Middle Cretaceous paleogeography and evolutionary history sketch of the Transdanubian Central Range in the light of key and reference sections

Paläogeographischer und entwicklungsgeschichtlicher Abriß der Mittelkreide des Transdanubischen Mittelgebirges an Hand von Basis- und Referenzprofilen

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With 11 text-figures

Abstract. Based on key sections the paper reviews the most important episodes in the history of the Transdanubian Central range, beginning with the Tisian uplifting phase at the end of the Aptian. It was followed by a slowly recurring sedimentation that ceased in the Middel Cenomanian.

These episodes can be summarized as follows:

Beginning of the Early Albian: Development of the synclinal, differential denudation.

Middle (and end) of the Early Albian: Allitization of areal dimensions, bauxite accumulation on the Upper Triassic carbonate terrain (Alsópere Bauxite).

Middle Albian: Paludal-lacustrine-marine sedimentation (Tés Clay); in the northeast part it developed from the Környe Limestone of reef facies by stagnation, but in the greater part of the region by subsidence, frequently with deposition of coarse detrital basal layers.

The sedimentary basin was subsiding unevenly, coarse detrital interbeddings indicate a material input from the northwest and a quicker subsidence in this area.

Paludal sedimentation is interrupted by oscillative episodes increasing in intensity upwards.

Late Middle Albian: The detritus input ceased, a rudist-bearing "platform reef" is formed over a large territory represented by the lower part of the Zirc Limestone. Two facies of the limestone are distinguishable: the southern and northern Bakony facies.

At Padragkut (southwest Bakony) the shoreline is fixed by the influx of redeposited bauxite.

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Late Albian: In the northern Bakony facies the barrier reef disappears and thus the basin becomes more open. This is reflected not only in the lithological features (appearance of glauconite and fine detritus of quartz and limestone) but in the fauna as well.

Middle Vraconian: For a short period the area becomes denuded; then a shallow-water, finely detrital marl sedimentation with a heavily glauconitic basal layer began to evolve. This is not present in the southern Bakony.

Late Early to Middle Cenomanian: Appearance of sand fraction; its later predominance and the rapid impoverishement of the marine fauna indicates a retreat of the sea.

Zusammenfassung. Anhand von Basisprofilen sind folgende wichtige Ergebnisse in der geologischen Geschichte des Transdanubischen Mittelgebirges, beginnend mit der Tisia-Phase des obersten Aptien bis zum mittleren Cenomanien, festzustellen:

Beginn des frühen Albien: Entstehung einer Synklinale, ungleichmäßige Abtragung.

Mitte (und Ende) des frühen Albien: Allitisierung von großflächigem Ausmaß und Anreicherung von Bauxit auf dem Relief von obertriadischen Karbonaten (Alsópere-Bauxit-Formation).

Mittleres Albien: Palustrisch-lakustrisch-marine Sedimentation (Tés-Tonmergel-Formation). Sie geht im NE aus der Környe-Kalk-Formation durch Versumpfung hervor. Der größere Teil des Gebietes senkt sich aber, und es tritt oft eine grobklastische Basalschicht auf.

Das Sedimentationsbecken sinkt ungleichmäßig ab, die grobklastischen Einlagerungen weisen auf eine Schüttung von NE und auf eine dort auftretende raschere Subsidenz hin.

Die palustrische Sedimentation ist durch oszillative und nach oben zunehmend stärker werdende marine Episoden gegliedert.

Ende des mittleren Albien: Die Zufuhr klastischen Materials hört auf, weiträumig entwickelt sich ein rudistenführendes „platform reef" (= unterer Teil der Zirc-Kalk-Formation). Die zwei Faziesräume des N-Bakony und des S-Bakony sondern sich voneinander ab.

Im Raum von Padragkùt (SW Bakony) ist die Küstenlinie durch Bauxitanreicherung erkennbar.

Oberes Albien: Im Faziesraum des N-Bakony wird durch das Verschwinden des barrier reef die Verbindung zum offenen Meer verstärkt. Dies kommt in den lithologischen Merkmalen (Feinschutt von Quarz und Kalk, Glaukonit) und im Faunenbild zum Ausdruck.

Mitte des Vraconien: In einem großen Teil des Gebietes tritt für kurze Zeit Abtragung auf. Anschließend setzen mit einer stark glaukonitischen Basisschicht feinklastische neritische Mergel ein. Diese fehlen im südlichen Bakony.

Ende des frühen Cenomanien – mittleres Cenomanien: Das Einsetzen der Sandfraktion und deren späteres Vorherrschen sowie die rasche Verarmung der marinen Fauna zeigen den Rückzug des Meeres an.

1. Introduction

The present distribution of the formations is shown in Fig. 1. The Austrian (or rather the Tisian) phase at the end of the Aptian played an important role in the birth of the Central Range syncline. This is indicated among others by the position of the formations older than the Tés Clay (Fig. 2). Flexing forms were followed by major vertical and occasionally, horizontal movements. Among these movements the recurring Eplény-Kardosrét fault line can be considered to be most important. The disappearance of complete or discontinuous Jurassic and Early Cretaceous sequences, even of the Tata Limestone NE of the fault and their restriction to a narrow strip in the Bakonycsernye-Mór area can be attributed to this fault line. The fact that this fault was still active is indicated not only by the erosion of the mentioned formations but also by the accumulation of weathered cherty pebbles or chert detritus in the area SW of Zirc.

2. Paleogeography and evolutionary history

2.1. Early to Middle Albian

The bentonite-rich bed occurring at the base of the Tés Clay is probably an indication of volcanism accompanying tectonic movements. As the result of the desilification which affected the volcanic ? materials after tectogenetic morphological differences had been lost to erosion, the allites shifted from the limb towards the axis of the syncline. The Tés Clay-covered bauxites, not affected by erosion (Fig. 3), indicate that the quality is improving in the direction of the limbs. This further suggests that allitization ceased earlier along the axis than it did on the limbs.

Due to the slow subsidence of the area, the terrestrial sedimentation was replaced by paludal-lacustrine-marine sedimentation of varied lithology of the Tés Clay Formation.

The average petrographic pattern of the lowermost 5 meter thick part of the formation between Zirc and Mór (Fig. 4) suggests a morphologically slightly dissected substratum. According to this, swamp sedimentation took place east of the Dudar-Jásd line while lacustrine sedimentation predominated in SW direction. Along the southern margin and also in the Bakonynána-Dudar transversal line, mainly limestones and calcareous marls were formed. On the basis of the marls and subordinate carbonaceous clays observed in the densely drilled Perepuszta and Tés area, it may be concluded that the limestone facies is varied by a persisting unevenness of the bottom relief. It is also striking that most of the bauxites are associated with carbonaceous basal layers. Sand and sandstone deposits are known only along the southern margin between Balinka and Mór, conglomerates only found in the surroundings of Zirc and Eplény.

