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DETRITAL FRAMEWORK ANALYSIS OF LOWER CRETACEOUS TURBIDITE SEQUENCE OF NESZMÉLY—4 BOREHOLE (W. GERECSE MTS., HUNGARY)

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ABSTRACT

Lower Cretaceous (Berriasian to Lower Aptian) turbidite sequence of W. Gerecse Mts. formed within the Bakony unit in norheastern part of the Transdanubian Mts.

On the basis of detrital framework grain analysis a possible history of the source area can be inferred. The sedimentation started by erosion of oceanic crust and continued dominantly by erosion of continental basement. The serpentinite, chloritite, gabbro and dolerite lithic fragments, as well as the greenschist facies rock fragments and volcanic glass have been derived from the erosion of an ophiolite complex. The sandstone is rich in quartz and sedimentary, metasedimentary lithic fragments originated from mature sedimentary rocks or slightly metamorphosed rocks. In the heavy mineral assemblage chromian spinel is predominant suggesting ophiolitic provenances, too.

KEYWORDS: Neszmély Sandstone Formation, Lower Cretaceous turbidite sequence, detrital, framework grain analysis, heavy minerals, provenance area

INTRODUCTION

The Lower Cretaceous clastic formations of Gerecse Mts. are situated in Bakony unit, in northeastern part of the Transdanubian Mts.

The formations of W. Gerecse Mts. differ considerably from that of the E Gerecse Mts. The western region consists mostly of sandstone sequence with a few thin conglomerate intercalations, while the eastern part is characterized by Bersek Marl, Lábatlan Sandstone and Köszörűkőbánya Conglomerate Formations (FÜLÖP, 1958). The paleogeographic connection between the E. and W. Gerecse is uncertain.

The studied Neszmély—4 (N—4) borehole explored the W. Gerecse Clastic Complex (CSÁSZÁR and HAAS, 1984) which was lately called Neszmély Sandstone Formation (CSÁSZÁR, pers. comm.), *Fig. 1.*

According to FÜLÖP (1958) the geological features of E. Gerecse Mts. show similarity to that of Rossfeld Formation, and show some criteria of flysch sediments (flute casts, trace fossils, graded bedding)(CSÁSZÁR and HAAS, 1979). It was deposited in a prograding submarine fan (KÁZMÉR, 1987) from Lower Berriasian to Upper Aptian — Lower Albian (SZTANÓ, 1989). On the basis of stratigraphic and tectonic observations of KÁZMÉR and KOVÁCS (1985), and KÁZMÉR (1988) the sedimentary basin was formed within the Bakony unit in the Alps during the Mesozoic time.

This work forms part of a new research program being carried out by the Hungarian Geological Institute to clarify geological similarities between the two parts of Gerecse Mts., as well as to establish their connection to the clastic developments of Alp-Carpathian-Dinarian region.

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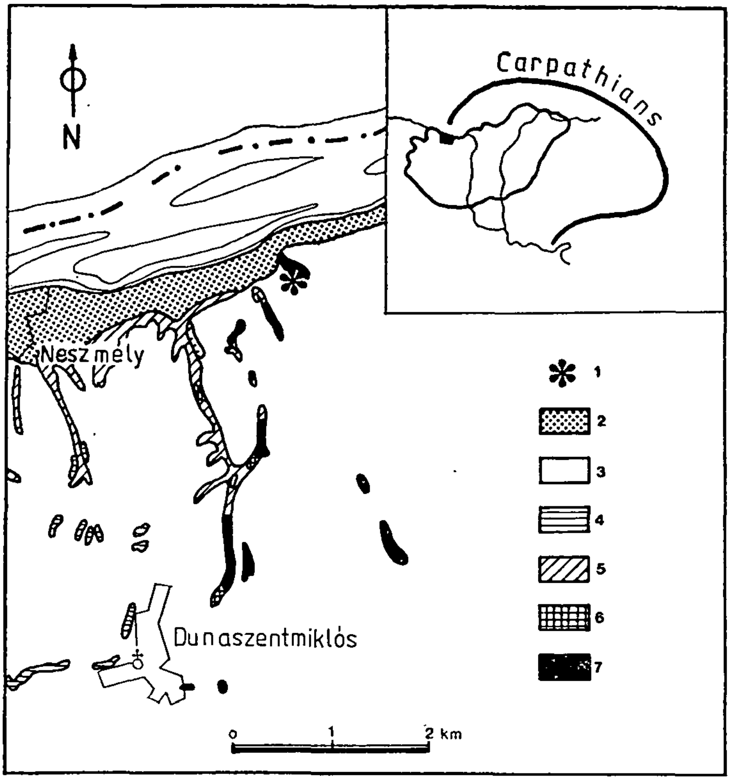

