*Acta Mineralogica-Petrographica, Szeged, XXXII, 21—36, 1991*

# GEOCHEMICAL FACIES ANALYSIS OF QUATERNARY PELITIC SEDIMENTS OF THE NORTH-EASTERN PARTS OF THE GREAT HUNGARIAN PLAIN (ALFÖLD)

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ABSTRACT

Within the framework of the geological mapping of the Great Hungarian Plain in the scale 1:100,000 mineralogical-geochemical analysis of sediments have been carried out from 94 boreholes of 30 m depth on the section of Nyírség-Szatmár Plain-Bodrogköz. Primarily, pelitic sediments exposed and their underlying and overlying beds were in the focus of the investigations. In this paper, the most important results are reviewed. On the basis of the detailed sedimentological, mineralogical and geochemical studies, it has become possible to characterize the formations from a mineralogical-geochemical point of view and distinguish the facies groups; in this way, the eolic and fluvial environments of the sedimentation are distinguishable from each other. The further aim of the authors is to suggest a new geochemical facies analysis model for the development of knowledge of Quaternary lithostratigraphical formations.

## INTRODUCTION

In course of the complex geological mapping of the Great Hungarian Plain (RÓNAI 1985), most of the loose near-surface sediments were prospected by shallow boreholes, typically 10 m deep, planted in a network of 1.5·1.5 kms. This depth and density was adequate on the regions lying to the East of the Tisza (Tiszántúl) and the Danube-Tisza interfluvial region (Duna-Tisza köze). These regions were formerly investigated in details by previous mapping and, consequently, quite a number of data were already available on them. Opposed to this, on the North-Eastern parts of the Alföld we had deficient information on near-surface layers. For a more profound and detailed knowledge on these parts, apart from the shallow boreholes planted in a network, there were 94 boreholes more planted along five sections with 30 m depth (*Fig. 1*). Most of the cores from these boreholes were subjected to, apart from routine analyses generally practiced in mapping, a more detailed mineralogical, sedimentological, geochemical and palaeontological analysis. The reports on these analyses are deposited in the archives of the Hungarian Geological Survey.

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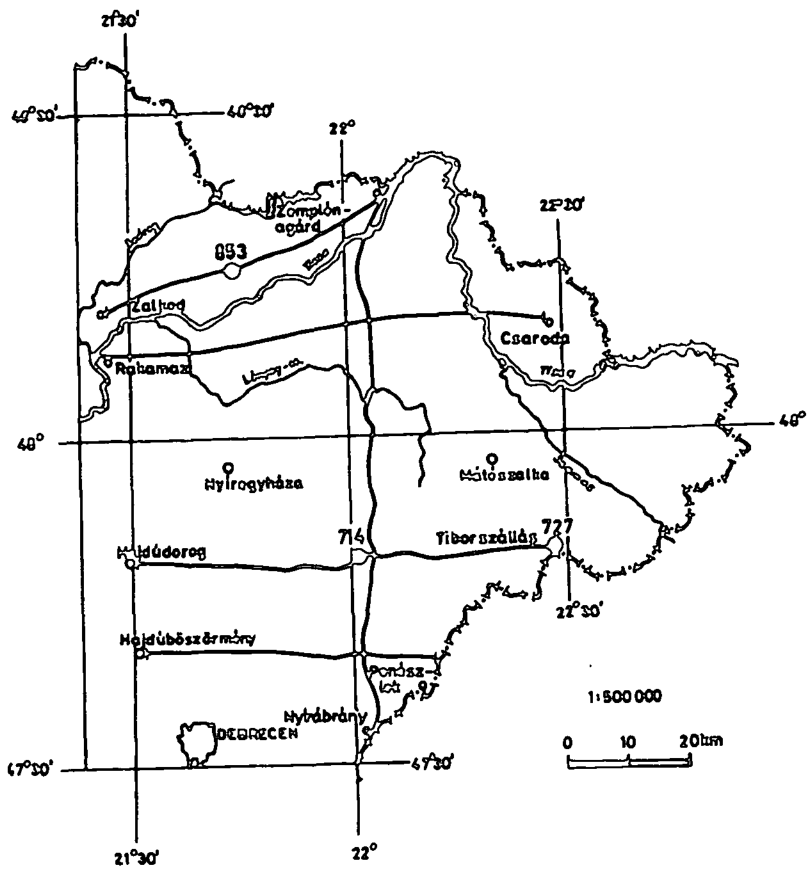


*Fig. 1.* Sketch map of the geological sections (o—o) and type-exposures (boreholes o 714, 727, 853).

One of the most important elements of these series of examinations has been the comparative geochemical analysis of the pelitic sediments, rich in fine grain fraction (BARTA and SZÖŐR 1983; BARTA *et al.* 1985). The mineralogical and geochemical analyses were focused on the determination of the mineral paragenesis which were not determinable by petrological microscopy, as well as the classification of the chemical character of the constituent formations. The clay mineral and carbonate paragenesis, amorphous and organic constituents were defined with thermoanalytical method, X-ray analysis and IR-spectroscopy.

Traditional wet chemical methods were used for the determination of the basic components of the sediments, its organic-, total sulphur- and lime content. Optical emission spectroscopy and atomic absorption spectroscopy were used for trace element analysis. From 28 components determined,13 were evaluated in details. The total U and Th content of the samples were determined lately (DARÓCZI *et al.* 1990), namely the so-called U-ekv value, that was also utilized in this paper.

The numerous data in our examination series enabled us to make a geochemical facies analysis on the samples (on the concept of "geochemical facies", see KEITH and DEGENS 1959; KREJCI-GRAF 1966; ERNST 1970). The primary aim of this was the facies classification of the formation by geochemical methods. A more profound knowledge on the lithofacies and the chemofacies can result in tracing relations in the processes of denudation, sedimentation and diagenesis.

The importance of geochemical analysis is further stressed by the lack of fossils, or scarcity of fossils in most of the samples (both vertebrate and malacological material), therefore their traditional biostratigraphical evaluation was impossible to accomplish. Moreover, on a considerable part of their grained sediments (sands) on this area, opened by these boreholes as well, sedimentological, palaeogeographical and litho-faciological analysis has already been performed (BORSY *et al.* 1981, 1985, 1988; CSONGOR and FÉLEGYHÁZI 1987; MOLNÁR *et al.* 1988), whereas no report on the intercalated pelitic formations has been published as yet.