East of Mór the Middle Cretaceous sedimentation begins with a grey clay, while east of Pusztavám it begins with Toucasia limestones of reef origin (Környe Limestone Formation). From these the Tés Clay evolves with grey marls and clay layers. According to the drilling evidence of Oroszlány (e.g. borehole 0—1825) the Környe Limestone ends at the Vértessomló Siltstone Formation side with a barrier reef abounding with corals, extending first towards the southwest as a vast reef body with pachyodonts. Later it was reduced to a comparatively narrow strip. Acting as a barrier (Fig. 5b), it separated the purely marine Vértessomló Siltstone from the Tés Clay which was only occasionally affected by a marine influence. As sedimentation progressed, the northwest limb of the basin was subsiding at a higher rate (Fig. 5a), this was compensated continuously by sedimentation also containing coarser detritus, e.g. conglomerate layers in boreholes Sur-1 and Nagyveleg. The axis of the basin bottom (Fig. 6), reflected by the zone of most frequent marine interbeddings, can therefore be drawn not near the northern limb but rather a little southwards from the medial line, between Zirc and Mór. Simultaneously with the sinking of the basin a smaller scale rising movement must have taken place in the more distant part of the NW limb. This allowed its major streams to repeatedly deliver coarse detritus to the basin over a longer period (Fig. 6).

The coarsest sediments, i.e. the conglomerates, consist only of pebbles of chert origin in both, the basal strata (West of the Kardosrét-Eplény line) and the higher strata (borehole Sur-1). The components of the sandstones appearing mainly in the upper parts of the sequence northeast of Mór, are quartz and quartzite. This indicates that the erosion had been relocated behind the carbonate terrain. This comparatively mature material suggests either a very distant source area or, more likely, a redeposition of nearby sedimentary rocks.

Until the appearance of the Zirc Limestone the seemingly uniform sedimentary basin of the Tés Clay remains a multitude of subbasins, varying not only in their size but also in their location. They were separated by swamp vegetation and possibly even by minor flat island-like elevations. This is indicated by the fact that lithological and paleontological correlations are impossible over larger distances. The analysis of the marine intercalations, mainly based on Ostracoda (Fig. 7), allowed even the most significant ingressions to be traced only approximately. A modern example of such a situation are the Everglades in Florida, U.S.A. Here, within an area of several thousand square kilometres, a maximum drop in elevation of 5 metres is encountered. Local differences in altitude are insignificant. In spite of this, the multitude of the geological features is significant.

The above comparison is not perfect because the sinking of the Everglades began about 5 thousand years ago and the oscillative changes of facies are yet untraceable. A subdivision of the basin explains the visible fact that sedimentation took place in a non-agitated environment. The latter is confirmed by calculations based on granulometric analyses. The aforementioned SE and SW attenuation of the idealized Tés Clay profile (Fig. 5) enables us to identify a sedimentary basin margin extending a maximum of 10 kilometres southeast of the present margin (Fig. 6).

The present morphology has retained certain features of the ancient one, although contrary trends are also possible (Mór graben).

Although I do not intend to enlarge upon theoretical questions concerning the present position of the major tectonic elements of the Hungarian Central Range Unit, there is one fact worth mentioning. Despite an ideal environment, we have no evidence of dinosaurs from the Tés Clay. This may indicate that a land bridge between the area in question and the continent was lacking.

2.2. Middle Albian

Various changes in sedimentation occurred almost simultaneously towards the end of the mid-Albian. The input of detritus ceased or decreased to a minimum and faciliated the settling of thick-shelled molluscs and the formation of the platform-like reef (Zirc Limestone Formation) in the progressing sea. The sea, source of carbonate-containing sediments, transgressed beyond the Tés Clay in a southwest direction. In the littoral zone (Pa-7) most bauxite minerals from the allite blanket overlying a carbonaceous base were incorporated without resilification. The red-coloured pelites of borehole U-421 (4 kilometres away) were converted to caolinite with addition of Silicium.

In the south Bakony, subsiding at a considerably faster rate that the northern part of the mountains, the strata are dominated by two facies types. Towards the inner part of the basin the reef facies increases in importance and frequency as compared to the littoral zone. A uniform limestone facies with a diverse gastropod fauna predominates and indicates a reduced salinity. Along with subsidence temporary emergences occurred frequently due to oscillation. Owing to the comparatively high precipitation, the establishment of little basins with a considerable freshwater content mainly in the marginal 1–2 kilometres usually representing higher subtidal to intertidal zones took place.

It is probably due to this fact that Mg-containing calcite and dolomite precipitation was not followed subsequently by gypsum or anhydrite.

In addition to the two predominant facies types, basins wide enough to enable a significant wave action were formed occasionally. Here true oolites along with orbitolines and intraclasts occurred. Five of WILSON'S facies zones have been distinguished in the area (Fig. 8).

At the very beginning of Zirc Limestone deposition a barrier reef probably existed in the northeast part in the Oroszlány-Környe line. Behind this the formation of platform-like reef structures with pachydonts began. Only in some places this vast, rather uniform formation was interrupted by channels and small basins. In spite of the slightly deeper position of the middle member as compared to the Eperkéshegy Member of reef-origin, hardgrounds with brown limonite coating, indicating short periods of emergence appeared. This is an indication for the differentiation of the region. The formation of the member was terminated by the localized recurrence of reef-like facies. At the same time the territory east of Pénzeskút was uplifted above sea level for short periods and karstified.

2.3. Upper Albian

The formation of the upper member (thinly bedded limestone) reflects a considerable paleogeographic change. The change in the fauna leaves no doubt about a change in the faunal province. The appearance of planktonic foraminifera provides evidence for the disappearance of the barrier reef. The presence of terrigeneous carbonate and quartz sand is an evidence of differential movements of the hinterland of the sedimentary basin. Glauconite is also a new material here; its significance is not yet understand completely. It is generally acknowledged that water slightly cooler than that in the tropics is, among other factors, essential for glauconite formation. As the territory of the Transdanubian Central Range was still covered by a shallow sea at that time the glauconite formation cannot be explained by the influence of cold water currents.

In the abundant literature on glauconite, it is in most cases agreed upon that formation of glauconite would not have been possible without proper source minerals, supposedly phylosilicates, mainly different kinds of micas or montmorillonites (KÖSTLER and KOHLER, 1973).

Source rocks are of outstanding importance: Even if it appears that an input of volcanic material may explain the origin of the glauconites occurring in most parts of Europe at that time, other sources for potassium cannot be excluded.

