Acta Mineralogica-Petrographica, Szeged, XXV/1, 97—107, 1981

RELATION BETWEEN THE MINERALOGICAL COMPOSITION AND FACIES OF THE SEDIMENTARY FORMATION OF THE NORTHERN AND NORTH-EASTERN CSERHÁT MTS (HUNGARY)

J. Andó

GEOLOGICAL SETTING

The following review is only a short outline of geology of the northern and north-eastern Cserhát Mountains, introducing only details sufficient for understanding of the methods and sediment-petrographic and faciological conclusions.

The Börzsöny, Cserhát and Mátra areas are built-up of Paleogene and Neogene sedimentary sequences, which are parts of a Tertiary basin bordered by the Veporid and Gemerid crystalline masses. These regions form separate mountains due to young tectonic movements and volcanism producing different materials. Consequently heir geomorphological developments are different, too. The tectonic movements resulted the orographic separation of the Cserhát from the Mátra Mountains, while he volcanic activity caused the separation of the Cserhát from the Börzsöny Mountains. The surficial Upper Oligocene psammitic rocks occurring in western and north-estern Cserhát Mts. extend, with similar bedding, under eastern margin of the volcanic mass of the Börzsöny Mts. The sedimentary and magmatic sequences of the eastern Cserhát Mts. and the western Mátra are the same even in details.

The elevated, strongly eroded western, northern and central parts of the Cserhát Mts. are characterized mainly by Upper Oligocene and Lower Miocene sediments and subvolcanic andesite dykes, while the tectonically deeper eastern and south-eastern parts are prevailed by younger, Middle and Upper Miocene and Pliocene ediments and subvolcanic andesite sequence.

Subsidence of the metamorphic basement and the majority of marine sedimen-ation took place in Middle Oligocene concluded from the data of borehole samples. he Paleogene sedimentary basin deepened eastward. It was proved by the Middle ligocene sequences of clay, clay-marl and silty clay-marl ("Kiscell Clay"). These ocks do not outcrop in the studied region.

After the deposition of the so-called "Kiscell Clay" a littoral — shallow-bathyal asin — with tendency for heteropic facies has been formed in the Cserhát region during Oligocene and Miocene. The inherited depth of the sedimentary basin resulted in different depositional conditions in the western and eastern parts of the Cserhát ts. Complete Oligocene-Lower Miocene sequence has been formed in the eastern nd north-eastern Cserhát containing open-sea, clastic sediments, while the western parts became a land after the Upper Oligocene delta-marginal sedimentation. This ontinuous sedimentation caused several problems in delimitation of the Upper Oligo-ene (Egerian) from Lower Miocene (Eggenburgian), as well as the Middle Oligocene strata from Upper one [Báldi, 1973]. According to the results of detailed studies he western Cserhát is characterized by a regression shifted from West to East during the end of Upper-Oligocene and beginning of Lower Miocene, while in the eastern Cserhát a marine sedimentation prevailed lasting to the end of the Lower Miocene.

The terrestrial sediments (variegated clay, fluviatile sand, gravel, rhyolitic tuffs,) which indicate end of the regression, are thin and can be traced only in patches.

Eastward from the studied area, in the Nógrád basin the terrestrial formations are overlain by parallic *coal-bearing sequence* with considerable thickness (Ottnangian) In the studied area the coal with sandy intercalations occurs only as an incomplete series, which pinching out westward. The coal-bearing or the continental sequences are overlain by silty clay (Schlier) indicating open-sea conditions due to the transgression of *Carpathian* times. This formation has been completely eroded later in the northern Cserhát area, but in the eastern Cserhát Mts. this forms the underlying of the *Carpathian — Lower Badenian volcanic sequence.* After the volcanic activity archipelago formed with shallow-water limestone ("Leitha-limestone"), and in the deeper parts with clay and marl, respectively. The formation of these rock-types endured into the *Sarmatian* stage. The marine sequences were changed to lacustrine-lagoonal-deltaic clastic and argillaceous sediments caused by the emergence and gradual enclosure of intervening basins during the Upper Sarmatian.

The last partial transgression of *Early Pannonian*, caused rapidly enclosing and freshening sounds, up to the line of the Pásztó and Alsótold basins. These sounds were infilled by fine-grained, argillaceous and marly clastic sediments.

This brief description shows that the area of the northern north-eastern Cserhát Mts. is formed overwhelmingly by Upper Oligocene — Lower Miocene, and subordinately by Middle Miocene clastic sediments. The lack of subsurface, borehole data, the studies concern only the surficial formations of these ages.

THE EVOLUTION OF THE DEPOSITIONAL ENVIRONMENTS, ON THE BASIS OF THE FACIES STUDIES

The Oligocene and Lower Miocene rocks form a continuous sequence in the studied area. During the mapping work sedimentological units have been distinguished characterizing an extended area becaused of the large variety of lithofacies which intersect the chronostratigraphic boundaries. The transport and deposition terrain has been reconstructed [Andó, 1973] for the given sequences with evaluation of log-probability distribution, using the data of Visher [1969]. In some sequences the evaluation of litho- and biofacies was possible [Andó, 1975], based on the simultaneous biostratigraphical and biofaciological studies of Báldi and Horváth [1970].