The volume of this paper does not allow a detailed presentation of the mineralogical and geochemical analyses; therefore, results will be presented on the basis of the three sections examined in the most detailed way. Interpretation of the results will be complemented by experiences on other boreholes as well.

## LITHOFACIOLOGICAL DESCRIPTION

The three 30 m deep boreholes selected for presentation here were deepened at three spots with different geological construction. Borehole Nr. 714 was situated in the Nyírség region, East of the village Kisléta, borehole Nr. 727 to the North-East of Tiborszállás on the Szatmár Plain, while borehole Nr. 853 was planted to the South of Karcsa in the Bodrogköz region (*Fig. 1.*). The boreholes transsected formations of similar age (Holocene and Upper Pleistocene) and different genetics and geological history. It is a common feature in the section with different layer sequence that fine and coarse grain sediments are alternating in them several times (independent and different from each other) and, the formations are void fossils.

In the sequence of borehole Nr. 714, Late Pleistocene eolic sediments dominate (eolian sand, loessy sand, loess; *Fig. 2.*) Different genetics can only be supposed for the densely alternating layers transsected at 12.6—15.6 m. These grey, dark grey sandy rocks, silty sand layers of a few cms width were formed in the depressions of the former sandmoulds. Their formation was possibly similar to those observable on recent surface as well: depressions getting damp and marshy in wet seasons and drying out in the dry season. Increasing sandy fraction indicates more dry, increasing pelitic fraction, dark colour and considerable organic content denotes more humid periods. This alternating layer complex was overlain by light yellow loess, loessy sand and, later, eolic sand. Under the alternating layer there was 2 metres of sand and below this, 10 m thick layer of loess. These deeper lying layers are already all grey. The sand varieties of the section are dominantly small grained, with roughly equal medium- and fine grain fraction (10—20%). In the loesses exposed, apart from coarse silt, the fine silt and clay content can reach 30—50 %, while sand content can occasionally exceed 30 %. The carbonate content of the sediment is small, enriching to some extent in the phase between 18.5—19.0 m.

In the section of borehole Nr. 727 (*Fig. 3.*) we can find silty layers with considerable amount of pelitic fraction and organic matter till 10 metres from the surface, probably the result of freshwater-riparian sediments. Starting from the surface, the colour of the layers is black, yellow, yellowish grey, grey, blackish-grey and brown. The light yellow sediments at the depth of 1.5—3.0 m are lime concretions. Probably the whole silty complex, or at least its upper meters are of

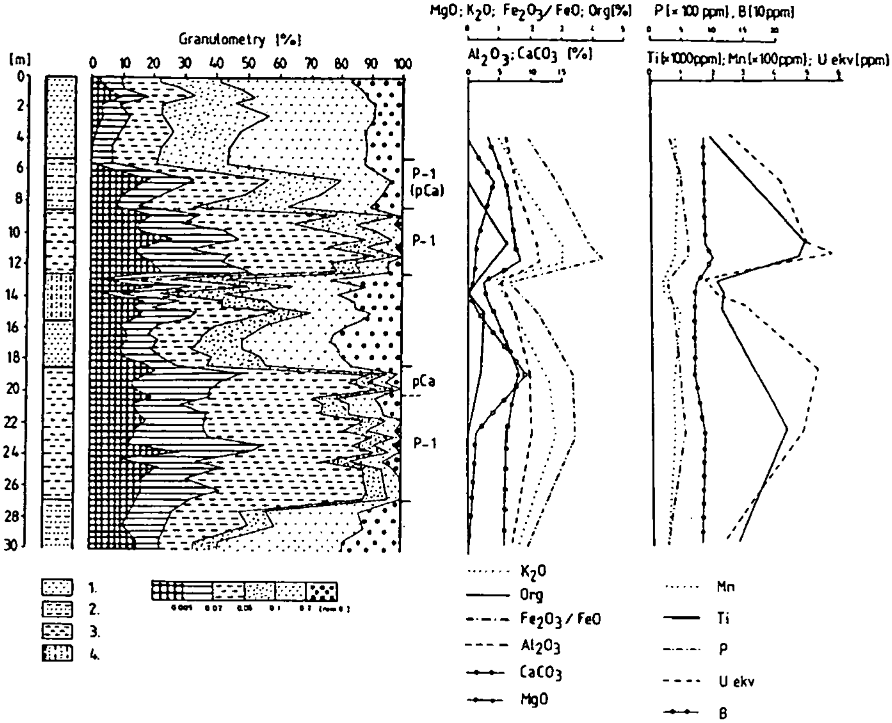


*Fig. 2.* Stratigraphy, lithological and geochemical facies of the borehole Nr. 714. 1=sand; 2=silty sand; 3=clayey silt; 4=sand and silty sand. P-1 and pCa=subfacies.

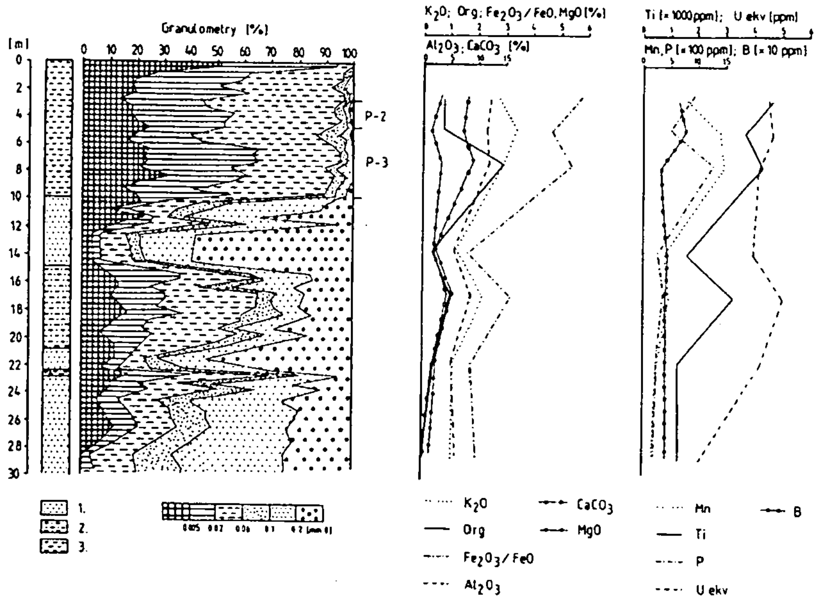


*Fig. 3.* Stratigraphy, lithological and geochemical facies of the borehole Nr. 727. 1=sand; 2=sandy silt and silty sand; 3=clayey silt. P-2 and P-3=subfacies.