2.4. Vraconian to Early Cenomanian

In the middle of the Mid-Vraconian, the northeast part of the sedimentary basin rose again above the sea level (Fig. 9). This initiated the weathering in the Oroszlány-Pusztavám area extending to the lower part of the middle member and occasionally to the Eperkéshegy Member. This territory is characterized by larger breaks in sedimentation. Here caverns 0.5—1.5 m in depth are filled with marl and clayey marl varieties of the Pénzeskút Marl, which abounds with glauconite. Basal detritus is missing entirely. In the surroundings of Jásd the degree of weathering is virtually negligible, although the detrital basal layer is 0.5 m.

West from here, at Bakonynána, the transition between Zirc Limestone and Pénzeskút Marl is considered to be continuous in spite of the fact that the 60—70 cm thick transitional section contains limestone detritus 0.5—3.0 cm in diameter in its middle part along with redeposited faunal elements. Phenomena indicating hardgrounds and small intraclasts are known from Olaszfalu and Pénzesgyőr. Glauconite content also significantly decreases in a SW direction, while sporadic faunal elements above the Eperkéshegy Member increase more and more in a SW direction and tend to become more and more related to the Southern-Bakony facies. The intertongueing of the two facies begins in the Bakonybél-Csehbánya area. According to one of the possible versions (Fig. 10), during the deposition of the lowermost third of the Pénzeskút Marl in the Northern-Bakony, lagoonal limestone deposition with isolated patch reefs was still in progress in the Southern-Bakony. In addition to faunal changes in a SW direction this is indicated by grading of the two formations into one another and by an increase in thickness of the upper member of the Zirc Limestone in the same direction. While in the Northern Bakony both rising and sinking movements took place, it is difficult to accept the same explanation for the unstable Southern Bakony facies. It is also difficult to explain the regression (Fig. 9) and transgression, not to mention the glauconitization and at the same time the existence of reef-building organisms.

According to another hypothesis concerning the contact of the two facies areas (Fig. 11), the age of the Northern and Southern Bakony facies can be considered to be essentially identical. This makes the cooling which probably had taken place by the time of major glauconitization more easy to explain. In spite of the evident signs of a transition, the original location of the two facies areas could be explained by horizontal tectonic movements. This idea stems mainly from the fact that the Northern Bakony Middle Cretaceous shows affinity to the fauna of the northern margin of the Tethys while the gastropods in the South Bakony are not characteristic for this paleogeographic position. It seems that this differentiation has persisted from the Early Cretaceous (similarities of the Gerecse Lower Cretaceous to the Rossfeld beds and the Mogyorósdomb Limestone to the South Alpine Biancone facies) into the Mid-Cretaceous.

In the early Vraconian, surprisingly coarse basal detritus of the glauconite-rich layers (deposited at the beginning of sedimentation cycle) is traceable only in the south. SW of the sedimentary basin, sedimentation is continuous (Jásd-Bakonynána-Olaszfalu-Pínzesgyö), breaks in sedimentation are insignificant. The sequence of the Pénzeskút Marl Formation, which is subdivided into 3 members, shows microplankton (Foraminifera, Calcispaerulidae) and ammonite assemblages characteristic for an open sea without any barrier. Beside vertical differences in lithology, horizontal differences are insignificant or barely traceable due to subsequent weathering. The most important changes are the increase in carbonate and decrease in glauconite content in a SW direction. Benthonic organisms are present in a frequency similar to that of the planktonic and nectonic organisms (rich, both in species and specimens). This indicates that even in the middle member, the depth of the sea did not exceed the mid- to sublittoral. The horizontal uniformity of the lower and middle sections of the formation indicates a transgression beyond the earlier formations of the sedimentary cycle, i.e. an open sea environment. Frequent coalified remnants of vegetation can be attributed to a not too distant coastline (confirmed also by recurring large-body spores).

Intermediate andesitic volcanism is indicated both by the hornblende-pyroxene group identified by micromineralogical analyses in the lower three-fourths of the key section and by the frequent occurrence of varied feldspars.

2.5. Late Early to Middle Cenomanian

As the first sign of the sub-Hercynian tectonic phase, the territory began to uplift at about the end of the early Cenomanian. The marls were gradually replaced by silts and more frequently by sandstones. In the latter, a metamorphic source area could be defined, on the basis of microminerals. Ammonites and Foraminifera significantly decrease both in species and specimen numbers, indicating a decrease in salinity in the regressional sequence. As a sign of the advancing coastline, large-body spores sharply increase in number. As a result of subsequent full-scale tectonic movements the entire region emerged and was subsequently differentiated morphologically. The axis of the Central Range subsided inequilaterally as compared to the limbs, facilitating partial preservation of the earlier sequences. This has made it possible for us to study the sediments of the regressive limb over an area of a few square kilometres.

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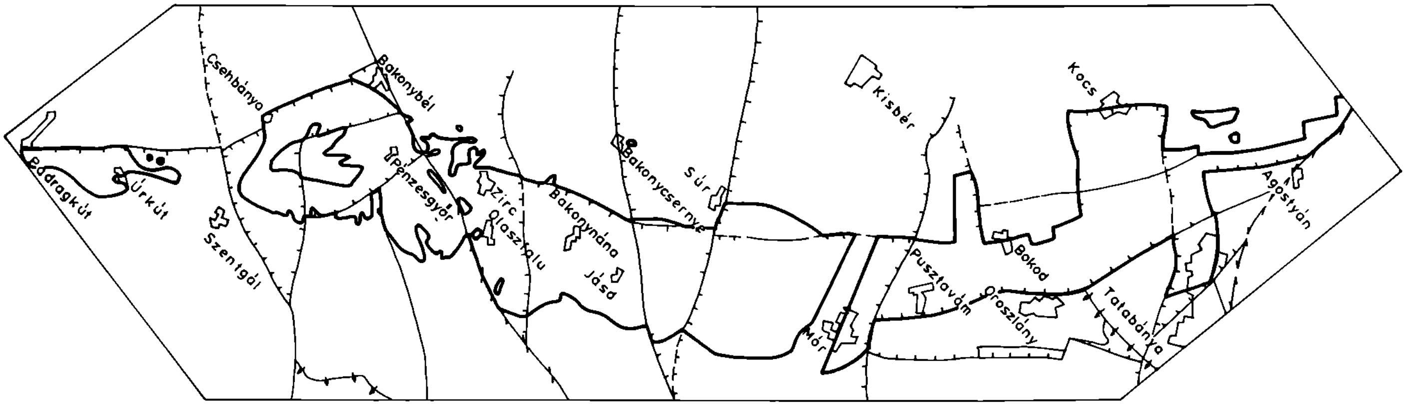
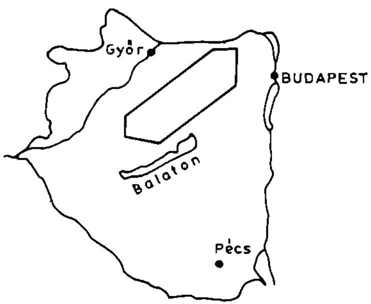
Abbreviations used in the Bibliography:

Bot. Közl. = Botanikai Közlemények (Budapest)
Bull. Cent. Rech. Explor-Prod. Elf-Aquitaine = Bulletin des Centres de Recherches Exploration-Production Elf-Aquitaine (Pua)
Földt. Közl. = Földtani Közlöny (Budapest)
Geol. Hung. Ser. Pal. = Geologica Hungarica, Series Paleontologica (Budapest)
MÁFI Évi Jel. = Magyar Állami Földtani Intézet Évi Jelentése (Budapest)
MÁFI Évk. = Magyar Állami Földtani Intézet Évkönyve (Budapest)
M. Kir. Földt. Int. Évi Jel. = Magyar Királyi Földtani Intézet Évi Jelentése (Budapest)
MTA Matematikai és Term. Tud. Értesítő = Magyar Tudományos Akadémiai Matematikai és Természettudományi Értesítő (Budapest)
Sitzungsb. = Sitzungsberichte der Österreichischen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse (Wien)

Fig. 1.

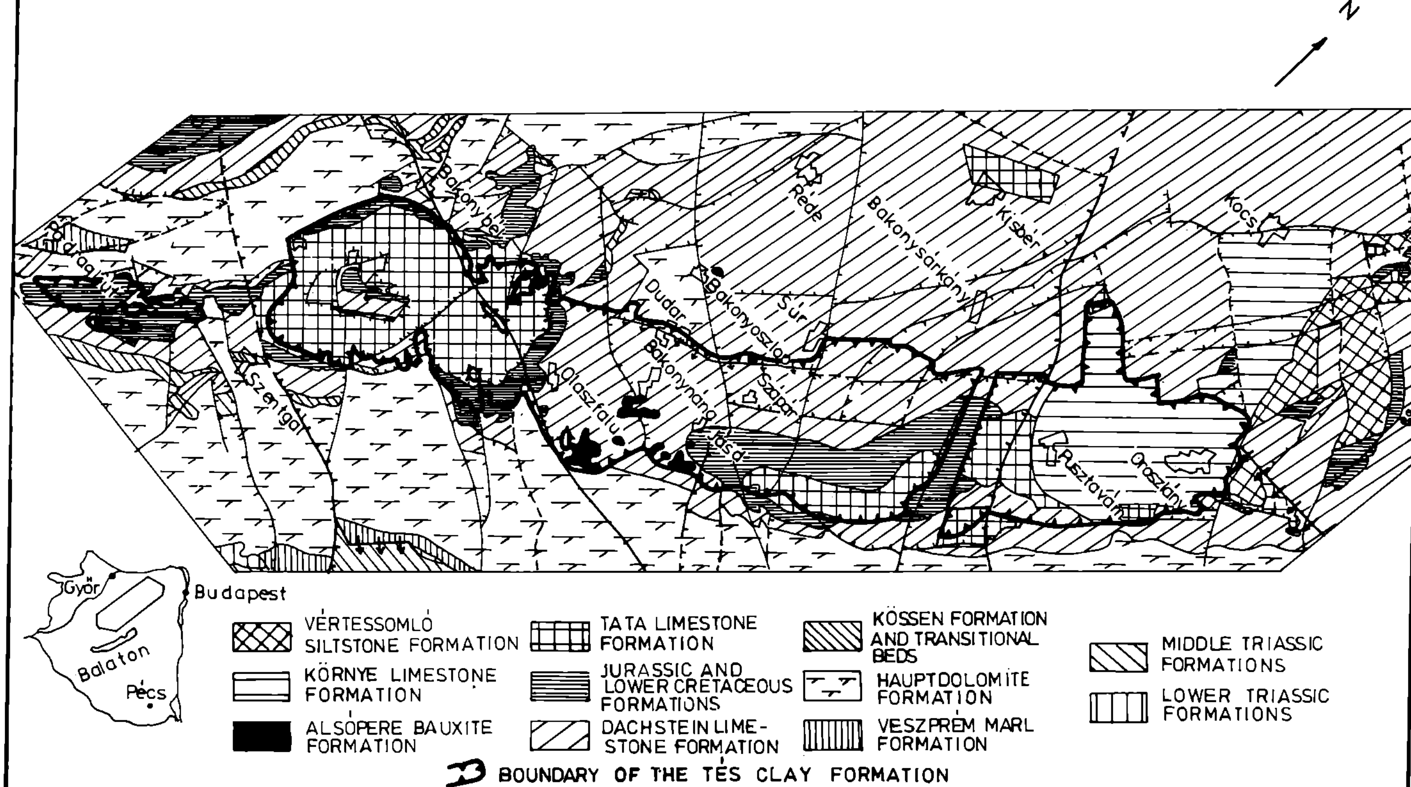




MID-CRETACEOUS FORMATIONS IN THE TRANSDANUBIAN CENTRAL RANGE
(EXCEPT TATA LIMESTONE FORMATION)

Fig. 2.

SUBCROP MAP OF THE TÉS CLAY FORMATION



ISOPACH MAP OF THE ALSÓPERE BAUXITE FORMATION IN NORTHEN BAKONY Fig. 3.

