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ON THE ORIGIN AND HYDROGEOLOGY OF NATRON LAKES IN THE SOUTHERN GREAT HUNGARIAN PLAIN

by

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Investigations for the complex elaboration, reclamation and utilization of the soda soils of the Great Hungarian Plain have been conducted for a long time in this country. It was not until the last years, however, that a detailed investigation of the Great Plain natron lakes was commenced (*J. Fehér* 1961—64, *J. Megyeri* 1963, *I. Kiss* 1963, *M. Andó—M. Mucsi* 1967, *M. Marián* 1969), though the exploration and knowledge of the natron lakes of different origin and of their changes are highly desirable.

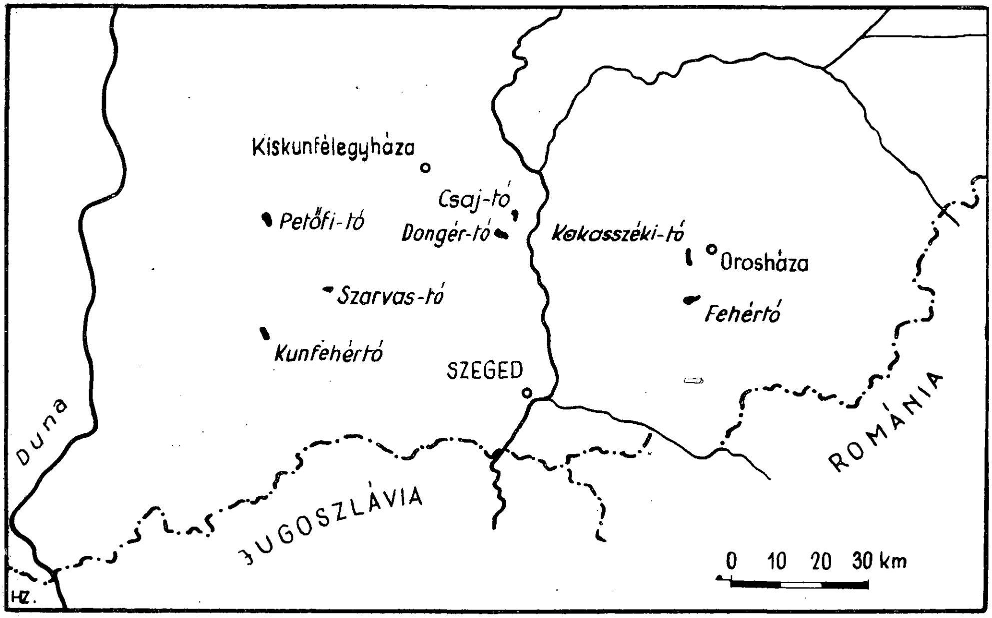

Fig. 1: Layout of the explored natron lakes of the southern Great Hungarian Plain

The results so far obtained in the geological exploration of the lakes under consideration are already sufficient for some kind of geological systematization of these, ecxept for the natron lakes of the Danube Valley. Hereafter, the author has attempted to review the origin, date of formation, geological setting and hydrogeology of the natron lakes of the southern Great Hungarian Plain.

LATEST PLEISTOCENE AND HOLOCENE HISTORY OF THE REGION

By the end of the Pleistocene, three landscape units of different geological setting and character had been formed in the southern Great Hungarian Plain.

1. The Danube-Tisza Interfluve Ridge is a territory with a heterogeneous surface elevated 30 m high above the Danube Valley and almost 40 m high above the Tisza alluvium. Geologically, it is constituted by eolian sediments (loess and wind-blown sand) locally more than 100 m thick, deposited in alternation for a considerable part of the Pleistocene. (*B. Molnár* 1961, *I. Mihältz* 1965). The Uppermost Pleistocene wind-blown sands were redeposited during the dry phase of the Holocene hazel-nut stage, and the present-day near-surface pattern of the Danube-Tisza Interfluve has been developed.

2. During most of the Pleistocene the southern Trans-Tisza Region was sinking more rapidly than the aforementioned territory. Therefore it was continually flooded by river waters, and several hundred meters of fluviatile sediment have been accumulated in it. At the end of the Pleistocene, however, the rate of subsidence was slowed down, so that the loesses of the last glaciation (W_3) were deposited for the most part, on a wet surface, still covering a considerable part of the southern Trans-Tisza Region (*I. Mihältz* 1966, 1968). In the more humid period of the Latest Pleistocene and Earliest Holocene the rivers of the southern Trans-Tisza Region were incised into the Latest Pleistocene relief and, in many places, into the humid loess mantle, and their channels were carved out in it. It was due to the specific mechanism of accumulation by the rivers of the southern Trans-Tisza Region that the rivers often changed their channels, giving rise to abandoned basin stretches, ox-bows, etc.

3. Between the wind-blown sand and loessridge of the Danube-Tisza Interfluve and the fluviatile and Uppermost Pleistocene infusion loess area of the Trans-Tisza Region lies the Tisza Valley—the depression carved out and filled up by the river at the end of the Pleistocene and the beginning of the Holocene (*I. Mihältz*, 1965, 1966). The Tisza Valley grows wider on both sides of the river south of Csongrád, attaining a maximum of 30 km in width. Its surface is covered by clayey infusion loess and Holocene fluviatile, flood-deposited and lacustrine sediments.

ORIGIN OF NATRON LAKES

Natron lakes occur in all three regions (landscape units) of the southern Great Hungarian Plain. The lakes of each region are in a close genetic connection with the geological history and structure of the region.

