THE QUATERNARY OF THE GREAT HUNGARIAN PLAIN
The landscape

To discover the geological particularities of a big lowland, which at a first glance looks monotonous and offers no curiosity, that may be an aim what can stimulate passionate research. The Great Hungarian Plain, called “Alföld” in Hungarian, is the biggest sedimentary basin in Europe, filled with Neogene sediments in great thickness. It has an area of 100 000 km², its average height is about a hundred m above the sea level and half of it is as flat as no more than 3–4 m of topographic level differences can be found on it. Walking on the Plain one can distinguish three kinds of deposits on its surface: wind-blown sand on the hills; loess and loess-like sediments situated above the level of the actual flood-plains; and silty clay in flat alluvial areas. A close look shows more differences in the sedimentary cover than was told above. The picture is more varied as taken from a satellite photo or from a detailed geological map. The variety is more obvious if we consider not only the top sediments of the surface, but also the stratification of the different layers forming various successions just under the surface. Differences are in age genetics, lithological composition, granulometric structure and chemical composition of the layers. These differences have a role in agrogeology, engineering geology, hydrogeology and also in the protection of the natural environment, in this modern branch of applied geology.

The main river of the Great Plain is the Tisza. Although the Danube is four times bigger than the Tisza, it marks the western border of the Plain but has a minimum share of catchment area in it. The Tisza, flows in the middle of the Plain and gathers tributaries almost from the whole lowland territory.

Due to fundamentals such as surface morphology, kinds of rock, river pattern and geological structure, characteristic regions have developed within the Great Plain. There are two sandhill regions, one between the rivers Danube and Tisza, with another in the northeastern part of the Plain, the Nyírség. Some loess-covered flat regions, such as Jászság, Hajdúság and Nagykunság are situated above the actual flood-plain level. They represent the Late Pleistocene surface. The main Holocene regions are: the Danube valley between Budapest and Mohács, the Szamos plain beyond Nyírség, the Hortobágy flood plain and the Körös basin.

Six chapters of this book have to give general information about the geology of the entire Great Plain, whereas the seventh chapter treats separately the geology of the most important regions. The meso-regions are grouped in two mega-regions: the territory between the Danube and Tisza and the Trans-Tisza territory.

Among the morphological and geological properties of the regions, the ground-water conditions are crucial importance. On a considerable part of the Plain the phreatic ground-water level lies near the surface, in a depth of one metre or less. On the other hand, there are regions where the average depth of the ground-water level is more than 10 m, and the seasonal fluctuation of the water level reaches 4–6 m. The odd thing about the quality of the ground-water is the peculiar diversity of its chemical components and the high degree of the mineralisation. This is due to the great variety of the finely stratified fluvial sediments, deposited on the flat surface by ever wandering rivers. Special importance must be attached to the sedimentary sequence through which the water level fluctuation takes place.

The sequence may be composed of lithologically very different sediments even in adjacent territories. The quality of the ground-water depends on the dissolved material of the different sedimentary beds belonging to the zone of fluctuation.

There are no extensive forests on the Plain. Some woods and groves are following the river channels. Nowadays there are also wood plantations scattered here and there. Characteristic sceneries are the vast grasslands, the meadows and pastures, many of which are spreading eastward from the Tisza river. There are extensive flat salty areas without any vegetation and also are hilly regions where the wind-blown sand is still actually moving among the bare dunes. The major part of the territory is ar-
series ranged stratigraphically to the Levantian substage. The lower part of the Upper Pannonian formation contains the oil and gas reserves of the Great Plain and it is rich in thermal water, too. The upper part of the formation includes brown coal (lignite) deposits near the edge of the Plain.

At the terminal part of the Pliocene the basin bottom became land surface due to the epirogenetic rise of the whole Carpathian territory. Fluvial sedimentation started in the inner part of the basin about the beginning of the Quaternary. As a result of a fluvial activity 600–700-m-thick sedimentary series were deposited in the deepest part of the basin.

Detailed paleontological studies were devoted to trace the biostratigraphic Plio-Pleistocene boundary, which was uncertain because the faunal sterility of long sedimentary sequences. Neither the cooling of the climate could be proved for lack of pollens in the sterile series. There have been found no reliable criteria to establish the stratigraphic inner boundaries of the Quaternary as correlated with the four big glaciations observed and demonstrated in the Alps. Paleontological investigations could only identify two biostratigraphic units in the Pleistocene fauna, an Older and Younger Pleistocene. It was in the middle part of our century when more faunal zones were distinguished in the Pleistocene (KRETSZI 1953, 1982) and much more climatic cycles were evidenced upon the results of pollen statistics (RÖNAI 1969).

Significant scientific achievements have produced the paleomagnetic analyses made on the core samples of two boreholes put down in the Körös Basin. This is a deep Quaternary local depression, where the sedimentation was continuous during the Quaternary. All paleomagnetic reversals and events have been demonstrated in the cores back to 5 million years. The change of the limnic sedimentation into fluvial was synchronous to the Matuyama–Gauss reversal (2.4 mill. y.). The paleomagnetic events contributed to the dating of the inner boundaries of the Quaternary sequence.

Another tool for stratigraphic correlation was recognised in the granulometric cyclicity of the fluvial sedimentary sequences, which could be correlated with the vertical Quaternary tectonic movements. The Pliocene tectonic movements can be characterised by uniform sinking processes over large areas in the Pannonian Basin. On the contrary, the Quaternary vertical movements have produced small blocks. In the earliest Pleistocene, which lasted from the Matuyama–Gauss paleomagnetic polarity change to the Olduvai event (2.4–1.6 mill. y.) the climate was moderately warm but very humid. The humidity was the decisive difference as compared to the Late Pliocene climate, which was hot and dry, almost desertic in the Carpathian Basin. During the earliest Pleistocene 100–150 m thick fluvial sequence was deposited in the three deepest local depressions.

The Early Pleistocene lasted from the Olduvai paleomagnetic event to the Brunhes–Matuyama reversal (1.6–0.7 mill. y.). The climate of this period changed very often. Moderately warm, temperate and cool periods alternated several times and the humidity also changed frequently. Not only the main annual temperature and the sum of the humidity was different, but the seasonal distribution of the precipitation and the temperature changed characteristically. In the Early Pleistocene about 200-m-thick sediment sequence was deposited in the three deepest local depressions. The other parts of the lowland territory sank a few ten meters only, except for the Nyírség where innumerable rivers coming from the North-Eastern Carpathians developed a big common delta.

The Middle Pleistocene sediments can hardly be differentiated from the Upper Pleistocene ones. The climate of both times was cold with few and short intervening temperate periods. There are no paleomagnetic events upon which the inner boundary be set between the two last stratigraphic units. The time span of 700 000 years includes the three last glaciations and almost the whole time which formerly was called Pleistocene. This is the really cold part of the Pleistocene in comparison with the respectively slightly warmer earliest and early periods. In the international geological literature the chronostratigraphic boundary between Upper and Middle Pleistocene is uncertain. Most stratigraphers consider the last two glaciations assignable to the Upper Pleistocene, which gives a time span of about 250–300 000 years. Others trace boundary in between the last and "next to last" glaciations, which means about 130 000 years.

During the last 700 000 years the subsidence was widespread over the entire Plain, but there were some opposite movements, too. The middle part of the region between the Danube and the Tisza as well as the region of Nyírség were lifted up at the end of the Late Pleistocene. Consequently, the fluvial sands on the surface transformed into wind-blown sands in a thickness of 30–50 m. This time coincided with the time of formation of the loess layers, therefore loess intercalations are to be found among the wind-blown sand layers. The speed of subsidence was generally slow in the Middle Pleistocene and faster in the Late Pleistocene. Thick silty and clayey layers represent the Middle Pleistocene in the borehole profiles. More sandy and partly gravelly are the sediments deposited during the Late Pleistocene. The big gravelly dejection cones of the Maros, Szamos and Sajó rivers advanced forward from the uplifted peripheries toward the inner part of the big Basin. Holocene sediments cover the big actual flood areas of the rivers. They represent about one quarter of the whole territory of the Great Plain. The thickness of the Holocene layers, gravels, sands and silts only exceptionally exceeds 2–4 m. In some parts of the huge alluvial plains big peaty layers have developed.
Detailed studies were devoted to the Quaternary climate history of the Great Hungarian Plain and they have provided remarkable results. For the 2.4 million years of the Quaternary, 25 remarkable climatic changes have been proved by numerous pollen finds. The Great Plain is a buffer territory between the big European climate zones, lying in the geometrical middle point of the continent. The Carpathian Basin is the meeting place of the oceanic, continental, boreal and mediterranean climate zones. The different influences are alternating in the daily and seasonally weather conditions, but there are months, even years during which one or the other effect is prevailing. The meteorological observations, dating back to more than 200 years, show that there were many years long periods too with the domination of one or the other influence. We can discover the same symptom investigating the many thousand years long climate periods of the past. The global changes in the European climate were not restricted to the growth or diminution of the annual temperature and of the humidity, but modification have been caused of the different seasonal distribution of these elements.

The climate of the Pannonian Basin was warm enough and very humid in the Earliest Pleistocene. During this 800 000-year-long period seven major climate cycles could be determined, during which the temperature and humidity changed considerably. By and large this was a temperate warm climate, the continuation of the hot and dry Pliocene climate, with diminishing warmth and growing humidity. The oceanic influence was dominating. During Early Pleistocene time the mediterranean climate influence entered the Carpathian Basin beside the oceanic one. They could prevail because the Alps and Dinarides had not emerged considerably yet. The Lower Pleistocene shows nine major climate cycles during a 900 000-year-long period. The climate was by and large a temperate forest climate. The warm and cool periods followed each other with greater differences than before. There were bigger changes in the seasonal distribution of the humidity, too. During this long period there could be demonstrated mediterranean climate cycles with hot and dry summers and mild humid winters, that is what the arboreal pollenss suggest. The orography of the southern part of the Carpathian Basin facilitated the prevalence of the mediterranean climatic influence in this time. Towards the end of this period the climate came nearer to the present climate of the Northern European cyclonic zone, to the zone of the west winds. Upon pollen statistics, six climate cycles can be distinguished in the Middle Pleistocene and four ones in the Late Pleistocene. They were almost entirely cool or cold. Four of the cycles were humid and six were dry. The climate on the whole resembles the North Scandinavian climate of today.

