ANN. INST. GEOL. PUBL. HUNG. | vol. LXX. | Budapestini, 1987

Proceedings of the VIIIth RCMNS Congress

GENERAL CHARACTERISTICS OF PANNONIAN s.l. DEPOSITS IN HUNGARY

by

Á. JÁMBOR, E. BALÁZS, K. BALOGH, I. BÉRCZI, J. BÓNA, F. HORVÁTH, I. GAJDOS, J. GEIGER, M. HAJÓS, L. KORDOS, A. KORECZ, I. KORECZ-LAKY, M. KORPÁS-HÓDI, J. KŐVÁRY, L. MÉSZÁROS, E. NAGY, G. NÉMETH, A. NUSSZER, S. PAP, GY. POGÁCSÁS, I. RÉVÉSZ, J. RUMPLER, M. SÜTŐ-SZENTAI, Á. SZALAY, K. SZENTGYÖRGYI, M. SZÉLES and L. VÖLGYI

The dominantly fine-grained, brackish-water sediments with large thicknesses which are underlain by Sarmatian and overlain by Pleistocene sedimentary rocks are generally considered Pannonian formations. Their extension covers the Pannonian and Transylvanian basins which belonged to the Central Paratethys sea (Fig. 1). The Pannonian formations constitute the last but one major sedimentary cycle of filling-up of these basins, isolated from the world ocean and also from the eastern Paratethys. This inland sea lay on the unstable basement between the European and African plates. Its water progressively freshened and the depression was completely filled up in spite of the extensional subsidence of an average of 1300 m and a maximum of 5000 m.

Fig. 1. Distribution of the Pannonian formations in the Carpathian basin

A detailed correlation between the Pannonian sedimentary complex and the marine sequences has not been solved, despite stratigraphic studies carried on for more than hundred years. The beginning of deposition of the Pannonian strata between 11–12 Ma seems to be well dated. The end of deposition is defined by the Pliocene/Pleistocene boundary. However, the age of this boundary is controversial and the determination of this boundary in the sedimentary sequence is often question-

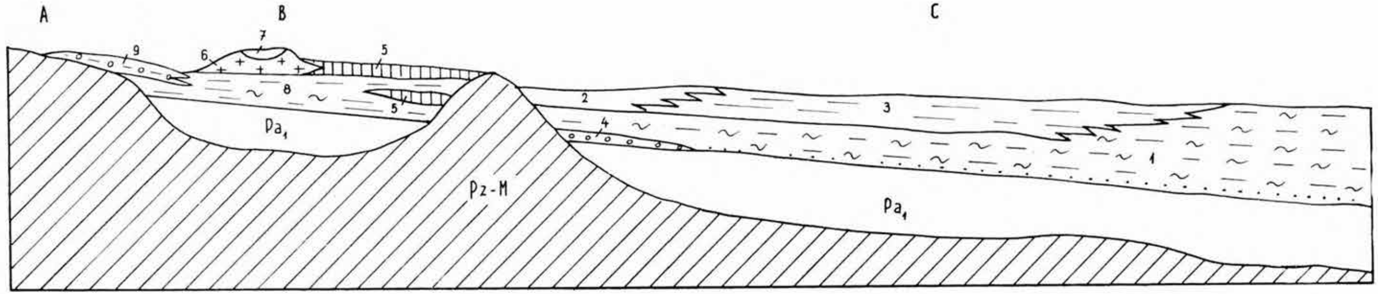


Fig. 2. Theoretical sketch of the position of facies units belonging to the Dunántúl Supergroup formations (compiled by Á. JÁMBOR, 1984)

1 Basin sediments of argillaceous marl and sand, *2* mountain marginal variegated clay, sand, *3* lignite, huminitic mud, *4* abrasional pearl-pebbles, quartz-sand, *5* freshwater limestone, *6* basaltic tuffite, *7* alginite, 8 lagoonal argillaceous marl, sand, *9* fluviatile variegated clay and sand.—A, B, C, Pz—M: see Fig. 3, Pa_1=Peremarton Supergroup beds

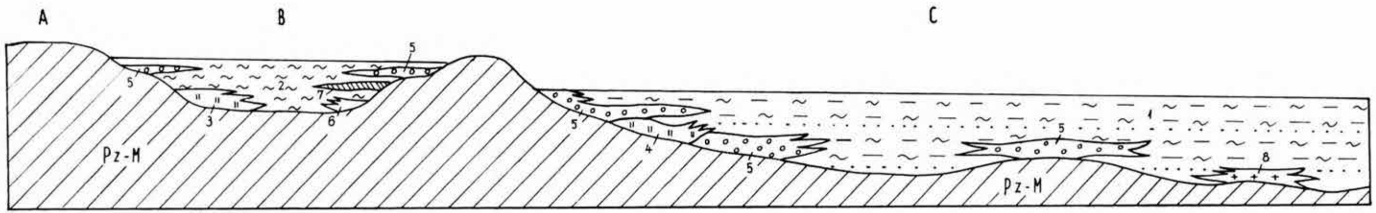


Fig. 3. Theoretical sketch of the position of facies units belonging to the Peremarton Supergroup formations (compiled by Á. JÁMBOR, 1984)

