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COVER: Subtatra furrow: A distinct depression on the northern side of the Tatra Mts. looking from the Spišská Magura region. On the skyline a ridge of Belianske Tatry Mts. with conspicuous elevation points Ždiarska vidla (in the centre) - Havran (right). The ridge consists of Mesozoic complexes. Photo: Ján Halečka.

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New paleogeographic and tectonic interpretations in the Slovakian Carpathians and their implications for correlations with the Eastern Alps and other parts of the Western Tethys. Part II: Inner Western Carpathians

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Abstract

The Inner Western Carpathians are defined as the Cimmerian part of the Western Carpathians with complex Hercynian, Cimmerian and Alpine history. They comprise those Western Carpathian units that were originally situated south of the Veporicum: the Črmelicum (part of the substratum of the Hronicum, subdivided in Črmeľ, Dobšiná and Ochtiná nappes), the Hronicum (Choč Nappe s. l. and the newly introduced Opátka Nappe), the newly introduced Muránicum (Strážov, Nedzov, Muráň, Stratená nappes), the Silicicum (Silica Nappe s. l.), the North-Rudabányaicum (Rudabánya Nappe), the Meliaticum (with the sialic block of Gemericum) and the South-Rudabányaicum (Torna, Szőlősardó and Brusnik nappes). Črmelicum, Hronicum, Muránicum, Silicicum and North-Rudabányaicum are united to the Upper Slovakocarpathian Unit that was rooted between the Meliaticum and the Veporicum.

The Cimmerian and Alpine geological evolution of the Central and Inner Western Carpathians is related to the opening and closure of the Meliata, Szarvaskő, South Penninic and Pieniny oceans and to the related development on the slopes and shelves of these oceans. In the Upper Permian and in the Triassic, continental and later oceanic rifting in the Meliaticum controlled the geological evolution of the Inner Western Carpathians. In the Jurassic, the geological evolution of the Inner and Central Western Carpathians was controlled by the closure of the Meliata Ocean within the Inner Western Carpathians and the opening of the Penninic Ocean within the Central Western Carpathians. The Cretaceous geological development of the Inner and Central Western Carpathians is controlled by the southward directed subduction of the South Penninic Ocean, and to a smaller part by the southward directed subduction of the Pieniny Ocean north of the Central Western Carpathians as well as by the northwards directed subduction of the Szarvaskő Ocean south of the Inner Western Carpathians. Connected with the subduction of these four oceans, nappes were formed at different times. As three of these oceans were southwards subducted, the main thrust direction is northwards directed. Only in the southern part of the Inner Western Carpathians the nappe thrusting in mainly southward directed connected with the northward directed subduction of the Szarvaskő Ocean.

The Cimmerian orogeny was connected with low grade, partly blueschist metamorphism and northward directed nappe thrusting (e. g. South-Rudabányaicum on Meliaticum). It occurred only in the Inner Western Carpathians. It is related to the evolution of the Meliata-Hallstatt Ocean and its slopes and shelves. The Middle Triassic to Middle Jurassic development on the northern slope and shelves was distinctly different from the contemporaneous development on the southern slope and shelf of the Meliata-Hallstatt Ocean. In the Middle Jurassic, the southern margin of the Meliata-Hallstatt Ocean was the active margin (southwards directed subduction). During the middle Oxfordian collision, not only the Meliaticum accretionary complex, but also the former slopes and outer shelfes of the Meliata-Hallstatt Ocean were elevated. The northern inner shelf of the Meliaticum (Hronicum) was transformed into the shelf of the Penninic Ocean, and therefore the deep water development continued uninterrupted until the Lower Cretaceous.

During the Alpine orogeny in the Upper Cretaceous and Lower Tertiary, the northern units of the Inner Western Carpathians were northwards thrust over the Central Western Carpathians. These movements were related to the southwards subduction of the Penninic oceanic branches. The southern units of the Inner Western Carpathians were southwards thrust during the Upper Cretaceous, in connection with the northwards directed subduction of the Szarvaskõ Ocean. The nappe thrusting of the Central Western Carpathians was only related to the southwards directed subduction of the Penninic oceanic branches.

The Črmelicum can be correlated with the Veitsch Nappe of the eastern Grauwackenzone of the Eastern Alps. The Gemericum is very similar to the western Grauwackenzone and to parts of the Noric Nappe. The Črmelicum, Hronicum, Muránicum, Silicum, North-Rudabányaicum, Meliaticum and South-Rudabányaicum correspond to the Upper Austroalpine of the Northern Calcareous Alps.

The Meliata Ocean and its slopes and shelves were not the continuation of the Vardar Zone and of the Subpelagonicum because they have a totally different event succession. Basic volcanism in the Vardar Zone began in the Middle Carnian, after it had ended in the Meliaticum and the oceanic sea-floor spreading in the Vardar Zone was mainly of Jurassic age. The Meliaticum and its slopes and shelves were situated north of the Vardar Zone. Likewise, the Cimmerian Ocean in northern Turkey was situated north of the Vardar Ocean, the remnants of which can be found in the melanges of the Izmir-Ankara Zone. Parts of the Cimmerian Ocean in northern Turkey have the same event succession as the Meliata-Hallstatt Ocean. Consequently, the Meliata-Hallstatt Ocean is either the direct continuation of the Cimmerian Ocean in northern Turkey (across the Kotel Zone/Strandzha nappes and parts of the Transylvanian nappes) or it was an ocean in the same position as the Cimmerian Ocean (north of the Vardar Zone) that ended both in the west and in the east in continental realms.

Key words: Inner Western Carpathians, stratigraphy, paleogeography, Hercynian, Cimmerian and Alpine evolution, nappe formation, correlation within the Western Tethys

Preface

This second part of the paper was the last larger work that I could finish together with my best friend, the great Carpathian geologist and best specialist of the Inner Western Carpathians, RNDr. Rudolf Mock, CSc., who died in a tragical accident on August 22, 1996. Nearly all decisive new tectonic results in the Inner Western Carpathians during the last 25 years were connected with his name, e.g. the first discovery of Middle and Upper Triassic deep water rocks of the Meliata-Hallstatt Ocean in 1973 (this means the discovery of this ocean themselve that he named), and connected with this result the discovery of the allochthonous nature of the South Gemeric Triassic rocks (the Silica Nappe that he named as well), the first discovery of the Jurassic accretionary complex within the Meliaticum in 1985, the interpretation of the Gemericum as intra-oceanic continental block within the Meliata-Hallstatt Ocean and the discovery of Triassic-Jurassic oceanic sequences in the Folkmar Suture Zone that were before regarded as Werfen beds or continental Permian, both in 1995. Decisive important new results in other part of the Western Carpathians, as the discovery of pelagic Triassic in the exotic pebbles from the Andrusov Ridge are also connected with his name. Moreover, he did a tremendous work in the Western Carpathian Triassic, Jurassic and Paleozoic micropaleontology and stratigraphy.

The present paper was finished in autumn 1995 and revised in the spring 1996, the last time that we worked for a week together. We decided to wait with the publication, until I had finished my field work in the Küre Complex of northern Turkey, the last important unit for the correlation with the Meliata-Hallstatt Ocean that we had not yet studied, after several month joint studies in the Vardar Zone of Macedonia and its continuation in the Axios Zone of Greece and the Izmir-Ankara Belt of Turkey. We made also several weeks joint field work in the Subpelagonicum of Greece and I wanted to show him those areas in Turkey that I had studied before without him (Karaburun peninsula; Karakaya Complex, Izmir-Ankara Belt). Only the small part of the correlation of the Meliata-Hallstatt Ocean with the Cimmerian Ocean in northern Turkey I had to add to the paper together with a few notes to papers that were published in the summer and autumn 1996. All other parts of the paper remained unchanged, even the order of description to ensure that this paper corresponds perfectly to the intentions of my dear friend Rudi.

1. Introduction

The early Alpine (Cimmerian) evolution of the Inner Western Carpathians is related to the evolution of the Meliata-Hallstatt Ocean from its opening in the upper part of lower Anisian to its closing in the middle Oxfordian (Kozur, 1991a, b). During the Middle and Upper Triassic, the Inner Western Carpathians comprised the Meliata-Hallstatt Ocean and its northern and southern slopes and shelves. During this time, the geologic evolution of the Inner Western Carpathians was controlled only by the evolution of the Meliata-Hallstatt Ocean and the interacting evolution at its slopes and shelves. During the Jurassic until the lower Oxfordian, the northern part of the Inner Western Carpathians was part of a sialic block between the closing Meliata-Hallstatt Ocean in the south and the opening South Penninic Ocean in the north and therefore influenced by the evolution of both oceans. After the closure of the Meliata-Hallstatt Ocean, the Inner Western Carpathians were part of a sialic block between the Szarvaskő Ocean in the south and the Penninic Ocean in the north, and their further evolution (e. g. nappe thrusting) was mainly related to the southward directed subduction of the South Penninic Ocean, but in the southern units also to the northwards directed subduction of the Szarvaskő Ocean.

The Inner Western Carpathians had a complex Hercynian, Cimmerian and Alpine history. In this complicated tectonic situation the knowledge of exactly dated stratigraphic successions in compared tectonic units is the most important base for any paleogeographic reconstruction within the Western Carpathians and Eastern Alps and for mutual correlations of both areas. Already the first evidence of the Meliata-Hallstatt Ocean in the Western Carpathians was based on paleontological dating of the Triassic part of the oceanic sequence by Kozur and Mock (1973a, b). Until this time, these rocks and the by far wider distributed, but before Kozur and Mock (1985) undated, Jurassic turbidites of the Meliaticum were regarded as the Upper Permian to lowermost Triassic base of the assumed autochthonous or parautochthonous Gemeric Triassic (Bystrický, 1964, 1973). Consequently, the discovery of the Triassic-Jurassic oceanic sequence of the Meliaticum led to a entirely new interpretation of the Inner Western Carpathians and their connection to other oceans (e. g. Kozur and Mock, 1973a, b, 1985, 1987, 1988; Horváth et al., 1977; Channell et al., 1979; Mock, 1980; Dumitrică and Mello, 1982; Hovorka et al., 1984; Kovács, 1982; Mahel', 1986; Kozur, 1989b, 1990a, b, 1991a, b; Vozárová and Vozár, 1992). Remnants of the Triassic-Jurassic sequence of the Meliaticum were recognized also in the Eastern Alps during the last years and initiated also there new geologic interpretations (Kozur, 1989b, 1991a, b; Mandl and Ondrejičková, 1991, 1993; Kozur and Mostler, 1992; Mandl, 1992; Gawlick, 1993a, b; Neubauer, 1994). These investigations have shown that in the Western Carpathians and the eastern part of Eastern Alps a very similar early Mesozoic evolution of the Meliata-Hallstatt Ocean, its slopes and shelves occurred, which explains many geological facts, such as the presence of chromian spinel in the Lower Cretaceous Roßfeld Beds of Northern Calcareous Alps transported from the south (Faupl and Pober, 1991). Also the presence of a Central Alpine Ridge south of the Upper Austroalpine (Brandner, 1984; Krainer, 1984; Channell et al., 1990; Leiss, 1992 and in a different model Brandner and Sperling, 1995) could be confirmed.

However, several new data in the Paleozoic and Mesozoic are inconsistent with previous paleogeographic and tectonic models of both Eastern Alps and Western

Carpathians and above all with previous correlations between the tectonic units of these two areas.

The main problems resulted from incorrect stratigraphic datings or unknown ages of units both in the Western Carpathians and in the Eastern Alps. Until recently, stratigraphic misinterpretations hindered not only the reconstruction of the tectonic evolution in a single tectonic unit, but also large scale correlations between the Western Carpathians and Eastern Alps. Very much stratigraphic misinterpretations (and in this connection wrong interpretations of the tectonofacies and tectonic evolution) occurred in the Middle Jurassic accretionary complexes of the Meliaticum. For instance, these beds have been for long time dated as Early Paleozoic at the Florianikogel in the Eastern Alps or as Scythian shallow-water Werfen facies in the neighbouring Edenhof section. Mandl and Ondrejičková (1991) recognized that these sequences belong to the Meliaticum, but assigned them to the oceanic Triassic succession (related to sea-floor spreading in the Meliaticum). Kozur and Mostler (1992) and Mandl and Ondrejičková (1993) proved that this sequence consists of Middle Jurassic turbidites with blocks of Triassic rocks of the oceanic and pre-rift sequence, in the Florianikogel section overlain by a coarsening upward sequence. The considerable consequences for the tectonic interpretation of this segment of the Eastern Alps, but also for the correlation with the Western Carpathians were discussed by Kozur and Mostler (1992).

Similar stratigraphic misinterpretations occurred also in the Inner Western Carpathians. For a long time, blocks of Middle Triassic ultramafic and mafic rocks (dismembered ophiolites of the oceanic Meliaticum) within evaporitic melanges with Permian evaporites at the base of higher nappes have been regarded as Permian rocks. Even long time after the discovery of the Triassic age of these rocks by Kozur and Mock (1973a, b) and Mock (1980) some Hungarian authors placed these rocks still into the Permian. Characteristic for papers of Kovács and Kovács and co-authors is that Kovács (1984) "proved" the Permian age of the ultramafic rocks and pillow lavas by the statement that these ultramafics and basic volcanics are intercalations within the Permian evaporites and "not associated with younger formations (not even tectonically)" in the Tornakápolna borehole despite of the fact that they are in this borehole and in other occurrences clearly tectonically juxtaposed to Upper Permian hypersalinar rocks of the overlying nappe. Kozur and Réti (1986) found lower Ladinian radiolarians in a sedimentary intercalation of the pillow lavas of the dismembered ophiolites in that borehole.

The Triassic age of oceanic remnants of the Meliaticum proven by Kozur and Mock (1973a, b) was surprisingly fast overtaken in new tectonic models not only in Slovakia, but also abroad (e. g. Horváth et al., 1977; Channell et al., 1979). This was largely caused by the great influence of the late Prof. D. Andrusov, who enthusiastically supported the new results and by the propagation of these results by the late RNDr. R. Mock CSc. However, after the discovery of the Middle Jurassic age and turbidite-olistostrome character of most of the rocks in the Meliata type locality by Kozur and Mock (1985), after the discovery that the "Ladinian-Carnian" Darnó "Formation" sensu Haas and Kovács (1985) are Middle Jurassic turbidites, olistostromes and melanges of a Middle Jurassic accretionary complex (Kozur and Mock, 1988; Kozur, 1991a, b), and after the interpretation of the entire Meliaticum as the Middle Jurassic accretionary complex of the southwards subducting Meliata Ocean (Kozur, 1991a, b) consisting mainly of Bathonian-Callovian turbidites and olistostromes (in which the oceanic Triassic rocks are blocks of different size), these decisive important results for the age and interpretations of the geological evolution of the Meliata-Hallstatt Ocean were not accepted in Hungary and polemically rejected by Kovács and other Hungarian geologists. Even the fact that Kozur (1991b) figured two plates of excellently preserved radiolarians from Middle Jurassic turbidites of the Darnó-hegy Middle Jurassic accretionary complex and the same Middle Jurassic turbidites of the Meliaticum accretionary complex were found by Kozur and Mostler (1992) from the southeastern part of the Northern Calcareous Alps, did not change the view of Kovács that the Meliaticum is a Triassic complex as his "Ladinian-Carnian" Darnó "Formation" (Haas and Kovács, 1985) from the quite obvious, and paleontologically well dated Middle Jurassic Darnó-hegy accretionary complex.

In the contrast, Kovács (1993) tried to declare any Middle Jurassic flysch as a non-Alpine development to demonstrate that it is impossible that Middle Jurassic flysch occurs in any part of the Tethys and to demonstrate that the Meliaticum (as Triassic unit !) can not be correlated with the "non-Alpine" Kotel Zone. Thus, Kovács (1993) pointed out that correlations of the Meliaticum and its shelves with the Kotel Zone (e. g. by Tollmann, 1988; Kozur and Mock, 1987, 1988; Kozur, 1991a, b) are an "absurdity", because in the Kotel Zone a Middle Jurassic flysch (turbidites) is present, the Triassic occurs not in situ, but in blocks within this Middle Jurassic turbidites, a correlation of the Meliaticum with the Transylvanian nappes is not possible because in the Meliaticum the oceanic crust has a Triassic age, but in the Transylvanian nappes Kimmeridgian pelagic sediments overlay pillow lavas, and (in the present day distribution !) continental crust lies between the Meliaticum of Western Carpathians and the Kotel Zone.

The latter fact must not be discussed, because in the present day distribution the remnants of oceanic Meliaticum of the Western Carpathians are separated by continental crust from all adjacent occurrences of oceanic crust, even from those of the Meliaticum of the Eastern Alps in direct and undisputed prolongation of the Meliaticum of the Western Carpathians.

The exclusion of a correlation of the Meliaticum with the Transylvanian nappes because of the occurrence of Kimmeridgian pelagic sediments on oceanic crust is very curious, because also Kovács correlated in all his reconstructions the Meliata-Hallstatt Ocean with an oceanic realm represented by a part of the Transylvanian nappes (for the last time by Haas and Kovács in Haas et al., 1995). The Transylvanian nappes, which are reconstructed from rather small nappe bodies, overthrust slices and from olistoliths in the Bucovinian Cretaceous wildflysch, contain different units. The Triassic is present in form of olistoliths and overthrust slices, and the Middle Jurassic is only known in form of olistoliths. Under this circumstances, it is not definitely to prove, which Upper Jurassic sequence (pelagic and shallow water rocks are known) belong to which Triassic sequence. Those pelagic Kimmeridgian sequences that follow above basalts are probably not the cover of the Triassic oceanic sequences of Meliaticum type. The history of the Transylvanian nappes remembers very much to that of the Pontides, where both Cimmerian oceanic branches are present that closed during the Middle Jurassic and basins that opened during the Jurassic and closed during the Cretaceous. May be that this development reaches toward the west until the Eastern Carpathians.

According to Kovács (1993), Middle Jurassic flysch (turbidites) is a development that excludes the Kotel Zone from Alpidic Triassic and Jurassic that is according to this author more or less identical from the Alps until China (sic !). Therefore he regarded the development of the Kotel Zone as "non-Alpine", despite the fact that nearly 10 years before Sengör (1984, 1985) had demonstrated in his splendid papers the Middle Jurassic final closure of the Paleotethys (Cimmerian Ocean) from the Strandzha nappes and Kotel Zone through the Cimmerian part of the Pontides until China, Kozur (1991a, b) had shown that the Meliaticum is the Middle Jurassic accretionary complex of the southwards subducted Meliata-Halstatt Ocean, and the presence of Middle Jurassic turbidites of the Meliaticum in the Eastern Alps was demonstrated by Kozur and Mostler (1992). Only in the last years, the resistance of some Hungarian authors against an interpretation of the Meliaticum (including the Darnó Complex) as Middle Jurassic accretionary complex seemingly came to an end, after the Jurassic age of the Meliaticum accretionary complex was independently confirmed by different authors not only in the Western Carpathians (e. g. Ondrejičková in Vozárová and Vozár (1992), but also in the Eastern Alps (e. g. Mandl and Ondrejičková, 1993). A clear sign for this change in mind can be found by Trunkó (1996), who wrote: "Kovács and Csontos (both pers. comm., 1994) consider the Darnó Series as a typical accretionary wedge of Jurassic age". Already Kozur and Mock (1988) had rejected the view of Haas and Kovács (1985) that there is a "Ladinian-Carnian" Darnó "Formation", and they recognized that the Triassic oceanic rocks are blocks in a Middle Jurassic accretionary complex (Middle Jurassic turbidites, olistostromes and melanges). As the latter view was rejected by Kovács who continued to regard these rocks as the "Ladinian-Carnian" Darnó "Formation", Kozur (1991b) demonstrated by two plates with Middle Jurassic radiolarians that these rocks were neither a stratigraphic formation nor of Ladinian-Carnian age, but a Middle Jurassic subduction-related accretionary complex.

The presence of Middle Jurassic turbidites of the Meliaticum accretionary complex with blocks of deep water, partly oceanic Triassic is the most characteristic tectonofacies for the Early Mesozoic oceanic development in the Inner Western Carpathians (and eastern part of Eastern Alps). Thus, the presence of this facies (which is unknown from the Vardar Zone and southwards adjacent oceans) in the Kotel Zone is an excellent evidence for the continuation of the Meliaticum and its shelf development into this area and does not exclude such a correlation as assumed by Kovács (1993) connected with repeated polemic against this correlation.

The large extent of Middle Jurassic deep-sea sediments in the Meliaticum and South-Rudabányaicum of the Western Carpathian was not recognized for a long time, because these mostly slightly metamorphic beds were often assigned to Scythian shallow marine Werfen Beds (as in the Eastern Alps !) or to a continental Permian succession without reliable paleontological evidence. Partly these rocks were assigned to the Early Paleozoic, as the Jurassic Meliaticum of the Brusník anticline, the Jurassic age of which was only proven by Ondrejičková in Vozárová and Vozár (1992). These stratigraphic misinterpretations were both in the Inner Western Carpathians and in the Eastern Alps partly supported by unreliable palynologic data, e. g. a palynologically "proven" Devonian age for Middle Jurassic turbidites of the Florianikogel, Austria, which were in that time regarded as Paleozoic sediments of the Grauwackenzone (Klaus, in Plöchinger, 1967).

New stratigraphic data and facies analysis from different units of the Inner Western Carpathians have shown that the paleogeographic situation and tectonic evolution is more complicated than formerly assumed. For instance, the Gemericum was a sialic block within the Meliata-Hallstatt Ocean, and perhaps two subduction zones are present in the meridian of the Gemericum that were possible active to different times with subduction in opposite directions. On the other hand, the separation of the Črmelicum from the Gemericum by the discovery of a northern Meliaticum suture zone allows an easy correlation of the Črmelicum with the eastern Grauwackenzone of the Eastern Alps (Veitsch Nappe), and also the separation of the South-Rudabányaicum Geyerstein Nappe (Kozur and Mostler, 1992) from the Hallstatt development allows a good correlation of this nappe with the South-Rudabányaicum of the Inner Western Carpathians (Kozur and Mostler, 1992).

Consequently, new models for correlation of Western Carpathian and East Alpine units require reconsiderations of correlations within the Western Carpathians and within the Eastern Alps. Moreover, new stratigraphic data have documented that units of similar stratigraphic content, lithologic successions and tectonic positions, so far unknown from the Eastern Alps or Western Carpathians, are present in these areas (e. g. Jurassic turbidites of the Meliaticum in the Eastern Alps, South Penninic units in the Western Carpathians) and are important for correlations between tectonic units of both mountain ranges.

In the present second part of the paper an overview about the Inner Western Carpathian units and their correlation with the Eastern Alps and other parts of the Western Tethys is given, the Early Mesozoic tectonic evolution of the Central and Inner Western Carpathians is shown and the age of the nappe thrusting in the Western Carpathians and its relation to the subduction of different oceans is discussed.

2. Definition and boundaries of the Inner Western Carpathians

The Inner Western Carpathians were used originally for the entire Western Carpathians south of the Pieniny Klippen Belt (e. g. Mahel' et al., 1968; Mahel', 1974) or they were included into the Central Western Carpathians of the same large scope (e. g. Andrusov, 1968). Kozur (1979) restricted the Inner Western Carpathians to those Western Carpathian units that originate south of the Veporicum. In this restricted scope, the Inner Western Carpathians correspond to the Cimmerides within the Western Carpathians. The Cimmerian orogeny in the Middle Jurassic to lower Oxfordian was in parts of the Inner Western Carpathians connected with a low grade, partly blueschist metamorphism, and a first, northwards directed nappe thrusting occured in that time.

But the Inner Western Carpathians had also a distinct Hercynian history with a widespread basic volcanism, partly also incomplete ophiolite sequences (Grecula, 1982), granites, mainly low grade to very low grade, rarely medium to high grade metamorphism, folding and fold nappes with low thrust distances.

The distinct Alpine overprint was in the northern units of the Inner Western Carpathians related to the Upper Cretaceous to Lower Tertiary southward directed subduction of the Penninic oceanic branches below the Veporicum and Tatricum that caused the northwards thrust of the northern superficial (Permo-Mesozoic) nappes of the Inner Western Carpathians. These nappes of Inner Western Carpathian origin overthrust during the Upper Cretaceous the entire Central Western Carpathians and form the highest nappe units above Veporic, Fatric and Tatric substratum. Pre-Permian Paleozoic units of the Inner Western Carpathians overthrust only the southern parts of the Veporicum. The Alpine southwards thrust of the southern superficial nappes of the Inner Western Carpathians is related to the Cretaceous northwards directed subduction of the Sarvaskö Ocean (that was perhaps connected with the Vardar Zone). This caused, e. g., the southwards thrust of the Silica Nappe over the Meliaticum and South-Rudabányaicum.

The separation of the Inner Western Carpathians from the Central Western Carpathians (dominantly medium to high grade metamorphic Hercynian basement, no Cimmerian orogeny, strong Alpine tectonics) is very easy and not disputed. The separation from the southwards adjacent units is disputed. A natural boundary is the southern boundary of the Cimmerian orogeny related to the opening and closing of the Cimmerian Meliata-Hallstatt Ocean. Taking this southern boundary of the Inner Western Carpathians, the southern slope and shelf of the Meliata-Hallstatt Ocean can be regarded as the southernmost Inner Western Carpathians. Using this southern boundary of the Inner Western Carpathians, the following units belong to this domain: Črmelicum, Meliaticum with the intra-oceanic sialic block of the Gemericum, as well as slopes and shelves of the Meliaticum (Hronicum, Muránicum, Silicicum, North-Rudabányaicum, South-Rudabányaicum).

Kovács (Fig. 1 in Kovács et al., 1989) assigned nearly the entire Inner Western Carpathians (except the Hronicum and parts of the Muránicum) as "Gemer Subunit" to the "Pelso Unit". However, this is not only inconsistent with the priority of the Inner Western Carpathians against the Pelso Unit, but a boundary Pelso Unit-Western Carpathians between the Silicum and Muránicum or inside the Muránicum does not show any understanding of the Western Carpathian geology or the Tethyan geology at all. This boundary applied for the Eastern Alps would leave only the Bajuvaricum and parts of the Tirolicum within the Upper Austroalpine, but parts of the Tirolicum, the entire Juvavicum, Meliaticum, the Geyerstein Nappe (South-Rudabányaicum) and the Grauwackenzone would belong to the Pelso Unit or an equivalent unit. To place a major boundary between two Superunits between the Juvavicum and Tirolicum or inside the Tirolicum would be the same nonsense then to place this boundary between the Silicicum and Muránicum or inside the Muránicum. Moreover, a "Gemer Subunit" is a step back to the time as the Silica, Bôrka, Radzim, Opátka and Stratená nappes were regarded as the parautochthonous cover of the Gemericum, the Brusník Meliaticum (Jurassic) as Gelnica Unit of the Gemericum and the Črmelicum as part of the Gemericum. Only in this view, partly outdated since more than 20 years, in a fixistic sense a "Gemer Subunit" of the "Pelso Unit" would exist. But it is known since more than 20 years that the "Gemer Subunit" is neither a unit nor a subunit, but comprises several nappes that belong to different units with different Hercynian, Cimmerian and Alpine history. The boundary between these two superunits sensu Kovács was overtaken in all newer Hungarian publications, even in international journals (e. g. Haas et al., 1995, Figs. 1, 2).

The Hercynian history of the "Bükkium" is very different from that of the Inner Western Carpathians, a Cimmerian orogeny is missing and a "Neotethyan" Jurassic-Cretaceous history can be observed (related to the evolution of the Jurassic Szarvaskő Ocean that closed in pre-Gosauan time within the Cretaceous). This totally different development of the "Bükkium" and the Inner Western Carpathians excludes the "Bükkium" from the Inner Western Carpathians, even if it was originally adjacent, and the Szarvaskő Ocean would be the back-arc basin of the southward subducted Meliata-Hallstatt Ocean.

Problematic is the position of the Szendrő and Uppony Paleozoic in northern Hungary as no Triassic-Jurassic cover of these rather southern type Devonian to Middle Carboniferous sequences are known. An Inner Western Carpathian character of these units is the northwest vergency (that may be, of course, also of Hercynian age), whereas southward adjacent units (e. g. Fennsíkum of the Bükk

Mts.) have a south-vergent character. Moreover, the Brusník Middle Carboniferous is a flysch, like in the Szendrő and Uppony Mts. This Paleozoic, in turn, is overlain by a very low grade metamorphic Permo-Triassic sequence of South-Rudabányaicum character except that the Permian is continental and has no evaporitic horizon. There are three possible explanations for the similarity of the Bashkirian rocks of the Brusník Nappe and of the Uppony-Szendrő Mts. (Éleskő Nappe sensu Kozur and Mock, 1987, 1988): (1) The Brusník Nappe had an original position south of the Torna Nappe and belong to the Szendrő-Uppony Unit. In this case the Brusník Nappe would be the only unit of the Uppony-Szendrő Paleozoic, in which the Permian-Triassic cover is preserved. In this hypothesis, the Uppony-Szendrő Paleozoic would belong to the Inner Western Carpathians, because the Triassic of the Brusník Nappe clearly indicate that it belongs to the southern shelf of Cimmerian Meliata-Hallstatt Ocean. (2) The Brusník Nappe had the same original position as the Torna Nappe, but in the contrast to the latter nappe, parts of the Paleozoic basement were preserved. We think that this possibily is the least probable explanation because the Upper Permian of the Torna Nappe is evaporitic (hypersaline marine), whereas the Permian of the Brusník Nappe consists of continental Red Beds. (3) The Brusník Nappe is a unit that was originally situated between the deposition area of the Torna Nappe and that of the Uppony-Szendrő Unit. We favour this last explanation and assign the Brusník Nappe to the southernmost Inner Western Carpathians belonging during the Cimmerian evolution to the (inner) southern shelf of the Meliata-Hallstatt Ocean and in the Lower and Middle Jurassic to the common shelf of the Meliata-Hallstatt and Szarvaskő oceans. In the two latter cases, the assignment of the Uppony-Szendrő Paleozoic is an open question. It may belong to the southern marginal parts of the Inner Western Carpathians, but it may also belong to the unit south of the Inner Western Carpathians. In favour of the latter possibility speaks that the Fennsíkum of the Bükk Mts. begins stratigraphically just above the youngest Carboniferous beds of the Uppony Mts. As both the youngest known beds of the Uppony Mts. and the oldest known beds of the Bükk Mountains are a Middle Carboniferous flysch, the Uppony Paleozoic and the Paleozoic of the Fennsíkum of the Bükk Mts. may be closely related to each other (Kozur and Mock, 1987, 1988). In that case, the Uppony and Szendrő Paleozoic would belong to the same unit as the Middle Carboniferous to Mesozoic sequences of the Bükk Mts. and therefore situated originally south of the Inner Western Carpathians. As the Permo-Mesozoic cover of the Uppony and Szendrő Mts. is unknown, this question cannot be decided.

For the moment, the Brusník Nappe and other nappes of the South-Rudabányaicum are regarded as the southernmost units of the Inner Western Carpathians. Its Triassic-Jurassic development, so far known, is clearly a southern slope to shelf development of the Cimmerian Meliata-Hallstatt Ocean and belongs therefore undoubtedly to the Inner Western Carpathian development.

3. Tectonic units of the Inner Western Carpathians

The subdivision of the Western Carpathians in large tectonic units is well established since many years (e. g. Maheľ et al., 1968; Andrusov, 1968). However, since the discovery of remnants of the Middle Triassic to Early Oxfordian Meliata-Hallstatt Ocean by Kozur and Mock (1973a, b), and the discovery of the Hercynian nappe structure of the Gemericum by Grecula (1982) considerable changes of the previous models were necessary for the Inner Western Carpathians that were originally situated south of the Veporicum (e. g. Kozur and Mock, 1973a, b, 1979, 1987, 1988; Kozur, 1979, 1991a, b, and in press a, Grecula, 1982; Vozárová and Vozár, 1992).

As the Inner Western Carpathians are regarded as a genetic unit (see chapter 2), they are not only restricted to Western Carpathian units that are today situated south of the Margecany-Lubeník Line (as southern surface margin of the Veporicum), but also the detached Permo-Mesozoic or Mesozoic superficial nappes of Inner Western Carpathian origin (Hronicum and Muránicum) are assigned to the Inner Western Carpathians despite of the fact that they form now mostly the highest nappe units above the Central Western Carpathian Veporic, Fatric and Tatric substratum. The below described units are Inner Western Carpathian units known from Slovakia.

Črmelicum

According to the prevailing view, the Gemericum of the Inner Western Carpathians overthrust the Veporicum along the Margecany-Lubeník Line. However, Kozur and Mock (1995) proved that between the Margecany-Lubeník Line and the Folkmar Suture Zone sensu Kozur and Mock (north of the Gemericum s. str.) an independent tectonic unit occurs that crops out as a narrow band of mainly Carboniferous rocks (Fig. 1). It was named as Črmelicum (after the Črmeľ Nappe, Grecula, 1982). The Črmelicum continues far west of the Gemericum, always in the same tectonic position between Veporicum in the north, which underthrust the Črmelicum, and Meliaticum in the south that is underthrust by the Črmelicum. In its metamorphic degree, lithologic content, Permo-Triassic envelope and in its stratigraphic content, the Črmelicum is fundamentally different from the Gemericum, from which it is separated by a slice of Meliaticum Middle Jurassic deep water sediments with blocks of Triassic rocks (ultrabasites, pillow lavas, red radiolarites, crystalline limestones).

The Črmelicum is part of the Paleozoic base of the Inner West Carpathian superficial nappes. As already shown by Kozur et al. (1976) and Neubauer and Vozárová (1990), the Črmelicum is very similar to the eastern Grauwackenzone of the Eastern Alps (Veitsch Nappe) and also its tectonic position is the same (northernmost basement unit of the Inner Western Carpathians and of the Upper Austroalpine, immediately adjacent to the Veporicum and Middle Austroalpine respectively). It is therefore an important unit for the correlation with the Eastern Alps (see chapter 6.).

Three nappes were discriminated within the Črmelicum, the Črmeľ, Ochtiná and Dobšiná nappes (Fig. 1). According to Grecula (1982, 1994a, b), the Črmeľ Nappe and therefore the Črmelicum is a Hercynian nappe structure. However, the Ochtiná Nappe lies upon the metamorphic Mesozoic envelope of the Veporicum near Lučenec, thus indicating an Alpine nappe thrusting of the Ochtiná Nappe, and therefore of the entire Črmelicum, upon the Veporicum. Already Neubauer and Vozárová (1990) recognized that the Carboniferous sequence of the Ochtiná Nappe lies in a nappe position upon the deformed Permo-Mesozoic envelope series of the Veporic crystalline complexes, but they did not name this nappe and assigned them, as all previous authors, to the Gemericum, from which it is separated by the oceanic Triassic-Jurassic complex of the Meliaticum.

In the following, the lithologic successions of the three nappes will be briefly described, partly without referring to different formation names established for these sequences. The relations between these formations are often hypothetical, and published stratigraphic successions of units that occur in different regions or are juxtaposed tectonically to each other, may yield a wrong base for paleogeographic reconstructions. For instance, the Dúbrava Beds have been assigned by Neubauer and Vozárová (1990) to the upper Bashkirian and lower Moscovian, and are according to these authors stratigraphically overlain by the upper Moscovian Hámor Formation. However, the Dúbrava Beds yielded Middle Triassic conodonts (see below).

The most complete and best dated succession of the Črmelicum is known from the Ochtiná Nappe. This nappe begins north of the westernmost Gemericum and continues as a narrow band between Meliaticum in the south and Veporicum in the north over a distance of about 45 km west of the Gemericum. The sequence of the Ochtiná Nappe was assigned to the Carboniferous Ochtiná Formation with unknown basement. The lower Ochtiná Fm. begins with metaconglomerates, metasandstones and phyllite intercalations overlain by phyllites, alternating with fine-grained sandstones and intercalations of basalts and basic volcaniclastics. Minor bodies of magnesites and ultrabasites sporadically occur. This predominantly clastic unit contains quartz, feldspar, scarce clastic mica and clasts of dark pyllites, metasandstones, lydites and scarce granites. Tournaisian-Viséan age is assumed by palynologic data (Bajaník and Planderová, 1985; Planderová, 1982). The upper Ochtiná Fm. consists of bedded dolomites (originally bedded, fossiliferous shallow-water limestones), usually metasomatically altered into magnesite, and black, graphitic shales. A latest Viséan-Serpukhovian age is proven by conodonts (Kozur et al., 1976).

Dated younger beds in stratigraphic succession are unknown above the Ochtiná Fm. According to Neubauer and Vozárová (1990), a Bashkirian to Moscovian succession of Rudňany Formation (assumed middle Bashkirian age) →Dúbrava Beds (assumed late Bashkirian-early Moscovian age)→Hámor Formation (assumed late Moscovian age) follows after a short early Bashkiran stratigraphic gap above the Ochtiná Fm.. However, the Dúbrava Beds belong to the Mesozoic envelope series of the Gemericum, partly to a slope succession from the Gemeric slope of the Meliaticum. *Paragondolella excelsa* Mosher from the Dúbrava Beds indicate a late Illyrian-early Fassanian age of a part of the Dúbrava Beds that exclude the above mentioned assumed succession.

The **Črmeľ Nappe** NE of the Gemericum was introduced by Grecula (1982) as a Hercynian nappe of the Gemericum. However, it is separated from the Gemericum by tectonic slices of melanges (Fig. 1), containing Meliaticum Middle Jurassic grey, black and green deep-sea shales and marly shales with blocks of Middle to Upper Triassic rocks (ultrabasites, basic tuffs, agglomerates, pillow lavas, red ribbon cherts, crystalline limestones). Moreover, a Permian to Lower Triassic envelope series is known involved in the nappe structure.

The Črmeľ Nappe consists of low-grade metamorphic rocks of the Črmeľ Group (Neubauer and Vozárová, 1990). The lower Črmeľ Group consists of metasandstones alternating with phyllites, and sporadic acidic volcaniclastics. The main part of the Črmeľ Group is formed by cyclical fine-grained metasediments associated with basic volcanics and volcaniclastics. In the upper part of the Črmeľ Group lenses of carbonates (partly altered to magnesites) and occasionally lydites are present. Near the top of the complex the sediments became coarser again. So far, the Črmeľ Group is only palynologically dated as Tournaisian-Viséan (Bajaník, Vozárová and Snopková, 1986). It corresponds therefore to the lower part of the Ochtiná Fm.

Permian and Lower Triassic rocks of the Črmelicum are above all exposed SE of Košická Belá to NW of Košice and west of Kurtavá skala to east of Krompachy. The mapped Permian and Triassic between these two occurrences (Bajaník et al., 1984) are often Middle Jurassic deep-water shales and blocks of oceanic and shallow-water pre-rift Triassic (see under Meliaticum). The Permian consists of continental brownish, violet and greenish-grey sediments (conglomerates, sandstones, siltstones, shales). Acidic volcanics also occur. An unique facies with thin-bedded cherts is also present. So far, continental Permian bedded cherts were only known from the Tregiovo Beds of Southern Alps. No hypersaline marine Upper Permian rocks are present, and continental Alpine Buntsandstein (fluviatile sandstones, siltstones, conglomerates) follows immediately above continental Permian (well exposed in temporary exposures east of Krompachy). As in the Alps, Hungary and in the Germanic Basin, an abrupt climatic change to more wet conditions is indicated by sedimentologic changes in the continental beds near the P/T boundary. Detailed investigations in these areas have shown that this climatic changes occurred in the late Dorashamian (= late Changxingian) (Kozur, 1989a, 1994b). The continental Alpine Buntsandstein is overlain by shallow-marine sandstones, siltstones, shales and by Werfen Beds.

The absence of hypersaline marine Upper Permian in the envelope of the Črmelicum indicates its rather northern position within the Paleozoic basement of the Inner Western Carpathian nappes.

In this connection, a nappe (named herein as Opátka Nappe after the village Opátka) with very low-grade metamorphic Middle Triassic to Middle Carnian rocks has to be discussed, which lies somewhat south of the Črmeľ Nappe above Gemeric basement (Fig. 1, O). This nappe was formerly regarded as part of the Stratená Nappe (Bajaník et al., 1984), but both the slight metamorphism and the lithologic succession distinguish the Opátka Nappe from the Stratená Nappe. The decollement plane at the base of the Middle Triassic of the Opátka Nappe suggests absence of Upper Permian hypersaline rocks (the usual decollement level for the southern nappes) indicating a northern position within the Inner Western Carpathians nappe pile. The sequence of the Opátka Nappe consists of dark dolomites, limestones, cherty limestones, Wetterstein Limestones and middle Carnian Reingraben Shales with *Halobia*. The absence of hypersaline Upper Permian beds in the Črmeľ Nappe and the presence of Lunz Beds are northern features in the northern shelf of the Meliaticum, typical for the Hronicum. For this reason it is possible that the Permo-Scythian of the Črmeľ Nappe is the original base of the Opátka Nappe. The presence of both cherty limestones and Wetterstein Limestones in the Ladinian-Cordevolian suggest a southern position within the Hronicum.

Németh (1996) found low grade metamorphic Permian and tectonically reduced Triassic beds between the Gemericum and the Opátka Nappe. He assigned these beds to the Bôrka Nappe comparing them with rocks in the Radzim area that we assign to the Radzim Nappe, which is of the same origin as the Bôrka Nappe (see below). As the tectonically reduced nappe slice of the Meliaticum has no blueschist facies, we assign these beds rather to the Meliaticum as it occurs in the Folkmar Suture Zone (see below). It does not contain Upper Permian evaporites as the Permian cover series of the Gemericum. Thus, it contains the northern slope facies of the Gemericum at the margin of the northern branch of the Meliaticum (see below).

The Dobšiná Nappe north of the Gemericum (Fig. 1) is tectonically most complicated and the various sequences in different parts of the nappe are not found in succession as shown by Neubauer and Vozárová (1990), but are tectonically separated. The Dobšiná Nappe is the only nappe of the Črmelicum, in which medium to high-grade metamorphic basement (gneisses, amphibolites) are present. These rocks are mostly tectonically separated from the

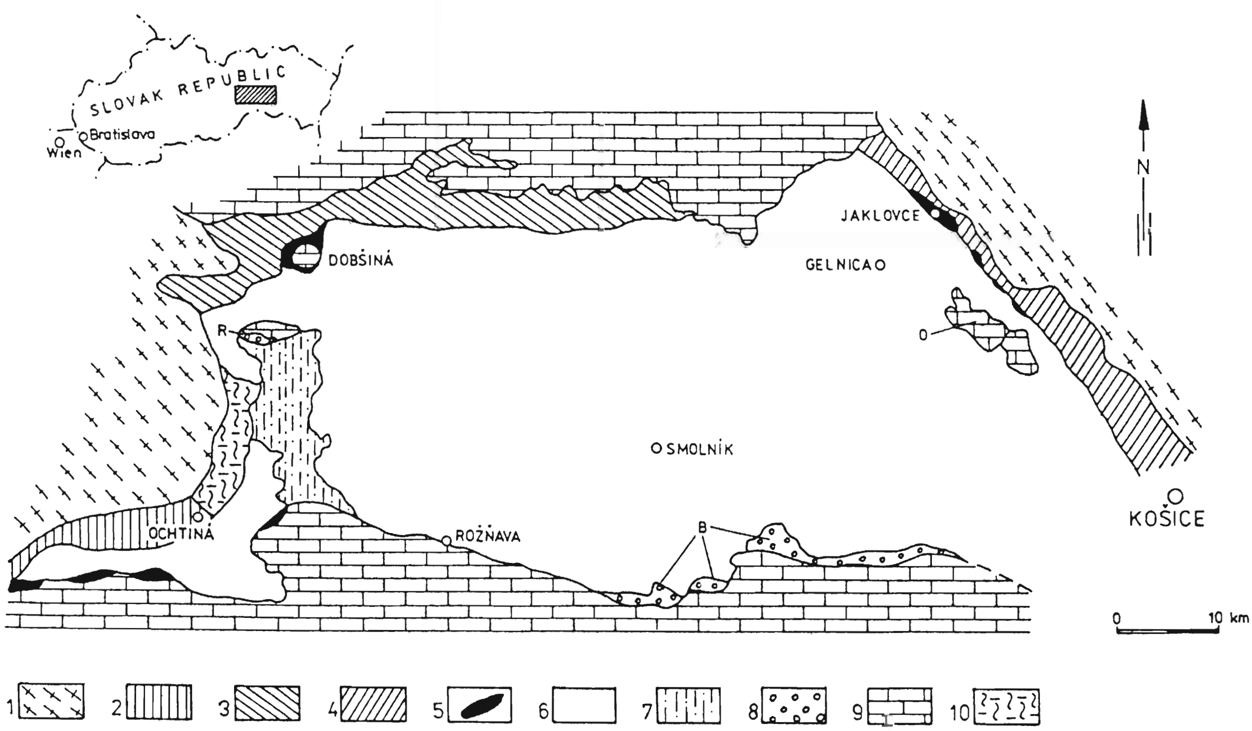

Fig. 1. Simplified sketch of tectonic units around the margin of the Gemericum s. str. 1 - Veporicum (Central Western Carpathians), 2 - 4 - Črmelicum, 2 - Ochtiná Nappe, 3 - Dobšiná Nappe (the continental Permian of the northern and eastern part belongs either to this nappe, as shown in the figure, or to the Stratená Nappe), 4 - Črmeľ Nappe (the continental Permian in the northwestern part belongs either to this nappe, as shown in the figure or to the Stratená Nappe), 5 - Oceanic Meliaticum (Middle Jurassic turbidites, olistostromes and melanges with blocks of dismembered ophiolites and sediments of the Middle-Upper Triassic oceanic sequences and partly with blocks of the pre-rift sequence), 6 - Gemericum s.str. (all nappes assigned by Grecula, 1982 to this unit except the Črmeľ Nappe) 7 - Triassic envelope series of the Gemericum (shallow-water limestones with basic tuffs and tuffites in the Middle Triassic part), partly transitional to the slope facies at the Gemeride slope of the Meliata Ocean (limestone and basalts), 8 - Slope facies at the southern Gemericum slope of the Meliata Ocean (pillow lavas, metamorphosed in HP/LT metamorphism to glaucophane schists, metamorphic slope limestones and shallow-water limestone olistoliths), Bôrka Nappe (B) and Radzim Nappe (R), 9 - Higher nappe units from the slope (except of Gemericum slope) and outer shelf of the Meliata Ocean (Opátka Nappe (O), Silica Nappe, Stratená Nappe, Torna Nappe etc.). 10 - Unit of unknown age and tectonic position.

low-grade metamorphic Dobšiná sequence, but at the base of the latter sequence pebbles of these rocks are present that indicate the original stratigraphic connection. The gneisses and amphibolites have been assigned to the Klátov Group by Neubauer and Vozárová (1990), but the Klátov Unit is only present in the southeastern Gemericum, far away from Dobšiná Nappe and separated from the Črmelicum by Triassic-Jurassic Meliaticum. Therefore the medium high-grade metamorphic rocks of the Dobšiná Nappe are the primary basement of this nappe, independent from medium to high-grade metamorphic rocks in the southeastern Gemericum. The age of this medium to high grade metamorphism is pre-Carboniferous, as Lower Carboniferous rocks within the Črmelicum are low grade to very low grade metamorphic (Ochtiná Nappe). Most probably the metamorphism is pre-Hercynian (or Silurian-Devonian Ligerian-Variscan sensu von Raumer and Neubauer, 1993). These metamorphics may be an equivalent of the Prieselbauer Complex that is regarded as the basement of the Veitsch Nappe (Neubauer and Vozárová, 1990) and has according to these authors an Early Devonian metamorphism age.