Holocene age but there are no fossil or other time-indicating proofs of that. Deeper lying sediments are of Upper Pleistocene age. Under the near-surface silt of 10 meters, the sequence is composed of alternating layers of grey sand and grey sandy silt in different thickness. The composition of grains and macroscopic features (e.g., unperfectly worn grains) denote riverine-riparian environment of sedimentation.

In the sequence of borehole Nr. 853 (*Fig. 4.*), till 22.5 meter depth we can find clay and fine silt, under it, sand is dominating. Along the whole sequence, grey colour is dominating with the exception of the top soil layer (30 cms) which is brown. Small-grained sand between 3.4—6.0 m is yellowish grey, the clayey silt between 9.0—25.0 m is greenish grey with spots stained by vivianite. Towards the bottom (till 24 m) the sands get more coarse; at 24.0 m reaching medium grain sand and, after it, getting again finer. As opposed to sand, layers of silt get finer towards the bottom with increasing clay content.

On the basis of the grain composition and macroscopic features as well as alternating amount of organic matter we can suppose that the borehole exposed variable riverine, riparian and marshy sediment. Under 21.7 m the genetics of the sand layers are uncertain, comprising features denoting riparian and eolic origin as well.

There are no proofs concerning the age of the layers. Probably the upper meters were deposited already in the Holocene, while deeper lying layers belong to the Upper Pleistocene.

## GEOCHEMICAL FACIES DIVISION

Analysis of the geochemical facies can be performed by several methods like suitable facies indicators — classification of mineral paragenesis, determination of elements, comparison of elements, organic and non-organic compunds, ratio of stabile isotopes etc. For the characterization of the variable clayey formations with different genetics, determination of mineral phases based on thermal analysis was used (mineral paragenesis classification). Thermoanalytical parameters based on characteristic run-off of **DTA** curves and corresponding temperature values as well as **DTG—TG** curves represent well the quality and quantity clay minerals and carbonates in the sample. The elements and pairs of elements seemingly most suited for facies indications were selected from the chemical data by computer-aided investigation. The pelitic formations in the near-surface Quaternary sediments of the North—Eastern parts of the Great Hungarian Plain were separated into geochemical groups presented below.

## CARBONATIC PELITE FACIES GROUP

This facies group comprises clayey silts and silty clay varieties where the total amount of carbonate exceeds 10 percent.

Carbonates are present in the sediments in the form of coating to mineral grains forming sometimes this lime silt veins or small concretions (some mms large). There are also some Molluscan shell fragments as well.

Sediments of this type are light yellow in air dry state, sometimes stained by ochre. The constituents found by our analyses were calcite, aragonite (in Molluscan shells only), magnesito-calcite, calcium carbonate with Mg content in the form of amorphous precipitates, siderite, dioctahedric clay mica (illite), illite-smectite