The discussion of the results of the mineralogical and sedimentological studies, which were done for each beds and sequences, are outside the aims of the sequences, the facies reconstructions and ages are summarized in Table 1. The reconstruction of depositional terrain from log-probability grain distribution diagrams is a suitable approach for calculating the former water-movement velocity. This gives the most important quantitative depositional character [Andó, 1973] which serves the basis for comparing numerically the given beds and sequences. With this method it can be determined the critical velocity, *i.e.* the limit of transport and resting states, and the mean and bottom velocities (on the basis of the mean size of the saltated and rolled grain populations, respectively). From these two data it can be calculated the velocity, and averaging the values of the individual bed, average water-movement velocity was calculated which is characteristic for to the whole sequence.

The quantitative and qualitative data of the facies of Upper Oligocene and Lower Miocene formations are shown in *Fig. 2.* This map shows clearly the evolutionary

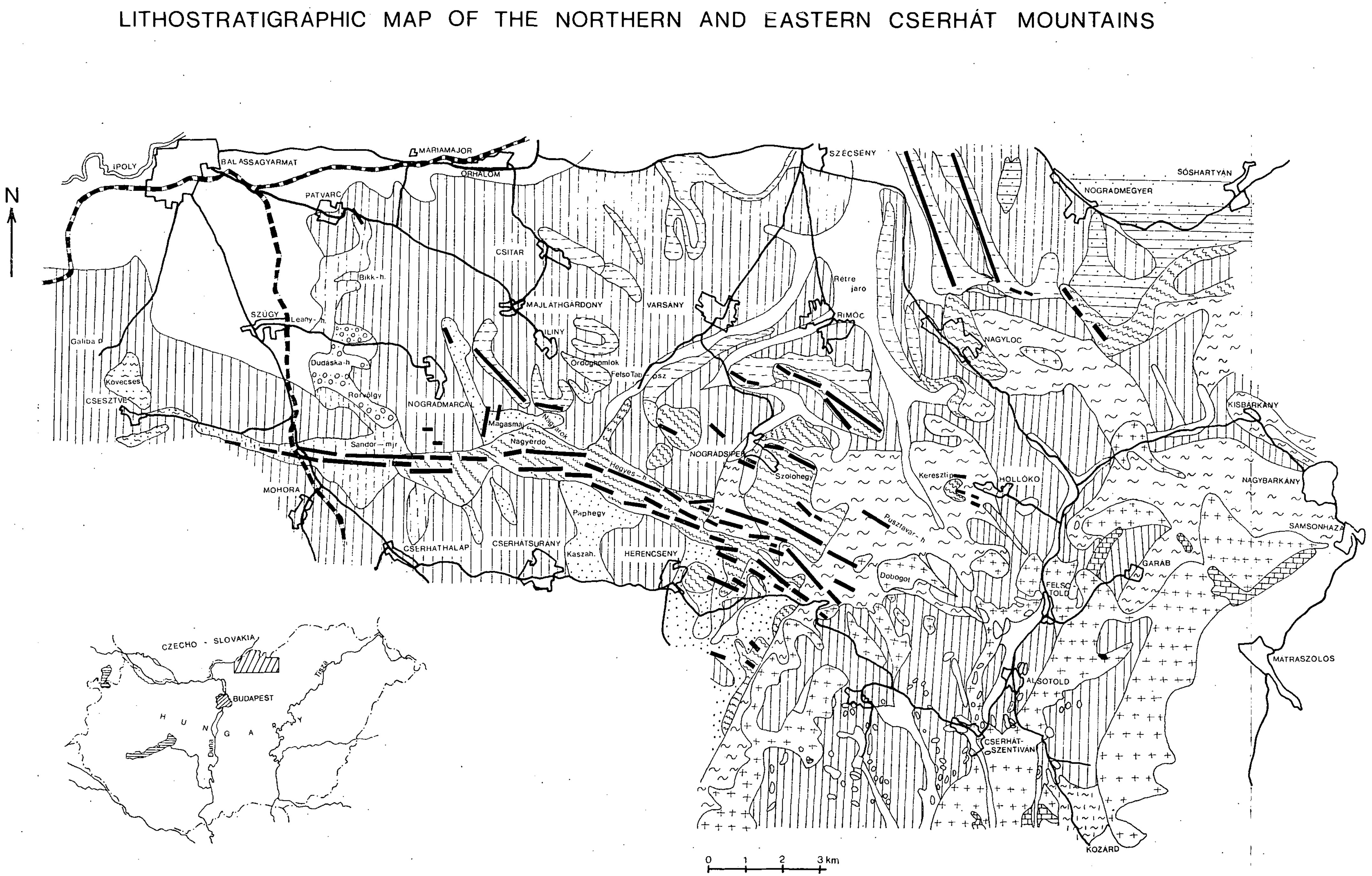

Fig. 1. Lithostratigraphic map of the northern and eastern Cserhát Mountains

Lithostratigraphic map of the northern and eastern Cserhát Mountains

LEGEND

Holocene	flood-plain sediments, stream deposits etc.
Pleistocene	loess, talus
Pliocene	loose sandstone, clay
"Meotian"	terrestrial sediments
Sarmatian	coarse limestone, marl, clay, loose sandstone
Badenian	Liethakalk, marl, sandstone
	andesite dikes
	bedded volcanites
Carpathian	"Schlier" of eastern Cserhát
Ottnangian	Terrestrial variegated clay - loose sandstone of Nagylóc
	cross-bedded loose sandstone - variegated clay - coal of Herencsény
Eggenburgian	glauconitic sandstone of northeastern Cserhát
	sandstone with clay intercalations of Csesztve
	loose sandstone of Iliny
	loose sandstone - silt of Csitár
	Anomia-bearing sandstone of Szügy
	Szécsény "Schlier"
Egerian	Mohora silt and sandstone with plant remains
	concretionary sandstone of Borsosberény

TABLE 1

Main characters of surfacial sedimentary sequences of the northern and northeastern Cserhát Mts.

Sequence	General petrological characters	Age	Facies
Concretionary sandstone of Borsosberény	Coarse- and medium-grained, loose sandstone with fine pebbles; with concretions and coquina beds	Upper Oligocene (Egerian)	Marginal deltaic, littoral