1 Open water argillaceous marl, sand, *2* lagoonal argillaceous marl, *3* mountain marginal variegated clay, pebble, *4* basin-marginal variegated clay, *5* abrasional pearl-pebbles, *6* lignite, huminitic mud, *7* freshwater limestone, *8* volcano-sedimentary beds.—A=highlands-uplands, B=lagoon of the mountain margin, C=basin, Pz—M=formations predating the Peremarton Supergroup able. For the acceptance of the 1.8 Ma or 2.4 Ma boundary an international agreement is necessary. It is even more difficult to determine the boundary of the Lower and Upper Pannonian which is now called the Pannonian s. str. and Pontian boundary. The *K/Ar* radiometric age determination of Transdanubian basalts yielded 5—6 Ma; paleomagnetic data suggest 8 Ma, and 7 Ma was inferred from the Mollusca and Vertebrata faunal investigations. Moreover, the meaning of these data is not very clear because of the poor understanding of the contemporaneous facies conditions.

In Hungary the Pannonian (s.l.) formations can be found in more than three-quarters of the country (75,000 km^2) and are often covered by Pleistocene deposits. Only Paleo-Mesozoic inselbergs rise above the surface of the Late Cenozoic basin. The elevation of the surface of the basin varies from 79 m to 250 m above sea level, which is the consequence of an Early Pleistocene uplift accompanied by intensive erosion and followed by further subsidence. The outcrops of the Pannonian formations can be found at the margin of the basin and in the Transdanubian Central Range. In addition, the Pannonian formations can be studied on the basis of many thousand exploration wells for petroleum, water and other mineral resources, and by the help of about 30,000 kilometers of high resolution seismic profiles.

The Pannonian (s.l.) formations are monotonous petrologically. In the lower Peremarton Supergroup and in the inner parts of the basin a sequence of less variability can be found, while in the upper Dunántúl Supergroup and at the basin margins the gelogic column is more heterogeneous (Figs. 2 and 3).

The most important rockforming minerals are quartz, feldspars, micas (muscovite, chlorite, biotite), clay minerals (illite, smectite) and heavy minerals (mainly of metamorphic origin, dominantly granulites), authigenes: calcite, dolomite, bacteriogenic pyrite and limonite. Accordingly, the complex is considered to be of average molasse composition.

The thickness of the Pannonian basin-fill varies strongly from place to place. There are many smaller or larger deep troughs separated by elevated basement swells. The greatest thicknesses can be found in the southeastern Great Hungarian Plain (Fig. 4).

The Pannonian usually develops with gradual transition from the underlying Sarmatian. In elevated areas a paraconformable contact can be observed. In this case the dip of the two complexes is the same, and both are brackish and usually pelitic. There is no obvious evidence of a break in sedimentation or subareal erosion. The detailed palaeontologic investigations, however, prove in this case the lack of the lowermost biostratigraphic zones. This kind of contact is explained by simultaneous or subsequent subaquatic erosion. The Pannonian (s.l.) formations always overlie unconformably the pre-Sarmatian beds. Transgressive sequences can be observed in three different levels in the Pannonian complex: at the middle and upper levels of the Peremarton-, and at the lower level of the Dunántúl Supergroup. As a consequence of the transgressions, Pannonian sedimentation extended to larger and larger areas.

In the caprock of the Pannonian formation a Middle and Upper Pleistocene periglacial series can be found which usually consists of fluvial sand, gravel and loess. It overlies the Pannonian sediments with little angular unconformity over a great part of Hungary. This is due to a latest Pannonian uplift and subareal erosion in Transdanubia and northern Hungary. In deep basin areas, however, the Pleistocene sedimentary sequence is complete, the transition is gradual and no erosional hiatus can be supposed, regardless of whether 1.8 Ma or 2.4 Ma is taken to be the Pannonian/Pleistocene boundary.