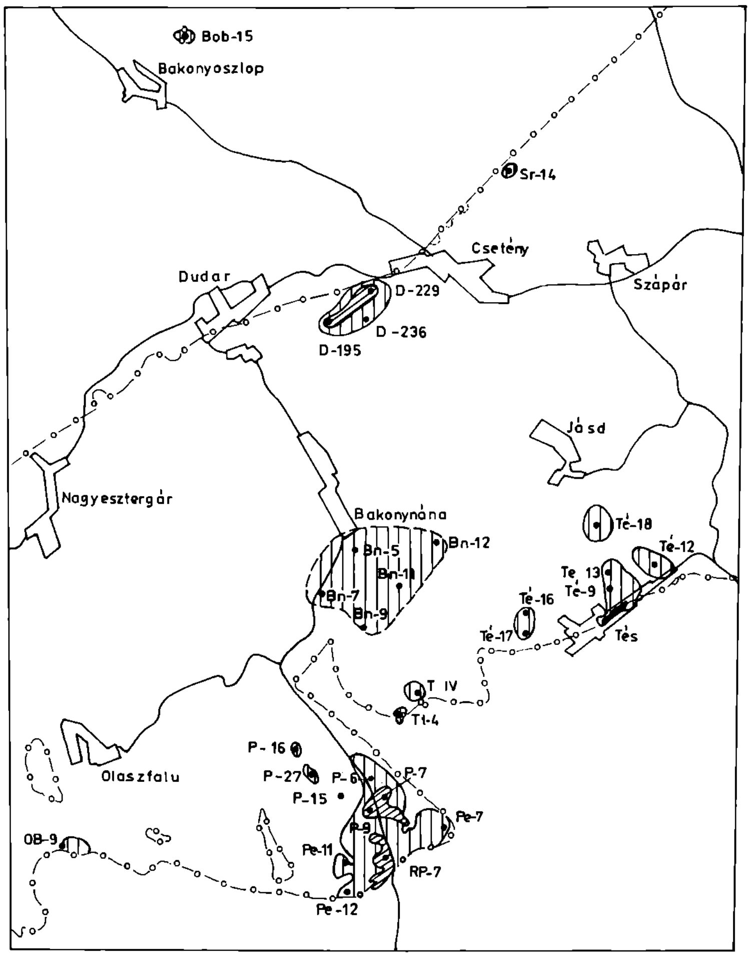


Fig. 4.

LAP-OUT MAP OF THE TÉS CLAY FORMATION IN NORTHEN BAKONY

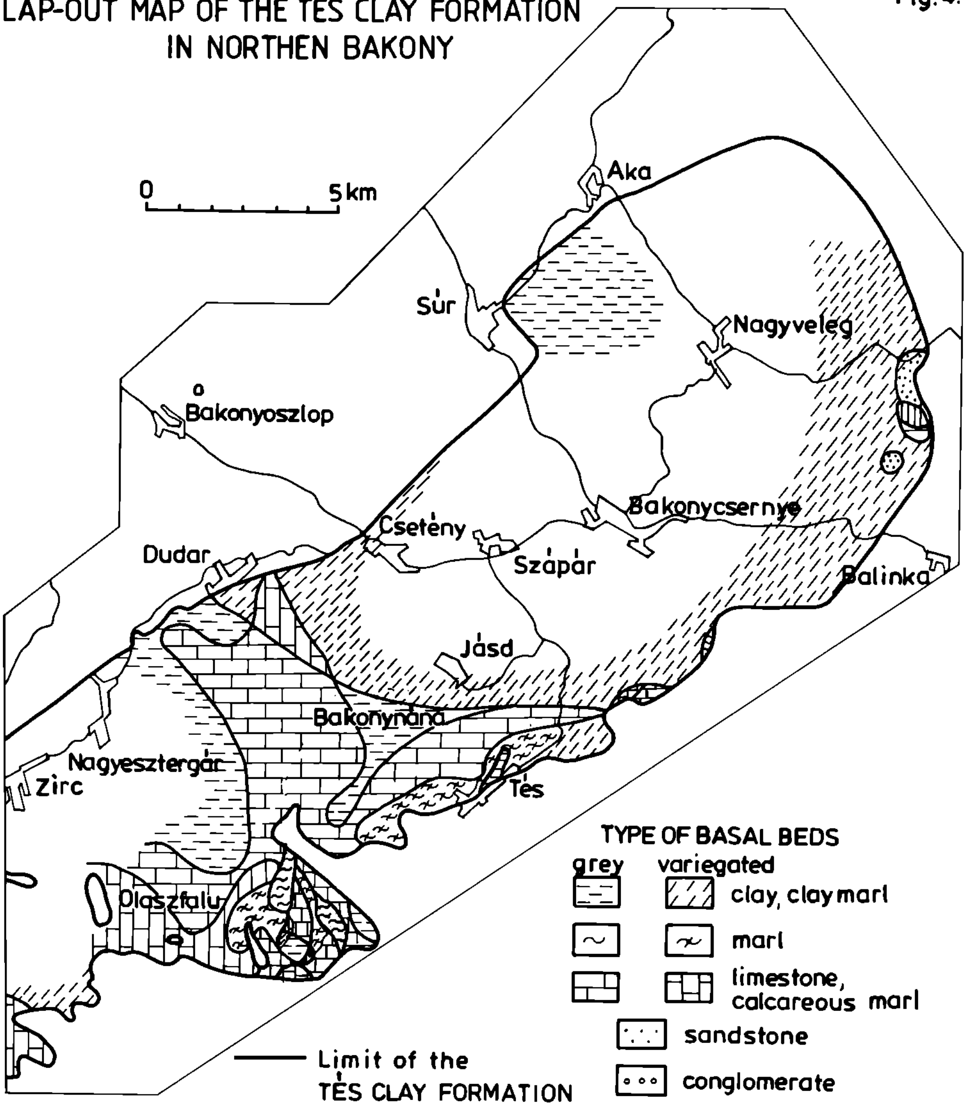
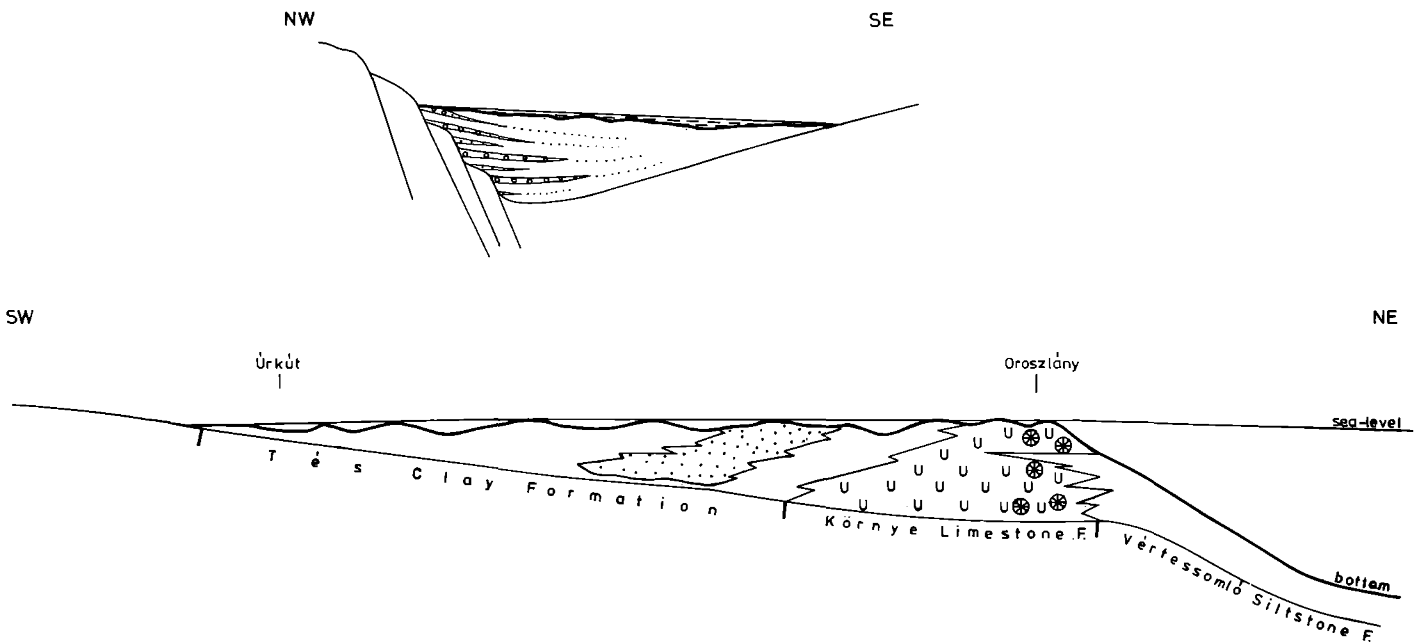


Fig. 5.