Mohara silt with plant remains	Siltstone with plant remains (underlying the Anomia-bearing sandstone of Szügy)	Egerian	Prodeltaic, deltaic lagoon
Szécsény „Schlier"	Calcareous silt; clayey silt, arenaceous silt	Egerian to Eggenburgian	Deep sublittoral to shallow sublittoral
Anomia-bearing sandstone of Szügy	Medium- to coarse-grained sandstone; fine-grained arenaceous silt; pebbly sandstone with traces of cross-bedding	Eggenburgian	Shallow sublittoral to littoral
Loose sandstone — silt of Csitár	Pebbly, coarse- to medium-grained sandstone with Ostrea banks and silty and pebbly intercalations (Overlying the Szécsény „Schlier")	Eggenburgian	Littoral to shallow sublittoral
Loose sandstone of Iliny	Alternation of loose, fine-grained sandstone and silt (Overlying the Szécsény „Schlier")	Eggenburgian	Shallow sublittoral to middle sublittoral
Sandstone with clay intercalations of Csesztve	Fine-to coarse-grained sandstone with clay intercalations and with cross-bedding in some places	Eggenburgian	Shallow sublittoral
Glauconitic sandstone of northeastern Cserhát	Loose sandstone with variable, fine to coarse grain-size	Eggenburgian	Shallow sublittoral,
Cross-bedded loose sandstone — variegated clay of Herencsény	Coarse-grained, cross-bedded and gray, fine-grained, loose or cemented sandstone; silty sandstone	Eggenburgian — Ottnangian	Deltaic-littoral and continental
Garáb „Schlier"	Clayey to fine-grained sandy calcareous silt	Carpathian (Middle Miocene)	Middle- and deep-sublittoral

tendencies and spatial connections of the facies observed on the surface. Within the Upper Oligocene the water-movement intensity decreased from west to east — northeast direction. A similar direction can be observed regarding of the sedimentary environments from deltaic-littoral to deep sublitoral. The Lower Miocene sequences how a similar tendency, too. These formations, however, deposited far easterly, and their accumulation terrain changed from west to east form deltaic-littoral only to iddle sublittoral depth, and the glauconitic sandstone in the eastern Cserhát Mts. suggests the renewed shallowing of the sedimentary basin.

Fig. 2 shows the schematized cross-sections of the studied sequences. These made possible to study the features of the Upper Oligocene — Lower Miocene regression