Fig. 1. Locality of Neszmély—4 (N—4) borehole and geology of surrounding area: 1. Neszmély—4 borehole; 2. Pleistocene terrace sand; 3. Pleistocene loess; 4. Pleistocene freshwater limestone; 5. Pannonian sand and mud; 6. Eocene sandstone and mudstone; 7. Neocomian sandstone

STRATIGRAPHY

Neszmély—4 borehole consists of alternating mudstone, marl, fine- and coarse grained sandstones and matrixsupported conglomerate, deposited by turbidite current. The sandstone facies are sublitharenite-litharenite or lithic arenite-lithic wacke (terminology after FOLK (1968) and DOTT (1964)), see further discussion below. On the basis of available Ammonites fossiles the sequence was formed from Lower Berriasian i to Lower Aptian (HORVÁTH, pers. comm).

Fig. 2 shows the stratigraphy, lithology, carbonate content and characteristic clastic components in the sequence.

HEAVY MINERALS

In the heavy mineral assemblage the grains of chromian spinel are predominant in association of augite, chlorite and a few kinds of metamorphic minerals such as garnet, staurolite, kyanite, epidote, actinolite (tremolite), apatite as well as stable minerals such as rutile, tourmaline, zircon *(Fig. 3a)*. Some opaque grains with hematized and goethitized surface show ilmenite-magnetite exsolution. Pyrite is also