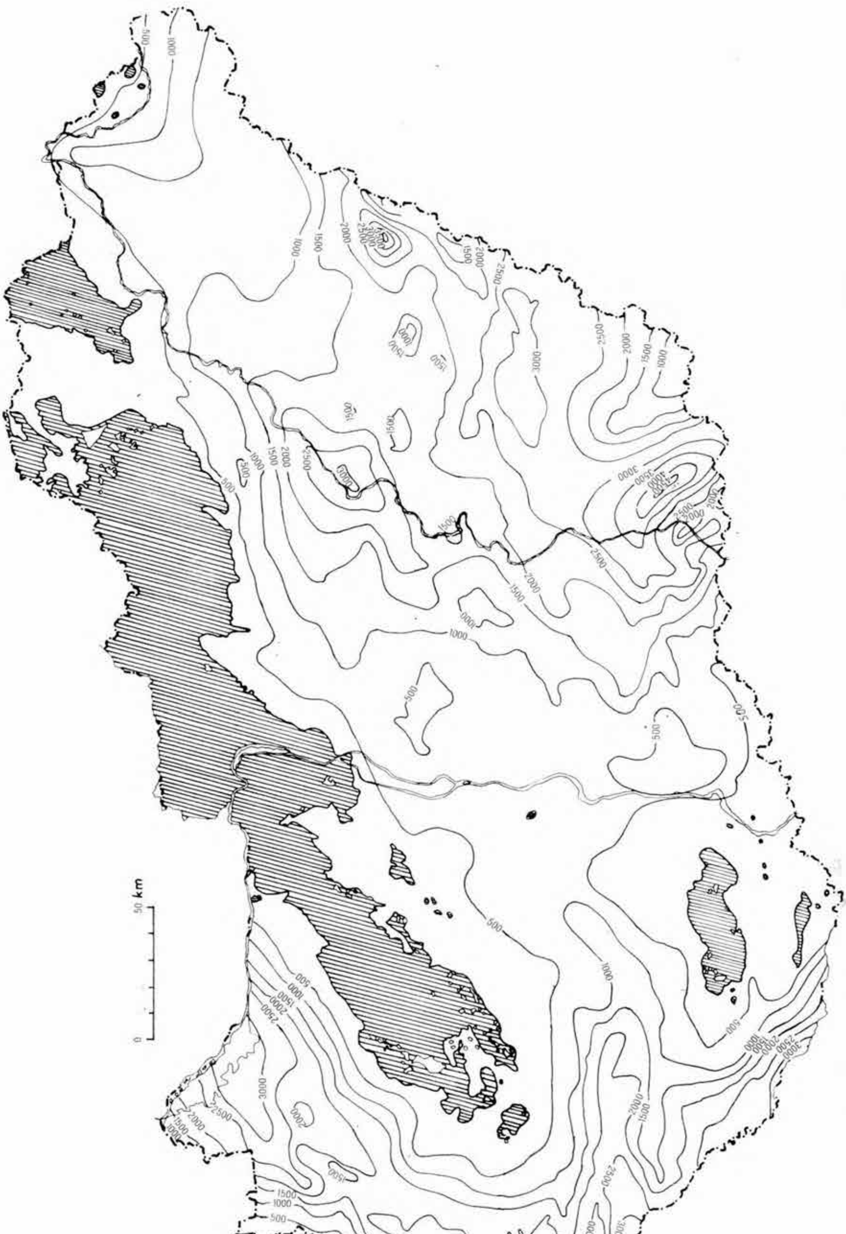


Fig. 4. Thickness of Pannonian s.l. deposits in Hungary (compiled by S. LENNER, 1984)

The process of filling-up of the Pannonian basin can be summarized as follows:

1 A climatic change at the end of the Sarmatian significantly altered the former sedimentation regime which was characterized by pelitic deposition in deep basins and ooidic limestone formation on the bains margins. The humid climate further decreased the salinity of the inland sea and led to the deposition of calcareous pelites. In north-eastern Hungary the volcanism proceeded with a new phase of rhyolite-tuff eruption. Its marks can be found also in the southern and central parts of Transdanubia in forms of thin tuff interbeddings. Diatomite and bentonite deposited in lagoons developed in deeper parts of the volcanic Tokaj Mountains.

2 The subsidence rate of the Pannonian basin increased due to important tectonic changes in the Early Pannonian. The subsidence was common, but varied in space. The source areas for clastic influx—the Alps and the Carpathians—uplifted.

Large amount of the erosional clastics was transported into the basin by rivers and thus a great deltaic sedimentation regime developed. In northern Hungary the delta-plain facies can be found. In the inner parts of the basin the maximum water depth could have reached 800 to 900 m, according to the seismic profiles (Fig. 5). In northern Transdanubia trachyte volcanism, in the southern Great Hungarian Plain basaltic eruptions took place which produced volcanic masses of a few cubic km.

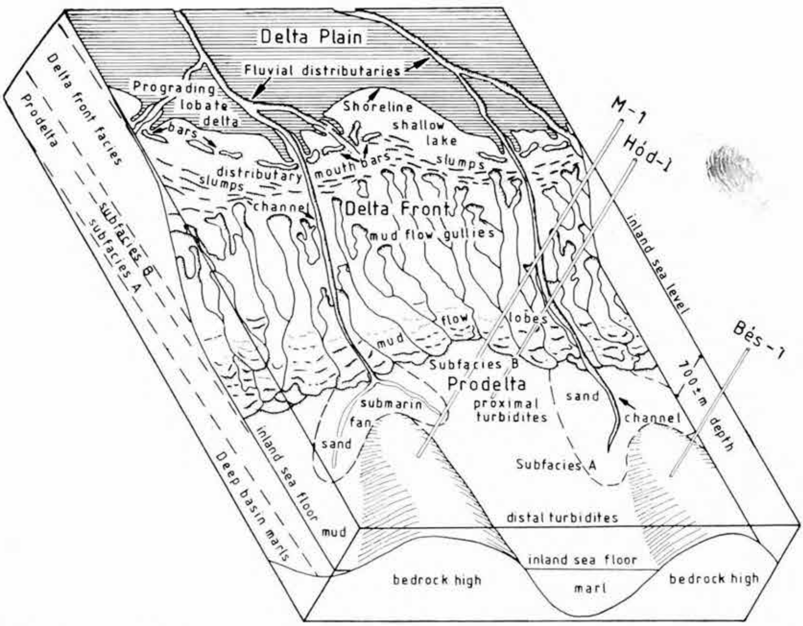


Fig. 5. General sedimentation system of the Pannonian s.l. sequence (compiled by I. BÉRCZI)

In the lagoons on the basin margins and in deep depressions pelites were deposited from suspension and mixed with biogenic sediments (diatomite, alginite). This sedimentation regime characterizes the upper two thirds of the Peremarton Group.