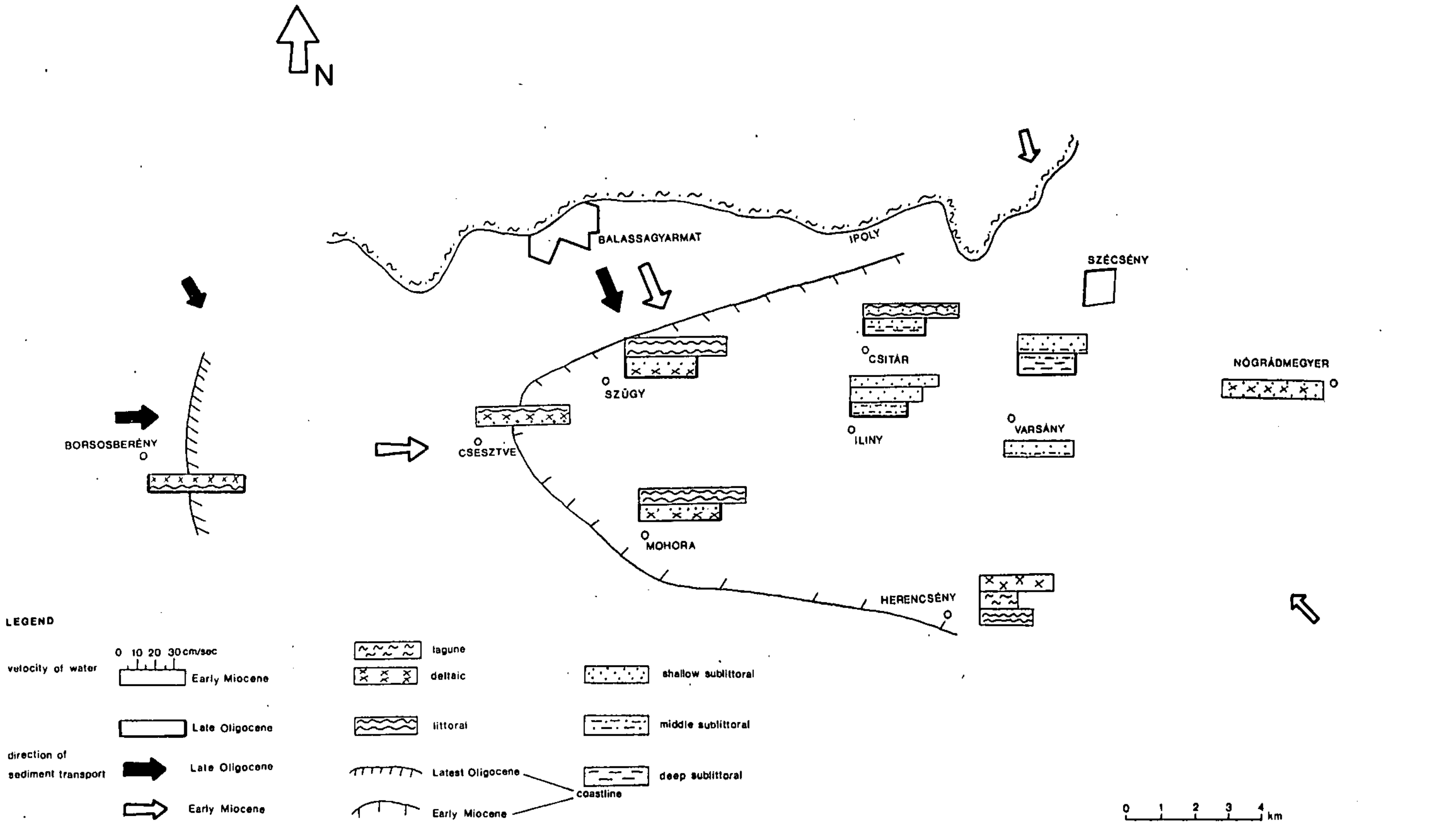

Fig. 2. Relation of the Upper Oligocene and Lower Miocene lithofacies types in the northern Cserhát Mts.

nd the paleogeographic consequences of the event as well. The shoreline of the Uppermost Oligocene sedimentary basin, with the recorded deltaic-littoral formations, ran in the western part of the mountains, near Borsosberény, along the present margin of the Börzsöny and Cserhát Mountains. Thus the fluvial material, which is characterized by the deltaic formations, may have transported from north-west — west direction. The deltaic zone can be traced to the Szügy — Mohora line, with a shallow sea easterly, and with deep subblittoral sea from Szécsény, respectively. During the Early Miocene, the sea-shore shifted to the Szügy — Csesztve — Mohora line, which corresponds with the above-mentioned basin-ward boundary of the deltaic zone of Uppermost Oligocene. The depth of the inner parts of the basin decreased simultaneously. On the basis of the upper Lower Miocene deltaic-terrestrial formations around Herencsény, occurring in the south-eastern part of the area, a south-eastern transportation and shoreline advancement can also be suggested. A large quantity of material transport and gradual infilling from this latter direction is a possible explanation of the Egerian-Eggenburgian shoreline shift from west to east direction, then causing simultaneous south to north land-formation — advanced by elevation too —, concluded from the deltaic zones *(Fig. 2)*.

EVALUATION OF THE MICROMINERALOGICAL STUDIES IN THE LIGHT OF THE SEDIMENT-ACCUMULATION ENVIRONMENT

The quality and the size-distribution of the detrital grains of the sediments are controlled mainly by the erosion terrain, the transportation-accumulation circumstances and the diagenesis. The different sedimentary environments may result spatially and temporally rather varied mineral composition of detrital material, transported simultaneously from the source area. Consequently simple evaluation of micromineralogical data may lead to an erroneous conclusions regarding the source area and the direction of transportation. In the interpretation the role of the relation between the energy of the transportation-deposition medium, the average grain-size of the sediment, as well as the density and size of the minerals enriched together [MOLNÁR, 1969] is significant. To solve this problem, the regional evaluation of the heavy minerals was carried out according to deposition environments of similar hydrodinamics. (The presentation of the basic data of the ca. 70 micromineralogical samples seems unnecessary, only the applied evaluation methods and the results are outlined here.) The following considerations were the basis for the evaluation.