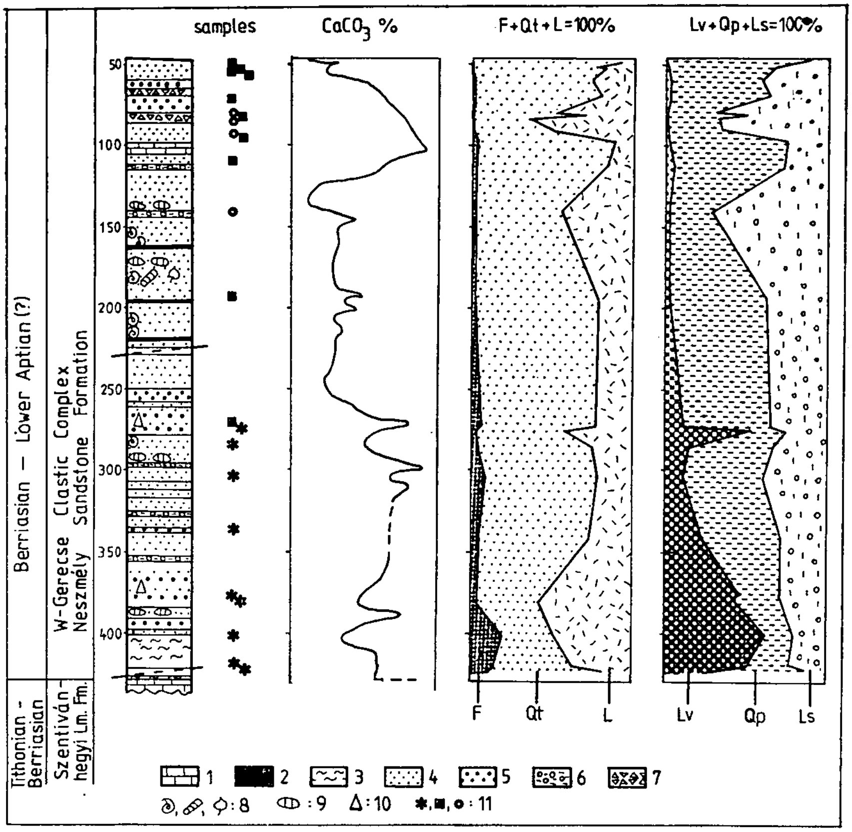

Fig. 2. Lithological section, carbonate contents and relative abundance of the main detrital components: 1. Limestone; 2. Mudstone; 3. Marl; 4. Fine to medium-grained sandstone; 5. Coarse grained sandstone; 6. Matrixsupported conglomerate; 7. Breccia; 8. Ammonites, trace fossils, plant fragments; 9. Carbonate nodules; 10. Normal gradation; 11. Samples from facies „a", „b", „c", respectively (explonation in the text)

enriched in certain levels. According to my preliminary microprobe analysis the chemical composition of chromian spinel is $Cr/(Cr+Al) \approx 0.7$ and $Mg/(Mg+Fe^{2+}) \approx 0.4$—$0.5$. The chromian spinel and orthopyroxene ((?) (which are not documented yet by microprobe analysis) grains may hint at an ophiolitic source area which must have been on the surface during the erosion.

Comparing the heavy mineral composition with that of the Oštrc Fm. (Zupanič *et al.*, 1981) and the Rossfeld Fm. (Pober and Faupl, 1988) a great similarity can be seen among them *(Fig. 3b)*. The exotic detritus of Rossfeld Formation (chromian spinel) originated from the Tethys' sutura belt which was to the south of the Northern Calcareous Alps (Decker *et al.*, 1988; Pober and Faupl, 1988).

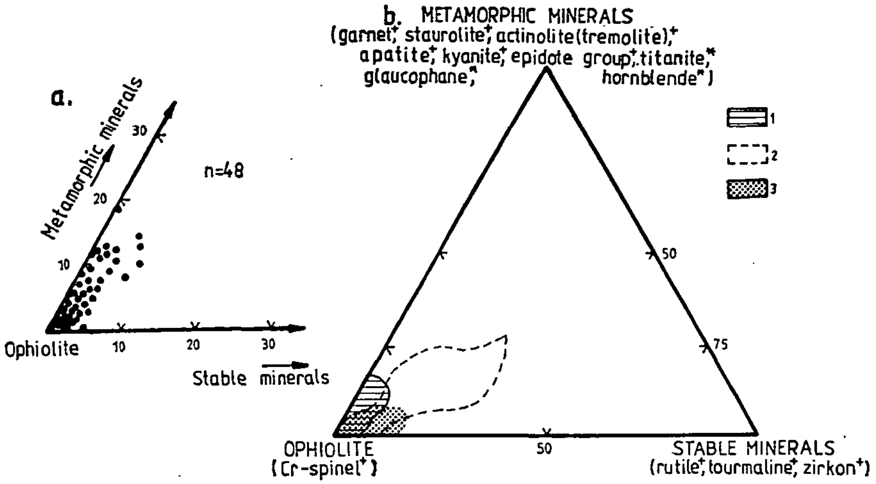

Fig. 3. Heavy mineral composition of N—4 borehole (a) compared to analogous sequences (b): 1. N—4 borehole; 2. Rossfeld Formation (POBER and FAUPL, 1988); 3. Oštrc Formation (ZUPANIČ *et al.*, 1981); +Heavy minerals in N—4 borehole; ∗ additional heavy minerals in analogous sequences. (Studied interval: 0.063—0.250 mm)

FRAMEWORK ANALYSIS

Method

A standard framework grain analysis was done by Dickinson's method using the ribbon counting technique on monomineralic and unstable lithic sandy grains, 0.0625 to 2 millimeter (e.g. GRAHAM *et al.*, 1976; MOORE, 1979; ZUFFA *et al.*, 1980; WINKLER, 1984, 1988; GARZANTI, 1985). Table 1. contains the classification and symbols of main grain types. These are the basis for the petrological F-Qt-L, Lv-Qp-Ls, F-Qm-Lt and P-Qm-K diagrams (DICKINSON and SUCZEK, 1979; DICKINSON, 1985). and the secondary petrological parameters, Qt(=C)/Q, P/F and Lv(=V)/L (DICKINSON, 1970).