Investigating the succession of the climates in the Pannonian Basin, we can discover a geographically S–N wandering character of the climate zones. In the earliest Pleistocene the climate of the Pannonian Basin was like the present climate in the North African coastline. Thence in the Early Pleistocene we had a climate of Italy and Greece. Thereafter it was followed by the cool climate of Continental Europe during the Middle Pleistocene and, at the end of the Late Pleistocene, the climate was like that of Scandinavia nowadays.

Concerning the tectonic development of the Great Plain, it can be observed as a certain balance between the subsidence of basin and the uplift of the mountain territories in the Carpathian Basin. During the Quaternary the maximum size of subsidence was 700 m in the Lowland, and the maximum size of uplift was 400 m in the mountains. The mountainous regions are twice bigger than the lowland surfaces. The total Quaternary denivellation exceeded thousand metres. The main fault lines stretch go from SW to NE. but there are secondary lines in N–S direction and also NW–SE crosslines.

In spite of the remarkable tectonic movements taking place during Quaternary time, the present-day grade of seizmicity of the Hungarian Great Plain is low. Hundred years of precise observation shows only a few earthquakes with the biggest ones hardly reaching degree 8 on the Richter Scale. Especially aseizmic is the Trans-Tisza territory. The earthquakes are not associated with the main Quaternary tectonic lines.

The geomorphology of the Great Hungarian Plain and the Quaternary rocks

Three geomorphological levels can be distinguished on the surface of the Great Plain. The lowermost one is the actual alluvial plain, the flood plain, covered by gravel, sand and silt. The second level is the Upper Pleistocene surface which lies 2–6 m higher than the flood-plain of the rivers in our days. Generally it is covered by loess and loess-like silts and clays. The third level is the surface of the sand dunes, that rises a few ten metres above the Holocene flat levels.

Rivers determine the topographic features of the lowland’s surface. There are two great sandy-gravelly dejection cones on the Plain. The Danube built the first one southward from Budapest, the second is the Nyírség in the northeastern part of the Lowland, formed by numerous rivers coming from the rainy Eastern Carpathians. The wind-blown sand is well-sorted granulometrically. The diameter of the main particle size is 0.1–0.2 mm representing 70–80% of the material.
Loess-like sediments cover the greater part of the flatlands, lying a little higher above the inundation plain. The thickness of the loess sediment is only a few metres; thicker loess sequence can be found in the peripheries of the Lowland and in Hajdúság. In the inner part of the lowland the loess cover is more silty than the typical loess and has a smaller lime content. It is a sort of marshy loess, infusion loess as called after the Hungarian nomenclature. That means that the sand flour carried on by the wind was then deposited on a wet surface or even in shallow water on the alluvial plain, and was mixed with fine-grained fluvial material. On the large flat plains, where the seasonal floods have deposited their finest material, we find many kinds of silt and clay. The proportion of them reaches 60–70% in some boreholes where the sinking was slow. The thickness of the clayey top sediments reaches 10–15 m in the Hortobágy and Nagykunság regions.

The largest amount of the Quaternary sediments was carried and deposited by the Tisza river on the Great Plain. The Tisza carries usually much more floating load than the Danube though the water output of the latter is three-four times bigger. More than 1/3 part of the Great Plain was regularly inundated by the floods of the Tisza river before the river regulations. At flood times the Danube inundates at the most 1/20 part of the Great Plain. Beside the Tisza it is the Körös river which carries the largest part of the sediments across the Great Plain.

The flood plains have variable micromorphology, due to the wandering rivers, the abandoned channels, the sand dunes accompanying the living branches and the backwaters. Apart from distinctly shaped forms there are very flat inundation plains, marshy depressions, peaty bogs. The morphology of the loess surfaces is much more even. There are extensive tablelands situated a bit higher than the flood plains without any kind of microrelief on their surface. On the other hand, there are again regions where the Pleistocene loess table lies in the shadow of a higher situated and well-watered region. In this case the creeks and brooks coming from the wet region cut narrow but deep channels into the loess surface. Most diversified is the morphology of the sandhill regions. All kinds of dune forms can be found here, but at the same time with large dry valleys and round flat surfaces, too. There are regions where the surface of the dunes are totally bare and the sand is still moving. Beside the main surface deposits there are others, which are present in small areas only. Such are the different evaporites: the meadow chalk or lime mud, the very widely stretching alkali salts and the iron ore concretions in sandy valleys. It is worth mentioning the specific red clays, which are found in the peripheries of the Plain and are alternating locally with loess layers. The original material of these formations is mostly eolian sand flour mixed with deluvial and eluvial slope material.

The geological key boreholes and the artesian drillings have discovered the complete Quaternary sedimentary series of the Great Plain. Gravelly beds are only found in the peripheries close to the foot of the mountains. It was only the Danube river that carried gravel far into the basin. We can find huge gravel cones deposited in the beginning of the Quaternary on the surface southward from Budapest (Pestlőrinc, Vecsés). Farther towards SE these gravels have been found in growing depth: in a distance of 20 km at 50 m depth; in 80 km distance at 200 m depth; in 160 km distance at 500–600 m depth. The terminal of the Danubian gravels is the local sub-basin between Csongrád and Szeged. This is the deepest local basin and the biggest and best underground water reservoir of the Great Plain. The two other deep side-basins, the South Jászság and the Körös basin were filled with fine-grained material: fine sand, sandflour, silt and clay.

The core material of the key boreholes have been granulometrically analysed very detailedly in the Sedimentary Laboratory of Szolnok. The analyses demonstrated granulometric cycles in the sedimentary series. It was found that the cyclic sedimentation is characteristic of fluvial deposits. The granulometric composition of the limnic sediments differs distinctly from the fluvial ones. Two kinds of fluvial sedimentary cycles can be distinguished: the complete, or symmetrical cycle and the semi-cycle. The complete one starts with coarse material, which turns gradually finer during sedimentation. The middle of the cycle is composed of the finest material, usually of fine silt or clay. Then the sedimentation continues with gradually coarser and coarser material and the cycle ends with coarse sand or gravel. The semi-cycle starts, like the complete one, with coarse material, but ends with the finest material. The silty-clayey beds pass sharply into coarse material initiating a new cycle.

The geologist, working in lowland territories, has much trouble with the classification and denomination of the mixed loose clastic sedimentary rocks. In most cases there are no real clays, silts or sands in the field, but mixtures. Thus the denomination of the material is a long and complicated procedure (e.g. yellow fine sand with some silty content and a little clay fraction; or, dark brown meadow clay with a large quantity of silt stratified with fine sand and sand flour etc.).

For the new and complex mapping of the Great Hungarian Plain, a very simple method was adopted for marking the granular loose material of mixed granulometry. The marking started from the granulometry. The main particle size fraction was marked with single code numbers:
(1) gravel  
(2) sand  
(3) sand flour  
(4) silt  
(5) clay

The sediment was marked with these numbers put in order according to the weight they shared in the whole material. For example, 452 represents a silt (4) material in which the clay particle size fraction (5) has the second rate and the sand (2) is also present with significant weight. It was decided to use the code number of a granulometric fraction twice if its weight exceeds 60% of the material. For instance, 332 is a typical loess sediment, the weight of the sand flour fraction being higher than 60% in it and in the second place there is also sand in the granulometry. As in the sand sediments the weight of the sand fraction is usually over 60% the code number begins with double 2 and the third number refers to the grain size of the sand:

(221) coarse sand  
(222) middle grained sand  
(223) small grain sand  
(224) fine sand

If the sand material contains silt or clay fractions in a considerable weight, they can be represented by a fourth number using a decimal point. E.g. 224.5 = fine sand with significant clay fraction. The code numbers proved very useful at the mapping. They helped to identify the similar sedimentary rocks in an extensive and variegated territory.

Above the Pannonian limnic layers and below the Quaternary fluvial sediments a specific variegated clay sequence is intercalated in most parts of the Plain. Its thickness may be 200–400 m, and it was deposited during the latest Pliocene. It is a terrestrial formation with very unsorted granulometry and characteristic by the fact that it is unfossiliferous. After the drying out of the Pannonian Lake the surface materials were redeposited several times by the rivers and by terrestrial mass-movements on the slight slopes. The lime content was leached out and the material shrunken into concretions. Due to the unsorted character it is best compressed and so most impervious.

The heavy mineral composition of the sands was analysed in order to discover the origin of the river loads and of the material deposited over the alluvial plains. It is rather complicated to draw inferences from the heavy mineral composition of the river sands to the mountainous source area. The Carpathian mountains are built of very different rocks and most part of the rivers flow across many parts of the mountains. The big rivers can gather similar heavy minerals from very different places along their long course in the mountains.

**Ground-water conditions**

In the Great Hungarian Plain the phreatic water level has vital importance. It generally lies near the surface and the agriculture as well as the engineering have much to do with this water. Not less important are the artesian waters, because the first water horizon is in most cases very mineralized, unsuitable for drinking and for other purposes, too. In Hungary 80% of the drinking water supply comes from underground sources.

The mean level of the phreatic water lies in 3 m depth below the surface. There are huge areas, where the depth is about 1 m or less. There are again others, not so extensive, where the depth is 6–8 m, in some parts more than 10 m. The water table fluctuates seasonally and according to multiyear periods. The size of the fluctuation depends on the humidity of the climate and on the granulometric condition of the water-bearing layers. In gravelly beds the fluctuation is small, usually a few dm only, in coarse sand it is 1–2 m yearly, in fine sand and silt 2–4 m, and in clays even more. The biggest fluctuation occurs in the fissures of clayey beds. The range of the multiannual fluctuation exceeds with 1–2 m the seasonal one. In the trendline of the multi-year fluctuation one can observe 14–16 and 28–30 year long rising and sinking periods.