NATRON LAKES OF THE DANUBE—TISZA INTERFLUVE RIDGE

Out of the natron lakes of the Danube-Tisza Interfluve Ridge, Lake Kunfehér (*I. Mihältz* and *M. Mucsi* 1964), Lake Szarvas (*M. Mucsi* 1968) and Lake Petőfi at Soltvadkert (Fig. 1) (*M. Mucsi* 1965, 1966, *M. M.-Faragó* 1966) are geologically most explored. The lakes of the Bugac area are being investigated at present (*B. Molnár* and *M. Szónoky* 1969).

At the end of the Pleistocene and in the dry phase of the Holocene hazel-nut stage, in the drainless depressions between the wind-controlled NW-SE-trending sand-dune rows of the Danube-Tisza Interfluve Ridge. the higher ground-water table of the more humid periods gave rise to permanent, though shallow-water lakes stretching, for the most part, in NW-SE direction in correspondence with the trend of the dune rows (Fig. 2).

The base of one of the groups of lakes is constituted by Latest Pleistocene loess (W_3). This is the case, for instance, with Lake Kunfehér (*I. Miháltz* and *M. Mucsi* 1964). This loess is directly overlain by lacustrine sediment—an evidence of the Earliest Holocene age of the lakes (*M. M.-Faragó* 1966).

In another group of the lakes the Latest Pleistocene loess is still followed by the wind-blown sands of the pine-birch and the dry hazel-nut phases of the Holocene. Consequently, the lakes were formed and the lacustrine sediments deposited

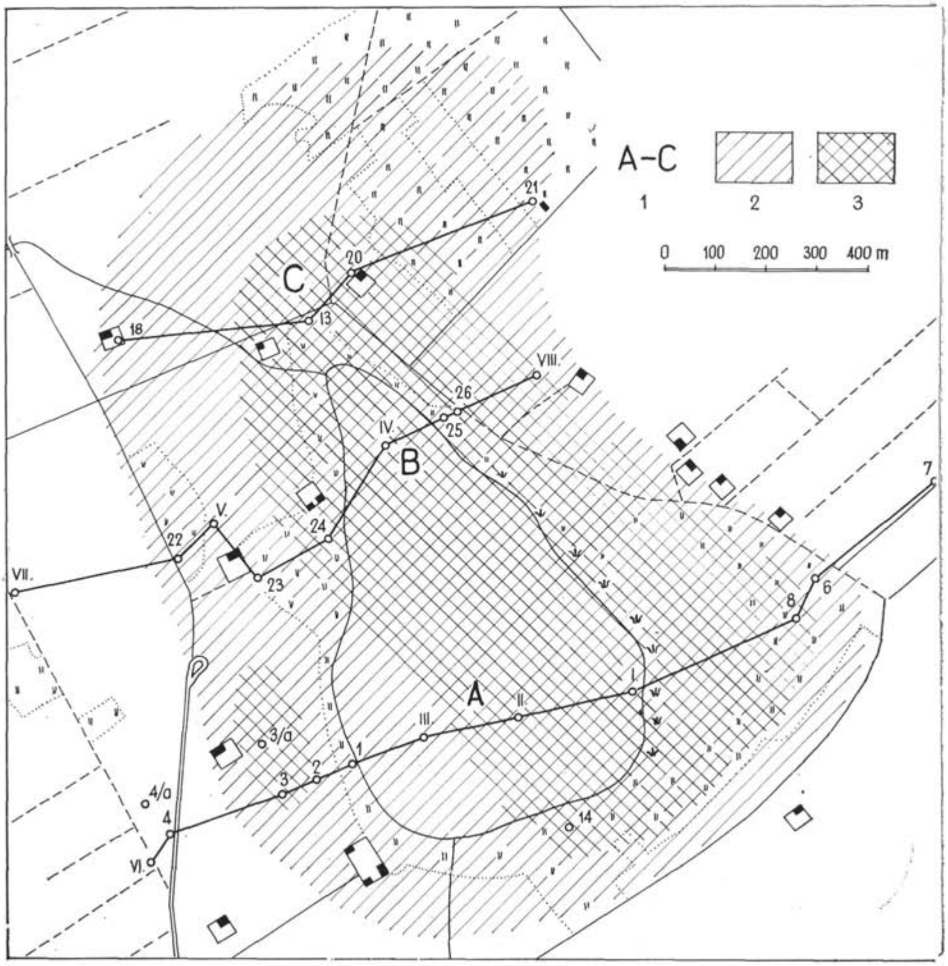

Fig. 2: Layout of Petőfi Lake at Soltvadkert and distribution of calcareous-silty deposits (by courtesy of M. Mucsi, 1965) 1. Boreholes and geological sections, 2. subsurface range of calcareous-silty, sediments, 3. subsurface range of calcareous silts

as late as the subsequent more humid period. An example of this group is Lake Petőfi (*M. M.-Faragó* 1966) (Fig. 3, Section A).

The Latest Pleistocene loess (W_3) was formed of air-borne dust deposited on a dry surface. Hence, it is looser than the infusion loess (sediment deposited on a wet surface), more sandy, poorer in fauna and characterized by a higher carbonate content as usual (Fig. 8a). The wind-blown sand consists of minute, well-rounded sand grains with a mat surface.