3 The Dunántúl Group was deposited under similar conditions but significantly shallower water (200—400 m). The deposition took place in a delta system formed under different morphotectonic and climatic circumstances. The topography of the source area became more rough producing nerating more and coarser clastics, so the proportion of sand in the sediments increased. The basin got increasingly filled-up.

The delta-slope sediments, which were dominant at the beginning, were progressively replaced first by delta plain deposits and later by lacustrine ones and eventually the basins got completely filled-up. On the delta-plain in the southern and southeastern forelands of the mountains large marshes and Taxodium swamp forests were formed. Lignite seams characterizing the middle and upper parts of the Dunántúl Supergroup developed here.

On the basin margins freshwater limestones were formed in latest Pannonian times in the intramontane basins of the Transdanubian Central Range.

In the middle and upper part of the Dunántúl Supergroup Na-alkaline basaltic tuff and basaltic lava flows occur in the Bakony Mts, in the Little Plain and northern Hungary. In Transdanubia the volcanic activity generally took place in the basins, and the water of the Pannonian lake penetrated into these volcanic craters, and led to the formation of alginite beds. In northern Hungary the volcanism took place on emergent land and the activity continued during the Pleistocene, too.

4 A marked break in sedimentation can be observed towards the end of Pannonian time. This is the consequence of renewed tectonic activity which led to uplift and erosion in the area of the present mountains and over much of Transdanubia. Over the rest of the country the subsidence continued and mostly terrestrial sediments were deposited.

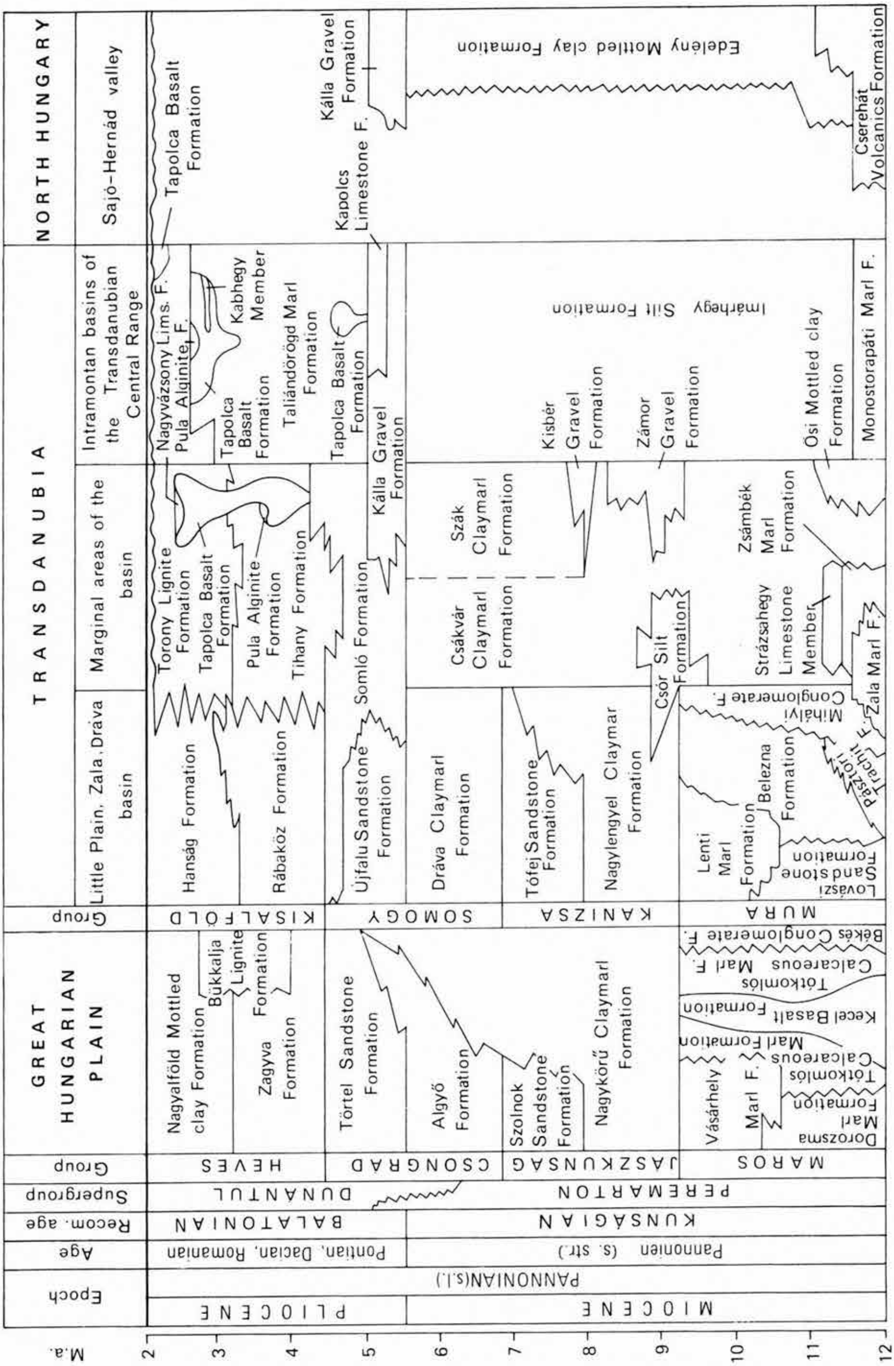
The two delta systems of the Pannonian basin mentioned above were similar from many points of view. Source areas for clastic inflow were in both cases the Alps and the western and eastern Carpathians. The clastic material was transported by rivers into the basins, where large delta systems were formed which prograded from the north and northwest towards the south. The younger delta system usually was superimposed with angular unconformity on the older one, as it can be seen on seismic profiles.