The crucial point of this method is the exact identification of detrital grains. In this work the optical analysis of secondary and diagenetic processes (MCBRIDE, 1985) proved to be very useful. Heavy minerals are ignored because of their different hidrodynamic behavior and geochemical resistance (MORTON, 1985). The intrabasinal grains are ignored, too (terminology after ZUFFA, 1980). Distinction between the extrabasinal and intrabasinal carbonate grains are difficult because of the different diagenetic effects (micritization, recrystallization, oxidized contours). Therefore the extrabasinal carbonate grains or detrital limeclasts (intraclasts, ooids, peloids, bioclasts) are not recalculated with other lithic fragments (DICKINSON, 1970, 1985), (Lc, Table 1.). Special counting technique can minimize the dependence of rock composition on grain-size (ZUFFA, 1980, 1985). Accordingly, the monomineralic crystals and other grains of sand size occuring in larger lithic fragments (e.g. granite) are classified as crystals rather than rock fragments. Inspite, the microcrystalline lithic fragments (e.g. phyillites) preserve their original texture during transportation. INGERSOLL *et al.* (1984) described in details that the using of Gazzi—Dickinson method on unsorted and different grain size fractions of the same sample is produce same results. Otherwise the sieving and multiple counts of different fractions are unnecessary.

TABLE 1

Classification and symbols of grain types
(slightly modified after DICKINSON *1970, 1985)*

A) Quartzose grains (Qt = Qm + Qp)
   Qt = total quartzose grains
   Qm = monocrystalline quartz (>0.0625 mm)
   Qp = polycrystalline quartz (or chalcedony)
B) Feldspar grains (F = P + K)
   F = total feldspar grains
   P = plagioclase grains
   K = kalifeldspar grains
C) Unstable lithic fragments (L = Lv + Ls)
   L = total unstable lithic fragments
   Lv = volcanic/metavolcanic lithic fragments
   Ls = sedimentary/metasedimentary lithic fragments
D) Total lithic fragments (Lt = L + Qp)
E) Lc = extrabasinal detrital limeclasts (not included in L or Lt)
   Note: Lc is not recalculated in plots (explonation in the text)

The advantages of the used ribbon counting method over the line- and point-countig method are as follows (VAN DER PLAS, 1962): (1) the studied bands are as wide as the largest grain diameter or even wider; (2) the center of particles are counted in the bands representing a random sampling; (3) if stratification is visible in thin section the homogneous areas can be separated and treated the results separately.

Using the above mentioned criteria 23 samples were analyzed, 400—500 grains per thin section. The grain distribution is Poisson-like, therefore the relative error is $1/\sqrt{n}$ ($\lesssim 5\%$ in our cases).

Results

On the basis of optical analysis the main detrital components of turbidite sequence are as follows:

(a) *Calcareous detritus.* The carbonate particles are micritized and hematized extraclasts of platform facies origin. They are mainly angular shaped, encrusting and calcareous algae detritus can also be seen. They originated by the erosion of older Mesozoic calcareous rocks and resedimented already in lithified condition. Bryozoan and Echinoid fragments are present.

(b) *Non-calcareous detritus.* Quartz is increasingly abundant upwards in the sequence *(Fig. 2)* Deformed monocrystalline quartz grains are dominant in the upper part of the profile and originated from mature sedimentary rocks (BASU *et al* 1975; YOUNG, 1976). Dissolution and diagenetic overgrowth are frequent.

Plagioclase usually ranges in composition from oligoclase to andezine. Chloritization, carbonatization and albitization are present by the effect of diagenetic processes. Orthoclase and microcline are rare.

(c) *Rock fragments.* In the lower part of the sequence dolerite with ophitic texture, serpentinite, chloritite, gabbro and greenschist facies rock fragments are characteristic *(Fig. 2, Fig. 4).* Similar ophiolitic and ultramafic fragments were found in Oštrc Formation and Rossfeld Formation. VASKÓ—DÁVID (1988) noted that radial chlorite, serpentinite and detrital chromite are also abundant in Lower Cretaceous sandstones of the Tatabánya basin.