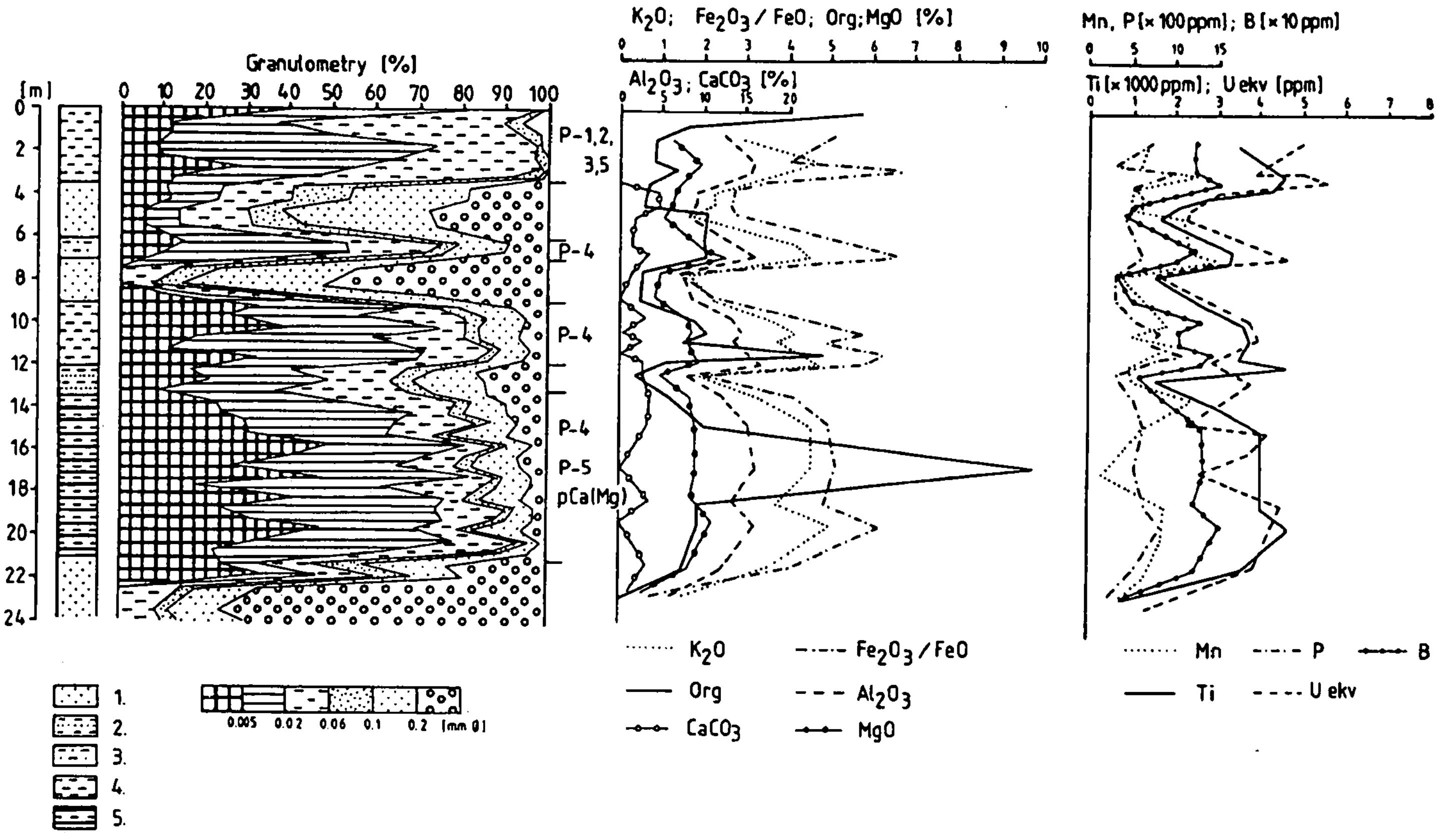


*Fig. 4.* Stratigraphy, lithological and geochemical facies of the borehole Nr. 853.
1=sand; 2=silty sand; 3=sandy silt; 4=clayey silt and silt; 5=silty clay. P-1 — P-5 and pCa(Mg)=subfacies.

(montmorillonite) mixed structure, kaolinite, sericite and X-ray amorphous precipitates. The carbonate content, determined by thermogravimetry, is 11.73—29.46 %, by Scheibler's calcimetry, 7.0—23.2 %. Its organic matter content is between 0.63—2.14 (thermogravimetric result) and 0.50—2.50 % (oxidimetric titration), respectively. TG parameters in respect of clay minerals are $H_2O(I)$ = 2.42— 4.17 %; $H_2O(II)$ = 1.30—1.43 %.

There were three types separated within the facies group corresponding to, at the same time, genetical categories as well.

### CALCIUM-CARBONATIC PELITE FACIES TYPE (MARKED AS pCa)

Silts, sandy silts formed in the depressions between the sand mounds, containing relatively high amount of carbonates can be assigned to this group. Their basement and, often, their cover is composed of, typically, eolian sand with rounded grains. Their type section is represented by borhole Nr. 714, where their geochemical character could be studied best (*Fig.* 2.). Their thermoanalytical character is demonstrated on the graph marked A on *Fig. 5*. Indicator minerals of the sediments are dioctahedric clay mica (illite) and calcite, typical feature is low organic matter content. Total amount of iron oxides ($Fe_2O_3/FeO$) = 2—3 % (the ferro- and ferri-iron content of the rocks were not determined separately, because after preparation samples got oxidated in course of storing), Mn=50—100 ppm, Mg=0.5—1.5 %. Formations of this type were found on the NE Alföld region only in boreholes deepened in the region of the Nyírség.

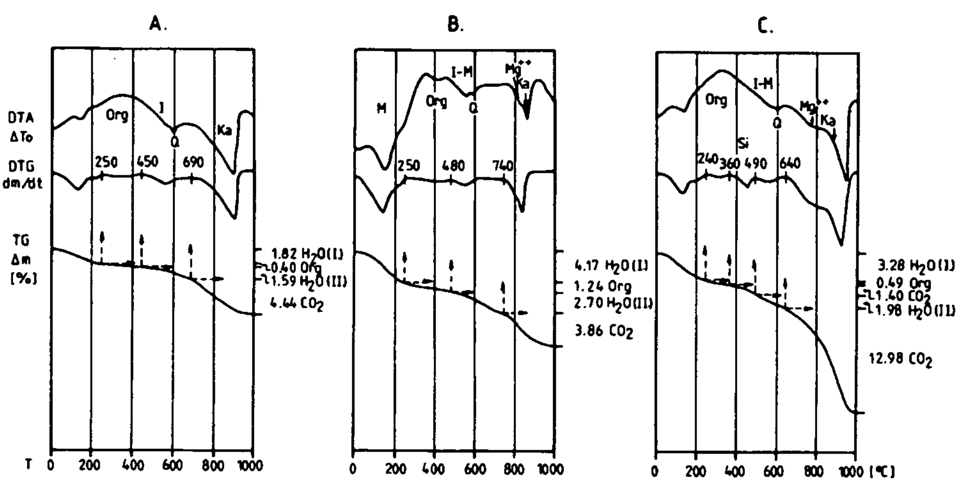


*Fig. 5.* Characteristic thermoanalytical curves and parameters of the carbonate-pelitic facies. A=pCa subfacies, borehole 714. 18.5—19.0 m B=pCa(Mg) subfacies, borehole 724. 5.5—6.0 m C=pCa(Fe) subfacies, borehole 724. 7.0—7.5 m Org=organic material, I=illite, I-M=illite-montmorillonite mixed layer, Q=quartz, Ka=calcite, $Mg^{++}$=protodolomite, magnesitocalcite, Si=siderite.

## CALCIUM—MAGNESIUM—CARBONATIC PELITE FACIES TYPE (MARKED AS pCa/Mg)

Part of the riverine and riparion clayey silts belong to this group. Their basement is clay, containing very few or no carbonate, under which we find riverine sand. The characteristic but fairly varied sediments of this type are well represented by samples taken from the 14.5—15.0 m and 18.0—18.5 m phases of borehole Nr. 853. The carbonate content of theses samples is over 10 %. Their thermoanalytical characteristics are represented on the graph marked B on *Fig. 5.* Indicator minerals for this group comprise magnesito-calcite (proto-dolomite), illite-montmorillonite mixed structure and a considerable amount of organic matter. Total iron oxide content ($Fe_2O_3/FeO$)=4—5%, Mn = 500—750 ppm, MgO = 1.5—2.5 %.

Such sediments were found in boreholes deepened on the Szatmár Plain and in the Bodrogköz region as well.

## SIDERITIC PELITE FACIES TYPE (MARKED AS pCa/Fe)

Light coloured yellowish grey, greyish green and bluish grey material formed at the border region of marshes, bogs in the oxidative environment of water inflows.

The basement and cover of these formations is composed of clayey layers containing no or very little carbonate with numerous plant fossils and Molluscan shell fragments.

The thermoanalytical characteristics of the subsurface are represented on graph marked C on *Fig. 5.* Indicator minerals are siderite, amorphous carbonates with $Mg^{++}$ and $Ca^{++}$ and calcite/magnesito-calcite. Characteristic clay mineral is illite-montmorillonite mixed structure. X-ray analysis could reveal the presence of sericite and chlorite as well. The facies is characterised by low organic matter content.

