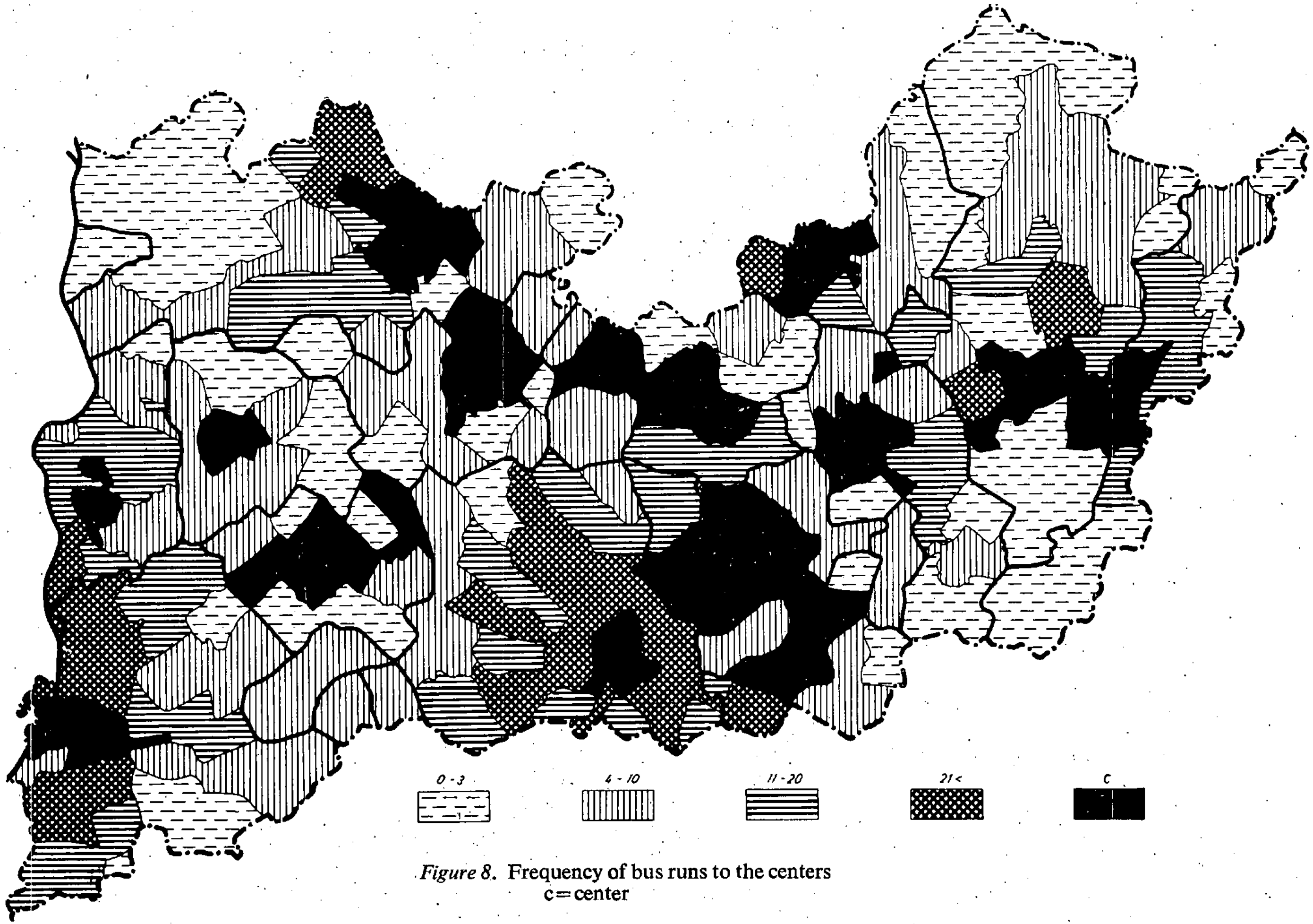


Figure 8. Frequency of bus runs to the centers
c = center

— high, if the number of daily runs is 15—30,
— very high, if the number of daily runs is over 30.

