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Protected Geological Objects in Kiskunság National Park in Hungary

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Abstract

Earlier conservation was mainly concerned with the protection of living natural objects. In the past few decades however it became apparent that the flora and the fauna of a given area are highly dependent on the geological and hydrogeological composition and conditions of their habitats. So the protection of these geological objects and recognition of them as real natural values along with the preservation of their conditions are just as important as the preservation of living nature.
We could get a brief overview of two protected objects, which can be found in the Kiskunság National Park. One of them are the carbonates precipitated from high salinity shallow water ponds due to an increase in the salinity, the chemical reaction (ph) of lacustrine water as a result of heavy evaporation and high temperatures around 30 degrees Celsius of the ponds´ water. The ratio of Mg/Ca in the lacustrine water is around 7-12 generally. Thus high magnesium content calcite is the first to precipitate as a primary mineral from the water altering into early diagenetic dolomite.
We can also find active, moving sand dune areas with related micro and macro forms of wind-blown sand in the Kiskunság National Park. The most frequent micro forms are sand waves. Their measures are largely dependent on the grain size and wind velocity.
We can identify the following macro forms in the area: sand drifts formed behind grass chunks sheltered from wind and „parabolic" dunes. On the gently sloping stoss side of the dunes with angles of $6\text{-}10^0$ sand particles are moved by saltation, after reaching the crest however these particles slump onto the leeward side creating avalanching forms. The newly formed leeward side has foreset planes with a maximum sloping of 34^0 . The avalanching process on the whole part of the slip front takes place not simultaneously but periodically, forming avalanching sand tongues at the bottom part of the front. The inside bedding of the dune is determined by the planes of the stoss and the lee-side, which comprise sets of laminae as a whole. Rainwater dissolves a part of the carbonates occuring in 10 % in the sand near the surface and after this carbonate content is precipitated bounding the particles together early diagenetic cemented sandstone is formed.
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Key words: nature protection, nature value, carbonate and blown sands sediments

Introduction

A couple of decades ago conservation was mainly concerned with the protection of existing natural life forms. Primarily the protection of forests and wild fowl were put into the center of preservation efforts. Afterwards more simple life forms and non-wooden plants were also put under protection. But only the most fascinating and spectacular, thus most valuable geological objects enjoyed such privileges as being under protection even all around the world. These were for example the geysers and geyserites of the Yellowstone National Park or the travertines deposited by hot springs in southern Turkey.
With the pass of time it became more and more apparent that conservation should involve those areas as well, which have already been partly affected by human activities and culture and we have to set forth the collective preservation of living and non-existing natural objects. In most cases there is a very strong interdependence between the two; one presupposes the existence of the other. We can

mention the following examples to this: the evolution or development of geological objects, the soil and its inhabitants or the water coverage of an area and the marshlands.
All these factors were basically taken into consideration in the foundation process of the Kiskunság National Park in 1975. So the examination of the geological objects were considered to be of crucial importance from the very start. Joining this project we extended the subject of our research to the whole area of the park. On one hand with our work we aimed at giving a more accurate and complete presentation of these objects to the experts visiting the national park. On the other hand we had the determination of the geological history of certain parts, the collection of data concerning their present conditions for setting up a comparative base for the identification of further changes in these were among the goals of our geological research as well. In the following part we would like to present you some results from this work.

Description of the Kiskunság National Park

The Kiskunság National Park was founded on 1st January 1975 in the area of the Danube Tisza Interfluve, south of the city of Budapest (Fig. 1.). It is a typical mosaic type park made up of not one single connected region but a number of minor parts having no connections with each other. Later on several wildlife preserves joined the area of the park, thus the whole area of the national park today exceeds 35,000 acres. Three major types of biotopes or habitats can be found in the area. The wetlands including the high salinity shallow water ponds, and the areas they occupied before their total drainage. Then the sand „pusztas" where in some places we can find active, moving wind-blown sand even today. And finally the belt of protected forests. There are a number of other special protected habitats besides these as well such as the ox-bow lakes or the peat marshlands.
We included all the habitats or biotopes in our geological investigations. In the following parts we would like to present the results of this research carried out on the areas of the ponds and the sand „pusztas" along with the valuable geological objects, which can be found there. In order we could get a better understanding of these we have to know the history of the wider geological environment in which they can be placed into to some extent as well.