The bulk of the sediments was deposited mainly below the O_2-H_2S boundary and therefore it contains more disseminated organic matter. The large-scale subsidence of the substratum of the basin was caused by the thinning of the crust and the lithosphere. As a result the heat flux in the Pannonian basin increased by about a factor of two compared with stable continental areas. Therefore the Pannonian (s.l.) formation could reach the oil generation window already below 1800 to 2500 m. This led to the generation of a number of minor oil and gas fields.

In Figures 6 and 7 the stratigraphic classifications of the Pannonian formations are shown. From the lithostratigraphic point of view the Pannonian strata can be divided into two main groups. The lower part containing dominantly pelites is called Peremarton Group, having previously been referred to as Lower Pannonian. The upper one is called Dunántúl Group. The lower part of the Peremarton Group consists of marls, calcareous marls, subordinately of conglomerates and sandstones. The upper part is made up of clays and marls with frequent sand and gravel interbeddings.

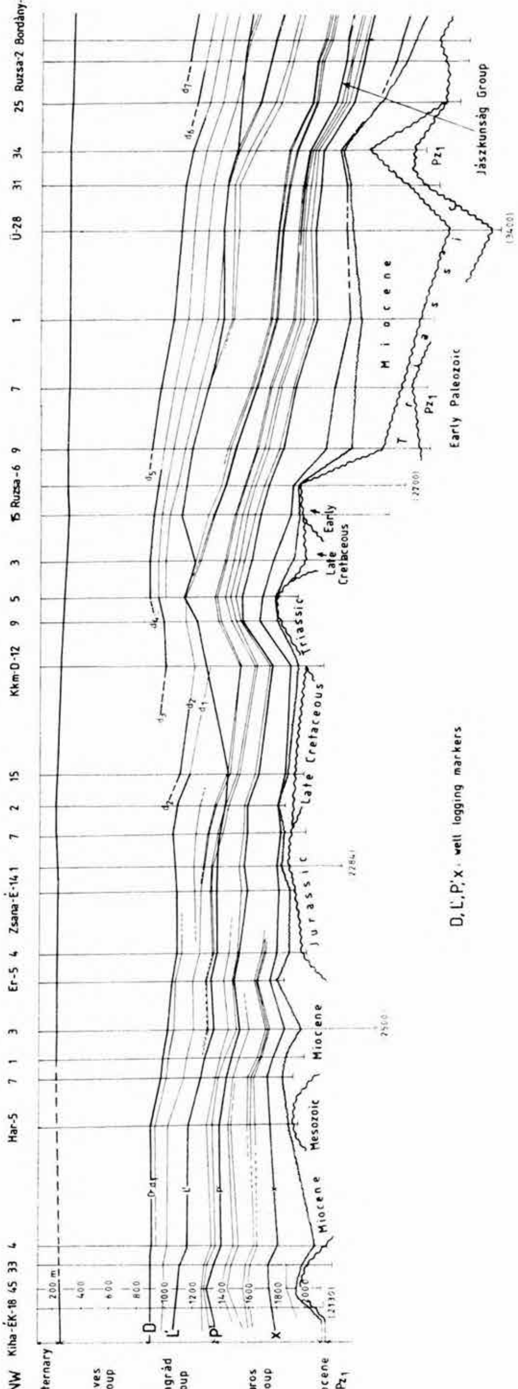
For the biostratigraphic subdivision of the Pannonian (s.l.) formation a rich and well-preserved mollusc fauna has been used since the end of the last century. The special Pannonian-brackish character is expressed in a fauna dominated by Congeria, Limnocardium and Melanopsis species and in the lack of all marine elements.

In the Recent decades the biostratigraphic importance of other fossil groups has been cleared up: vertebrates, ostracods, thecamoebans, diatoms, foraminifers, nannoplankton, spores and pollen grains, ichnofossils and sponge-spicules. All inland sea groups turned out to be of special Pannonian brackish character, i.e. low specific diversity and high density. Our recent biostratigraphic classification possibilities are shown in Fig. 8.