Above the metamorphic crystalline basement, a low-grade metamorphic sequence begins with conglomerates, sandstones, slates that tends to fining upwards. It is assigned to the Rudňany Formation, to which seemingly different units in various parts of the Črmelicum have been assigned. The clasts contain gneisses and amphibolites from the underlying crystalline basement. This sequence is overlain by the Zlatník Formation that consists of greenish and grey slates, fine-grained metasandstones with basic volcaniclastic layers and thin metabasalts. In the lower part of this formation carbonate bodies occur that contain a rich fauna. Despite of the fossil content, the age was somewhat disputed. The macrofauna was assigned to the Westphalian C-D (Rakusz, 1932) or uppermost Westphalian B (Bouček and Přibyl, 1960), but the macroflora indicates Westphalian A-B (Němejc, 1953 in Neubauer and Vozárová, 1990). The latter age assignment was confirmed by Kozur and Mock (1977) by conodonts that indicate a Westphalian A age (middle Bashkirian according to Kozur, 1984).

The paralic Hámor Formation west of Dobšiná consists of conglomerates, sandstones and slates with some anthracitic coal seams. The clasts consists of phyllites, metaquartzites, lydites, scarce granitoids and acidic volcanics. The Hámor Fm. was palynologically dated as Westphalian D-Stefanian A by Ilavská (1964 in Neubauer and Vozárová, 1990), corresponding to the upper Moscovian to Kasimovian (Kozur, 1984). Despite the fact that it lies not in stratigraphic superposition on the Zlatník Fm., such a position is indicated by the age of the two formations (Neubauer and Vozárová, 1990).

Continental Permian rocks, juxtaposed to the Dobšiná Nappe, belong to the basal part of the Stratená Nappe. However, it cannot be excluded that the Dobšiná Nappe is the slightly detached Paleozoic basement of the Stratená Nappe.

According to Maheľ (1986), the Črmeľ Group (part of the Črmelicum) is a remnant of the original substratum of the Hronicum. As discussed above, the Permian-Lower Triassic envelope of the Črmeľ Nappe is partly preserved. Evaporitic sediments are missing in the Upper Permian. The P/T boundary lies in continental beds, the marine sedimentation begins within the lower Scythian. Therefore the Črmelicum may be, in agreement with the view of Maheľ (1986), a remnant of the original substratum of the Hronicum. As discussed above, the Črmeľ Nappe may be the original substratum of the Opátka Nappe that is only a little detached from the Črmeľ Nappe (in its present position maximally 5 km). Its Middle Triassic to Carnian sequence with a distinct Raibl horizon can be assigned to the Hronicum.

South-Rudabányaicum, North-Rudabányaicum, Silicium, Muránicum and Hronicum

The stratigraphic content of these nappe piles was described repeatedly in numerous papers and summarized in books about the geology of the western Carpathians (e. g. Andrusov, 1965, 1968; Maheľ et al., 1968, 1974; Maheľ, 1986). It will not discussed in the present paper. Only the distinctive facial units are listed, some general trends will be shown, and the original position will be discussed, if necessary.

The South-Rudabányaicum (Kozur, 1991a, b) comprises nappes from the southern slope and outer shelf of the Meliata-Hallstatt Ocean or of the southern branch of the Meliata-Hallstatt Ocean (in the meridian of the Gemericum). It comprises the unmetamorphic Szőlősardó Nappe and the anchimetamorphic Torna Nappe (Fig. 2), as well as the low grade to very low grade metamorphic Brusník Nappe introduced by Kozur (in press a). The stratigraphic successions of the Szőlősardó and Torna nappes and above all the differences to the northern slope and shelf of the Meliaticum were discussed by Kozur (1991a, b).

The original position of these two nappes is disputed. Kozur and Mock (e. g. 1987, 1988) assigned both to the southern margin of the Meliaticum, Csontos (1988) assigned both to the northern margin of the Meliaticum, and Kovács (e. g. 1984) assigned the Torna Nappe to the southern margin of the Meliata-Hallstatt Ocean, the Szőlősardó Nappe as assumed lower slice of the Silica Nappe to the northern margin of the Meliata-Hallstatt Ocean. The view of Csontos (1988) is based on his reconstruction of the Meliata-Hallstatt Ocean as a Neotethyan ocean south of the Bükk Mountains that was still open in the Upper Cretaceous. In this reconstruction, the Rudabánya Nappe (Bodva facies sensu Csontos) is the lateral equivalent (E - W) of the eastern Bükk Mountains, the Silica Nappe the lateral equivalent (E - W) of the Fennsíkum (nappe of the Bükk plateau) and the Torna Nappe was placed immediately north of the Fennsíkum and shown as the lateral equivalent (E - W) of the Muránicum. The Gemericum was shown as the transitional segment (in E - W direction) between the Bükk-Fennsíkum and the Silicicum. This reconstruction is in basical conflict with many geological data, e. g. there is no evidence for any oceanic Cretaceous rocks in the Meliaticum, and any facies transition between the totally different Fennsíkum and the Gemericum are absent. For this reason, the hypothetical reconstruction by Csontos (1988) that was mainly based on structural geology without adaequate consideration of other geological evidences was not taken into consideration in later papers and even not mentioned by Trunkó (1996). However, some of the basic statements in this paper are acceptable. For instance, the Torna and the Szőlősardó nappes were surely rooted on one side of the Meliata-Hallstatt Ocean and not on the opposite sides of this ocean. The lithological succession is nearly identical, the event succession and faunal succession are identical and distinctly different from any other shelf and slope development of the Meliata-Hallstatt Ocean. This is not a local convergence, as both equivalents of the unmetamorphic, and to a small extent also of the metamorphic South-Rudabányaicum can be found also in the Estern Alps (Geyerstein nappe as unmetamorphic South-Rudabányaicum, and metamorphic slices of South-Rudabányaicum character in the Edenhof section in the southeastern Northern Calcareous Alps as equivalents of the Torna or Brusník nappes, Kozur and Mostler, 1992). The real question is therefore, whether both sequences originate at the southern margin or at the northern margin of the Meliata-Hallstatt Ocean. Our arguments for a position at the southern margin of the Meliata-Hallstatt Ocean were published in Kozur and Mock (1988), Kozur (1991a, b) and Kozur and Mostler (1992). Together with some new aspects, they are: (1) The Triassic crustal mobility was in the Szőlősardó and Torna nappes considerably higher than in units that were derived from the northern margin of the Meliata-Hallstatt Ocean as it is indicated from the below listed differences. (2) The rifting at the later southern slope of the Meliaticum began earlier than at the later northern slope (and earlier than in the later Meliata-Hallstatt Ocean themselves) in a time (Bithynian-early Pelsonian) as the oceanic connection to the world ocean was not yet established. The subsidence in these earliest rift basin was gradual and these basins were partly still euxinic. Therefore at the later southern slope of the Meliata-Hallstatt Ocean pelagic sediments (mainly dark euxinic rocks) overlay with gradual contact the underlying shallow water limestones. Only in this part continental rift volcanism with acidic, intermediate and basic volcanism occur in the upper Bithynian and lower Pelsonian. In the Meliata-Hallstatt Ocean and its northern slope the rifting began within the Pelsonian contemporaneously with the establishment of a free connection to the world ocean. Its onset is characterized by a sudden subsidence of the carbonate platform and deposition of red pelagic limestone (Žarnov Limestone Formation Kozur and Mock, 1985, junior synonym: Dunnatető Formation by Kovács et al., 1988) in an extremely extensional regime indicated by numerous fissure in the underlying shallow water limestone, filled with red pelagic limestone of the Žarnov Formation, and the onset of throughout basic volcanism in the Meliata-Hallstatt Ocean. (3) Already at the Bithynian/Pelsonian boundary and in the lower Pelsonian, terrigenous siliciclastic material (siltstones and shales) occur. In this time all Inner Western Carpathian units north of the Meliaticum are free of any terrigenous siliciclastic input and are built up of mostly shallow water, rarely pelagic clastica-free limestones. Even in the Pelsonian of the Central Western Carpathians a carbonate platform without any siliclastic input is present. Pelsonian basins within the Inner Western Carpathians that would be a trap for silicilastic sediments, have also no siliclastic input. A derivation of any unit with siliciclastic input in the lower Pelsonian (Bódvarákó Formation) from the northern margin of the Meliata Ocean is therefore definitely impossible. There was no Pelsonian subaerially exposed basement near to the deposition area of those Inner Western Carpathian units that were derived from north of the Meliata-Hallstatt Ocean, but such elevated source areas must be present south of the Meliata-Hallstatt Ocean, as they are present in the Southern Alps and other South Tethyan units. (4) Distinct volcanic activity begins at the southern slope of the Meliata-Hallstatt Ocean in the upper Bithynian and lower Pelsonian, where tuffits and tuffs are present and clasts of acidic, intermediate and basic volcancis are transported in the basin. No such volcanic activity is knwon from north of the Meliata-Hallstatt Ocean. (5) The upper Anisian to Cordevolian of the southern slope of the Meliata-Hallstatt Ocean is characteriszed by limestones with slump breccias, intraformational breccias and grain-sized resedimentation (allodapical limestones). Especially in the Alps (Geyerstein Nappe), the clayey intercalations are often tuffitic. Also this development shows a higher crustal mobility than in the deposition area north of the Meliata-Hallstatt Ocean, where either shallow water limestones or Hallstatt Limestones without widespread redeposition are present. (6) In the middle Carnian a thick clastic Raibl horizon is present at the southern slope and outer shelf of the Meliata-Hallstatt Ocean that is missing in the units adjacent to the northern margin of the Meliata-Hallstatt Ocean. Only in the Muránicum terrigenous Lunz Beds (mainly of insignificant thickness) are present and thick Lunz beds are only known from the Hronicum, far away from the nor-thern margin of the Meliata-Hallstatt Ocean. The transport of siliclastic terrigenous material from the north to the northern slope of the Meliata-Hallstatt Ocean could be only go through channels that cross the middle Carnian shallow water platform of the Silicicum. However, such channels can be nowhere observed in the vast and well exposed middle Carnian carbonate platform of the Silicium. As there are no block faultings in the middle Carnian of the Silica Nappe, the presence of such large channels is not very probable. (7) The upper Carnian and Norian south of the Meliata-Hallstatt Ocean (Szőlősardó and Torna nappes) are characterized by Pötschen Limestone (platy, cherty, marly, bedded limestones with thin terrigenous shale intercalations), whereas at the northern margin ei-ther Hallstatt Limestone or (more distant from the Meliata-Hallstatt Ocean), Dachstein Limestone were deposited, both free of any shale intercalations. (8) The Middle Jurassic south of the Meliata-Hallstatt Ocean is a typical active margin sequence with olistoliths of sandstones and acidic volcanics from an island arc. The northern margin is at that time the passive margin with a quiet deep water sedimentation.

These differences between deposits from the northern and southern slope and outer shelf of the Meliata-Hallstatt Ocean are clearly recognizable in Slovakia, in parts of northern Hungary and in the southeastern part of the Northern Calcareous Alps (Kozur and Mostler, 1992). The difficulties in the interpretation come from the highly tectonized Rudabánya Mountains in northern Hungary. There, small slices of Meliaticum and slope deposits from the northern and southern slope of the Meliaticum are tectonically juxtaposed. The tectonic situation is so complicated that it is sometimes even difficult to decide whether strong lithologic changes in few 100 m are lateral facies changes or tectonic juxtaposition in an area that is generally not well exposed. Thus, Kovács et al. (1988) wrote that the Bódvalenke Formation changes strongly within few 100 m and numerous untypical variants of this formation are present. As this formation is partly a strongly condensed unit of few 10 m for the long time interval from the upper Anisian to the upper Carnian, such abrupt lateral facies changes are not very probably. Rather different tectonic slices were there put into one formation that is also indicated by the fact that rapidly sedimented calciturbidites were also put into this formation by Kovács et al. (1988). The view of Trunkó (1996) that the Raible Beds occur also north of the Meliata-Hallstatt Ocean, because they are present in the Bódvalenke Limestone that belongs undoubtedly to the northern margin of this ocean is a circular conclusion. As a part of the Bódvalenka Formation occurs acording to Kovács et al. (1988) above the Bódvarákó Formation with upper Bithynian to lower Pelsonian siliciclastic beds unknown from any unit of the Western Carpathians north of the Meliata-Hallstatt Ocean, but common in units from south of the Meliata-Hallstatt Ocean (also in the Alps), a part of the Bódvarákó Formation was derived from south of the Meliata-Hallstatt Ocean and the presence of Raible beds is then a logical consequence. As other parts of the Bódvalenke Formation are shown by Kovács et al. (1988) to overlay the Žárnov Limestone ("Dunnatető Limestone"), obviously different units were united in the Bódvalenke Formation. The interfingering of the "Dunnatető Limestone" with the Bódvarákó Formation shown by Kovács et al., (1988) and in many other publications by Kovács is nowhere recognizable and also rather unlogical. The Žarnov Limestone is a highly oxygenated open sea basinal deposit with a rich open sea fauna, the Bódvarákó Formation is a partly euxinic, but also in the non-euxinic part restricted basin development with a restricted basin fauna without connection to the open sea faunas. Hardly to imagine that such different basinal facies with different pelagic faunas interfinger each other. Moreover, all previous datings of the Bódvarákó Formation have yielded conodonts and radiolarians of Bithynian to early Pelsonian age, whereas the Žarnov Limestone has a middle or late Pelsonian to Illyrian age. Formations of different ages, however, cannot stratigraphically interfinger. Thus, the indicated interfingering of both formations by Kovács et al. (1988) and in other papers of Kovács is either an unproven hypothesis or there are sections with tectonic juxtaposition of both formations that we do not know.

Likewise improbable is the interfingering of Hallstatt Limestones and Bódvalenke Limestone (starved sedimentation with submarine subsolution) with the rapidely deposited thick Szőlősardó Marls (Raible Beds) in a borehole as indicated by Trunkó (1996) as a further evidence for the presence of clastic Raible beds on the northern slope of the Meliata-Hallstatt Ocean. Seemingly, also these units are tectonically juxtaposed, independently from the fact that in a borehole the lateral extent of lithostratigraphic units cannot be studied.

The reconstruction by Kovács to place the Szőlősardó and Torna nappes at the two opposite side of the Meliata-Hallstatt Ocean is based on two unproven assumptions. As in his opinion an invariable metamorphic succession from the anchimetamorphic to epimetamorphic Torna Nappe through the anchimetamorphic Meliaticum to the umetamorphic Silica Nappe (including its assumed lower slice, our Szőlősardó Nappe) is present, he concluded that there must be a nappe pile Torna Nappe→Meliaticum→Szőlősardó slice of the Silica Nappe. And as he assumed only southwards directed nappe transport in the southern part of the Inner Western Carpathians (toward the north until the Silica Nappe), the highest nappe must be that nappe with the northernmost origin. Both assumptions of Kovács cannot be confirmed. What are the facts: The assumed metamorphic succession does not exist in this simple manner. The Torna Nappe is indeed anchimetamorphic or epimetamorphic. The Meliaticum is partly anchimetamorphic, partly unmetamorphic and partly it underwent the highest known Cimmerian metamorphic overprint, the blueschist facies. Alone these differences in the metamorphic degree within one unit show that the metamorphic degree does not depend from the present position in the nappe pile, but it is a transported metamorphism. The hypothetical nappe pile established by Kovács and repeatedly published as really existing nappe pile, cannot be confirmed. In the type area of the Torna Nappe, the half window of the Turnianska kotlina, the Torna Nappe is directly overlain by the Silica Nappe without traces of Meliaticum between these nappes, because the Meliaticum lies in a deeper tectonic position as the Torna Nappe. Also in other occurrences, the South-Rudabányaicum lies always above the Meliaticum. Especially impressive this is shown in the Brusník anticline, where the below described Brusník Nappe of the South-Rudabányaicum lies on Meliaticum, as proven also in a borehole (Vozárová and Vozár, 1992). In those areas, where the metamorphic Torna Nappe is replaced by the unmetamorphic Szőlősardó Nappe, the position of the Szőlősardó Nappe is the same as that of the Torna Nappe, between the Meliaticum below and the Silicum above, as well recognizable along the southern margin of the Slovakian Karst (Aggtelek Karst) and in the Mokrá Lúka window. Also the exclusively southwards directed transport of the nappes in the southern part of the Inner Western Carpathians cannot be confirmed. The Cimmerian nappe thrusting was, in agreement with the southwards directed subduction of the Meliata-Hallstatt Ocean, northwards directed (e. g. South-Rudabányaicum on Meliaticum), and only the far younger, Cretaceous thrusting of the Silica Nappe was southwards directed (see later). Thus, the classical field observations of the Inner Western Carpathians that the southwards directed thrust of the Silica Nappe is a younger movement, could be confirmed.

As Kovács (in all his papers that deal with this problematic) has published his hypothetical nappe pile as a real existing nappe pile (as already discussed in Kozur and Mock, 1988), Trunkó (1996) has overtaken this erroneous nappe succession as a real existing succession and used it for supporting of the hypothesis by Kovács. Thus, Trunkó (1996, p. 152) wrote: "Finally a potentially decisive argument against a southernly emplacement of Szőlősardó is the metamorphic succession: corresponding to the position in the nappe pile, rocks of the Tornaicum are anchi- to epimetamorphic, those of the Meliaticum are anchimetamorphic while the Silicicum is not metamorphosed; Szőlősardó is not metamorphosed either." This is a classical circular conclusion. First, Kovács established on the base of different metamorphic overprints a non-existing hypothetical nappe succession and subsequently Trunkó (1996) stated that the metamorphic succession fits exactly into this (non-existing !) nappe succession.

The third nappe of the South-Rudabányaicum, the Brusník Nappe, has a low grade, in the Permo-Triassic part very low grade metamorphic sequence that is exposed in the Brusník anticline. This sequence begins above the thrust plane with a Bashkirian siliciclastic flyschoid sequence (Turiec Formation sensu Vozárová and Vozár, 1992) consisting of graded shales, siltstones, sandstones, acidic tuffs, tuffitic sandstones and clayey, micritic or organodetritic limestones. The limestones yielded Bashkirian conodonts (Ebner et al., 1990). The Turiec Formation is overlain unconformably by variegated, coarse clastic, continental Permian Red Beds, followed with stratigraphic contact by Lower Triassic sandstones and shales (Vozárová and Vozár, 1992). The lower (to middle?) Anisian consists of Gutenstein and Steinalm Limestones, transitionally overlain by middle Anisian to Carnian grey, locally pinkish-grey cherty limestones with intercalations of dark-grey shales. The Middle Triassic to Carnian succession is very similar to the Torna and Szőlősardó Nappe successions (as already stated by Vozárová and Vozár, 1992) and has also the same fauna. The difference to the other two nappes of the South-Rudabányaicum is the presence of continental coarse clastic Permian instead of the hypersaline marine Upper Permian, and the presence of a part of the low grade metamorphic Hercynian basement (Bashkirian flysch), whereas the thrust plane of the Torna and Szőlősardó nappes is the base of the Upper Permian hypersaline horizon.

The Brusník Nappe lies, like most occurrences of the South-Rudabányaicum, on Meliaticum that was before Ebner et al. (1990) and Vozárová and Vozár (1992) generally assigned to the "Gelnica Group" of the Gemericum, but it is a Middle Jurassic accretionary complex with olistoliths of basalts and other rocks of the Meliaticum.

The North-Rudabányaicum (Rudabánya Nappe, not shown in Fig. 2) has only a restricted distribution because it represents the narrow slope belt between the Meliata-Hallstatt Ocean and the adjacent northern outer shelf with Triassic transitional facies between the Silica Nappe and the sedimentary sequences of the Meliaticum. In the meridian of the Gemericum, it represents the northern slope facies at the northern branch of the Meliaticum. The facial similarities and differences of the sequences of the South- and North-Rudabányaicum are discussed by Kozur (1991a, b).

The Silicicum (Mello, 1979; Biely, 1989) was mostly used in a very wide sense, comprising all nappes of the Upper Subtatricum, North and South Gemeride Triassic sensu Andrusov (1968), which were included into the Gemeride Triassic, before Kozur and Mock (1973a, b) proved the nappe character of the Gemeride Triassic. In this sense, the Silicicum is a too large unit comprising (in our subdivision) the North-Rudabányaicum, Silicicum and Muránicum as well as parts of the South-Rudabányaicum. This Silicicum sensu lato is the equivalent of the entire Tirolicum and Juvavicum of the Eastern Alps. We restrict, as Kozur (1991a, b) did, the Silicicum to the Silica Nappe that may consist of more than one nappe (e. g. the Triassic-Jurassic sequence of Bleskový prameň south of Drnava, Slovakian Karst belongs probably to an independent nappe of the Silicicum). In this restricted sense, the Silicicum was derived from the northern outer shelf of the Meliata-Hallstatt Ocean. It is characterized by hypersaline Upper Permian, marine Scythian with first limestone intercalations in the lower Scythian, Ladinian-lower Tuvalian (Kozur and Mock, 1974) Wetterstein Limestone (in the Ladinian partly replaced by basinal limestones and cherty limestones), overlain by Tuvalian brachiopod-crinoid limestone and upper Tuvalian-Norian Hallstatt limestone and Rhaetian Zlambach Marls (for Upper Permian to Oxfordian sequence see Mock, 1980 and Kozur, 1991a, b). Laterally, the Hallstatt Limestone is replaced by shallow-water limestone, similar to Dachstein Limestone. Interesting is a clastic horizon in the uppermost Rhaetian and lowermost Hettangian near Bohúňovo that may contain blue amphiboles (Aubrecht, pers. comm., see under Meliaticum). Very characteristic is the sudden change from lower Oxfordian radiolarites to upper Oxfordian shallow-water limestones (Mišík and Sýkora, 1980; Kozur, 1991a, b). The North-Rudabányaicum may be united with the Silicicum s. str., but for the moment we separate this slope facies with clear facies transitions to the Meliaticum, mainly for its easy correlation with corresponding units in the Alps. The lithologic succession of the Silica Nappe is shown in Fig. 2.

The Muránicum is introduced herein for the Stratená, Muráň, Strážov and Nedzov nappes. It corresponds to the North Gemeric Triassic and Upper Subtatricum sensu Andrusov (1965). It has in its southern units (Stratená and

Muráň nappes) the northernmost occurrence of hypersaline rocks in the Upper Permian of Western Carpathians. Very characteristic are thick Ladinian Wetterstein Limestones (laterally partly replaced by Wetterstein Dolomite), overlain by Carnian dolomites that may contain thin distal Lunz shales. In the northern units (Strážov and Nedzov nappes), the Hauptdolomit represents the entire Norian. These two nappes have transitional character to the originally northward adjacent Choč Nappe of the Hronicum (Maheľ, 1986) and their assignment to the Muránicum or Hronicum is a matter of convention. However, in the last years the Hronicum was always restricted to the Choč Nappe s.l. (compare Biely, 1989) and already Andrusov (1968) placed the Choč Nappe in his Middle Subtatricum, but the Strážov and Nedzov nappes in his Upper Subtatricum. In the southern units (Stratená and Muráň nappes), upper Carnian to lower Norian Hauptdolomit is overlain by Norian Dachstein Limestone, partly erroneously named as Tisovec Limestone; the term Tisovec Limestone was rejected by Krystyn et al. (1990) by well founded reasons. Youngest known preserved beds are of Liassic age. The Silicicum is distinguished by the presence of uppermost Carnian and Norian Hallstatt Limestones in large parts of the unit and the absence of Ladinian and Carnian dolomites indicating a more southern position nearer to the Meliaticum.

The Hronicum (Middle Subtatricum sensu Andrusov, 1968) is used in the sense of Biely (1989) for the Choč Nappe and near related nappes or partial nappes or slices, but additionally the Opátka Nappe (see under Črmelicum) is added. In the southern Biely Váh Subunit of the Choč Nappe, Reifling Limestones, thick Lunz Beds and upper Carnian-Norian Hauptdolomit are present. In the northern Čierny Váh Subunit of the Choč Nappe, the Anisian-Norian sequence consists mainly of dolomites, in the lower part also of dark limestones. The dolomites are subdivided by terrigenous Lunz Beds. In the frontal (northernmost) part of the Choč Nappe, thin intercalations of variegated claystones with marly dolomites are present in the Norian Hauptdolomit that remember to Carpathian Keuper. Characteristic for the Choč Nappe is furthermore a thick continental Permian with melaphyres and a continental Permian-Triassic transition without Upper Permian evaporites. Marine beds begins only above the continental Alpine Buntsandstein within the lower Scythian.

The Opátka Nappe (see under Črmelicum) is a small remnant of the Hronicum that was only a little detached from its Črmelicum basement.

The nappes of the North-Rudabányaicum, Silicicum, Muránicum and Hronicum are always in tectonically highest positions above other Inner Western Carpathian or Central Western Carpathian units. For these units the name Upper Slovakocarpathian Unit, analogous to the Upper Austroalpine Unit, is introduced. The Upper Slovakocarpathian Unit lies in the same tectonic position as the Upper Austroalpine Permo-Mesozoic nappes of the Northern Calcareous Alps. The Črmelicum as part of the substratum of the Hronicum belongs also to the Upper Slovakocarpathian Unit.

The low-grade metamorphic envelope series of the southern Veporicum (Föderata Unit, southernmost Permo-Mesozoic cover unit of the Central Western Carpathians) displays a nearly identical succession with the Choč Nappe as the originally northernmost unit of the Inner Western Carpathians. The Föderata Unit is characterized by continental Permian with a continental Permian-Triassic transition, lower Scythian quartzites and conglomerates, upper Scythian Werfen beds, dark and light Middle Triassic shallow-water limestones interfingering with pelagic Ladinian-Cordevolian cherty limestones, clastic Lunz Beds and Hauptdolomit. Only the presence of Dachstein Limestone above the Norian Hautpdolomit in a part of the Choč Nappe indicates a slightly more southern original position of the Choč Nappe compared with the Föderata Unit. The main difference is the low grade metamorphism in the Föderata Unit caused by different later tectonic development. The transitional development of Choč Nappe and Föderata Unit is important for the rooting of the Inner Western Carpathian surface nappes.

All facies transitions can be observed from the Föderata Unit (envelope series of the southern Veporicum) through the nappes of the Hronicum, Muránicum, Silicicum, North-Rudabányicum to the Meliaticum. This indicates original adjacent position of these units in the mentioned succession, which is their original N - S distribution. For instance, upper Carnian and Norian are characterized by Hauptdolomit facies in the Hronicum, Dachstein Limestone and similar shallow-water limestone above upper Carnian dolomites in the Muránicum, Dachstein Limestone and above all Hallstatt Limestone above Wetterstein Limestone in the Silicicum, and Hallstatt Limestones above a continuously pelagic Pelsonian-Carnian sequence in the North-Rudabányaicum. Clastic Lunz Beds are thick and with sandstones in the Choč Nappe, thin and shaly in the Strážov and Muráň nappes and absent in the Silica and Rudabánya nappes. The exceptional occurrence of distal Lunz Beds with *Halobia* in the Opátka Nappe can be explained with its original northern position as part of the Hronicum (see above). The clastic middle Carnian beds in the southernmost nappes (Torna, Szőlősárdó nappes) can be explained by the original position of these nappes at the southern slope and adjacent outer shelf of the Meliata-Hallstatt Ocean. All nappes of the Western Carpathians and Eastern Alps that were rooted on the southern slope and shelf of the Meliata-Hallstatt Ocean have clastic Raibl beds transported from the south (Kozur and Mock, 1987, 1988; Kozur, 1991a, b; Kozur and Mostler, 1992).

Similar transitional changes of paleogeographic importance can be observed in the Upper Permian and Scythian. In those nappes that rooted in the north (Choč Nappe, Črmeľ Nappe), the entire Permian is continental, and a continental Permian-Triassic transition can be observed, as in the envelope of the Veporicum. The marine sedimentation began within the lower Scythian. In the more southerly rooted nappes, e. g. Silica and Rudabánya nappes, the Upper Permian is hypersaline marine with gypsum and few dolomites containing marine euryhaline ostracods and foraminifers. The P/T boundary lies in shallow-marine beds and first limestones occur in the lower Scythian. The nappes of the Muránicum have transitional character between these two Permian-Scythian developments. In the Upper Permian some evaporites are present, but the P/T boundary is mostly in continental beds with basal conglomerates and the marine sedimentation begins a little above the basal conglomerates. However, much of the marine lower and middle Scythian are sandstones, siltstones and shales and only in the upper Scythian marls and limestones dominates.

A very important feature for paleogeographic reconstructions is the upper Carnian-Norian subsidence in the slope and outer shelf successions of the Meliata-Hallstatt Ocean. As shown by Kozur (1991a, b), the sea-floor spreading in the Meliaticum ended at the base of the middle Carnian. Crustal cooling connected with this event caused subsidence on the adjacent slope and outer shelf. This is well recognizable on the outer shelf, where Middle Triassic to middle Carnian shallow-water algal limestones and other shallow-water sediments are overlain by pelagic limestones, often Hallstatt Limestones (Silica Nappe). Similar development can be observed along the entire outer shelf of the Meliata-Hallstatt Ocean in the Western Carpathians and Eastern Alps. In the slope deposits, this subsidence caused by crustal cooling cannot be recognized, because it occurs within Middle Triassic to Upper Triassic deep-water sequences, in which a further subsidence is not recognizable by sedimentologic changes.

By this development the outer shelf of the Meliata-Hallstatt Ocean is well distinguished from the outer shelf of South Tethyan oceans. Because there the oceanic sea-floor spreading began in the middle Carnian or became more pronounced at that time, the opposite development (shoulder uplift) can be observed. For this reason pelagic Middle Triassic (or even Olenekian)-Cordevolian deposits are there overlain by shallow-water Upper Triassic limestones and dolomites (e. g. in the Subpelagonicum, Southern Alps, Drauzug, Balaton Highland). This different behaviour of the outer shelves along different oceans is important for paleogeographic reconstructions (see chapter 6).

In the slope development of the Rudabánya Nappe, interfingering of typical Meliaticum facies (e. g. red Ladinian cherts) with more marginal developments (cherty limestones) can be observed in the Ladinian and Cordevolian, and typical sediments of the outer shelf (e. g. upper Norian Hallstatt Limestones) occur. By this, a continuous facies succession from the Meliaticum oceanic sequence to the outer shelf sequence can be observed. On the other hand, a facies transition between the Meliaticum shelf deposits and the envelope of the Veporicum is present (see above), and consequently continuous Triassic facies successions from the Meliata-Hallstatt Ocean until the Central Western Carpathians can be observed.

The continuous Triassic-Jurassic facies successions are broken by the Meliata-Hallstatt Ocean. The units that derived from the southern slope of the Meliata-Hallstatt Ocean (South-Rudabányaicum sensu Kozur, 1991a, b; Kozur and Mostler, 1992; Torna, Szőlősardó and Brusník nappes of the western Carpathians, Geyerstein Nappe of Eastern Alps) are distinctly different and do not fit in the continuous facies successions observed at the northern margin. Distal clastic input (shales, siltstones, in the Eastern Alps also some detrical quartz) in the uppermost lower Anisian and Pelsonian, and thick distal Raibl beds (shales, marls) do not fit in any slope development from the northern slope of the Meliaticum. Because of the general higher terrigenous influx, condensed limestones of Hallstatt Limestone type are missing or rare on the southern slope, where marly and cherty limestones prevail. Also in the Jurassic, the differences are pronounced. Olistoliths of sandstones and acidic volcanics in well dated Middle Jurassic turbidites and olistostromes of the South-Rudabányaicum (Grill and Kozur, 1986; Kozur, 1991a, b), indicating southward directed Middle Jurassic subduction of the Meliata-Hallstatt Ocean, are unknown from the Middle Jurassic of the northern slope of the Meliaticum.

The above mentioned differences and discontinuities in the Triassic-Jurassic facies development are well explainable with the position on the two opposite sides of the Meliata-Hallstatt Ocean. However, the Upper Permian-Jurassic development of the southwards adjacent Bükk Mts. is so different that the Bükkium was probably juxtaposed by later large scale lateral movements, but an explanation of the Jurassic sea-floor spreading in the Szarvaskő area (Bátor Nappe) by back-arc opening in front of the subducting Meliata-Hallstatt Ocean cannot be excluded (Kozur, 1991a, b).

It is very interesting that the pre-Cimmerian history is very different on both sides of the later Meliata-Hallstatt Ocean. North of the later Meliata-Hallstatt Ocean the Carboniferous followed above (? pre-Hercynian) medium to high grade metamorphics and is rather of molasse type, with shallow-water Middle Carboniferous. South of the later Meliata-Hallstatt Ocean the Middle Carboniferous is a deep-water flysch and there are no indications that an Early Paleozoic medium to high grade metamorphic basement was present. Thus, between the later northern and southern slope/shelves of the Meliaticum already a Hercynian suture zone with Middle Carboniferous or post-Middle Carboniferous closure was present. Consequently, the Meliata-Hallstatt Ocean opened apparently at the place of a Hercynian Middle Carboniferous suture zone. Already Grecula (1994a, b) assumed that the place of the later Meliata rift was anticipated by the Hercynian development. The same can be observed in northern Turkey, where the latest Permian to middle Triassic opening of the Cimmerian Ocean was near and partly at the place of a Hercynian remnant basin.

The Alpine development of the Inner Western Carpathians began in the upper Oxfordian. Until the lower Oxfordian, the Jurassic of the southern and northern nappes of the Upper Slovakocarpathian Unit is similar and seemingly only controlled by the development of the Meliata-Hallstatt Ocean (Jurassic is unknown or only the lower part is known in the nappes between the Silicicum and the Hronicum). The lower Oxfordian radiolarites of the

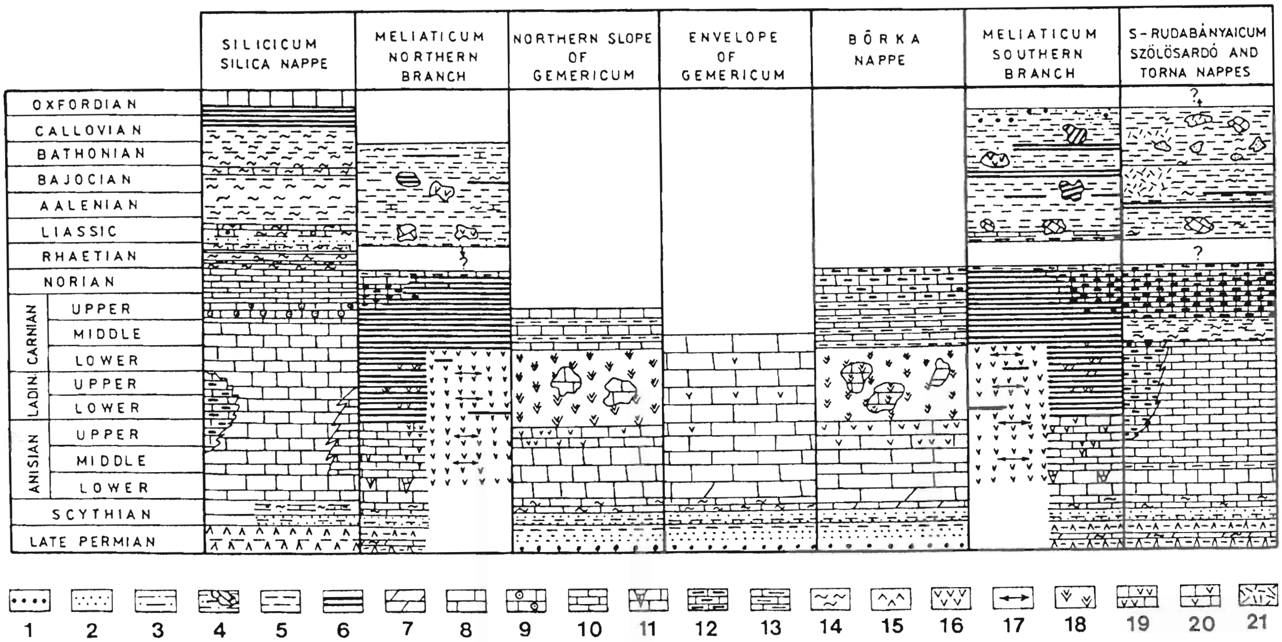

Fig. 2. Late Permian to Oxfordian sequences of the Inner Western Carpathians in the meridian of the Gemericum from the South-Rudabányaicum (southern slope and outer southern shelf of the Meliata Ocean) in the south to the Silicicum (northern outer shelf of the Meliaticum) in the north. North-Rudabányaicum (northern slope of the Meliaticum) with transitional facies between Meliaticum and Silicicum was omitted for space reasons (for its Late Permian to Jurassic sequence see Kozur, 1991a, b). Thickness of the units not at scale. 1 - conglomerate, 2 - sandstone, 3 - siltstone, 4 - silty-shaly turbidites with olistoliths, 5 - shale, 6 - radiolarite, 7 - dolomite, 8 - shallow-water limestone, 9 - partly oolitic limestone, 10 - pelagic limestone, 11 - fissure fillings of pelagic limestones in shallow-water limestones, 12 - cherty limestone, 13 - marly limestone, 14 - marl, 15 - evaporites (gypsum, anhydrite), 16 - basic and ultrabasic rocks (pillow lavas, gabbros, serpentinites, basaltic tuffs), 17 - sea-floor spreading, 18 - basaltic agglomerates, tuffs, basalts, in the Bôrka and Radzim nappes altered to glaucophane schists, 19 - basalt intercalations (often amygdoidal basalts) in limestones, 20 - basic tuffs in limestones, 21 - acidic volcanics.

Silica Nappe are overlain by upper Oxfordian and younger shallow-water limestones, and subsequently by freshwater deposits, known from pebbles (Mišík and Sýkora, 1980) or from fissure fillings. In the Choč Nappe the deep-water development continued until the Neocomian. This indicates separated tectonic development since the upper Oxfordian. Whereas the deposition area of the Silica Nappe was elevated during the middle Oxfordian final closure of the Meliata-Hallstatt Ocean, the Choč Nappe was involved in the inner shelf of the South Penninic Ocean and the deep-water deposition continued. During the subduction of the South Penninicum the Choč Nappe (with higher nappes, like the Strážov Nappe, on its back) was northwards transported. Other nappes remained near to the root zone (e. g. Stratená, Opátka, Muráň nappes). The southernmost units, in turn, were southwards thrust during pre-Gosauan time. We think that this southward thrust that can be found from the southern units of the Inner Western Carpathians (e. g. Silica Nappe) to the Bükk Mountains south of the Inner Western Carpathains, is related to the pre-Gosauan northward directed subduction of the Szarvaskő Ocean in the Bükk Mts.

The question of the root zone of the nappes that originated from the slopes and shelves of the Meliata-Hallstatt Ocean is connected with the position of the suture zone of the Meliata-Hallstatt Ocean and will be therefore discussed in the following chapter.

Meliaticum

The Meliata-Hallstatt Ocean is the decisive element of the Cimmerian development of the Western Carpathians and Eastern Alps. The position of the root zone of this ocean is very important for paleogeographic reconstructions within the Western Carpathians and Eastern Alps and for their mutual correlation.

The geologic evolution of the Meliata-Hallstatt Ocean in the Western Carpathians has been described by Kozur (1991a, b); for lithologic successions and their stratigraphic datings see these papers (compare also Fig. 2). Subsequently, the same development was found and well dated by radiolarians and conodonts in the eastern part of Eastern Alps (Kozur and Mostler, 1992; Mandl and Ondrejičková, 1991, 1993). The most important phases in the geological evolution of the Meliata-Hallstatt Ocean were:

- Aborted continental rifting in the Upper Permian. A hypersaline marine belt was formed by this rifting and first basic effusiva extruded. This hypersaline marine belt was not connected with the South Tethyan marine Permian of the Southern Alps, Dinarides and Vardar Zone, but the continuation of an Upper Permian Cimmerian rift zone in northwestern Turkey (Kozur and Kaya, 1994; Kozur, in press b). Between these two marine Permian belts an elevated area without Permian sediments or with continental Permian sediments was present. Parts of this belt are: The Central Alpine Belt south of the Meliaticum and its slopes and shelves (in the reconstruction by Brander and Sperling, 1995 SW of the Northern Calcareous Alps, see Fig. 6), the southernmost part of the South-Rudabányaicum (Brusník Nappe) and a zone without or continental Permian (e. g. Karaburun Zone, northern part of the Bolkardağ Unit) between the South-Tethyan Permian in the southern Taurus and south of it and the North-Tethyan Permian in the Karakaya Complex and north of it in Turkey.

- After the end of the Upper Permian rifting a broad, slowly sinking shallow water area without rift grabens was present during the Scythian.

- Development of a slowly sinking carbonate platform in the Aegean.

- Breaking up of the Lower Anisian carbonate platform in the latest Bithynian and Pelsonian, and a little later beginning of the oceanic rifting. Maximum creation of oceanic crust during the Ladinian and continuation of the sea-floor spreading in the Cordevolian. Contemporaneous deposition of deep-sea sediments (red ribbon radiolarites with thin intercalations of red deep-sea clays). Like in the oceanic ribbon chert sequences of Panthalassa in Japan, conodonts are common on the surface of some shales (Kozur and Imoto, in press., Kozur and Mock, in prep.). This indicates a very low input of terrigeneous material as in the Panthalassa Ocean and consequently, a very low sedimentation rate that is mainly controlled by the biologic activity (higher sedimentation rate in the bedded radiolarites, very low sedimentation rate in the red shales between the chert beds).

- In connection with the extensional regime lystric faults were formed in the adjacent continental part that are in their deeper part connected with greenschist metamorphism. This explains, why lower Anisian limestones of the pre-rift sequence occurring as blocks in the oceanic Meliaticum sequences are always low-grade metamorphic, even if the Meliaticum is unmetamorphic.

- Sudden end of the sea-floor spreading at the base of the middle Carnian due to re-organisation of the plate movements in the (Western) Tethys.

- Possible first, short-lasting northwards directed subduction in the latest Triassic and earliest Jurassic in the northern branch of the Meliata-Hallstatt Ocean.

- Middle Jurassic southwards directed subduction of the Meliata-Hallstatt Ocean (in the meridian of the Gemericum: southwards directed subduction of the southern branch of the Meliata-Hallstatt Ocean).

- Latest Middle Jurassic closure of the southern branch of the Meliata-Hallstatt Ocean in the meridian of the Gemericum. Subduction of the southern part of the intra-oceanic continental block of the Gemericum. Beginning of the northward directed nappe thrusting of the South-Rudabányaicum on the Meliaticum accretionary complex.

- Final closure of the Meliata-Hallstatt Ocean at the end of the lower Oxfordian. Northwards directed nappe thrusting of the South-Rudabányaicum on the Meliaticum and of the Meliaticum on the Gemericum. In the more northern units shear zones were probably created that were used in later compressional tectonic processes during the Cretaceous as thrust planes for nappes. Probably also in this time the southern superficial Permo-Mesozoic or Mesozoic Inner Western Carpathian nappes (North-Rudabányaicum, Silicicum) were detached from their basement, but not yet (significantly) transported.

Rocks of the oceanic Meliaticum sequence can be found in three tectonic positions: (1) Imbricated thrust sheets near the suture zone of the Meliaticum. (2) Southwards thrust Alpine nappes, partly on units south of the Inner Western Carpathians (e. g. Darnó Nappe on Fennsíkum in the Darnó-hegy area near Recsk in northern Hungary) and northwards thrust Cimmerian nappes on the Gemericum (Radzim Nappe). (3) Blocks in evaporitic melanges in the Permian evaporitic sequences at the base of higher nappe units.

In the evaporitic melanges, blocks of the oceanic Meliaticum (Jurassic turbidites as well as Middle Triassic dismembered ophiolites and deep-sea sediments) are tectonically involved in the Upper Permian gypsum-bearing sequences. Such evaporitic melanges with blocks consisting exclusively of oceanic Meliaticum rocks, are known at the base of the Szőlősardó Nappe and of the Torna Nappe of the South-Rudabányaicum. Weathered rocks are never involved in these melanges indicating that the thrust was immediately after the closure of the Meliata-Hallstatt Ocean or the thrusting began already during the southwards directed subduction, when already accreted parts can be overthrust. At the base of nappes of the North-Rudabányaicum and Silicicum as well as at the base of some Juvavic nappes in the Alps, beside of Meliaticum blocks (among them metamorphic basic and ultrabasic rocks of the Meliaticum with blue amphiboles), also blocks of shelf or slope deposits (mostly the pre-rift sequence of Scythian sandstones, marly limestones and Lower Anisian platform carbonates) are present in the Permian evaporitic melanges, among them also yellowish weathered carbonates. As these carbonates are also weathered in fresh outcrops (e. g. gypsum quarries), a long time of subaerial weathering is indicated before the southwards directed overthrust of the Silicicum. Moreover, these evaporitic melanges contain almost exclusively hard rocks of the Triassic oceanic se-quence, but only exceptional blocks of the Jurassic turbidites. These differences indicate that the nappes of the South-Rudabányaicum thrust northwards over the Meliaticum just after and partly perhaps already during the formation of the Meliaticum accretionary complex during the Cimmerian orogeny. The southwards thrust of the Silica Nappe was considerably later, in a time, where blueschist metamorphic rocks were already brought to the surface and parts of the Meliaticum were covered by nappes of the South-Rudabányaicum that were, however, to a large part already eroded. Moreover, in the time of the southwards thrust of the Silica Nappe, the Jurassic turbidites were to a large part already weathered and by this the hard blocks of the Triassic oceanic sequence (dismembered ophiolites, red radiolarites) within the Jurassic turbidites were strongly enriched at the overthrust surface.