GENERALIZED SECTIONS SHOWING THE TERMINAL SEDIMENTATION OF THE TÉS CLAY FORMATION IN THE TRANSDANUBIAN CENTRAL RANGE



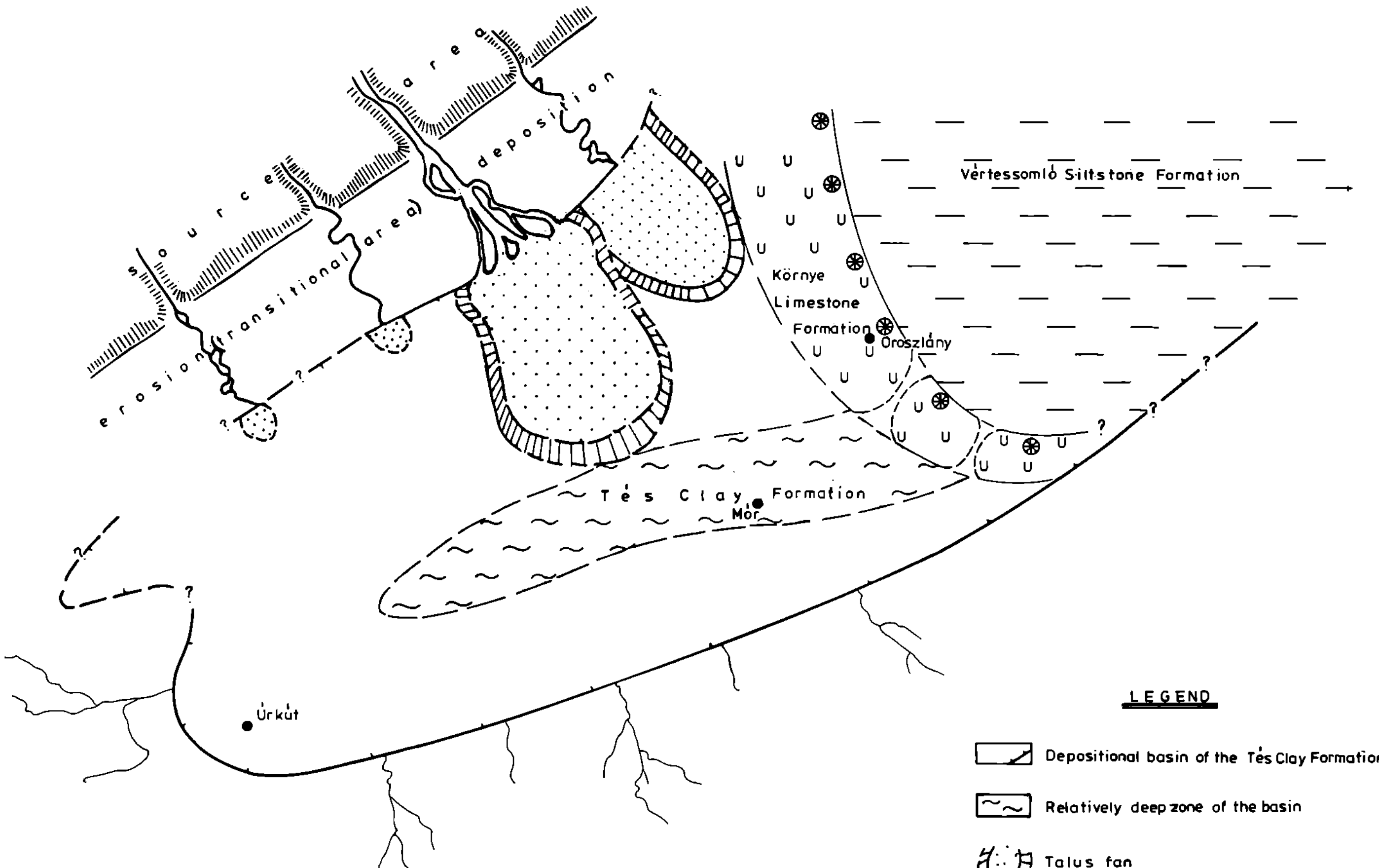
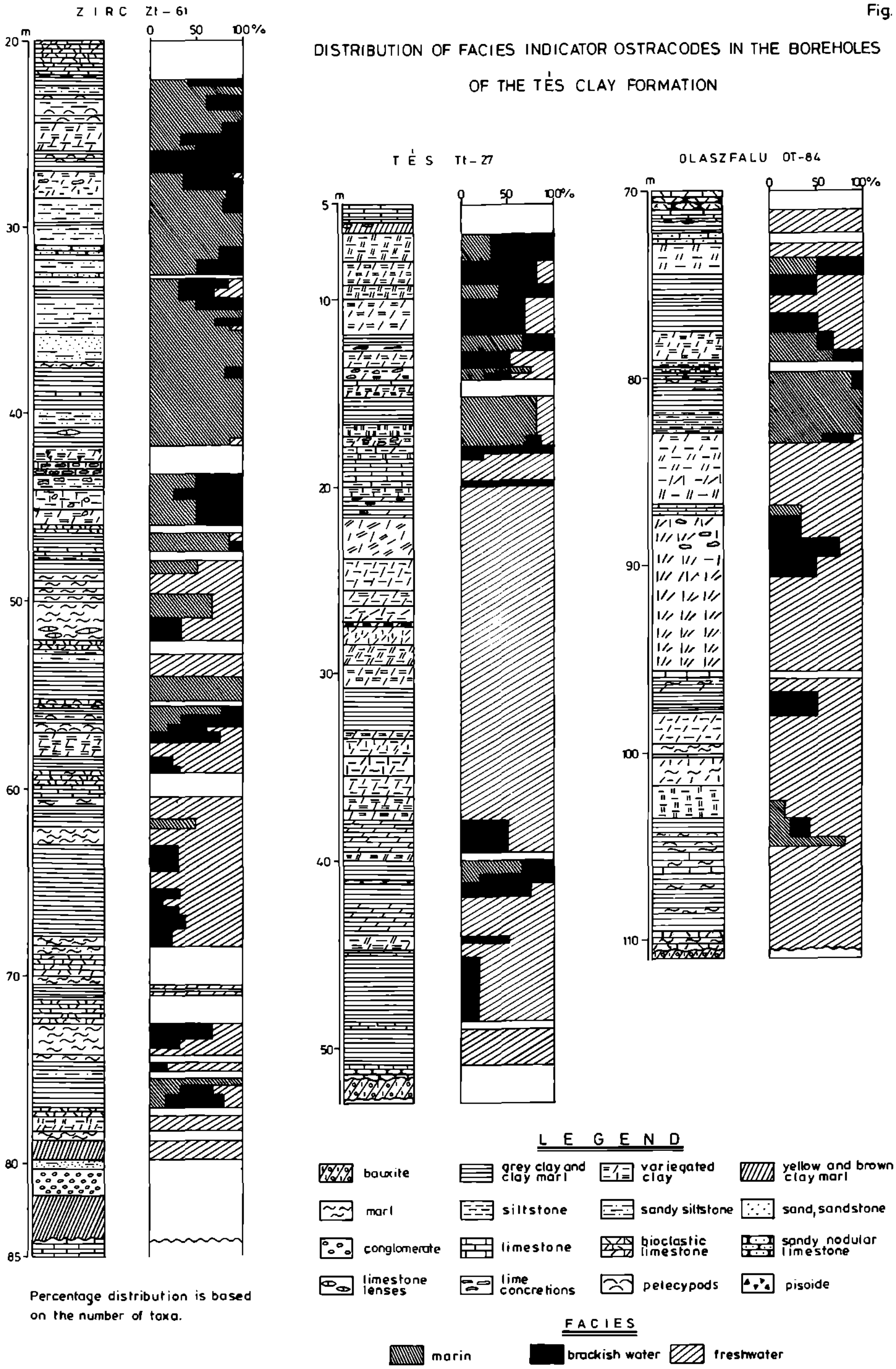