Compiled by Hungarian Stratigraphical Commission Pannonian Working Group 1984

Fig. 6. Lithostratigraphical classification of the Pannonian s.l. formations in Hungary


WNW
Kiha-ÉK-18
45
33
4
Har-5
7
1
3
Er-5
4
Zsana-É-14
1
7
2
15
Kkm-D-12
9
5
3
15 Ruzsa-6
9
7
1
Ü-28
31
34
25
Ruzsa-2
Bordány-1
Quaternary
Heves Group
Csongrád Group
Maros Group
Miocene
Pz1
D
L'
P'
X
200 m
400
600
800
1000
1200
1400
1600
1800
Miocene
Mesozoic
Miocene
Miocene
Jurassic
Late Cretaceous
Triassic
Late Cretaceous
Early Cretaceous
Miocene
Trias
Early Paleozoic
Pz1
Pz1
Jászkunság Group
D, L', P', X : well logging markers

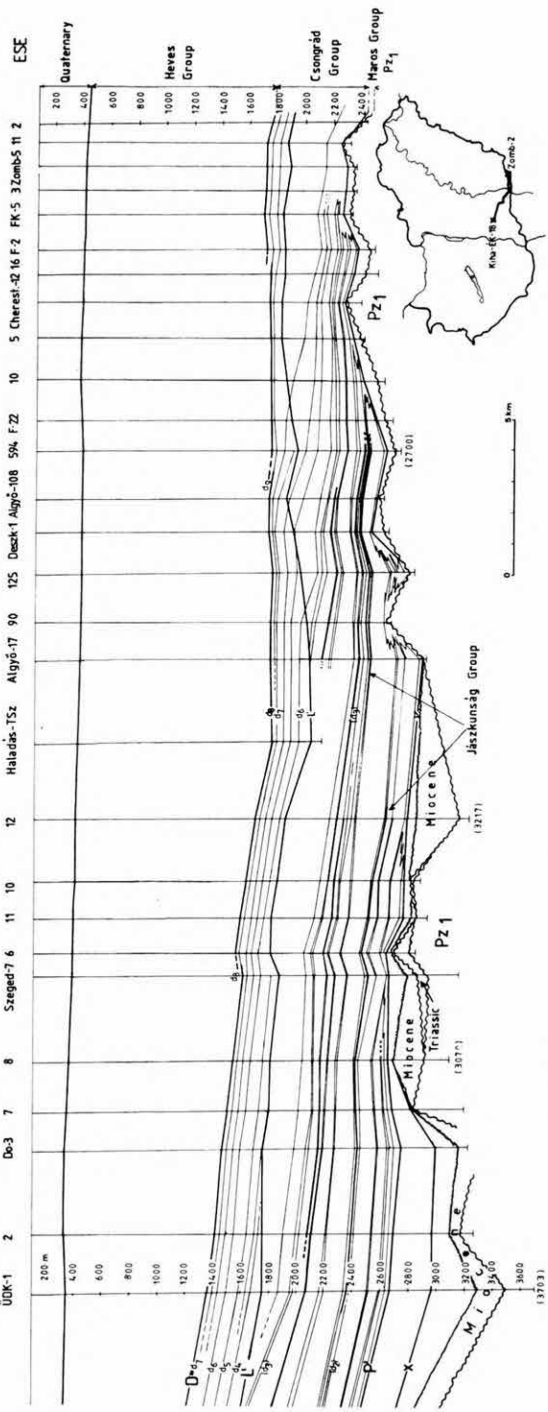


Fig. 7. Well-logging profile of the South Hungarian (Pannonian) (I. GAJDOS—S. PAP)

The molluscs, ostracods and the microplankton floras show a similar fourfold subdivision, which can be due to environmental constraints. At the end of the Sarmatian and at the beginning of the Pannonian the salinity of the inland sea varied within extremes of hypersaline and oligohaline due to a Mediterranean-type climate with hot summers and humid winters. It resulted in a strong selective pressure imposed on the biom. Hence the earliest Pannonian low specific diversity of fauna including the inland sea microfauna.

This special earliest Pannonian biome was succeeded by a very diversified Pannonian—brackish inland sea floral and faunal complex, of which ancestors partly had ingressed from the eastern Paratethys and then flourished in the Pannonian basin and partly survived the climatic changes at the end of the Sarmatian. They enriched the flora and fauna of the second level.

The next larger biotic change roughly coincides with the lithostratigraphic boundary between the Peremarton and Dunántúl Groups, when the previous predominantly pelitic sedimentation was succeeded by a balanced pelitic—psammitic depositions. The associated biotic changes unambiguously prove a significant and relatively rapid decrease in the salinity of the inland sea.

The still saline inland sea was essentially filled-up due to the increased rate of erosion. The brackish-water flora und fauna was followed by terrestrial flora and fauna. The distinction between these latter and the Pleistocene elements is therefore impossible. Furthermore, it is to be emphasized that the filling-up of the depression took place at different rates in different local basins.