The yield which can be produced from the uppermost waterbearing layer is generally small. Only the gravelly beds give a major amount of water, but areally they are of a small extent. From sandy aquifers lying near the surface the normal dug wells can produce 5–10 l water per minute, because the layers are thin and the grain-size is fine. In coarse sand the yield of phreatic wells can be 50–100 l/min. The horizontal flow of the ground water is very slow in phreatic aquifers due to the small gradient of the layers and to the fine particle size granulometry. It explains the very different chemical composition of the ground water in neighbouring territories. The richest regions in phreatic water are: 1) the Holocene Danube valley from Budapest to Baja; 2) the mouth of the Sajó river; 3) the mouth area of the Szamos and Tisza rivers.
The chemical character of the uppermost ground water shows an astonishing variety over the Great Plain. Close to each other we can find water with 400–500 mg/l and with 2000–5000 mg/l dissolved solids content. The kind of salts can be very different also. Widespread are the alkaline waters with overwhelming sodium-hydrogencarbonate content. Frequent are the bitter waters with sodium or magnesium-sulphate ions. Here and there there are sodium chloridic waters. Near to the rivers and in sandy hills there are also normally mineralised calcium-hydrogencarbonate waters.

In the years of 1950–1954 parallel with the geological mapping all the dug wells over the Great Plain were registered. Around 700 000 wells had been listed. The depth of the wells, the depth of the water table below the surface, the amount of water in wells, the temperature of water and the type of construction of the wells were measured and registered. From many wells water sample was taken for chemical analyses. The results of the registration and the mapping have been published in a monograph edited in 1956. Later, in 1961, a map was compiled and printed showing the average depth of the ground water table below the surface on a scale of 1:200 000.

The knowledge of the deeper-situated ground waters derives from thousands of artesian drills and wells, constructed during the last hundred years. In monitoring the makeup of the Great Plain especially that of the Trans-Tisza region, the discovery of the artesian aquifers and the drilled wells had crucial importance. The river pattern is very poor here, and the uppermost ground water very mineralized, almost undrinkable. The first artesian wells were constructed in 1878 and 1884. It was quite a miracle for the country people to see the thick water columns bursting out from the soil and rising as highly as to ten or twenty metres above the surface providing clear and healthy water where the lack of water had been the greatest evil. In a few years hundreds of artesian wells were drilled, and after twenty years, at the end of the century more than one thousand artesian wells were put in function in Hungary, mostly in the Great Plain.

We find the best artesian aquifers in a local basin around the southern part of the Tisza river. Excellent sandbeds are to be found here in a depth ranging from 200 to 400 m and the pressure conditions are also favourable. The water in wells rises above the surface already from 100–200 m depth and the water of the flowing wells is very good for drinking. The temperature of water coming from these depths is about 20–30 °C, which means that the drinking water has to be cooled. The yield is good, 200–300 l/min. can easily be gained from a simple well. The mineralization of the water is very low, solids by 300–400 mg/l, mainly sodium-hydrogencarbonate, are dissolved in it. The deeper-situated layers are also rich in water. Sandy-gravelly beds are to be found down to a depth of 1000–1200 m. From a depth of 1600–2000 m excellent thermal water can be gained in a rather big amount.

There is no side-basin in the Great Plain, which is so extensive with so good aquifers in such a big number, other than this one in the southern zone of the Tisza river. The Szatmár plain has also good aquifers, but only 100–200 m deep. There are numerous sandy layers in the hills of Nyírség in 200–300 m depth. The yields are medium, the quality is good. The pressure conditions are disadvantageous as compared to the situation in the southern Tisza basin. Going downward the water heads stand lower and lower. It is almost the same situation as in the sandhills between the Danube and the Tisza.

There are regions in the Great Plain which are very poor in artesian water. Such is the southern part of Jászság, where exploitable aquifer can only be found deeper than 500–700 m. Poor is in artesian water the Körös basin and not very rich is the Nagykunság.

The pressure conditions have outstanding importance in the Great Plain. In the hilly sand regions the pressure gradient is negative down to about 500–800 m. In this depth the negative gradient changes to a positive one. Overflowing water can only be found deeper than 1000 m. The low-situated flat areas in the Trans-Tisza region have positive pressure gradient. The water heads rise as we go deeper and deeper in the basin. The rate of the rising is different horizontally as well as vertically. It depends on many factors, such as the distance from the peripheries, the thickness and the granulometry of the aquifers, the character of the sedimentary series above and below the aquifer, the dipping of the layers, the tectonic makeup etc. Beside the territories with positive and negative pressure gradient, there are others, where there is no gradient, where the water table is hydrostatically balanced. Negative is the pressure gradient in the sandhills between the Danube and the Tisza and in Nyírség. Positive is the gradient along the foothills of the mountains and around the sandy hills.

The Hungarian Basin is known for its conspicuous geothermal anomaly. While outside the Carpathians the underground temperature is growing in every 30–35 m depth interval by 1 °C, in the Hungarian Basin 18 m is the average distance for 1 °C growth of temperature. It means that we can gain 70–80 °C warm water from as deep as 1000 m. There are, however, deviations from this average. In some parts of the Plain a depth interval of 8–10 m is enough for a temperature growth of 1 °C to be recorded. There are other places where 28–30 m is necessary to achieve the same growth. The explanation of the geothermal anomaly is the higher situated and thinner Earth’s crust below the
infiltration territories—can be explained the seasonal water level fluctuation appearing without or semipermeable layers. Only with the propagation of the pressure waves—descending from the ranging from 500 to 1000 m. These aquifers are covered by manv-hundred-metre-thick impermeable bigger at every depth than in a year of drought. In any case the range of the water level fluctuation retardation in great depths. The velocity of the pressure waves is enough to transfer the rise of the rise of water level indicates that the process of the recharge has started. But the water flows very slowly toward the middle part of the basin and

Great Plain. The local differences in the anomaly are caused by the lithologies and stratification of the Quaternary and Pliocene sedimentary sequences in the different parts of the basin. About 400 thermal wells are now functioning in the Great Plain.

The mineralization of the artesian waters is very uniform. It is in striking contrast with the varied mineralization of the phreatic waters. In the deep-situated Quaternary and Pliocene sediments there are only two kinds of water: Ca-Mg/hydrogencarbonate and Na-hydrogencarbonate waters. The first is to be found in the infiltration regions, in the sand dunes and in the peripheries; the latter is in the deep-situated layers of the flat regions with positive pressure gradient. In gravelly and coarse sand sequences the mineralization of water is growing with the depth, in clayey-silty layers the mineralization is high even in the uppermost layers. The chemical components of the artesian waters are changing from time to time even if there was no water production from the wells. The change does not follow one direction. The amount of dissolved salts or any of the ions can increase or diminish and the trend may change reversely, too. A disadvantage of the artesian waters is given by their gas content. It is small in the Quaternary and Pliocene aquifers, nevertheless, it causes inconveniences for the construction of wells and in confined waterworks. The gas can filter from deeper situated layers upward and can be syngenetic in swamp-peaty beds. Most frequently it is methane gas (CH₄) which appears in the wells, but there are also wells with N₂ and CO₂ gas content.

Water of the Quaternary layers is in communication with atmospheric waters. The recharge of the water-bearing beds comes from the surface. Fossil water can only be expected in the Lower Pannonian layers, where the water has sodium-chloridic character. The infiltrating atmospheric water carries Ca-Mg/carbonate solution and maintains this chemical character in gravelly and coarse sand layers to a depth of 300–600 m. Towards the depth the quality of the water changes to Na-hydrogencarbonate type. That change occurs as a rule when water crosses silty and clayey beds in its long way toward the depth. In clayey and silty sequence the change of Ca-Mg and Na ions proceeds already near the surface in the downward-seeping water. So just below the ground surface the water has sodium hydrogencarbonate character.

The velocity of the horizontal seepage can be examined by hydrodynamic and hydrochemical measurements in limited areas. To check the long-distance water movement in a huge basin, such as for instance in the Great Hungarian Plain, is really a hard task. To get information on the movement of water in the different deep aquifers with different granulometry and structure, the Hungarian Geological Institute constructed check-wells in the Great Hungarian Plain. The check-wells are equipped with automatically recording piezometers, which display the movements in the order of millimeter.

The written curves of the water level movements display the fluctuations caused by the earth tide, by atmospheric pressure changes, by seasonal and multiannual discharge and recharge in the underground aquifers. The size of the fluctuation caused by tidal movements is about 2–3 cm, that of the atmospheric pressure changes is 10–20 cm; the seasonal fluctuation ranges between 1 and 3 m and the multiannual fluctuation exceeds many metres in the Great Hungarian Plain. Both fluctuations caused by the earth tide and by atmospheric pressure change appear with the biggest amplitude in the deepest wells and are sometimes unobservable in shallow wells.

Very regular is the seasonal fluctuation of water table in different depths. It appears in all depths at about the same time. In spring there is a rise in the water level in all wells. It culminates at the end of the season. The summer begins with a decrease of the water level, the lowest point sets in autumn. Then it begins again a rise at the end of the autumn and a standstill follows in winter. This regime of the water level fluctuation can easily be explained in the uppermost phreatic aquifer. In springtime the infiltration of the thawing snow rises the ground water level. In summer, the decrease of the water table can be attributed to the heavy evapotranspiration. The rise in autumn can be ascribed to the rainy autumnal season and the standstill in winter to the frozen surface. This explanation cannot be applied to the water fluctuation observed in the aquifers situated at depths ranging from 500 to 1000 m. These aquifers are covered by many-hundred-metre-thick impermeable or semipermeable layers. Only with the propagation of the pressure waves—descending from the infiltration territories—can be explained the seasonal water level fluctuation appearing without retardation in great depths. The velocity of the pressure waves is enough to transfer the rise of the water level from the regions of infiltration to the middle part of the Great Plain and to depths of many hundred metres in a few days.