The values of the categories were chosen seemingly arbitrarily; this is not really so because the value limits were determined by the sharp differences in the frequ ency of bus runs.

c) The ratio of those traveling with railway and bus season tickets to the population is also very illuminating from the point of view of the microregions. The inclusion of this factor in the analysis is justified by the fact that so far we have not taken rail traffic into consideration. The transportation of goods is less interesting in this respect. On the other hand the majority of regular travelers do not leave the microregions and thus this fact must be reckoned with. The heaviness of road traffic doest not fully reflect the frequency of bus runs, but the frequency of bus runs does reflect the ratio of the traveling population because the vehicles passing through the settlements are used in different measures by the suburban and rural populations. Consequently there is a difference also between settlements with the same amount of goods traffic or same number of bus runs. The number of those traveling by bus is essential because it corrects the afore-mentioned difference and reflects the relation between the center and the settlements; at the same time it is possible to show by it the influence of road and rail traffic combined. Of course the statistical material of the regular travelers does not reflect the full number of commuters beacuse many people of the settlements near to centers travel also by other vehicles and this is not included in our data. Yet the limits of error are not wide because in the winter season the majority of even those otherwise using their own vehicles buy season tickets. The difference does not alter the essence anyway, because those traveling with their own vehicles are counted in the survey of road traffic (Fig. 9.).

The numbers of those regularly traveling by rail and bus compared with the number of population can be classified simas above. shus the number of regular rail and bus travelers is

— low, if the ratio of regular travelers is below 0—5%;
— medium, if the ratio of regular travelers is 5.1—10%;
— high, if the ratio of regular travelers is above 10%.

According to the figure the number of regular travelers is high in the settlements near to centers and having rail and road connections. The other extreme is represented by settlements with unfavorable transport conditions farther away from traffic nodes. Besides assessing the transport geographic situation of the settlements these data, similarly to the other data concerning transport, can be used also independently for the examination of other phenomena such as the reorganization or mobility, etc. of the population.

d) In the assessment of the transport situation the time or distance of traveling is an indispensable factor. In transport, distance is a seemingly constant, in reality however, a very relative factor, the judgment of which depends on the vehicle used; therefore it is better to reckon with time. The different branches of transport are much better united on this basis because in the determination of the time zones that vehicle can be considered with which the destination can be soonest reached. This is roughly identical with the isochronic maps; the difference is that we consider the settlements as points independently from their extent in order to make their categorization easier (Fig. 10).