Total iron oxide content ($Fe_2O_3/FeO$)=5—7%, Mn = 1500—5000 ppm. MgO = 2.0—2.5 %.

On our area, only two boreholes exposed such type of sediments. Borehole Nr. 724 in the Nyírség, to the North of Mérk and borehole Nr. 852 in the Bodrogköz, to the North of Cigánd. This later sample contained some kaolinite as well.

## LOW OR NO CARBONATE PELITE FACIES GROUP

The pelitic sediments exposed by the boreholes are, on the basis of their grain size composition, clayey silt or silty clay varieties. Their carbonate content is 5%, often with no carbonate at all. Their colour is varied, in air-dry state from greenish grey and brownish grey till dark grey, in some cases, stained by yellow and brown limonite, black manganese dioxide or blue vivianite. Mainly they are microlaminated or striped, occassionally with plant fossils, Molluscan shell fragments, manganese dioxide or limonite micro-concentrations. Constituents detected include montmorillonite, chlorite, sericite, illite, kaolinite, vivianite, amorphous pyrite, carbonate precipitate. Organic matter in the samples can be present in the form of macroscopically observable plant remains or intermittent material disperged between the grains as well as huminelignine complexes. The indicator minerals and characteristic geochemical composition is discussed in details at the specific description because of their widely variable values.

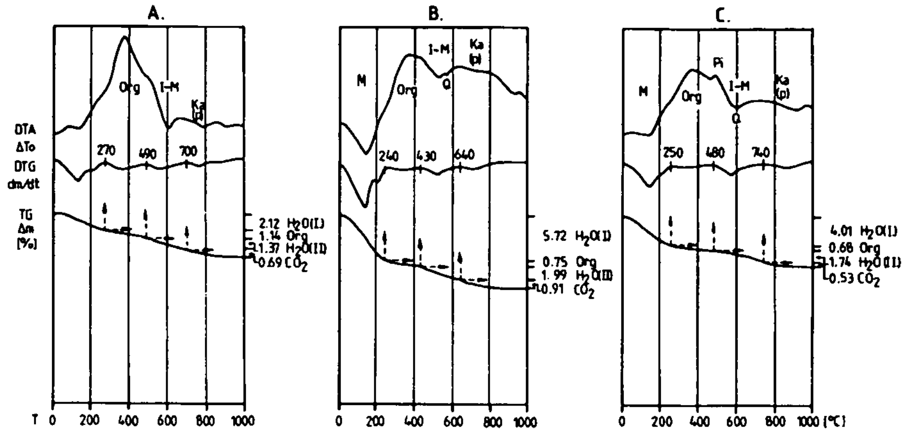


*Fig. 6.* Characteristic thermoanalytical curves and parameters of the low-carbonate /carbonate-free pelitic facies
A=P-1 subfacies, borehole 714. 10.0—10.5 m
B=P-2 subfacies, borehole 727. 2.0—2.5 m
C=P-3 subfacies, borehole 727. 4.5—5.0 m
Org=organic material, I-M=illite-montm. mixed layer,
Q=quartz, Pi=pyrite, Ka(p)=gel magnesite and calcite

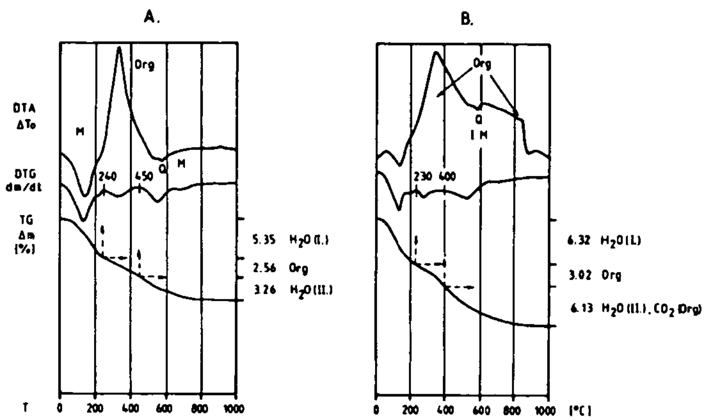


*Fig. 7.* Characteristic thermoanalytical curves and parameters of the low-carbonate /carbonate-free pelitic facies
A=P-4 subfacies, borehole 853. 11.0—11.5 m
B=P-5 subfacies, borehole 853. 17.0—17.5 m
Org=organic material, I-M=illite-montm. mixed layer, Q=quartz

## LOESSY FACIES TYPE (MARKED AS P-1)

Silty sediments transported by the wind deposited quite often on temporarily wet surface (hydro-aerolite) belong to this group. They are typically yellow or grey in their deeper layers. Their clay and fine silt content can reach 30—40%, but quite often, sand content can also reach as much as 20—30%. In the sequence of the borehole Nr. 714, the basal parts (20—27 m) are interrupted by two humic soil layers, 40 cms thick each. Its basement is eolic sand, the upper parts are carbonatised, gradually shifting into calcium-carbonatic pelite subgroup. Within the sections, this series can occur repeated several times. Typical sediments of this type can be studied in borehole Nr. 714 (*Fig. 2.*). Their thermoanalytical characteristics can be seen on the graph marked A on *Fig. 6.* Indicator minerals comprise illite-montmorillonite mixed structure, chlorite and carbonate precipitate. Parameters denoting clay-mineral content are: $H_2O(I)$=1.5—2.5 %, $H_2O(II)$=1.0—2.0 %. Organic matter content = 0.5—1.7% (oxidimetric titration). $CaCO_3$ content = 0.5—2.0 %. Chemical parameters:

Total iron oxide content ($Fe_2O_3$/Fe))=3—4 %, Mn = 50—100 ppm, P = 300—400 ppm, B/Ga = 2.0—2.5.

Sediments belonging to this type were exposed by boreholes deepened in the Nyírség region.

## RIVERINE, RIPARIAN, HUMIC PELITE FACIES TYPE (MARKED AS P-2)

Sediments of this type are grey silt varieties, microlaminated, rich in micas, containing 20—30 % clay fraction with no Molluscan shells and plant fossils. They are void of carbonates or contain carbonate precipitates only. No amorphous pyrite was found in them. The most typical sample for this facies can be found in the sequence of borehole Nr. 727 (*Fig. 3*).

Its thermoanalytical characteristics are presented on graph B of Fig. 6. Its indicator mineral is the illite-montmorillonite mixed structure. X-ray analyses could detect the presence of chlorite and kaolinite as well.