A peculiar feature of the lacustrine sediment is that calcareous silt layers with a carbonate content of 30 to 90% are common in it. These are white, greyish-white, slightly humic, if at all; though commonly loose, crumbling in dry state, they are sometimes represented by a hard variety. In some places, the carbonate silt may extend well over the range of the present-day water-table, while in others it is the water-table that is of greater extension. This evidences that the lake must have meanwhile changed its shape, as carbonate silt could be deposited only in case of totally waterlogged environment (Fig. 2, 3, Section 3). The material of the carbonate layers derives from a local depression, i. e. from the high carbonate content of the ground-waters which have flowed toward the lake. Nota bene, the ground-waters exsolved great amounts of carbonate from the sands of Danube origin and from the loesses and precipitated them at the end of the Holocene hazel-nut phase and in the subsequent oak phase (*M. Mucsi* and *M. M.-Faragó* 1966).

The calcareous silts are always overlain by humic, often dark-grey, lacustrine sediments. Having a substantially lower carbonate content, these were deposited in the oak phase of the Holocene. At last follows the recent, uppermost layer constituted either by totally loose, liquid, lacustrine mud, or by small-grained sands of wind-blown sand origin. As proved by palynological analyses (*M. M.-Faragó* 1966) and by the investigation of the fauna (*M. Mucsi* 1963, 1966), the lithology of sediments in the natron lakes of the Danube-Tisza Interfluve is particularly suitable for investigations into the history of the Holocene climate of the region.

NATRON LAKES OF THE SOUTHERN TRANS-TISZA REGION

Out of the natron lakes of this region, Lake Fehér at Kardoskút and Lake Kakasszék by Orosháza have been investigated and treated in detail (Fig. 1, 4, 5) (*B. Molnár* and *M. Mucsi* 1966, *B. Molnár* and *M. Szónoky* 1969). These lakes have developed from the ox-bows of abandoned river channels, a fact evidenced by their narrow, long-outstretched shape.

An important evidence in the dating of the lakes is the loess layer occurring in many places, which represents the last glaciation, W_3, of the Pleistocene (Fig. 4, 5, 6). Accordingly, the fluviatile sands and silts below the loess must have been deposited before the last glaciation, probably in the W_2—W_3 interstadial. The vicinity of the lakes is of morphologically deeper position and loess is absent in these places, being replaced by channel-filling fluviatile, flood-laid and lacustrine sediments (Fig. 4, 5, 6).

At Lake Kakasszék the incision fo the river valley and its subsequent filling-up may have begun at the end of the Pleistocene, in one of the interstadials. This is suggested by the fact that on the eastern side of the lake the longshore dune range, extending parallel with the paleochannel, crops out still from below the loesses (Fig. 5, 6). The fine-grained sandy loesses of the eastern side (Fig. 8, C/2) and also the fine sand intercalations, observable within the loesses in many places, are proofs