The geology of the Danube Tisza Interfluve

The Hungarian region of the Danube Tisza Interfluve bordered by the rivers of Danube and Tisza occupies a 200 kms long and 100 kms wide area south of the city of Budapest streching as far as the Yugoslavian border. In this area the river Danube flowing southeastward toward Szeged deposited its alluvium on the Upper Pliocene (Pannonian s.l.) lacustrine deposits in all likelihood till as long as the Günz-Mindel interglacial period. During the Günz-Mindel interglacial the Danube river occupied its present day tectonic erosional valley flowing from the north to the south. From this moment onwards within the area of the Danube-Tisza Interfluve easterly winds transporting dust particles deposited loess during the interglacials, while at the time of glacial intervals westerly winds predominated in the area, blowing sand out of the Danube riverbed and forming wind-blown sand deposits in the region. These two complies a vertically alternating succession sometimes exceeding 140 ms in thickness.
During the Holocene the wind-blown sand on the surface continued its movement creating lines of dunes with NW-SE trending. During periods with higher rainfall in the Holocene the groundwater level rose significantly creating shallow ponds between the dune lines. Present day geological maps clearly indicate these processes (Fig. 2).
On the basis of the geological development, morphology and geological objects on the surface the area of the Danube-Tisza Interfluve can be divided into three major units:
a.) The Danube Valley with an average elevation of 100 ms above sea level is a 20-30 km wide tectonical, erosional depression. The lower unit of the strata is made up of Upper Pliocene (Pannonian s.l.) deposits overlain by 20-70 m thick gravel and sand in 5-10 m thickness. The upper unit is made

up of 1-4 m thick alluvial clay, fine-grained aleurite and deposits with a 30-70 % carbonate content respectively. In some places within the abandoned riverbeds peat was formed as the final stage of the upfilling process.
b.)The ridge in the middle of the Danube-Tisza Interfluve morphologically is a somewhat more elevated, elongated area with a great variety of landforms, which rises above the Danube Valley by 30 meters on the average (110-130 meters above sea level) and by 40-50 meters above the surface of the Tiszanian deposits. The majority of the Ridge is covered by wind-blown sand, while in a minor part fine-grained sandy loess (typical loess), its altered and sodic forms and lacustrine carbonates can be found on the surface (Fig. 2). The surficial wind-blown sand overlying the loess deposits in the majority of the cases varies between 1-20 meters in its thickness.
c.)We use the term Tisza Valley to identify the depression eroded and later filled up by the meandering Tisza river during the Holocene, i.e. the Holocene alluvium of the River Tisza. The itinerant Tisza river eroded and filled up its valley in 5-10 kms width avulsionally, which has an average elevation of 80 metres above sea level today.