Fig. 6.

PALEOGEOGRAPHIC SKETCH MAP OF THE TÉS CLAY FORMATION

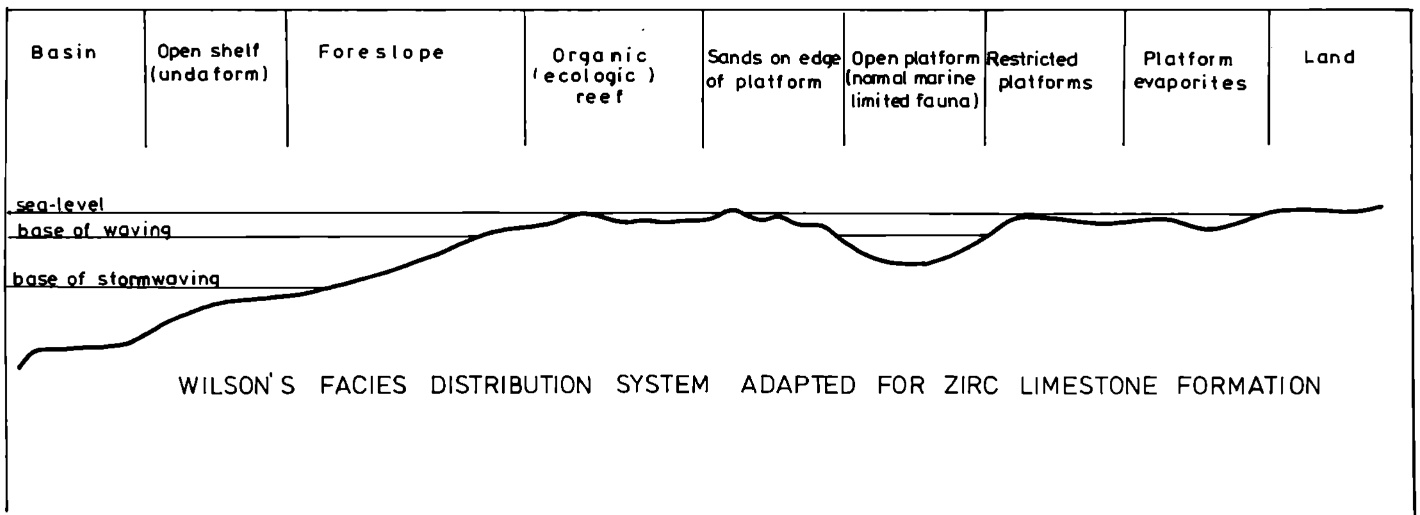
Fig. 7.

DISTRIBUTION OF FACIES INDICATOR OSTRACODES IN THE BOREHOLES OF THE TÉS CLAY FORMATION



Percentage distribution is based on the number of taxa.