For the stratigraphic subdivision of the marginal sequences mollusc, ostracods and planktonic microfossils are the best. In the inner parts of the basins the thick successions cannot be easily subdivided, because of the rarity of fossils due to greater water depths and unfavourable preservation conditions. The vertebrate, nannoplankton, foraminiferal, thecamoeban, diatom, spore and pollen remains and the ichnofossils often help the subdivision of some sequences, but general use is hampered by their limited occurrence. In areas of inner basins the Pannonian (s.l.) can be stratigraphically subdivided by means of well-logging markers, up-to-date seismic profiles and by lithological trend analysis.

Three important unconformities can be traced by seismic stratigraphic methods in the Pannonian formations.

1 The oldest is at the base of the Pannonian and it appears above basement highs which may consist of either pre-Neogene or older Miocene rocks. In the deep depressions (Makó trough, Dráva basin, Little Plain, Derecske trough, Jászság depression), however, the Sarmatian to Pannonian transition was characterized by uninterrupted sedimentation and the unconformity continues here with correlative conformity.

2 In association with the prograding delta system subaqueous redistribution of deposits occurred which led to local unconformities of rather different age.

3 The younger unconformity can be observed between the Pannonian (s.l.) and Pleistocene sediments above basement highs. This boundary is, however, conformable in the deep basin areas.

Seismic stratigraphy units can be usually well correlated with other stratigraphic or facies units seismic facies units. The seismic facies unit A corresponds to the basal and deep basin facies, B and C correspond to the prodelta (turbiditic series), D_1 corresponds to the prograding delta-front, E corresponds to the deltaplain and lagoonal-facies, while F corresponds to the fluvial—lacustrine and terrestrial facies. This is demonstrated in Fig. 9 by a seismic profile from eastern Hungary.