It was possible to count of the average grain-sizes of rolling clastics moving together with heavy minerals by determination of densities, grain-sizes of heavy minerals and using the equation referring to rolling transportation: $\frac{r_1}{r_2} = \frac{d_2-1}{d_1-1}$. The rolling clastics are mostly quartz feldspar and rock-fagments. Those layers deposited from these transported grain-size domain can easily be determined from the log-probability grain distribution diagrams.

The calculations have been done for heavy minerals having 0,15 mm average grain-size, and following densities.

Group 1: chlorite (2.8 g/cm^3)
Group 2: tourmaline (3.2 g/cm^3)
epidote-zoisite (3,3g/cm^3)
titanite (3.5 g/cm^3)
apatite (3.1 g/cm^3)

andalusite (3.1 g/cm^3)
disthene (3.6 g/cm^3)
staurolite (3.7 g/cm^3)
amphiboles (3.3 g/cm^3)
pyroxenes (3.3 g/cm^3)

Group 3: magnetite-ilmenite (5.2 g/cm^3)
zircon (4.7 g/cm^3)
rutile (4.1 g/cm^3)
garnet (4.0 g/cm^3)

The above mentioned heavy minerals can be compared with the following grain-sizes (in order of increasing specific gravity): smaller than 0.20 mm; 0.20 to 0.27 mm; above 0.27 mm average size transported by rolling. The average frequencies of heavy minerals having different density were calculated in the different grain-size of the clastic sediments group (Table 2). The heavy minerals of smallest density enrich in rocks containing small to medium, those of medium specific gravity enrich in rocks of medium to big, and the heaviest minerals enrich in rocks containing biggest rolling-transported grains, respectively.

On the basis of this method, the heavy mineral frequencies were compared regionally, within groups having been distincted by the size of the rolling-transported grain populations *(Figs 3* and *4)*. This procedure enables to eliminate the factors originated from the different transportation-sedimentation circumstances which distort the mineral frequency percentages, and gives a good result which characteristic for the original source area. Taking these considerations into account, studies were made — from surficial formations — on the regional distribution of some heavy minerals. These were selected from those of evaluable frequency and of reference to the erosional area. Evaluating the distribution, of the mainly metamorphic garnet and chlorite data on the transport directions and the build-up of the erosional area were expected *(Fig. 3)*. The comparison of these data to those in Table 2 shows that the changes of frequencies of garnet and chlorite are controlled mainly by the hydrodynamic properties of the sedimentary basin but according to the above-mentioned considerations, the effect of this factor can be eliminated. Namely, these two minerals area represented with nearly identical percentages within the hydrodynamically uniform Upper Oligocene — Lower Miocene, as well as Middle Miocene sediments of the studied region. This suggests a source area of rather uniformly-distributed epi- and mesometamorphic rocks. The percentage distribution is slightly shifted toward the garnet in the Upper Oligocene beds of the central North-Cserhát area (*i.e.* around Szügy, Mohora, Iliny), and in the Middle Miocene beds of the south-eastern parts. This corresponds with the position of the sedimentary facies and the shoreline, and the erosional-transportational directions determined from the grain-distribution studies (see *Fig. 2*). The smaller fluctuations in the ratio of these two minerals can be interpreted by the different energy and composition of the western and south-western material supply, and by the somewhat diferent structure of the drainage areas. The somewhat irregular garnet/chlorite ratio of the Ottnangian beds in the south-eastern part of the area may be connected with the Late Miocene changes of the terrain and the supposed south-eastern transportation (see *Fig. 2*).

The presence of andalusite, disthene, staurolite, pyroxene, and tourmaline in the heavy mineral fractions suggests smaller magmatic and metamorphic masses beside the main garnet and chlorite containing source area. The former metamorphic minerals originated from metamorphic rocks having diferent facies. The above-