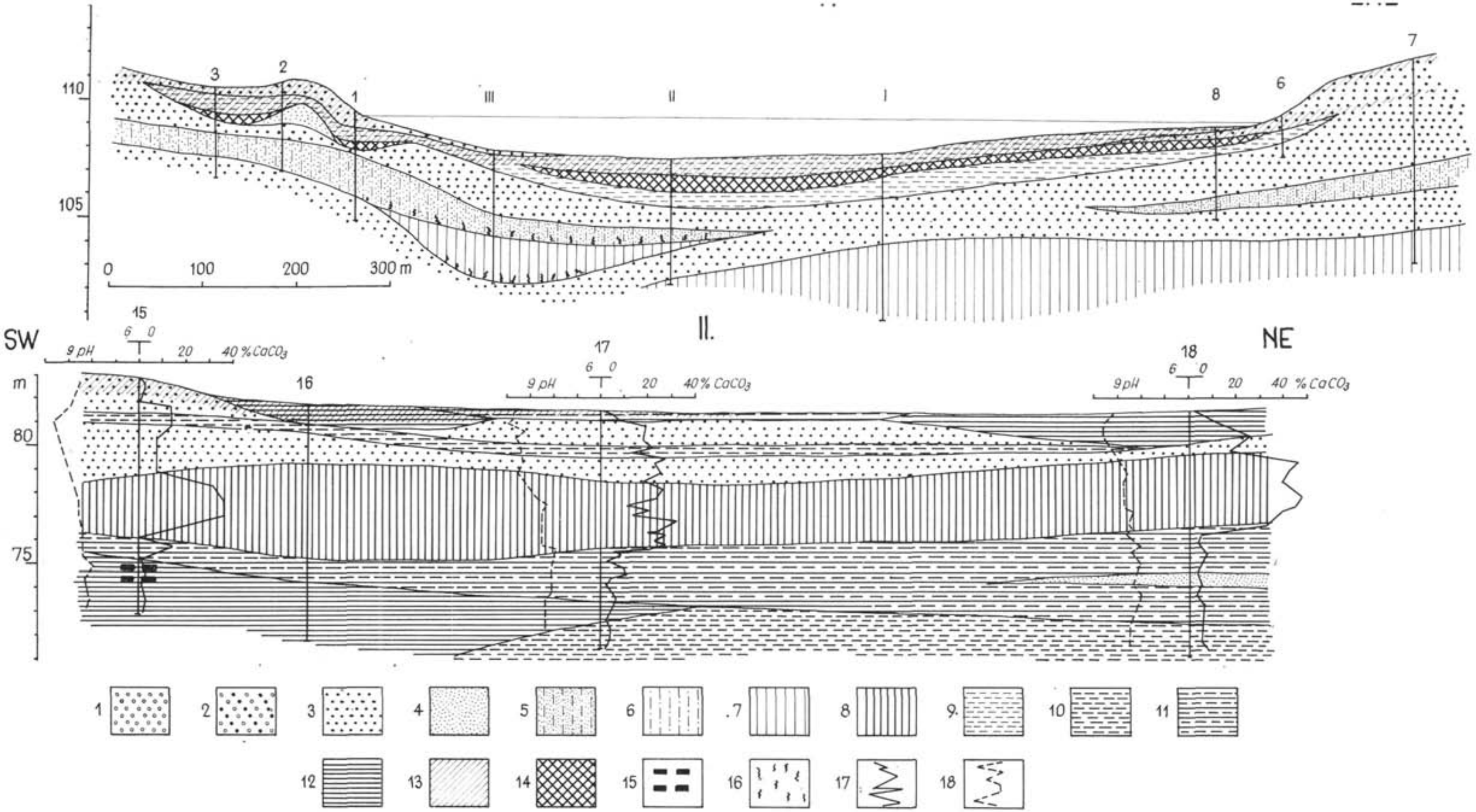

Fig. 3: Lake Petőfi (A) in the Danube-Tisza Interfluve (M. Mucsi, 1965) and Lake Dongér in the Tisza Valley (II) (B. Molnár, M. Mucsi and L. Magyar, 1969). Geological type sections. 1. medium sand with coarse sand (0,2 to 2,0 mm∅), 2. medium sand (0,2 to 0,5 mm∅), 3. small sand (0,1 to 0,2 mm∅), 4. fine sand (0,06 to 0,1 mm∅), 5. loessic fine sand (0,02 to 0,1 mm∅), 6. loess with fine sand (0,02 to 0,1 mm∅), 7. typical loess (0,02 to 0,05 mm∅), 8. alkalized infusion loess (0,005 to 0,05 mm∅), 9. coarse silt (0,02 to 0,06 mm∅), 10. fine silt with coarse silt (0,005 to 0,06 mm∅), 11. clayey, fine silt (0,005 to 0,02 mm∅), 12. clay (0,005 mm∅), 13. humic sediment, 14. calcareous silt, 15. slightly peaty layers, 16. strata with plant fossils, 17. carbonate content, 18. pH value