Lacustrine carbonates

Fifteen years ago there were almost as many as 150 smaller ponds in the area of the Danube-Tisza Interfluve, the largest of which were only some kms long and some 100 ms wide. Even the deepest pond had a maximum depth of 2 meters, but the majority of the ponds were hardly some 10 cms deep. From ponds on the Ridge and the Danube Valley carbonates have been precipitated, as it can be clearly seen from the occurrences of carbonate deposits on surficial geological maps.(Fig.2.) Due to the droughts of the past decade, i.e. the below the average rainfall in the area, the intensive forestation of the region (primarily with paper birch) and thus the higher evaporation of trees, the increased demand for water for communal purposes and irrigation during the dry intervals, which was supplied from watertable and artesian aquifers,there was a significant decrease (some meters) in the level of groundwater in some cases. This resulted in the drainage of the ponds. Carbonates precipitated in ponds however clearly indicate the location of the once existing lakes. The thickness of the carbonates varies between 0,4-1,0 meters generally (Fig. 3). The carbonate content of the mud displays great variety having a maximum value of 70 % (Fig. 4).
Not only these processes were responsible alone for shaping the lakes on the Ridge, but the continuous rearrangement of wind-blown sand deposits throughout the whole Holocene also changed their geographical locations and the extension of their borderlines. Sand dunes overlying the carbonate deposits, that had been precipitated from the lake are clear evidences of such processes (Molnár B. 1991).
In the areas around the lakes the salt content in solution of the groundwater has an average rate of 500-2000 mg/l. Among the anions values of Na (+K), among the cations values of hydrocarbonate reach high levels in the groundwater. (Fig. 5)(Molnár B.-Kuti L. 1978).
The ponds on the ridge got their supplies of water from the rainfall and the groundwater flowing towards the direction of lakes with high salt content. The lakes situated in the Danube Valley got their water supplies on one hand from water, which flooded the majority of this area during the annual high water level periods and remained back following the withdrawal of the river. On the other hand in a minor part groundwater flowing towards the Danube Valley from higher elevated areas of the Ridge ensured the water supply of the ponds.
The dissolved salt content increased to 7-70,000 mg/l in ponds having depths of some ten centimeters due to the long lasting summer droughts and the increased evaporation as a result of the high daily temperatures reaching values of 30 degrees Celsius sometimes. As a result of this the chemical reaction /ph/ of the lacustrine water reached values of 9-11, and even the water temperature increased as well sometimes reaching values of 30 degrees Celsius (Szépfalusi J. 1970; 1976; 1977).
During the early fall period large amounts of fresh water have been added to this type of lacustrine water by means of autumn rainfall reducing the salt content and the relative quantity of potassium and