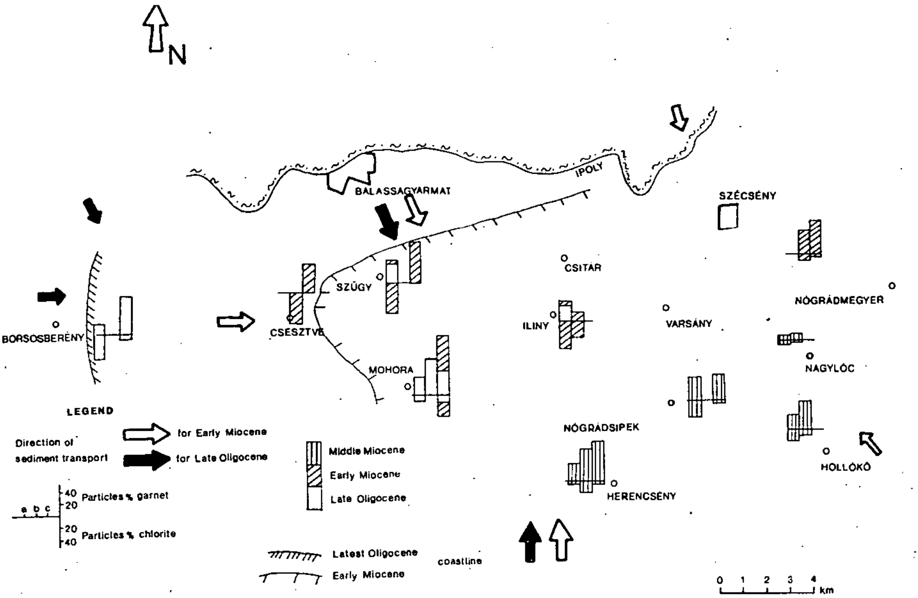

Fig. 3. Spatial distribution of garnet and chlorite in the Upper Oligocene; Lower and Middle Miocene surfacial rocks of the northern Cserhát Mts. *a*: <0.20 mm; *b*: 0.20 to 0.27 mm; *c*: >0.27 mm dominant sizes for grains shifted on the bottom. Direction of sediment origin supposed by micromineralogical studies: → for Late Oligocene; ⇒ for Early and Middle Miocene.

TABLE 2

Average frequency of heavy minerals in the 0.1 to 0.2 mm grain-size portion, calculated for the size-selected, rolled-saltated grain population (//// = greatest average frequency)

	Mineral	Average size of particles rolled-saltated on the bottom		
		<0.20 mm	0.20—0.27 mm	>0.27 mm
		Frequency of minerals in particles %		
	Chlorite	/23.0///	//24.0////	7.5
Specific gravity ↓	Apatite	0.2	///1.0///	0.4
	Andalusite	0.1	—	///0.9///
	Actinolite	0.1	—	///0.3///
	Tourmaline	2.2	4.5	///6.0///
	Epidote-zoisite	1.1	///2.0///	1.4
	Biotite	1.7	///3.3////	0.3
	Oxi-and green amphibole + glaucophane	0.6	///1.6////	1.1
	Pyroxenes	1.0	2.7////	0.4
	Titanite	0.4	///1.0////	0.1
	Disthene	0.2	0.7	///0.8///
	Staurolite	0.1	0.6	///1.0///
	Garnet	15.0	36.0	//54.0///
	Rutile-anatase	1.0	///1.5////	0.9
	Zircon	0.2	///0.3////	0.2
	Magnetite-ilmenite	3.4	6.8	///8.5///
	Dia-and epigenetic ingredients	50.3	22.7	15.9

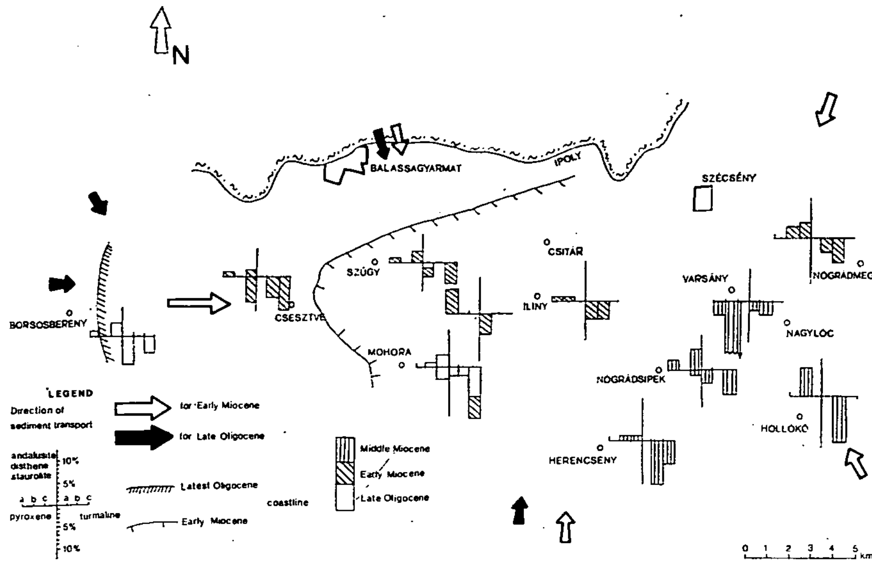

Fig. 4. Spatial distribution of andalusite, disthene, staurolite; and pyroxene and tourmaline in the Upper Oligocene, Lower and Middle Miocene surfacial rocks of the northern Cserhát Mts. *a*: <0.20 mm; *b*: 0.20 to 0.27 mm; *c*: >0.27 mm dominant sizes for grains shitfed ont the bottom. Direction of sediment origin supposed by micromineralogical studies: ➞ Late Oligocene; ⇒ Early and Middle Miocene.

mentioned minerals were studied in areal distribution, too *(Fig. 4)*. The comparison of the corresponding rock-types shows that the temporal and areal distribution of andalusite, disthene and staurolite (mineral association suggesting strong metamorphism have not any significant orientation. On the other hand, the pyroxene appears as an anomaly, occurring merely in some places, with medium to high amount. The significant amount of pyroxene together with the associated hyaline content of the "light-fraction" in the continental sequence around Nagylóc can be attributed to the local effect of the Middle Miocene volcanism. However, in the interpretation of the recorded smaller enrichment westerly (at Mohora and Csesztve), one should bear in mind temporal transport from the basic magmatites in the basement of the southern area. This latter interpretation is made probable by the fact, that the scarce Upper Oligocene — Lower Miocene volcanic detritus is dominantly of rhyolitic and rhyodacitic in composition.