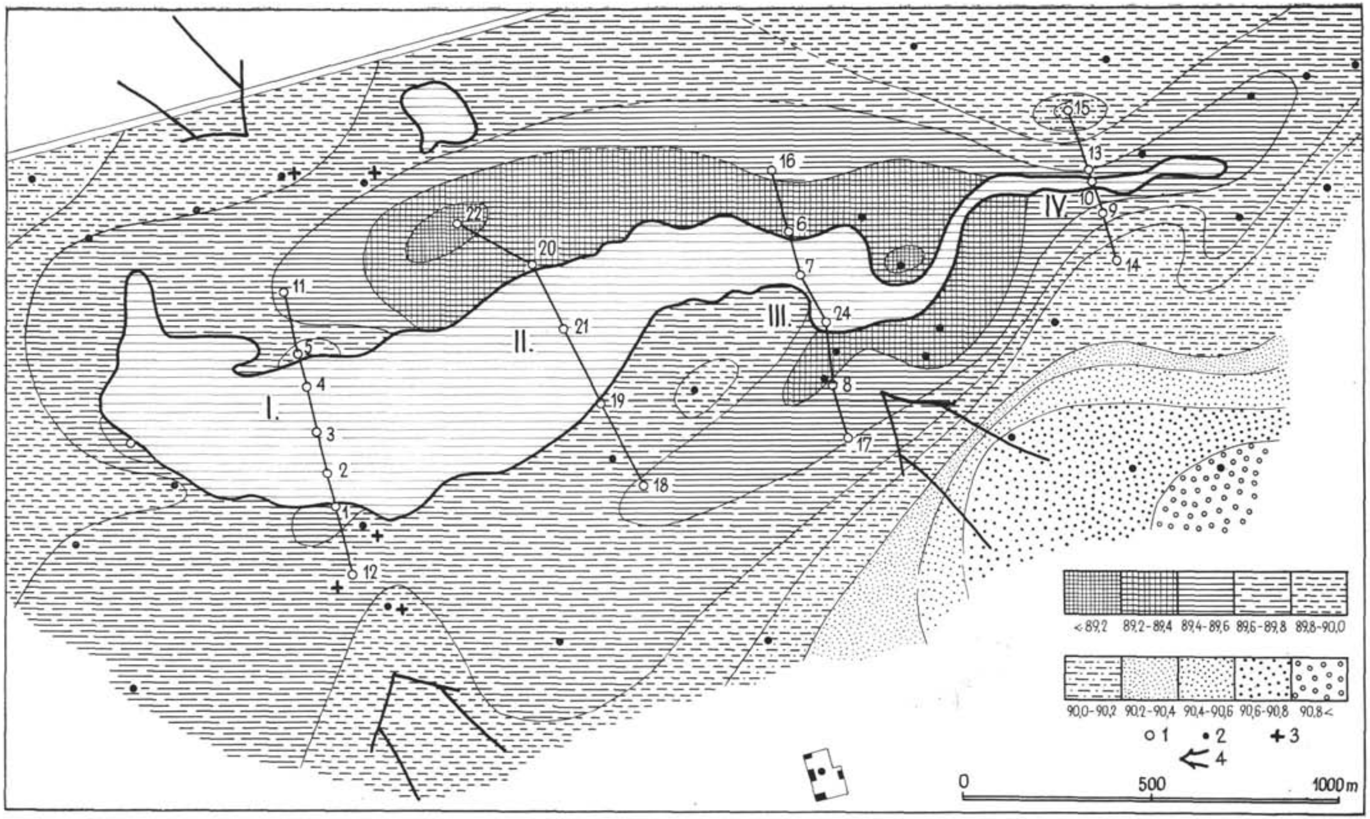

Fig. 4: Layout of Lake Fehér at Kardoskút, with altitude (a. s. l.) of ground-waters as observed at high water level in springtime, with locations of boreholes and section lines. 1. Boreholes, 2. location of measured wells, 3. shaft-wells with water emerging to surface, 4. supposed flow direction of ground-waters

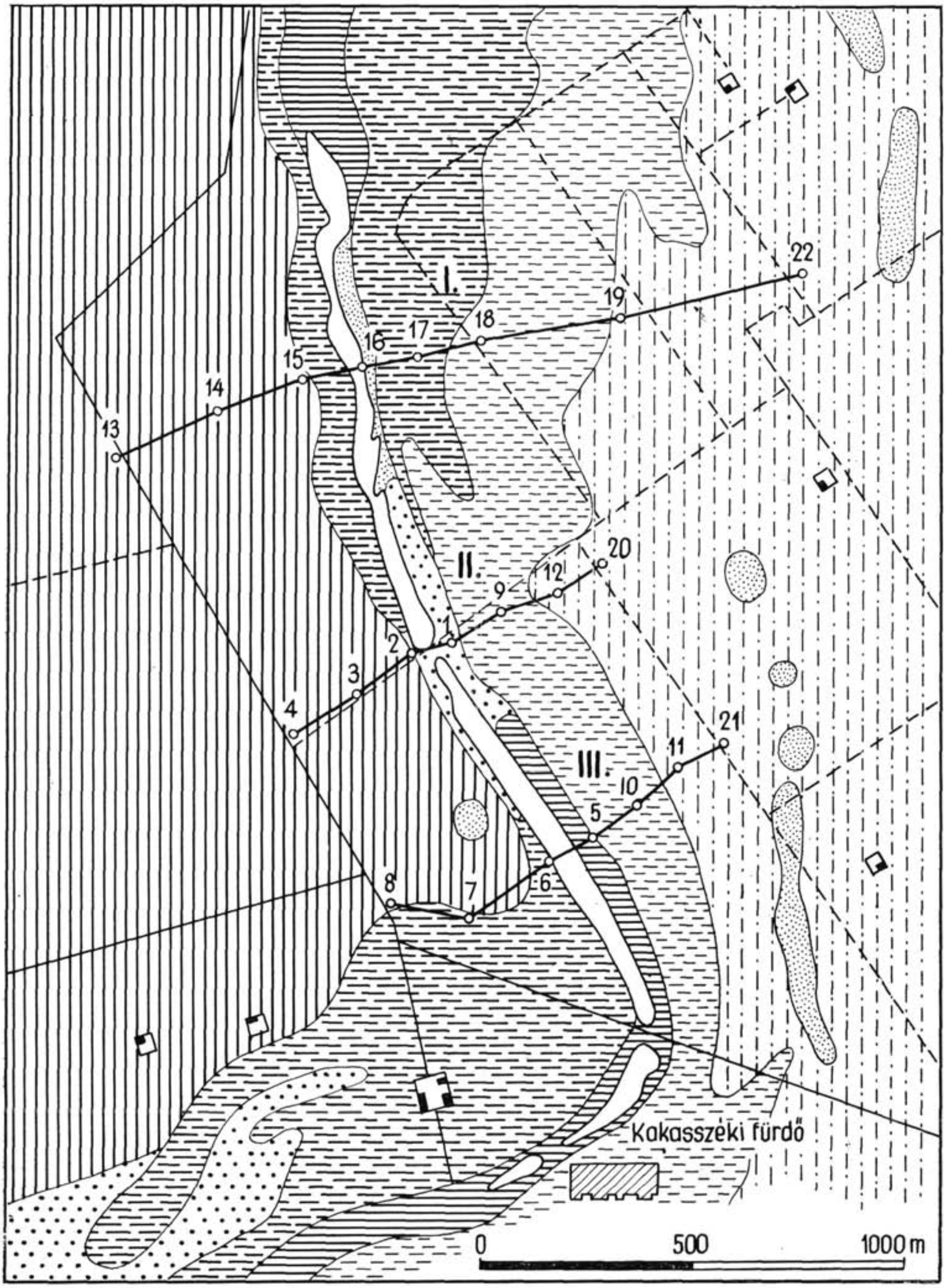

Fig. 5: Layout of Lake Kakasszék geological formations of its vicinity, location of boreholes, and geological section lines (according to B. Molnár and M. Szónoky, 1969). (For legend, see Fig. 3.)

for the admixture of sands blown out from the flood-plain during the last loess deposition. Consequently, they prove that the river must have appeared already earlier here. The loesses on the western side of the lake are not sandy because this bank of the river was steeper and the winds could blow out sands only from the flat floodplain of the eastern bank (Fig. 8, C/1). Below the loess it is medium sand that predominates throughout the area (Fig. 5, 8, C).