Serpentinite fragments are too small for exact identification of texture. Inpenetrating type of nonpseudomorphic texture can be found on fragments referring to serpentinization in higher grade metamorphic condition. The pseudomorphic texture showing lower P, T conditions is absent except for a few fragments explained as bastite. The rocks containing the above mentioned texture type may consists of only antigorite, antigorite+chrysotile or antigorite+chrysotile+lizardite (PAPP, pers. comm.).

Volcanic glass *(Fig. 5)*, chlorite precipitating in radial symmetry in amygdales or chlorite with mozaic structure are rare, but they may reflect the basaltic parts of ophiolite complex. Epidote, clinozoizite, albite and actinolite may have been the fragments of greenschist facies layers of ophiolite complex, too.

In the upper part of the sequence the sedimentary and sightly metamorphic rock fragments are predominant *(Fig. 2)*, such as sandstone, shale, phyllite, quartzite and red radiolarite.

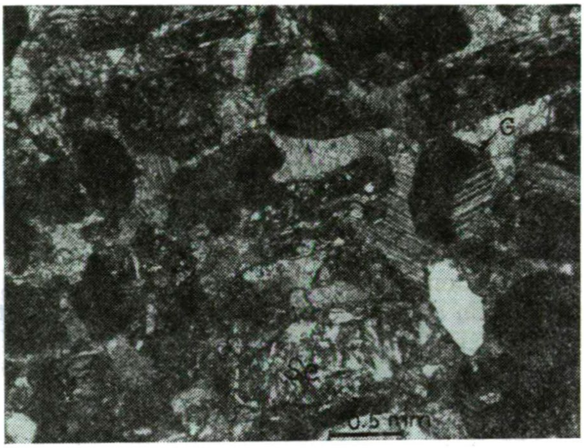

Fig. 4. Photomicrograph showing gabbro (G) and serpentinite (Se) fragments. In the gabbro fragment the plagioclase is albitized and the dark minerals are chloritized. XN.

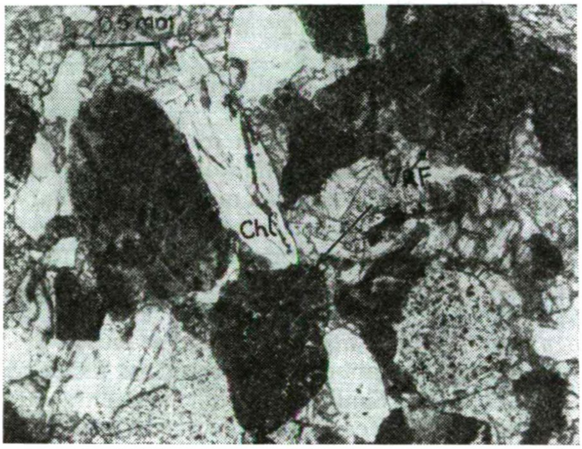

Fig. 5. Photomicrograph showing limonitized and parcially chloritized fragment of volcanic glass with typical vitreous texture. Close to it there are chloritite (Chl) and chloritized dolerite fragments (VRF). Only the plagioclase can be identified from the original texture. The groundmass is chloritized and hematized. According to the former nomenclature its name is diabase. 1N