Parameters denoting clay-mineral content are: $H_2O(I)$=3—6 %, $H_2O(II)$=2.0—4.0 %. Organic matter content = 1.50-5.00 % (oxidimetric titration). $CaCO_3$ content = 0.0—2.5%. Chemical parameters:

Total iron oxide content ($Fe_2O_3$/FeO)=5—6 %, Mn=500—1500 ppm, P = 500—1000 ppm, B/Ga = 2.0—3.0.

Sediments belonging to this facies were exposed by boreholes deepened in the Bodrogköz and the Szatmár Plains.

## RIVERINE, RIPARIAN, LACUSTRINE, ENTROPHIC PELITE FACIES TYPE (MARKED AS P-3)

Clayey silts of dark grey, blackish gray, brownish grey colour can be assigned to this group. These sediments were probably formed in small eutrophic basins on the flood plains of the rivers in reductive environment. They often contain bluish knots of vivianite as well as blackish grey spots of humus. In the humic layers and spots we find no macroscopically observable plant fossils, but fairly frequently, there are fragments of Molluscan shells here. The clay mineral typical of the faces is an illite-montmorillonite mixed structure. Its disperged organic matter content is considerable, bound to the montmorillonite, just the same as its sulphur content present in the form of amorphous pyrite and in organic bounds. The samples contain no carbonate, at the maximum, a very small amount of carbonatic precipitate.

Typical example of this facies can be studied in the samples of borehole Nr. 727. Its thermoanalytical features are presented on graph C of *Fig. 6.*

Parameters denoting clay-mineral content are:

$H_2O(I)$ = 4—7 %, $H_2O(II)$ = 1.5—3.0 %. Organic matter content = 1.0—3.5 % $CaCO_3$ content = 0.0—1.5 %. Chemical parameters: Total iron oxide content ($Fe_2O_3/FeO$) = 4—6 %, Mn = 1200—5000 ppm, P = 500—1500 ppm, B/Ga = 3.0—4.0.

Sediments belonging to this facies can be found in the Bodrogköz region and the Szatmár Plains.

Pelite facies type of upfilling dead branches and sedimentary depressions on interfluvial regions (marked as P-4) and marshy (peat) pelitic facies (marked as P-5).

Clayey-sandy silts, silty-sandy clays filling up the former dead branches of rivers, flood plain depressions can be classified into this group. In these sediments, apart from 40—70 % of pelite content, we could find in almost each sample 15—25% of sand as well. These sediments are typically of greenish grey colour with spots of vivianite and plant remains. In the fluctuation zone of the soil waters they are yellow, with stains of ochre. Amorphous pyrite is not typical, it can mainly occur towards the cover of the sequence in the eutrophic subfacies (P-3). This type is typically void of carbonates or poor in carbonate, but the layers may form a transition towards the Mg-rich amorphous carbonatic facies (pCa/Mg).

Clay mineral typical of this facies is the montmorillonite, the organic matter is in finely disperged state (type P-4) or in the form of lignite (type P-5). These dark grey, dark brown clay stripes contain turfy matter. Their characteristics can be studied in borehole Nr. 853 (*Fig. 4*), their thermoanalytical features are presented on *Fig. 7*. Parameters denoting clay-mineral content $H_2O(I)$=5—7 %, $H_2O(II)$=3—6 %. Organic matter content, determined by titration, is 2—3 % for P—4 and 10—20 for P-5.

Chemical parameters: Total iron oxide content ($Fe_2O_3/FeO$)=4—8 %, Mn= 200—1500 ppm, P=400—1100 ppm, B/Ga = 4—7.

On *Fig. 8.*, the alternation of facies types in borehole Nr. 853 in function of depth is presented, compiled on a temperature scale of uniform intensity.

## EVALUATION OF INDICATOR ELEMENTS, PAIRS OF ELEMENTS

Armed with knowledge on facies types presented above, a mathematical-statistical elaboration of the main components, trace elements and pair of elements were performed. Relation of several elements were studied including Al/Ti, K/Al, K/Na, Ca/Mg, Fe/Mn, V/Cr, Cr/Ni, Ba/Sr, B/Ga, Li/B, P/B ratios.

Independent of qualitative description of the rocks we have performed a linear regression analysis of the chemical parameters of all samples. The aim of our interest has been the description of basic geochemical correlations, revealing regional similarities and differences and studying the rules of the connection of elements. After computer assisted investigations, the following results seem to be valid and worth for publication.

On *Fig. 9.*, the investigation of the relation of the elements Al, K, B, and Ga proves the divergent geochemical character of the regions of the Norther Eastern part of the Great Hungarian Plain.

The Bodrogköz region (Zemplénagárd-Zalkod sections) is different from the Nyírség formations, on the basis of higher Al and K values of the former. In spite of the fact that the correlation of K and Al on both territories is very strong and