The size of the yearly fluctuation of the water table is influenced by the humidity of the year. In humid years with thick snow in winter and with rainy autumn, the range of the fluctuation is bigger at every depth than in a year of drought. In any case the range of the water level fluctuation is proportionate to the recharge of the aquifers. The rise of water level indicates that the process of the recharge has started. But the water flows very slowly toward the middle part of the basin and

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to a greater depth. Whatever slow is the movement of water, the underground circulation is steady. Water moves from the infiltration territories toward the middle and the bottom of the basin. From the accumulation centre, water moves upward, giving way to the superior pressure. The upward movement proceeds as far as to the uppermost aquifer. From here the evapotranspiration transmits water to the air, and closes the circulation.

It is very difficult to measure the speed of the water flowing through innumerable and differently permeable layers for a long distance. However the speed has crucial importance, because the real recharge of the deep-situated aquifers depends on the speed of the filtration. In our days isotopic measurement helps to assess the absolute age of the underground waters. C¹⁴ measurements made by the Laboratory of the Institute of Water Management (VITUKI) have demonstrated that waters infiltrated in the northern mountain regions moved in the Plain 50 km in a depth of about 100 m within 8000–10 000 years. Waters recorded in a depth of 1100 m turned out to be 22 000 years old in the middle part of the Plain (Csongrád).

### Economic geology

Centuries ago the traditional aim of the geological reconnaissance was to discover mineral resources. It happened only in the second part of the past century that attention was paid to the geology of the lowlands, at that time seemingly lacking in useful mineral resources. First the soils were mapped in the Plain. In this respect the agrogeological mapping, which started in Hungary at the end of the 19th century, was a pioneering activity. The first international agrogeological conference was organized in Budapest in 1909. Later oil and gas fields were discovered in the Plain and, apart from them, the underground water has become the most important “mineral” resource of the Great Plain. Nevertheless the agricultural land and the fertile soils were always and remain to our days the most important national wealth of the Great Plain.

One may adopt very different methods of soil classification and for their mapping all over the world. In spite of many endeavours to find an internationally acceptable classification of the soils and though the international soil maps are compiled on small scale, the detailed soil maps are being very differently prepared in the various countries even today.

The soil mapping always had an adjoint purpose in each country. It was expected that the map give a basic economic evaluation of the land. The point was to help the valuation of the land properties, giving basis for the fiscal taxation. Such an evaluation of the rent of the agricultural properties was fixed in Hungary in 1913 to serve as a basis for taxation till today. The revision of this work is in progress in our days.

The value of the agricultural land depends not only on the geological properties but on human impacts, too. The most efficacious alteration in the rent of the land can be achieved by irrigation. In Hungary, the first attempt for constructing large-scale irrigation plants on the Great Plain was made between the two great wars. The actual works started after the Second World War. Two dams were built on the Tisza river at Tiszalök and Kisköre. Main irrigation canals were constructed to make possible the irrigation of about 400,000 hectare land. But the capacity of the irrigation plants was not utilised entirely for years. Only a third or a half of the equipped territory was watered regularly. The technical construction work had not been squared with the education of the peasants. Irrigated farming is a special culture, it needs a very intensive schooling when introduced in a new territory.

Although the difficulties are big and of many kinds, the irrigation is essential for the economic development of the Great Plain. The future project is the third dam, which is to be established at Csongrád. This will accomplish the canalisation of the Tisza river and will render possible the creation of the Danube–Tisza navigation canal, somewhere in the middle part of the sandhill region.

One of the most harrowing lack is the missing of building materials in the Great Plain. No hard rocks, no gravel, not even sharp grained sand are available. The rounded grains of the windblown sand are not appropriate for building. The lack of the mineral building materials is all the more sensible, because there are no forests on the lowland, the timber is also missing. There are some brickyards based on loess and loesslike materials, but the quality of their products is not first class. The deficiency of the building materials on one hand, the shallow depth of the ground water table on the other, furthermore the delicacy of the loose granular sediments at foundation make that the engineering geology has to accomplish many difficult tasks and has an outstanding importance in every kind of construction on the lowland.

Lowland clays are very good for pottery. Pottery has ancient tradition in the Trans-Tiszta region. Famous artisans are working today at Mezőtúr, Hódmezővásárhely, Orosháza, Szentes.

It was in the first years of the 1960s that relatively rich oil and gas fields were discovered in the Great Plain. The oil and gas prospection and production started in the Transdanubian part of Hun-
gary, in the 1930s. Investigations were also made in the northern part of the Alföld (1918–1936 and 1950–1953), later on in the middle part, around Szolnok (1953–1960), but with little success. A few gas-producing wells were established, but oil was found in small quantity. In 1964 it was discovered the oil field near Szeged and Algyő, that became the most productive area in the country.

The oil and gas are stored in Pliocene and Miocene sediments at about 2500–3500 m depth. The reserves are not big. The producing structures are of small or medium size, and scattered over large areas. The prospecting was followed in the middle and southern part of the region between the Danube and Tisza and in the Trans-Tisza region near the Transylvanian border. The oil and gas prospection discovered thermal water in many places. They were utilised as thermal baths, but much more for heating of glass houses, greenhouses and, at places, heating buildings and hospitals. The best reserves of thermal water are to be found in the lower part of the Upper Pannonian (Pliocene) layers. They are filled with anomalously hot water. The depth of these sediments is 1600–2400 m in the southern part of the big lowland.

The impact by man is decipherable from the surface of the big Plain. The first effect of the human activity was the deforestation of the lowland. Though originally only groves and wood galleries flourished along the rivers, even much of the trees fell victim to fire. An influence of human origin was the regularization of the rivers and the drainage of about one fourth of the territory of the big Plain. Thanks to the river regularization and to the drainage, the size of the arable land grew by 2.5 million hectares at the expense of pastures and meadows. Considerable work was done to ameliorate the salty surfaces and to drain the peaty areas.

With the growing density of the population the settlements increased, the road net thickened, the extent of gardens, households and farms increased. The development also brought about disadvantageous effects. The pollution of the rivers, lakes and the ground water is a big problem all over the Plain today.

Nowadays, the protection of the natural environment is major concern of the geologists. The designation of rubbish grounds and dung water depots, the prevention of the damages caused by chemical fertilizers and plant protectors against pesticides, necessitates the assistance of the geologist. A kind of protection of the natural environment is the establishment of national parks and protected national areas. There are two natural park territories now in the Great Plain; the Hortobágy and the Kiskunság National Parks.

Apart from the activity of the Hungarian Geological Institute, which is a central State Institute, Geological Local Bureaus were organised in several parts of the country. The Bureau of Szeged and Debrecen serve the territory of the Great Plain. The scope of the Bureau’s duties is the engineering-geological detail mapping, the search for local construction materials, the scientific control of mining activities, the collaboration with local authorities in town and land planning and in the protection of the natural environment.
The region between the Danube and Tisza

The region between the two big rivers consists of three parts. The Holocene Danube valley; the northern part of the sand hills, which leans against the Tertiary hills of the Gödöllő region; the southern sandy island with a separate morphology. The basin bottom declines from NW to SE. It is formed from Paleozoic and older rocks, here and there covered with relatively thin Mesozoic and Tertiary layers. The thickness of the Pannonian (Pliocene and Miocene) granular layers is 400–1000 m in the northern and western part; 2000–3000 m in south-east. The thickness of the Quaternary is 50–100 m in the northern and western part, 300–600 m in the south-eastern corner.

The Holocene Danube valley

After the Danube breaks through the defile of Visegrád and turns sharply to the south its alluvial valley is narrow as far as it approaches the surroundings of Budapest. Southward from Budapest the Holocene valley gets widening and its width is 15–20 km in a distance of 50 km from Budapest. The valley is quite flat, but there are some little sand dunes near the bank of the river channels. The broad valley stretches about 200 km long to the south and then it narrows again below the big island of Mohács. This is the recent alluvial plain of the river with two surface level; the New Holocene one, 2–4 m high above the mean water level of the river, and the Old Holocene one, which lies about 6–8 m high above the river.

Most parts of the surface is covered with a narrow silty and loamy stratum. In relatively small areas there is river sand on the surface. The top of them were transformed to windblown sand. Underground a coarse gravel bed stretches overall, the thickness of it makes a few meters in the northern part of the valley and 15–20 m in the southern part. The fine grained cover over the gravel bed also is thickening from north to south. Below the Holocene layers here and there, there are appearing Pleistocene sediments, which have been saved from the erosion of the Danube. Some little spots of the Tertiary Pannonian surface have even been remained as testimony hills amidst the recent Danube sediments. The thickness of the Pannonian layers changes between 50–100 m below the recent Danube valley.

The phreatic water is stored in the gravel bed, but the water level rises up into the fine-grained cover. The seasonal fluctuation of the water level is small in the gravel layer, it grows but in the sand and the silt cover. The average depth of the water table is 1–2 m, it is only deeper in the dunes bordering the river channels. The phreatic water is generally mineralized, 2–3 g/l dissolved solids can be measured in the water samples. Frequent are the sodium-hydrogencarbonate waters in connection with the salt-affected soils. The artesian wells produce water from the Pannonian (Pliocene) beds. The Holocene gravels, close to the surface, are full of water, however the water is usually very salty and it can easily be polluted from the surface.

Mineral resources of the region are sand and gravel as building materials. Huge gravel pits are under exploitation southward from Budapest (Délegyháza). The most important mineral resource is the agricultural land, the soil. It is fertile on the Old Holocene surface rising above the actual floodplain. On the young Holocene surface there are extensive salty soils.