sodium ions - being in challenge for earlier precipitation - and increasing the ratio of Mg/Ca ions . Thus in the majority of the year ratio of Mg/Ca had values of 7-12 in the lakes (Molnár B. 1980).
Thus high magnesium content calcite requiring less energy was the first to precipitate as a primary mineral from the lacustrine water and later altered into early diagenetic dolomite due to the further increase in the Mg/Ca ratio of the intersticial water, which remained back during the process. In some of the cases the Mg/Ca ratio of the lacustrine water reached the critical value of 40 as well, thus we could identify magnezite in the carbonate profile of the lakes as well (Müller, G.-Irion, G.-Förstner, U. 1972; Molnár B.-Szónoky M.-Kovács S. 1980).
However, the early diagenetic alteration was so rapid that we could not trace phases of pseudo- and proto-dolomite, which comply a transition between the calcite and dolomite phases.
In case of the carbonates of Lake Fertõ situated in the area of a collective Austrian-Hungarian national park in Western Hungary having a somewhat higher precipitation rates, transitional proto-dolomites could also have been identified (Molnár B.-Dinka M. 1997).
Following the cessation of the water coverage the upward capillary migration of the groundwater having a totally different chemical composition from that of the lakes ignited an anadiagenetic process as calcite was precipitated into the pores of the dolomite mud, which afterwards solidified forming a hard carbonate rock.
The formation and diagenesis of carbonates are summarized on Figure 6.
During the fall and the summer as it can be seen on the figure the lakes were filled with water derived from rainfall and groundwater migrating towards them. During the late spring and summer periods the water level of the ponds were greatly reduced as a result of rapid evaporation despite the supplies of water coming from groundwater.
The salt content have been concentrated, the chemical reaction (ph) and ratio of Mg/Ca increased in the lacustrine water. From this high magnesium content calcite have been precipitated altering into dolomite or magnezite in an early diagenetic way. The sindiagenetic alteration of the carbonate mud have started as well. On the shore salt flowers, all sorts of bioturbations, bird-foot structures and poligonal mud cracks were created.
We can classify the lakes situated in the Danube-Tisza Interfluve on the basis of geochemical, X-ray, and d^{13} O and d^{18} O stable isotope geochemical analysis. By applying values of d^{13} O and d^{18} O onto a diagram we are able to distinguish different fields, which characterize the depositional environments of the given lakes as well (Fig. 7)(Molnár B.-Botz R. 1997).
Upward left on the graph we can find points indicating eolic type sediments - Pleistocene loess and Holocene wind-blown sand -, which give the base of the lakes. The d^{13} O content of these generally have values close to zero or somewhat above zero. Their value of d^{18} O is around -4 -- -5.
Downward to the left we can notice points of the peat-carbonate lakes. These are characterized by the least -7 -- -10 d^{13} C and -5 -- -7,5 d^{18} O isotope values. Between this and the former field we can find a transitional field having characteristics of deposits - mostly wind-blown sand - lying right under the carbonate succesions. In them we can find relatively low d^{13} C values between 0,0 -- -2,5, and even lower values of d^{18}O between -3,5 -- -7.
Finally upwards to the right on the diagram can we find the points indicating the clearly carbonate (dolomitic) lacustrine deposits and lakes. In these we have relatively less negative d^{13} C and d^{18} O values.
On the basis of what can bee seen on the diagram we can clearly tell apart the eolic and lacustrine depositionary environments. Within the lacustrine environment we can distinguish the primary -i.e. having values of those closer to the rainfall and groundwater - and evaporational lake types.
On the basis of the examined carbonate successions we can talk about four major evolutionary types of lakes in the area of the Danube-Tisza Interfluve, which are the following (Fig. 8):
„A" type peat, carbonate lakes with relatively changing water levels and a more steady water coverage. These lakes can be characterized by varying, but relatively more negative d^{13} C values and high organic carbonate content. The carbonate has a composition of calcite precipitated in a major part as a result of the CO_2 deprival of plants, and evaporation in only a minor part. Geomorphologically these lakes are situated close to the highest western part of the Danube-Tisza

Interfluve Ridge.
„B” type ephemeric lakes displaying patterns of evaporation and having a relatively shallow water suffered seasonal changes in their extension and location due to heavy evaporation.
„C” type lakes, which are the same as „B” type ones considering their ephemeric features, seasonal area changes and carbonate composition, i.e. they have dolomitic composition so evaporation must have played the crucial part in the precipitation of carbonates. However their values of $d^{18}O$ is more negative with a -3,0 -- -3,5 rate than those of „B” type lakes and there is no rise of these values in the succession profile.
Geomorphologically these lakes occupy a deeper area in the Danube Valley. In these types of lakes the water is derived predominantly from the remnants of the floods of the Danube and not from sources of rainfall and groundwater. In these areas due to the high carbonate and salt content calcareous- sodic, hydromorph, primarily solonchak and solonetz soils were formed having a very characteristic halophiton flora.
It is well know that rainfall in areas having a higher elevation above the sea level and at a lower temperature has more negative $d^{18}O$ values. The water of the river Danube on its Hungarian part is derived in 85 % from the Alps. So it gets its sources from the melt water and the rainfall of the Alps.
The average $d^{18}\,O_{SMOW}$ rate of the water of the Danube River at Vienna is -11,7 (Rank,D. in Deák J. et al. 1992.) This means a -2,5 difference expressed in $d^{18}\,O_{PBB}$.
So the difference of -3,0 -- -3,5 of the $d^{18}\,O$ values of the „B” and „C” type lacustrine dolomites can be derived from this predominantly, and only the remaining part can be considered as the effects of the rainfall and groundwater.
From the side of practice the recognition of differences between the O isotopes of lacustrine carbonates in lakes situated in the Danube Valley and the morphologically higher Ridge is of crucial importance. In the past few years in the area of the Kiskunság National Park due to a significant decrease in the groundwater level the quite valuable wetland biotopes or habitats could have been sustained by means of artificial supply of water to the lakes only. This method was succesfully utilized in case of the ponds in the Danube Valley. It is very important to emphasize that we do not have to expect serious changes in the biota of these ponds since they got their supply of water from the river Danube, thus this way conditions almost similar to those of the original in the lakes could have been created.
However we have to expect changes in the conditions of ponds on the Ridge once we are to ensure the water supply of them from the river Danube and not from sources of collected rain water.
"D" type carbonates are displaying features of diaganetic effects. The lower part of them have already undergone the first phase of diagenesis - lithification, cementation -,thus they form solid rock. Consequently their geochemical and isotope chemical values display stronger fluctuations. These ponds are situated primarily on the lower side of the Ridge sloping towards the river Tisza, where groundwater migration has patterns of SE flowage.
The lakes together with the carbonates deposited in them comprise rather valuable natural objects in the Kiskunság National Park. Within the field of geology we usually have to set up conclusions about the certain geological processes by examining the outcome itself, i.e. the rocks formed. However in case of the previously mentioned ponds it is possible to observe the process itself as well besides their outcomes. So in a way they serve as actual geological examples of presently observable processes too.