This explanation of the occurrence of Meliaticum blocks at the base of the Silica Nappe involves no difficulties in the Western Carpathians, where the Silicicum is the highest nappe pile, lying in its present position south of or on the Meliaticum suture zone. However, evaporitic melanges are also present at the base of the Hallstatt nappes in the Eastern Alps that are situated north of the Meliaticum suture zone (wherever it is placed), and where the northward transport of the Hallstatt nappes is obvious. The only explanation is, that these Hallstatt nappes slid intra-Jurassic above remnants of the Meliata rift or above the suture zone, but subsequently, during the or immediately after the elevation of the suture zone area, they slid northward in the northward adjacent deep-water basin what is proven by field data (Plöchinger, 1979, 1984; Tollmann, 1981). In the Cretaceous, they were northwards transported on the back of the underlying superficial nappes. According to this explanation, however, a part of the Juvavicum must be rooted south of the Meliaticum. This would explain, why in parts of the Juvavicum thin distal Raibl Beds are present. So far, this fact was explained by the narrower shelves at the western end of the Meliata-Hallstatt Ocean.

The roots of the oceanic Meliaticum, its adjacent slopes and shelves in the Western Carpathians has been assumed often in the Rožňava Line (named by Reichwalder, 1971) south of the Gemericum (e. g. Maheľ, 1974, 1986). Consequently, the Gemericum was regarded as the Paleozoic basement of the Silica Nappe (Mello and Vozárová, 1984).

The suture character of the Rožňava Line was already recognized by Maheľ (1974). Kozur and Mock (1995) named this suture as Rožňava-Šugov Suture Zone because of the occurrence of large amounts of glaucophane schists in the Šugov Valley. It strikes E - W, in its western part NE - SW. The suture character of the Rožňava-Šugov Suture Zone south of the Gemericum was confirmed by new stratigraphic data indicating that the Meliaticum south of the Gemericum represents imbricated thrust sheets of a Bathonian to Callovian (? lower Oxfordian) accretionary complex. It was demonstrated that large parts of the mapped Scythian rocks of this area are in reality a Bathonian to Callovian flysch of this accretionary complex consisting of turbidites and olistostromes overlain by a coarsening upwards sequence. The well known oceanic Triassic rocks of the Meliaticum occur only as blocks or olistoliths in this Middle Jurassic flysch or are parts of melanges. As in the Florianikogel Nappe of the Eastern Alps, the amount of the Triassic rocks is subordinate against the Jurassic rocks, but in the Inner Western Carpathians the largest blocks of the oceanic Triassic are by far larger than those in the Eastern Alps. As the Triassic oceanic sequence consists predominantly of hard rocks (dismembered ophiolites, radiolarites, cherty limestones), but the Jurassic oceanic rocks consist predominantly of soft rocks (turbiditic shales and siltstones), in areas with bad outcrops often only the Triassic rocks of the Meliaticum can be found, even if they represent only a few percents of the amount of the Jurassic rocks.

The blocks of oceanic Triassic to Bajocian consist of very low grade to low grade metamorphic (HP/LT metamorphism) or unmetamorphic dismembered Middle Triassic to Cordevolian ophiolites and of a Middle Triassic to Bajocian oceanic sedimentary succession. The latter one consists of Pelsonian and Illyrian red pelagic limestones, partly with amygdoidal basalts, Ladinian to Cordevolian red ribbon radiolarites and red deep-sea shales, partly intercalated with pillow lavas, Upper Triassic variegated radiolarites and grey cherty limestones, grey pelagic Liassic limestones and shales, and Aalenian-Bajocian black, siliceous manganese shales, black and grey radiolarites. This situation is also present around the Meliata village, the Meliaticum type locality (Fig. 3).

Blocks of low-grade metamorphic (greenschist facies) lower Anisian light-coloured recrystallized shallow-water limestones and Scythian limestones, marls and shales of the same metamorphic degree are also present at some places in the Middle Jurassic accretionary complex. These rocks represent the pre-rift sequence preserved at the margins of the ocean.

The view that the Silica Nappe and other Inner Western Carpathian Mesozoic nappes have been derived from the Rožňava-Šugov Suture Zone and the northward adjacent Gemericum could not be confirmed. In the Šugov Valley, a slope facies of the Meliaticum is exposed that does not fit in the transition between the Meliaticum and the Silicicum, as does the North-Rudabányaicum with rock types both of the Meliaticum and of the Silicicum and interfingering between them (Kozur, 1991a, b). In the Bôrka Nappe (Leško and Varga, 1980) of the Šugov Valley, a sequence of glaucophane schists (originally basic magmatics, including pillow lavas, tuffs and basaltic agglomerates) and slope limestones with many shallow-water limestone blocks occur. Mello et al. (1983) assigned this sequence to the Meliaticum, and they proved a Carnian age for limestones overlying the glaucophane schists. The age of the blueschist HP/LT metamorphism was dated by Maluski et al. (1993) as about 160 - 150 Ma (see also Neubauer, 1994) confirming a largely Middle Jurassic subduction of the Meliata-Hallstatt Ocean with a final closure at the end of the lower Oxfordian, as shown by Kozur (1991a, b).

This sequence of the Bôrka Nappe (Fig. 1) is similar to the low-grade metamorphic Triassic envelope of the Gemericum that occurs in the western part of the Gemericum (Figs. 1 and 3). This Triassic envelope of the Gemericum has been assigned to the Carboniferous Dúbrava Fm. (Neubauer and Vozárová, 1990), but, as mentioned above, it contains *Paragondolella excelsa* (Mosher), a typical upper Anisian to lower Ladinian conodont species. This Gemeric Mesozoic envelope begins above continental Permian with Scythian sericitic phyllites. The conodont-dated Middle Triassic is characterized by light-coloured, recrystallized, usually shallow-water limestones with intercalations of basic metatuffs. This Triassic development is unique in the Western Carpathians and Alps. The presence of a low-grade metamorphic Triassic envelope of the Gemericum, totally different from any facies of the southern and northern shelves of the Meliaticum, excludes that the Gemerides are the Paleozoic basement of the Silica Nappe or any other nappe originating from the shelf of the Meliaticum. Moreover, the presence of a transitional facies from this envelope series to the Meliaticum at the southern margin of the Gemerides (Bôrka Nappe) is an evidence that the unmetamorphic Mesozoic nappes of the Inner Western Carpathians cannot be rooted in the Rožňava-Šugov Suture Zone.

Biely and Fusan (1967), Andrusov (1968), Kozur and Mock (1973a, b and later papers) did not root the Silica to Choč nappes in the Rožňava-Šugov Suture Zone, but between the Gemericum and Veporicum. The root zone was partly named as Gemeric Suture Line (Andrusov, 1968). However, the Gemeric Suture Line is a junior synonym of the Margecany-Lubeník Line, along which the Veporicum is underthrust below the Črmelicum. Therefore, the somewhat southwards adjacent suture zone between the Gemericum and the Črmelicum as root zone of the northern branch of the Meliaticum and of the Upper Slovakocarpathian nappes was named as the Folkmar Suture Zone by Kozur and Mock (1995).

Along the Folkmar Suture Zone, there are very large bodies of Middle Triassic dismembered ophiolites of the Meliaticum (e. g. ultrabasites of the former asbestos quarry at Dobšiná and ultrabasites and pillow lavas in the vicinity of Jaklovce). Ladinian red ribbon radiolarites and red shales interfingering with pillow lavas, as well as Anisian red pelagic limestones are known from Jaklovce (Kozur and Mock, 1985). Recent investigations have shown that these rocks of the Meliaticum are present also in several other places along the Folkmar Suture Zone, particularly in an old basalt quarry 1 km west of Košické Hámre and its surroundings, near Folkmar, and in the surroundings of Dobšiná. Moreover, also other rocks of the Meliaticum oceanic sequence occur, such as Upper Triassic cherty limestones and above all Middle Jurassic deep-sea sediments (greenish and black, partly marly shales, limestone breccias with belemnites). Low-grade metamorphic crystalline limestones (lower Anisian ?) of the prerift sequence are also present. They are well exposed in an old quarry at Jaklovce, where they are overlain by reddish to violet pelagic limestones and basalts. As in the Meliata type locality, the pelagic limestones fill numerous large fissures in the underlying crystalline limestone.

The dismembered ophiolites and the sedimentary oceanic rocks along the Folkmar Suture Zone were originally assigned to the lowermost Triassic (e. g. Andrusov, 1968), subsequently the ultrabasites and pillow lavas were regarded as Mesozoic (?Triassic, ?Jurassic) of unknown tectonic position (Bajaník et al., 1984), and only Mock recognized that these rocks are dismembered Ladinian to Cordevolian ophiolites of the Meliaticum (see Kozur and Mock, 1988, 1995). The Middle Jurassic rocks were mostly mapped as Scythian Werfen Beds, partly also as continental Permian (Bajaník et al., 1984), especially in the area around Dobšiná and between Jaklovce and Košické Hámre (most of the Meliaticum along the Folkmar Suture Zone, see Fig. 1).

Beside the typical oceanic Meliata development, an interesting slope facies is present that consists of bedded to massive shallow-water and pelagic limestones with intercalations of basic tuffs, basalts and basaltic agglomerates, overlain by thick basalts (Fig. 2, northern slope facies of the Gemericum). This sequence is especially well exposed in the above mentioned old basalt quarry, 1 km west of Košické Hámre. In the same outcrop and in its surroundings, rocks of the oceanic sequence are also present (e. g. Middle Triassic ultrabasites and pillow lavas, Ladinian red radiolarites, Aalenian to Bajocian black manganese shales, Middle Jurassic greenish grey, partly siliceous shales). The above mentioned slope sequence can be found also about 150 m W of the above mentioned old quarry at Jaklovce.

The above slope facies is transitional between the oceanic Meliaticum and the Triassic envelope of the Gemericum (Fig. 2). It is similar to the slope facies at the southern margin of the Gemericum (Bôrka Nappe), but unmetamorphic, anchimetamorphic or altered to greenschist facies.

The presence of a special slope facies at both the southern and northern margins of the Gemericum (transitional facies between the Triassic envelope of the Gemericum and the oceanic Meliaticum) and the presence of oceanic Meliaticum both south and north of the Gemericum indicate that the Gemericum was a block with continental crust within the oceanic Meliaticum (Figs. 3, 4). In its present position, the Gemericum is bordered by two Jurassic suture zones, the Folkmar Suture Zone in the north and the Rožňava-Šugov Suture Zone in the south (Kozur and Mock, 1995). West and east of the Gemericum, these suture zones merge into a single suture zone, the Rožňava-Folkmar Suture Zone (Kozur and Mock, 1995).

The two branches of the Meliata-Hallstatt Ocean, present in the meridian of the Gemericum, show some differences in their Jurassic successions. The Bathonian and Callovian rocks of the southern branch consist of distal, usually greenish-grey turbidites, which are overlain by a latest Callovian (? to lower Oxfordian) coarsening upwards sequence, and underlain by black manganese shales of Aalenian-Bajocian age. The matrix of these Jurassic rocks is carbonate-free, and radiolarites or silicified turbidites are common. Deposition below the CCD is indicated. In the Folkmar Suture Zone, black and greenish-grey Middle Jurassic deep-water shales are common, but turbidites and cherts in the Bathonian (Callovian rocks were not yet found) are very rare. The shales are sometimes carbonatic, and limestone breccias with belemnites are also present. Consequently, in certain levels deposition above the CCD is indicated.

The subduction history of both branches is also different. As already pointed out by Kozur and Mock (1988), the subduction of the Meliata-Hallstatt Ocean began in the latest Triassic, indicated by first turbidites in the upper Norian, Rhaetian and basal Liassic. The majority of turbidites is, however, of Bathonian and Callovian age. In the meridian of the Gemericum, Bathonian-Callovian turbidite-olistostrome complexes are only known from the southern branch of the Meliaticum. A southwards directed subduction is indicated by the presence of olistoliths of Middle Jurassic sandstones and acidic volcanics in the Middle Jurassic of the southern slope deposits of the entire Meliaticum (Kozur, 1991a, b). The Middle Jurassic of the northern slope and outer shelf is a deep water development from a passive margin sequence without turbidite-olistostrome units.

According a pers. comm. of Dr. R. Aubrecht, Bratislava, in late Rhaetian Zlambach Marls and in basal Liassic clastic deposits of the Silica Nappe near Bohúňovo, Slovakian Karst, dominating glaucophane-like blue amphiboles were found in the heavy mineral associations. However, repeating of the sampling in the same level (but not necessarily in the same beds) has not brought these blue amphiboles and therefore, for the moment, contamination cannot be excluded. If further sampling will confirm the presence of blue amphiboles near the Rhaetian-Liassic boundary in the Silica Nappe, a latest Triassic northwards directed aborted subduction in the northern branch of the Meliaticum would be indicated. A derivation of the blue amphiboles from the Gemericum is not possible, because the Gemericum s. str. was separated by the northern branch of the Meliata-Hallstatt Ocean from the sedimentation area of the Silica Nappe, and in the Črmelicum no HP/LT metamorphism is known. Moreover, the blue amphiboles of the Gemericum are mineralogically different (Dr. R. Aubrecht, pers. comm.). The clastic sediments disappear above the basal Liassic. The presence of clastic upper Rhaetian and lowermost Liassic beds in southern parts of the Silicicum speaks in favour of an aborted northwards directed subduction in the uppermost Triassic and lowermost Jurassic, even, if the mentioned blue amphiboles in the heavy mineral spectrum of these clastic sediments were a contamination and do not belong to these beds. Until the end of the Bathonian no further signs for subduction can be found in the northern branch of the Meliaticum. Younger sediments have not been found in the northern branch and no dated coarsening upwards sequence has been recognized up to now in the Meliaticum of the northern branch. The exact time of the final closure of the northern branch of the Meliaticum is therefore unknown. However, it must be younger than Bathonian and older than or as old as the uplift of the Silicicum in the middle Oxfordian. Thus, the final closure of the northern branch of the Meliaticum in the meridian of the Gemericum seemingly coincides with the final closure of the entire Meliata-Hallstatt Ocean in the middle Oxfordian.

The melange character of the Folkmar Suture Zone is obvious. Rocks of the Črmelicum, especially Permian and Lower Triassic sandstones, siltstones, shales, conglomerates, and rocks of the Meliaticum are involved in these melanges. This can be, for instance, observed south of Jaklovce in an area, where Bajaník et al. (1984) mapped Permian of the "Krompachy Unit". In this area, the "continental Permian" consists of numerous slices of Middle Triassic ultrabasites and less abundant deep water sediments of the Meliaticum that are juxtaposed with slices of Lower Triassic violet and grey sandstones and siltstones of the Črmelicum that we have dated by *Neoschizodus laevigatus* (von Ziethen) and *Unionites* sp. We have not found slices of Permian rocks in this area, but they may be present as well. The juxtaposition of slices of oceanic Meliaticum with slices of the slope facies between the Meliaticum and the Gemericum Triassic cover also indicates the melange character. In the Rožňava-Šugov Suture Zone the oceanic Meliaticum and the slope facies between the Meliaticum and the Gemericum Triassic cover are spatially separated.

The melange character with juxtaposition of blocks of Meliaticum and Črmelicum indicates horizontal movements along the Folkmar Suture Zone. However, this does not mean that the Gemericum was later squeezed into the Meliaticum, because slope deposits (with shallow water limestone blocks, basic volcanics and agglomerates), which are transitional between the Gemericum Triassic envelope and the oceanic Meliaticum, are present both at the southern and northern margins of the Gemericum. These slope deposits are totally different from the slope deposits of the North-Rudabányaicum and South-Rudabányaicum, with transitional facies to the adjacent foreland shelves. In the Rožňava-Šugov Suture Zone the slope sediments are always altered in blueschist facies. The same is the case in the Radzim Nappe (see below), a nappe on the Gemericum that originated from the Rožňava-Šugov Suture Zone. In the Folkmar Suture Zone, these slope deposits and basic volcanics are either unaltered or very low grade metamorphic. For this reason, the slope sequence of the Folkmar Suture Zone cannot be derived from the southern margin of the Gemerides by nappe transport, but only from the northern margin of the Gemerides that must be in this case also adjacent to a branch of the Meliata-Hallstatt Ocean, as the southern margin. Finally, if the Rožňava-Šugov Suture Zone was in the meridian of the Gemericum the only suture zone of the Meliaticum, then the Gemericum must be a part of the northern slope and shelf of the Meliaticum and the substratum of the Upper Permian to Jurassic North-Rudabányaicum and Silicicum. However, the Gemericum has a low-grade metamorphic Triassic cover series that occurs in the western part of the Gemericum (see Figs. 1 and 2). This Upper Permian and Triassic sequence is totally different from the northern slope and outer shelf deposits of the North-Rudabányaicum and Silicicum.

The Middle Triassic of the Bôrka Nappe (Leško and Varga, 1980) contains a sequence of glaucophane schists (originally basic magmatics, including pillow lavas, tuffs and basaltic agglomerates), slope limestones and many shallow-water limestone blocks. Mello et al. (1983) assigned this sequence to the Meliaticum (it is rather a typical slope sequence between the southern branch of the Meliata-Hallstatt Ocean and the Triassic shallow shelf of the Gemericum) and they proved a Carnian age for limestones overlying the glaucophane schists. The age of the blueschist HP/LT metamorphism was dated by Maluski et al. (1993) as about 160 - 150 Ma (see also Neubauer, 1994) confirming a largely Middle Jurassic subduction of

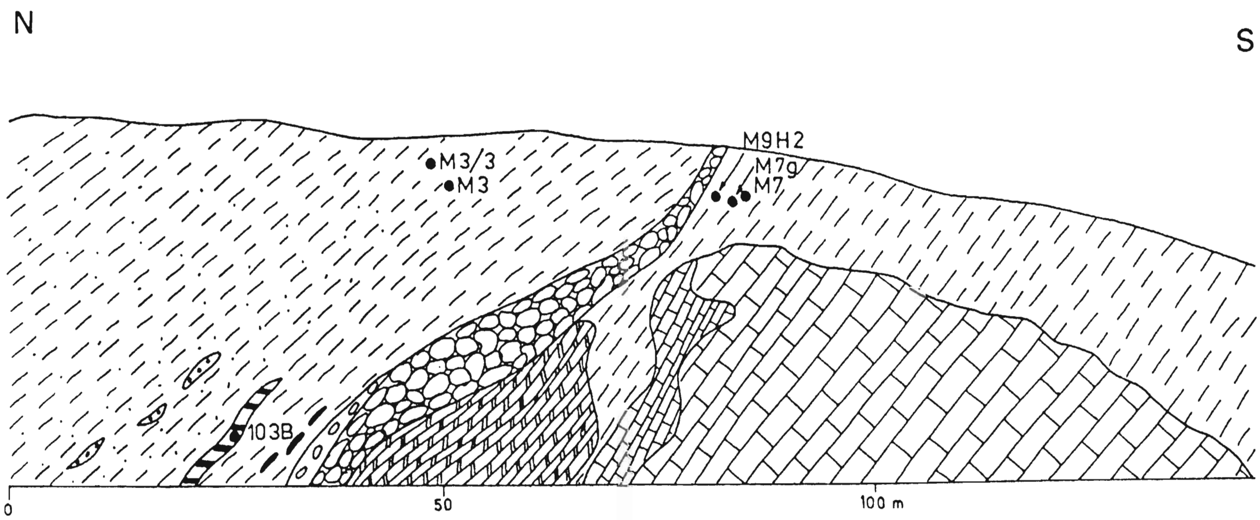

Fig. 3. Meliata type section after Kozur et al. (1996). Indicated sample numbers yielded rich Middle Jurassic radiolarian faunas described by Kozur et al. (1996). 1 - Greenish-grey distal turbidites (shales, siltstones with few radiolarite intercalations) of Bathonian to Callovian age, 2 - Proximal turbidites (shales, siltstones, sandstones, conglomerates) of Late Callovian to Early Oxfordian age, 3 - Olistoliths of pelagic dark Liassic limestones within the Bathonian-Callovian turbidites, 4 - Conglomeratic bodies within the proximal turbidites, 5 - Larger radiolarite intercalation at the boundary between the distal and proximal turbidites, 6 - Nearly matrix-free olistostrome of Carnian dark, cherty limestone olistoliths, 7 - Light-grey Late Norian limestone olistoliths within the Bathonian-Callovian turbidites, 8 - Red ribbon radiolarites of Ladinian age, 9 - Pelagic Pelsonian reddish limestones that penetrate in numerous fissure fillings in the underlying platform carbonates, 10 - White, recrystallized Early Anisian shallow-water limestones of the pre-rift sequence.

the Meliata-Hallstatt Ocean with a final closure in the middle Oxfordian as shown by Kozur (1991a, b). These slope deposits are totally different from the slope deposits of the North-Rudabányaicum and South-Rudabányaicum, with transitional facies between the Meliaticum and the adjacent foreland shelves.

During the blueschist metamorphism, the southern branch of the Meliata-Hallstatt Ocean in the meridian of the Gemericum was definitely closed, because the blueschists of Šugov Valley were derived from the northern slope of the southern branch of the Meliaticum at the southern margin of the Gemericum. Consequently, the Gemeric continental block had already collided with, and was partly underthrust beneath the continental crust south of the Meliaticum. In agreement with the southward directed subduction, the underthrusting of the continental block of the Gemericum was southward directed. This is clearly indicated by the metamorphism, which is blueschist metamorphism for the Triassic slope facies at the southern margin of the Gemericum (Bôrka Nappe of Šugov Valley), but maximally greenschist metamorphism (often anchimetamorphic or unmetamorphic rocks occur !) for the Triassic slope facies at the northern margin of the Gemericum (Folkmar Suture Zone).

In this connection the Radzim Nappe (introduced herein) is very interesting. It is located upon the northwestern part of the Gemericum (Fig. 1, R), only about 5 km SSW of the Folkmar Suture Zone at Dobšiná. The sequence corresponds to that of the Bôrka Nappe at the southern margin of the Gemericum and displays the same blueschist metamorphism as that nappe. The sequence begins with phyllitic slates and sandstones of Early Triassic age, overlain by Werfen Limestones. The Middle Triassic sequence consists of light-coloured limestones with some intercalations of grey limestones, diabase metatuffs and metabasalts. The basic volcanics are altered to glaucophane schists. The volcanics are dated as Middle Triassic by conodonts from intercalated limestones. This sequence is overlain by Upper Triassic dark platy limestones. It is tectonically overlain by a small, unmetamorphic remnant of the Silica Nappe consisting of Olenekian marly limestones, followed by Anisian Gutenstein Limestone, Steinalm Limestone (with intercalations of Schreyeralm Limestone) and Ladinian Wetterstein Limestone. The exceptional presence of HP/LT metamorphic rocks of the Meliaticum in such a northern position indicates a tectonic transport from the south. The northwards thrust of the Radzim Nappe was connected to the final closure of the Meliata-Hallstatt ocean during the middle Oxfordian. As the southern branch of the Meliata-Hallstatt Ocean in the meridian of the Gemericum was closed earlier (Callovian), the blueschists of the southern slope of the Gemericum may be already at the surface during the middle Oxfordian. The southwards directed thrust of the Silica Nappe on the Radzim Nappe was considerably later, during the Upper Cretaceous.

Gemericum

As mentioned above, the Gemericum is bordered by two Jurassic suture zones, the Folkmar Suture Zone in the north and the Rožňava-Šugov Suture Zone in the south (Fig. 1) that merge in the west (NW of Rakovä, south of Ploské) into one united suture zone, the Rožňava-Folkmár Suture Zone. Close to the southeastern corner of the Gemericum, the Folkmar Suture Zone and the Rožňava-Šugov Suture Zone also strongly converges, but their assumed branching area a little SW of Košice is covered by younger sediments and partly by higher nappes. Nevertheless, also east of Košice the Gemericum is no longer present and only one suture zone of the Meliaticum (Rožňava-Folkmár Suture Zone) is present. As the Gemericum is completely surrounded by suture zones with the oceanic Middle Triassic to Middle Jurassic sequence of the Meliaticum, it is regarded as an intra-oceanic continental block (see above, under Meliaticum).

For a long time, the Gemericum was regarded as an anticlinal structure of low-grade metamorphic Paleozoic rocks with Cambro-Ordovician beds in the core and Devonian to Carboniferous beds at the flanks. The rocks were assigned to the Gelnica and Rakovec series (or groups). Medium to high-grade metamorphic rocks in the southeastern Gemericum were assigned to the Klátov Unit. The Črmelicum was regarded as a part of the Gemericum, but it is separated by oceanic Meliaticum from the Gemericum (see above). For a detailed historical review of the lithostratigraphical subdivision see Grecula (1982).

Grecula (1965, 1971, 1973) and Grecula and Varga (1979) recognized the internal nappe structure of the Gemericum. Grecula and Varga (1979) separated a northern Rakovec Nappe and a southern Gelnica Nappe (the Gelnica town, however, lies in the northern Gemerides). A totally new lithostratigraphic subdivision, and on this basis, a new tectonic interpretation was given by Grecula (1982). He recognized several basement nappes and slices and regarded them as Hercynian nappes. The Črmeľ Nappe, which was assigned also to the Gemericum, we consider as part of the Črmelicum. Because it is separated from the Gemericum by slices of oceanic Triassic-Jurassic Meliaticum, this nappe is surely a post-Hercynian nappe. The basement nappes of the Gemericum s.str. are not separated by Permian and younger rocks and partly covered by a Triassic envelope unit. Therefore, we agree with Grecula (1982) that these nappes or slices are Hercynian structures with Alpine rejuvenation.

The age of the Lower Paleozoic sequences of the Gemericum is not well known. Only palynological data (Planderová and Snopková, 1979 in Grecula, 1982; Snopková and Snopko, 1979) are available from the Gemericum and they are in agreement with former age assignments of the lithostratigraphic units according to the anticlinal model. However, this does not prove the anticlinal model, but rather indicates that the palynomorphs are so badly preserved that the former age assignment influenced the determination of the palynoflora. This can be observed also in the metamorphic Meliaticum, in which Jurassic rocks, now well dated by radiolarians, were assigned to the Devonian, Permian or Triassic, always in agreement with former age assignments of these rocks. As also the so far known radiometric data are inconsistent, the consistent lithostratigraphic subdivision of the Lower Paleozoic of the Gemericum by Grecula (1982) was a very important step towards the better understanding of the complicated tectonical structure of the Gemericum.

Three formations were discriminated by Grecula (1982), the Betliar Fm., the Smolník Fm. and the Hlinec Fm. The Betliar Fm. consists of black, rarely greyish-green, laminated, graphitic-sericitic phyllites with intercalations of fine-grained metapsammites. In the upper Betliar Formation, a consistent lydite horizon with some acidic to intermediate volcaniclastics and a locally developed limestone horizon with some basic volcaniclastics are present. Palynological data (Planderová and Snopková, 1979 in Grecula, 1982; Snopko and Snopková, 1979) indicate a Late Silurian to Early Devonian age for the upper Betliar Fm. First dissolvings of lydites for conodonts yielded only badly preserved Muellerisphaerida of Late Silurian age.

The Smolník Fm. consists mainly of greenish, rarely violet phyllites with intercalations of greenish or grey metapsammites as well as basic and acidic volcanics and volcaniclastics. The age of this formation is unknown. Grecula (1982) assumed Early to Middle Devonian age on the base of stratigraphic superposition on the Betliar Fm.

The Hnilec Fm. consists mainly of acidic and intermediate volcanics and volcaniclastics (e. g. Gelnica Porphyroid Complex), basic volcanics (e. g. Rakovec Diabase Complex, Klátov amphibolites) and black phyllites and metapsammites. The age of this formation is unknown. According to Grecula (1982), it is Late Devonian to earliest Carboniferous, but radiometric data (Semenenko et al., 1977) are dispersed between 430 Ma and 350 Ma (Upper Silurian to lowermost Carboniferous). May be that different units are united into this formation. As in Europe porphyroids are mainly of Ordovician age, such an age is assumed or not excluded by some authors (e.g. Fusán et al., 1955; Andrusov, 1964). Sequences, rich in diabases, but without lydites and limestones in the accompanying shales (phyllites) have in the Eastern Alps often an Ordovician age as already stated by Andrusov (1953) who assigned in that time the Rakovec Diabase Complex to the Ordovician. The majority of the authors assigned this complex to the Devonian (e. g. Fusán et al., 1955; Andrusov, 1965; Grecula, 1982) or to the Lower Carboniferous (Fusán et al., 1953), but none of the assumed ages is fossil proven or confirmed by consistent radiometric data.

Especially characteristic are the black lydites and black shales of the upper Betliar Formation that occur in the same lithostratigraphic succession with under- and overlying beds in different nappes or slices. By this, the imbricated structure of the Gemericum can be well demonstrated (Grecula, 1982). He distinguished within the herein used Gemericum s. str. the Rakovec, Kojšov and Mníšek nappes (northern nappe group, former Rakovec Nappe of Grecula and Varga, 1979) and the Prakovce, Humel, Medzev and Jedľovec nappes (southern nappe group, former Gelnica Nappe of Grecula and Varga, 1979). According to Grecula (1982), these Hercynian nappes are fold nappes with a low distance transport; they may be partly tectonic slices, but this is a matter of convention.

Surprisingly, in the map by Bajaník et al. (1984) again the old hypothesis of a single anticlinal structure for the

Gemericum was applied. Based on this assumption, the identical lithostratigraphic horizon of the black lydites (upper Betliar Formation) was assigned to the Lower-Middle Silurian in the assumed core of the anticline, but on the assumed flanks of the anticline, the same beds have been assigned to the Upper Silurian and more "outside" to the Lower Devonian. The different age assignments for the same lithostratigraphic unit in Bajaník et al. (1984) is not supported by any geological data and also not by reliable biostratigraphic or radiomatric data.

As demonstrated by Grecula (1982), the Rakovec Nappe in the northern marginal part of the Gemericum is a remnant of a Hercynian oceanic belt with MORB basalts and an incomplete ophiolitic sequence. The Kojšov and Mníšek nappes have according to Grecula (1982) an oceanic island type of volcanism and the other nappes derived from an area with thinned continental crust.

The Gemericum has a Triassic envelope consisting of low grade metamorphic Lower Triassic sericitic phyllites, chlorite slates, marly limestones and above all of light-coloured crystalline Middle Triassic limestones with layers of diabase tuffs (Fig. 2). These beds have been up to now regarded as Carboniferous Dúbrava Beds, but a conodont fauna with *Paragondolella excelsa* (Mosher) indicates a Middle Triassic age.

The contemporaneous occurrence of middle Anisian to Cordevolian ophiolites in the Meliaticum, of basaltic agglomerates and basalts at the northern and southern slopes of the Gemericum, and of basaltic tuffs in the Gemeric Triassic envelope series indicate that a tensional regime prevailed in the Gemericum during the Middle Triassic to Cordevolian sea-floor spreading in the two branches of the Meliaticum to the north and to the south of the Gemericum. The presence of transitional facies between the Triassic Gemeric envelope series and the Meliaticum at both the northern and southern margin of the Gemericum (Figs. 2), and the large amounts of basalts and basaltic agglomerates in this facies confirms the view that the Gemericum was in the Triassic and Jurassic a continental block within the Meliata-Hallstatt Ocean (see under Meliaticum and Figs. 4, 5).

4. Late Permian and Early Mesozoic development of the Central and Inner Western Carpathians (Figs. 4, 5)

After the Hercynian orogeny, the entire area of the Western Carpathians was during the Lower Permian a subaerial denudation area or continental sedimentation area. The later Tatricum was a denudation area, whereas in the later Veporicum and in the Inner Western Carpathians partly thick Lower Permian continental sequences were deposited. Permian volcanism occurred mainly in areas with greater thickness of sediments, as in the extra-Tethyan Hercynian intramontane basins, apparently related to Hercynian fault zones. Melaphyres occur only in areas with thick Lower Permian deposits (e. g. Choč Nappe). The Late Permian age of the Choč Nappe melaphyres could not be confirmed. The sediments above the melaphyres yielded Middle Permian sporomorphs, but these sediments overlie the melaphyre-bearing sequences after a gap. Therefore the melaphyres can be assigned to the Lower Permian as in other Middle European molasse basins.

In the Late Permian, the continental rifting began in the area of the later Meliaticum and its outer shelves (South-Rudabányaicum, North-Rudabányaicum, Silicicum). Hypersaline marine deposits, in the Western Carpathians mainly without halite, but rich in gypsum, were deposited. First basic volcanics are present. North of this area, the Upper Permian is characterized by subaerial denudation, but few terrestrial Permian sediments (undated red conglomerates and sandstones below Lower Triassic rocks) may be also present. Also south of the Upper Permian hypersaline rift basin a continental area (with Permian continental Red Beds) is present (Brusník Nappe of the South-Rudabányaicum). On highs within the rift basin, the hypersaline marine Upper Permian is also missing or replaced by continental Red Beds (Gemericum and Meliaticum slope facies at the southern and northern margin of the Gemericum).

The Scythian paleogeography follows the Late Permian one, but the marine transgression prograded toward the north. The basin axis was in the area of the later Meliata-Hallstatt Ocean, but also there only shallow-water deposits occur; however, lower Scythian limestones and marls are present (Kozur and Mock, in prep.). In the South-Rudabányaicum, North-Rudabányaicum and Silicicum, lower Scythian marine sandstones and siltstones with few limestone intercalations are present. The upper Scythian (upper Olenekian) sediments consist of limestones and marls. Toward the north, in the Hronicum and in the Črmeľ Nappe, the continental Permian is overlain by thin continental Buntsandstein, followed by shallow-marine sandstones and siltstones of early Scythian age. The upper Scythian sediments are represented by limestones, marls and shales. The marine transgression in the Scythian of the Inner and Central Western Carpathians was latest in the Tatricum, where shale intercalations of the Scythian basal conglomerates yielded middle Scythian (lower Olenekian) sporomorphs (Fuglewicz, 1979). Only the upper Scythian of the Tatricum is marine, but sandstones and siltstones are present in contrast to the limey-marly facies in the southern units.

In the lower Anisian the entire area of the Inner and Central Western Carpathians formed an uniformly sinking carbonate platform, on which thick limestones and dolomites were deposited that are free of any terrigenous clastic input. In some shallow restricted intraplatform basins both in the Inner and Central West Carpathians, black "Gutenstein Limestone" was deposited.

During the upper part of lower Anisian (upper Bithynian) and in the lower Pelsonian, rifting began at first in the South-Rudabányaicum or at the boundary between this later southern slope unit and the Meliaticum. There began a fast, but continuous subsidence and radiolarian mudstones, siltstones and grey pelagic marly limestones and dolomitic marls were deposited. There was not yet an open connection to the world ocean because these beds have a restricted basin fauna and they are often dysaerobic, sometimes euxinic. First Triassic volcanics are known from that time interval. Contemporaneously, the crustal mobility became higher in the area south of the later Meliata-Hallstatt Ocean. There, block faulting connected with acidic, intermediate and basic volcanism occurred. This distinctly higher crustal mobility is indicated by input of terrigenous, silty-shaly, especially in the South-Rudabányaicum of the Alps also sandy material and clasts of acidic, intermediate and basic volcanics as well as by the sedimentation of tuffitic material.

Sea-floor spreading in the Meliaticum began during the Pelsonian. Very rapid subsidence and a strongly extensional regime is indicated by reddish pelagic limestones abruptly overlying the shallow-water limestones, and by numerous fissures in the shallow-water limestones that are filled by that reddish pelagic limestones. First pillow lavas and ultrabasites are known from that time interval (Kozur and Mock, 1988; Kozur and Mostler, 1992). On the northern slope of the Meliaticum, a similar rapid subsidence began, but volcanics are missing. On the southern slope, the pelagic sedimentation with some volcanism continued. On the northern shelf of the Meliata-Hallstatt Ocean, platform sedimentation continued, but some intraplatform basins opened. In the entire Central Western Carpathians deposition on a carbonate platform continued. Few shallow intraplatform basins are present. In the Illyrian, the Pelsonian conditions continued.

During the Ladinian (Fig. 4), the rate of the sea-floor spreading reached its maximum. Most of the pillow lava-chert successions of the Meliaticum have a Ladinian age. In the intraoceanic continental block of the Gemericum, the entire Middle Triassic is characterized by shallow-water, light-coloured limestones with some layers of basic tuffs. Toward the Meliaticum, both on the southern and northern slope of the Gemericum, this succession changed into pelagic slope limestone with shallow-water blocks and increasing amounts of basaltic tuffs, agglomerates and basalts. In the contrast, on the slopes of the northern and southern shelves of the Meliaticum, continuous pelagic conditions, at the southern slope with some volcanic activities, on the northern slope without volcanic activities prevailed, and the red radiolarite facies of the Meliaticum interfingers in a certain interval (upper part of lower Ladinian to Cordevolian) with cherty limestones. On the northern shelf, the carbonate platform with some intraplatform basins continued. On the outer shelf (Silicicum), there is a tendency for a shallowing within the Upper Ladinian and Cordevolian. Some of the intraplatform basins are overlain by shallow-water Wetterstein Limestones. In contrast, on the inner shelf (Hronicum) shallow-water carbonates are more and more replaced during the Upper Ladinian by pelagic Reifling Limestone from rather wide and open intraplatform basins. Such pelagic deposits can be also found on the adjacent part of the Veporicum, whereas in the other areas of the Central Western Carpathians the sedimentation of platform carbonates continued. The described general situation of the Ladinian continued in the Cordevolian.

A very distinct change occurred in the middle Carnian (Raibl event). In the Meliaticum, the sea-floor spreading ended (no basic magmatics younger than Cordevolian are known), and variegated cherts or cherty limestone overlie the oceanic crust or red radiolarites of Ladinian to Cordevolian age. Middle Carnian distal clastic Raibl Beds (marls, shales, siltstones) reached from the south until the southern slope of the Meliaticum, but the pelagic sedimentation was not interrupted. On the northern slope, the pelagic sedimentation and on the outer shelf (Silicicum), the carbonate platform sedimentation without any clastic influx continued. However, the inner shelf (Hronicum) was affected by clastic input (Lunz Beds) from the north. In the Muránicum thin distal Lunz Beds (marls, shales, siltstones) are present. Clastic Lunz beds are also present in the entire Central Western Carpathians, but in the South Penninicum and on its margins, Upper Triassic is absent due to a strong earliest Liassic uplift with strong subaerial denudation. At least parts of this area may belong to an Upper Triassic denudation area.

In the upper Carnian and Norian, the deep pelagic sedimentation continued in the Meliaticum and its slopes. On the northern outer shelf (Silicicum) a distinct subsidence can be observed caused by crustal cooling after the end of the sea-floor spreading in the Meliata-Hallstatt Ocean. This subsidence was probably also present on the slopes, and on the southern outer shelf, but within the continuous pelagic sedimentation of these units this subsidence is not recognizable. In the contrast, the inner shelf (Hronicum) is characterized by low subsidence, following a slight uplift or stagnation of subsidence, and dolomites were deposited. In the southern Veporicum, the same depositional history can be observed. In the remainder of the Central Western Carpathians, the upper Carnian and Norian is characterized by very low subsidence or slight uplift. In the South Penninicum and the adjacent northernmost Veporicum as well as in the southernmost units of the Tatricum, pre-Rhaetian Upper Triassic is missing and at least in parts of these areas subaerial denudation during this time interval can be assumed that removed partly all Triassic rocks. Toward the south (northern Veporicum) and toward the north (Fatricum, Tatricum) continental-lagoonal Carpathian Keuper was deposited.

In the Rhaetian distinct changes in the tectonofacies can be observed. Tectonic unrest, connected with the beginning of an assumed aborted northward-directed subduction in the northern branch of the Meliata-Hallstatt Ocean (and outside the meridian of the Gemericum at the northern margin of the Meliata-Hallstatt Ocean) lead to increasing input of terrigenous material, and the starved sedimentation of the Hallstatt Limestone on the northern slope and outer shelf was replaced by Zlambach Marls. From the Hronicum in the south to the Krížna Nappe in the north, the Rhaetian is characterized by a transgression, indicated by the deposition of Kössen beds above Hauptdolomit or a thin Dachstein Limestone intercalation, above continental-lagoonal Carpathian Keuper or after a gap caused by subaerial denudation. Only in the Tatricum the

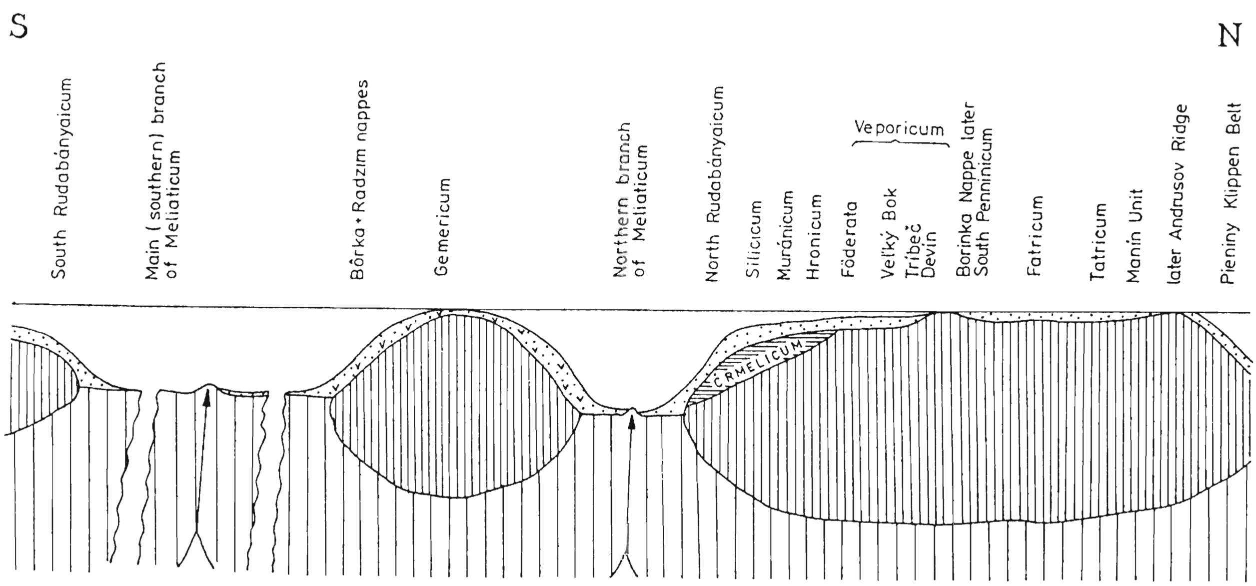

Fig. 4. Schematic cross section from the South Rudabányaicum (southern slope and outer shelf of the Meliata Ocean) to the southern part of the Pieniny Klippen Belt in the meridian of the Gemericum during the Ladinian. Not at scale. Continental blocks strongly exaggerated. Sea-floor spreading in the southern and northern branches of the Meliata Ocean. Basic volcanism on the slopes of the Gemericum and to a lesser degree in the envelope series of the Gemericum. South Penninic Ocean not yet present. Pieniny Klippen Belt was a deep water belt with connections to the east.

Rhaetian is mainly continental or a continental denudation area was present. The Tatricum (with exception of its southernmost units) was neither reached by the Rhaetian transgression from the south nor by marine Rhaetian from the north (Pieniny Klippen Belt).

In the basal Liassic, the assumed aborted subduction in the northern branch of the Meliata-Hallstatt Ocean continued and clastic beds were furthermore deposited in the southern parts of the Silica Nappe. Above this basal horizon, the Liassic is transgressive and the water depth become successively greater. The northern margin of the Meliata-Hallstatt Ocean changed into a passive margin (or remained a passive margin, if the assumed aborted northwards directed subduction was not present). In the Choč Nappe the Liassic is transgressive, and crinoid-bearing cherty limestones above Lower Liassic crinoid limestones indicate successive subsidence. In the northern Veporicum a very short uplift at the base of the Jurassic removed in many places the marine Rhaetian. This uplift is followed by a transgression. In the northernmost Veporicum and adjacent marginal parts of the South Penninicum the uplift at the base of the Jurassic was very pronounced and not only the Rhaetian, but also the Carnian and Norian sediments (if deposited) were removed, before the Liassic transgression began with coarse breccias. This short, but very pronounced uplift preceded seemingly the beginning of the oceanic Jurassic rifting in the South Penninicum. The Liassic of the Fatricum and Tatricum is transgressive, but in parts of the Tatricum the entire Liassic remains clastic, and in parts of the northern Tatricum the transgression began only in the Dogger. As in the northernmost Veporicum, in the southernmost Tatricum a distinct uplift was present in the earliest Liassic that caused strong subaerial denudation. By this, the Upper Triassic sediments (if deposited) were removed and partly all Triassic deposits were eroded before the beginning of the Liassic transgression. This strong uplift on both sides of the later South Penninic Ocean immediately before the beginning of the rifting in this ocean indicates that this rifting began in the axial zone of an uplift. The upper Liassic of the Fatricum is already pelagic.

The Dogger is characterized by a southward directed subduction of the Meliaticum in the Bathonian and Callovian and by oceanic sea-floor spreading in the South Penninicum (Fig. 5). The adjacent areas are strongly influenced by these events. The Bathonian and Callovian sequences at the southern margin of the Meliata-Hallstatt Ocean (or of its southern branch in the meridian of the Gemericum) are characterized by turbidites and olistostromes. Turbidites and olistostromes with large sandstone olistoliths and acidic volcanics (partly olistoliths) are present also on the adjacent southern slope of the Meliata-Hallstatt Ocean, indicating the presence of a volcanic island arc. The northern slope and outer shelf of the northern branch of the Meliata-Hallstatt Ocean is characterized by pelagic sedimentation and continuous subsidence at a passive margin. Bathonian and Callovian are there often represented by radiolarites.