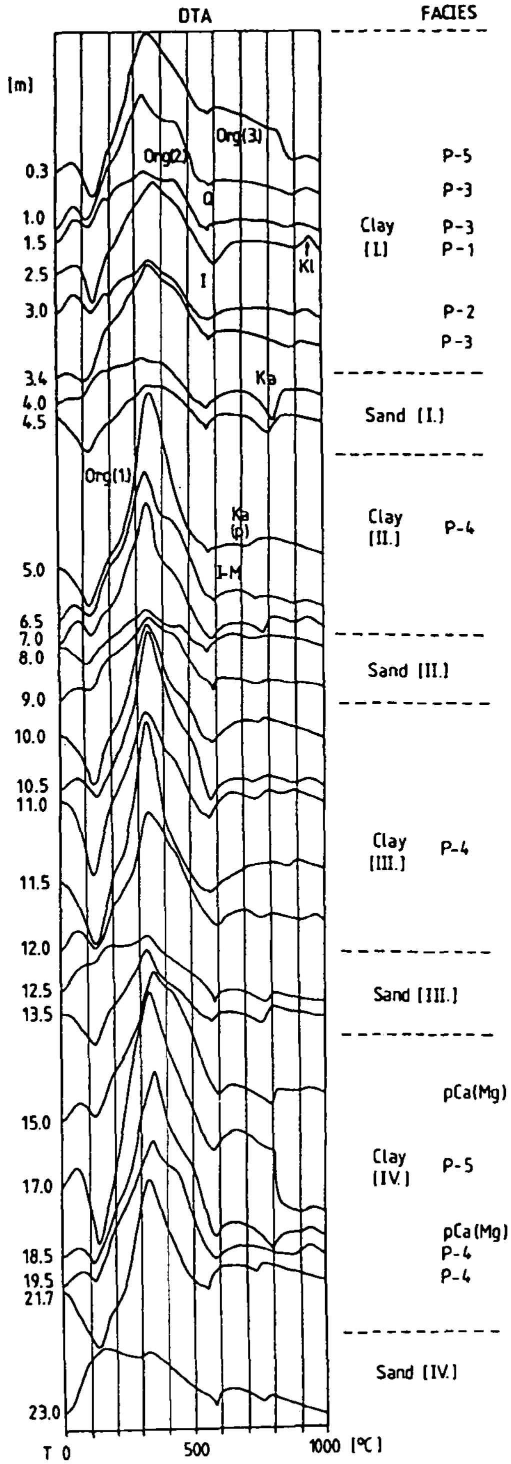


*Fig. 8.* **DTA** curves representing the change of the mineral-geochemical facies from sequence of the borehole 853.
Sand (IV)=sand from river channel; Clay (IV)=pelitic and peaty sediments from filling cut-off meander; Clay (III)=pelitic sediments deposited between river-branches; Sand[III] and [II]=river-sand, Clay[II]=pelitic sediments deposited between river-branches; Sand[I]=eolic redeposited sand of river-side; Clay [I]=eutrophic and "peaty" pelitic sediments of flood-plains.
Org.(1.2.3)=organic materials, I=illite, I-M=illite-montm. mixed layer, Kl=kaolinite, Q=quartz, Ka=calcite, Ka(p)=gel magnesite and calcite.

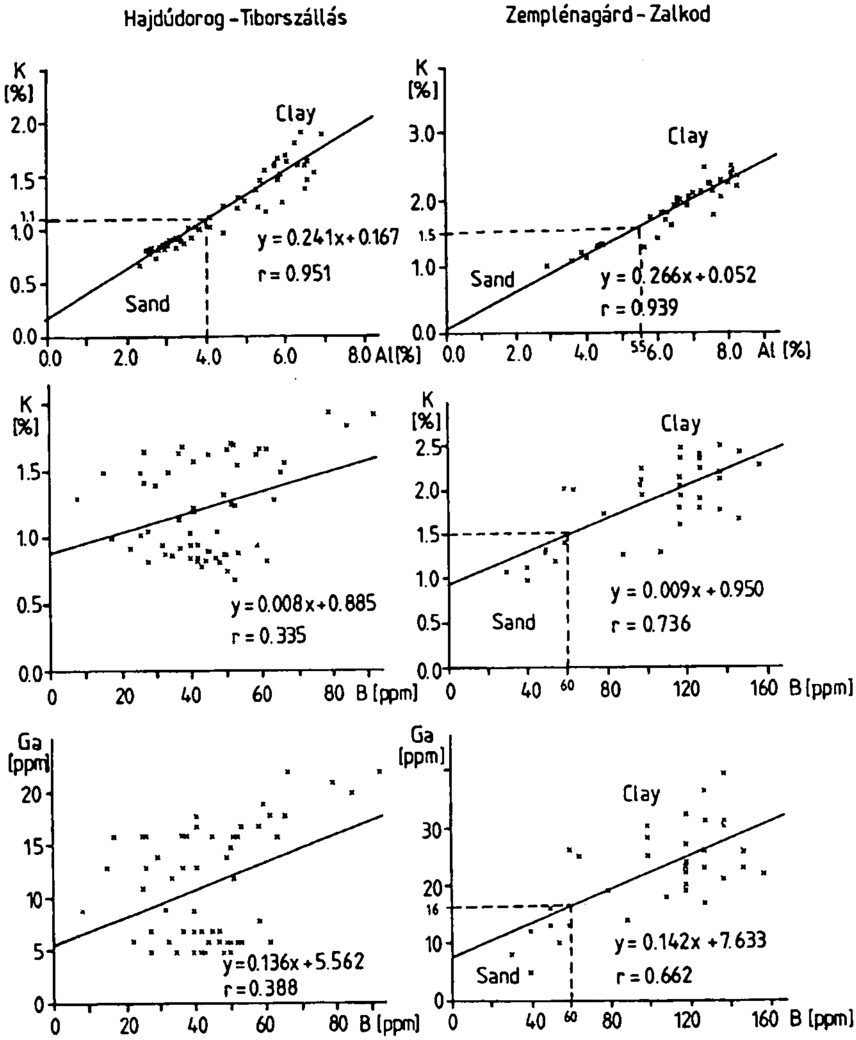


*Fig. 9.* Geochemical differentiation between pelitic sediments (Clay) and the grained under- and overlying beds (Sand) from boreholes of the sections Hajdúdorog-Tiborszállás and Zemplénagárd-Zalkod.

practically equal, there are considerable differences in the element pairs K/B, B/Ga in comparing the relevant regression coefficient values. Apart from obvious differences in the quality and quantity of the pelitic fraction, they are obviously connected with micromineralogical character as well.

Ca- and Mg- ions connected to, in the first place, hydrogene carbonates, were mostly dissolved from the clayey layers and precipitated in other clayey layers in the form of secondary carbonates. In the carbonate-free layers and those of low carbonate pelitic layers, the ratio of Ca/Mg ions is 1.0. Dolomitisation typical for the Danube-Tisza interfluvial region (MOLNÁR 1980; MOLNÁR and KUTI 1983) cannot be demonstrated on the North-Eastern parts of the Alföld, proving the differences in sedimentation and diagenetic conditions.

The value of Mg content is roughly equal and, there is a close correlation in the values of Al, K, and Fe as well, but fairly independent of Ca (*Fig. 10*).