Sand dune areas

There are a lot of sand dune areas in Hungary. But the most valuable, protected wind-blown sand deposits - active even today - and sand dunes can be found in the Kiskunság National Park. The erosional processes of ice and rivers stem from gravity effects. As opposed to this wind is derived from differences in air pressure. For this reason its work is primarily not linear but areal. Similarly to the fluvial regime sediments in the wind regime are transported by traction, saltation or in suspension. These differences in the forms of transportation are much more emphasized in the wind regime, thus materials transported by traction, saltation or in suspension are more separated in the eolic deposits as well. If the material in move has a grain size lower than 0,05 mm-s thanks to its lower velocity of free fall it can be transported in suspension at a longer distance forming for example the base material of loess deposits. The outcome of this process is very often the separation of the clay and silt fractions from the rest of the material in the deposits in a way through the "sieve" effect of the wind. The 1,00 mm grains move on the surface with saltation, grains larger in diameter than 2 mm however roll. The eolic deposits are generally well sorted.

The process of the eolic transportation and the certain depositional forms are well observable in a lot of places within the Kiskunság National Park, but the most spectacular and best place for observation is situated near the town of Kecskemét called the No.IV. sand dune area at Fülöpháza, where the wind-blown sand is still in movement even today (Fig. 1).

On the wind-blown sand deposits we can distinguish micro and macro forms of sand. The most frequently occurring and characteristic micro forms are the sand waves. (Fig.9.) Their measures,i.e the keel heights or amplitudes, the wavelengths and their bifurcations are largely dependent on the velocity of the wind and the grain size of the sand . The main average grain size of wind-blown sand varies between 0,1 - 0,2 mm in the area of the Kiskunság National Park. In case of the sand waves as opposed to the fluvial ripple marks the coarser grains, which may have diameters of 0,8 mm here occupy the crest area of the waves and not the trough part situated between the two waves (Fig. 10) (Molnár B. 1998).

Sand drifts are frequently occurring macro forms in these deposits (Fig. 11). In case of these forms we have some kind of an obstacle, usually grass chunks behind which areas sheltered from wind are formed making possible the deposition of sand there. This way sand bodies with a tongue form are created behind these natural obstacles, which stand in the way of the wind.

Another characteristic macro form of the Fülöpháza sand dune area is the "parabolic" dune having features similar to that with a NW-SE strike. This form can be found 10-20 m higher than its surroundings. (Fig.12.) All the "parabolic" dunes have a crest (highest point) and a slip front with several avalanching forms.