The Dogger of the South Penninicum is characterized by mafic and ultramafic rocks of the oceanic sequence and by Bündnerschiefer as well as radiolarites. In marginal parts, scarp breccias and turbidites are present. Silicicum, Muránicum, Hronicum and Veporicum, the common shelf of the Meliata-Hallstatt Ocean in the south and the South Penninic Ocean in the north, are characterized by pelagic sediments (above all cherty limestones and radio-

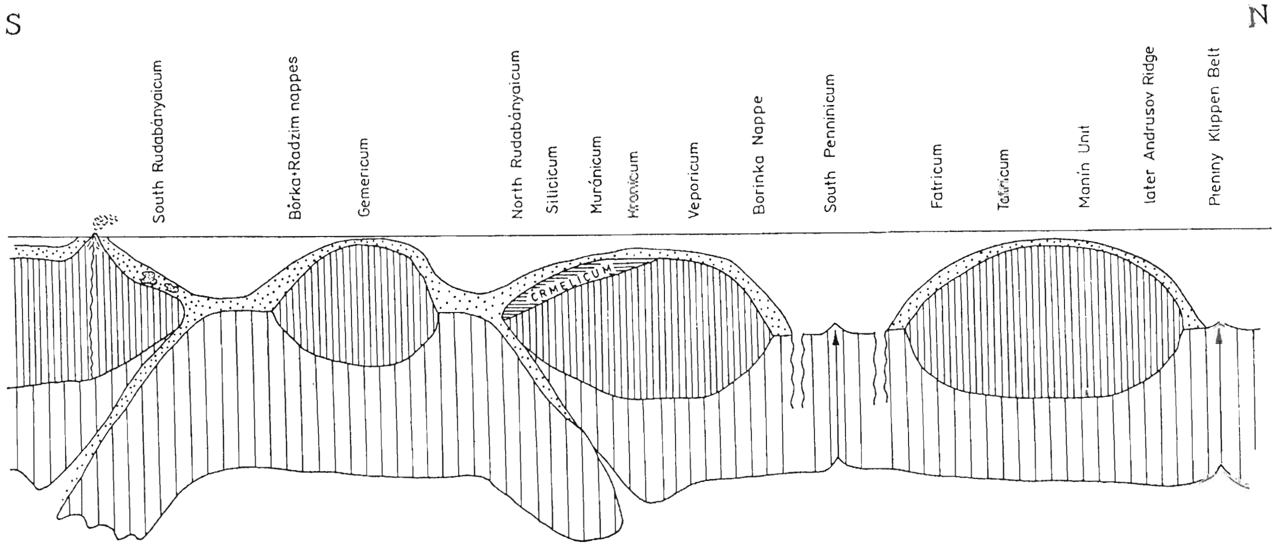

Fig. 5. Schematic cross section from the South Rudabányaicum to the southern part of the Pieniny Klippen Belt in the meridian of the Gemericum during the Bathonian. Not at scale. Continental blocks strongly exaggerated. Sea-floor spreading in the South Penninicum and in the Pieniny Klippen Belt. Active, southwards-directed subduction zone at the southern margin of the Meliata Ocean. Inactive Rhaetian-earliest Liassic subduction zone at the northern margin of the northern branch of the Meliaticum.

larites). Cherty limestones and radiolarites characterize the Middle Jurassic deep-water sequence of the Fatricum north of the South Penninicum. Shallow-water and pelagic limestones, cherty limestones and condensed red limestones of the Dogger in the Tatricum indicate that this area was a submarine ridge between the deep-sea developments of the South Penninicum and the Pieniny Ocean.

The middle Oxfordian is characterized by the final closure of the Meliata-Hallstatt Ocean. Upper Oxfordian deposits are missing from the Meliaticum and adjacent slope units. Contemporaneously, the lower Oxfordian radiolarites of the Silica Nappe are overlain by upper Oxfordian shallow-water limestones indicating that this area was involved in the uplift around the Meliata suture zone that was caused by crustal thickening due to the collision.

In the Choč Nappe, the pelagic development continued throughout the Upper Jurassic and Neocomian and the sedimentation ended in the Upper Neocomian. After the final closure of the Meliata-Hallstatt Ocean in the middle Oxfordian, the upper Oxfordian-Neocomian history of the Choč Nappe was that of the southern inner shelf of the South Penninic Ocean at the margin of an elevated area around the Meliata suture zone.

The oldest nappe thrusting in the Western Carpathians was related to the Bathonian-lower Oxfordian southward directed subduction of the Meliata-Hallstatt Ocean, and to its middle Oxfordian final closure. In this northwards directed nappe thrusting the South-Rudabányaicum thrust on the Meliaticum and part of the Meliaticum (Radzim Nappe) on the Gemericum. During the middle Oxfordian collision, shear zones were created in the Inner Western Carpathians north of the Meliaticum that were during the Upper Cretaceous reactivated as thrust planes.

In a large part of the Veporicum, the sedimentation ended, as in the Choč Nappe, at the end of the Neocomian. Related to the southward-directed subduction of the adjacent South Penninic Ocean, the Veporicum was underthrust beneath the Inner Western Carpathians. By this process, the crystalline basement and the low-grade metamorphic Paleozoic of the latter unit were detached from the Permo-Mesozoic envelope and from each other, and underthrust beneath the northern Meliata suture and the Gemerides. This process caused the above mentioned end of the sedimentation in the northern units of the Inner Western Carpathians and in most of the Veporicum except its northern marginal units. In the Aptian to lower Cenomanian time also these units were overthrust by the Hronicum.

The subduction of the South Penninic Ocean lasted until the Turonian. In the lower Turonian, an uplift occurred in the Fatricum and by this, the sedimentation in the Krížna Nappe ended at the top of the Cenomanian. In the upper Turonian, the Krížna Nappe gravitationally slid upon the Tatricum, immediately followed by overthrusting of the Choč Nappe over the Krížna Nappe (Plašienka, 1995). In that time (immediately after the Turonian), the South Penninic Ocean of the Western Carpathians was surely closed (only in eastern Slovakia, its closure may be later), but the subduction of the Pieniny Ocean below the Central Western Carpathians continued.

5. Age of the nappe formation in the Western Carpathians

Neubauer (1994) published a detailed analysis about the age of the nappe thrusting in the Eastern Alps and Western Carpathians and he came to the conclusion that the age of the nappe thrusting decreases more or less continuously from the highest toward the lowest tectonic units, if these units were not overprinted by younger thrust processes. With some modifications, we can confirm this view. However, the different age of the nappe thrusting depends not only on the tectonic superposition, but also on the involvement in the nappe thrusting triggered by subduction of different oceans and from the geographic position during the nappe thrusting. For instance, the Choč Nappe of the Hronicum with nappes of the northern Muránicum (e. g. Strážov Nappe) on its back, form the highest nappe pile above the Tatricum, Fatricum and Veporicum. However, this tectonically highest nappe pile was thrust upon the tectonically much deeper Krížna Nappe later than this nappe thrust upon the Tatricum. The Choč Nappe could not thrust over the Krížna Nappe (rooted north of the South Penninicum) before the South Penninic Ocean was closed. Moreover, the nappe thrusting become not only more or less continuously younger in the lower tectonic units, but sometimes distinctly discontinuously younger with a considerably time break between the thrusting of nappes, immediately overlying each other, or with reversed time succession of the thrusting, as in the above mentioned example.

The oldest post-Hercynian nappe thrusting in the Western Carpathians occurred in the southernmost units of the Inner Western Carpathians. In connection with the southwards directed subduction of the Meliata-Hallstatt Ocean during the Bathonian to lower Oxfordian interval, the South-Rudabányicum thrust northward on the accretionary complex of the Meliaticum. This nappe thrust culminated during the middle Oxfordian final closure of the Meliata-Hallstatt Ocean. In this time also parts of the Meliaticum accretionary complex thrust on the northwards adjacing Gemericum. This earliest nappe thrusting in the South-Rudabányaicum is in agreement with the view of Neubauer (1994) that the South-Rudabányaicum as southernmost unit of the Western Carpathians must be the oldest nappe pile despite of the fact that he has not given data for that thrusting, but only for the next younger thrusting of the underlying Meliaticum upon the Gemericum, for which he assumed 160 - 150 Ma. This latter age is that of the blueschist metamorphism of the Bôrka Nappe. This age indicates the end of the subduction of the southern main branch of the Meliaticum by collision of the continental splinter of the Gemericum with the southern foreland of the Meliata-Hallstatt Ocean. By this process, the Gemericum was thrust under the accretionary complex of the Meliaticum and the southern foreland of the former Meliata-Hallstatt Ocean. The transition area of the southern Gemericum to the Meliaticum (original place of the Bôrka Nappe) was during this process so deeply buried that blueschist metamorphism occurred. This process, however, does not post-date the thrusting of the Silicicum as shown in the scheme by Neubauer (1994), but it considerably pre-date the southwards thrust of the Silica Nappe that is related to a younger subduction process of an other ocean (Szarvaskő Ocean). The southward thrust of the Silica Nappe during pre-Gosauan time was related to the Cretaceous northwards directed subduction of the Szarvaskő Ocean south of the Inner Western Carpathians. In that time, the southwards directed thrusting affected all southern units of the Inner Western Carpathians and the immediately southwards adjacent units (e. g. Fennsíkum in the Bükk Mts.). By this southwards directed nappe thrusting, Inner Western Carpathian units partly overthrust southwards adjacent units (e. g. Darnó Nappe of the Meliaticum on Fennsíkum). However, this unusual southern position of an Inner Western Carpathian unit may be also caused by rejuvenation of the thrust planes during the Tertiary. The northernmost unit of the Inner Western Carpathians that was southwards thrust, is the Opátka Nappe that is only slightly detached (maximally 5 km) from its Črmelicum basement. This thrusting, however, was not related to the (earlier) southwards thrusting of the Silica Nappe, but is only a late (? Tertiary) slight detachment of the Middle Triassic to Carnian cover of the Črmeľ Nappe.

The northern units of the Inner Western Carpathians and the Central Carpathians units were northward thrust during the Upper Cretaceous in connection with the southwards directed subduction of the Penninic Ocean.

The underthrusting of large parts of the Veporicum below the northern part of the Inner Western Carpathians connected with the detachment of the high-grade metamorphic crystalline basement and the low-grade metamorphic Paleozoic rocks of the Črmelicum from each other and from the Permian-Mesozoic envelope (Hronicum) was near the Barremian/Aptian boundary (around 120 - 125 Ma), indicated by the end of the sedimentation in the underthrust and low-grade metamorphic Veľký Bok envelope unit of northern (but not northernmost) Veporicum at the end of the Neocomian. Because this underthrusting caused uplift (by crustal thickening) in the overlying unit, the sedimentation ends also in the Choč Nappe during the upper Neocomian.

The thrusting time of the Veporicum is discontinuously younger than the thrusting time of the Meliaticum and of the South Rudabányicum, separated by a time gap of more than 30 Ma. This is caused by the fact that these nappe thrustings are related to the subduction of different oceans, the Meliata-Hallstatt Ocean and the South Penninic Ocean respectively.

The following, originally northward adjacent more lower tectonic units fit fully in Neubauer's model. In units that belong to the northernmost parts of the Veporicum (within the Malé Karpaty, Tríbeč, Považský Inovec Mts.), the sedimentation ranges higher, up to the Albian. The thrust plane between the exposed parts of the South Penninic units and the northernmost Veporic units is latest Turonian to earliest Coniacian in age, because in the Belice Unit below the northernmost Veporicum of the Považský Inovec Mts. Turonian is still present. However, the closure of the South Penninic Ocean must be soon after this time, because immediately after the upper Turonian thrusting of the Krížna Nappe over the Tatricum, the Krížna Nappe was overthrust by the Choč Nappe of Inner Western Carpathian origin that could not thrust through an open South Penninic Ocean. In eastern

Slovakia, the South Penninic Ocean may stay open longer, perhaps until the Early Tertiary.

A deviation from the model by Neubauer (1994) is the upper Turonian thrusting of the Krížna Nappe over the Tatricum immediately followed by the post-Turonian thrusting of the tectonically much higher Choč Nappe upon the Krížna Nappe. However, this deviation is caused by the fact that these nappe thrustings are related to the subduction of different oceans, in this case to the subduction of the South Penninic Ocean and the North Penninic Ocean (Pieniny Ocean) respectively. The thrusting of the Krížna Nappe was related to the subduction of the Pieniny Ocean that was already active since pre-Albian Early Cretaceous time as indicated by the transport of exotic pebbles from the Andrusov Ridge to the Tatricum and Fatricum during Albian time. The thrusting of the Choč Nappe is at first related to the subduction of the South Penninic Ocean and this thrusting over Veporic units started seemingly in the latest Lower Cretaceous in agreement with the model of Neubauer (1994). However, the Choč Nappe could not thrust over the Krížna Nappe before the South Penninic Ocean was closed because the Krížna Nappe was rooted north of this ocean. The thrusting of the Choč Nappe over the Krížna Nappe after the closure of the South Penninic ocean was either related to this closure or to the subduction of the Pieniny Ocean that ended much later.

6. Correlation of the Inner Western Carpathians with the Eastern Alps

(Tab. 1)

About for a century, the tectonic models of the Alps have been successfully or erroneously overtaken in the Western Carpathians or they have at least greatly influenced the models elaborated in the Western Carpathians. In the past few years, new models of the tectonic evolution and paleogeography in the Early Mesozoic of the Western Carpathians, especially in connection with the Meliaticum, have strongly influenced tectonic and paleogeographic models in the Eastern Alps (e. g. Kozur, 1989b, 1991a, b; Mandl and Ondrejičková 1991, 1993; Kozur and Mostler, 1992; Mandl, 1992; Gawlick, 1993a, b; Neubauer 1994).

Tab. 1
Correlation of Inner Western Carpathian and East-Alpine tectonic units

Inner Western Carpathians	Eastern Alps
Črmelicum	Veitsch Nappe
Gemericum	part of the Noric Nappe and Western Grauwackenzone
Čierny Váh Subunit	Lower Bajuvaricum (e. g. Frankenfels Nappe)
Hronicum	
Biely Váh Subunit	Upper Bajuvaricum (e. g. Lunz Nappe)
Strážov and Nedzov n.	Traunalpen facies of the Tirolicum
Muránicum	
Muráň and Stratená n.	Triesting facies and Ötscher facies of the Tirolicum
Silica Nappe	Juvavicum (upper Carnian to Norian Hallstatt facies)
Rudabánya Nappe	Juvavicum (upper Anisian to Norian Hallstatt facies)
Meliaticum	Meliaticum, e. g. Florianikogel Nappe
Szőlősardó Nappe	Geyerstein Nappe
Torna Nappe	unnamed low grade metamorphic South-Rudabányaicum at Edenhof section (Kozur and Mostler, 1992)
Brusník Nappe	no known equivalents

New stratigraphic and tectonic results concerning the Meliaticum and its southern slope in the Eastern Alps (Mandl and Ondrejičková, 1991, 1993; Kozur and Mostler, 1992; Gawlick, 1993a, b,) and new results in the Inner Western Carpathians (chapter 3) facilitate the correlation of the Inner Western Carpathians with the Eastern Alps. The key question remains the position of the Meliata-Hallstatt Ocean and connected with this problem the position of the root zone of the Northern Calcareous Alps. In the Eastern Alps, the Northern Calcareous Alps were either rooted near the Periadriatic Line north or east of the Licicum (Drauzug and its eastern continuation, e. g. Tollmann, 1977, 1986, 1988, 1989, 1990; Fuchs, 1985; Neubauer, 1994) or north of a Central Alpine Ridge (e. g. Brandner, 1984; Krainer, 1984; Kozur, 1991a, b; Kozur and Mostler, 1992; Leiss, 1992, present paper). Bauer (1987) also rooted the Upper Austroalpine of the Northern Calcareous Alps north of the Central Alpine Mesozoic, but he placed also the South Penninicum and the Lower Austroalpine south of the Northern Calcareous Alps.

Brandner and Sperling (1995) presented a third model for the position of the Meliata-Hallstatt Ocean and of the root zone of the Northern Calcareous Alps as well as for the Mesozoic paleogeography of the Eastern Alps (Fig. 6). According to this model, the Northern and Southern Alps were separated by the Austroalpine-Adria Transfer Zone (AAT) sensu Laubscher (1991) that was active through the Mesozoic and until the Neogene. The Meliata-Hallstatt Ocean and the Northern Calcareous Alps were in this model situated perpendicularly to the AAT with the Meliata-Hallstatt Ocean SE of the entire Austroalpine. Units of the Central Alpine Ridge were situated in this model SW of the Northern Calcareous Alps between them and the Southern Alps. The Drauzug was situated immediately NE of the AAT adjacent to the Lombardian Basin of the Southern Alps SW of the AAT. In this position, the Drauzug was SW of the Central Alpine Units and far away from the Northern Calcareous Alps and from the Meliata-Hallstatt Ocean.

Before the position of the Meliaticum suture zone in the Eastern Alps is discussed, those units are regarded, which are correlated today in the same manner by most of the authors.

Long before we have recognized the separation of the Črmelicum from the Gemericum by Triassic-Jurassic oceanic sequences of the Meliaticum (see chapter 3), the Carboniferous of the Črmelicum, especially of the Ochtiná Nappe, has been compared with the Veitsch Nappe of the eastern Grauwackenzone (Kozur et al., 1976; Neubauer and Vozárová, 1990). But the Ochtina Nappe has been assigned in that time to the northern marginal part of the Gemericum and was not regarded as an independent nappe. Lithostratigraphic successions, ages, magmatism, metamorphism and metasomatic alteration of shallow-water limestones into magnesites in the Črmelicum correspond to the development in the Veitsch Nappe of the eastern Grauwackenzone. For comparison of the sequences of the Ochtiná Nappe with those of the Veitsch Nappe see Kozur et al. (1976), Neubauer and Vozárová (1990) and Neubauer et al. (1994). According to Neubauer et al. (1994), the Veitsch Nappe occupies the northernmost position within the eastern Grauwackenzone, just adjacent to the Middle Austroalpine. Exactly the same position has the Črmelicum that occupies the northernmost position of the Inner Western Carpathian Paleozoic units, just adjacent to the Veporicum.

Only Kovács (in Ebner et al., 1991; Fig. 11) correlated the eastern Grauwackenzone with the Brusník Paleozoic that is, however, originally situated south of the Meliata-Hallstatt Ocean and belongs to the Paleozoic basement of the South-Rudabányaicum ("Tornaicum"), as correctly recognized by Vozárová and Vozár (1992). The Bashkirian flysch of the Brusník Paleozoic is basically different from any Middle Carboniferous of the Grauwackenzone, and this made the correlation by Kovács unexplainable. But also in other respects, the reconstruction of the Middle Carboniferous paleogeographic situation by Kovács is inconsistent with all known geological data. It shows already in that time an arrangement of the Carboniferous units in the Carpathian arc, a Tertiary feature. Moreover, the Carboniferous of the Veitsch Nappe was correlated with the central parts of the Gemerides. However, the Veitsch Carboniferous belongs to the eastern Grauwackenzone that was correlated by Kovács in the same figure in different manner (see above). Moreover, the Gemericum s. str. (central part of the Gemerides s. l. in the reconstruction by Kovács) has no Carboniferous and this made the correlation by Kovács still more courious, as the sequence of the Veitsch Nappe consists exclusively of Carboniferous beds. Finally, Kovács indicated a large amount of Carboniferous basic volcanics at the southern margin of the Gemericum, but the large amount of basic volcanics (former Rakovec Series) in the Gemericum are at the northern margin of the Gemericum and their age is unknown. This reconstruction by Kovács is not explainable, as Paleozoic basic volcanics are not shown at the southern margin of the Gemericum in any map (see map of Bajaník et al., 1984). Perhaps Kovács regarded the glaucophane schists (originally basic volcanics) of the Bôrka Nappe above the southern margin of the Gemericum or other Triassic basic volcanics of the Meliaticum as Carboniferous basic volcanics. Because of the numerous inconsistencies and obvious mistakes in this reconstruction, the two other authors of Ebner et al. (1991) did not followed it. But this reconstruction was nevertheless repeated in Kovács (1993, Fig. 3) despite the paper of Vozárová and Vozár (1992) was already published and quoted by Kovács (1993).

The Gemericum s. str. is similar to the western Grauwackenzone and parts of the Noric Nappe. If the Klátov Amphibolite Complex have a pre-Hercynian (or Silurian-Devonian Ligerian-Variscan) metamorphism, a similarity with the Kaintaleck Nappe (Neubauer et al., 1994) of the eastern Grauwackenzone would be indicated (Kozur, in press a). According to Neubauer et al. (1994), both the Noric Nappe and its equivalents in the Western Grauwackenzone and the Kaintaleck Nappe have a more southern original position than the Veitsch Nappe. This is also the case for the Gemericum compared with the Črmelicum.

Already before the recognition of the nappe character of the Silica Nappe by Kozur and Mock (1973a, b), the units that are assigned today to the Hronicum (nappe character known since the beginning of the century, Lugeon, 1903), Muránicum (name introduced herein, see chapter 3), Silicicum (Kozur and Mock, 1973a, b) and North-Rudabányaicum (Kozur, 1979, 1991a, b) were correlated with the Upper Austroalpine of the Northern Calcareous Alps (e. g. Andrusov, 1960, 1968; Tollmann, 1969; Mahel', 1974). Only some nappes from the northern or southern part of the Upper Austroalpine of the Eastern Alps and few Upper Slovakocarpathian units of the Western Carpathians were correlated with other units in that time and partly also later. Thus, Mahel' and Malkovský (1984) and Mahel' (1986) correlated the Bajuvaricum with the Krížna Nappe. However, the root zone of the Krížna Nappe is the Čertovica Suture Zone between the Veporicum and Tatricum, whereas the root zone of all Upper Austroalpine nappes, to which belong also the Bajuvaricum nappes, is south of the Lower (and Midle) Austroalpine (Tollmann, 1986). Tollmann (1972) correlated the south Gemeric Triassic (the later Silica Nappe) with the Triassic of the Balaton Highland and of the Drauzug, but later (e. g. Tollmann, 1975, 1986, 1989) he correlated the Silica Nappe with the Juvavium of the Northern Calcareous Alps, as Kozur and Mock (1973a, b) did.

The correlation of individual nappes of the Upper Austroalpine and of the Upper Slovakocarpathian units is mostly not useful because of the long distances between these nappes, in which no Upper Austroalpine or Upper Slovakocarpathian nappes are known, which are buried by Neogene volcanics or younger sediments. In the Eastern Alps, the Meliata-Hallstatt Ocean became very narrow and finally ended in the Hallstatt area or somewhat further east. Also its shelves became narrower. For this reason, "northern" facies elements, such as terrigenous Lunz Beds and Carpathian Keuper reached more southern positions than in the Western Carpathians, but some of the Juvavic units with distinct distal Raibl Beds may be equivalents of the South-Rudabányaicum (see chapter 3: Meliaticum). The southernmost occurrence of typical Carpathian Keuper in the Western Carpathians is in the northern part of the Veporicum (= northern part of Lower Austroalpine, see Kozur and Mock, 1996), whereas Carpathian Keuper reaches as far south as the northernmost nappes of the Upper Austroalpine of Eastern Alps (Frankenfels Nappe). However, this do not mean that the Frankenfels Nappe must be correlated with the Krížna Nappe (with Carpathian Keuper) as erroneously done by some authors (e. g. Mahel', 1986). Thin variegated shales occur in the upper part of the Norian Hauptdolomit of the northernmost marginal parts of the Choč Nappe and are regarded already by Andrusov (1965) as equivalents of the Carpathian Keuper. This indicates that parts of the Choč Nappe can be correlated with the Lower Bajuvaricum. The southern unit (Biely Váh Unit) of the Choč Nappe with Reifling Beds, thick Lunz Beds and upper Carnian to Norian Hauptdolomit corresponds to the Upper Bajuvaricum (e. g. Lunz Nappe).

The Muránicum corresponds to the Tirolicum of the Calcareous Pre-Alps. In the northern Muránicum (Strážov and Nedzov nappes) Wetterstein Limestone, thin distal Lunz beds, Norian Hauptdolomit are present and Dachstein Limestone is missing. This part of the Muránicum corresponds to the (southern) Traunalpen facies of the Tirolicum. The southern Muránicum (Muráň and Stratená nappes) is distinguished by the presence of Norian Dachstein Limestone above Carnian-lower Norian Hauptdolomit. It corresponds to the Calcareous Pre-Alpine Dachstein Limestone facies of the Tirolicum (Triesting facies with Ladinian Wetterstein Limestone in the east, and Ötscher facies with Ladinian-lower Carnian Ramsau Dolomite in the west). As in the Alps, Norian Hallstatt Limestone, characteristic for the Juvavicum, is absent.

The Silicicum in the herein used reduced content (Silica Nappe and near related, undescribed nappes or slices) corresponds to parts of the Juvavicum as already stated by Kozur and Mock (1973a, b). Those parts of the Juvavicum, in which the Hallstatt Limestone begins already in the Anisian, corresponds to the Rudabánya Nappe (Kozur, 1979) of the North-Rudabányaicum, but partly also to the South-Rudabányiacum. However, not all the mapped Hallstatt Limestones of these nappes are typical Hallstatt Limestones. Thus, in the Geyerstein Nappe (typical South-Rudabányaicum of the southeastern Northern Calcareous Alps, Kozur and Mostler, 1992), the Hallstatt Limestone is in reality Nádaska Limestone as in the South-Rudabánayicum of the Inner Western Carpathians.

Thus, those units of both the Western Carpathians and the Eastern Alps that were deposited at the slopes of the Meliata-Hallstatt Ocean, display uninterrupted pelagic deposits in the middle Anisian to Rhaetian time interval. In the Western Carpathians Ladinian red radiolarites, typical for Ladinian sedimentary Meliaticum sequence, interfinger with cherty limestones of the slope deposits. In the Hallstatt area, such Ladinian red radiolarites are missing in the Juvavicum, but seemingly also in the continuation of the Meliaticum (see below).

A hypothetical Triassic ocean was postulated south of the Hallstatt facies belt already in some earlier reconstructions (e. g. Fuchs, 1985 and Lein in Flügel and Faupl, 1987). In other reconstructions (Tollmann, 1988), in which a continuation of the Vardar Ocean until south of the Hallstatt Zone was assumed, in the Triassic no ocean was shown in the Eastern Alps and Western Carpathians, but in agreement with opening time of the Vardar Ocean, a Middle-Upper Jurassic ocean was shown south of the Hallstatt Zone and south of the Gemeric Triassic (Silicicum), in the Tithonian also south of the Licicum. This ocean was assumed to be broadest in the Tithonian (in that time the Vardar Ocean was broadest). However, south of the Silicicum the ocean was already closed during the Tithonian and consequently the hypothetical ocean (Meliata-Hallstatt Ocean) was not the continuation of the Vardar Ocean.

Despite of the fact that a Triassic-Jurassic or at least Jurassic ocean was postulated south of the Hallstatt Zone, no remnants of this ocean were proven for a long time and according to Tollmann (1989) oceanic Meliaticum is unknown from the Eastern Alps. Kozur (1989b, 1990a, b, 1991a, b) assigned blocks of basic and ultrabasic rocks from Haselgebirge evaporitic melanges at the base of Juvavic nappes to the Meliaticum, because such rocks occur in the same tectonic position at the base of higher Inner Western Carpathian nappes. There, they were partly dated as Ladinian by radiolarians from intercalations of red shales and red radiolarites in the pillow lavas (Kozur and Réti, 1986). Subsequently Mandl and Ondrejíčková (1991), Kozur and Mostler (1992), Mandl (1992) and Mandl and Ondrejičková (1993), found the typical accretionary complex of the Meliaticum with Middle Jurassic turbidites overlain by a coarsening upwards sequence at the southern margin of the eastern end of the Northern Calcareous Alps, at the Florianikogel and in the Edenhof section. As in the Meliaticum of the Western Carpathians, these Jurassic beds contain blocks of red Ladinian radiolarites, basic volcanics, ultrabasites of Middle Triassic age and rarely grey cherty limestones of Upper Triassic age. The red radiolarites partly interfinger with red cherty limestones (Edenhof section) and much of the red radiolarites are early diagenetically silicified filamentous limestones, but true radiolarites deposited below the CCD are also present. These two types of radiolarites are present also in the Meliaticum of the Western Carpathians, but interfingering of red Ladinian cherty limestones with red radiolarites is restricted to the slope development outside the Meliaticum. This indicates that the sequences of Florianikogel and Edenhof were situated close to the margin of the oceanic development and probably close to the western end of the oceanic development of the Meliaticum.

Further to the west, the characteristic red Ladinian radiolarites were no more found, but a deep-water trough continued in continuation of the oceanic Meliaticum until the Hallstatt Zone. This prolongation of the Meliaticum in the Hallstatt area (thinned continental crust ?) was seemingly a deep-water basin with cherty limestones (Reifling Limestones, Pötschen Limestones). However, a narrow rift zone with basic and ultrabasic rocks was seemingly also present in this area, as such rocks are known in evaporitic melanges at the base of some Juvavic units also in the Hallstatt area. Gawlick (1993a, b) found up to 1.5 cm large components of red cherty limestones and greyish-green radiolarites in an Upper Jurassic breccia. He assigned the components to the Triassic Meliaticum deep-sea facies on the base of some broken conodonts. No data were given, whether these conodonts were derived from the red cherty limestones or from the radiolarites, but probably they were derived from the red cherty limestone.

Triassic greyish-green radiolarites are not known from the Meliaticum that is dominated by red ribbon cherts, in the Upper Triassic accompanied by black and grey radiolarites and in that time often replaced by cherty limestones. However, such grey-green radiolarites are very common in the Middle Jurassic of the Meliaticum. The figured thin section of this grey-green radiolarite by Gawlick (1993a) has the typical microfacies of the Jurassic radiolarites of the Meliaticum and also the size spectrum of the indeterminable radiolarians corresponds to Middle Jurassic radiolarites and not to Triassic ones. The data by Gawlick (1993a, b) rather confirm the view that in the Hallstatt area no more red ribbon cherts on oceanic crust were present. Triassic-Jurassic sequences of the Meliaticum deposited below the CCD on oceanic crust are therefore in the Eastern Alps only known from southern margin of the easternmost Northern Calcareous Alps (Mandl and Ondrejičková, 1991, 1993; Kozur and Mostler, 1992; Mandl, 1992). However, Gawlick (1993a, b) is insofar right that the rocks that he assigned to the Meliaticum belong to this unit and in geographic sense, this part was surely the westernmost part of the Meliata-Hallstatt Ocean, even if it was already largely deposited on thinned continental crust.

Both oceanic rift zones and subduction zones represent plate boundaries that may continue as a transform fault on the adjacent continent. Until the Hallstatt area, a deep-water trough with oceanic and thinned continental crust was seemingly present in continuation of the oceanic crust of the Meliaticum in the Inner Western Carpathians. Blocks of basic and ultrabasic rocks are known from evaporitic melanges within the Haselgebirge of the Hallstatt area. Thus, the rifting process was also obvious in the Hallstatt area, but it did perhaps no more lead to the opening of an oceanic trough with oceanic crust overlain by radiolarites.

Very interesting is the further continuation of the plate boundary on the continental shelf that should be a zone of high seismic activity during the Middle Triassic to Middle Jurassic time. Because the horizontal movements along this zone were probably not so significant to cause a juxtaposition of different facies zones, it is very difficult to recognize such fossil transform faults. Indications for such a continental plate boundary will be most probably only synsedimentary fault structures and perhaps locally restricted, but repeated occurrence of breccia during the Triassic to Middle Jurassic. During the Middle Triassic time of sea-floor spreading in the Meliata-Hallstatt Ocean, possibly also the presence of lavas that would be exceptional for the Northern Alps, could indicate such a continental plate boundary. Moreover, continental rifting that preceded the oceanic sea-floor spreading, reaches often deeper into a continent than the later sea-floor spreading.

The narrow zone of continental Upper Permian rifting with Haselgebirge evaporites, the axial part of which was situated at the place of the later oceanic rifting of the Meliaticum, continued toward the west until Hall, east of Innsbruck. Thus, this continental rift zone continued far west of the later oceanic rift of the Meliaticum into an area that corresponds to the southernmost part of the Lechtal Nappe (Tollmann, 1985 and there quoted papers) or to the Inntal Nappe (Brandner, pers. comm). In the Ladinian of this area, the restricted basinal facies of the Partnach Beds is present. The relatively northern position of the continental continuation of the Meliaticum plate boundary excludes the possibility that the Meliata-Hallstatt Ocean was situated near the Alpin-Dinaric Line. In the contrast, the Inntal Nappe and the Krabachjoch Nappe were situated in continuation of those units situated south of the Meliata-Hallstatt Ocean (South-Rudabánayicum). Terrigenous material in the Anisian of the Krabachjoch Nappe is in agreement with this correlation, because these Anisian terrigenous sediments are always a southern feature (Brandner, 1974).

In western continuation of the southern Lechtal Nappe near Flirsch repeated formation of breccias can be observed in the Lower Jurassic to Middle Jurassic Eisenspitz breccia. In the same area, Carnian, Norian and upper Rhaetian breccias are present (Huckriede, 1959; Tollmann, 1976a, 1985). This unique long interval with repeated breccia formation could be related to a long-existing transform fault zone in prolongation of the plate boundary within the Meliata-Hallstatt Ocean. Eisbacher et al. (1990) pointed out that structural complications in the southernmost Lechtal Nappe are probably partly inherited from synsedimentary fault structures that had developed during the subsidence stage of the Northern Calcareous Alps platform. Again, these synsedimentary fault structures are in the continental prolongation of the rift axis of the Meliata-Hallstatt Ocean. Finally, in the Arlberg Beds in the westernmost Northern Calcareous Alps, the only Ladinian (Tollmann, 1985) or Cordevolian (Bechstädt et al., 1976) lavas (intermediate volcanics) of the Northern Calcareous Alps outside the Meliaticum occur. Again, these volcanics occur in southern part of the Lechtal Nappe.

The Middle Jurassic accretionary complex of the Meliaticum with blocks of oceanic Triassic and low-grade metamorphic pre-rift carbonates from the easternmost part of the Eastern Alps corresponds both in its facies and in its tectonic position to the occurrences of the Meliaticum accretionary complex in the Inner Western Carpathians. The position of this Meliata suture zone is in the Inner Western Carpathians always at the southern margin of the Črmelicum that corresponds to the Veitsch Nappe of the eastern Grauwackenzone. This zone is the root zone of the Upper Slovakocarpathian units that correspond to the Upper Austroalpine of the Northern Calcareous Alps. In the easternmost part of the Eastern Alps, the Jurassic accretionary complex lies also at the southern margin of the Upper Austroalpine of the northern Calcareous Alps. For this reason we assume that the root zone of the Northern Calcareous Alps lies at their southern margin, north of the Central Alpine Ridge (Kozur and Mostler, 1992).

In the easternmost Northern Calcareous Alps not only remnants of the Meliaticum, but also units, originally situated south of the Meliaticum were found (Kozur and Mostler, 1992). They correspond in facies, microfauna and metamorphism to the South-Rudabányaicum of the

Inner Western Carpathians. Characteristic is the occurrence of the conodont *Gladigondolella* already in the Pelsonian and Illyrian, whereas in the units from the northern margin of the Meliaticum *Gladigondolella* begins within pelagic sequences only in the Ladinian. There are both low-grade metamorphic beds (in the Edenhof window), as in the Torna Nappe, and nearly unaltered beds (Geyerstein Nappe, CAI 2.5 - 3), as in the Szőlősardó Nappe. The Geyerstein Nappe corresponds to the Geyerstein slices assigned to the Hohe Wand Nappe (Tollmann, 1976b) or to slices from the Hallstatt "South Channel" by Tollmann (1985). The so-called "South Margin Element" with lower Anisian "Flaserkalk" overlain by yellowish micrites may belong to the Geyerstein Nappe (Kozur and Mostler, 1992), but it is detached from this nappe. It could be also an independent nappe of the South-Rudabányaicum corresponding to the Brusník Nappe as it has continental Permian. In any case, it does not belong to the same unit as the Tirolicum of the Calcareous Pre-Alps. On the other hand, it lies in continuation of the Tirolicum Inntal Nappe beyond the western end of the Meliaticum (see above). All characteristic lithostratigraphic units of the South-Rudabányaicum are present in the South Rudabányaicum of the Northern Calcareous Alps, such as pelagic siltstones-mudstones in basinal facies of early Pelsonian age (with clasts of slope and carbonate platform limestones, basic and intermediate volcanics and sand grains), Nádaska Limestone, thick distal Raibl Beds and upper Tuvalian to Norian pelagic, often cherty limestones (Kozur and Mostler, 1992). This development is unrelated to the sequence of the Juvavic nappes that were derived from the northern margin of the Meliata-Hallstatt Ocean. The terrigenous material in the Triassic of the Geyerstein Nappe was derived from the south, indicating the presence of a carbonate platform and a source area of terrigenous material in the south. This confirms the presence of a Central Alpine Ridge south of the Northern Calcareous Alps, as postulated by Brandner (1984) and Krainer (1984). The latter author recognized a S - N Permo-Mesozoic facies succession Drauzug-Gurktal Nappe (Permo-Mesozoic of Middle Carinthia)-Pfannock slice-Central Alpine facies (Stangalm Mesozoic)-Northern Calcareous Alps. Brandner (1984) stated that the assignment of a part of this succession (Stangalm Mesozoic) to the Middle Austroalpine (rooted north of the Northern Calcareous Alps) would destroy the clearly recognizable facies successions of this area.

Kázmér and Kovács (1985) assumed a continental escape of the Drauzug-Balaton Highland area during the Oligocene and they assumed a Triassic position of the Balaton Highland south of the Northern Calcareous Alps. However, as pointed out by Tollmann (1989, p. 40), "there is no northern tectonic boundary that could serve as strike-slip fault". He furthermore pointed out that Kázmér and Kovács (1985) "constructed such a fault by combining several fractures with different trends... and a postulated connection between these elements - constructing a Middle Kärnten fault that does not exist". However, also Tollmann (1989) assumed a large-scale eastward-directed drift of the Licicum, but of Jurassic age. Jurassic eastward drift of the East Alpine-Western Carpathian block or parts of them were also assumed by Kozur and Mock (1987, 1988). Also in the reconstruction by Tollmann (1988), the Balaton Highland was originally situated south of the Northern Calcareous Alps.

The original more western position of the Licicum during the Triassic was concluded from the "exotic" presence of Norian Hauptdolomit in a meridian, where in the present position in the Southern Alps Norian Dachstein Limestone and in southern units of the Northern Calcareous Alps Dachstein Limestone and Hallstatt Limestone are present. However, also in the Balaton Highland, Norian Hauptdolomit is present, representing in the Keszthély Mts. and in the southern Bakony Mts. the entire Norian below the Kössen Beds, and in the northern Bakony Mts. the lower and middle Norian below upper Norian and Rhaetian Dachstein Limestone. Therefore, the problem of the "exotic" Norian Hauptdolomit in the Drauzug remains unsolved even after the assumption of several 100 km of lateral displacement. By assumption of a Central Alpine Ridge between the Drauzug and the Northern Calcareous Alps, the presence of Norian Hauptdolomit in the Drauzug would be easy explainable, even if it was not displaced since the Triassic several 100 km to the east from its original position. This does not mean that we exclude such an original position of the Drauzug that seems to be well founded (Bechstädt, 1978; Prey, 1978; Tollmann, 1978; Schmidt et al., 1991). But even, if such large-scale lateral movements since the Triassic took place, an explanation for the "exotic" position of the Norian Hauptdolomit of the Balaton Highland (in this model situated between the Southern Alps and Eastern Alps) is necessary.

An important aspect of the Drauzug was not discussed in previous papers. At the outer shelves of the Meliaticum in the Western Carpathians and Eastern Alps, upper Carnian and Norian rapid subsidence can be observed (see chapter 3), related to crustal cooling after the middle Carnian end of the sea-floor spreading in the Meliaticum. In the Drauzug, an upper Carnian and Norian shallowing after Middle Triassic to Cordevolian pelagic sedimentation can be observed. This is also the case in the Dobratsch section, where beside pelagic Middle Triassic sediments also thick basic volcanics (up to 120 m volcaniclastic sediments with some lavas) are present (Bechstädt et al., 1976, 1978). This is the characteristic event succession for the outer shelves along the southern Tethys, e.g. in the Southern Alps, Balaton Highland, in the Bosnian Zone and in the Subpelagonicum. Pelagic Middle Triassic to Cordevolian, partly (e. g. Subpelagonicum) pelagic upper Scythian to Cordevolian deposits, among them also Hallstatt Limestones (e. g. Bosnian Zone, Subpelagonicum) are overlain by upper Carnian to Norian shallow-water limestones or dolomites, often separated by distinct clastic Raibl Beds. In the South Tethyan oceanic realms and on the slopes, strong basic volcanism begins in the middle Carnian, contemporaneously with the end of the sea-floor spreading in the Meliaticum. Seemingly, the Raibl event was connected with an important re-arrangement of the plate motions (end of the tensional regime in the Meliata-Hallstatt Ocean, beginning of rapid sea-floor spreading in many parts of the southern Tethys). This caused also the different behaviour of the outer shelves of the Meliaticum (subsidence because of crustal cooling) and of the South Tethys (reduced subsidence or shoulder uplift).

Because the Drauzug has the South Tethyan event succession, it does not belong to the shelf of the Meliaticum, but to the northern shelf of the Southern Tethys. Consequently, its position was not near to the root zone of the Northern Calcareous Alps, as assumed by Tollmann (1977), independently from the question, whether it was originally situated far in the west of its present position or not. For this reason, it does not belong to the same tectonic unit as the Upper Austroalpine of the Northern Calcareous Alps that was situated at the slope and shelf of the Meliata-Hallstatt Ocean, from which it is separated by the Central Alpine Ridge as already recognized by Brander (1984) and Krainer (1984). For this reason, the Drauzug cannot be assigned to the Upper Austroalpine, but it is an independent unit. The term Licicum (Tollmann, 1977) is used for this unit.

If the strong eastward-movement of the Drauzug and Balaton Highland in post-Triassic time would be a reality, the Balaton Highland would be situated during the Triassic south of the Northern Calcareous Alps (e. g. Tollmann, 1988). As for the Drauzug, the Balaton Highland has a South Tethyan event succession with widespread pelagic sedimentation until the Cordevolian or Julian, distinct distal Raibl event, upper Carnian shallowing and Norian Hauptdolomit. Also the Balaton Highland did not belong to the shelf of the Meliaticum, but to the northern shelf of the Southern Tethys. In the case of a Triassic position of the Balaton Highland between the Southern Alps and Northern Calcareous Alps, also the western part of the Igal Unit south of Lake Balaton would have a Triassic position between the Southern Alps and the Balaton Highland. Kozur (1994a) described from the borehole Inke south of Lake Balaton an oceanic melange with serpentinites, low-grade metamorphic acidic metavolcaniclastics, albite-sericite slate (originally intermediate volcanics), microconglomerates, strongly altered light limestones and black, siliceous shales. The latter are an dysaerobic sediment that contains pyritized radiolarians of late Carnian age. A similar sequence, but without serpentinites was discovered by Kozur, Krainer and Mostler (unpublished) from the South Karawanke Koschuta Unit. The melange in the Inke borehole belongs seemingly to an accretionary complex, but the Triassic rocks are so different from those of the Meliaticum that it was surely not part of the Meliata accretionary complex. The sequence from the Koschuta Unit may belong to the outer shelf of this ocean.

Consequently, Tollmann may be right that an ocean was present between the Southern Alps and the Northern Alps in the segment that is today missing between both areas. However, this ocean was part of the Southern Tethys, and the Northern Calcareous Alps were not the northern shelf of this ocean. Both Drauzug and Balaton Highland belong to the northern shelf of this South Tethyan Ocean. In the contrast, the Upper Austroalpine of the Northern Calcareous Alps and the Upper Slovakocarpathian units of the Western Carpathians were situated at the slopes and shelves of an other, Northern Tethyan Ocean, the Meliata-Hallstatt Ocean, as northwestern continuation of the Cimmerian Ocean sensu Kozur (1991a, b, 1994c) that corresponds in parts to the Paleotethys sensu Şengör (1985). In the Eastern Alps, the shelf areas of both oceans were separated by the Central Alpine Ridge. Because the South Tethyan Ocean was already open in the Permian (Catalano et al., 1991; Kozur, 1989c, 1993, 1994d) and the subduction of the South Tethyan Ocean was northward-directed, the Lower Permian gabbros of MORB geochemical character, recognized by Thöni (1990) from the Koralpen-Saualpen crystalline, may be a relict of the subduction zone of this South Tethyan Ocean. Pelagic Lower Permian conodonts (Ramovš, 1982) indicate that at least a pelagic trough was present in the Lower Permian south of the eastern part of Northern Alps. The subduction of this hypothetic ocean (Vardar Ocean sensu Tollmann, 1988) was probably in the Cretaceous (Lavant flysch). For this reason it is possible that the chromian spinel from the Lavant flysch of the Drauzug and from the Roßfeld Formation of the Northern Calcareous Alps were derived not only from two geochemically and in age different ophiolitic sequences as shown by Faupl and Pober (1991), but from two oceans. The chromian spinels from the Roßfeld Formation were transported from the south (therefore Penninic origin is excluded) and were derived from obducted ophiolites of the Meliaticum. The Lavant flysch was far in the west of the western end of the Meliata-Hallstatt Ocean, if the Drauzug was rooted west of its present position. A derivation of the chromian spinel of the Lavant flysch from obducted ocean floor of the Meliaticum is therefore not probably. If, however, an ocean was present south of the Licicum (Tollmann, 1988), a derivation of the chromian spinel from this South Tethyan is probable.

The assumption of the suture zone of the Meliata-Hallstatt Ocean in the Eastern Alps north of a Central Alpine Ridge explains the following geological facts that are not or difficult to explain with the model of a suture zone between the Northern and Southern Alps.

1. The Southern Alps have a totally different Middle Triassic crustal mobility from that of the shelf of the Meliaticum (Brandner and Sperling, 1995).

2. There is a sequence that derived from the southern margin of the Meliata-Hallstatt Ocean (e. g. Geyerstein Nappe of the South-Rudabányaicum) that has a North Tethyan event succession and has no transitional character between the Northern and Southern Alps. If the Meliata-Hallstatt Ocean was situated between the Northern and Southern Alps, this unit should have South Alpine character, at least in the crustal mobility.

3. The Ladinian-Cordevolian microfauna of the Southern Alps and of the Northern Calcareous Alps is even in facially indentical beds very different. The differences are so great that in this time interval a continental barrier is probably.