The sandhills between the Danube and Tisza

This region is a huge fluvial dejection cone made by the Danube during the Quaternary. The Danube roved over the whole territory and deposited its loads everywhere. Its gravel is to be found in increasing depth from Budapest to Csongrád and Szeged. Its sand, silt and loam sediments are to
be found everywhere and in every depth. The surface is covered with windblown sand and with loess. At the end of the Pleistocene the territory was tectonically lifted up. The fluvial sand has been transformed to blown sand and loess was settled between the sand dunes. In the northern part of the territory the loess layers are thin and they are appearing in small ranges. In the southern part of the region the loess is the dominating sediment and the blown sand slips in small bands into the loess cover. In contrast to the actual surface, the Neogene basement is a huge inclination from N to S and from W to E. The thickness of the Quaternary layers grows from 20 m to 400 m from north to south and from 50 m to 500 m from west to east. The Pannonian (Pliocene and Miocene) limnic sediments have a thickness of 500–1000 m in northwest and 3000–4000 m in the southeast.

The phreatic ground-water table lies near the surface, its average depth is about 2 m. Bigger depth can be found under the highest elevations, in the northern part of the region, around Lajosmizse and Kecskemét (4–6 m), and in the southern part, below the southwest fringe of the sand hills, and below a thick loess sequence (8–10 m). The water bearing layers are thin and in spite that there are several aquifers in the very stratified sequences, the amount of the water stored in the layers is small. The phreatic ground-water is not so mineralized, as it is in the Trans-Tisza territory. The average content is below 1 g/l. Nevertheless there are places where the dissolved solids amount to more than 2–3 g/l. The latter are waters with sodium-hydrogencarbonate, others with high sulphate content.

In the deeper Quaternary sedimentary series there are many water-storing layers. If the amount of the phreatic water is small, or if the uppermost aquifer is polluted, being close to the permeable surface, one can find enough good water in a depth of 100–200 m. But the yield of the wells is mediocre. The conditions of the water supply are investigated by five well plants of the Geological Institute, situated along a line from west to east across the sand hills. The check-wells are registering the water-level fluctuations, that is the pressure changes at 5 places in 15 different depths. Half of the wells discover the Quaternary aquifers, the other half those of the Upper Pannonians. The results of the last ten years observation show a constant lowering of the piezometric heads. The pressure gradient is negative in the wells of the sandhills. It is about 500 m deep, where the gradient turns to become a positive one. The geothermal anomaly is not so high as everywhere in the Trans-Tisza region. A single exception is, near the Tisza river, the region of Tiszakécske, where the highest anomaly was measured in the whole Great Plain.

Mineral resources are lacking in this region, as like as in other places of the Great Plain. The most important wealth is the soil. In the past centuries the sandy soil was estimated as a poor soil. Now, after the spreading of orchards and vineyards, the value of the sandy lands has grown considerably. The oil and gas prospecting started soon enough in this region after the second world war. Investigations were made in the neighbourhood of Nagykőröös, Kecskemét, Kerekegyháza, Ízsák with no significant result. Later in the southern part of the sand dunes, gas producing structures of middle capacities were discovered (Úllés, Ásatthalom, Zsana).

The Tisza valley

The Tisza is the main river of the Great Plain. It flows in the N-S axis of the lowland. Its catchment area embraces the major part of the flat land and also the sandhills between the Danube and the Tisza. The Danube, the bigger river, gathers the water of a few little creeks from a small territory of the sandhills. The major part of the hills is drained by the Tisza. The Tisza springs in the NE part of the Carpathian Mountains (the Woody Carpathians) in a height of 800 m. Along its 960 km long course it drains a territory of 157 000 km² large. Only about 250 km of its course flows through mountain territory, 710 km from its entire length is the lowland section. In the mountains the river has a very steep gradient, on the lowland it is the most inert, lazy stream. Its slope gradient is 4.4 cm/km along its lowland section, but along the last 350 km of its course the slope gradient is only 2.3 cm/km. As the river steps out to the Great Plain at Tokaj its flood plain grows enormously. The width of the recent flood plain changes between 10–25 km, but there are sections, where the floods inundate territories which are some 30–40 km away from the river banks.

Though the Tisza river has appeared only from as late as the end of the Pleistocene, it wandered over vast territories during the short Holocene period. The same is to be told of its tributaries. Therefore the present morphology of the surface does not correspond with the past morphology, subsisted in the different periods of the Holocene and Pleistocene. Due to the same reason the present morphologic regions do not correspond to the geological regions, which developed during the Quaternary.

The yield of the Tisza river is mediocre. In the middle part of the Great Plain it is 600 m³/s. The Danube carries four times more water at the same latitude. However the floods of the Tisza are much more dangerous, because the river carries 40 times more water in flood time than at low level. In the case of the Danube this ratio is only 1:10. The individuality of the Tisza river is also reflected by its load-carrying capacity. Extremely big is the quantity of the floating load of the river. At the gauge
station of Szeged the average quantity of the floating river load is 12.2 million m³ per year. More than the floating load of the Danube at the same latitude. This enormous river load is spreading over the bottom of the huge alluvial plain at least twice a year.

The plain of Szatmár

Between the sandhills of the Nyírség and the volcanic mountain range, which follows as an inner ring the Carpathians, there is a little lowland intersected by innumerable rivers and brooks on the surface. It is the meeting place of the Szamos, Kraszna, Túr and Tisza rivers mentioning the significant ones only. The lowland is a foredeep before the Northeastern Carpathians, filled with Pannonian lake sediments in a thickness of 500–1000 m, and with Quaternary fluvial sediments in a thickness of 50–200 m. The rivers are running from all directions toward the plain with big fall and their slope gradient decreases abruptly at the border of the plain. Consequently, gravel beds deposited in many rows one above the other in the bottom of the small basin. The surface sediments are sand, silt and peaty loam. Ground-water is abundant in any depth.

Mineral resources are sand and gravel, peat and underground water.

The region between the Tisza and the Bodrog river

A large number of the rivers coming from the very precipitous Carpathians converge between the Zemplén mountain and the sandhills of Nyírség. They enter together in the middle part of the Great Plain through the Tokaj-gate. Before this gate there is a large bay between the rivers Bodrog and Tisza. Today the main channel of the Tisza lies in the middle part of the bay, but there was a branch which once flew just below the hills of Nyírség. The northern part of the bay is called Bodrogköz, the southern part Rétköz. Silty-clayey layers cover the surface with peaty areas. Some windblown sand ranges cross the bay coming from the northeast, from a region, which once was a part of the Nyírség, before the Tisza broke through the sandhills.

The ground-water level lies close to the surface and is mineralised enough. The Tokaj-gate collects all running waters from a rather big territory and leads them through a narrow defile to the middle part of the Great Plain. The veritable plain begins beyond the Tokaj-gate.

The region of Mezőség and Taktaköz

A huge alluvial plain is opening in front of the Tisza river after having passed the Tokaj-gate. The river is winding with big curves over the land changing several times its flow direction. Southward the Pannonian block of the Hajdúság drives it toward the west, then the barely covered foothills of the Zemplén mountain pushes it to the south. At its right bank a little poorly drained bay stretches, called Taktaköz. Further more downwards a large meadow land opens, the Mezőség, between the foothills of the Bükk mountains and the Tisza river. It is a flat territory, covered partly by a thin loess layer, elsewhere by silty-clayey soils and sodic soil big areas. The thickness of the Quaternary layers grows from the foothills towards the river bank and reaches over there about 100 m depth. Below the Quaternary sequence the Upper Pannonian layers hide a lot of lignite beds. Over large territories the lignite beds are settled close to the surface, under a few metres of Quaternary cover. The location is suitable for open cast mining. The vast gravel field at the lower section of the Sajó river has an economic importance. All the other brooks have deposited their gravel fans along the foothills, but they are of small extent.

The ground-water table lies near the surface and there are vast territories, where the ground-water steps to the surface in springtime and are staying there over months. Near the western border of the Mezőség a check-well plant was constructed by the Geological Institute, at Erdőtelek. Four wells are registrating the water-level fluctuations in 18 m, 78 m, 249 m, 321 m depths. The first two wells are tapping Quaternary aquifers, the lower two Upper Pannonian layers. Both sequences are rich in water, the specific yields are 200–300 l/min/m. The pressure gradient is negative till the depth of 300 m, below that level the gradient becomes positive. It means that the atmospheric precipitation has the possibility to filter through the differently permeable layers till 300 m depth. The chemical type of the waters reconfirm the seepage conditions. Till 300 m depth the waters have calcium-magnesium-hydrogen carbonate character. Below this depth the sodium content begins to grow and takes the dominating place of the calcium. The water heads of all wells show a continuous sinking course from 1973 to 1980. Locally the geothermal anomaly is high. There is a thermal bath in Mezőség.
kövesd, where the water is taken from 860 m depth from Mesozoic layer. The temperature of the water is 76 °C in this depth, which proves a high geothermal gradient: 13 m/°C.

Many boreholes for oil were deepened in the region of Mezőkeresztes in the first years of 1950-s, but without considerable result.

Jászság

If we follow the foothill plain toward west moving away from the Tisza river, we reach a county, which has a firm geographic individuality, called Jászság. “Jász” is the name of an ethnic group which has inhabited the territory since the Hungarian contest, in the 9th century. The axis river of the county is the Zagyva, which follows a very straight N-S tectonic line between the mounts of Mátra and Cserhát. Reaching the plain the river changes its flow direction and bends to SE toward the Tisza. The northern part of the county is covered by the debris cones of three rivers: the Galga, Zagyva and Tarna. They are forming a rather low topographic chain before the foothills. The southern part of the county is quite flat. Large sodic soils cover the scarcely inhabited surface.

In the northern part a loess zone follows the fringe of the mountains. It is crossed by the Tarna river and by a gravelly sand range following the river. This range makes a half arch in SW direction along the former course of the Tarna. The northern part of the Jászság is a fertile and densely populated land. The Quaternary sedimentary sequence has a thickness of 100–200 m in the northern part and 300–400 m in the south. Below the Quaternary sediments 1500–2000 m thick Pannonian lake deposit can be found in the middle part of the region, thickening toward the south.