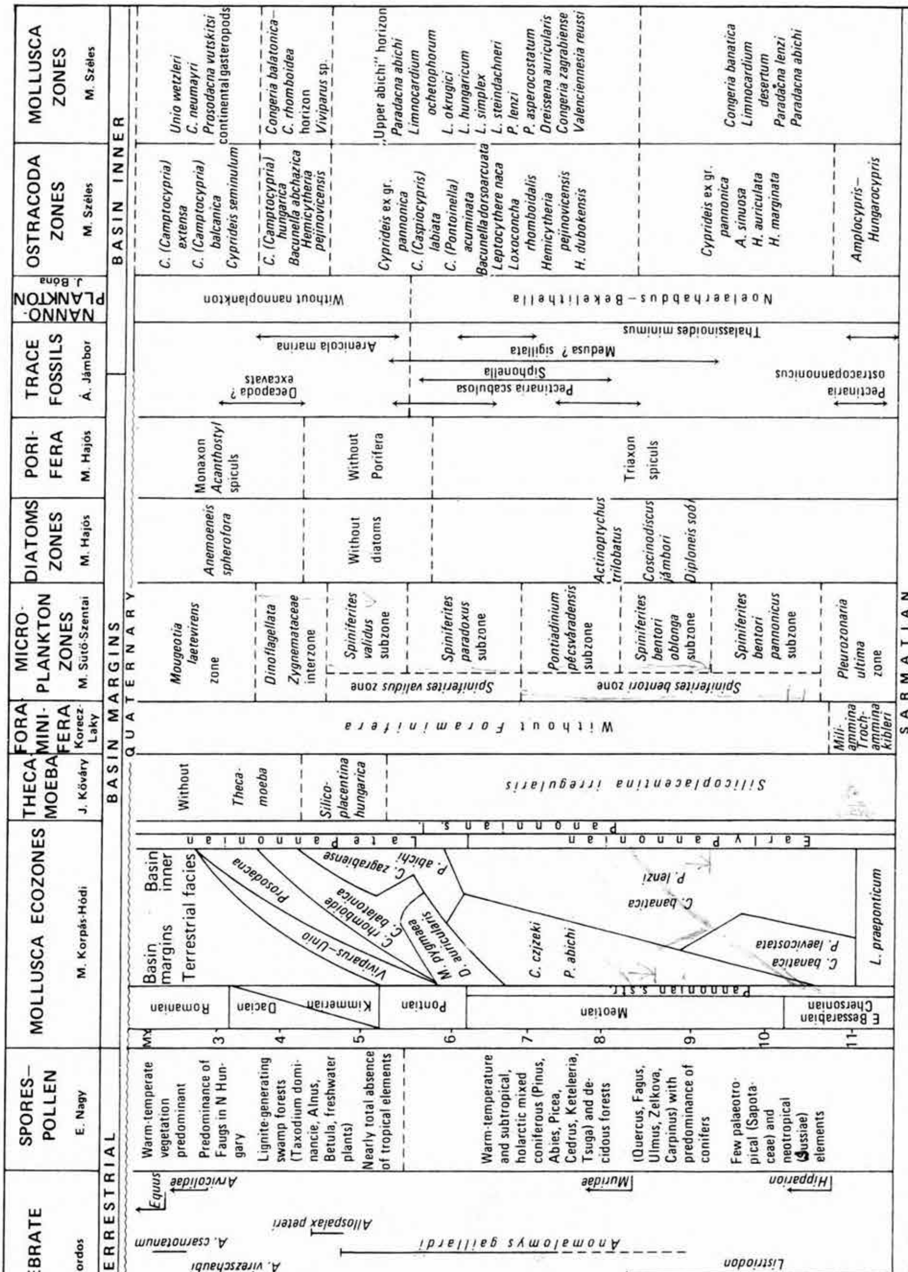


Fig. 8. Biostratigraphic subdivision of Pannonian sequences

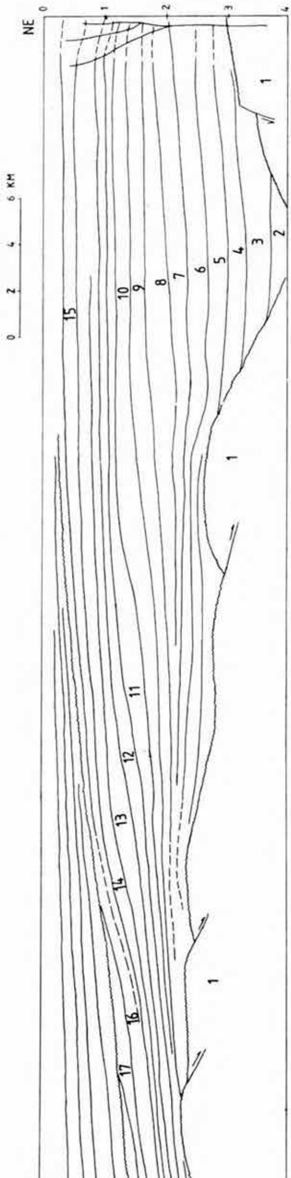


Fig. 9. Seismic profile parallel with the strike depression (after Z. BERKES, GY. POGÁCSÁS and B. SZANYI, 1983)

1 Neogene basement formations, *2—23* Neogene depositional (sub)sequences

The Pannonian (s.l.) formations are tectonically quiet or slightly disturbed. The most characteristic structural forms are compaction anticlines. The length of these anticlines is about 5—10 km, with maximum of 35 km. Their width is about 1—2 km with a maximum of 10 km. In the marginal areas of the anticlines there are often normal faults with a throw of about 5—10 m, rarely 50—100 m. According to the seismic profiles typical structures are listric faults due to differential compaction.

In the southern and northern parts of Mecsek mountain overthrusts can be observed which involve the layers of the Dunántúl Supergroup. The most important fault zone crossing the Pannonian formations can be traced for several tens of kilometers in west—southwest direction in eastern Hungary. Dominantly strike-slip movement took place along this fault zone. Folded structures are probably in southwestern Hungary, where the "Sava folds" extend to Hungary from Yugoslavia.

The Pannonian formations are one of the most important complexes of the country from the point of view of mineral exploration. 60% of the gas and oil fields can be found in this formation. The lignite, drinking- and thermal water resources are also important. From the non-metallic minerals the following are the most important: quartzite sand, bentonite, kaoline, diatomite and building materials (clay, sand, gravel).

E. BALÁZS, I. BÉRCZI, J. KŐVÁRY, A. NUSSZER and **Miss M. SZÉLES**
Hungarian Hydrocarbon Research
and Development Institute
SZÁZHALOMBATTA
H-2443. P.O.B. 32.
Hungary

K. BALOGH
Institute of Nuclear Physics
DEBRECEN
H-4026. Bem tér 18/c
Hungary

J. BÓNA and **Mrs. M. SÜTŐ-SZENTAI**
National Mineral Exploration
and Drilling Company
KOMLÓ
H-7300. Kossuth Lajos u. 1.
Hungary

I. GAJDOS, S. PAP and **Á. SZALAY**
Oil Exploration Company
SZOLNOK
H-5001. Munkásőr u. 43.
Hungary

J. GEIGER and **I. RÉVÉSZ**
Hungarian Hydrocarbon Research and
Development Institute, Algyő Base
SZEGED
H-6701. P.O.B. 30.
Hungary

F. HORVÁTH
Roland Eötvös University,
Department of Geophysics
BUDAPEST
H-1083. Kun Béla tér 2.
Hungary

Á. JÁMBOR, Mrs. M. HAJÓS, L. KORDOS, Miss A. KORECZ, Mrs. I. KORECZ-LAKY, Mrs. M. KORPÁS-HÓDI and **Mrs. E. NAGY**
Hungarian Geological Institute
BUDAPEST
H-1442. P.O.B. 106.
Hungary

L. MÉSZÁROS and **G. NÉMETH**
Oil and Gas Extraction Company
NAGYKANIZSA
H-8801. Szabadság tér 22.
Hungary

GY. POGÁCSÁS and **J. RUMPLER**
Geophysical Exploration Company
BUDAPEST
H-1068. Népköztársaság u. 59.
Hungary

K. SZENTGYÖRGYI
Hungarian Hydrocarbon Research
and Development Institute
SZOLNOK
H-5000. Munkásőr u. 43.
Hungary

L. VÖLGYI
National Oil and Gas Corporation
BUDAPEST
H-1502. P.O.B. 22.
Hungary