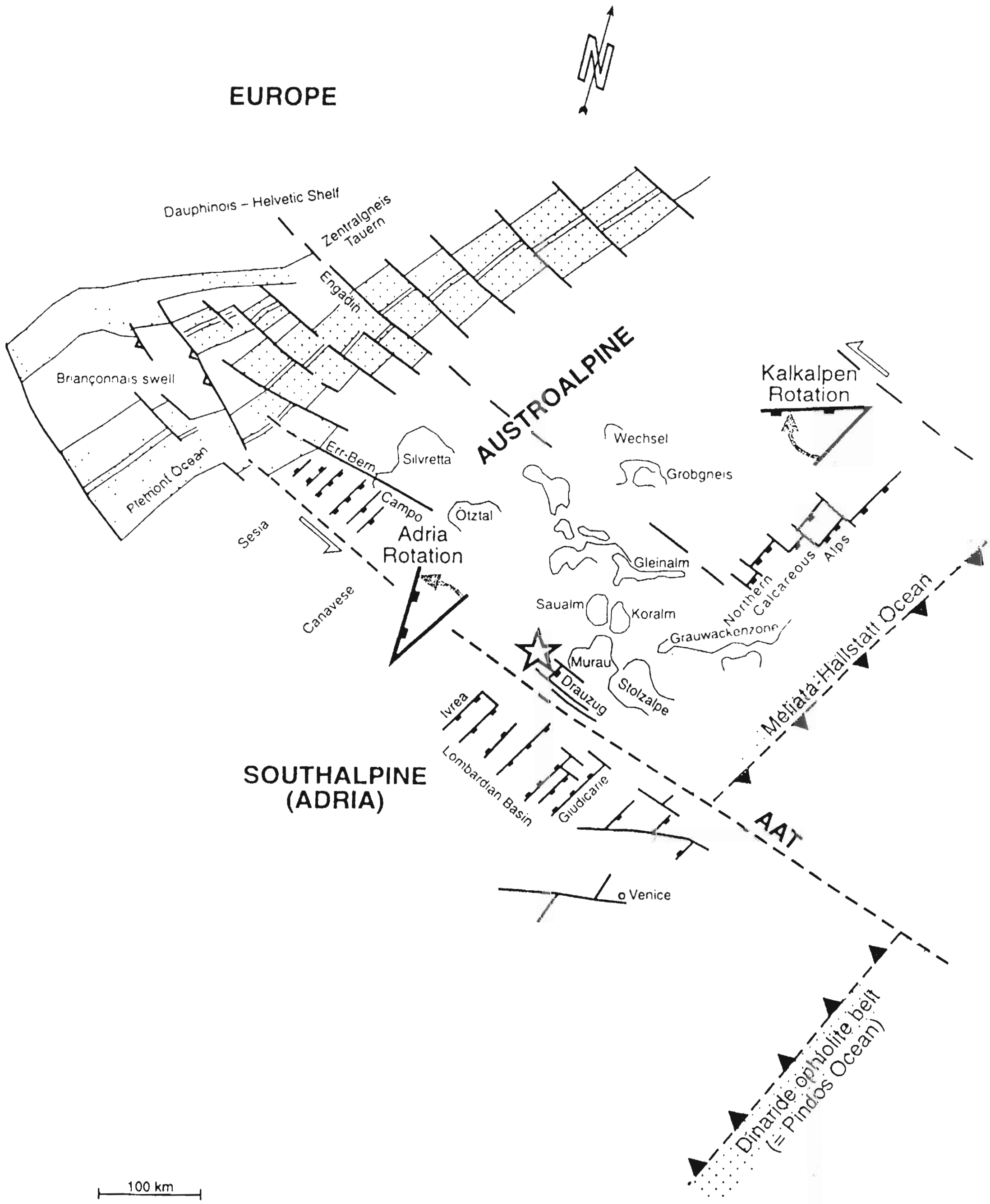

Fig. 6. Alternative Early Mesozoic paleogeographic reconstruction of the Alps by Brandner in Brandner and Sperling (1995).

4. In the units that were derived from the southern slope and outer shelf of the Meliata-Hallstatt Ocean, clastic input in the Anisian and in the Carnian comes from the south. If the Meliata-Hallstatt Ocean was situated between the Northern and Southern Alps, then the transport of the clastic material must come from or through the Sou-thern Alps. In this case, however, the big differences in Lower and Middle Triassic crustal mobility and in the fauna between these units and the Southern Alps cannot be explained.

5. The S - N Permo-Mesozoic facies succession Drauzug-Gurktal Nappe (Permo-Mesozoic of Middle Carinthia)-Pfannock slice-Central Alpine facies (Stangalm Mesozoic)-Northern Calcareous Alps (Krainer, 1984) would be destroyed, if the Central Alpine facies would be placed north of the Northern Calcaceous Alps.

6. The Drauzug has a South Tethyan event succession that is not known from the slopes and shelfes of the Meliata-Hallstatt Ocean. Also faunistically, there are strong similarities to the Southern Alps.

In the model of Brandner (in Brandner and Sperling, 1995, see Fig. 6, explanation of the model, see above), the strong differences in Middle Triassic to Cordevolian crustal mobility and faunas between the Southern Alps and the Northern Calcareous Alps as well as the strong differences of the Drauzug from the Northern Calcareous Alps can be well explained as in the previous model. The siliciclastic input in the Pelsonian and Julian in the South-Rudabányaicum of the southeastern corner of the Northern Calcareous Alps is more difficult to explain in the model by Brandner, but a source area that was originally situated E or SE of the Northern Alps would be possible. This model has, on the other hand, some additional advantages. It takes into consideration the clockwise rotation of the Northern Calcareous Alps and the anti-clockwise Adria rotation of the Southern Alps (Channell et al., 1992; Channell, 1996). Moreover, in this model it is no longer necessary to look for an E - W continuation of all units in the Eastern Alps and Inner Western Carpathians (and south of them) that were originally situated south of the Meliata-Hallstatt Ocean. For instance, there are no equivalents of the Brusník Bashkirian flysch in the Northern Alps. Baskirian flysch is known from the Southern Alps (Viséan to Bashkirian Hochwipfelflysch), but the Hochwipfelflysch is overlain by marine Upper Carboniferous and marine Permian, whereas the Bashkirian flysch of the Brusník Nappe is overlain by continental Permian rocks. The Triassic of the Brusník Nappe is also totally different from the South Alpine Triassic, but identical with the Triassic of the South-Rudabányaicum. Thus, the Brusník Nappe cannot be correlated with any South Alpine development on the base of similiar Bashkirian development because the entire post-Bashkirian development is basically different from any South Alpine development. On the other hand, the Brusník Carboniferous has also no equivalents in the Northern Alps. In the model of Brandner, it would be originally situated east of the Alps. However, there may be also a very simple explanation in our presented model: The Middle Carboniferous of the South Rudabányaicum of the Northern Alps is unknown. The "South Margin Element" has probably a continental Permian development (Prebichl Beds) and no hypersaline Upper Permian. This is similar to the Brusník Nappe of the South-Rudabányaicum. The Carboniferous below this continental Permian is unknown.

A combination of the above model by Brander with our herein presented model (with an assumed position of the Meliata-Hallstatt Ocean N of a Central Alpine Ridge, at the southern margin of the North Alpine Upper Austroalpine) seems to be possible.

7. Correlation of the Meliata-Hallstatt Ocean, its slopes and shelves within the western Tethys under special consideration of new results in northern Turkey

The correlation of the Cimmerian Inner Western Carpathians toward the east (Fig. 7) is more difficult than the correlation with the Eastern Alps. Some of the Austrian and all Hungarian geologists favour a correlation of the Meliata-Hallstatt Ocean with the Vardar Ocean. This correlation results from a time, as south of the Peninnicum only a single Tethyan ocean, the Vardar Ocean, was assumed. In general, no specific correlations between certain units were carried out, but the Vardar Ocean was used as this single Tethyan ocean to which belong all oceanic remnants in the Western Tethys south of the Penninicum. In Dal Piaz et al. (1995) even the Pieniny Ocean (that has a North Penninic position) was included in such a Tethyan Vardar Ocean. Every oceanic remnants that are today situated between the Pieniny Ocean and the Vardar Ocean sensu stricto, consequently also the remnants of the Meliata-Hallstatt Ocean, are in this model automatically situated within the Vardar Ocean. In papers that did not recognize the continuation of the Meliata-Hallstatt Ocean until the Eastern Alps, the continuation of the Vardar Ocean until the Alps was assumed. Ophiolitic detritus in the Roßfeld Formation, which was derived from the south, was therefore originated from the Vardar suture zone (Faupl and Pober, 1991). As the source area of the ophiolitic detritus in the Roßfeld Formation are ophiolitic bodies from the Meliata-Hallstatt Ocean, such hypothesis about the derivation of this ophiolitic detritus from the Vardar Ocean can be evaluated as an indirect correlation of the Meliata-Hallstatt Ocean with the Vardar Ocean.

A modified correlation of the Meliata-Hallstatt Ocean with the Vardar Ocean was presented by Tollmann (1988). He correlated such units with the Meliata-Hallstatt Ocean, its slopes and shelves that have an identical event succession (e. g. the Kotel Zone with Middle Jurassic flysch containing blocks of pelagic Alpine Triassic). As the Vardar Ocean has a totally different event succession with different opening and closing times, Tollmann (1988) introduced for these units a hypothetical northern branch ("Nordstamm") of the Vardar Ocean. By this, he preserved the correlation of the Meliaticum with the Vardar Zone, but de facto he correlated the Meliata-Hallstatt Ocean, its slopes and shelves with units that originated north of the Vardar Ocean.

Only Kovács and his followers in Hungary correlated in the last years repeatedly the Meliata-Hallstatt Ocean and its slopes and shelves with the Vardar Zone sensu stricto, Kovács (1993) even with still more inwards situated Subpelagonian units.

The Middle Triassic of the Vardar Zone consists mainly of shallow water carbonates with widespread acidic to intermediate volcanism. Only in the innermost Vardar Zone olistoliths of pelagic Ladinian siliceous limestones, shales, cherts and above all pietra verde (acidic to intermediate volcanoclastic beds) are known (Obradović and Goričan, 1988). Basic volcanism in basins within the Vardar Zone began in the upper Carnian or Norian (after the end of the sea-floor spreading in the Meliata-Hallstatt Ocean). The sea-floor spreading with ophiolites began probably later, during the Jurassic. As pointed out by Robertson and Karamata (1994), the ophiolitic rocks of the Vardar Zone of Serbia are largely undated, but ophiolitic basalts are locally dated as Callovian-early Kimmeridgian. Parts of the ophiolites in the Vardar-Axios Zone are of Cretaceous age (e. g. Meglenitsa ophiolite, Robertson et al., 1996).

Best dated are the ophiolites and accompanying radiolarites of the Vardar Ocean in the Izmir-Ankara Zone. Bragin and Tekin (1996) reported radiolarites of late Norian, Early Jurassic, Kimmeridgian-Tithonian, Early Cretaceous and Albian-Turonian ages. The outcrop of the upper Norian and Liassic radiolarites has been re-studied. The upper Norian radiolarites are filamentous radiolarites deposited above the CCD, in some blocks, they interfinger with red, cherty limestones. Contemporaneous shallow intra-platform basins with a restricted basin conodont fauna consisting exclusively of *Mockina slovakensis* (Kozur) are also present in the Izmir-Ankara Zone (Kaya, Kozur and Saddedin, in prep.). Consequently, in the Upper Triassic a breaking up of a pre-existing (Middle Triassic) carbonate platform is indicated. The Liassic to Bajocian radiolarites are true oceanic radiolarites, partly intercalated with black, siliceous manganese shales. Thus, the Liassic (or Rhaetian) is the oldest age, from which oceanic seafloor spreading can be expected in the Vardar Ocean of the Izmir-Ankara Zone. However, so far, Liassic radiolarites were not found above ophiolitic basalts. In the contrast, Upper Jurassic to Middle Cretaceous radiolarites are often deposited above ophiolitic basalts.

Middle Carnian and younger cherty limestones, partly connected with basic volcanism, are present mainly in the inner part of the Vardar Zone, but in other parts also in the Upper Triassic shallow water platform carbonates were deposited. Upper Triassic pillow lavas and red radiolarites of the Vardar Zone are so far only known from the innermost Vardar Zone (Obradović and Goričan, 1988). According to the new Triassic radiolarian zonation presented by Kozur Mostler (1994), one of the Triassic radiolarian faunas of the Diabase-Chert Formation of the innermost Vardar Zone, figured by Obradović and Goričan (1988), has an upper Carnian to Norian age (only long-ranging species of this time interval are present), the other fauna has a Norian age (by Obradović and Goričan, 1988, these radiolarites were correctly dated as upper Carnian to Norian), all other radiolarian faunas from the Diabase-Chert Formation, as correctly indicated by Obradović and Goričan (1988), are of Jurassic age (Callovian to early Kimmeridgian).

Obradović and Goričan (1988) figured also Lower Ladinian radiolarians from the innermost Vardar Zone. Referring to this occurrence, Kovács (1993, and in Haas et al., 1995) reported the presence of Ladinian red radiolarites above pillow lavas from the Diabase-Chert Formation of the Vardar Zone to prove his preconception that the Meliata-Hallstatt Ocean is the prolongation of the Vardar Ocean and has the same event succession with the same time of sea-floor spreading. However, as correctly stated by Obradović and Goričan (1988), the lower Ladinian radiolarian fauna was not from the Diabase-Chert Formation, but from olistoliths of the "Porphyrite-Chert Formation" consisting of siliceous limestones, siliceous shales, cherts, acidic to intermediate tuffs (of the pietra verde type of the South Tethyan Buchenstein Beds) and acidic to intermediate volcanics. This development is diametrally different from the Ladinian ophiolites and cherts of the Meliata-Hallstatt Ocean and not an evidence for the same development in the "Neotethyan" Vardar and Cimmerian Meliata-Hallstatt oceans, as pointed out by Kovács (1993). It confirms the long known different development of the Meliata-Hallstatt and Vardar oceans.

Unfortunately, Kovács' obviously and intentionally wrong quotations of correct statements by Obradović and Goričan (1988) were overtaken by Trunkó (1996) who wrote: "In the Vardar Zone in former Yugoslavia there are also red radiolarites of Ladinian-Carnian age overlying some pillow lavas. In this way Kozur's argument, we could not link Meliata to Vardar, because oceanization in Vardar would have only begun in the Jurassic, evaporates." It is not well understandable why Trunkó (1996) has overtaken the statements by Kovács without checking the source data an similar attempts to porove his preconceptions are common in papers by Kovács.

The subduction of the Meliata-Hallstatt Ocean and of the Vardar Ocean did not only occur to different times, it was also directed in opposite directions. The subduction of the Vardar Ocean was northwards directed, in Greece, Macedonia and Serbia northeastwards directed (in present coordinates).

The Early Mesozoic development of the Vardar Zone is diametrally different from the geologic evolution of the Meliata-Hallstatt Ocean with Ladinian ophiolites and cherts, and Middle Jurassic southwards directed subduction. For this reason, Kozur (1991a, b) and Kozur and Mock (1995) correlated the Meliata-Hallstatt Ocean and its slopes and shelves through the Kotel and Strandzha zones with the Cimmerian Ocean (sensu Kozur, 1991a, b) of northern Turkey (= Paleotethys sensu Şengör, 1984, 1985) and its slopes and shelves.

The correlated units by Tollmann (1988) and Kozur (1991a, b) are identical, because Tollmann assigned those units to his hypothetical "Nordstamm" of the Vardar Ocean that were assigned by Kozur (1991a, b) into the Cimmerian Ocean. In Plate 1 by Tollmann (1988) is clearly to seen that he rooted the Kotel Zone and the Strandzha nappes at the northern slope and shelf of his hypothetical "Nordstamm" of the Vardar Ocean. His correlation Kotel Zone→Transylvanian nappes→Silica Nappe→Hallstatt Zone, is identical with the correlation by Kozur (1991a, b). But the use of the term "Nordstamm of the Vardar Ocean" is very misleading as clearly to seen in Trunkó (1996) who wrote that "the Vardar Nordstamm of Tollmann (1987) [this paper appeared according to a personal correcture of the author on the reprints in 1988] is obviously part of the Vardar Zone s. l. and not that of a Cimmerian Ocean". The Kotel Zone and other units around the "Nordstamm of the Vardar Ocean" can be well correlated with the Paleotethyan Cimmerian Ocean of northern Turkey and not with the continuation of the Vardar Ocean in the Izmir-Ankara Belt. As in northern Turkey the Cimmerian Ocean and the Izmir-Ankara Belt follow in N - S direction separated by the Sakarya continental block, it is obvious that the Kotel Zone (oldest pelagic rocks are there of late Scythian age) is part of the Cimmerian Ocean with totally different opening and closure times and successions as in the Izmir-Ankara Belt (continuation of the Vardar Zone), in which the oldest pelagic rocks are red radiolarites of late Norian age (Bragin and Tekin, 1996).

Kovács (1993) designated correlations of the Meliaticum and its shelves with the Kotel Zone (e. g. Tollmann, 1988; Kozur and Mock, 1987, 1988; Kozur, 1991a, b) as an "absurdity", because in the Kotel Zone a Middle Jurassic flysch (turbidites) is present, Triassic rocks do not occur in situ, but in blocks within this Middle Jurassic turbidites, and (in the present day distribution !) continental crust lies between the Kotel Zone and the Meliaticum of the Inner Western Carpathians. Moreover, according to Kovács, such a correlation must go across the continental crust of the Bukovinian and Subbukovinian nappes and can be therefore excluded. The latter opinion is many times repeated in the papers of Kovács, and also mentioned by Trunkó (1996). It is difficult to evaluate because it is obviously based on a not explainable, basic misunderstanding of the Carpathian Triassic-Jurassic paleogeography by Kovács, because nobody wanted to correlate the Meliata-Hallstatt Ocean with the outermost Carpathians, the Scythian Platform or the Ukrainian Shield and only in such cases a crossing of the depositional area of the Bukovinian and Subbukovinian nappes would be necessary. As well recognizable in Plate 1 by Tollmann (1988), the connection of the Meliata-Hallstatt Zone with the Kotel Zone must go in all possible correlations along the inner side of the Bukovinian and Subbukovinian nappes, both in the case as this zone is regarded as part of the Paleotethyan Cimmerian Ocean (e. g. Şengör, 1984, 1985; Kozur, 1991b) or as part of the "Nordstamm" of the Vardar Ocean (Tollmann, 1988).

According to Kovács (1993) the presence of Middle Jurassic flysch (turbidites, olistostromes) excludes the Kotel Zone from Alpine Triassic and Jurassic that is according to him more or less identical from the Alps until China. Therefore, he regarded the development of the Kotel Zone as "non-Alpine", despite the fact that the presence of Middle Jurassic turbidites in the Paleotethys from the Pontides in the west to China in the east was already demonstrated by Şengör, 1984, 1985, and the presence of Middle Jurassic turbidites of the Meliaticum with blocks of pelagic Triassic was published by Kozur and Mock (1985), Kozur (1991a, b) and Vozárová and Vozár (1992) for the Western Carpathians and by Kozur and Mostler (1992) and Mandl (1992) for the Eastern Alps within the classical area of the Alpine Triassic.

The presence of Middle Jurassic turbidites of the Meliaticum accretionary complex with blocks of deep-water, partly oceanic Triassic is the most characteristic tectonofacies for the Early Mesozoic oceanic development in the Inner Western Carpathians (and eastern part of Eastern Alps). Thus, the presence of this facies (which is unknown from the Vardar Zone and southwards adjacent oceans) in the Kotel Zone is an evidence for the continuation of the Meliaticum and its shelf development into this area and does not exclude such a correlation as assumed by Kovács (1993) connected with polemic against this correlation.

For the correlation of the Meliata-Hallstatt Ocean with eastern parts of the Western Tethys, the comparison of the geological evolution (event succession) of the compared units is very important. The presence of certain rock types without their context in the geological evolution, is of minor importance. Hallstatt Limestones, for instance, are also present in the Subpelagonicum, and for Kovács (1993) this presence of Hallstatt Limestones is an important evidence for the correlation of the Meliata-Hallstatt Zone with the Subpelagonicum ("Maliak Ocean") and zones with Hallstatt Limestones within the Dinarides (Bosnian Zone). However, in the outer shelves of the Subpelagonicum, Hallstatt Limestones (often deposited above intermediate volcanics or tuffs), occur from the upper Scythian or Anisian up to the Cordevolian and are overlain by shallow water carbonates. In the northern outer shelf of the Meliaticum, the Hallstatt Limestones occur in the upper Carnian and Norian overlying shallow water carbonate platforms. Thus, the event succession is basically different.

There is no tectonic unit in the Dinarides, Hellenides and in the Vardar-Axios Zone from Slovenia to Greece that has the event succession of the Meliata-Hallstatt Ocean, its slopes and shelves. But this area is extremely shortened and several units may be totally overthrust and not present at the surface as to seen in the Olympos window. Therefore, the continuation of the Vardar Zone and northwards adjacent zones in Turkey are better suited for correlation of the Meliata-Hallstatt Ocean, its slopes and shelves. There, the remnants of the Vardar Ocean are exposed over a very long distance in the Izmir-Ankara Zone and the remnants of the Cimmerian Ocean north of the Izmir-Ankara Zone are also well exposed, but unfortunately stratigraphically not well investigated.

As shown in all reliable reconstructions of the Early Mesozoic paleogeography of Turkey, at least three oceanic basins were present from S to N, the Antalya Zone as continuation of the Pindos Zone, separated by the continental block of Menderes-Taurides from the Izmir-Ankara Zone (continuation of the Vardar Zone), followed by the Sakarya continental block and the Paleotethys or Cimmerian Ocean as the northernmost oceanic realm consisting of two basins.

Only Kovács (1993), who never worked in Turkey, in the Vardar Zone or other units that he so often correlated in his reconstructions, presented reconstructions from literature compilations that contradict all geological data in the correlated units. For instance, Kovács (1993) constructed a Sicilian-Aegean ocean on the base of assumed subduction-related turbidite-olistostrome units. However, the compared units have totally different ages and are also genetically very different, as the Lercara Formation in Western Sicily (Lower Permian), the Mufara Formation of the same area (not a subduction related turbidite-olistostrome unit, but distal Raibl Beds of middle Carnian age); the Monte Facito "Formation" of the Lagonegro Basin, in its type area a siliciclastic, partly turbiditic and olistostromal Olenekian (upper Scythian) deepening upwards sequence without any relation to subduction, in other areas likewise not subduction-related Middle Triassic to middle Carnian basinal to slope sequences with volcanics were also assigned to the Monte Facito Formation; Lower Triassic turbidites and olistostromes of the Phyllite Group of Crete Island; and the Upper Triassic turbidite and olistostromes of the closing Karakaya Basin of northwestern Turkey. This "Aegean-Scilian" Ocean sensu Kovács (1993) crossed not only his Hallstatt-Oman Ocean (an other hypothetical ocean sensu Kovács that was also based on wrong correlations and misunderstanding of the literature), but openend and closed to totally different times (e. g. pre-Permian opening in Sicily and closure in post-Serravallian time, and Late Permian opening and upper Norian closure in the Karakaya Complex of northern Turkey). Even faunistically, there are very big differences within this "ocean" and its assumed shelves, for instance the upper Dorashamian *Cariver-Follicucullus-Ishigaconus* radiolarian fauna of Sicily (Kozur, 1993a) and the contemporaneous, but totally different *Imotoella excelsa-I. levis* radiolarian fauna from the Karakaya Complex (Kozur, in press), or the typical South Tethyan Ladinian-Cordevolian *Pseudofurnishius* conodont faunas of western Silicy and the Northern Te-thyan conodont faunas of the Karakaya Complex. He presented different paleogeographic variants, from which none is worth to be discussed in detail, because all contain assumptions that are not in agreement with any field observations or published data. In his first variant he showed a Triassic opening of the "Neotethys" to which he assigned also the Meliata-Hallstatt Ocean with a Middle Jurassic closure (the time of the strongest sea-floor spreading or opening in most "Neotethyan" oceanic branches). This "Neotethys" sensu Kovács (1993) runs from the Meliata-Hallstatt Ocean through the "Maliak Ocean" towards Oman and a large part of this "Neote-thys" opened inside of, and under an large angle to the "Palaeotethys". In a second variant he connected this "Neotethys" north of the Menderes Massif to Oman and in a third variant this connection runs south of the Menderes Massif, and the Karakaya Zone was placed imme-diately north of the Menderes Massif. In all his reconstructions the Karakaya Zone was connected with a Vardar-Axios Zone including the Subpelagonicum that he rooted NE of Almopia.

Independently from such "outstanding" reconstructions as presented by Kovács (1993), there are differences in the evaluation of the "Paleotethys" in serious papers indicating a lack in stratigraphic data that opens the possibility for totally different interpretations.

According to Şengör and Yilmaz (1981) and Şengör (1984, 1985), the Karakaya back-arc basin opened during the Upper Permian to lowermost Triassic due to southwards directed subduction of the "Paleotethys" in the north (assumed typical development in the Küre Complex). During the Upper Triassic, the continuing southwards directed subduction of the "Paleotethys" and the southwards directed subduction of the Karakaya back-arc basin caused the opening of the "Neotethys" in the south.

According to Demir and Özçelik (1987) there was one ocean south of the Zonguldak Paleozoic complex that closed in pre-Upper Triassic time. During the Upper Triassic, one "Neotethyan" Ocean opened. The Beykoz Group in the Pontides and the Sazak Group on Sakarya belong to the shelf of this ocean. By the opening of this ocean (oceanic sea-floor spreading began according to this model in the Liassic) the accretionary complex (with remnants of old crust) of the pre-Upper Triassic ocean was subdivided into a Pontide part (Bekirli Group) and a Sakarya part (Karakaya Complex, not mentioned). The northwards directed subduction of this ocean began in the Middle Jurassic, connected with granitic intrusions, and continued during the Cretaceous. This subduction caused the opening of the Black Sea back-arc basin. The collision of the Pontide and Sakarya blocks was in pre-Maastrichtian time.

According to the opinion of Ustaömer & Robertson (1994, 1995), the Karakaya Complex was regarded as the remnant of the main "Paleotethyan" Ocean, but they assumed a northward-directed subduction of the Karakaya "Paleotethys" and by this the Küre back-arc basin was opened during the Permian that closed during the Upper Triassic to Middle Jurassic. However, in Pickett and Robertson (1996) the southward directed main subduction of the Karakaya Ocean was recognized that followed according to these authors after the northwards directed subduction. An aborted northwards directed subduction before the main southwards directed subduction may be present, but it did surely not cause the opening of a Permian Küre back-arc basin because the Karakaya basin did not open before the earliest Triassic or latest Permian as correctly assumed by Şengör since many years (see above). Moreover, the pillow lavas of the Küre Complex were dated (Aydin et al., 1995) with 170± Ma (Middle Jurassic) what excludes a relation to an assumed Permian opening as back-arc basin.

As pelagic Permian deposits were unknown from the Karakaya Complex prior 1994, when Kozur and Kaya (1994) reported pelagic upper Dzhulfian (upper Wuchiapingian) and Dorashamian (Changxingian) conodonts from the Karakaya Complex and Okay and Mostler (1994) assumed erroneously the presence of Lower Permian red radiolarites in the Karakaya Complex, Ustaömer and Robertson (1995) explained the exclusive occurrence of shallow water Permian limestones by the presence of Permian sea-mounts that can be, however, excluded for facial reasons (see bellow). Pickett and Robertson (1996) used the wrong stratigraphic data by Okay and Mostler (1994) and believed therefore the presence of Lower Permian radiolarites (see below). The Permian shallow water carbonate platform sediments were in that paper explained as carbonate platforms on Gondwanan continental slivers seemingly because they found a clastic terrigenous base of the Middle Permian shallow water carbonates. This explanation would be in good agreement with the facies of these platform sediments, but it contradicts totally the distinctly northern character of the Permian fauna (Leven and Okay, 1996, Kozur, in press, see below).

Also according to Okay and Mostler (1994), Leven and Okay (1996) and Okay et al. (1996), the Karakaya Ocean was the main "Paleotethys", open during the entire Late Paleozoic and closing during the Triassic. They assumed a southwards directed subduction of this "Paleotethys", but they did not recognize any ocean north of the Karakaya Basin, such as the "Paleotethys" sensu Şengör or the Küre back-arc basin sensu Ustaömer and Robertson (1994). The base for the assumption that the Karakaya Complex was the remnant of the big Paleotethyan Ocean open since at least the Carboniferous was the presence of a block of beige weathered limestone with pinkish chert nodules and thin chert layers with Bashkirian conodonts in the Hodul Unit, and of a block of "Sakmarian-Artinskian" red radiolarites in the Çal Unit that were regarded as the sedimentary base of the Çal Unit probably above oceanic crust. However, as shown below, the entire hypothesis is based on a wrong age determination of the radiolarite that is in reality of late Dorashamian (latest Permian) age. The pelagic cherty limestone of Bashkirian age was also re-studied and the (Early) Bashkirian age could be confirmed. However, in the Karakaya Complex pelagic limestones, partly also lydites of Silurian to Bashkirian age are present that belong to a pre-Cimmerian (Hercynian) cycle that caused partly also low grade and medium to high grade metamorphism, whereas in other parts the Early Paleozoic to Middle Carboniferous rocks are unmetamorphic. Between the Bashkirian and latest Dzhulfian pelagic limestones (Kozur and Kaya, 1994), no pelagic deposits are present in the Karakaya Complex. From this stratigraphic interval only shallow water platform carbonates are known that have mostly a Guadalupian age, subordinately Moscovian, Gzhelian (?), Asselian, Sakmarian and Artinskian ages (Leven and Okay, 1996).

According to our new results in the Karakaya Zone and in the Küre Complex that were got in cooperation with Prof. C. Göncüoğlu, Ankara, Prof. O. Kaya, Izmir, a team of the Turkish Petroleum Company (Dr. M. Aydin, Dr. O. Demir, Dr. F. Kuru and Dr. H. Yakar) and Dr. K. Tekin, MTA, Ankara, the Karakaya Ocean opened in the latest Permian as assumed by Sengör (1984, 1985) and for the first time fossil-proven by Kozur and Kaya (1994). In the northern marginal part of the Karakaya Zone (e. g. around Igdir) the opening was within the lower Scythian. There, the lowermost Scythian begins with shallow water deposits, including conglomerate layers that do not contain any marine Permian rocks. Within the lower Scythian, a rapid deepening occurred and the Dienerian (upper part of lower Scythian) yielded already pelagic conodonts and radiolarians (Kozur et al., 1996). In this area, Permian blocks are also missing in the Upper Triassic turbidite-olistostrome sequence, and therefore it is probably that in this northern marginal part of the Karakaya Zone a gap was present in the entire Permian, as in the adjacent Istanbul block.

Pre-Upper Permian pelagic rocks in the Karakaya Zone are olistoliths from the pre-rift basement (own data from Silurian, Devonian and Lower Carboniferous pelagic limestones with conodonts and radiolarians, and lower Bashkirian beige pelagic limestones with pink chert nodules and layers, Okay and Mostler, 1994 and own data) and belong to the Hercynian orogenetic cycle. Predominantly Middle Permian platform carbonates (Leven and Okay, 1996) are common in the Karakaya Zone. Like the lower Anisian platform carbonates in the Meliaticum, they are not in situ, but blocks in the turbidites-olistostromes of the accretionary complex (in the Karakaya Basin of Late Triassic age) or in (? Middle Triassic) volcaniclastic sequences. For the turbidites and olistostromes of the accretionary complex and for the volcaniclastic sequences different names were used in some papers, such as Bahçecik Formation, Çal Unit, Hodul Unit, Kendirli Formation, Nilüfer Unit, Olukman Formation, Orhanlar Greywacke, Ortaoba Unit (Koçyigit et al., 1991; Okay et al., 1991; Altiner and Koçyigit, 1993; Okay and Mostler, 1994; Okay et al., 1996; Picket and Robertson, 1996). The dating of these units is mostly very bad.

The Hodul Unit (? = Kendirli Formation, the olistostromal upper part may correspond to the Olukman Formation by Koçyigit et al., 1991; Altiner and Koçyigit, 1993) is largely upper Carnian and lower Norian according to the occurrence of *Halobia styriaca* (Mojsisovics), *H. suessi* Mojsisovics and other *Halobia* species, as well as some ammonoids in shales and sandstones.

The age of the Orhanlar Greywacke is unknown. The matrix is so far undated, but the blocks consist mainly of Lower Carboniferous and older limestones and lydites. Only south of Mustafakemalpasa (south of the Marmara Sea) upper Guadalupian to lower Dzhulfian shallow water limestone blocks occur in olistostromes that are according to Leven and Okay (1996) similar to the olistostromes in the upper part of the Hodul Unit. In this latter area, the Orhanlar Greywacke may be the lateral equivalent of the Hodul Unit. However, those parts of the Orhanlar Greywacke, in which the olistoliths consist exclusively of Lower Carboniferous and Upper Silurian-Lower Devonian limestones as well as Silurian to Carboniferous lydites, may be also a Lower Carboniferous Hercynian flysch.

The phyllites, conglomerates and recrystallized limestones of the Kalabak Unit may be a pre-Karakaya unit as discussed by Pickett and Robertson (1996).

The volcaniclastic debris flows of the Çal Unit (= Baheçik Formation by Koçyigit et al., 1991; Altiner and Koçyigit, 1993) SE of Çan were regarded as Upper Permian by Okay and Mostler (1994), Okay et al. (1996) and Leven and Okay (1996) on the base of undated limestone clasts that were regarded as Upper Permian. However, our investigation of these limestones in the locality with "Lower Permian" radiolarites (see below) yielded uppermost Scythian conodonts for the unmetamorphic limestones, whereas the low grade metamorphic limestones did not yield fossils. As the unmetamorphic radiolarite blocks have an uppermost Permian age (see below), the metamorphic limestones are probably Hercynian metamorphites. The basic volcanics and volcaniclastic debris flows, however, are in this locality of Middle Triassic, and not of Late Permian age. Upper Scythian (upper Olenekian) basic volcanics (in general amygdoidal basalts) are also common in the Karakaya Complex (Wiedmann et al., 1992). "Sakmarian-Artinskian" red, partly greenish radiolarites of the Çal Unit, that would be a convincing evidence for a continuous Late Paleozoic deep-water or even oceanic succession (Okay and Mostler, 1994; Okay et al., 1996; Leven and Okay, 1996; Pickett and Robertson, 1996), were re-investigated and yielded upper Dorashamian radiolarians (in all parts of the block) of the *Imotoella excelsa-I. levis* fauna, which is totally different from the contemporaneous South Tethyan *Ishigaconus scholasticus-Cariver-Follicucullus-Lacisus* radiolarian faunas of western Sicily (Kozur, 1993a, and in press, Kozur and Tekin, in prep.). This radiolarian fauna is both important for the dating of the latest Permian opening of the Karakaya Basin and for paleogeographic reconstructions because it indicates that during the Upper Permian no open marine connection between the northern and southern Tethys was present. It is very interesting that all well dated Dorashamian rocks of the Karakaya Zone are pelagic limestones and radiolarites (Kozur and Kaya, 1994; Kozur, in press); only one sample of shallow water limestone is so far known that "can be assigned to the Dorashamian Stage with some degree of certainty" (Leven and Okay, 1996, p. 157). In the contrast, all pre-Dzhulfian limestones are shallow water platform carbonates. In the Dzhulfian, there are pelagic limestones, (reef) slope limestones and rarely shallow water platform carbonates. Obviously, a Middle Permian carbonate platform was broken up during the Dzhulfian, and in the Dorashamian already pelagic conditions prevailed. Therefore, the view of Ustaömer and Robertson (1995) that the Permian shallow water limestones of the Karakaya Zone were derived from intra-oceanic seamounts cannot be confirmed. Also the wide distribution of these predominantly Middle Permian shallow water limestones within the Karakaya Zone over a distance of more than 1000 km speaks against the view that these limestones represent deposits from seamounts, the more, as no Middle Permian pelagic rocks or slope sediments were found in the Karakaya Zone. Because of these obvious inconsistencies, this model was abandoned by Pickett and Robertson (1996) and the Permian shallow water carbonate platform deposits were regarded as platform carbonates from continental blocks that drifted away from Gondwana.

The very local Ortaoba Unit with basalts, grey radiolarites and sandstones is totally undated and it is even not clear that it belongs to the Karakaya Complex.

The Nilüfer Unit (low grade metamorphic basalts, volcaniclastic debris flows, recrystallized limestones is mainly of middle Triassic age according to the age of the metamorphic limestones (lowermost Ladinian by Kaya and Mostler, 1992), but a Cordevolian part is surely also present, because the youngest metamorphic limestones have a Cordevolian age (Kozur and Kaya, in prep.). However, there are also Hercynian low grade metamorphic sequences of the same lithology that are partly also assigned to the Triassic Karakaya Complex.

Because of the very bad dating of the most units, the Karakaya Complex is herein used undivided for the Cimmerian sequences of NW Turkey with oldest pelagic rocks in the uppermost Permian (or, in the north, in the lower Scythian), Lower and Middle Triassic volcanosedimentary sequences with pelagic grey and red limestones, partly of Hallstatt Limestone type or ammonitico rosso, radiolarites, and olistoliths of predominantly Middle Permian shallow water carbonates and uppermost Permian pelagic limestones. Middle Carnian to Norian siliciclastic turbidites and olistostromes with olistoliths or large blocks of predominantly Middle Permian shallow water carbonate platform limestones, Dzhulfian shallow water and slope limestones, Dorashamian grey pelagic limestones and red radiolarites, Lower and Middle Triassic pelagic limestones and basic volcanics are widest distributed within the Cimmerian Karakaya accretionary complex.

The presence of (Permian-) Triassic ophiolites became in the last time doubtful. Ophiolitic rocks that were formerly assigned to a Permo-Triassic obduction of ophiolites from the Karakaya Ocean (Okay et al., 1991), were proven to be emplaced during the Late Cretaceous (Okay et al., 1996), and therefore do not belong to the Karakaya Basin.

The closure of the Karakaya Basin was within the Upper Norian. The youngest fossils of the Karakaya flysch matrix are lower and middle Norian halobiids and ammonoids, the oldest fossils from the unconformably overlying beds were proven by Kuru (in press) as Rhaetian. Both the opening and the closure time of the Karakaya Basin are in full agreement with former assumptions by Şengör and Yilmaz (1981) and Şengör (1984, 1985). The subordinate occurrence of radiolarites and the newest results that most of the ophiolites, so far assigned to the Karakaya Complex, are younger and were emplaced during the Upper Cretaceous (Okay et al., 1996) speaks against those hypotheses that work with a large "Paleotethyan" Karakaya Ocean of Late Paleozoic and Triassic age. Seemingly only a narrow Triassic oceanic belt was present. The short time interval with pelagic rocks (latest Permian to Late Triassic) and basic volcanics (proven Late Scythian to Cordevolian, may be latest Permian to Cordevolian) favours also a narrow oceanic basin what is in good agreement with the view of Şengör (1984, 1985).

The "Paleotethyan" succession of the Küre Complex was lithostratigraphically subdivided by Aydin et al. (1995) in the low grade metamorphic Bekirli Group consisting of basic volcanics, tuffs and above all in the upper part shales and some recrystallized limestones, and the overlying unmetamorphic or very low grade metamorphic Akgöl Formation, partly also named as Akgöl flysch. The Bekirli Group was assigned to the Late Paleozoic-Middle Triassic on the base of fossil dated Middle Triassic limestones in the uppermost part of the Bekirli Formation. However, restudy of the "interfingering" of Middle Triassic limestones in the uppermost Bekirli has shown that these shallow water limestones are pressed, but unmetamorphic and tectonically sliced into the low grade metamorphic Bekirli Group. These Middle Triassic shallow water limestones (typical North Alpine succession with black "Gutenstein" Limestone and light-coloured Steinalm Dolomite) are underlain by hypersaline beds with "rauhwackes", shallow marine Werfen beds and shallow marine to continental sandstones of Alpine Buntsandstein type. Directly on the Bekirli Group a Scythian basal conglomerate is present that contains mostly quartz pebbles from the underlying metamorphics, but also few pebbles of unmetamorphic dolomite that are probably of Middle-Late Permian age.

The Lower and Middle Triassic shallow water rocks were assigned as Sirçalik Formation to the Bekirli Group by Aydin et al. (1995). However, they are not intercalations in the upper part of the Bekirli Group, but follow unconformably over low grade metamorphic rocks of the Bekirli Group. Consequently, they are separated from the Bekirli Group, but the name Sirçalik "Formation" can be preserved. Compared with the North Alpine equivalents, it is rather a group with several distinct formations.

The Bekirli Group is intruded by Hercynian granites. It represents a Hercynian basement. Thus, a large part of the "Paleotethys" of the Küre Complex is in reality a low grade metamorphic Hercynian unit with Hercynian granites. A short marine shallow sea ingression was present within the (Middle-Late) Permian, the Triassic started with a basal conglomerate which is followed by a typical North Alpine Scythian-Anisian shallow water sequence (Sirçalik Group).

The Akgöl "Formation" of Aydin et al. (1995) contains three different units: A thick unaltered pillow lava sequence nearly without sedimentary intercalations, a siliciclastic turbidite-olistostrome flyschoid sequence and a molasse type shallow water sandstone-siltstone-shale sequence with some conglomerates. The pillow lavas are part of an oceanic or suboceanic sea-floor, as the slivers of ophiolites that were obducted either directly on the Middle Triassic shallow water limestones or are tectonic slivers or big blocks within the Akgöl Unit. According to Aydin et al. (1995), the basalts have a K-Ar age of 170 ± 7 Ma (Middle Jurassic). However, there are also basalt and ultrabasite clasts in Norian turbidites-olistostromes of the Akgöl Unit that must have a pre-Norian in age. As the basalt clasts are unaltered, they are younger than the low grade metamorphic Hercynian basic volcanics of the Bekirli Formation. According to Ustaömer and Robertson (1994), the basalts have a supra-subduction zone chemistry.

The thick turbidite-olistostrome part of the Akgöl Unit consists of siliciclastic turbidites, mainly graded siltstones and shales, and olistostromes. According to Ustaömer and Robertson (1994) the chemistry of the sediments plot mainly in the active margin (island arc) field, some plot in the passive margin field. Rich trace fossil associations show rather deep water, but no bathyal-abyssal environments below the CCD. This is also indicated by an often present carbonate content in the matrix. As the youngest olistoliths are pelagic lower Ladinian limestones, the oldest age of the Akgöl flysch is apparently Upper Triassic. This age is also indicated for a part of the turbidite-olistostrome sequence that contain an enigmatic fossil (Kozur and Tekin, in prep.) that is in the Antalya nappes in southern Turkey indicative for Norian age. The upper part of the Akgöl flysch is surely Lower or Middle Jurassic.

The shallow water upper part of the Akgöl Unit displays molasse character. It is not yet well dated, but partly overlain by Upper Jurassic beds. Thus, the upper age range of the upper Akgöl Unit seems to be Middle Jurassic. In the Küre area, the upper part of the Akgöl Unit may transgressively overly the Middle Triassic shallow water platform carbonates (Sirçalik Group), or even the Bekirli Group, but often they lay tectonically above these units.

The Küre Complex consists therefore of two units: (1) A Hercynian basement (Bekirli Group), transgressively overlain after a short Middle or Upper Permian shallow marine ingression by a Scythian-Middle Triassic (Anisian to lower Ladinian) shallow water sequence (Sirçalik Group) that is overlain by the transgressive proximal upper molasse part (Jurassic) of the Akgöl succession that contains only pebbles of local rocks from the underlying Bekirli and Sirçalik groups. This unit is named herein as the Küre Ridge. It separates the Küre Basin in the north from the Karakaya Basin in the south. (2) Obducted ophiolites and Middle Jurassic basalts in a flyschoid sequence of turbidites and olistostromes of the Akgöl succession (Karadagtepe Formation), overlain as well by the molasse part of the Akgöl succession. This second unit belongs to the supra-subduction Küre Basin, but contains also rocks from the pre-existing Paleotethyan Proto-Black Sea Basin (Kozur et al., 1997).

The Karadagtepe Formation (for Karadagtepe Member of Aydin et al., 1995) contains exclusively exotic clasts consisting of small clasts of unmetamorphic (lower) Anisian lydites, red radiolarites of unknown, but pre-Upper Triassic age, pre-Upper Triassic basalts, and above all of partly big blocks of an breaking up Anisian carbonate platform with pelagic limestones as old as the earliest Anisian *Chiosella timorensis* Zone.

The olistoliths within the flyschoid turbiditic-olistostromal Karadagtepe Formation of the Akgöl Unit indicate much of the Cimmerian evolution of the slope toward a northwards adjacent ocean (Kozur et al., 1997). An upper Scythian to Pelsonian (Middle Anisian) breaking up of a shallow water carbonate platform is indicated by the presence of shallow water, slope and basinal limestones of this age. In the Anisian basinal limestones, paleopsychrospheric ostracods begin in the early Anisian *Neogondolella regalis* Zone. Since that time, the deposition area of these limestones was included in the realm with cold oceanic bottom water currents and must be therefore near to an open ocean.

The reconstructed succession from these exotic pebbles is very similar to the Meliaticum sequence. Different is the somewhat earlier opening and the beginning of the turbidites in Norian, but an earlier opening and earlier beginning of the subduction is a general feature for the eastern part of the Paleotethyan Cimmerian Ocean that becomes broader toward the east. Very similar and partly identical is the development in the Kotel Zone and in the Dobrogea.

In an originally more northern development, the molasse type upper Akgöl Unit is conformably or paraconformably overlain by Upper Jurassic and Lower Cretaceous turbidites and olistostromes. This sequence together with the underlying equivalents of the Akgöl Unit were named as Beykoz "Formation" by Aydin et al. (1995). This Beykoz Unit (including the equivalents of the Akgöl Unit) contains rather different olistoliths compared with those from the Küre Basin. There are common and partly large olistoliths of the Zonguldak Paleozoic including unaltered Upper Devonian and Lower Carboniferous shallow water limestones and continental Upper Permian and Lower Triassic red sandstones and conglomerates. The Zonguldak Paleozoic corresponds to southern marginal parts of the Scythian Platform as assumed by Okay et al. (1994) for the Istanbul block to which the Zonguldak Paleozoic was so far erroneously assigned. The presence of partly large blocks of these extra-Tethyan rocks in the Beykoz Unit, but its absence in the Akgöl Unit of the Küre Basin indicate a more northern source area of the rocks in the Beykoz Unit compared with the Küre Basin. This is insofar interesting as in the Beykoz Unit also olistoliths of Permian limestones are present. They consist partly of shallow water limestones, mostly of the shelf edge, but partly also of slope limestones and basinal limestones. The dated Permian rocks belong to the Guadalupian Series and subordinately Dzhulfian-Dorashamian rocks may be also present. For some pelagic rocks only a broad age determination as Upper Carboniferous to Permian could be given, but partly the base of slope limestones contain also Guadalupian shallow water fossils. The basinal Upper Carboniferous to Permian (probably also Guadalupian) limestones contain pelagic free-swimming Ostracoda (Myodocopida) that belong mostly to the often bathypelagic Cypridinidae, whereas paleopsychrospheric ostracods, indicating a broad, open connection to the world ocean were not yet found. These mainly Guadalupian limestone olistoliths are in their age and facies very similar to the Permian olistoliths from the Tauridian flysch of SE Crimea on the other side of the Black Sea (Miklucho-Maklay and Miklucho-Maklay, 1966). Very characteristic are shallow water limestones with ammonoids that contain no conodonts. Prof. JU. Zakharov, Vladivostok gave one of the authors, ammonoid-bearing limestones from blocks of the Tauridian flysch in Crimea. They had exactly the same facies and contained only very much shallow water fossils, but no conodonts, even not shallow water conodonts. The same facies was found in an olistolith from the Beykoz Unit. It is very interesting that even pelagic beds, both basinal and calcarenitic slope limestones that yield in Sicily often more than 1000 Permian conodonts per kg sample weight, have not yielded any conodonts. Also the ostracod fauna of the basinal facies is very curious consisting only of Myodocopida (mainly Cypridinidae) and few Cladocopida (Polycopidae). Additionally, an Upper Carboniferous *Streptognathodus* (conodont) was found.