The phreatic ground-water level lies in 3–4 m depth in the northern part of the region and in 5–6 m depth in the southern part. The south Jászság is renowned from the deeply situated ground-water level and from the extraordinary big seasonal and multi annual fluctuation of this level. The ground-water lies and moves in clayey-silty layers, which cover in big thickness the surface. It is obvious that the ground-water is very mineralized in the clayey sediments. Sodium hydrogen carbonate and sodium-magnesium sulphate are the dominant ions in the water.

The southern part of the Jászság has another extraordinary property, too. The Quaternary sediments as well as the Upper Pannonian ones are very clayey down to a depth of 700–800 m. In consequence, the quantity of the underground water is exceptionally small. This is one of the regions of the Great Hungarian Plain which is very poor in underground water.

Two geological key boreholes have been drilled in the Jászság territory. One was put down at Jászladvány in 1965, the other at Hevesvezetkeny in 1971. The Jászladvány borehole, which was sunk to a depth of 950 m, has turned out to be a veritable “museum” of different paleontological finds. The Quaternary stratigraphy of the region could have been determined with enough accuracy based upon the Mollusca, Ostracoda, Vertebrata and pollen finds in the bore cores. The Plio–Pleistocene boundary was found at a depth of 432 m. The Levantian and Upper Pannonian boundary was found at 735 m. The Quaternary sediment series has been proved continuous and divided in four parts.

<table>
<thead>
<tr>
<th>Upper Pleistocene</th>
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<tr>
<td>Middle Pleistocene</td>
<td>130–270 m</td>
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<tr>
<td>Lower Pleistocene</td>
<td>270–345 m</td>
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<tr>
<td>Lowest Pleistocene</td>
<td>345–432 m</td>
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The stratigraphic division has been changed later, after having the results of paleomagnetic measurements at disposal. 50 m from the top of the cores was considered as to be Upper Pleistocene, from 50–130 m the layers were put in the Middle Pleistocene. The other divisions did not change.

In the four parts 24 climate zones have been demonstrated upon the pollen finds. Pollens were very numerous in the cores all along the boreholes. Except at the end of the Pliocene sequence. The granulometric analyses of the core samples showed 10 fluvial sedimentary cycles in the Quaternary sediment sequence. The scientific results achieved at Jászladvány served as a basis of comparison with the analyses and results of the later-drilled holes and core samples analysed.

The geothermal conditions at Jászladvány agree with the average temperature anomaly, characteristic of the whole territory of the Great Plain. The average geothermal gradient is 18 m/°C in the Great Plain.

In order to get information on the conditions of water supply in the southern Jászság, the Geological Institute profited the geological key boreholes to construct artesian observation wells to the best aquifers. In Jászladvány 4 check-wells were built to the following depths: 12 m, 168 m, 331 m, 907 m. The wells proved the very poor capacity of the aquifers. The specific yield of the wells were 5.4; 1.9; 3.2; 15.1 l/min/m. The water of the wells was very mineralized. The salt content was diminishing toward the depth.
The Gödöllő hills

At the northwestern edge of the Great Plain the boundary toward the mountains has a curvilinear configuration. A range of the Pannonian hills, the Gödöllő hills, are running crossward here, toward the middle part of the Plain. The hills are tectonically densely dismembered. The main tectonic lines are directed straight N–S. The Galga and Zagyva rivers follow this fault line while they flow among the mountains. Nevertheless the continuation of this fault line can be searched for onwards among the Gödöllő hills till the first section of the Rákos brook. The abrupt edge of the hills northwest from Cegléd coincides with the N–S Zagyva line. Besides this fault some other longitudinal and crosswise tectonic lines can be demonstrated in the region.

The core of the Pannonian hills consists of clay and sand layers. The hills are covered by loess sequence the thickness of which can reach 25–30 m. The stratification of the loess sequences and the intercalated fossil soils were very carefully investigated in this region (Mende).

The first ground-water level lies in a depth of 25–30 m on the top of the hills. The water is not very mineralized, it is Ca–Mg hydrogen carbonatic type. On the flat surface around the hills the ground-water level lies again near the surface. There are few artesian wells in the hilly region. First because the Pannonian layers are poor of water, secondly because the pressure conditions are disadvantageous.

The Nyírség

After having roughly demonstrated the regions on the right side of the Tisza river, let us see now the geological and geomorphological land units on the left side. The first is the large sandhill region, called Nyírség. Without tectonic reflection and conception, the existence of this geological body cannot be explained. It is a large island, which emerges to a height of 60–70 m from the flat plain around. It has no connection with any mountain feature which could explain the origin of the fluvial gravel and sand composing the core of this big territory in a thickness of 100–300 m. The area of the Nyírség is about 5000 km². It stretches about 110 km long in N–S direction, its maximum width being 50 km. The hypsometric niveau of the plain around the sandhills is 100–110 m above sea level. The summits of the hills go to 180 m height. The east and west boundary of the main body of the sand region follows a strait N–S line.

The Pannonian lake sediments, which form the bottom of the Quaternary sandhills, lie in a depth of 100–300 m below the sandy surface. At the north edge of the hills the Quaternary sediment sequence is 50–100 m thin. The major part of the Quaternary sediments is sand with rather thin silty and clayey intercalations. At the bottom there are gravelly or gravel beds, but in the eastern part only. Below the Pannonian limnic sediments the boreholes found an extremely thick Miocene volcanic rock series, which could be the subsided prolongation of the Zemplén mountains or, maybe the continuation of the northeastern volcanic chain, the Vihorlát, Gutin, Avas. The drillings did not reach the bottom of the volcanic layers till 3000 m depth. There is no knowledge about it, what kind of rocks—probably Paleozoic—form the bottom of the Miocene formation.

The territory was the huge dejection cone of the rivers, which came from the very rainy Woody Carpathians during the first part of the Quaternary. At the end of the second part of the Quaternary the territory had been lifted up. The rivers walked round the emerged territory and deepened the surrounding to such an extent that the territory obtained the shape of a terrestrial island. The sand layers on the surface have been transformed to windblown sand, and the morphology of the surface became hilly. The ranges of the sandhills conserved the N–S direction of the former river valleys. At the south border of the sand island the sediments change to sandy loess and to loess. Westward, the sandhills are bordered by the loess-table of the Hajdúság. The sand of the Nyírség is poor in lime content. This is a difference compared with the kind of sands in the Danube–Tisza region. The grains of the sand layers in the Nyírség are not so well rounded and they are coarser than the grains of the Danubian sands. They are closer to the type of the fluvial sands. Which means they are younger as the wind-blown sands.

The phreatic ground-water lies everywhere close to the surface, and if it is not polluted from above, it is good drinking water. The pollution is easy through the sandy surface. The deeper-situated Quaternary layers are storing good and enough water. The 100–200 m deep wells can cover the supply.
Due to the orography, there are no overflowing wells. The water level of the drilled wells lies 10–20 m deeply under the surface. There are very few thermal wells and baths in the Nyírség. The water temperature in the Quaternary and Miocene layers corresponds to the average value of the Great Plain.

**Hajdúság**

The region, which is called Hajdúság, is a small, but very characteristic part of the Great Plain. It is a long and narrow piece of the Pannonian surface, which emerges relatively high—as a little table—from the neighbourhood. The Pannonian top-layers approach here the actual surface very closely. They are covered by a loess coat, which is about 10–30 m thick at the most. Below the loess cover there are Quaternary sand and clay layers. Amidst the loess and clay layers there are intercalated special red clay zones in several beds. Nevertheless the thickness of the whole Quaternary sequence is 50–100 m only. The Hajdúság loess is a kind of intermediate formation between the typical loess and the infusion loess. This territory was a relatively high-situated part of the Great Plain, which was never flooded by river. There are no fluvial sediments settled on it.

This highly situated Pannonian ridge formed a dam against the river deltas by which the Nyírség area has been built. It is also the frame of the sand dunes on the west side of the Nyírség nowadays. The north part of the loess table is abruptly cut down by the Tisza river. This part forms the opposite doorpost of the Tokaj gate, facing to the Kopasz-hegy. The south end of the loess region is not so well determined. The long and narrow Pannonian table gets widening and lowering as we go to the south and the semi-typical loess sediment gradually changes to sandy loess, silty loess, to the kind of loess homely in the Alföld.

It is not easier to trace the west and east boundary of the Hajdúság loess table. The Hortobágy and the Tisza rivers have eroded the west border of the Hajdúság. The rivers enlarged their alluvial plain to the detriment of the loess table. In the same time on the eastern border wind-blown sand rests on the loess table, originating from the higher situated Nyírség, pushing the boundary between the loessic and sandy territories more towards the east in detriment of the loess surface. In consequence of the bilateral assaults the Hajdúság loess table got a fringed shape. The table is about 90 km long and 10–20 km wide. The Hajdúság table forms an intermediate step between the Hortobágy plain, which lies at 90 m height above the sea level, and the Nyírség, the core body of which lies above 150 m. The surface of the Hajdúság is in 110–120 m height above the sea level. Below the Pannonian and Miocene layers Paleozoic and Mesozoic mountain ranges are found in the bottom of the basin, extending in SW–NE direction. They are situated relatively high here, which is proved by the small thickness fo the Pannonian layers. The thickness of the Pannonian layers is 300–400 m in the northern part of the region and 1100–1300 m in the south.

The phreatic ground-water table lies relatively deep (5–15 m) under the loess table. There are places where the uppermost water level lies deeper than 20 m below the surface. The conditions of the water supply are not good in the Pannonian strata. The wells have small yield and the pressure conditions are not the best. Between the two World Wars oil prospecting drillings were made in this area, without considerable success. The explorers found excellent thermal water in Hajdúszosobszló. After having drilled further boreholes for water supply, they developed the biggest thermal bath in Hungary at Hajdúszosobszló. Later on the thermal water prospecting has continued in Debrecen and a nice thermal bath was constructed in the town, which lies right on the Nyírség–Hajdúság frontier.