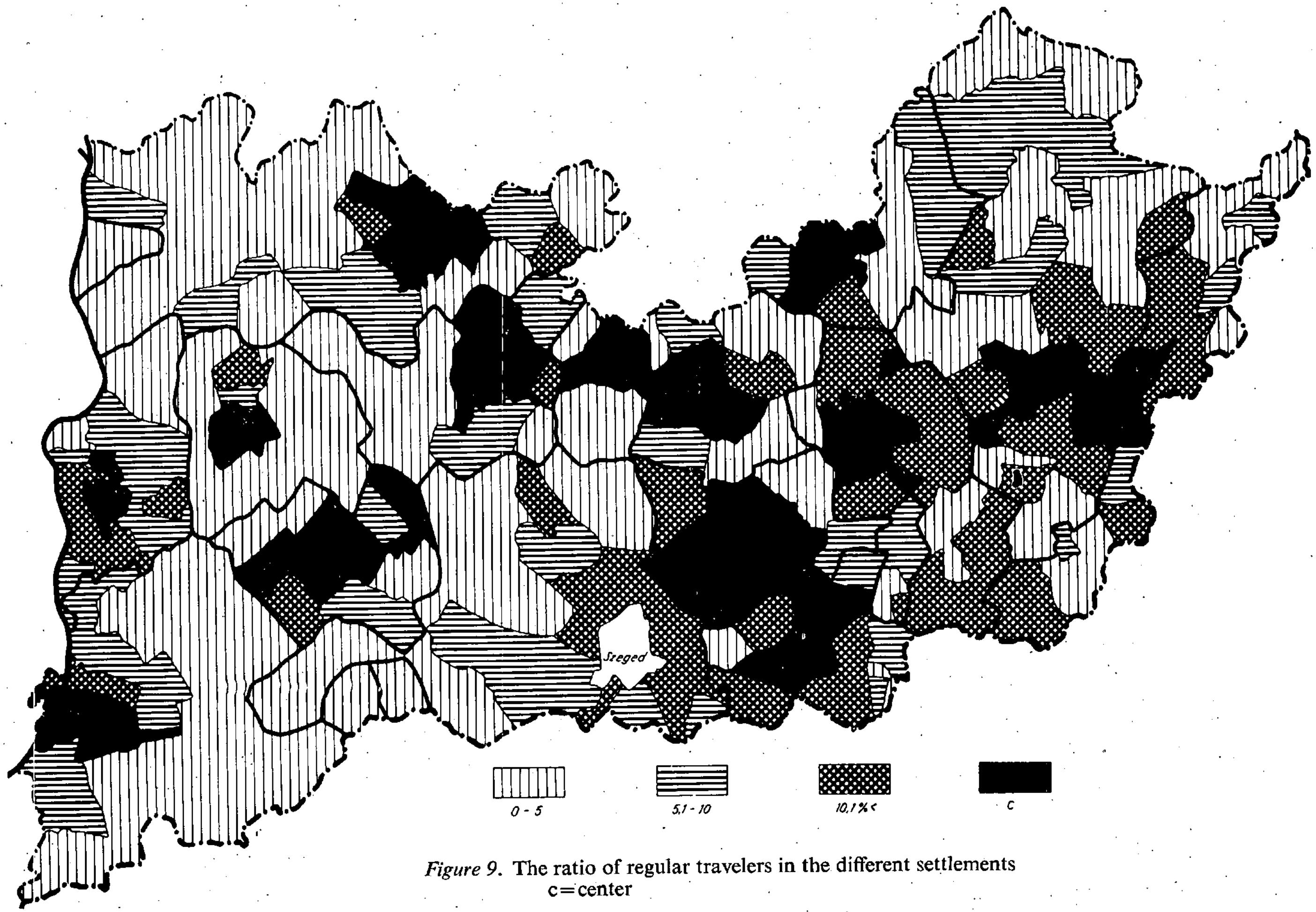


Figure 9. The ratio of regular travelers in the different settlements
c = center

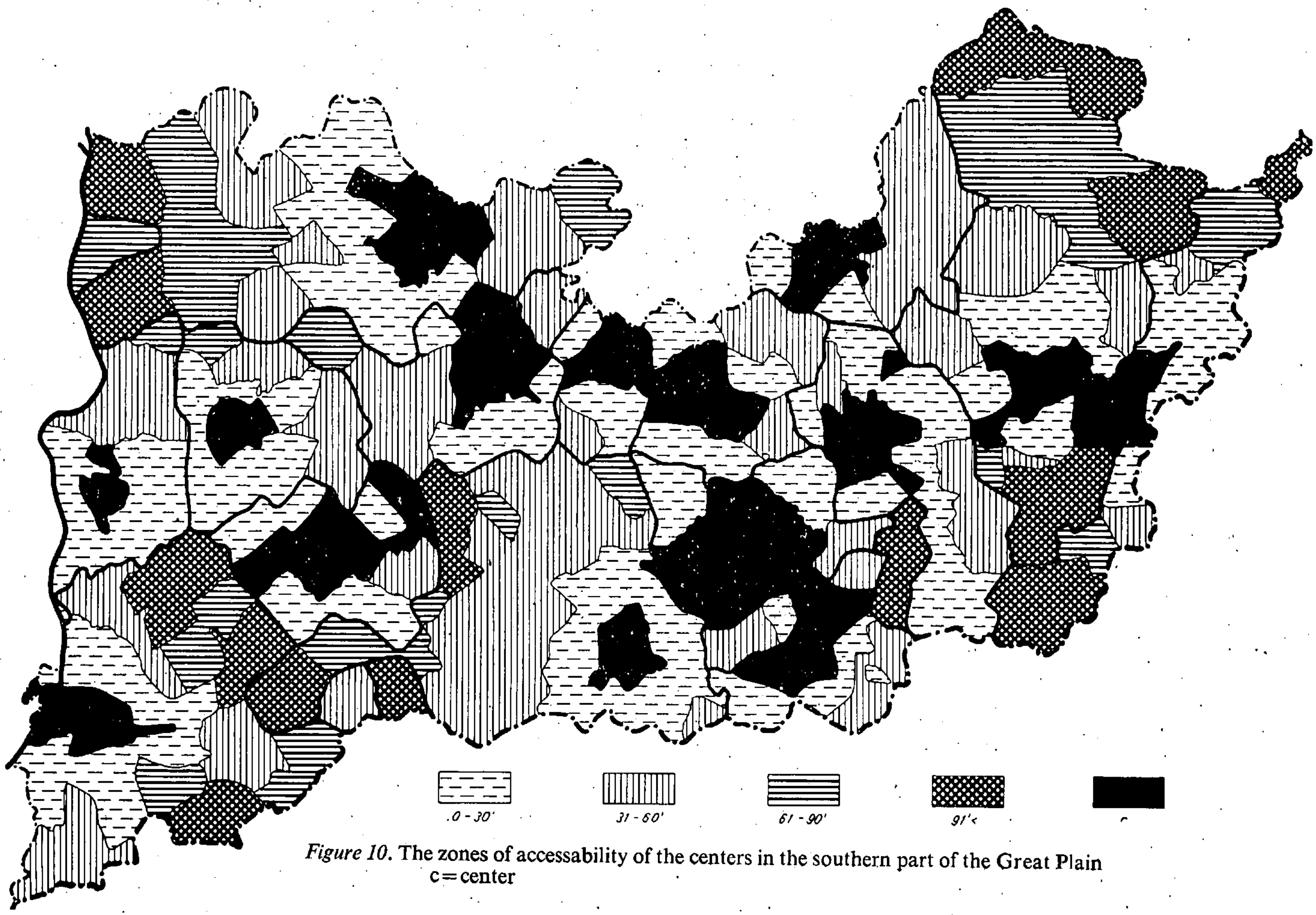


Figure 10. The zones of accessability of the centers in the southern part of the Great Plain
c = center

Under consideration of the time of approach counted from the centers the settlements can be classified according to the categories mentioned earlier. Approachability is

— excellent, if the center can be reached within 30 minutes,
— good, if the center can be reached in 31—60 minutes,
— medium, if the center can be reached in 61—90 minutes, and
— poor, if the time of reaching the center is more than 90 minutes.

In the classification we considered the economic and administrational centers as destinations which at the same time are centers of attraction also from the point of view of traffic. Disturbing factors may be some centers with lesser attraction wich offer a little advantage to the settlements of the area and at the same time figure with the same weight as the more important centers in the determination of the time zones. It is well known that the influence of a center within unitary time zones depends on its size and (the number of) its functions. The influence of Szeged 20 km from the town is incomparably stronger than that of Kiskőrös for example. The time zone of settlements near to smaller centers is indeed irrationally favorable, but as we will see, this is marred by the ratio of other indicators.

In the following the problem is how the factors mentioned can be combined so that they should indicate with the least possible distortion the transport geographic situation of the settlements.

In the course of the description of the factors we have seen that, although not always in the same degree, their territorial variations point in the same direction, for they reflect essentially the same process. On this basis they can be combined mechanically. It is only the time of approach that shows an opposite tendency; thus we can count this in as divisor. The combining formula is

$$K = \frac{a+b+c}{x}, \text{ where}$$

K = transport situation
a = category value of bus runs,
b = category value of goods traffic,
c = category value of ratio of travelers to the population,
x = category value of the time of approach.

If we increase the number of categories for the factors, we receive finer and more precise data. For the present purpose the number of categories is sufficient because even a more detailed analysis does not give an essentially more precise picture (Fig. 11).

The survey table reflects excellently the zone of settlements with favorable transport facilities around the centers together with the other extreme, the zone of villages with unfavorable, peripheral situation the development of which just for this reason differs in many respects from that of the former group. Very low are the values of the villages around Szeghalom, the settlements around Mezőkovácsháza, and Kiskunhalas (not counting a few neighboring villages and the area of the recently abolished district of Dunavecse. The last mentioned is equally far from Kecskemét and Kalocsa; this is why its indicators are poor. The difference between the centers is also striking, which is understandable because the stronger the economic and social influence of a center, the more settlements it attracts. (See the difference between Baja and Kiskun-