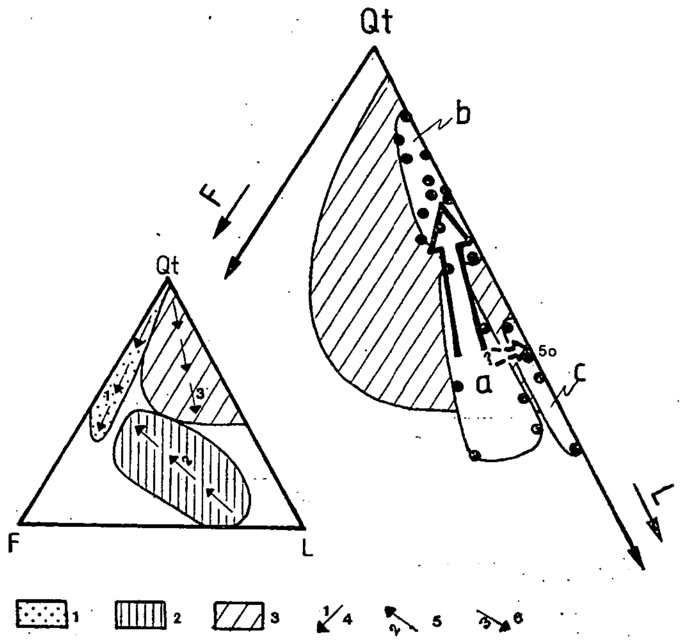

Fig. 6. Triangular plots of framework grain analysis (Dickinson's method, 1970, 1979, 1985) F-Qt-L diagram: F, Qt, L see Table 1.; 1. Continental block provenances; 2. Magmatic arc provenances; 3. Recycled orogen provenances; 4. Decreasing maturity or stability; 5. Increasing ratio of plutonic to volcanic sources; 6. Increasing ratio of oceanic to continental materials; a, b, c different petrological fields in each plots; bold and dashed arrows show the petrological development trends upwards in the sequence in each plots

Three petrological facies were recognized among the arenite samples *(Fig. 2, Fig. 6, Fig. 7)*:

— Facies "a" is litharenite with average composition $F_7Qt_{57}L_{36}$. The quartzose grains are mostly chert. They contain a lot of remnants of ultramafic bodies of the ophiolite complex.

— Facies "b" rich in quartz and sedimentary rock fragments is sublitharenite with average composition $F_1Qt_{80}L_{19}$, reflects continental source area.

— The average composition of very coarse grained facies "c" is $F_1Qt_{48}L_{51}$. Red radiolarite fragments are abundant in this facies.

Petrographic transition between the above-mentioned facies "a" and "b" is continuous, but between facies "a" and "c" is questionable, *(Fig. 6, Fig. 7)*. The starting point of the facies evolution trend is doubtful considering that remnants of magmatic arc provenances may have also been preserved in some other submarine fans of the basin. The percentage of total feldspar is very low in all sample. Polycrystalline to total quartz ratios (Qp/Qt) are around 0.4 in facies "a" and 0.6 in facies "b". In facies "c" it is highly variable from 0.3 to 0.9, while volcanic to unstable lithic rock fragments and plagioclase to total feldspar ratios are 0.1—0.7 in facies "a" and under 0.1 in facies "b" *(Fig. 8)*. Variability of composition is more characteristic in Lv-Qp-Ls diagram than in F-Qt-L, therefore the former plot is more useful for determining the provenance area than the latter one.

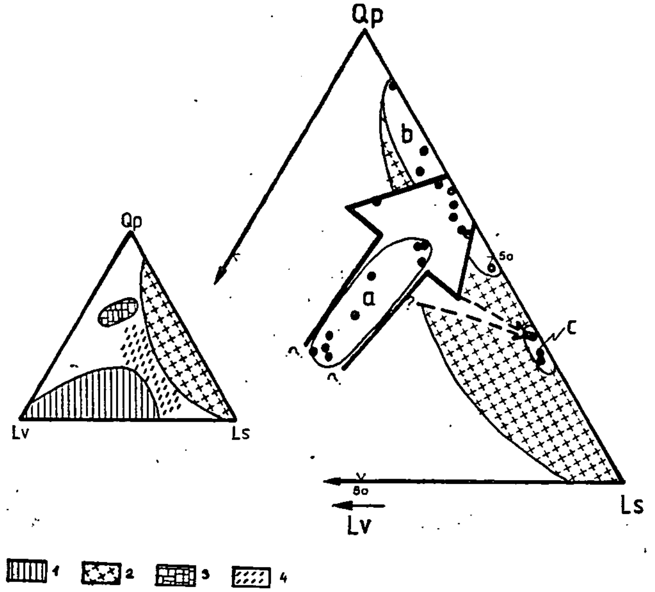

Fig. 7. Lv-Qp-Ls diagram: Lv, Qp, Ls see Table 1.; 1. Arc orogen sources; 2. Collision suture and fold-thrust belt sources; 3. Subduction complex sources; 4. Mixed orogenic sands; bold and dashed arrows see Fig. 6.