The most important natural wealth in this region is the agricultural land. The loess soil is very fertile and the territory is proper for every kind of cultures.

**Hortobágy**

Hortobágy is the name of the huge alluvial plain, which stretches from Tiszalök to Tiszafüred and Karcag. It is also the name of the river, which springs in the northern part of this plain and flows in its axis toward south, and falls into the Körös river. The plain is about 80 km long and 20–40 km wide. It is really so much of a plain, that there are not even a few meter high elevations on it. The region is the floodplain of the Tisza. Before the regulation of the river, the floods, coming from the Tokaj-gate, had swept through the whole plain staying there for months. The coarse material of the river load accumulated in sandhills formed along the bank of the river. The fine-grained material moved to the distant flat alluvial surface. The surface therefore is covered by silt, sand flour and clay. The thickness of the alluvial clay deposits is more than 10 m along the Hortobágy river, which is the draining channel of the region.
The soil of the plain is mostly natronized salty soil with barren surface. Nevertheless there are small parts where the level of the surface is higher situated than the flood plain and the soil is not natronized, but fertile. Sometimes 20–40 cm topographic difference is enough to change the fertility. Yet dominant are the deserted surfaces, uninhabited waste lands. The people use the territory as pasture ground and call it “puszta”.

Long ago endeavours were made to ameliorate the deserted land by irrigation, by the construction of fish ponds, by special soil treatment. A rather big part of the Hortobágy is now a National Park, a reservatum for plants and birds. It is also a touristic sight and showplace. Famous are the stud farms and horse races.

The ground-water lies near the surface (1–2 m) in the middle part of the plain, a little bit deeper in the north and south part (3–5 m). The seasonal and multiannual fluctuation of the ground-water level is big: 1–3 m seasonally, 3–5 m in longer periods. The chemical components of the dissolved solids are very different in the water. There are good drinking waters as well as very mineralized, sodium-rich and sulphate-rich waters. There are places, where the chlorid-ion content is striking high. It was considered that the salt water filtrates along tectonic lines from the deep situated Miocene salty rocks upwards to the surface. Later detailed investigations did not justify the supposition.

Between the two World Wars to the order of the Hungarian Government some oil prospecting boreholes were drilled in the territory, but without considerable success. In the Quaternary layers, the thickness of which is 200–300 m, there are good aquifers with healthy and abundant water.

A scientific key borehole was drilled in the northern part of the territory, close to the village of Egyek in 1972. The borehole was deepened to 700 m depth. The Plio-Pleistocene boundary was found in 250 m depth. Below that the drilling advanced in Levantian clay sediments till 500 m and stopped in Upper Pannonian lake sediments. Though the profile was rather clayey, several good water stocking layers were found, first of all, in the Quaternary sequence.

Waters are of calcium-hydrogencarbonatic character down to the depth of about 50 m. Below that the dominant salt is sodium-hydrogencarbonate. Three check-wells were constructed in Egyek for the observation of the artesian water level fluctuation. Two wells observe the movements in the Quaternary sediments, one is put down to the depth of Levantian–Upper Pannonian boundary. The regime of the water level fluctuation in the wells is very regular. A gradual decline of the water table has been registered during the last 10–12 years in the deepest aquifer (494 m) only.

**Region in the middle section of the Tisza river**

The middle section of the Tisza river between the Tokaj-gate and Szolnok is morphologically not at all monotonous territory. Between the two distant alluvial plains, the Mezőség on the right side of the river and the Hortobágy on the left side, there is a large zone, which follows closely the river and which is formed from innumerable abandoned river channels with a big number of sand dunes following the channels. The sand dunes developed in parallel ranges follow two distinct directions: N–S and NW–SE. These latter seem to be earlier in age and it is possible that they are not the dunes of Tisza river, but of the ancient Sajó. This hilly region is broad enough (25–30 km) in the vicinity of Kisköre, where the second Tisza dam has been built in 1975–1980. A lot of huge abandoned meanders can be found here, the size of which are larger than the actual meanders of the Tisza river. It suggests that a bigger river was running here in the beginning of the Holocene.

Between the sandhill ranges there are silty-loessial sediments in the trenches; here and there patches of sodic soils can be found and all these in a confused labyrinth. The meander zone of the Tisza today is a wide band, dissected in small blocks which seem to be governed by tectonic movements. The right bank of the river is not so diversified. It is almost flat and a major part of the territory is covered by loess. Little brooks and temporary creeks are joining the Tisza. The surface of the southern part can be utilised as pasture only. The Kisköre dam was built in this region and the huge irrigation plant with the main canals and small distributor pipes. The reason of the establishment of this great work is the aridity of the region. The climate is warm in summer, the rainfall very little. Extensive salty soils cover the surface, the melioration of which was expected from the irrigation.

The first ground-water level lies in 1–2 m depth below the surface and in 4–6 m depth in the sand dunes. The fluctuation of the ground-water level in 2–6 m depends on the distance from the river and the granulometric composition of the layers with water moving therein. The first water-bearing layers contain rather salty water. The sodium and sulphate content is big everywhere.

The Quaternary sediments are mostly clayey. The artesian water supply can be taken from a few sandy layers with moderate yield.

The long-term geological mapping work started in this middle part of the Great Plain in 1964–1965 and this has given opportunity to make some experimental geological key boreholes to depths
ranging from 100 to 300 m. Later these holes were used for the construction of check-wells. This is the explanation why we have several artesian check-wells of limited depth in this region. From north to south, they are at Besenyszög, Ölalla, Szolnok, Tószeg and Ócsöd. The wells are tapping Quaternary layers with little yields and strongly fluctuating water heads. The mineralization is growing with the depth.

Nagykunság

This is the very middle of the Great Plain. It is the most remote from the mountain regions, most flat and most clayey on the surface as well as in greater depths. It has no running water on the surface. The rivers flow around the borders of the region, the land has no water on the surface and very little below that. The first underground water level lies 8–10 m deep in some parts of the territory and has 2–3 g/l of dissolved solids. The fluctuation of the water level is big, it can be 5–8 m in some years.

In contrast to the flat surface the basin bottom has a varied relief. The hard rock bottom lies in a depth of 2500–3000 m in the southern and western part of the region and in 1400–1700 m in the northern part. A Cretaceous flysch range runs here from SW to NE as a 1000 to 1500-m-high mountain. Under the south part of the region Paleozoic and older metamorphic rocks constitute the basement. They are overlapped by 1200–1300-m-thick Pannonian lake sediments and 200 to 300-m-thick Quaternary layers. The territory is the southern continuation of the clayey Hortobágy plain. The pressure conditions as well as the chemical type of the underground water change very rapidly horizontally and vertically alike. The Quaternary sediment sequence has few and thin waterbearing beds. In the Pliocene sequence the hydrogeological conditions are slightly better. Thermal baths and the hot water utilisation proves this.

The Hungarian Geological Institute had made a 500 m deep geological key borehole near Kengyel. Another 800 m deep borehole was put down by the oil prospection near Karcag. Both drills crossed rather clayey layers. Some sandbeds were in the upper part of the holes. The Quaternary bottom was found in 200 m depth near Karcag, and in 300 m depth at Kengyel. Utilising the Kengyel borehole, the Geological Institute constructed three artesian check-wells to the following depths: 66 m; 177 m; 311 m. This well plant was the first check-well group established in the Great Plain, which is regularly in function from 1967. Later on a fourth well was built to the phreatic water level at 13 m depth. The pressure gradient is negative down to about 100 m, which is extraordinary, because we are in the middle part of the Great Plain on a flat surface, where the positive pressure gradient is normal. The gradient changes from negative to positive one below 100 m. The yield of the aquifers is very small, generally about 5 l/min/m. The geothermal gradient is 13.0 m/°C, thus the thermal anomaly is greater, than it is usual on the Great Plain. The mineralization of the waters is rather high. In the Kengyel borehole the weight of the dissolved solids is growing from the top to a depth of 300 m, from 881 g/l to 1783 g/l. The seasonal ground-water level fluctuation is less than 1 m. There is a tendency of lowering in the piezometric level observable in the last years. In the deepest well the piezometric water level sank nearly 5 m during 14 years. The velocity of the horizontal seepage in these fine-grained material is very slow, also slow is the recharge to the aquifers.

The only mineral resource of the region is the clay for brickyards and for pottery. There is a little gas production from the Karcag borehole.

The Körös basin

Among the rivers of the Great Plain the Körös river is the second in importance after the Tisza. It is not the biggest tributary of the Tisza, but it waters the biggest part of the lowland. It flows in the W–E axis of the eastern half of the Great Plain. Considering its length, its water yield and the size of its catchment area it ranks after the Maros and the Szamos. The major part of the course of the two other tributaries falls to the mountain territories, whereas the Körös flows in a long section across the plain. The main river is formed by four confluent smaller rivers: Sebes–Körös (Fast-streaming Körös), Fehér-Körös (White Körös), Fekete-Körös (Black Körös) and Berettyó. The length of the river is 364 km, its catchment area is 27,500 km², and its water discharge at the mouth of the river is 105 m³/s.

The Körös and its tributaries are gathering waters from a huge mountain territory and the debris of many kinds of rocks. The debris is deposited in the Körös basin, which is a subsidiary side basin of the Great Plain. It is the second deepest Pliocene–Pleistocene depression in the frames of the Great Plain. The Paleozoic basin bottom lies here in a depth of 3000–4000 m. It is overlain directly by Miocene (Lower Pannonian), Pliocene (Upper Pannonian) and Quaternary deposits. The
thickness of the Quaternary sequence is 200–500 m and mostly consist of silts and clays with intercalated few and thin sand beds. The sediment series represents the whole Quaternary without considerable hyatuses. This was proved by the paleomagnetic measurements made on the core samples of two boreholes sunk in the Körös Basin at Dévaványa and Vészttő. In the bore cores the measurements displayed all polarity changes and events, known from the international paleomagnetic scale. The distances between the paleomagnetic polarity changes measured on the cores were proportionate to the time elapsed between the polarity reversals.