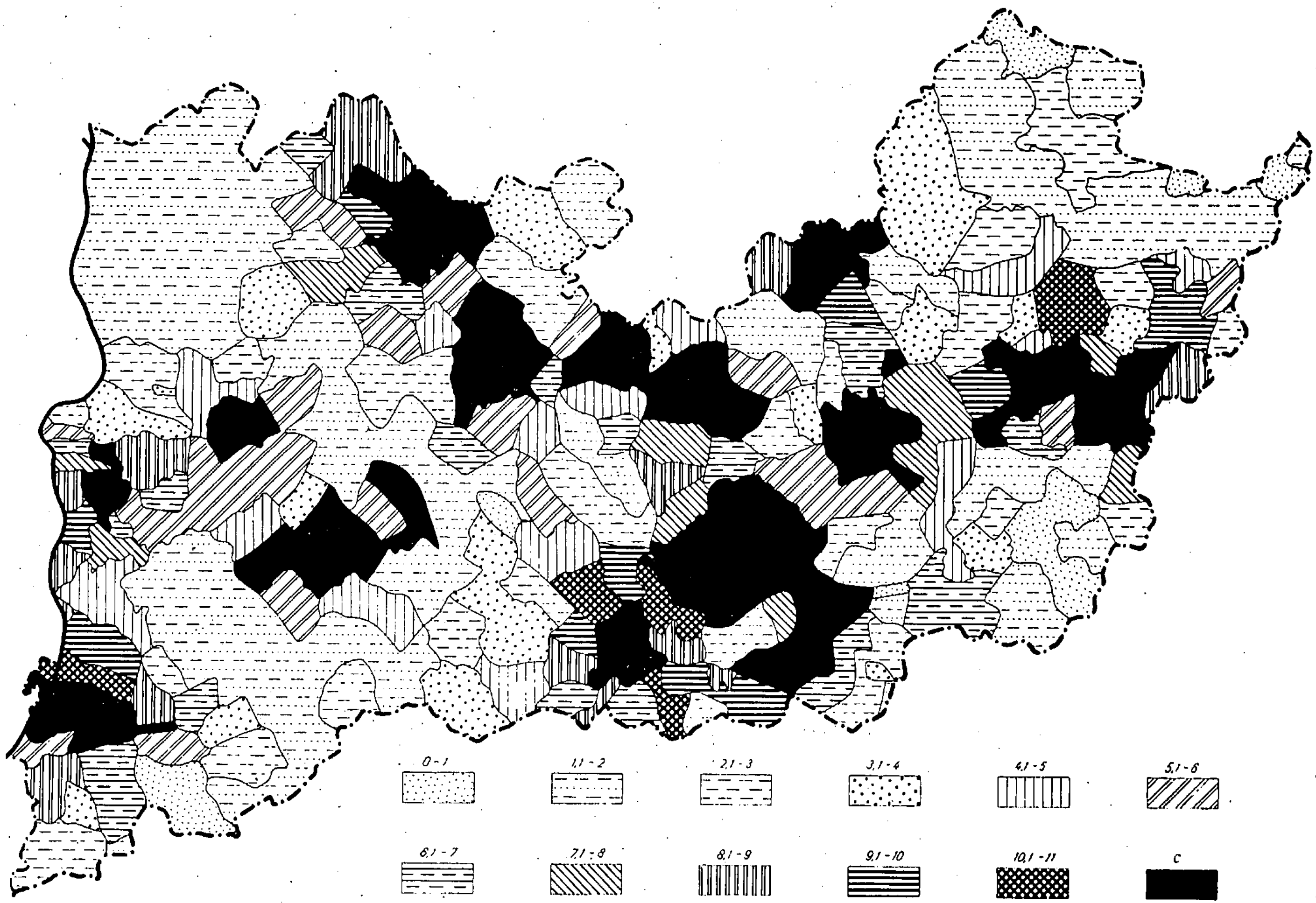


Figure 11. The transport geographic situation of the settlements of the southern part of the Great Plain c=center

halas). The figure clearly shows that the centers exert their influence on the settlements of the microregions also through the transport geographic situation.

The figures of transport geography partly bring us nearer to the determination of the microregions, partly — and this is even more important — they are indispensable for analyzing and judging the ecomic and social movement of the regions. We shall see later that there is for example a very close connection between the transport situation and migration. Its influence on the reorganization of the population is also demonstrable.

CONTENTS

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