In Holocene time the river abandoned its channel, where an ox-bow lake was formed. In the water-covered part of the lake the fine-grained, chiefly clayey, sediments of this ox-bow lake can already be found.

As for its origin, Lake Fehér of Kardoskút was formed in the same way, though possibly a little later (*B. Molnár* and *M. Mucsi* 1966). The identity in origin is well demonstrated by a comparison of single sections of the two lakes. As evident from Fig. 6, the two profiles are totally the same in character, the only difference consisting in that Lake Fehér is the result of the combination of two ox-bows. In the eastern, narrower, part of the lake used to be a larger channel, in the western part a smaller one (Fig. 4). This is proved by differences in the lithology of the channel-filling material, for the eastern channel contains essentially coarser sediment, mainly medium-grained sands (*B. Molnár* and *M. Mucsi* 1966). The present-day, greater, width of the western part is due to underwash and resultant collapse of the river bank there.

NATRON LAKES OF THE TISZA VALLEY

Of these, Lake Dongér at Pusztaszer has been investigated in detail (*B. Molnár*, *M. Mucsi* and *L. Magyar* 1969) (Fig. 3, 7).

An important key to the understanding of the origin of the lakes here may be provided by the loess layer present. According to the results of M. M.-Faragó, it seems to have been deposited under a warm climate, probably in the W_2—W_3 interstadial.

During the last stadial, W_3, the amount of precipitations decreased, so that fluvial accumulation was interrupted, being replaced by deposition of the aforementioned loess layer. Both the formations, the fluviatile-flood-deposited sequence below the loess and the loess itself, transgress over the present-day eastern boundary of the Danube-Tisza Interfluve and continue westwards under the Holocene windblown sands, too.

Early in Holocene time, under a climate becoming warmer and wetter, rainfall grew more abundant, the flood-plain of the Tisza widened again, and the river dissected the loess deposits of W_3, wearing away their upper part in many places. The sediments deposited that time can also be traced for a little destance westwards under and within the wind-blown sands, as shown by Fig. 3, Section II, Borehole 15.

In the dry hazel-nut phase of the Holocene, with overall wind-blown sand movement, these sands migrated southwestwards here too, in accordance with the predominant wind direction, enveloping a part of the Lowermost Holocene flood-deposited sediments, too.

As a result of the post-hazel-nut, more humid, climate, stagnant waters left over by the frequent floods have been preserved. Farther away from the Tisza, only fine-grained sediments have been deposited in a water of low energy, and the rate of accumulation was slowed down. In the near-channel zones, however, the river had greater accumulating power. Therefore, the areas farther off have with