In any case, there was a pelagic basin north of the Küre Basin or, more probably, the Küre Basin was a supra-subduction basin that opened at the southern margin of this northern basin. It is named by Kozur (in press) as Proto-Black Sea Basin. Only for this basin the term Paleotethys sensu stricto could be applied. For the moment is not clear, whether this basin was a remnant ocean of a Hercynian ocean and the Guadalupian shallow water (mostly the fauna of the shelf edge, often with corals), slope and basinal limestones indicate the widening of the basin by down-faulting of its margin, or whether these rocks indicate the breaking up of a shallow water carbonate platform during the Guadalupian. In both cases, the pelagic rocks from olistoliths in the Beykoz Unit are the oldest pelagic Permian rocks in Turkey. An Upper Permian beginning of the southwards directed subduction of this oceanic basin (Proto-Black Sea Basin), which lead to the opening of the Karakaya back-arc basin, is possible. In this case the view of Şengör & Yilmaz (1981) and Şengör (1984, 1985) that the Karakaya Basin is the back-arc basin of the southwards subducted Paleotethys would be fully confirmed. In any case, the model of Şengör and Yilmaz (1981) and Şengör (1984, 1985) is the only model that fits with paleontological data. It must be only a little modified (Kozur, in prep.).

According to this modified model an oceanic basin (Proto-Black Sea Basin) existed in the Late Paleozoic and Early Mesozoic immediately south of the Scythian platform (stable Eurasia). This ocean was probably a remnant basin of a Hercynian ocean. During the Middle Permian, an extensional regime prevailed and the Proto-Black Sea Basin became broader by down-faulting of the carbonate platform at the northern margin (? and southern margin) of the ocean. Probably in the Upper Permian, a southwards directed subduction began that lead to the opening of the Karakaya back-arc basin in the uppermost Permian. During the Late Scythian and the Middle Triassic, the Küre Basin came into the existence on the southern shelf of the Proto-Black Sea Ocean, indicated by the down-faulting of the carbonate platform south of the Proto-Black Sea Ocean. Flysch sedimentation began in the Upper Triassic (Akgöl and Beykoz units) and supra-subduction basalts (and ophiolites ?) were produced in the Lower and Middle Jurassic. By this latter event, the united sedimentation area of the Akgöl and Beykoz Unit at the southern margin of the Proto-Black Sea Ocean was disrupted in the sedimentation area of the Akgöl Unit at the southern margin of the Küre Basin (slope of the Küre Ridge) and the Beykoz sedimentation area at the northern margin of the Küre Basin. At the end of the Middle Jurassic, the Proto-Black Sea Ocean was totally subducted and with the arrival of the southern margin of the Scythian platform at the northern margin of the Küre supra-subdcution basin (Beykoz Unit sedimentation area), the northwards directed subduction of the Küre Basin began. This subduction caused during the Cretaceous the opening of the Black Sea. As the Black Sea rift was somewhat oblique to the northern margin of the Küre Basin, the Black Sea rift was partly situated within the southern marginal part of the Scythian Platform, partly within the Beykoz sedimentation area. For this reason, in the western part of the middle Pontide region remnants of the Scythian Platform (Zonguldak Nappe) can be found, whereas in the southeastern Crimea the Beykoz Unit occur with the same Middle Permian shallow water, slope and pelagic limestone ollistoliths as in the middle Pontides. During the generally southwards directed nappe thrusting in connection with the "Neotethyan" closing in the Izmir-Ankara Zone, the remnants of the Küre Basin were thrust on the northern part of the Küre Ridge, whereas the Zonguldak Nappe thrust over a part of the Beykoz Unit.

In the western continuation of the Küre Basin (e. g. Kotel Zone) also a basin opening during the late Scythian can be observed. Jurassic supra-subduction basalts could not be produced because the Paleotethyan Proto-Black Sea Ocean ended in the meridian of the middle Pontides. Thus, in the Kotel Zone only pelagic upper Scythian and Triassic is present, overlain by Jurassic flysch that contain the pelagic Triassic as blocks. This development is already nearly identical with the development in the Meliaticum and confirms the correlation of the Meliata-Hallstatt Ocean and its slopes and margins with the Kotel Zone and other Cimmerian units by Kozur and Mock (1987, 1988), Tollmann (1988) and Kozur (1991a, b).

As a whole, the new paleontological and stratigraphic results in northern Turkey have confirmed the model published by Şengör and Yilmaz (1981) and Şengör (1984, 1985). The only minor difference is that the Paleotethyan remnant ocean or pelagic Late Paleozoic trough was a little further in the north than assumed by Şengör (despite the fact that he assumed the northernmost position of this ocean among all published reconstructions of the Paleotethys), and probably far narrower than shown in the reconstructions by Şengör or in other Paleotethyan reconstructions.

Important for the correlation of the Meliaticum and its slopes and outer shelves with units in the eastern part of the Western Tethys is the fact that south of the Cimmerian Ocean of Turkey, the continuation of the Vardar Zone is present and well exposed (Izmir-Ankara Belt). The Izmir-Ankara Belt is separated from the Karakaya Zone (southern part of the Cimmerian Belt) by a low grade Hercynian basement with shallow water Mesozoic cover (Sakarya Block). However, because of the northwards directed subduction of the Vardar Ocean in the Izmir-Ankara Belt, a southwards directed nappe thrusting can be observed north of the Izmir-Ankara Belt. By this, in many places, sequences of the Karakaya Complex are situated as nappes above the oceanic melanges of the Izmir-Ankara Zone. A similar situation can be observed at the Darnó-hegy in northern Hungary, where Meliaticum is thrust over the Fennsikum ("Bükkium") that may be according to Kozur (1991a, b) the northernmost occurrence of the Vardar Zone in Europe. By small scale back-thrusting partly also the rocks of the Izmir-Ankara Belt are thrust over the Karakaya Complex.

New investigations about the time of the rifting in the Izmir-Ankara Zone have shown that the Middle Triassic consists of shallow water carbonates, underlain by undated, but probably Lower Triassic shales, siltstones and sandstones (Kaya, Kozur and Saddedin, in prep.). As in the Vardar Zone, first pelagic rocks occur in the Upper Triassic. However, partly the carbonate platform continued until the Upper Norian. Shallow intraplatform basins with a restricted basin conodont fauna consisting exclusively of *Mockina slovakensis* were found by Kaya et al. (in prep.). On the other hand, first red radiolarites are present within the upper Norian (Bragin and Tekin, 1996). These red radiolarites are filamentous radiolarites deposited above the CCD. True deep-sea radiolarites and ophiolite-radiolarite sequences are not known before the Jurassic (Bragin and Tekin, 1996). The breaking up of the carbonate platform and the beginning of the oceanic rifting in the Vardar Ocean occurred therefore in the same time from the Izmir-Ankara Zone of Turkey, Axios Zone of Greece until the Vardar Zone of Macedonia and Serbia. The same oceanic opening is present also in the Mures Zone of Romania and in the Szarvaskő Ocean of northern Hungary as possible prolongation of the Vardar Ocean. As the Szarvaskő Ocean was regarded by Kozur (1991a, b) as possible back-arc basin of the southwards subducting Meliata Ocean, an identical event succession seems to be present in the Inner Western Carpathians and immediately southwards adjacent areas and in northern Turkey, where Sengör (1984, 1985) assumed that the "Neotethyan" Vardar Ocean opened during the Upper Triassic and Jurassic by southwards directed subduction of the "Paleotethyan" Cimmerian Ocean.

The Karaburun Zone immediately south of the Izmir-Ankara Zone shows an upper Scythian to Middle Triassic aborted rifting that lead to the deposition of upper Scythian to Cordevolian Hallstatt limestones, cherty limestones, cherts, intermediate volcanics and tuffs, overlain by Middle Carnian to Lower Cretaceous shallow water platform carbonates. Neither this typical South Tethyan development that is similar to the developments in part of the Subpelagonicum and to the Bosnian Zone, nor the Vardar Ocean of the Izmir-Ankara Zone show any similarity in their geological evolutions to the Meliata Ocean and its slopes and outer shelves. On the other hand, in parts of the Cimmerian Ocean and its slopes outer shelves of northern Turkey, the development is very similar to the Meliata ocean and its slopes and shelves in the Inner Western Carpathians (see above). Moreover, typical North Alpine lithological units (e. g. Alpine Buntsandstein, Werfen Beds, Gutenstein Limestone, Steinalm Dolomite) can be found in this area in the same sequen-tial succession.

The above mentioned data exclude a correlation of the Meliata Hallstatt Ocean with the Vardar Ocean. As the correlation of the Vardar Ocean s. str. and the Subpelagonicum with the Karakaya Ocean exists only in the reconstruction by Kovács (1993) that is not founded by geological data and contradict basically all well founded previous correlations of the Izmir-Ankara Zone with the Vardar Zone, there is also no possibility to correlate the

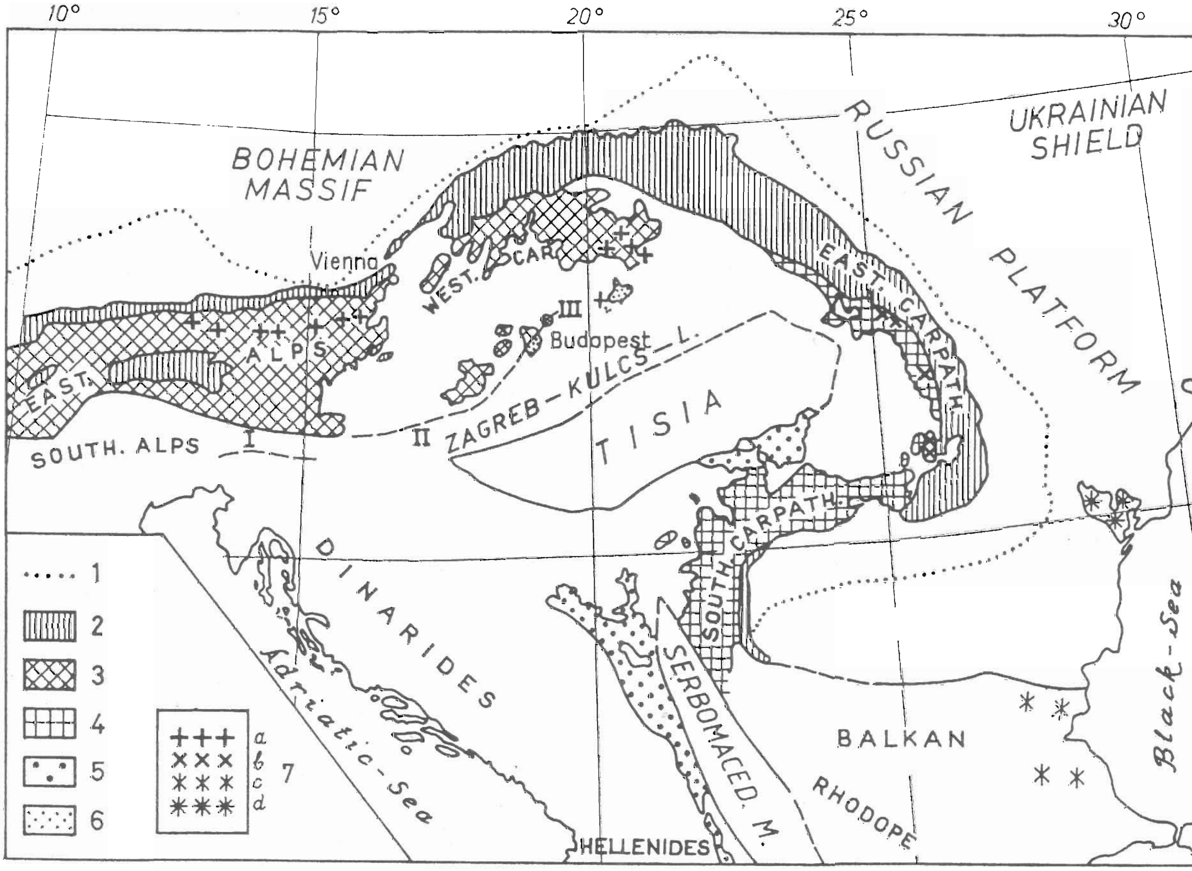

Fig. 7. Position of the Meliaticum in the Inner Western Carpathians and Eastern Alps and position of the Cimmerian remnants in the Eastern Carpathians and in the Eastern Balkan. 1 - Outer margin of the molasse sedimentation, 2 - Penninic windows and North Alpine flysch of Eastern Alps, Pieniny Klippen Belt to Silesian Unit of Western Carpathians, 3 - Lower, Middle and Upper Austroalpine and Licicum of the Eastern Alps, Transdanubian Mid-Mountains NW of the Balaton Line and of the Buda Line, Central and Inner Western Carpathians, 4 - Median Dacides of Eastern and Southern Carpathians (in the Eastern Carpathians Bucovinian and Subbucovinian nappes), 5 - Vardar Zone and Mures ophiolitic belt, 6 - Dinaric and Vardar units in Hungary, 7 - Remnants of the Cimmerian Ocean. (a) Meliaticum of the Eastern Alps and Western Carpathians, in the Eastern Alps mostly only blocks in evaporitc melanges at the base of Juvavic nappes except the Florianikogel Nappe in the southeastern part of the Upper Austroalpine, (b) Transylvanian nappes, (c) Kotel and Strandzha Unit (root zone of the Strandzha nappes not clear), (d) Dobrogea.

Cimmerian Ocean across the Vardarzone s.str. ("Südstamm" of the Vardar Zone sensu Tollmann, 1988).

This left open only two possibilities: (1) A direct connection of the Pontide Cimmerian Ocean, its slopes and outer shelves through the East Balkan Kotel Zone and Strandzha nappes to the Meliata-Hallstatt Ocean, its slopes and shelves, as assumed by Tollmann (1988: under the name "Nordstamm" of the Vardar Ocean) and Kozur (1991a, b). (2) The Meliata-Hallstatt Ocean was a short oceanic trough in the same paleogeographical position as the Cimmerian Ocean north of the later Vardar Ocean, but ending both in the east and in the west with no oceanic continuation to any ocean in the east, as assumed by Stampfli (1996).

8. Conclusions

1. The discussed Slovakian part of the Inner Western Carpathians comprises the Črmelicum (Črmeľ, Dobšiná and Ochtiná nappes; part of the basement of the Permo-Mesozoic superficial Inner Western Carpathian nappes), Hronicum (Choč Nappe s. l. and newly introduced Opátka Nappe; northern inner shelf of the Meliata-Hallstatt Ocean, from the upper Oxfordian to Neocomian southern inner shelf of the South Penninic Ocean), the newly introduced Muránicum (Strážov, Nedzov, Muráň, Stratená nappes; northern shelf of the Meliata-Hallstatt Ocean, transitional zone between northern inner and outer shelf of the Meliata Ocean), Silicicum (Silica Nappe s. l., northern outer shelf of the Meliata Ocean), North-Rudabányaicum (Rudabánya nappe; northern slope of the Meliata-Hallstatt Ocean), Meliaticum (Middle Jurassic accretionary complex of the subducted Meliata-Hallstatt Ocean), Gemericum (sialic block within the Meliata-Hallstatt Ocean), South-Rudabányaicum (Szőlősardó, Torna and Brusník nappes; southern slope and shelf of the Meliata-Hallstatt Ocean). The nappes of the Hronicum, Muránicum, Silicicum and North-Rudabányaicum are always in the highest

tectonic position above deeper Inner Western Carpathian and Central Western Carpathian nappes. These nappes are therefore united to the Upper Slovakocarpathian Unit, analogous to the Upper Austroalpine Unit. The Črmelicum as assumed part of the substratum of the Hronicum is assigned as well to the Upper Slovakocarpathian Unit.

2. The Gemericum was a sialic block within the Meliaticum. It is separated from the Črmelicum in the north by the Folkmar Suture Zone with remnants of the Triassic-Jurassic oceanic sequence of the Meliaticum, formerly mostly regarded as Scythian Werfen Beds or continental Permian in an assumed syncline within the northernmost Gemericum s. l.

3. The Gemericum displays a Triassic envelope series consisting of low-grade metamorphic shallow-water limestones with some basic tuffs.

4. Both at the northern and southern margin of the Gemericum slope deposits are present that are transitional between the Gemeric envelope series and the Meliaticum. They consist of slope limestones with blocks of shallow-water limestones, basaltic agglomerates and basalts. The southern slope unit of the Gemericum (Bôrka Nappe and newly introduced Radzim Nappe) is altered in HP/LT metamorphism. The metamorphism age of the glaucophane is 160 - 150 Ma (Maluski et al., 1993). This is in good agreement with the middle Oxfordian closure of the Meliata-Hallstatt Ocean. The northern slope unit is known from the Folkmar Suture Zone, where it occurs beside oceanic Meliaticum that is unmetamorphic, anchimetamorphic or low grade metamorphic, but not in blueschist facies.

5. The presence of a Triassic low-grade metamorphic envelope series of the Gemericum excludes that the Gemericum was the substratum of the Silica Nappe or any other nappe of the Upper Slovakocarpathian Unit.

6. The Triassic slope facies at the northern and southern margin of the Gemericum is entirely different from the slope facies at the southern and northern margins of the Meliata-Hallstatt Ocean. Therefore the Upper Slovakocarpathian nappes cannot be rooted at the southern or northern margins of the Gemericum.

7. The Alpine geological evolution of the Inner and Central Western Carpathians is controlled by the opening and closure of the Meliata-Hallstatt, South Penninic and North Penninic (Pieniny) oceans and related development on their shelves.

8. Continental rifting during the Upper Permian formed an elongated hypersaline basin with the axis about in the position of the later spreading axis of the Meliata-Hallstatt Ocean. This continental rifting influenced only parts of the Inner Western Carpathians.

9. The Middle and Upper Triassic development of the Inner Western Carpathians and of the southern parts of the Central Carpathians was controlled by the evolution of the Meliata-Hallstatt Ocean and of its shelf seas.

10. After the end of the sea-floor spreading in the Meliata-Hallstatt Ocean (contemporaneous with the middle Carnian Raibl event), distinct subsidence took place at the slopes and outer shelves of the Meliaticum caused by crustal cooling. By this, pelagic sedimentation began also in those areas, in which before shallow-water carbonate platform sedimentation prevailed (e. g. upper Tuvalian-Norian Hallstatt Limestones above Ladinian to lower Tuvalian Wetterstein Limestone in the Silica Nappe). This upper Carnian-Norian rapid subsidence, caused by crustal cooling, is typical for the slopes and outer shelves along the entire Meliata-Hallstatt Ocean. At the outer shelves of the South Tethys an opposite development can be observed. Middle Triassic to Cordevolian or upper Scythian to Cordevolian Hallstatt Limestones or other pelagic sediments are there overlain after a mostly distinct Raible horizon by upper Carnian to Norian shallow-water limestones or dolomites.

11. In the latest Triassic and earliest Jurassic, perhaps a short northward-directed subduction occurred in the northern branch of the Meliaticum, indicated by clastic input (? with blue amphiboles) in parts of the Silica Nappe.

12. The Middle Jurassic to lower Oxfordian geologic evolution of the Inner and Central Western Carpathians is controlled by the closure of the Meliata-Hallstatt Ocean and opening of the South Penninic and North Penninic (Pieniny) oceans.

13. The nappes of the Gemericum are probably Hercynian nappes that were Alpine rejuvenated. The Črmelicum has, however, an Alpine nappe structure.

14. The Callovian to middle Oxfordian northwards directed nappe thrusting of the South-Rudabányicum on the Meliaticum accretionary complex and of blueschist metamorphic Meliaticum on the Gemericum are related to the southwards directed subduction of the Meliaticum and the underthrusting of the Gemericum below the Meliaticum accretionary complex.

15. The Cretaceous southwards directed thrusting of the Silica Nappe over Meliaticum or South-Rudabányaicum is related to the Cretaceous northwards directed subduction of the Szarvaskő Ocean.

16. The Cretaceous northwards thrust of the other Inner Western Carpathians and Central Carpathian nappes is related to the southwards directed subduction of the South Penninic Ocean and partly (Fatricum, Tatricum) to the subduction of the Pieniny Ocean. These nappes were formed in the time interval from the Aptian to uppermost Turonian or lower Coniacian.

17. The new subdivision of the Inner Western Carpathians and new stratigraphical data in the Eastern Alps made the correlation between the Eastern Alps and Inner Western Carpathians more easy. The Črmelicum corresponds to the Veitsch Nappe of the eastern Grauwackenzone. The Gemericum can be correlated with the western part of the Northern Grauwackenzone and with a part of the Noric Nappe s. l. The Middle Jurassic accretionary complex of the Meliaticum and the South-Rudabányaicum have in the Alps and Western Carpathians the same lithostratigraphic and event succession, and they are situated in the same tectonic position (southern margin of Upper Austroalpine eastern Grauwackenzone in the Eastern Alps, southern margin of the Črmelicum in the Inner Western Carpathians). Only in the meridian of the Geme-

ricum there are two suture zones of the Meliaticum, one north of the Gemericum and south of the Črmelicum, and the second south of the Gemericum. The root zone of the superficial Permo-Meoszoic nappes of the Inner Western Carpathians is always (also in the meridian of the Gemericum) south of and on the Črmelicum, as it lies in the Northern Calcareous Alps south of and on the Grauwackenzone.

18. The Drauzug has the South Tethyan event succession and cannot be assigned to the Upper Austroalpine. It is an independent unit (Licicum) at the northern shelf of the South Tethyan Ocean separated from the Upper Austroalpine by the Central Alpine Ridge with Central Alpine Mesozoic facies (Stangalm Mesozoic).

19. If the Balaton Highland was in the Triassic situated between the eastern part of the Northern Calcareous Alps and the Southern Alps, a separating Central Alpine Ridge must be also present, because also the Balaton Highland displays Norian Hauptdolomit, an "exotic" facies between the Norian Dachstein Limestone of eastern parts of Southern Alps and Norian Dachstein Limestone and Hallstatt Limestone in the eastern part of the Northern Calcareous Alps.

20. There is no unit in the Vardar-Axios Zone (and its continuation in the Izmir-Ankara Zone) and in the Dinarides and Hellenides with the event succession of the Meliaticum. In the contrast, within the Cimmerian Ocean of northern Turkey, eastern Bulgaria and in the Dobrogea, the event succession of the Meliata-Hallstatt Ocean can be found and all typical North Alpine lithostratigraphic units are present. In eastern direction, an increasingly earlier opening can be observed, but also the subduction begins in many places in the lower Norian or already in the Middle Carnian, but there are also areas with Middle Jurassic flysch. The final closure was, as in the Meliata-Hallstatt Ocean, at the end of the Callovian or within the Oxfordian.

21. The Meliata-Hallstatt Ocean lies north of the Vardar Ocean as the Cimmerian Ocean in Turkey. Either the Meliata-Hallstatt Ocean was the direct northwestern continuation of the Cimmerian Ocean or it represent a short oceanic basin in the same tectonic position as Cimmerian Ocean, and in its paleogeographic continuation, but without direct oceanic connection to the Cimmerian Ocean (Stampfli, 1996).

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Raw materials of the Neolithic polished stone artefacts from the site Bajč (SW Slovakia)

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Abstract

A site Bajč - Medzi kanálmi (SW Slovakia) belongs to unique ones with an extremely high number of stone artefacts found there. Evaluation of a pottery assemblage dates it into the Želiezovce group and a polished industry documents a period of the terminal Middle-Neolithic. Petrographic analyses (a polarization microscope) has shown that stone artefacts from Bajč were made of numerous kinds of sedimentary, igneous and metamorphic rocks. The work presents their characteristics and discusses presumable provenience of their primary occurrences.

Key words: Bajč, late Middle-Neolithic, polished stone artefacts, raw materials

Introduction

Installation of a new kind of a stone working tool - an axe and chisel - is closely connected with incipient Late Stone Age (the Neolithic) represented by the Linear Pottery culture in SW Slovakia and with settled way of living of farmers in this period. Production of flat stone axes and shoe-last chisels started also the application of new technologies - firstly sawing, grinding, polishing, later also boring. Stone tools were used first of all in working-up of wood (for a house-building, production of tools wooden parts, and other artefacts).

But from the archaeological point of view Slovak studies on Neolithic and Aeneolithic used to give priority mainly to evaluation of the pottery inventories giving the best possibilities for their cultural and chronological classification according to existing typological and ornamental tables. Polished stone industry as one of the groups of artefacts found in sites or cemeteries used to be only at the end of interest, that was usually confined to typology of tools or occasionally to consideration of cultural relations on account of a shape resemblance. A work analysing polished industry as a complex together with types of raw materials has been missing up to now here. The gap has been gradually filled in last years with evaluations of some assemblages from particular archaeological sites or regions of Slovakia.

In connection with petrographic identification of polished artefacts raw materials also a question of primary sources definition of these materials used for stone industry, or tipping-out of important distribution centres, is coming to the limelight.

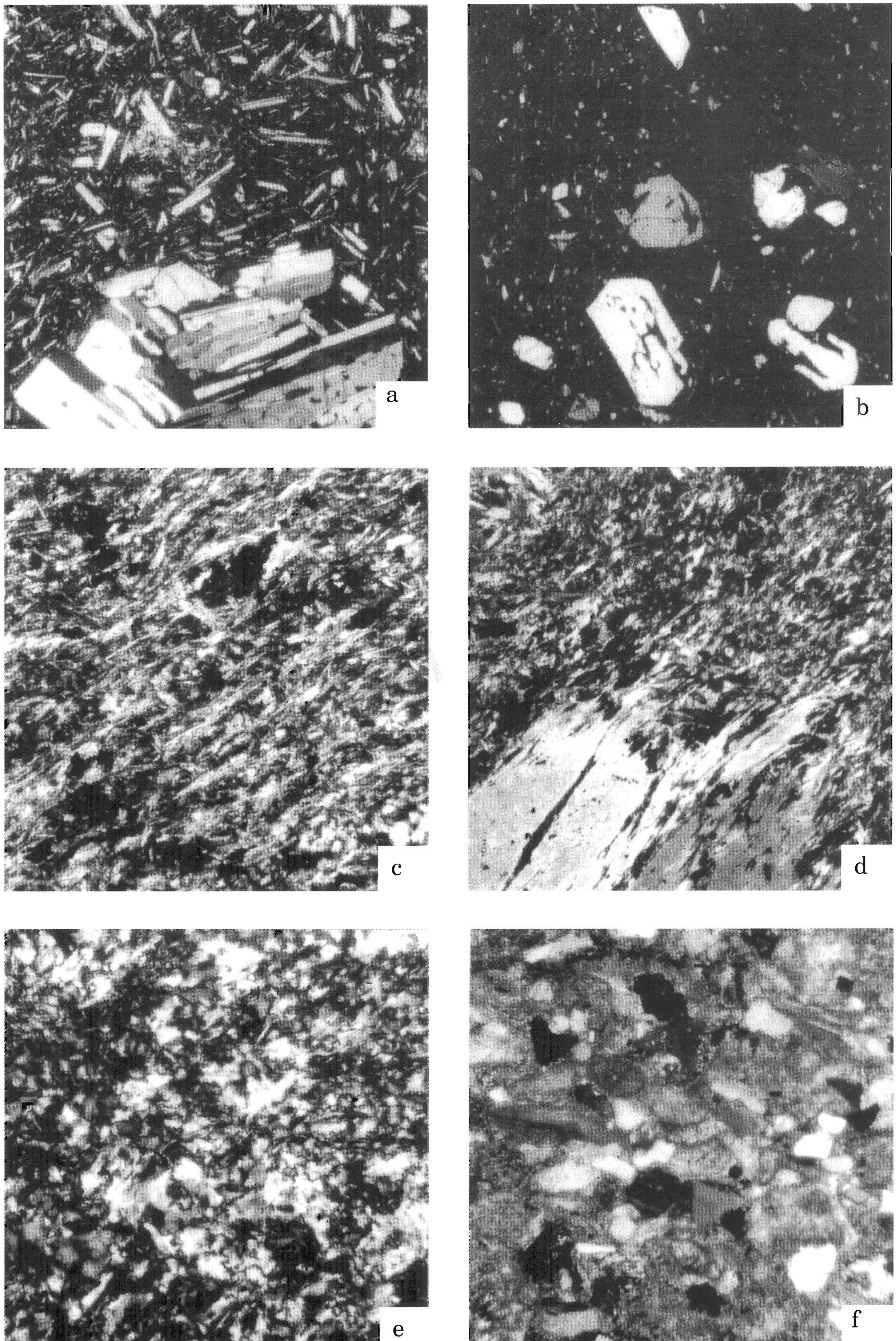
Petrographical research of stone polished artefacts has its own specifities both in macro- and microscopic studies. In the former case limitation in raw-material specification is done by a ground and then polished surface of the tool under evaluation alone, usually covered with patination of various thickness. In microscopic analysis, on the other hand, a problem is sometimes connected with gaining of a section suitable for taking a sample necessary for getting a cut. In this case they are first of all entire specimens into which an intervention (sawing-out of a thin plate) is often beyond all aesthetic reasons for an archaeologist. That's why only fragments or damaged artefacts are used for taking a sample almost exclusively. For this reason such microscopic research in various sites or regions can be of limited value.

Of course, it depends at the first place on number of specimens evaluated by macroscopic petrographical analysis as well as microscopic one. This ratio can be rather different for individual sites. Then the question is an extend to which a gained result could be considered as a complete one.

A certain aid, or a way out, in petrographic evaluation of entire specimens of the polished industry is seen in using of petrophysical methods, too (Husák and Cheben, 1987; p. 230).

Petrographic information of a raw-material qualities can

Pl. I. a - Glomerophyric (plagioclase) fabric of andesite with fine-crystalline and glassy matrix. Bajč - 30., magn.: 37x, X polars, negat.: 91334, b - Plagioclase and pyroxene phyric andesite with glassy matrix. Bajč-128., magn.: 45x, X polars, negat.: 91336, c - Fine-grained actinolite schist with well developed foliation. Bajč-121., magn.: 86x, X polars, negat.: 91337, d - Porphyroclastic fabric of anthophyllite schist. Bajč-6., magn.: 45x, X polars, negat.: 91344, e - Antigorite serpentinite. Bajč-8, magn.: 86x, X polars, negat.: 91333, f - Calcarenite. Bajč-221., Magn.: 86x, X polars, negat.: 91335. ▶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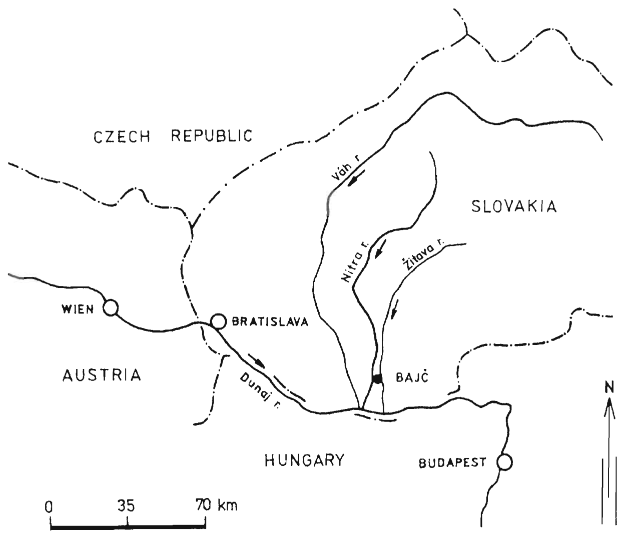

Fig. 1 Location of the site Bajč.

be used also in reconstruction of particular production phases, mainly sawing and boring. It can help also in determination of suitable abrasive materials used in sawing, boring or finishing of stone tools surfaces.

A polished stone industry collection is deposited in the Institute of Archaeology of Slovak Academy of Sciences in Nitra. Thin sections are included into databasis resources in the Department of Mineralogy and Petrography of Faculty of Natural Sciences, Comenius University, in Bratislava. For particular cuts those fragments from polished stone industry collection were chosen that gave also an opportunity for macroscopic characterization of as-wide-as-possible palette of used rock types. Just this was the main aim of detailed study of the entire stone artefacts collection. On this basis a provenience of particular raw-material types could be studied, too.

Site characteristics

The Neolithic site in Bajč (Fig. 1) is situated on a sand dune between defunct meandering arms of river Žitava approximately 200 m east of its already canalized bed. The whole revealed and excavated area covered 2,7 ha. The Neolithic settlement was documented on space of 1,9 ha.

Within a several-years-lasted field excavations of the Neolithic site in Bajč, position Medzi kanálmi, (distr. of Komárno) a numerous assemblage of polished stone industry was revealed, being the object of our evaluation in this work. From typological point of view flat axes, shoe-last chisels, globular maces, semi-products, semi-finished articles, raw material as well as various fragments of damaged or repaired tools were found there. A piece of a raw material, a stone stake, shoe-last chisel together with a globular mace were unearthed in a skeletal grave. According to these findings we can presuppose a handicraftsman producing polished stone industry at the site was burried here.

First settlement of the site with its beginning coinciding with the end of the Middle-Neolithic is at the same time connected with a climate change during the Atlanticum. The change had caused that the Želiezovce-group bearers came to this microregion without preceding settlement, i.e. they got into original natural environment (only a population living on the left bank of the river Žitava was under investigation). In vicinity of the site an original forest, undevastated by man, spread there. Maybe somewhere here lies an explanation of a great number of woodworking tools found on the area of the site under research.

Since similar situation has not been documented from other sites of the Linear culture and the Želiezovce group in Slovakia for the present, we can presume a population group have been living in the site, activity of which was oriented on specialized production of polished industry. Finds of this industry at the explored area were spread equally. It means that no cluster of finds was excavated indicating explicitly a possible production workshop.

Finds of rubbers usually made from damaged or broken tools represent a relatively numerous group. Mostly they are bodies of shoe-last chisels. They also provided an information about used rock type.

The great number of polished stone artefacts, flat axes and shoe-last chisels, had to be made of raw material from more distant regions. From the archaeological point of view the petrographic analysis can help to define regions of Bajč raw materials primary sources occurrence and by this way to confirm or extend regions with which cultural relations are documented by pottery imports.

For recent stage of kind studies of particular raw materials used for polished stone industry found in the III.-stage settlement of the Želiezovce group (end of the Middle-Neolithic) in Bajč 61 thin sections were microscopically studied from fragments of 60 surviving artefacts. These are representing a full spectrum of raw materials revealed at the site under archaeological investigation - the entire assemblage of the polished stone finds from Bajč contains 350 pieces. But these are only a known part of unknown bulk of polished stone production in Bajč.

As far as typology is concerned, two types are predominating in the polished stone industry (Fig. 2) assemblage in Bajč - a flat axe with shoe-last vaulting and a shoe-last chisel. Thanks to their numerousness we can study also their length and width-and height indices. The length of flat axes varies from 6 to 17 cm. Variability of the chisels length is bigger. It ranges from 7 to 24,5 cm. The width-and-height index shows a bigger variability, too, in comparison with the flat axes. The chisels found in Bajč occur both narrow and high (the average index 4,5 : 2,5 cm) as well as wider and smaller (the index 2,5/3,5 : 3,5/4,5 cm).

Raw materials

Besides artefacts typology and their ranking to discrete culture, types of raw material used and provenience of its primary occurrences are main aims of modern archeological studies.

By naked eyes performed studies are strictly limited by rock grain-size and patination of individual artefacts. So

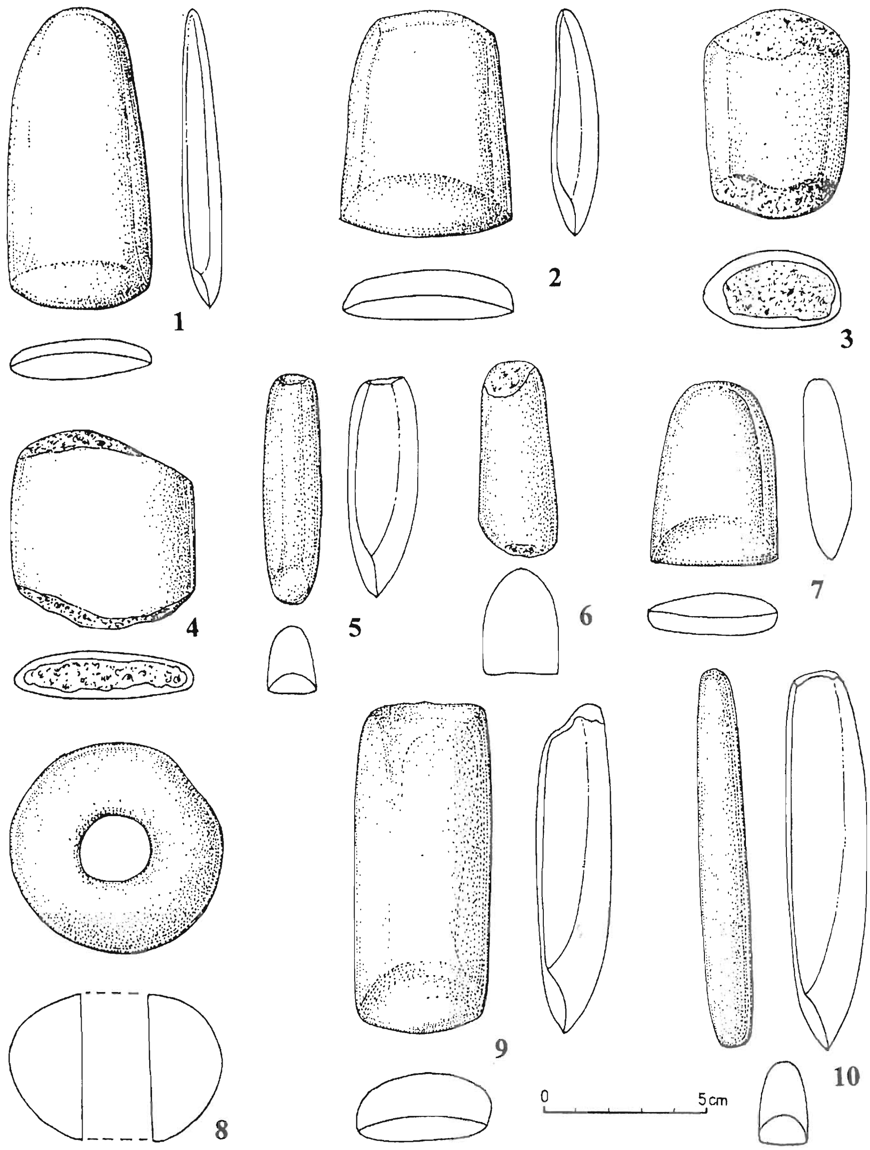

Fig. 2 Bajč - types of polished tools.

thin section studies allow us to characterize raw materials in details, which is the first step for consequent approximation of artefacts raw material to geological bodies. Realized studies of several tens of thin sections from site Bajč prove above generalized opinion.

Igneous rocks

Among Neolithic/Aeneolithic artefacts from various sites of the Slovak republic territory plutonic as well as volcanic rocks are present (Hovorka and Illášová, 1995; Illášová and Hovorka, 1995; Hovorka and Soják; in print). For the site studied artefacts made from intrusive as well as effusive rock types are present in subordinate amount only.

Pyroxenite

Fragment of axe (MK-87/B-5) under consideration is composed. It consists of two different parts composed of various rock-types. The first one is turquoisegreen rock type which gradually pass into darkgrey schistose rock of aphanitic appearance. For this part of the artefact small negative forms (being products of the artefact weathering) on surface of the artefact are observable.

Mentioned two rock constituents are distinguishable in thin sections, too. Turquoisegreen portion of the artefact is represented by fine-grained (1 - 1,5 mm) anchimonomineral clinopyroxene aggregate of hap-hazard orientation. Between clinopyroxene crystals there occur small clino-zoisites of irregular shape. They represent the most probably product of plagioclase recrystallization. The second part of the artefact is formed by aggregate of monoclinic colourless tremolite-actinolite of longcolumnar shape with only very slight pleochroic (green) colours. Among amphibole columns there are disseminated ilmenite crystals and film-like Fe hydrates.

Given mineral composition and mutual space relation of mentioned two rock constituent of the artefact under consideration allow us to characterize original rock type as layered pyroxenite (with probable admixture of plagioclases), which underwent metamorphic recrystallization under greenschist pT conditions. Orthopyroxene layers (bands) preferentially recrystallized into amphibole aggregates, while clinopyroxene layers (bands) in recrystallization processes survived.

Clinopyroxene phyric andesite

This typical volcanic rock consists (B-128) of phyric clinopyroxene within submicroscopically grained matrix. It consists of very fine-grained crystals of needle-like plagioclases (0,1 mm) and volcanic glass. Pigment of fine-grained ore minerals is present in subordinate amount only.

The presence of substantial amount of volcanic glass in the rock matrix determines physical properties of the given rock-type.

Two pyroxene andesite

For this type of raw material fine-grained phyric clino- and orthopyroxene are characteristic. Plagioclases are present in the form of glomerophyric aggregates deposited within hemicrystalline submicroscopic matrix. Rock under consideration has locally slightly fluidal fabric (B-30). In the other (B-86) fragment originally yellowishbrown glassy matrix is recrystallized into fine-grained aggregate of secondary minerals (Pl. I/b).

Dolerite

This rock type is characterized by completely holocrystalline character. In substantial (over 10 volume perc cent) amount clinopyroxene, lathy plagioclase and leucoxenized ore minerals are present. Rock under consideration has subophitic fabric, which allow us to rank it among subvolcanic rock-types. Based on the fact that dolerite studied is partly recrystallized (plagioclase yields saussurite aggregate and ore minerals recrystallized into leucoxene) the original provenience is not univocal (pre-Tertiary versus Late Tertiary origin).

Sedimentary rocks

Within the set of artefacts studied, those made from sedimentary rocks are seldom. Each of characterized rock-type is represented by one artefact only.

Calcarenite

Rock of this artefact (BMK/B-222) is formed of clasts of calcite shells of different organism and in less amount of clasts of micritic limestone. Together they form approximately 70 per cent of the rock mass. In spaces between shells there is present also microfauna, namely foraminiferas. Some of carbonate clasts have surface limonite film, clasts of this type belong to extraclasts (Pl. I/f).

In thin section also clasts of quartz, micas, feldspars and devitrified volcanic glass are detectable. Very sporadically crystals of zircon, tourmaline, and rutile are present. Quartz crystals are of angular till subangular character. Characteristic is the presence of glauconite crystals, which is dicriminant mineral for just young sediments. Glauconite is well rounded, so it transport from distant sources should be supposed.

Triassic biohermn limestone

Yellowish limestone (5 x 6 cm ball-like bored artefact No. B/22) of homogeneous type. Characteristic is the presence of Frondigularia (Foraminifera), Dacygladacae, shells of conches. In thin section filling of originally empty spaces and agglutinates (pelets) are visible. Limestone is comparable to limestone of Wetternstein type (Anisian - Norik = Triassic age). On the base of shells present and rock fabric it should be compared to Wetternstein limestones of the Slovenský kras Mts. on the southern rim of the Western Carpathians Gemeric zone.

Concordantly bedded silicite

Light chocolatebrown axe (B-4) of 6 x 3 x 1,5 cm dimension is composed of fragments of spucules, radiolarians and silty fraction of quartz. Sporadically also flakes of chlorite, as well as decomposed dark mica, zircon are present. The groundmass of the rock studied is composed of submicroscopically grained quartz-chalcedony aggregate. The reddishbrown colour is the result of irregular spots of iron oxides (hematite ?). The discussed rock type belongs, with certain degree of probability, to Doggerian (Jurassic).

Vitroclastic tuff

Raw material of this type (Bajč-Vlkanová, B-34b) is characterized by weakly developed preferred oriented fabric. It is characterized by the presence of illite aggregates on zones of microshearing. In the given rock also admixture of clasts of volcanic glass of brown colour and quartz, sporadically also micas and feldsdpars are present.

They reach 0,5 to 1 mm dimension. In less amount also nests of authigene carbonate crystals as well as ore minerals are rock constituents.

Metamorphic rocks

This rock group is of the most complicated origin. It is reflected in physical properties, which fundamentaly differ even within this rock group. Among artefacts of the given site the metamorphic rocks are the most widespread. Their basic characteristics are as follows.

Greenschist

To this group of metamorphic rocks belong those which originated under relatively low temperature (to approx. 50 °C) within the uppermost levels of the Earth's crust. In the following text the various types of greenschist are characterized differing in mineral composition, grain-size and fabric.

Spinel-hornblende-anthophyllite schists

Similarly as on the other western Slovakian sites (Hovorka et al., 1997) we dealt with very fine-grained (0,X mm dimension of rock-forming minerals) rocks. They have pronouncedly schistose fabric. Greenschists under consideration are mostly of darkgrey colour. The prevailing rock-forming mineral is anthophyllite with variable proportion of hornblende and grass-green spinel with high Al_2O_3 contents (60 - 62 per cent: Hovorka et al., 1997).

Green spinel (present in amount till 20 per cent) forms clusters or individual xenoblastic crystals spread over areas of rectangular shape, e. g. spinel is one of pseudomorphic phases after orthopyroxenes.

Locally observed felty fabric of needle-like anthophyllite aggregates allow to classify rocks under consideration as nephritoids (Illášová and Hovorka, 1995).

Rarely present relics of orthopyroxenes have been observed. Various stages of their replacement by anthophyllite aggregates are characteristic. Origin and possible provenience of this, in central Europe not yet known rock type, has been discussed in paper by Illášová and Hovorka (1995). In this type of greenschist fan-like anthophyllite aggregates have neen observed. On places diffuse phlogopitization documents very complicated and multistadial history of these rocks.

Tremolitic and anthophyllitic (mostly anchimonomineral) schists

Artefacts of this type are characterized by the presence of lense-like dark nests within the lighter matrix mostly of darkgrey till greenishgray colour. Nests have dimensions to 1 cm, locally even to 1,5 cm. They are oriented by their longer axes conformly with the schistosity of given greenschist. On artefact surfaces which underwent weathering processes negative relief approximately mimetize their shape and size. Mineral aggregates concentrated within discussed nests are coarse-grained in comparison to the rock matrix.

Besides amphibole crystals other main phase present are fine blades of phlogopite, which are the product of superposed metasomatic processes. The zones of phlogopitization are of diffuse limits to the country monomineral amphibole aggregate. The dark colours of the rock decribed is conditioned by the presence of fine-grained ore (mostly magnetite) pigment.

Another rock-types of this category are characterized by the porphyroclastic fabric. In this case to 3 mm porphyroclasts are formed by colourless monoclinic amphiboles, which are rimmed by fine-grained amphibole aggregate. Optical properties of this aggregate correspond to that of groundmass fine-grained amphibole aggregate.

Type of fabric and mineral composition indicate that the rock under consideration is product of metamorphic recrystallization of pyroxene-rich (pyroxenite) rocks under the greenschist pT conditions.

Albite-amphibole schists

They are mostly very fine-grained (0,2 - 0,5 mm) rocks with well developed foliation. In this type of the greenschist green pleochroic monoclinic amphibole is dominant. According to the albite morphology and size the artefacts studied should be divided into:

a) equal grained types, and

b) porphyroblastic types with albite (till 2 mm) porphyroblasts. Namely types quoted ad a) gradually pass into monomineral varieties composed mostly of amphiboles.

In all thin sections studied fine-grained magnetite pigment causes dark colour of the given rock-types.