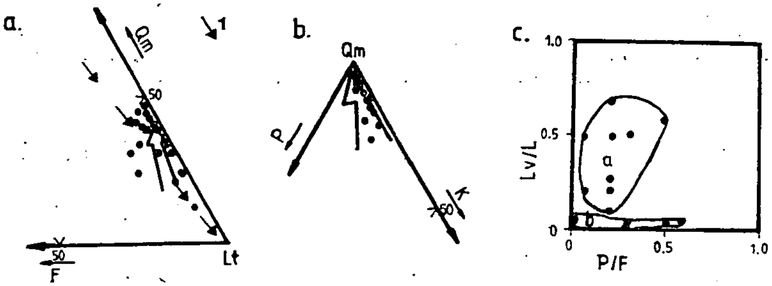

Fig. 8. F-Qm-Lt (a), P-Qm-K (b) diagrams and Lv/L to P/F ratio (c): F, Qm, Lt, P, K, Lv, L see Table 1.: 1. Increasing ratio of chert to quartz; a, b in Fig. 8c see *Fig. 6*.

SANDSTONE PETROGRAPHY AND GEODYNAMIC FRAMEWORK

The appearance and relative abundance of detrital components of arenites are in good correlation with source area(s) (Dickinson, 1970, 1985; Dickinson and Suczek, 1979; Ingersoll and Suczek, 1979; Valloni and Maynard, 1981; Schwab, 1981). Certainly, the provenance types of Dickinson and Suczek are strongly generalized and can only by used with other stratigraphic considerations, otherwise they may lead to recognition of incorrect population (Mack, 1984). On the basis of triangular plots the provenance areas can be determined, however, further studies are inevitably required to reliably interpret the possible tectonic position of the depositional basin.

Our flysch data points fall into the "recycled orogen provenances" field (F-Qt-L diagram, see *Fig. 6*) and "collision suture and fold — thrust belt sources" field as well as "mixed orogenic sands" field (Lv-Qp-Ls diagram, see *Fig. 7*), consequently. It can be well correlated with the previous note of Lower Cretaceous paleotectonic events. Thus the evolution of W. Gerecse Mts. in that time was probably connected with the collision event in the Eastern Alps, that produced the Rossfeld Formation, and the clastic sequence of E. Gerecse Mts. as well.

CONCLUSIONS

On the basis of framework grain analysis a possible history of the source area can be inferred.

The Jurassic calcareous sedimentation was replaced by siliciclastic turbiditic sedimentation in Berriasian. The sedimentation started by erosion of the oceanic crust and continued dominantly by erosion of the continental basement evidenced by increasing quantity of quartz and sedimentary rock fragment and by decreasing ophiolitic one. We considered, that greenschist facies rock fragments, serpentinites, dolerite and gabbrofragments, volcanic glass as well as chlorite and detrital chromian spinel grains have been derived from the erosion of an ophilitic complex *(Fig. 7,* facies "a"*)*.

The intensity of ultramafic material supply was changing *(*see *Fig. 2)*. In periods of diminishing ultramafic material supply the outer self and continental slope or uplifted continental crust might have been eroded by the effects of slight geotectonic uplifts and their fragments could have been transported to the basin *(Fig. 7,* facies "c"*)*

At last, the sandstone is rich in quartz and sedimentary lithic fragments which were formed by erosion of the continental basement containing sedimentary and metamorphic rocks *(Fig. 7,* facies "b"*)*.

Two analogous series can be found in Ivanščica Mts. (Oštrc Fm.) and in Northern Calcareous Alps (Rossfeld Fm.). Ophiolitic detritus (lithic fragments and chromian spinel) are present in large quantities in both regions.

On the basis of our present studies of Neszmély—4 borehole we could manage to reconstruct the history of the source area, however, the tectonic position of the microplates remained questionable.

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