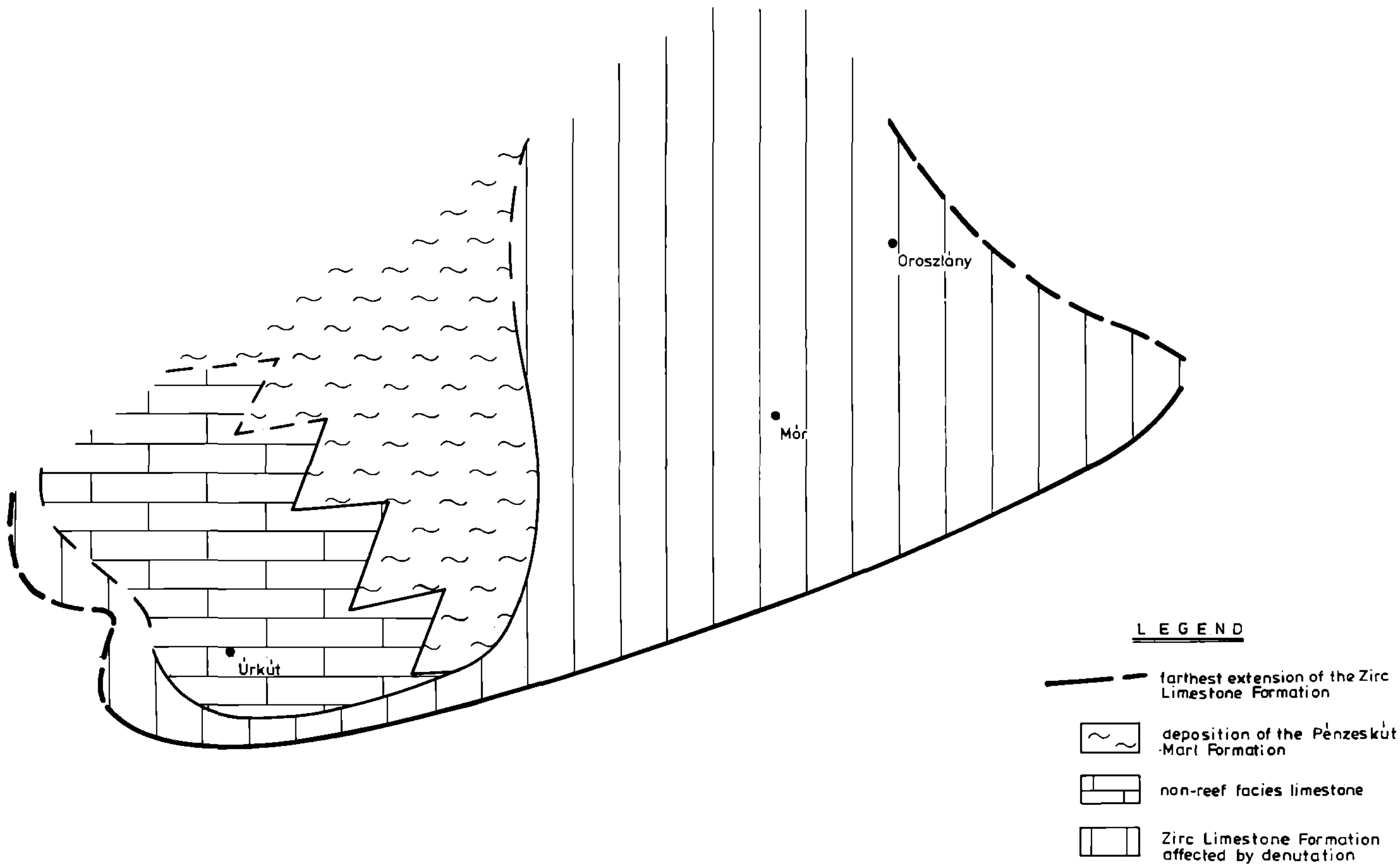
Fig 8.



WILSON'S FACIES DISTRIBUTION SYSTEM ADAPTED FOR ZIRC LIMESTONE FORMATION

Fig. 9.

FACIES DISTRIBUTION IN THE TRANSDANUBIAN CENTRAL RANGE AT THE MAXIMUM OF THE MIDDLE VRACONIAN REGRESSION



CONNECTION BETWEEN THE TWO MAIN FACIES OF THE ZIRC LIMESTONE FORMATION

Version Nº1

Fig. 10.

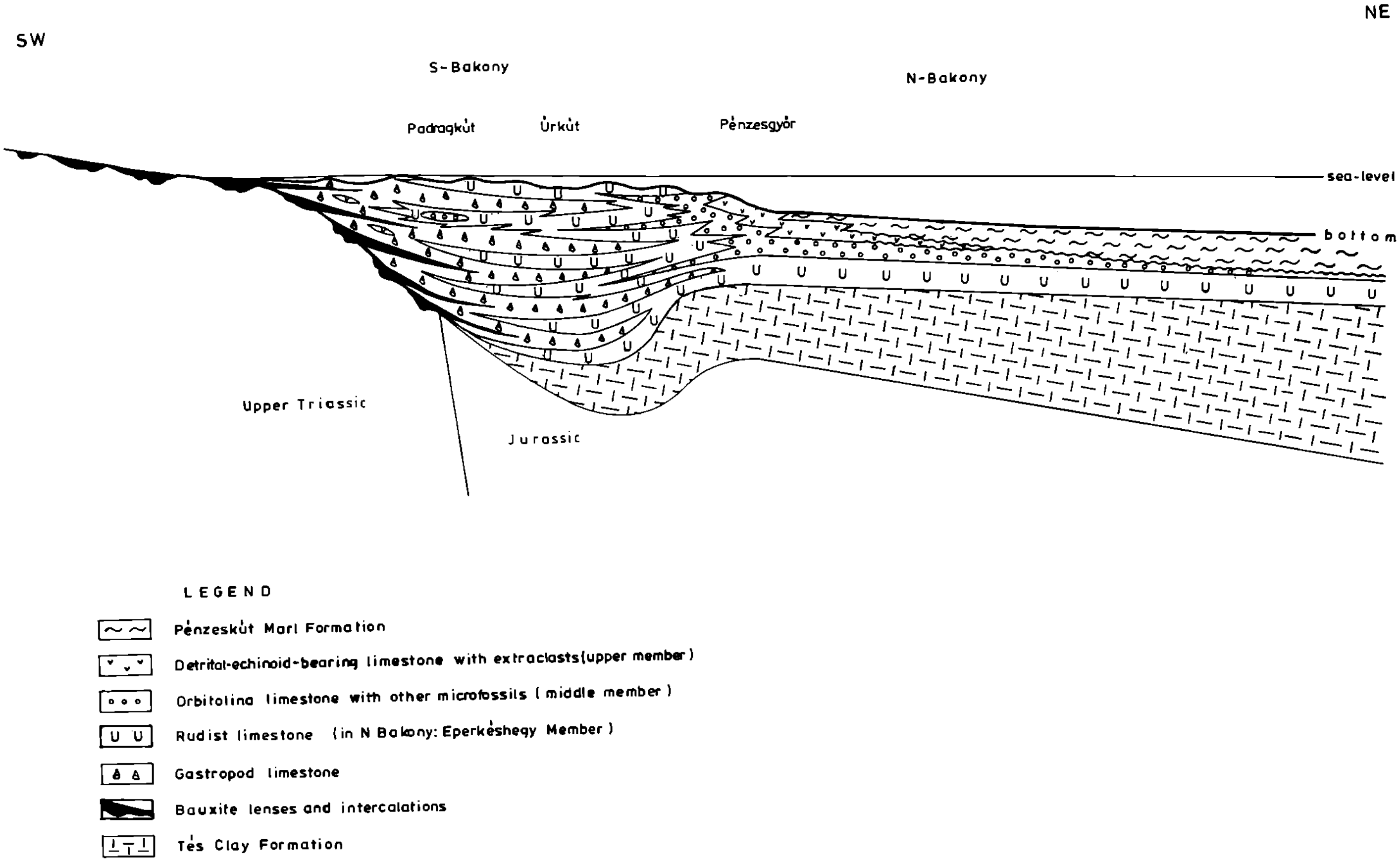


Fig.11.

CONNECTION BETWEEN THE TWO MAIN FACIES OF THE ZIRC LIMESTONE FORMATION

Version №2