Amphibolite

They represent fine-grained (2, sporadically to 3 mm) rock-types mostly with well developed foliation. They are composed of two minerals: amphibole and plagioclase. Pronouncedly dominant presence of amphibole in several cases allow as to classify such types as melamaphibolites.

Plagioclases of the given rock types often recrystallized into fine-grained aggregate of saussurite character.

Leptynite

Leptynites represent rocks of high-grade metamorphic origin. They are light in colour, mostly foliated. They are composed of quartz, plagioclase, and bluishgreen amphibole, minerals of the epidote group and accessories (sphene, zircon). Leptynite represented by artefact B-41 is penetrated by hair-like veinlets with epidote-group minerals filling.

Antigorite serpentinite

Antigorite serpentinites are hydratation products of original peridotite. Mentioned process underwent under temperature higher that 350 °C.

Artefacts made from antigorite serpentinite (B-3, B-219, B-185) are either light-green with black nests of ore minerals, or darkgrey with irregular nests of rusty-brown carbonates (till 5 mm). They are of massive fabric, in thin section there is observable local foliation of antigorite flakes. Rock under discussion are anchimonomineral. Except of strongly prevailing antigorite they contain magnetite pigment and Mg-Fe carbonates. Generally this rock type corresponds to antigorite serpentinite described in paper by Hovorka and Illášová (1995) (Pl. I/e).

Raw material provenience

Calcarenite based on the presence of glauconite on one site, and rock constituents of the given artefact on the other one, we suppose Neogene age of rock under discussion. Strata of calcarenites of discussed type are known to occur as members of Neogene Pannonian basin filling as well.

Triassic bioherm limestone in several Western Carpathians mountain ranges belongs to the often occurring rock type. Just the same is valid for the Northern Calcareous Alps. At time being we prefer river Danube pebbles as the source of artefact under discussion.

Concordantly bedded silicite of the most probably Jurassic age rarely occur within some of Western Carpathians mountain ranges (e. g. Strážovská hornatina Upland). More abundant are occurrences in the Northern Calcareous Alps. Also in this case we prefer river Danube pebbles as the possible source of raw material for this artefact.

Vitroclastic tuff represent local raw material, taken from some of central Slovakian Late Tertiary volcaniclastics occurrences.

Pyroxene- and pyroxene-plagioclase phyric *andesites* represent one of the main products of Late Tertiary volcanic activity. The closest volcanic fields are those of the Pohronský Inovec and Vtáčnik Mts. to the north and Börszony Mts. on Hungarian territory to the south. Southern periphery zones of the Štiavnica stratovolcano are composed of volcaniclastics of fine-grained breccia and sandy types.

Based on this, these areas should be excluded as possible source areas of this type of raw material.

Based on the size of artefacts made from andesites we should consider that the most probable raw material represent gravels of the river Hron in the lower part of its valley. The abrasion processes acted upon andesite blocks transported by river favour this type of raw material. Use of rock blocks on the places of their occurrences we can not exclude.

Holocrystalline *dolerite* based on high degree of its primary magmatic features we consider to be the product of Mesozoic volcanic activity. Also in this case its source should be the gravel deposits in the river Hron valley.

Greenschists represent the prevailing type of raw material on locality studied. Within this group of raw material there are several rock-types which originated from different protolith.

Spinel-hornblende-anthophyllite schists correspond to types described from numerous sites from the western Slovakia (Hovorka et al., 1997). In above paper discussion on their origin is presented in details. Based on it we sum up: 1) provenience of this more-or-less exotic raw material is located westward of places of their deposition, 2) based of rock fabric and their mineral composition for which relics of original clinopyroxene is characteristic, we consider outer contact-thermic aureole of granitic massif as the most probale place of discussed rock origin, 3) as the most probable place of such rock occurrences is area on the southern rim of the Krkonoše Mts. in the Czech republic, even in that area discussed rock types (with Al-rich green spinel) have not been described yet.

Tremolitic an anthophyllitic (mostly anchimonomineral) schists by their mineral composition as well as fabric (mostly felty, often porphyroclastic, without plagioclase) mostly correspond to rocks, which we described in the past (Illášová and Hovorka, 1995) as "nephritoids". Primary occurrences of such rock-type are not known from the state territory. As probable localities some geological units of the Bohemian massif in the territory of the Czech republic and Austria as well as river Danube pebbles should be taken into consideration. At time being problem of raw material provenience we consider not to be solved yet - we follow study of this problem.

Albite-amphibole schists represent relatively widespred rock-type in numerous central European geological units. They are known to occur in the Malé Karpaty Mts., Spišsko-gemerské rudohorie Ore Mts. to the east of described localities, as well as geological units being part of eastern rim of the Bohemian Massif. The Malé Karpaty Mts. geographically are closest to the archeological sites in western Slovakia, and rock complexes forming the Pezinok-Pernek Formation ought to be taken into consideration. Beside this pebbles of the rivers Hron and Danube should also be the source of already partly elaborated raw material of above type artefacts.

Amphibolite represent sporadically present raw material of given site. Amphibolites of very similar mineral composition, fabric and degree of preservation occur in Hlboká and Drahožická valleys in the Tríbeč Mts., in the Malé Karpaty Mts. as well as in other mountain ranges of central Slovakia, Bohemian Massif and the Eastern/Northern Alps. It is well-known that amphibolites represent common rock-type within middle to high grade metamorphic complexes. Our knowledge of this problematic allow us to consider the following sources of this type raw material: a) primary occurrences in the Tríbeč and Malé Karpaty Mts., b) pebbles of the river Hron (derivatives from the central Slovakian mountain ranges) and Danube (derivatives from the southern slopes of the Bohemian massif as well as from the Northern Alps.

Leptynites represent rare rock type in nature as well as rare raw material of Neolithic/Aeneolithic artefacts known from the central European sites. The only one fragment of axe made from leptynite confirm such rare occurrences of leptynites. Leptynites are member of leptyno-amphibolite complexes which are typical rock-sequences of central European Variscides (the Bohemian Massif, the Eastern Alps as well as the Western Carpathians; Hovorka et al., 1996).

The closest leptynites occurrences are located on the southern slopes of the Nízke Tatry Mts., as well as geological units located on the northern rim of the Slovenské rudohorie Mts. The only known artefact, which has no specific features, made from this rock type, do not allow us to solve the problem of its provenience.

Antigorite serpentinite is spite of its relatively seldom occurrence in nature, artefacts made from this raw material are one of frequently used raw material in the western Slovakia (Hovorka and Illášová, 1996). The closest antigorite serpentinite occurrences are known from the Slovenské rudohorie Mts. (area of Brezno).

Their exploration from bodies in mentionead area is more-or-less impossible (rural areas distant from the Hron river valley, huge forests, mountaneous morphology, etc.). Antigorite serpentinites are known from the area of city Brno as well from the area of Austrian-Hungarian boundary. They are known from the river Danube pebbles. As artefacts studied made from antigorite serpentinites have not any special features, the problem of original rock sources is not yet solved.

Discussions and conclusions

Following summary is intended to help comparison of findings frequency according to particular groups of inventories, some of them being not only from SW Slovakia.

From the full number of 568 pits revealed in Bajč, a pottery material was found in 466 of them. Considering a statistic average of occurrence of one stone tool to one pit, the ratio is 1,6 pit to 1 stone artefact. These data show an unusual frequency in occurrence of this archaeologically evaluated artefacts type just here in Bajč.

This phenomenon is even more remarkable in a quantitative comparison between polished stone tools and a number of houses in individual sites. Investigation of a site with the Linear Pottery culture and the Želiezovce group in Štúrovo, has resulted in the ratio of 32 ground plans of houses and approximately equal number of pits as in Bajč to 7 flat axes and 4 another fragments (Pavúk, 1994; p. 121, Tab. 50), what is extremely low number not only in comparison with Bajč. Somewhat better situation is in Patince, where 14 ground plans of houses come to 11 artefacts. On a site in Bylany this ratio was 1 : 50. Frequency of polished-industry findings is alike more numerous also in another sites of SW Slovakia (Blatné, Dvory nad Žitavou, a cemetery in Nitra). Comparison with other central-European sites from the period under research was done by Pavúk (1994; p. 122).

The observed ratio (house : polished artefact) is even more remarkable under consideration of the time factor, i. e. number of a site horizons. The sites in Patince and Štúrovo have disposed of 12 (11) artefacts to 6 (10) site horizons. On the other side, in Bajč where 3 horizons were distinguished, the ratio is 1 : 116.

In the Neolithic period tribes which occupied the territory to the north of the river Danube (southern slopes of the Carpathians) belong to those producing linear pottery. It is typical for people with settled style of living. The Neolithic, in contrast to the Palaeolithic period, is characterized by more complicated shape of tools and weapons, but simultaneously by the greater number of raw material types used for their construction. For the Neolithic period bored tools and weapons are typical. In site Bajč - Medzi kanálmi, pottery relics belong to the Želiezovce group and so stony artefacts studied should be ranked to the late Middle Neolithic period.

Results of more than 60 thin sections studied document that raw material of axes and the other weapons and tools were made from sedimentary, eruptive as well as metamorphic rocks. The most often used raw material type were various types of greenschists, which at least in part have been gathered among river Danube gravels. To this rock category belongs also unique rock type - spinel-hornblende-anthophyllite schist (Hovorka et al., 1997). Primary occurrences of such rock type is not known from the central Europaen occurrences. The main phases of this rock type have been studied by the use of electron microprobe from several western Slovakian localities (l. c.)

For green spinel high content of alumina is characteristic. Another interesting rock type represent pyroxenite, as well as antigorite serpentinite, various limestone types, and volcaniclastics. From the aspects of distance of primary raw materials occurrences, it should be stated that raw materials have their sources:

a) within the close neighbourhood of site Bajč, or from not very distant occurrences,

b) some of them are from distant sources: from the southern slopes of the Bohemian massif, from the Sudetes, and from the Grauwackenzone of the northern Alps.

In comparison with the other archaeological sites on the territory of Slovakia (the area of Spiš county: Hovorka and Soják, in print, Šarišské Michaľany: Hovorka and Šiška, in print, or the area of the western Slovakia: Illášová and Hovorka, 1995) raw materials from the site Bajč are characterized by unique proportion of materials used as well as types of raw materials.

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Priepustnosť a prietočnosť hornín paleogénu Hornádskej kotliny

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Permeability and transmissivity of the Paleogene rocks in the Hornád Basin (East Slovakia)

Data from 127 aquifer tests provided a picture of permeability and transmissivity distribution in particular lithostratigraphic members of the Central-Carpathian Paleogene in the Hornád Basin. The studied formations have various proportions of sandstones, claystones, siltstones and conglomerates. After transferring specific capacities of wells to approximative logarithmic parameters - permeability index Z and transmissivity index Y, statistical characteristics of the distribution of the Z and Y values were converted to estimates of respective distribution characteristics of hydraulic conductivity k and transmissivity T. Envisaged permeability increase with increasing share of sandstones and conglomerates in the tested well intervals has not been corroborated. On the contrary, in two lithostratigraphic members an inverse dependence (permeability increase with decreasing share of sandstones) was found. Mean permeability decreases with depth below ground surface according to exponential dependence. The expected mean permeability in chosen particular depths serves therefore as the best value for an objective comparison of particular formations. Expected geometric mean of hydraulic conductivity in particular formations ranges from 8×10^{-6} to 2×10^{-5} $m.s^{-1}$ at the depth of 20 m and between 1×10^{-6} and 1×10^{-5} $m.s^{-1}$ at the depth of 50 m. Geometric means of transmissivity are between 1×10^{-4} and 4×10^{-4} $m^2.s^{-1}$.

Key words: Paleogene of Central Carpathians, permeability, transmissivity, hydraulic conductivity distribution

Úvod

Pri hydrogeologickom výskume Hornádskej kotliny, ktorý realizoval Geologický ústav D. Štúra (Jetel et al., 1990), sa získal podrobný obraz o distribúcii hodnôt hydraulických parametrov hornín paleogénu tohto regiónu syntetickým zhodnotením značného množstva údajov hydrodynamických skúšok v starších vrtoch a údajov získaných vlastnými výskumnými vrtmi. Rozsah skúmaného územia sa v podstate zhodoval s geomorfologickým celkom Hornádskej kotliny: išlo o územie medzi Vikartovcami, Spišskou Novou Vsou, východným okolím Spišských Vlách, západným úpätím Braniska, Levočou a Spišským Štvrtkom.

V zmysle Grossa et al. (1984) paleogén tu reprezentujú štyri viac-menej sukcesívne litostratigrafické jednotky podtatranskej skupiny centrálnokarpatského paleogénu: borovské súvrstvie („bazálna litofácia"), hutianske súvrstvie („ílovcová litofácia"), zuberské súvrstvie (flyšový vývoj) a bielopotocké súvrstvie (pieskovcový vývoj). Borovské súvrstvie predstavuje dva litotypy: v nadloží prevažne karbonátového mezozoika medzi Spišskými Vlachmi a Betlanovcami sú to prevažne karbonátové brekcie, zlepence, pieskovce až prachovce, na Z od Betlanoviec až po Vikartovce sú vyvinuté polymiktné zlepence a pieskovce. Hutianske súvrstvie tvoria ílovité prachovce až prachovité ílovce s polohami jemnozrnného až strednozrnného pieskovca. Zuberské súvrstvie buduje väčšinu povrchu územia a predstavuje flyšové striedanie pieskovcov a prachovcov. Bielopotocké súvrstvie vystupuje hlavne na S a SV pri úpätí Levočských vrchov. Tvoria ho pieskovce a zlepence s vložkami prachovcov a ílovcov.

Metodika hodnotenia

Predmetom hodnotenia boli údaje 127 odberových skúšok rozčlenené podľa litostratigrafickej príslušnosti. Regionálne hodnotenie vyšlo zo spracovania hodnôt aproximatívnych logaritmických parametrov - indexu priepustnosti Z a indexu prietočnosti Y (Jetel, 1985a, b) s použitím sčasti inovovanej metodiky (Jetel, 1995b). Na odvodenie hodnôt Z a Y slúžili namerané alebo extrapolované hodnoty štandardnej (jednotkovej) mernej výdatnosti q_1 pri znížení hladiny o 1 m. Úroveň priepustnosti a prietočnosti v jednotlivých súboroch charakterizujeme vo forme mediánu Md(Z) a Md(Y) a aritmetického priemeru M(Z) a M(Y). Ukazovateľom variability sú hodnoty s_Z a s_Y (odhad smerodajných odchýlok v základnom súbore) odvodené z nameraných výberových smerodajných odchýlok ich vynásobením hodnotou $\sqrt{n/(n-1)}$ (n = počet údajov). Pri prepočte na príslušné hodnoty koeficienta filtrácie k a koeficienta prietočnosti T sme použili logaritmickú prepočtovú diferenciu d definovanú vzťahom

$$d = \log T - \log q \quad (1)$$

(Jetel, 1985a, b), kde T = koeficient prietočnosti v $m^2.s^{-1}$, q = merná výdatnosť v $m^3.s^{-1}$ na 1 m, t. j. v $m^2.s^{-1}$. Pri bežných vrtoch v danom regióne sme použili zovšeobecnenú regresnú rovnicu

$$d = 0{,}18\ Y - 0{,}61 \quad , \quad (2)$$

ktorú sme najnovšie odvodili z regresných závislostí skutočných (priamo stanovených) hodnôt d od indexu Y vo vrtoch s priamo stanovenými koeficientmi prietočnosti T hornín centrálnokarpatského paleogénu v Hornádskej kotline a Spišskej Magure (porov. Jetel, 1995c). Vzťah (2) vyjadruje priemernú závislosť bez zreteľa na hĺbkovú pozíciu skúšaného úseku, takže je vhodný napr. na prepočet priemerných hodnôt Y a Z zo súborov zahŕňajúce dáta z úsekov s rozličnou hĺbkovou pozíciou. Keďže ide o zovšeobecnenú spriemerovanú štatistickú závislosť, môže sa skutočná diferencia d od očakávanej hodnoty z uvedenej rovnice v jednotlivých prípadoch výrazne odlišovať. Na prepočet konkrétnych hodnôt Y a Z z úsekov v malej hĺbke - v pripovrchovej zóne - použí-vame pre centrálnokarpatský paleogén rovnicu

$$d = 0{,}05\ Y - 0{,}10 \quad , \quad (3)$$

ktorú sme odvodili pre dáta z úsekov v pripovrchovej zóne paleogénu Spišskej Magury (Jetel, 1995c).

Očakávanú prepočtovú diferenciu d z rovnice (2) alebo (3) sme dosadzovali do prepočtového vzorca (Jetel, 1985a, b).

$$k\ (m.s^{-1}) = \text{antilog}(Z+d-9) = 10^{(Z+d-9)} \quad (4)$$
$$T\ (m^2.s^{-1}) = \text{antilog}(Y+d-9) = 10^{(Y+d-9)} \quad . \quad (5)$$

Aritmetickému priemeru M hodnôt indexu Z a Y zodpovedá geometrický priemer G hodnôt koeficienta k a T (tab. 2):

$$G(k) = \text{antilog}\ [M(Z) + d-9] = 10^{[M(Z) + d-9]} \quad (6)$$
$$G(T) = \text{antilog}\ [M(Y) + d-9] = 10^{[M(Y) + d-9]} \quad . \quad (7)$$

Normálne (Gaussovo) rozdelenie hodnôt Z alebo Y je potom indikáciou lognormálneho rozdelenia hodnôt koeficienta k alebo T.

Takto odvodené geometrické priemery G(k) a G(T) možno aplikovať ako reprezentatívne charakteristiky strednej úrovne priepustnosti a prietočnosti pri bežnom

Tab. 1
Charakteristiky rozdelenia hodnôt indexu prietočnosti Y a indexu priepustnosti Z v skúšaných úsekoch hornín paleogénu Hornádskej kotliny
Distribution characteristics of transmissivity index Y and permeability index Z in the tested intervals of Paleogene rocks in the Hornád Basin

súvrstvie Formation	n	R(Y)	Md(Y)	M(Y)	S_Y
bielopotocké	15	3,27 - 6,05	5,44	5,10	0,867
zuberské	64	3,18 - 6,73	5,08	5,02	0,754
hutianske	29	4,01 - 6,34	5,03	5,05	0,584
borovské	19	4,02 - 6,51	5,33	5,25	0,673

súvrstvie Formation	R(Z)	Md(Z)	M(Z)	s_Z	Z_{20}	Z_{35}	Z_{50}
bielopotocké	1,44 - 4,66	3,75	3,58	0,914	3,91	3,50	3,08
zuberské	1,56 - 5,49	3,73	3,73	0,941	3,79	3,55	3,31
hutianske	2,52 - 5,42	3,69	3,74	0,741	3,77	3,32	2,87
borovské	2,04 - 5,40	3,84	3,79	0,794	3,88	3,80	3,73

n - počet údajov, R(Y), R(Z) - rozpätie zistených hodnôt Y a Z, Md(Y), Md(Z) - mediány hodnôt Y a Z, M(Y), M(Z) - aritmetické priemery hodnôt Y a Z, s_Y, s_Z - odhad smerodajných odchýlok v základnom súbore hodnôt Y a Z, Z_{20}, Z_{35}, Z_{50} - hodnoty indexu Z očakávané v úseku so stredom v hĺbke H = 20, 35 a 50 m podľa príslušnej regresnej rovnice Z = f(H).

n - number of data, R(Y), R(Z) - range of the Y and Z values, Md(Y), Md(Z) - medians of Y and Z, M(Y), M(Z) - arithmetic means of Y and Z, Z_{20}, Z_{35}, Z_{50} - values expected in the interval with the middle in the depth of 20, 35 and 50 m according to the respective regression equation, s_Y, s_Z - estimates of standard deviations in the Y and Z populations.

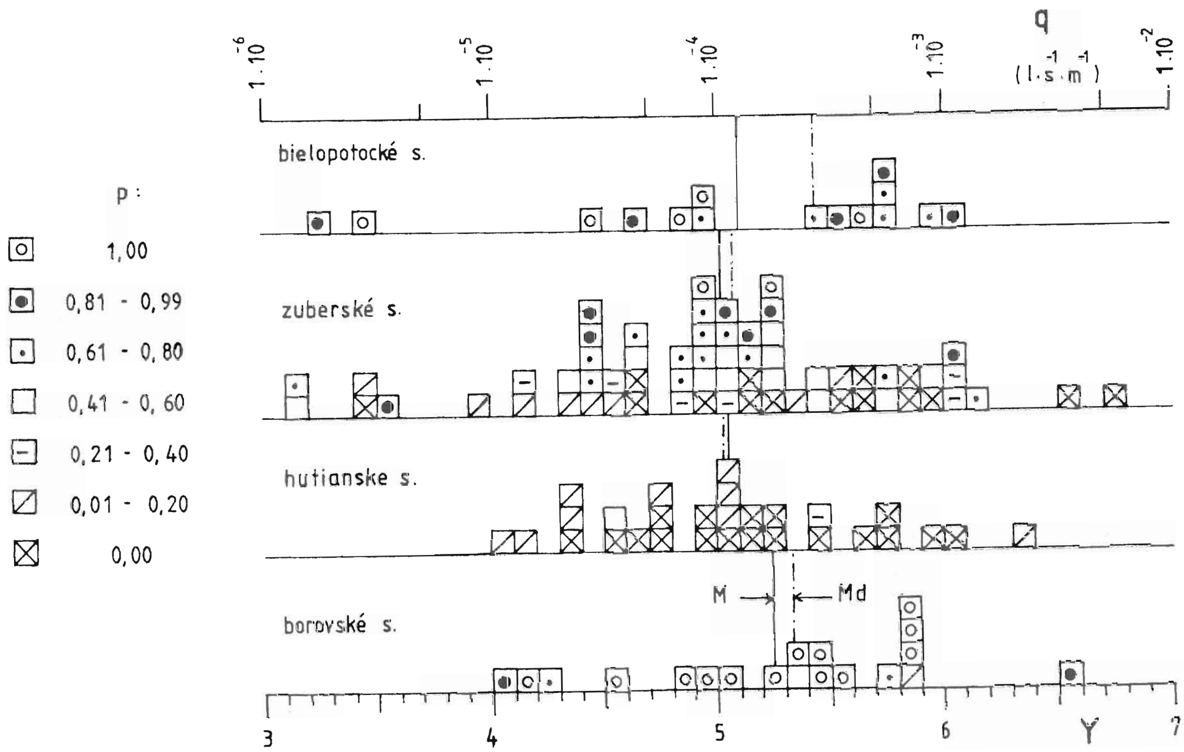
Tab. 2
Odhad koeficienta prietočnosti T a koeficienta filtrácie k odvodený s použitím vzťahu (2) - (5) z charakteristík rozdelenia hodnôt indexu prietočnosti Y a indexu priepustnosti Z v skúšaných úsekoch hornín paleogénu Hornádskej kotliny
Estimates of transmissivity T and hydraulic conductivity k derived from the distribution characteristics of transmissivity index Y and permeability index Z from the relations (2) - (5) in the tested intervals of Paleogene rocks in the Hornád Basin

súvrstvie Formation	R(T)	Md(T)	G(T)	c_T
bielopotocké	$1{,}8.10^{-6}$ - 3.10^{-3}	$6{,}4.10^{-4}$	$2{,}6.10^{-4}$	IIIe
zuberské	$1{,}7.10^{-6}$ - 9.10^{-3}	$1{,}7.10^{-4}$	$1{,}5.10^{-4}$	IIId-IVd
hutianske	$1{,}3.10^{-5}$ - 4.10^{-3}	$1{,}5.10^{-4}$	$1{,}6.10^{-4}$	IIIc-IVc
borovské	$1{,}4.10^{-5}$ - 5.10^{-3}	$3{,}1.10^{-4}$	$3{,}8.10^{-4}$	IIId

súvrstvie Formation	R(k)	Md(k)	G(k)	k_{20}	k_{50}	c_k
bielopotocké	3.10^{-8} - 7.10^{-5}	$1{,}3.10^{-5}$	$7{,}7.10^{-6}$	$1{,}2.10^{-5}$	$2{,}0.10^{-6}$	Ve
zuberské	3.10^{-8} - 8.10^{-4}	$7{,}6.10^{-6}$	$7{,}6.10^{-6}$	$8{,}9.10^{-6}$	$3{,}4.10^{-6}$	Ve
hutianske	4.10^{-7} - 4.10^{-4}	$6{,}9.10^{-6}$	$7{,}9.10^{-6}$	$8{,}3.10^{-6}$	$1{,}0.10^{-6}$	Vd
borovské	1.10^{-7} - 4.10^{-4}	$1{,}0.10^{-5}$	$1{,}3.10^{-5}$	$1{,}7.10^{-5}$	$1{,}1.10^{-6}$	IVd-Vd

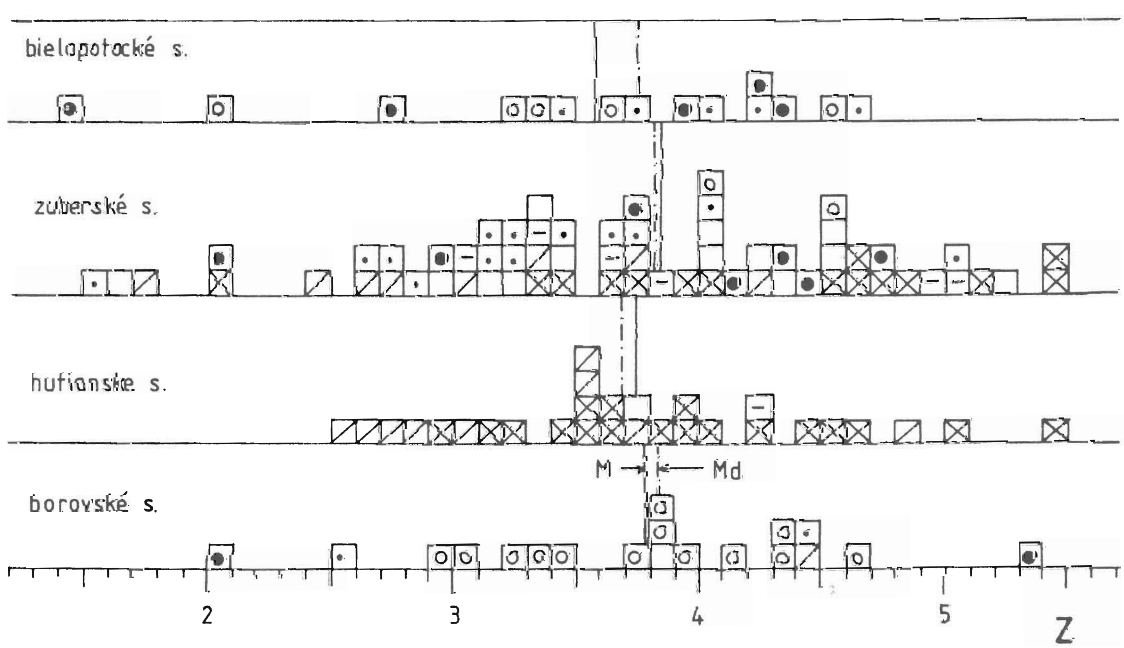
T v $m^2.s^{-1}$, k v $m.s^{-1}$, R(T), R(k) - rozpätie odhadu hodnoty T a k, Md(T), Md(k) - mediány hodnôt T a k, G(T), G(k) - geometrické priemery hodnôt T a k (na odhad stredných hodnôt sa použil vzťah (3) pri zubereckom a hutianskom súvrství a vzťah (2) pri ostatných súvrstviach) k_{20}, k_{50} - očakávaná hodnota koeficienta filtrácie v hĺbke 20 a 50 m, c_T, c_k - trieda prietočnosti a priepustnosti zodpovedajúca hodnote G(T) a G(k).

T in $m^2.s^{-1}$, k in $m.s^{-1}$, R(T), R(k) - range of estimated T and k values, Md(T), Md(k) - medians of T and k, G(T), G(k) - geometric means of T and k (according to the equation (3) for Zuberec and Huty formations and (2) for other formations), k_{20}, k_{50} - expected hydraulic conductivity in the depth of 20 and 50 m, c_T, c_k - transmissivity and permeability class corresponding to the respective value of G(T) and G(k).



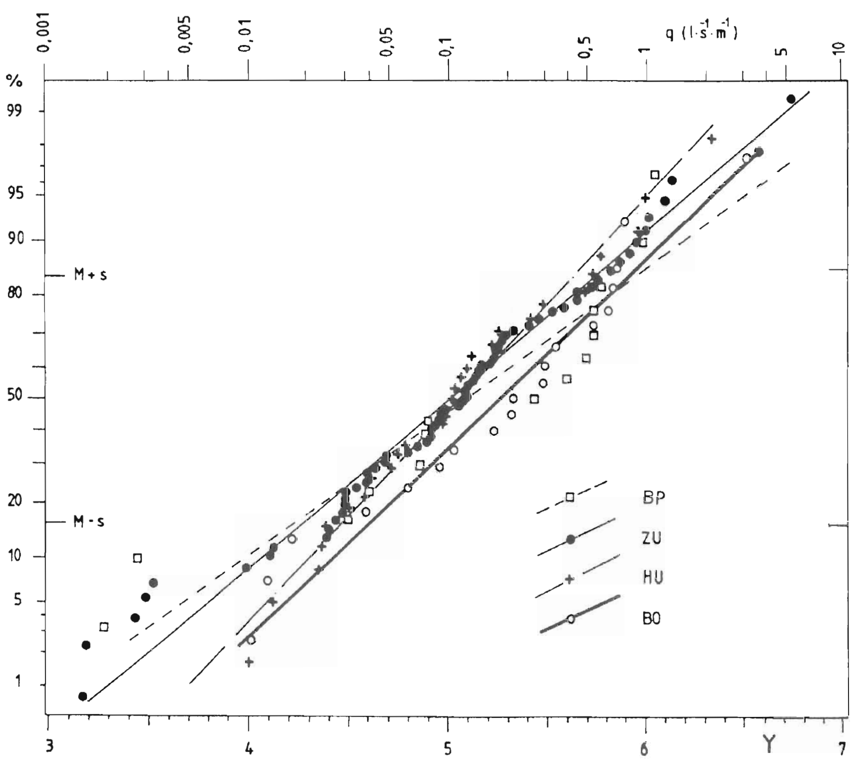
Obr. 1. Histogramy indexu prietočnosti Y v skúšaných úsekoch paleogénu Hornádskej kotliny. p - pomer celkovej hrúbky pieskovca a zlepenca k celkovej dĺžke skúšaného úseku vo vrte, q - merná výdatnosť, M - aritmetický priemer, Md - medián.

Fig. 1. Histograms of transmissivity index Y in the tested intervals of the Paleogene rocks in the Hornád Basin. p - ratio between the total thickness of sandstones and conglomerates and the total length of tested well intervals, q - specific capacity, M - arithmetic mean, Md - median.



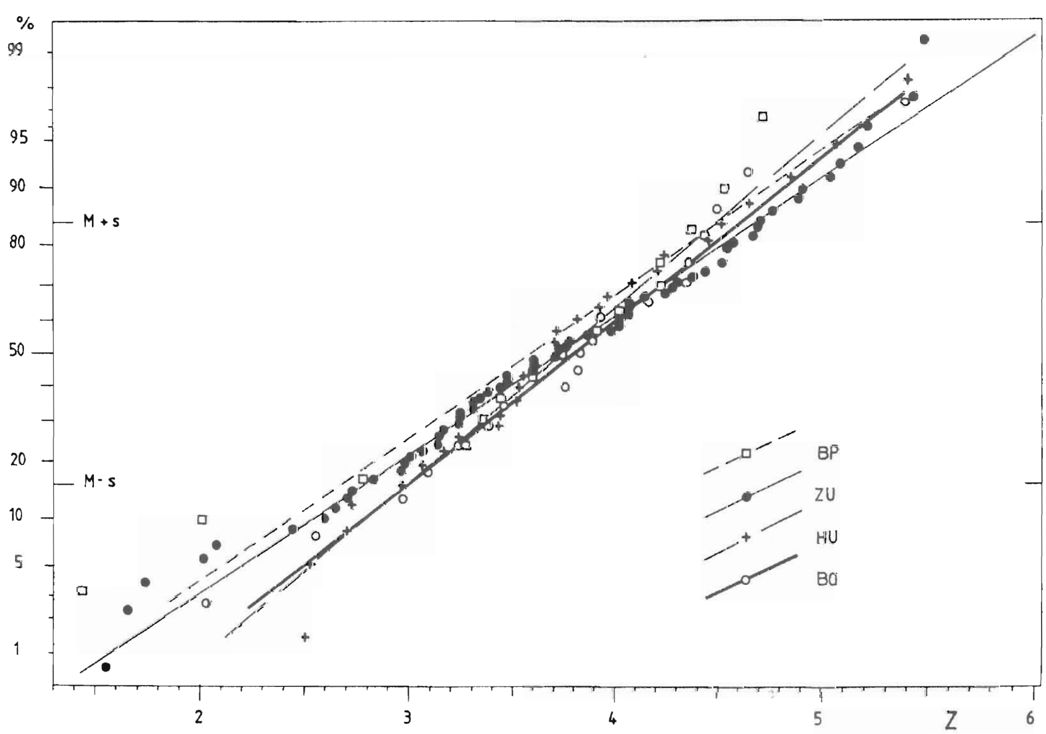
Obr. 2. Histogramy indexu priepustnosti Z v skúšaných úsekoch paleogénu Hornádskej kotliny. Vysvetlivky ako pri obr. 1.

Fig. 2. Histograms of permeability index Z in tested intervals of the Paleogene in the Hornád Basin. Explanations see Fig. 1.



Obr. 3. Kvantilový graf indexu prietočnosti skúšaných úsekoch paleogénu v Hornádskej kotline. Y - index prietočnosti, q - merná výdatnosť, M - aritmetický priemer, s - smerodajná odchýlka. BP - bielopotocké súvrstvie, ZU - zuberské sú-vrstvie, HU - hutianske súvrstvie, BO - borovské súvrstvie. Kumulovaná relatívna početnosť je vynesená na vertikálnej osi.

Fig. 3. Transmissivity-index frequency graph for tested well intervals of the Paleogene in the Hornád Basin. Y - transmissivity index, q - specific capacity, M - arithmetic mean, s - standard deviation, BP - Biely Potok Formation, ZU - Zuberec Fm., HU - Huty Fm., BO - Borové Fm. Cumulative relative frequency is indicated on the vertical axis.



Obr. 4. Kvantilový graf indexu priepustnosti skúšaných úsekoch paleogénu v Hornádskej kotline. Z - index priepustnosti. Ostatné vysvetlivky - pozri obr. 3.

Fig. 4. Permeability-index frequency graph for the tested well intervals of the Paleogene in the Hornád Basin. Z - permeability index. Other explanations see Fig. 3.

porovnávaní vlastností jednotlivých členov. Efektívna priemerná priepustnosť vo veľkých objemoch hornín sa dobre zhoduje s geometrickým priemerom hodnôt stanovených skúškami vo vrtoch (porov. napr. Witherspoon et al., 1980, alebo Broch a Kjørholt, 1994), pričom v štatisticky homogénnom prostredí s lognor-málnym rozdelením priepustnosti vyjadruje geometrický priemer efektívnu priepustnosť pre dvojrozmerné prúdenie (Gutjahr et al., 1978; Dagan, 1979). Keďže M(Y), M(Z), G(T) a G(k) predstavujú iba výberové priemery ovplyvnené náhodnými odchýlkami od skutočného priemeru základného súboru, vyčíslili sme pre ne aj príslušné intervaly spoľahlivosti, vnútri ktorých leží s 90 % pravdepodobnosťou skutočný priemer charakterizujúci dané súvrstvie v skúmanom rozsahu hĺbky (tab. 3, obr. 5).

Hodnoty koeficienta filtrácie a prietočnosti majú v štatisticky homogénnom prostredí spravidla aspoň približne lognormálne rozdelenie (Jetel, 1985a). Z matematicko-štatistického hľadiska je potom najvýstižnejšou charakteristikou ich strednej hodnoty matematická nádej lognormálne rozdelených hodnôt (tab. 4)

$$E_L(x) = G(x) \cdot \psi(n, s) \quad , \quad (8)$$

kde G(x) = geometrický priemer hodnôt x a symbol ψ (n, s) označuje Aitchisonovu a Brownovu funkciu počtu údajov n a smerodajnej odchýlky z hodnôt log x. Hodnoty tejto funkcie uvádza Aitchison a Brown (1957; podrobnejšie pozri Jetel, 1985a). Hodnota $E_L(x)$ predstavuje strednú hodnotu s maximálnou vierohodnosťou pre dané rozdelenie, t. j. takú strednú hodnotu, pre ktorú je pravdepodobnosť generovania daného empirického rozdelenia najvyššia.

Pri hodnotení úrovne priepustnosti používame osemstupňovú klasifikáciu priepustnosti (Jetel, 1982) a úroveň a variabilitu prietočnosti hodnotíme podľa klasifikácie Krásneho (1993). Pri hodnotení variability priepustnosti sme aplikovali tie isté kritériá, ktoré pre ňu navrhol Krásný (1993).

Popri základnom štatistickom spracovaní (tab. 1 - 4) sme údaje podrobili aj korelačno-regresnému rozboru z hľadiska vzťahov medzi priepustnosťou na jednej strane a hĺbkou stredu skúšaného úseku (tab. 5) alebo podielom pieskovca (tab. 6) na strane druhej. Jedným z cieľom rozboru bolo overiť závery predbežného spracovania údajov zo západnej časti kotliny (Jetel, 1989). Štatistickú významnosť zistenia korelačnej závislosti medzi skúmanými premennými sme testovali porovnaním zistenej hodnoty Studentovho kritéria

$$t = r \sqrt{m/(1-r^2)} \quad (9)$$

(r = absolútna hodnota výberového koeficienta lineárnej korelácie, m = n-2 = počet stupňov voľnosti, n = počet skúmaných dvojíc údajov) s hodnotami distribučnej funkcie Studentovho rozdelenia $S_m(t)$ uvedenými v tab. 3.2 Boľševa a Smirnova (1983) a prevzatými z tabuliek Pearsona a Hartleyho (1956). Z príslušnej hodnoty $S_m(t)$ sme odvodili hladinu významnosti

$$\alpha = 2[1 - S_m(t)] \quad . \quad (10)$$

Štatistická istota, s ktorou možno prijať hypotézu skutočného jestvovania korelačného vzťahu, je potom určená ako

$$P = 100(1 - \alpha)\,(\%) \quad . \quad (11)$$

Pre pomerne nízke hodnoty štatistickej istoty P < 90 % pri viacerých sledovaných závislostiach sme oproti porovnávaniu zistenej hodnoty t s bežne tabelovanými hodnotami vybraných úrovní α boli nútení použiť uvedený zložitejší postup.

Pre závislosť priemernej priepustnosti od hĺbkovej pozície skúšaného intervalu sú výsledné priemerné charakteristiky priepustnosti súvrství skreslené rozdielmi v priemernej hĺbke stredov skúšaných úsekov. Na objektívnejšie porovnanie priemernej úrovne priepustnosti súvrství sme preto pri každom súvrství stanovili aj hodnoty indexu priepustnosti Z očakávané podľa príslušnej regresnej rovnice z tab. 5 pri hĺbke stredu skúšaného úseku H = 20, 35 a 50 m (Z_{20}, Z_{35}, Z_{50}). K týmto hodnotám sme potom odvodili aj príslušný odhad priemerného koeficienta filtrácie v hĺbke 20 a 50 m k_{20}, k_{50} (tab. 2). Príslušné prepočtové diferencie d k hodnote Z_{20}

Tab, 3
Intervaly spoľahlivosti stanovenia priemerných hodnôt Y, Z, T a k pri 90-percentnej pravdepodobnosti
90-percent confidence intervals of mean Y, Z, T and k

súvrstvie formation	M(Y)	M(Z)	G(T) $m^2.s^{-1}$	G(k) $m.s^{-1}$
bielopotocké	4,71 - 5,50	3,17 - 4,00	9.10^{-5} - 8.10^{-4}	3.10^{-6} - 2.10^{-5}
zuberské	4,86 - 5,17	3,53 - 3.92	1.10^{-4} - 2.10^{-4}	5.10^{-6} - 1.10^{-5}
hutianske	4,86 - 5,23	3,51 - 3,98	1.10^{-4} - 2.10^{-4}	5.10^{-6} - 1.10^{-5}
borovské	4,98 - 5,52	3,47 - 4,10	2.10^{-4} - 8.10^{-4}	6.10^{-6} - 3.10^{-5}

Symboly ako v tab. 1 a 2
Symbols as in Tab. 1 and 2.

Tab. 4
Odhad matematickej nádeje lognormálne rozdelených hodnôt koeficienta prietočnosti T a koeficienta filtrácie k skúšaných úsekov hornín paleogénu Hornádskej kotliny
Estimated mathematical expectance of lognormally distributed values of transmissivity T and hydraulic conductivity k in the tested intervals of Paleogene rocks in the Hornád Basin

súvrstvie formation	$E_L(T)$ $m^2.s^{-1}$	$E_L(k)$ $m.s^{-1}$
bielopotocké	$1,4.10^{-3}$	$4,8.10^{-5}$
zuberské	$6,3.10^{-4}$	$7,0.10^{-5}$
hutianske	$3,7.10^{-4}$	$3,1.10^{-5}$
borovské	$1,1.10^{-3}$	$5,8.10^{-5}$

$E_L(T)$, $E_L(k)$ - matematická nádej koeficienta prietočnosti T a koeficienta filtrácie k odvodená z rovnice (8)

$E_L(T)$, $E_L(k)$ - mathematical expectance of transmissivity T and hydraulic conductivity k derived from Eq. (8)

a Z_{50} sme odhadli podľa rovnice (2) a (3), do ktorých sme dosadili fiktívne hodnoty Y_{20} a Y_{50}, odvodené pre predpoklad, že stredná hodnota indexu prietočnosti úsekov s konštantnou malou dĺžkou klesá s hĺbkou rovnakou rýchlosťou (s rovnakým koefi-cientom b) ako stredná hodnota indexu Z. Fiktívnu hodnotu Y_H pri uvažovanej hĺbke H (20 a 50 m) v takom prípade vypočítame ako

$$Y_H = M(Y) + b\,[H - M(H)] \quad , \quad (12)$$

pričom z tab. 5 dosadíme priemernú hĺbku M(H) a regresný koeficient b. Hodnoty k_{20} a k_{50} uvádza tab. 2.

Výsledky hodnotenia

Výsledky regionálneho zhodnotenia priepustnosti a prietočnosti skúšaných úsekov hornín centrálno-karpatského paleogénu Hornádskej kotliny uvádza tab. 1 - 6 a obr. 1 - 5. Po dôkladnej revízii a spresnení vstupných údajov a po úprave v zmysle inovovaného postupu odvodenia hodnôt Z, Y i d (Jetel, 1995b) sa predkladané výsledky a závery od záverečnej správy Jetela et al. (1990) sčasti odlišujú.

Pri priestorovej aplikácii charakteristík z tab. 1 - 4 a z obr. 1 - 5 treba brať do úvahy, že pre priestorovú neuniformitu prietočnosti pripovrchovej zóny v hydrogeologickom masíve, danej vplyvom reliéfu, uvedené charakteristiky prevažne zodpovedajú kategórii dnovej (dolinovej) prietočnosti T_v (Jetel, 1990), a preto charakterizujú iba vlastnosti pripovrchovej zóny v depresných častiach územia - v dolinách a v spodných úsekoch svahov. Boli totiž odvodené z výsledkov hydrogeolo-gických vrtov situovaných prevažne v dolinách. Pozitívne anomálne hodnoty odrážajú prietočnosť T_f puklinových zón, ktoré v zmysle Pličku (1968, 1970) predstavujú tektonicky podmienené pásma viac-menej rovnobežných a takmer zvislých puklín, prebiehajúcich nezávisle od smeru a sklonu vrstiev a ktoré často predisponujú priebeh terénnych depresií. V elevačných častiach územia treba očakávať prietočnosť s rádovo nižšou úrovňou (svahová prietočnosť T_s). Neuniformita prietočnosti ovplyvňuje aj vypočítané charakteristiky priepustnosti (Jetel, 1990).

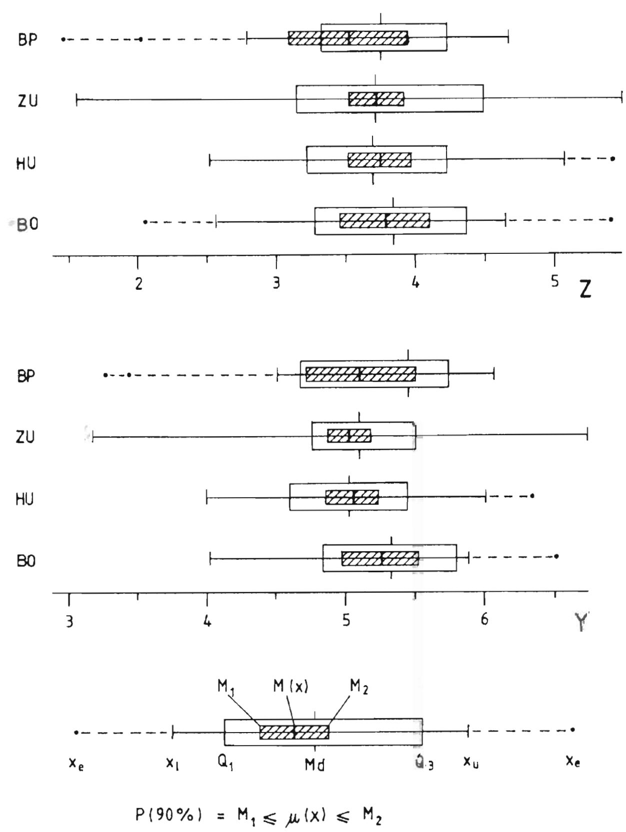
Pieskovcové bielopotocké súvrstvie možno v priemere charakterizovať ako dosť slabo priepustný kolektor s veľmi vysokou variabilitou priepustnosti (trieda Ve). V jednotlivých úsekoch sa priemerná priepustnosť pohybuje od veľmi slabej (VII. trieda) až po miernu (IV. trieda). Veľmi vysoká smerodajná odchýlka s_Z v takom zdanlivo homogénnom prostredí naznačuje výrazný rozdiel medzi priepustnosťou nerozpukaných partií hrubolavicovitého pieskovca a partií postihnutých rozpukaním v puklinových zónach a v zóne pripovrchového rozvoľnenia. Tradičná

Tab. 5
Závislosť indexu priepustnosti Z v horninách paleogénu Hornádskej kotliny od hĺbky H stredu skúšaného úseku vo vrte
The dependence of the permeability index Z in the Paleogene rocks of the Hornád Basin upon the middle depth H of the tested interval in the well

súvrstvie Formation	n	a	b	r	P(%)	R(H)	M(H)
bielopotocké	15	4,47	-0,0279	-0,457	91	9 - 63	32,0
zuberské	64	4,12	-0,0161	-0,366	99,7	6 - 144	24,2
hutianske	29	4,36	-0,0299	-0,445	98	6 - 65	20,7
borovské	19	3,98	-0,00503	-0,235	67	10 - 140	38,8

n - počet údajov, a, b - regresná konštanta a regresný koeficient v rovnici Z = a + bH, H - hĺbka stredu skúšaného úseku (m), r - výberový koeficient lineárnej korelácie, P - štatistická istota existencie korelačného vzťahu vyjadrená ako P = 100(1- α), kde α = hladina významnosti (pravdepodobnosť omylu), R(H), M(H) - rozpätie a aritmetický priemer hodnôt H.

n - number of data, a, b - regression constant and regression coefficient in the equation Z = a + bH, H - the depth of the middle of the tested interval (m), r - sample coefficient of linear correlation, P - statistical confidence of correlation existence expressed as P = 100(1- α), where α - significance level (error probability), R(H), M(H) - range and arithmetic mean of H values.