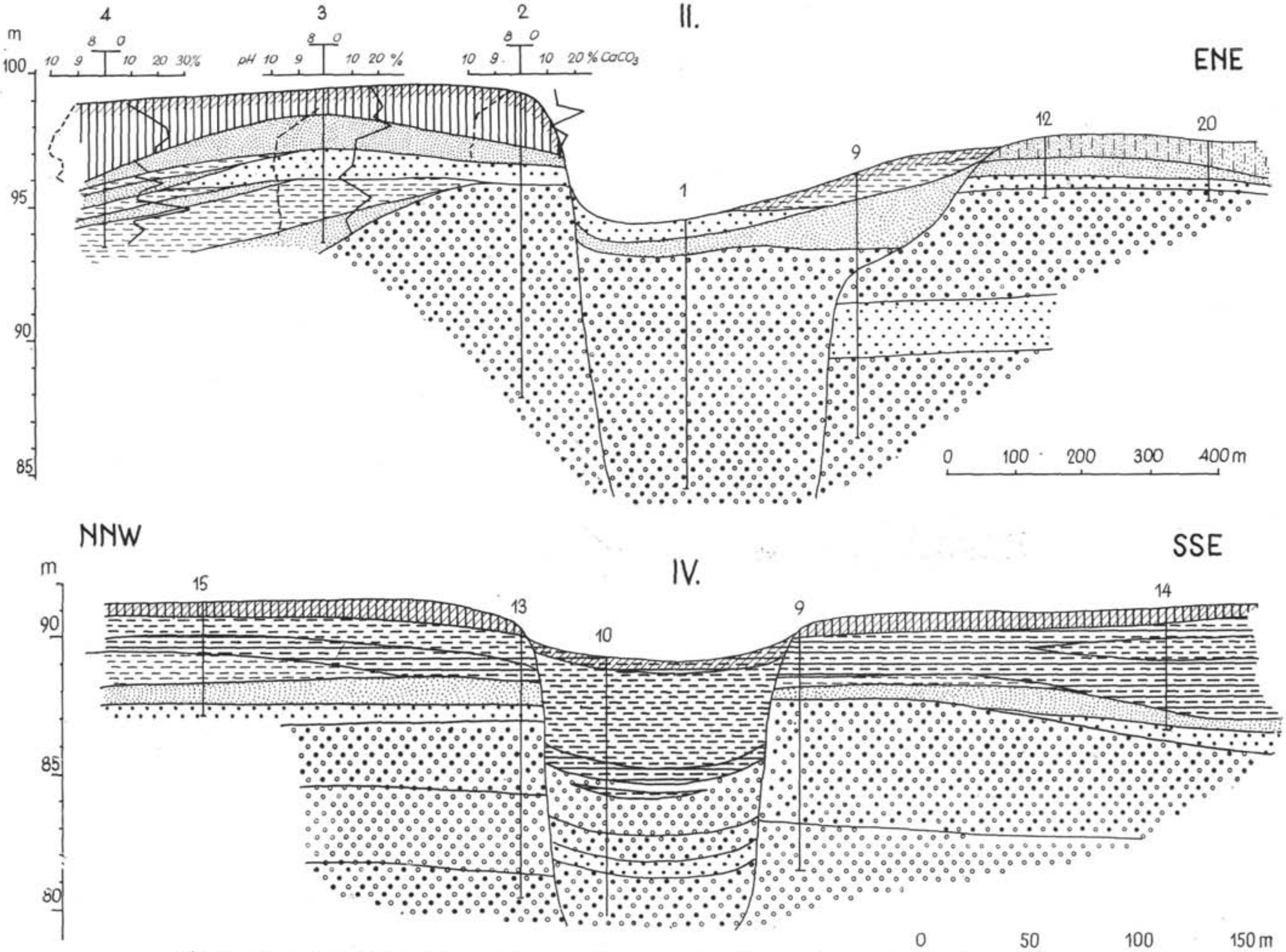

Fig. 6: Geological type sections of Lake Kakasszék in the Trans-Tisza Region (II) (B. Molnár, and M. Szónoky, 1969) and Lake Fehér at Kardoskút (IV) (B. Molnár and M. Mucsi, 1965). (For legend, see Fig. 3.)

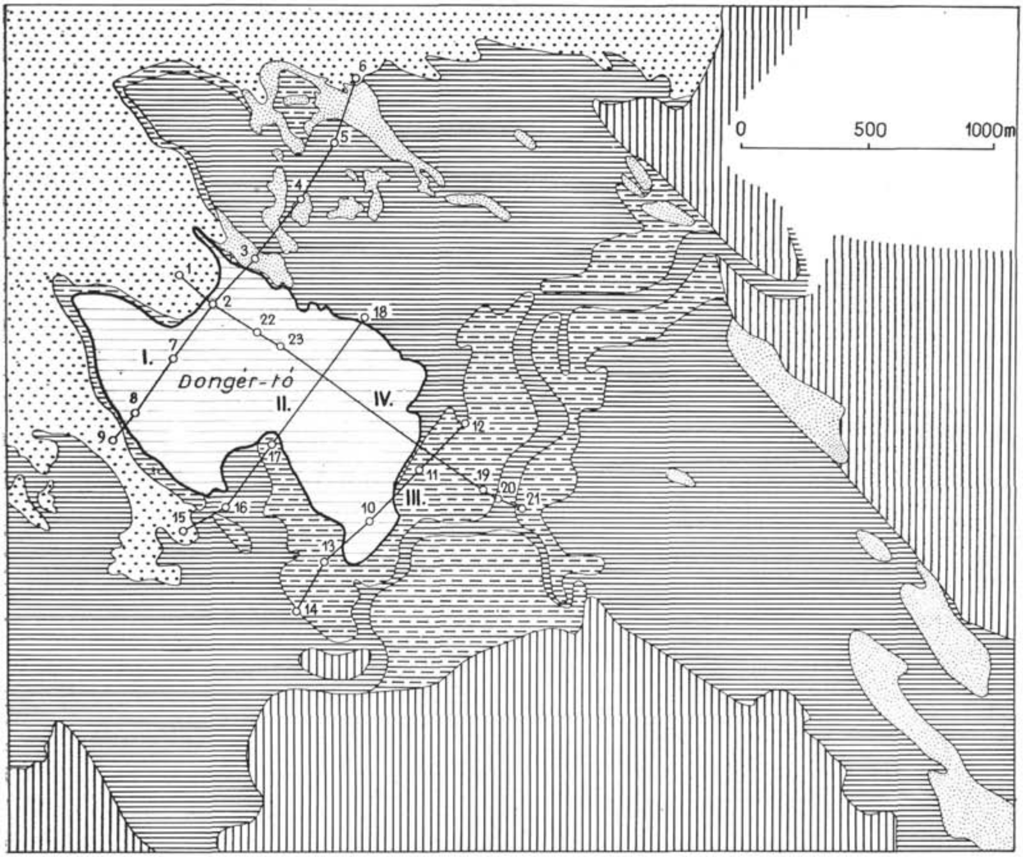

Fig. 7: Layout of Lake Dongér, geological formations of its vicinity, location of boreholes, and geological section lines (B. Molnár, M. Mucsi and L. Magyar, 1969). (For legend, see Fig. 3.)

time become lower in altitude (relatively „subsided") and the waters left over there have accumulated in intermittent shallow-water lakes. The granulometric curves of the sediment types deposited in the vicinity of Lake Dongér are shown in Fig. 8b).

Lake Dongér has been formed in the same way at the intersection of the sand ridge of the Danube-Tisza Interfluve and the Tisza Valley (Fig. 7). Just like Lake Dongér, the lakes of the Tisza Valley are of irregular shape.

HYDROGEOLOGY OF THE LAKES

A common characteristic of the natron lakes of the southern Great Hungarian Plain is that their waters are shallow, attaining a maximum of a few decimeters in depth. Under natural conditions every lake is supplied by local-depression-bound ground-waters and by meteoric waters.