The tourmaline is relatively common in the studied formations. The study on the areal distribution suggested some enrichment in the Middle Miocen sandy beds (i.e. in the south-eastern terrain), in contrast to the rather uniform tourmaline-content of the Upper Oligocene — Lower Miocene beds. On the basis of the appearance of the tourmaline as tiny euhedral brown or greenish-brown, sometimes fragmented violet-blue grains, the origin from granitic or related rock-types is probable. According to the areal distribution, this supports the assumption of a northward transport of erosional material from the basement of the Great Hungarian Plain having been on the surface in Late Oligocene — Middle Miocene times (see *Fig. 2*).

All possibilities of mistakes cannot be cleared even with the above-outlined procedure. In the method the rolled and the saltoted grains are counted together, and there is no information either on the long transportation phase, or on the possible repeated redeposition of the mineral. Other distorting factor may be those quantitative changes of the diagnetic and altered minerals, which are independent of the hydrodynamic circumstances. However, one must take into account these factors in the appraisal of the reliability of the conclusions.

The sedimentary formations of the Cserhát Mts. contain fine-grained (*i.e.* suspended) fraction in different quantity [Andó, 1973; 1975]. Important in this fraction the role of the *clay minerals.* On the basis of the derivatographically studied fine-grained fraction, the following main type of clay minerals were distinguished; illite, montmorillonite, kaolinite, a mineral with mixed illite-montmorillonite structure, montmorillonite plus kaolinite; illite plus kaolinite, illite-montmorillonite plus kaolinite.

The clay minerals of the clasts are mainly detrital in origin [Nemecz, 1973]. Thus the clay-mineral composition is firstly determined by the weathering in the erosional region, and by the differential deposition. According to observations, this latter is markedly influenced by the chemical properties of the depositional medium. In spite of this fact, a kaolinite — illite — montmorillonite depositional rate succession is established, and this corresponds to a similar clay-mineral succession from the river delta toward the basin. This suggests a facies-index value for the clay-mineral composition. Following these considerations, a study has been carried out on the clay minerals of the sedimentary terrains distinguished by the energy of the depositional media (see *Fig. 2).* In the evaluation it was considered, that there are possibilites for slight syngenetic changes of the minerals and structural fragments, as well as hydrolysis or clay-mineralization of the magmatic material entering the basin. The relation of the characteristic mineral association and the accumulation terrain is tabulated — on the basis of studies on 60 samples — in Table 3. (N.B. Because of the small amount, the detailed derivatographic determination of the chlorite encountered difficulties, thus its respective analyses are given in the micromineralogical studies.)

The data of Table 3 (first row) show, that the detrital formations of the studied region are dominated by the minerals with mixed illite-montmorillonite structure, and by associations prevailed by illite. The facies distribution of the certain frequency of the minerals shows, that the proportion of the *illite* decreases in the marine sequence of the delta. On the other hand, this mineral cannot be traced in littoral — shallow subareas without direct connection with river inflows. Illite predominates again in the continental formations. In accordance with the data of the literature on the differential deposition, *montmorillonite* shows an opposed distribution in the formations. However, montmorillonite has a relative frequency in the near-shore accumulation terrain connected to the river delta. Kaolinite, without association to other clay minerals, appeared only in the continental formations.

Most general in occurrence, *i.e.* most independent of the characters of the accumulation terrain is the mineral with mixed *montmorillonite-illite* structure. The *montmorillonite-kaolinite* mineral association appeared in the low-energy marine, and in the continental sediments. The *illite-kaolinite* mineral association characterizes mainly the sublittoral areas.

Examination of the proportions of mineral associations within single facies contributes the detailed evaluation of the outlined relationships. According to data in Table 3, the deltaic formations are characterized mainly by illite and partly by

TABLE 3

Interrelation of the clay-mineral composition and the site of deposition of the surfacial detrital rocks of the northern and eastern Cserhát Mts.