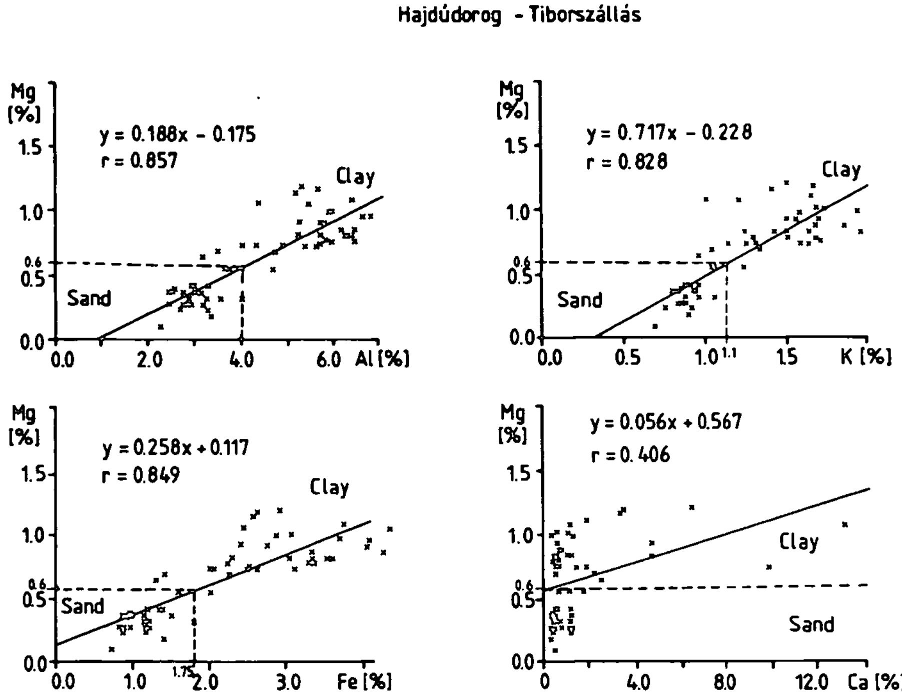


*Fig. 10.* Correlation between Mg and Al, Fe, K, Ca on the basis of the study of pelitic sediments (Clay) and grained over- and underlying beds (Sand) from boreholes of the section Hajdúdorog-Tiborszállás.

Accumulation of Mg took place in the formations examined as a result of the fine (bio)mass flourishing in the marshy environment.

Analysis of the carbonate-free and low carbonate content pelitic facies was performed on the most clayey samples selected from each borehole, most of them were absolutely void of carbonates, the rest containing < 3 % $CaCO_3$. Our primary aim was to distinguish between oxidative and reductive environments. Element relations between Al/Ti and Fe/Mn were most informative from this respect. Among more oxidative circumstances, coloured minerals with Ti content dissolve more intensively (hydrolise better). Thus, beside aluminium, more titanium is getting into solution, further promoted by the presence of sulphur compounds turned to sulphates in oxidative environment. This process takes place typically different for the different facies types. In case of P-1 (eolic) type and P-2, P-3 in case of river-side flood plain sediments organic matter and amorphous pyrite, in case of P-4, P-5 interfluvial depressions, bogs organic matter, amorphous pyrite and vivianite indicate a more reductive environment.

The separation of iron and manganese in sediments is also a process strictly dependent on facies relations.

By considerable organic matter content, in the presence of humine materials and in acidic pH, i.e., reductive environment, these ions enter into solution more intensively and are being transported in the form of hydrogene carbonates and, by a change in the pH getting into more oxidative conditions they are precipitated. These regularities can be studied on *Fig. 11.*

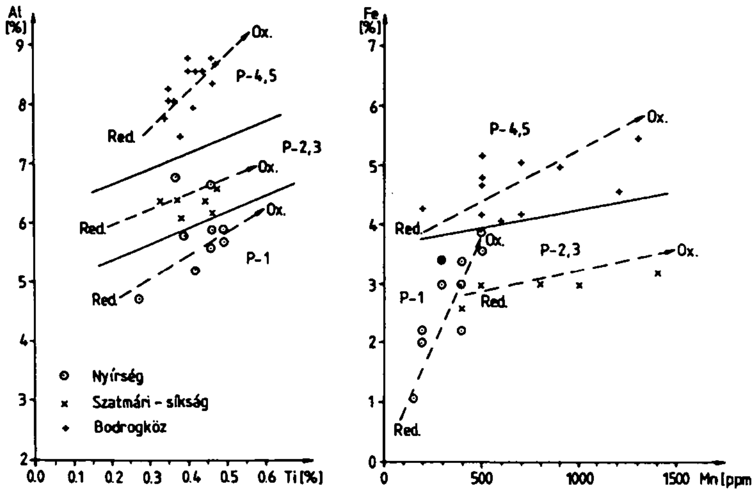


*Fig. 11.* Correlation between Al-Ti and Fe-Mn element pairs on the basis of the study of low-carbonate ($CaCO_3$ < 3 %) pelitic sediment from NE Tiszántúl (Transtibiscia). P-1, P-5= subfacies, oxidative (Ox.) and reductive (Red.) environments.

Finally, the chemofaciological analysis on the three boreholes presented above was performed. *Fig. 12* demonstrates the result of correlation studies on the basis of the element pairs K/B. The individual genetical units can be separated very well in the coordinate system. In field I., sediments of eolic reworked sands and inter-mound sediments resembling infusional loess are grouped. In field II.,

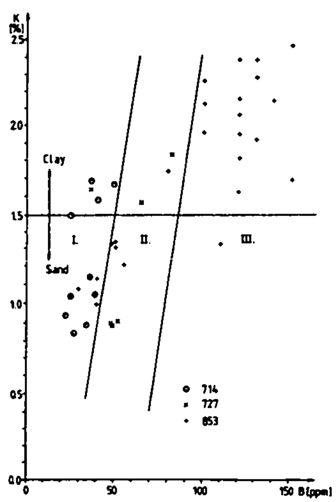


*Fig. 12.* Chemofacies-analysis of the clayey beds (Clay) and of the grained over- and underlying formations (Sand) from boreholes 714., 727., and 853. on the basis of the K/B ratio. I.=eolic, II.=fluviatilic, III.=lymnic (paludal) sediments.

riverine sands and riparian pelitic sediments, in patch III., upfilling of dead branches, limnic basins, marshes can be separated.

Our statistical analyses indicate that by the correlative evaluation of other pairs of elements we can trace the different areas of origin as well. This paper, however, does not aim at presenting this very complex evidence which can be studied only by detailed granulometric, grain-morphological and micromineralogical investigations.


## ACKNOWLEDGEMENT

This work was supported by Foundation Grant of OTKA No. 154.


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*Manuscript received, 22 November, 1990*