The surface of the Körös basin is covered by Holocene alluvial silts and clays. Here and there remnants of the Pleistocene surface can be found with loessial sediments. There are large marshy territories with peat layers. The territory was frequently inundated with water staying for long time on the surface.

The rivers are coming with steep slopes from the 1000–1800 m high mountains. As they are reaching the border of the lowland at about 100 m height above sea level, the slope of the channels becomes very moderate. The rivers begin meandering, bifurcating. They are changing several times their course. Though the territory is crossed by innumerable abandoned river branches. The alluvial plain changes for a marshy lake during the flood time. After the regulation of the rivers the peaty areas have been drained and the floods warded off.

The protection against repeated sudden floods is the most embarrassing problem of the region. The four initial rivers, which compose the Hármás-Körös (Three-branched Körös) river collect the running waters from a large mountain territory facing west, where the precipitation carrying winds are coming from. The rivers, as they reach the lowland, are converging to one point and they meet in the surroundings of Gyoma. From here waters are carried away in one single channel, called Hármás-Körös. The capacity of the united river bed, which has to carry away the average water output of the member rivers, cannot receive and hold the flood waters if they are coming in at the same time. The member rivers can carry all together cca 2000 m³/sec amount of water in flood time, and the united Hármás-Körös can carry away at maximum 1200 m³/sec water only. The surplus must be spread out over the alluvial plain. The total floating load of the member rivers is about 500 000 m³ in a year, and the Hármás-Körös can carry away 400 000 m³ as maximum. The difference is sedimented yearly on the plain.

It goes from the above related circumstances that the phreatic ground-water level lies close to the surface in many places and it is also easy to understand that the fluctuation of the water level is big in the clayey-silty sediments. The phreatic ground-water is generally mineralized. The average salt content is about 2 g/l, but water samples with 5–6 g/l, even over 10 g/l dissolved solids were found.

Though the Körös basin is the second deepest Quaternary local basin within the frames of the Great Plain, it is poor in artesian water. Among the clay and silt sediments few are the sandbeds, and if there are some, they are thin and mostly fine-grained. The Hungarian Geological Institute established four geological key boreholes across the territory of the Körös basin in W–E direction. The boreholes were put down near Szarvas, Dévaványa, Vészttő and Komádi. Later 15 artesian check-wells were built upon the results of the boreholes. 3 wells at Szarvas, 4–4 wells at Dévaványa, Vészttő and Komádi have been constructed to check the level fluctuation in different depths. Part of the wells are tapping Quaternary layers, and others the Pliocene aquifers. The yield of the check-wells is small: 10–20 l/min/m. The yearly fluctuation of the water table grows from the surface toward the depth. The multiannual curve of the water level regime is tending downward. It was the Szarvas well-plant, where the automatic water gauge was first installed in 1975. From that time we have continuous written data from the piezometric fluctuation. The pressure gradient is positive in all four wells. That means that the ground-water moves upward in the investigated part of the basin. The infiltration territories are remote, situated beyond the political frontier, in the foothill region of the Transylvanian mountains. The water quality shows some relation with the atmospheric water in the shallow depth, in two wells out of the four (Dévaványa, Komádi). In the deeper situated aquifers and in the two other wells (Szarvas, Vészttő) the waters have sodium-hydrogencarbonate character at every depth. The total weight of the dissolved solids is slightly growing to the depth. Water temperature in the four check-wells corresponds to the normal situation in the Great Plain. The geothermal gradient is 16–18 m/°C. We can expect about 60 °C warm outflowing water from the depth of 1100 m.

Two of the boreholes in the Körös basin became renowned on account of the paleomagnetic measurements made on the core samples taken from the holes. From the Dévaványa (1116 m) and from the Vészttő (1200 m) boreholes core samples were sent to Halifax (Canada) for paleomagnetic polarity measurements to be made in the Laboratory of the Dalhousie University. The data have proved that the Quaternary and the Pliocene sedimentation was continuous in this region, with a fundamental contribution to the knowledge of the Quaternary stratigraphy secured. In correlation with sedimentological, faunistic and floristic finds and facts, the Plio-Pleistocene boundary was found.
around the time of the Matuyama–Gauss paleomagnetic boundary, that is 2.4 million years ago. The Olduvai event is the dividing zone between the Oldest and the Old Pleistocene (1.8–1.6 mill. years). The Brunhes–Matuyama paleomagnetic boundary divides the Lower Pleistocene from the Middle Pleistocene. Between the Middle and Upper Pleistocene there is no paleomagnetic event that can serve as the stratigraphic division. The sedimentation rate can also be determined from the paleomagnetic data. This rate was almost steady (0.2 mm/year) during the Quaternary in the Körös basin. The paleomagnetic measurements served as basis for the time schedule of the fluvial sedimentation cycles and for the chronological succession of the climate periods, which have been established upon the pollen finds.

The Körös basin was the place of oil and gas prospection in the 1960–1970 years, but as to now without considerable success. The agricultural productivity of the region is also moderate.

The southern section of the Tisza valley

The most valuable part of the Great Lowland is in every respect the southern part of the Tisza valley. The most productive and best cultivated agricultural land can be found here. This is the richest subsurface water reservoir. Some industries also developed in the region the raw material of which can be found in the territory. Last but not least the richest oil and gas fields were discovered here. The oil production promoted a considerable processing industry. The people of the region have appropriate capacities to utilize the favours of the nature. They are creative in economic, cultural and organisatory play-ground. Szeged, the centre of the region is a town of schools, industry and arts.

The Tisza river flows through this territory in a 100–150 m broad and 10–15 m deep channel, carries in average 900 m$^3$/s water and yearly 12 million m$^3$ suspended load. The range of the water level fluctuation is 12 m. The Körös river carries on an average 85 m$^3$/s water. The Maros river is transporting 190 m$^3$/s water into the Tisza. As for the Tisza and Körös rivers, their floods and caprices were the educators of the Hungarian hydrologists and engineers, who possess international reputation.

The alluvial plain of the Tisza river is surrounded by flood-prevented surfaces covered by fertile loess soils. The uppermost ground-water level lies in 3–4 m depth and is strongly mineralized. There is an opposition in the lime content of the phreatic ground-water and of the soils. Where the soils are poor in CaCO$_3$ the ground-water has it copiously and where the ground-water has no Ca ions, the soils have them.

The best artesian aquifers are to be found in 200–400 m depth and have clear soft water with little dissolved material. These are the best aquifers all over the Great Plain. The mapping staff of the Hungarian Geological Institute set two important geological key boreholes in the territory: at Csongrád and Mindszent. The boreholes crossed nearly 700 m of Quaternary beds and stopped at the depths of 1200 m and 1500 m respectively, in Pliocene sediments. In the drilled sections are built of silty and clayey rocks to as deep as 100–200 m. Below this level, the major part of the layers are sandy, and sometimes even gravelly. The most sand beds were found in the Csongrád borehole, they were the coarsest too and could be followed down to a depth of 1100 m. This part is the deepest point of the Quaternary sedimentation and the central part of the Quaternary accumulation. The Mindszent borehole was 1500 m deep and though it has also crossed many sand layers, the clayey layers represented a bigger proportion than those of the Csongrád borehole section.

In Csongrád and in Mindszent artesian check-wells were constructed for the best aquifers in different depths. The water heads of these wells have shown a considerable decline in the last 8–10 years. The South-Tisza region is the best thermal water reservoir of the Great Plain. The geothermal anomaly is not so high as in the middle part of the Great Plain, but here there are thick sand layers with large quantities of water in the depth interval of 1500–2500 m. The pressure conditions are excellent. From a depth of 100–200 m one can have overflowing water and the water heads rise 15–20 m high above the surface from a depth of 1000 m, to 40–60 m high from a depth of 2000 m. The thermal wells are best exploited in the towns Szentes, Szeged and Hódmezővásárhely.

The Orosháza plateau

This area, which is surrounded by three rivers, is a region of half-circular shape, slightly elevated above the alluvial plains. The surface is covered by loess deposits, which are intersected by fluvial channels and riverside sandhills. There is no running water now in the channels and the sandhills are in transition to become blown sand. The surface is flat, excepted the former river channels and the following sand borders.

The deep core of the plateau is formed by a higher part of the hard rock basin bottom protruding
from SE to NW. The Neogene basement of the plateau lies 1000 m higher than the surroundings.

The buried mountain range strikes in SE direction and attaches to the Transylvanian mountains which emerge to the surface in a distance of 50–60 km. The thickness of the Quaternary fluviatile layers is 250–350 m in the middle part of the region and the Pliocene (Pannonian) sequence does not surpass 1500–2000 m. The plateau is a prosperous agricultural land, with good soils and the cultivation of various profitable plants. The mother rock of the soils is a sort of clayey-silty-sandy loess with very mixed granulometry. The granulometric mixture of the sediments is characteristic in vertical and horizontal directions, too. It is due to the innumerable abandoned river channels, former creeks, widening alluvial strips and buried or unburied sandy river borders or to the several redeposition of the material.

The uppermost ground-water level lies in 4–6 m depth below the surface. Its mineralization is low, about 1–2 g/l dissolved solids are found in the water samples. The major component is the sodium hydrogen carbonate. The fluctuation of the water level is 2–4 m yearly.

Among the Quaternary sediments there are good artesian waterbearing layers. The yield of the artesian wells is 500–1000 l/min, the type of the water is sodium hydrogen carbonate. The pressure conditions are not good, the pressure gradient is negative to a depth of 200–300 m. At the same time the geothermal gradient is 13 m/°C in the middle part of the plateau, which is far better than the average of the whole Plain.

The territory is poor in mineral resources. Beside some sand and clay pits, the oil prospection produced very modest results in the region of Pusztaföldvár and Battonya. The gas-and-oil-bearing structures are small and areally dispersed. The main economic wealth is the agricultural land and the subsurface water.
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