	Illite	Montmorillonite	Kaolinite	Illite montmorillonite	Montmorillonite-Kaolinite	Illite + Kaolinite	Illite montmorillonite
1. total frequency found in all sedimentary rocks	25	10	3	32	6	22	2
Deltaic	6.6 57	1.6 15	—	3.4 28	—	—	—
Lagoon, Prodeltaic	3.4 26	1.7 12	—	3.4 26	1.5 12	1.6 12	2 12
Deltaic-sublittoral	3.4 40	1.6 20	—	3.4 40	—	—	—
Littoral	—	—	—	5 50	—	5 50	—
Shallow sublittoral	—	—	—	5 43	—	6,7 57	—
Middle subblittoral	1.6 17	3.4 33	—	1.6 17	—	3.4 33	—
Deep sublittoral	—	—	—	3.5 77	1.5 33	—	—
Terrestrial „variegated" rocks	8.4 33	1.7 6	3 13	6.7 26	1.5 6	3.5 26	—
Fluviatile or eolian deposits	1.6 33	—	—	—	1.5 33	1.6 34	—

Remarks: Numbers in the upper right corners show the facies distribution of the mineral frequencies found in the studied sedimentary rocks (vertical columns), those in the lower left corner show the percentage mineral frequencies within the facies (horizontal lines).

illite-montmorillonite. It is striking, that while the kaolinitic mineral associations are lacking in the deltaic sediments, the montmorillonite of low deposition rate is represented here. This suggests, that the deposition in the deltaic circumstances differ from that under undisturbed, experimental conditions. The rapid sedimentation, the pH and concentration changes, the redeposition, mixture may result in getting of the coagulable montmorillonite also into the sediment. Other possible factor to be considered is the usual hydratational weathering, i.e. the post-depositional clay-mineralization of the poorly-sorted detritus.

The most heterogenous mineral composition characterizes the sediments of the delta-marginal bay, and the continental formations. In the former terrain only the independent appearance of kaolinite is missing. The appearance of this mineral supposes intensive leaching. The diverse mineral composition can be interpreted by the possible enclosure, and thus slighter sorting effect of the delta-marginal bay, and by redepositional-mixtural possibilities and local variations in the depositional conditions on the land, respectively. The illite-montmorillonite, illite and kaolinite content of the littoral — shallow sublittoral zones, as well as the montmorillonite mineral content of the deep sublittoral zone supports the role of the differential deposition. The middle sublittoral zone is characterized by more varied mineral ssociations and locally formed volcanogenic clay deposits (Szécsény Schlier, Varsány). The fluvial and eolian sediments are distinguished, as a result of the more intensive leaching, by illitic-montmorillonitic mineral associations.

SUMMARY

The lithostratigraphic mapping of the mainly Tertiary, detrital surficial sedimentary formations of the northern and eastern Cserhát Mts. served as basis for the reconstruction of the sediment accumulation environments. The basis for the facies nalyses was the grain-size distribution study by log-probability diagrams. The derived grain-size distribution curves show clearly the distinct fractions of the differently transported (rolled, saltated or suspended) grains. The diagram indicate the size ranges of the grain populations. The literature on sediment transport gives equations for the relationship of grain-size and water movement, velocity and the depositional boundary-velocity can be calculated from the size of the differently transported grain populations. These values give one of the most important quantitative characteristic of the former environment. Analyzing the data regionally, the changes in the accumulation terrain can be traced.

The method enabled also a more reasonable evaluation of the heavy mineral studies. From the specific gravity — grain-size equation for rolled sediment transport made possible to count the size of the light minerals transported and deposited together with the heavy mineral associations of 0.1 to 0.2 mm size and different density. On the basis of the fact, that the light fraction constitutes the main quantity of the rock, this calculation gives what size of rolled grain population serves as basis for the comparison of heavy mineral frequency of the given rock. Those beds, which were deposited from these rolled grains of calculated size range can be easily assigned from the log-probability grain distribution diagrams. The heavy mineral data, which were evaluated regionally by this method, are in good agreement with the results having been derived from facies and environmental reconstruction on the basis of grain-size distributions.

REFERENCES

ANDÓ, J. [1973]: A szállítási-leülepedési térszín vizsgálata a log-normál szemcsepopulációk elemzése alapján. Földtani Közlöny, **103** Budapest

ANDÓ, J. [1975]: Method for a common evaluation of petrographical and paleontological investigation of detrital sedimentary formations. Annales Univ. Sci. Budapestiensis de R. Eötvös, Sectio Geologica **19**.

BÁLDI, T. [1973]: Mollusc Fauna of the Hungarian Upper Oligocene (Egerian). Akadémiai Kiadó, Budapest

BÁLDI, T., HORVÁTH, M. [1970]: Jelentés az 1970. évi Cserháti rétegtani vizsgálatokról. Manuscript. Eötvös Loránd Tudományegyetem, Kőzettan-Geokémiai Tanszék. Budapest, 1970.

MOLNÁR, B. [1969]: A szemcsenagyság- és nehézásványösszetétel összefüggései. Földtani Kutatás **12**, 2, Budapest.

NEMECZ, E. [1973]: Agyagásványok. Akadémiai Kiadó, Budapest

VISCHER, G. S. [1969]: Grain size distributions and depositional procces. Journal of Sed. Petrol., **39**.

Manuscript received, June 9, 1980

J. ANDÓ
Department of Petrology and Geochemistry
Eötvös Loránd University
Budapest, VIII., Múzeum krt. 4/A.