On the gently sloping stoss side with angles of $6\text{-}10^0$ sand particles are moved by saltation after reaching the crest however these particles slump onto the leeward side creating avalanching forms. The avalanching process on the whole part of the slip front takes place not simultaneously but periodically, forming avalanching sand tongues at the bottom part of the front. This way the sand dune moves forward 0,5-1,0 meters annually. The newly formed leeward side has a maximum sloping of 34^0 .

Thus basically these two processes are responsible for the creation of bedding inside the dunes (Fig.13.). Inside the dunes low angle strata on the stoss side comprise bedding sets with the high angle foreset planes on the forward moving, avalanching lee-side (Fig. 14).

We can find the following differences between the sand dunes at Fülöpháza and the typical "parabolic" dunes: on one hand they tend to have larger extensions considering their lengths. On the other hand in case of the former changes of some ten degrees may occur in the wind direction creating more slumps on avalanching sides and deformed strata laminae either next to or on top of each other.

The wind-blown sand has high carbonate content 5-10 percent. A part of it is dissolved by rainwater migrating near the surface, and then later precipitated in the pores of sand binding sand particles together. The outcome of the process is early diagenetic sandstone (Fig. 15). We have relevant knowledge of sandstones similar in the area of the Deliblát.

According to what have been stated above we can consider the sand dune area at Fülöpháza as another actual geological example, where geological proceses are still observable even today. For this reason on one hand was it necessary to put this area under protection besides other major factors such as the appearances of a flora characteristic of sand "pusztas" in the region.

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Figures

Fig. 1.:Areas of the Kiskunság National Park in Hungary. M: Miklapuszta

Fig. 2.: Geological map of the Danube-Tisza Interfluve and the extension of the present and contemporaneous lacustrine depositional environments (carbonates). (From the map of Hungary on a scale of 1:300.000, Balogh, K. et al 1956). 1. Alluvium, 2. Reposited loess, 3. Sodic loess and clay, sand, 4. Wind-blown sand, 5. Loessy sand, 6. Typical loess, 7. Alluvial loess, 8. Clayey loess, 9. Lacustrine carbonate.

Fig. 3.: Section of dolomite mud from Danube-Tisza Interfluve area.

Fig. 4.:Maximum carbonate content in percent at Miklapuszta (Kiskunság National Park) (Molnár, B. - Kuti, L. 1999).

Fig. 5.: Chemical elements of ground-water around natron lakes (Molnár B. - Kuti L. 1978).

Fig. 6.: Model for evolution and diagenesis of carbonate at Danube-Tisza Interfluve (Molnár B. 1991).

Fig 7.: Diagrammatic representation of $\delta^{13}C$ and $\delta^{18}O$ values. 1. Loess and wind-blown sand underlying carbonate deposits, 2. Sample data taken from the substratum deposits, 3. Data of lacustrine deposits (Molnár B. - Botz R. 1996).

Fig. 8.: Type geologic section of the Danube-Tisza Interfluve, showing the location of lake types, i.e. carbonate section types, 1. Gravel, 2. Silt, 3. Loess, 4. Aeolian (wind-blown) sand, 5. Elevation above sea level in metres (Molnár B. - Botz R. 1996).

Fig. 9.: Sand-waves on wind-blown sand in Kiskunság National Park at Fülöpháza.

Fig. 10.: Sand wave in coarser grains on the crest in Kiskunság National Park at Fülöpháza.

Fig. 12.: „Parabola” dune with its lee side (the avalanching side) where slumping has created tongue forms in Kiskunság National Park at Fülöpháza.

Fig. 13.: Cross section explaning the theoretical cross-bedding of parabola dune in Kiskunság National Park at Fülöpháza.

Fig. 14.: Cross-strata in the dune. These sets were originally stoss-side deposits, angles of strata are 8-10^{o} Kiskunság National Park, Fülöpháza.

Fig. 15.: Mainly rainwater bound carbonate (cemented) early diagenetic sandstone in Kiskunság National Park at Fülöpháza.