Ground-water flow is illustrated well by the ground-water map of the vicinity of Lake Fehér at Kardoskút, showing the conditions of high springtime water level,

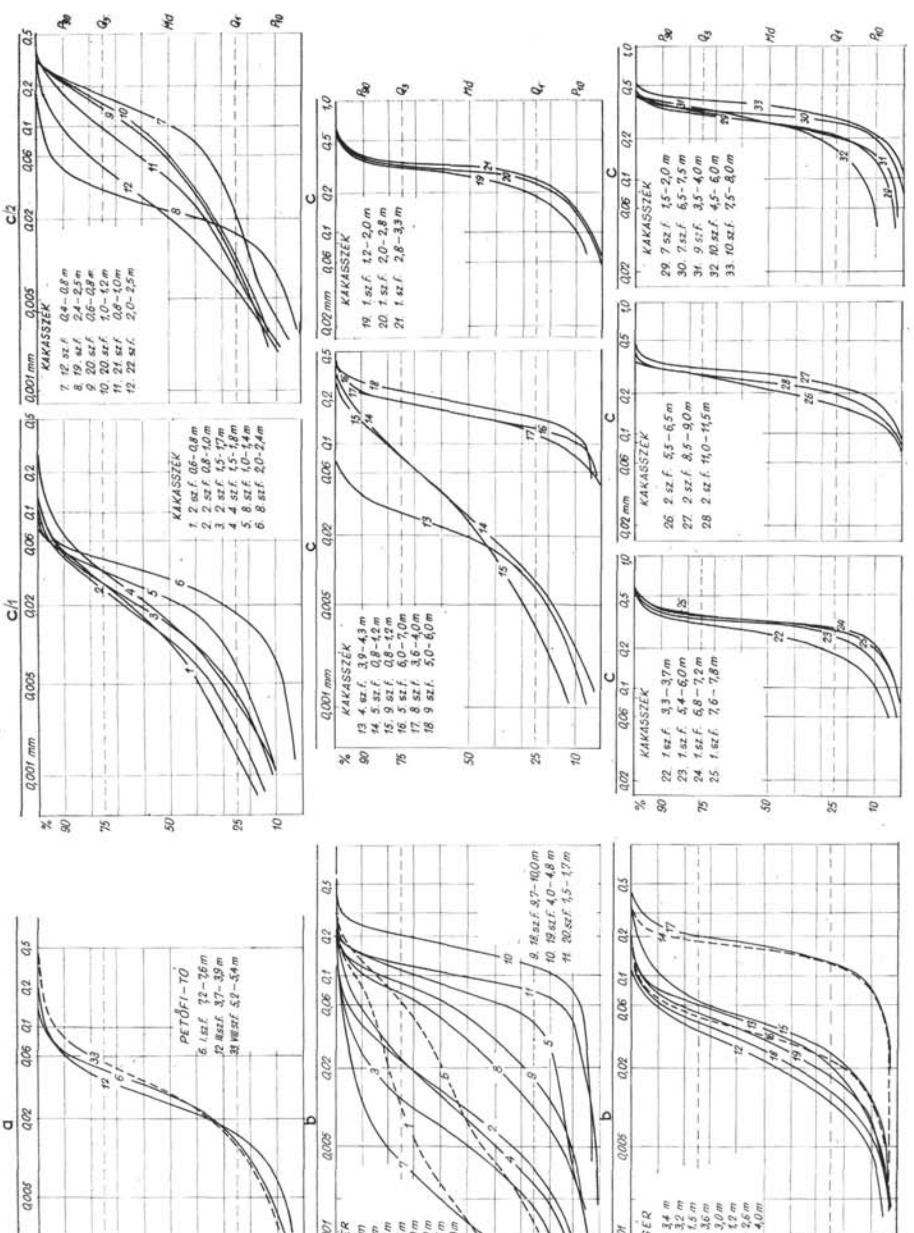

Fig. 8: Granulometric curves of sediment types exposed in the area and vicinity of the investigated lakes. a) typical granulometric curves of the loesses exposed in the area of Lake Petőfi, b) typical granulometric curves of sediments in the area and vicinity of Lake Dongér (top: fluviatile-flood-deposited and lacustrine; bottom: eolian sediments), c) the same in the area and vicinity of Lake Kakasszék

referred to sea level (Fig. 4). Within this area, having a relative relief of 2.5 to 3.5 m, the ground-water table slopes markedly toward the lake. In springtime the ground-water may emerge from shaft-wells and boreholes and flow into the lake. The same phenomenon has been observed in the case of Lake Dongér, for example. In extremely dry seasons, in autumn, most of the lakes run dry.

The most intensively alkalized areas lie close to the lake, where the greatest amount of water evaporates. Alkalization is brought about, beside the given hydrogeological characteristics, by concentration of the salts of ground- and meteoric waters.

SUMMARY

Genetically, three types of lakes have been explored hitherto in the southern Great Hungarian Plain, each having been closely linked with the geohistory of a landscape unit of characteristic geological setting:

a) deflation lakes of the Danube-Tisza Interfluve, *b)* ox-bow lakes of the Trans-Tisza Region, and *c)* pre-flood-control lakes of the Tisza Valley. The paleostreams of the Trans-Tisza Region lakes can be traced back to the end of Pleistocene time. Since the beginning of the Holocene they have evolved as ox-bow lakes. The Danube-Tisza Interfluve lakes were formed early in Holocene time and after the Holocene hazel-nut stage. The Tisza Valley lakes appeared at the beginning of the Holocene.

The large-scale alkalization of the deeper portions of lake vicinity has been produced by the strong evaporation of depression-bound meteoric and ground-waters and by their salt concentration.