Obr. 5. 90-percentné intervaly spoľahlivosti pre aritmetické priemery indexu priepustnosti Z a indexu prietočnosti Y v skúšaných úsekoch paleogénu Hornádskej kotliny. Md - medián, Q_1, Q_2 - 25-percentný a 75-percentný kvantil, x_1, x_u - minimálna a maximálna hodnota po vylúčení extrémnych hodnôt, x_e - extrémne hodnoty, M(x) - výberový aritmetický priemer, M_1, M_2 - dolná a horná hranica 90-percentného intervalu spoľahlivosti, μ(x) - skutočný aritmetický priemer základného súboru.

Fig. 5. 90%-probability confidence intervals for arithmetic means of permeability index Z and transmissivity index Y in the tested well intervals in the Paleogene of the Hornád Basin. Md - median, Q_1, Q_2 - 25-percent and 75-percent quantils, x_1, x_u - minimum and maximum value after excluding the extreme values, xe - extreme values, M(x) - sample arithmetic mean, M_1, M_2 - lower and upper limits of 90%-confidence interval, μ(x) - true arithmetic mean of population.

predstava o výrazne vyššej priepustnosti tohto súvrstvia oproti pelitickým a flyšovým členom sa nepotvrdila. Hornádska kotlina sa tak od Šarišskej vrchoviny (Jetel, 1994b; Zakovič et al., 1995) a Spišskej Magury (Jetel, 1995c) odlišuje. Výberový priemer M(Z) je nižší ako v ostatných členoch, medián Md(Z) je naopak najvyšší, ale rozdiely medzi členmi nie sú štatisticky významné. Odhad G(k) je potom prakticky zhodný pri bielopotockom, zuberskom aj hutianskom súvrství. V skúšaných úsekoch bielopotockého súvrstvia sa so štatistickou istotou P = 91,3 % prejavuje výrazný pokles priemernej priepustnosti s hĺbkou H stredu skúšaného úseku. Opisuje ho regresná rovnica

$$Z = 4{,}47 - 0{,}0279\ H \qquad (H \text{ v m}). \qquad (13)$$

Nepotvrdila sa ani pozitívna závislosť medzi podielom pieskovca p v skúšanom úseku a indexom priepustnosti, ale naopak sa so štatistickou istotou P = 80,7 % paradoxne preukázala opačná závislosť: pokles priemernej priepustnosti skúšaného úseku s rastúcim podielom pieskovca (tab. 6).

Najlepšie preskúmaným členom paleogénu skúmaného územia je zuberské súvrstvie. V priemere sú to dosť slabo priepustné kolektory s veľmi vysokou variabilitou priepustnosti (trieda Ve). S vysokou istotou P = 99,5 % (α = 0,005) sa v skúmaných úsekoch preukázala závislosť in-dexu Z od hĺbky stredu úseku (tab. 5). Napriek naj-širšiemu možnému rozpätiu hodnôt podielu pieskovca p v skúšanom úseku od výhradne ílovcových úsekov (p = 0) až po čisto pieskovcové úseky (p = 1) sa tu nezistila pozitívna korelácia medzi indexom Z a podielom p. Podobne ako v bielopotockom súvrství aj tu však možno opäť so štatistickou istotou P = 78 % konštatovať opačnú závislosť - rast Z s poklesom p.

Hutianske súvrstvie predstavuje člen s najvyšším podielom pelitov, ale v pripovrchovej zóne nevykazuje výrazne odlišné hydraulické parametre ako členy s podstatne vyšším zastúpením psamitov. Pripovrchová zóna hutianskeho súvrstvia je v priemere dosť slabo priepustným kolektorom s veľkou variabilitou priepustnosti (Vd). S vysokou výraznosťou (P = 98,4 %) sa tu opäť prejavuje závislosť indexu Z od hĺbky H stredu úseku. Prevažnú väčšinu súvrstvia tvorí ílovec a prachovec (priemerný podiel pieskovca v skúšaných úsekoch je 0,05), čo znemožňuje sledovať koreláciu medzi priepustnosťou a podielom p. Maximálna priemerná priepustnosť pripovrchovej zóny v hutianskom súvrství sa viaže na porušené pásma - puklinové zóny (Jetel, 1989). Údaje z väčšej hĺbky nie sú k dispozícii. Pre preukázanú funkciu celého telesa hutianskeho súvrstvia ako stropného izolátora nad borovským súvrstvím (Jetel et al., 1990) a rýchlosť poklesu priepustnosti s hĺbkou (tab. 5) možno v hutianskom súvrství v hĺbke väčšej ako 100 m v priestore mimo puklinových zón očakávať iba veľmi slabú až nepatrnú priepustnosť.

Borovské súvrstvie možno v skúšaných úsekoch hodnotiť v priemere ako dosť slabo až mierne priepustný kolektor s veľkou variabilitou priepustnosti (trieda IVd-Vd). Na rozdiel od ostatných členov je tu závislosť medzi indexom Z a hĺbkou H iba veľmi málo signifikantná (so štatistickou istotou iba 67 %). Nepreukázala sa ani korelácia medzi indexom Z a podielom p, čo je pri prevahe úsekov s výhradným zastúpením pieskovca a zlepenca pochopiteľné (priemerná hodnota p z úsekov v tomto súvrství je 0,88).

Tab. 6
Závislosť indexu priepustnosti Z v horninách paleogénu Hornádskej kotliny od podielu pieskovca p v skúšanom úseku vrtu
The dependence of the permeability index Z in the Paleogene rocks in the Hornád Basin upon the proportion p of sandstones in the tested interval of well

súvrstvie Formation	n	a	b	r	P(%)	R(p)	M(p)
bielopotocké	15	6,24	-3,027	-0,356	81	0,71 - 1,00	0,88
zuberské	63	3,94	-0,443	-0,157	78	0,00 - 1,00	0,42
hutianske	29	-	-	(-0,065)	-	0,00 - 0,50	0,05
borovské	19	-	-	(-0,101)	-	0,05 - 1,00	0,88

n - počet údajov, a, b - regresná konštanta a regresný koeficient v rovnici Z = a + bp, p - podiel pieskovca a zlepenca v skúšanom otvorenom úseku vrtu (celková hrúbka pieskovca a zlepenca v skúšanom intervale delená dĺžkou tohto intervalu), r, P ako v tab. 5, R(p), M(p) - rozpätie a aritmetický priemer hodnôt p.

n - number of data, a, b - regression constant and regression coefficient in the equation Z = a + bp, p - the proportion of sandstone and conglomerate in the tested open interval of well (total thickness of sandstones and conglomerates in the tested interval divided by the interval length), r, P as in Tab. 5, R(p), M(p) - range and arithmetic mean of p-values.

Diskusia a zhrnutie

V bielopotockom, zuberskom a hutianskom súvrství skúmaného územia sa prejavuje málo tesná, avšak štatisticky významná závislosť priemernej priepustnosti od hĺbky stredu skúšaného úseku (tab. 5). Z regresných koeficientov rovníc typu Z = a + bH v rozpätí b = -0,016 až -0,030 vyplýva, že tu priemerná priepustnosť v pripovrchovej zóne klesá v priemere o 31 - 50 % (t. j. na 50 - 69 %) východiskovej hodnoty na každých 10 m zväčšenia hĺbky stredu skúšaného úseku. Podstatne menej výrazný je tento pokles v borovskom súvrství. Zákonitý pokles priemernej priepustnosti s hĺbkou má za následok relatívne podhodnotenie vypočítaných priemerov priepustnosti súvrství s väčšou priemernou hĺbkou M(H) stredu skúšaných úsekov (borovské a bielopotocké súvrstvie) oproti členom s výrazne menšími hodnotami M(H) (tab. 5).

Ak sa toto skreslenie neberie do úvahy, odlišuje sa od ostatných členov o niečo vyššou priemernou priepustnosťou G(k) borovské súvrstvie, kým hodnoty G(k) ostatných členov sú takmer zhodné. Rozdiel v priemernej priepustnosti borovského súvrstvia a ostatných členov má však iba veľmi malú štatistickú významnosť. Pokiaľ ide o priemernú prietočnosť, najvyššie hodnoty všetkých ukazovateľov vykazuje borovské a bielopotocké súvrstvie, ale to je najmä v bielopotockom súvrství skôr dôsledok veľkej dĺžky otvorených úsekov ako vyššej priepustnosti.

Ako ukazuje obr. 3 a 4, možno empiricky zistenú viacmenej symetrickú distribúciu hodnôt Y a Z aproximovať pre jednotlivé súbory normálnym (Gaussovým) rozdelením, lebo usporiadanie bodov možno najmä v strednej časti grafu aproximovať priamkou. Na opis zisteného ľavostranne asymetrického rozdelenia hodnoty koeficientov filtrácie a prietočnosti možno preto použiť lognormálny model (porov. Jetel, 1985a). Z hľadiska matematicko-štatistickej teórie to opodstatňuje vyjadrenie maximálne vierohodného odhadu stredných hodnôt vo forme matematickej nádeje $E_L(k)$ a $E_L(T)$ (tab. 4) v zmysle vzťahu (8). Pre vysokú vyriabilitu priepustnosti sú hodnoty $E_L(k)$ 3,9x až 8,8x vyššie ako príslušné hodnoty G(k) a hodnoty $E_L(T)$ sú 2x až 5x vyššie ako G(T). Naj-vyššiu hodnotu $E_L(T)$ má bielopotocké súvrstvie, najvyššie $E_L(k)$ zuberské súvrstvie a najnižšie E_L hutianske súvrstvie.

Po korekcii porovnávaných stredných hodnôt priepustnosti na rozdiely v priemernej hĺbke stredov skúšaných úsekov, t. j. po odvodení hodnôt Z_{20}, Z_{35}, Z_{50} (tab. 1), k_{20} a k_{50} (tab. 2) sa zvýrazní vyššia priepustnosť borovského súvrstvia oproti ostatným členom, a to najmä pre hĺbku 50 m. Najnižšiu priemernú priepustnosť bude mať v hĺbke 20 m aj 50 m hutianske súvrstvie.

Očakávaný rast priemernej priepustnosti s rastom podielu pieskovca v skúšanom otvorenom intervale sa neprejavil ani pri jednom zo skúmaných súvrství. Naproti tomu sa preukázala opačná závislosť - rast priemernej priepustnosti s poklesom podielu pieskovca v bielopotockom a zuberskom súvrství (tab. 5). Na neplatnosť tradičnej schémy priepustný pieskovec: nepriepustný ílovec v paleogéne Hornádskej kotliny poukázal už Cabala (1976) a Jetel (1989). Neplatnosť tejto predstavy sme potvrdili aj v niektorých iných regiónoch paleogénu a flyšovej kriedy Západných Karpát (Jetel, 1992, 1994a, 1995a). V silno spevnených horninách sa pre diagenetické zmenšenie medzizrnovej priepustnosti primárne rozdiely v priepustnosti pieskovca a ílovca alebo prachovca stierajú. Hydraulické vlastnosti horninového masívu sa pri rozhodujúcej úlohe puklinovej priepustnosti homogenizujú bez ohľadu na litolo-gické rozdiely do tej miery, že kvantitatívne rozdiely v priemernej priepustnosti psamitov a pelitov (obr. 1 - 2) často nemožno konštatovať. Tam, kde sú vyvinuté krehké rozpukané pelity a drobnorytmické sekvencie popri menej rozpukaných laviciach psamitov, môžu mať dokonca úseky budované pelitmi vyššiu priemernú priepustnosť ako psamitické úseky. Maximálna priepusnosť a prietočnosť sa v sekundárne homogenizovanom horninovom masíve viaže na tektonicky podmienené puklinové zóny.

Záver

Z rozboru vyplýva, že pri dominujúcej závislosti priemernej priepustnosti od hĺbkovej pozície skúšaných úsekov sú rozdiely v priemernej priepustnosti pripovrchovej zóny jednotlivých litostratigrafických členov veľmi málo výrazné. Výraznejšie sú iba rozdiely v stredných hodnotách E_L lognormálneho rozdelenia. Relatívne najvyššiu priemernú priepustnosť v prevažnej väčšine ukazovateľov má borovské súvrstvie, a to výraznejšie po korekcii na vplyv rozdielnej hĺbky skúšaných úsekov. Najnižšiu priemernú priepustnosť po takejto korekcii vykazuje hutianske súvrstvie.

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Permeability and transmissivity of the Paleogene rocks in the Hornád Basin (East Slovakia)

Hydrogeological research of the Hornád Basin provided a detailed picture of the permeability and transmissivity in the Paleogene rocks of the region by elaborating data from 127 hydrodynamic tests in earlier and new wells. In the Paleogene of Central Carpathians 4 lithostratigraphic units are distinguished: the Borové Formation (basal carbonate breccias, conglomerates, sandstones and siltstones), the Huty Formation (prevalently claystones and siltstones), the Zuberec Formation (flysch facies: alteration of sandstones and siltstones) and the uppermost Biely Potok Formation (sandstones and conglomerates with claystone and siltstone intercalations). The assessment has been based upon the calculation of approximative logarithmic parameters - permeability index Z and transmissivity index Y (Jetel, 1982, 1995b, see also Krásný, 1993), derived from standard specific capacities of wells at the drawdown s = 1 m.

After transferring specific capacities to the indices Z and Y, the statistical characteristics of distribution of Z and Y (Tab. 1) were converted to estimates of respective characteristics of hydraulic conductivity k and transmissivity T (Tab. 2) according Eq. 4 and 5 where d is the logarithmic conversion difference defined by Eq. 1 (q = specific capacity). For estimating the difference d, empirical regression equations are used: Eq. 2 for various depths, Eq. 3 for depth less than 20 - 30 m.

The average permeability and transmissivity levels are expressed in terms of medians Md(x) and arithmetic means M(x) of logarithmic parameters Z and Y or by geometric means G(x) of hydraulic conductivity k and transmissivity T (Eq. 6 and 7). As the distribution of hydraulic conductivity and transmissivity can be approximated by lognormal model, lognormal mathematical expectance $E_L(x)$ (Tab. 4) was calculated as well (see Aitchison and Brown, 1957).

In the Biely Potok, Zuberec and Huty Formations a significant dependence of permeability index Z on the depth H of the middle of tested interval was evidenced (Tab. 5). Linear decrease of a logarithmic parameter - permeability index Z - with depth implies exponential decrease of hydraulic conductivity k.

In consequence of the permeability decrease with depth, mean permeabilities calculated from data related to different depths are distorted (biased) because the mean values from different formations correspond to different mean depth position of tested intervals. For more objective comparison eliminating the bias of mean formation characteristics, expected mean values of permeability index Z in the depths of 20, 35 and 50 (Z_{20}, Z_{35}, Z_{50}) were determined according to the regression equations from Tab. 5. In additon, the expected hydraulic conductivities k_{20} and k_{50} (Tab. 2) were estimated from the values of Z_{20} and Z_{50} respectively.

Expectable increase in mean permeability with increasing share of sandstones within the tested intervals could not be evidenced in any of tested formations. On the contrary, even an inverse dependence - increasing permeability with diminishing proportion of sandstones - was found in the Biely Potok and Zuberec Formations (Tab. 6). In contrast to some other regions, the recent assessment has not verified the premise of higher permeability of the Biely Potok Fm. (sandstones) in comparison with other members of the Paleogene containing higher proportion of claystones and siltstones.

The nonvalidity of the traditional scheme permeable sandstones: impermeable argillaceous rocks in the Paleogene of the Hornád Basin has already been pointed out by Cabala (1976) and Jetel (1989). The invalidity of this scheme was evidenced also in some other regions of the Paleogene and the Cretaceous Flysch in the West Carpathians (Jetel, 1992, 1994a, 1995a). In strongly indurated rocks with decisive importance of fissure permeability, the primary differences in permeability between sandstones and argillaceous rocks fade away as a result of diagenetic changes reducing primary intergranular permeability. The hydraulic properties of the rock massif are homogenized without respect to primary lithology to the extent that any quantitative difference in mean permeability of arenaceous and argillaceous rocks cannot often be observed. In brittle argillaceous rocks and small-scale rhythmic sediments adjacent to less fractured sandstones, the intervals in argillaceous rocks could have even higher mean permeability than sandstone intervals. The maximum per-meability is most often observed in tectonically predisposed joint zones.

We can conclude that at the dominant control of mean permeability by depth position of tested intervals the differences in mean permeability of particular lithostratigraphic members are rather indistinct. More distinct are only the differences in the lognormal mathematical expectance $E_L(x)$. On correcting the compared mean permeabilities (hydraulic conductivities) for the differences in depth position of tested intervals, e. i. after calculating the expected values of Z_{20}, Z_{35}, Z_{50}, k_{20} and k_{50}, the mean permeability in the Borové Fm. - especially in greater depths - is distinctly higher than in other members while the minimum permeabilities are expected in the Huty Fm. Relatively higher transmissivities of the Borové and Biely Potok Formations are mainly due to greater lengths of the tested intervals.

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Blue amphiboles and microfossils from the Mesozoic Basement of the Vienna Basin (borehole Smolinské 27), Slovakia

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Abstract

Occurrence of detrital blue amphiboles was verified in the Mesozoic basement of the Vienna Basin - in the core from the borehole Smolinské 27. A heavy minerals association was obtained from the calcareous claystones in the depth of 1559.0 - 1561.0 m. The following minerals were determined: blue, amphibole, chlorite, chloritoid, garnet, Cr-spinel, zircon, rutile, tourmaline. The blue amphibole is dominant (39 %). Ferro-glaucophane and crossite were identified by microprobe analysis. According to biostratigraphical results (forams and nannos) the age of the sediments containing heavy minerals is Lower Albian.

They belong to the Klape or Manín Unit of the Western Carpathians.

Key words: Slovak part of Vienna Basin, Mesozoic basement, Blue amphiboles, Aptian, Albian, Foraminifera, Calcareous nannofossils

Introduction

The borehole Smolinské 27 is situated south of the town of Gbely (about 5 km), see Fig. 1. The basement under Neogene formations (Pannonian, Sarmatian, Badenian, Karpatian and Ottnangian sediments) was penetrated at the depth of 1545 m.

The basement of the Vienna Basin in the area of the villages of Smolinské, Štefanov, Koválov and the settlement of Bištava (borehole Smolinské 14, 21, 22, 27; Štefanov 51, Bištava 2, 3., Koválov 3) has been regarded as a part of the Klippen Belt since the 1950, see Bílek 1953; Buday and Špička, 1965; Buday et al., 1967; Biely et al., 1973; Jiříček, 1979; Mišík, 1985; Kysela, 1988; Wessely et al., 1993 and others. On the grounds of similarity in lithology and stratigraphy to the sediments of the Czorstyn and Kysuca or Klape Units, the Mesozoic rocks of the basement have been associated with the Klippen Belt. This elevated structure was verified by drilling. It is in direct continuation of the Klippen Belt, which stretches under the Eggenburgian sediments close to the village of Podbranč. The latest published conception about the position of tectonic units in the basement of the Vienna Basin (Wessely et al., 1993) see Fig. 1. Mišík (1985) determined clastic grains of blue amphibole and chloritoid in the drill core Smolinské 27 (further SM-27). This fact is an additional evidence about the relevance of this part of the basement to the Klippen Belt - Klape or Manín Unit. As is known, pebbles of blue schist facies have been found externally from the Tatricum. They are the components of gravitational flow conglomerates of the Middle Cretaceous in the Klape Unit (surroundings of the town of Považská Bystrica). See Kamenický, 1973; Mišík and Sýkora, 1981; Šímová and Šamajová, 1981; Šímová, 1982a, b; Martin, 1991, Dal Piaz et al., 1995 and others. The pebbles of blue schists have been found in the "flysh" sediments of the Middle Cretaceous Manín Unit - Súľov window (Ivan and Sýkora, in prep.) as well. Clastic grains of sodic blue amphiboles were identified in the Middle Cretaceous turbiditic sandstones in the Klape and Manín Units (Mišík and Sýkora, 1981). Several times they were described in the pebbles of limestones (Barremian to Aptian). These pebbles belong to the Albian - Cenomanian conglo-merates of the same tectonic units (Mišík and Sýkora, l. c.). Blue amphiboles were found in the Upper Creta-ceous sandstones of the Brezová Group as well (Wag-reich and Marschalko, 1995).

The origin of the sediments of the Klape Unit is being discussed at present in Slovak geological literature (Mišík, 1996; Plašienka, 1996). In addition to the earlier hypothesis about existence and position of the Pieninic exotic ridge or Andrusov ridge, Plašienka (1995) intro-duced a new idea. He derived the origin of the sediments of the Klape flysch Basin from the so-called "ultragemeric exotic units" - that is from the South. The Klape Unit to-gether with Manín Unit were

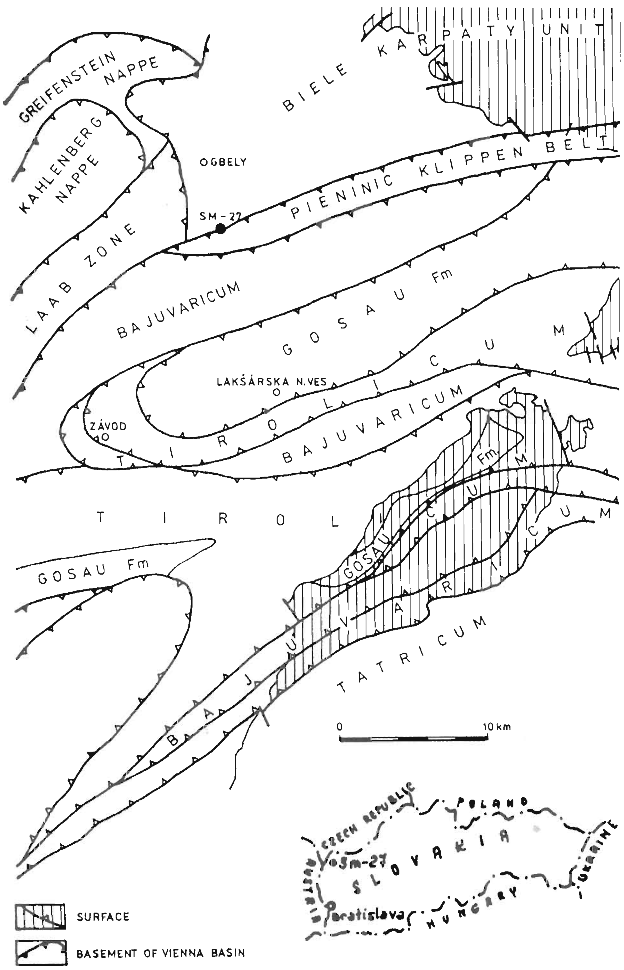


Fig. 1. The map of geological units in the basement of the Vienna Basin - according to (Wessely et al., 1993).

explained as the subunits of the Krížna Nappe. It is not the object of this paper to comment on this new idea, but we note that it raises many questions to deal with. It is true, that it does not explain the more important problems resulting from the rock composition of the above mentioned conglomerates of the Klape and Manín Units. But it is derived from facts, which cannot be ignored.

Detrital blue amphiboles have been known in the Eastern Alpine territory as well. The glaucophanes were found in "Walserberg-Serie" ? Penninicum (Woletz, 1967). Crossite and ferro-glaucophane have been found in the sandstones (Turonian and Lower Coniacian) in the Walsertal zone - South Penninicum (Winkler and Bernoulli, 1986). The glaucophanitic amphiboles are present as a part of the heavy mineral association in the terrige-neous facies of the Rossfeld Fm. - Reichraming Nappe (Decker et al., 1987). Detrital glaucophane, ferro - glaucophane and crossite occur in the Cretaceous sediments of the Northern Calcareous Alps - Allgäu and Lechtal Nappes as well (Winkler, 1988).

Methods

Petrographical and biostratigraphical data were obtained from the rocks of the borehole SM-27 (interval 1559.0 - 1561.0), which were kindly given to us by Nafta Gbely a. s. The content of heavy minerals was studied. Grain concentrate was produced by dissolving the samples in 10 % acetic acid. The silt and sandy fractions were obtained by water washing of insoluble residue and then separated in bromoforme. The heavy minerals were determined under the petrographic microscope (by counting 150 grains). Microprobe analysis of blue alkalic amphiboles was done in thin section by electron microprobe JEOL 840 A, operating at 15 kW, 15 nA, ZAF, operating system SESAME. Natural and synthetic minerals were used as standards (Si - SiO_2, Al - spinel, Mg - spinel, Na - albite, Zn - ZnO, Fe - Fe_2O_3, Mn - MnO, Cr - chromite, Ti - rutil, Ca - wollastonite, K - adular. Biostratigraphical results were obtained by thin section study (forams) and smear slides study (nannos) by using microscope Carl Zeiss Jena and Jeol SEM.

Description of the rocks of the borehole Smolinské 27 core interval 1559.0 - 1561.0 m

The first microscopic analysis of the rocks from the drill core (interval 1560.0 - 1561.0 m) was done by Mišík (1985). The sediments in this interval are gray, spotted marls, which contain organic detritus and clastic terrigenous admixture. Foraminifers: *Thalmaninella ticinensis* (Gandol-fi), *Hedbergella sp.*, fragments of bivalves, echinoderm pla-tes, plant tissue, radiolarians and ostracodes were found. *Cadosina* cf. *semiradiata olzae* and *Cadosina* sp. were also determined. The terrigenous admixture is formed by clay, grains of silt to very fine sand. The prevalent mineral is quartz. Muscovite, chlorite and chlori-toid occurred com-monly and amphiboles in thin sections were found rarely. Mišík, l. c. identified blue amphibole with the extinction angle γ/c 10°.

Our repeated thin section analysis (interval 1559.0 - 1561.0 m) is in conformity with Mišík, l. c. description. Apart from the above mentioned allochems, mudstones to wackestones contain fragments of punctate brachiopods, fish teeth and holothurian sclerit of *Theelia sp.* Pyritised sceletons of radiolaria *Archaeodictyomitra sp.*, *Praecono-caryomma sp.* were found in the insoluble residue. Parts of the core has higher clay content and are formed by calca reous claystone. The terrigenous grains are concentrated in the parts of sediment affected by bioturbation. In the heavy mineral silt - size residum Cr-spinel, zircon, garnet, tourmaline and rutile were identified (beside above mentioned minerals).

Heavy minerals assamblage of interval 1559.0 - 1560.0 m: blue amphibole 39 %, chlorite 27 %, chloritoid 12 %, garnet 6 %, Cr-spinel 5 %, zircon 4 %, rutile 4 %, tourmaline 3 %.

We notice, clastic blue amphiboles in sediments of the Klape Unit in the vicinity of Považská Bystrica (see introduction) have been found in turbiditic sandstones.

Chemistry of detrital amphibole grains

Recalculated according to the unpublished programme RECAMP (Spear, F, Kimball, K, 1991, Macintosh Co.).

Tab. 1
Composition of amphiboles

	Ferro-glaucophane				Crossite	
SiO_2	54.90	54.86	55.37	54.86	55.41	55.15
TiO_2	0.89	0.01	0.05	0.05	0.01	0.14
Al_2O_3	5.84	8.21	8.78	9.10	6.88	3.11
Cr_2O_3	0.02	0.02	0.00	0.00	0.03	0.16
FeO	20.05	21.53	21.07	19.97	23.47	22.96
MnO	0.20	0.12	0.24	0.00	0.31	0.18
MgO	8.66	5.04	4.90	4.62	5.51	8.39
CaO	0.70	0.46	0.40	0.54	0.50	1.79
Na_2O	5.26	6.37	6.54	6.85	6.37	6.16
K_2O	0.27	0.03	0.00	0.00	0.00	0.00
ZnO	0.10	0.02	0.02	0.00	0.00	0.10
	96.89	96.67	97.37	95.99	98.49	98.14
Number of cations on basis of 23 oxygens						
Si	7.988	7.994	7.993	7.997	7.976	7.952
Al^{IV}	0.012	0.006	0.007	0.003	0.024	0.048
Al^{VI}	0.990	1.405	1.487	1.561	1.144	0.481
Ti	0.097	0.001	0.005	0.005	0.001	0.015
Fe^{3+}	0.216	0.372	0.314	0.317	0.566	1.080
Mg	1.878	1.095	1.054	1.004	1.182	1.803
Fe^{2+}	2.224	2.252	2.230	2.118	2.259	1.689
Mn	0.025	0.015	0.029	0.000	0.038	0.022
Ca	0.109	0.072	0.062	0.084	0.077	0.277
Na	1.484	1.800	1.831	1.936	1.778	1.722
Na^{M4}	1.461	1.789	1.818	1.911	1.733	1.633
K	0.050	0.006	0.000	0.000	0.000	0.000

The alcaline amphiboles of a similar chemical composition occur in the area of the town of Považská Bystrica. They appear as clastic grains in sandstones and in the blue schist pebbles (Martin, 1991 and unpub-lished

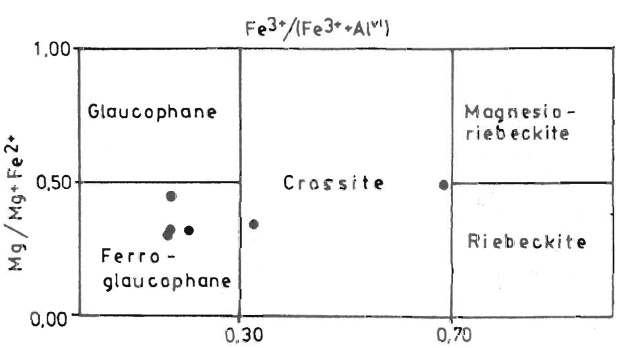


Fig. 2. The position of the blue amphiboles in the nomenclature diagram (Leake, 1978).

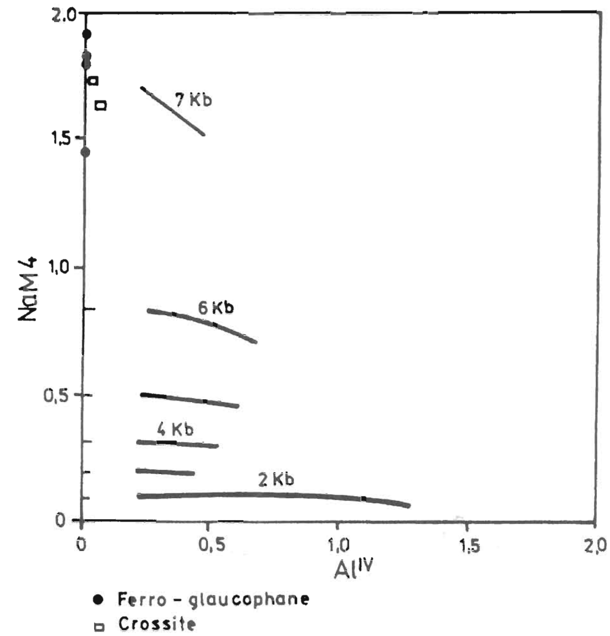


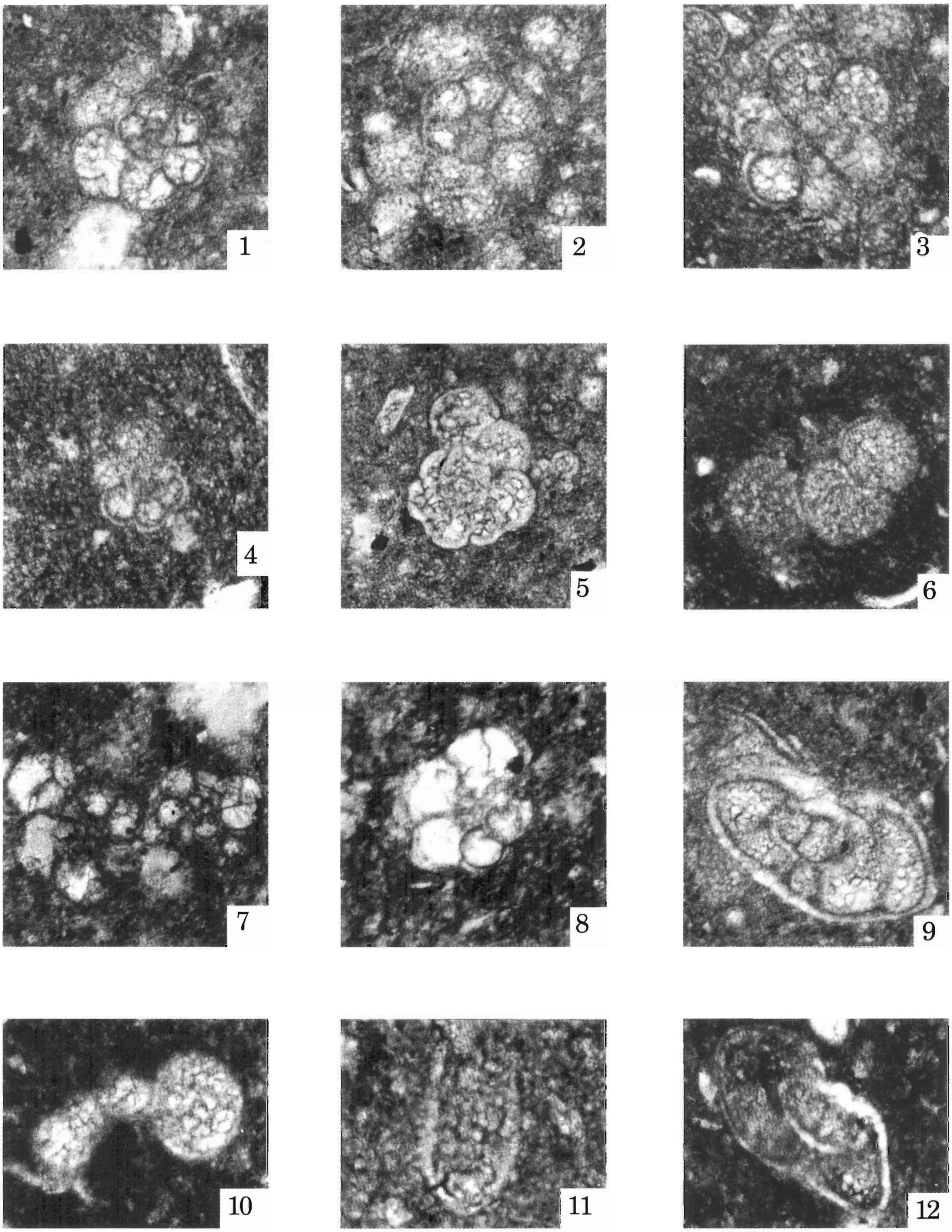
Fig. 3. Na_{M4}/Al^{IV} diagram in na amphiboles (Brown, 1979) for the assesment of pressure conditions of glaucophane genesis.

analysis Ivan and Sýkora, in prep.). In accordance with chart by Brown (1977, Fig. 2) we suppose they were formed by metamorphosis in pressure conditions of about 7 kB (Fig. 3).

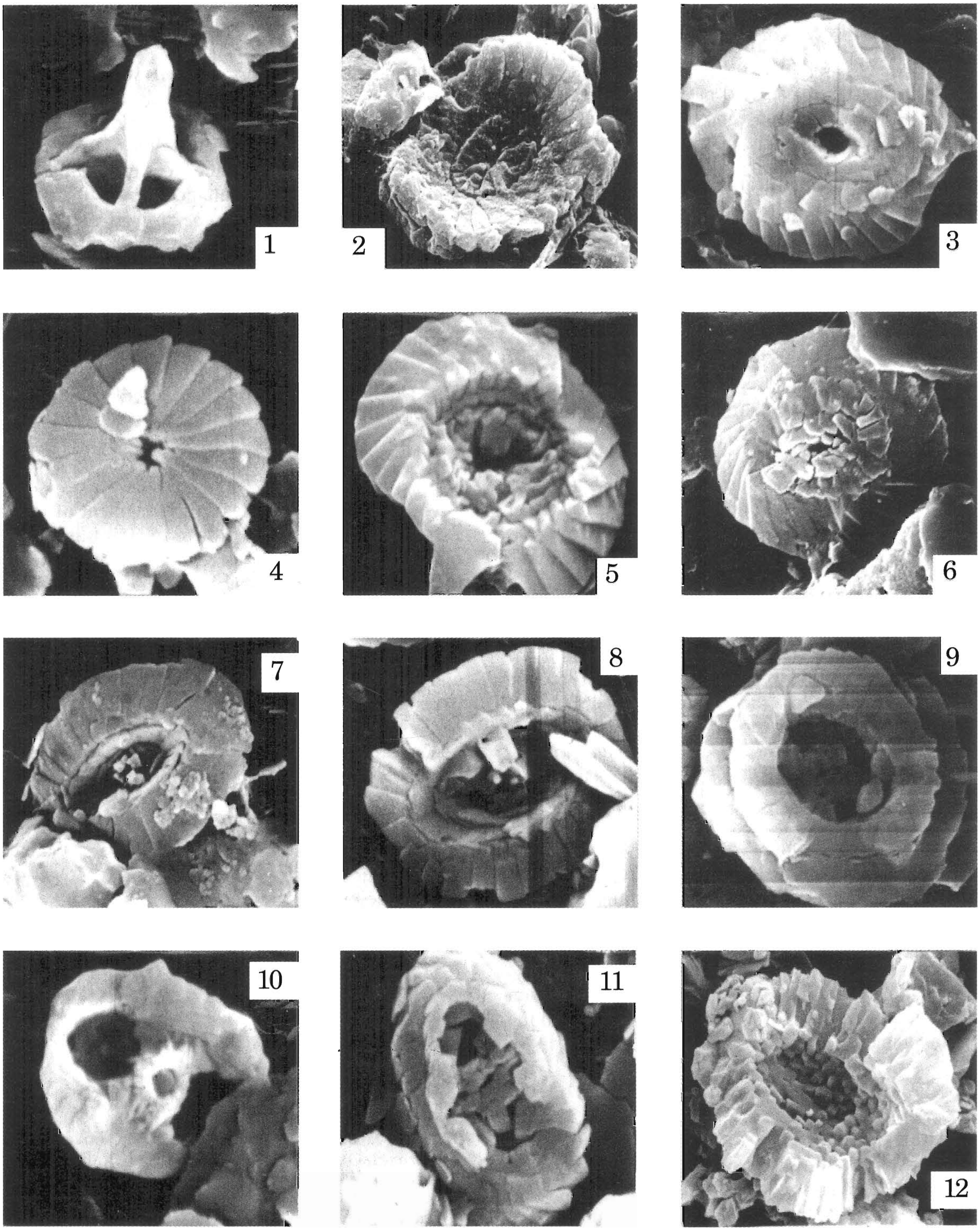
Biostratigraphy

The rocks from the Mesozoic basement of the Vienna Basin in the borehole SM-27 indicated Cretaceous age. Mišík (1985) recognized the foraminifers *Thalmaninella ticinensis* (Gandolfi) and *Hedbergella sp.* in thin sections from the interval 1560.0 - 1561.0 m and considered this formation as Albian. Salaj (in Kulmanová, 1988) identified the asociation *Hedbergella trocoidea* (Gandolfi), *H. roberti* (Gandolfi), *Gaudryina sp.* of the Lower to Middle Albian age, in thin sections of the sediments interval 1560.65 to 1562.0 m. Samuel (1981, p. 113) gave biostratigraphical data (Lower to Middle Albian) based on free foraminifers recognized from the rocks of the interval 1558.0 to 1562.0 m. Gašparíková (1988, p. 118) using calcareous nannofossils determined the Lower Albian age of sediments (interval 1558.2 - 1558.3 m) and Upper Albian (interval 1560.65 to 1561.3 m).

On the basis of the presented stratigraphical data a lack of uniformity in the attained results was found. The drill-core rocks were part of a brittle - ductile zone (pre-Neogene in age), which is obvious by naked eyes study. Therefore our sediments age determination in interval 1559.0 - 1561.0 m was done from the selected undisturbed samples by using calcareous nannofossils and foraminifers. We suppose the disturbance is responsible



Pl. I. Photomicrographs of forams. 1, 2, 4 and 5 - *Ticinella sp.*, 1 - 165x, 2 - 150x, 4 - 135x and 5 - 145x. 3 - T. bejaouensis Sigal., 150x, 6 - *T. roberti* (Gandolfi), 135x, 8 - *Hedbergella cf. globigerinellinoides* (Subbotina), 7 - 160x, 8 - 165x, 10 - *H. globigerinellinoides* (Subbotina), 135x, 9 - *Anomalina sp.*, 135x, 12 - *A. (Gavelinella) sp.*, 130x, 11 - *Colomiella recta Bonet.*, 250x. Figs 7, 8 - core 1, core box 3, interval 1559.0 - 1560.0 m. Figs 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12 - core 1, core box 3, interval 1560.0 - 1561.0 m. Micrographs by D. Boorová.



Pl. II. SEM photomicrographs of calcareous nannofossils. 1 - *Prediscosphaera columnata* (Stover) Perch-Nielsen, 10 000x, 2 - *Watznaueria barnesae* (Black) Perch-Nielsen, 5000x, 3 - *Ellipsagellosphaera fossacincta* Black, 6300x, 4 - *Discorhabdus ignotus* (Górka) Perch--Nielsen, 11 600x, 5 - *Cyclagelosphaera rotaclypeata* Bukry, 8000x, 6 - *C. margereli* Noel., 5500x, 7 - *Biscutum ellipticum* (Górka) Grün and Allemann, 11 000x, 8 - *?B. salebrosum* (Black) Perch-Nielsen, 11 600x, 9 - *Microstaurus chiastus* (Worsley) Grün and Allemann, 9000x, 10 - *Tranolithus salillum* (Noel) Crux., 10 000x, 11 - *Glaukolithus diplogrammus* (Deflandre) Reinhardt., 11 600x, 12 - *Nannoconus truitti truitti* Brönnimann., 3500x.Figs 1 - 12, core 3, core box 1, interval 1560.0 - 1561.0 m. Photomicrographs by Ivan Holický, Geological Institute, Slovak Academy of Sciences.

for discrepan-cies in the stratigraphical ranking of rocks in the interval 1558.0 - 1562.0 m.

Foraminifers

The depth of 1559.0 - 1561.0 m contained planktonic and benthic (both calcareous and agglutinated species) foraminifers. The high stage of forams recrystallization allowed mostly determination of genus. The foraminiferal assemblage from the interval 1559.0 - 1560.0 m is characterized by domination of planktonic species *Hedbergella Brönnimann and Brown.* The following foraminifers are present: *Hedbergella sp.*, *Hedbergella cf. globigerinellinoides* (Subbotina) (Pl. I, Fig. 7 and 8), *Hedbergella globigerinellinoides* (Subbotina). The presence of representatives *Planomalina (Globigerinelloides)* (Cushman and Ten Dam) is very rare. The transverse sections of benthic species *Dorothia sp.* and *Anomalina sp.* were found extremely rare. The age of the sediment in interval 1559.0 - 1561.0 m is probably Aptian.

Microplankton is also the dominate component in thin sections from the interval 1560.0 - 1561.0 m. Together with *Hedbergella sp.* and *Hedbergella globigeri-nellinoides* (Subbotina) (Pl. I, Fig. 10) representatives of planktonic species *Ticinella Reichel - Ticinella sp.* (Pl. I, Fig. 1, 2, 4 and 5), T. bejaouensis Sigal (Pl. I, Fig. 3) and *T. roberti* (Gandolfi) (Pl. I, Fig. 6) were determined. The first appearance of *T. roberti* mentioned by Caron (1985) in the Lower Albian. According to (Salaj and Samuel, 1966) the stratigraphical extent of this genus in the Western Carpathians is Upper Aptian to Lower Al-bian. *Ammodiscus sp.*, *Dorothia sp.*, *Frondicularia sp.*, *Anomalina sp.* (Pl. I, Fig. 9), *A. (Gavelinella) sp.* (Pl. I, Fig. 12) represent the rare benthic component of the association.

The ostracods and tintinids *Colomiella sp.* and *C. recta Bonet* (Pl. I, Fig. 11) were found in addition to foraminifers. They are significant from the stratigraphical point of view. Borza (1978, 1980) mentioned the occurrence of *Colomiella recta* in the Lower Albian of the Western Carpathians.

The microfossil association identified in a thin section of the sediments interval 1560.0 - 1561.0 m indicated the Lower Albian age.

Calcareous nannofossils

The studied sample contains a poor nannoassociation, coccolith preservation is rather bad, affected by dissolution. The calcareous nannofossils assemblage from the interval 1560.0 - 1561.0 m (sse Pl. II) contains rare specimens of *Prediscosphaera columnata*, nannoco-nes - *Nannoconus truitti truitti* Brönnimann (common), *N. donnatensis* Deres and Acheriteguy (rare), *Braarudosphaera africana* Stradner (rare), which indicate the Albian age of sediment. In addition, Neocomian and older nannofossils (*Conusphaera mexicana* Trejo, *Biscutum salebrosum*) (Black) Pearch-Nielsen were found.

The presence of *Prediscosphaera columnata* (Stover) Perch-Nielsen allows us to recognize the standard nannoplankton Zone CC8 sensu Sissingh (1977) and Perch-Nielsen (1985) - *Prediscosphaera columnata*, which documents the upper part of the Lower Albian to Middle Albian age. An analogous zonal determination has been made by Gašparíková (1984) in the Kysuca Group of the Klippen Belt and in the Krížna and Manín Units of the Strážovské vrchy Mts. in the Western Carpathians. The nannoplankton was correlated there with the foraminiferal zone *Ticinella roberti* and *Thalmanninella ticinensis subticinensis.* The stratigraphical range has been expanded to the upper part of the Lower Albian to Middle Albian. Our studied sample contained no specimens of *Eiffellithus turriseiffeli* (Deflandre) Reinhardt (unlike Gašparíková, 1988), which indicates the standard nannoplankton Zone CC 9 sensu Sissingh (1977) and Perch-Nielsen (1985) and documents the Upper Albian age.

Conclusions

We note that in the Mesozoic basement of the Vienna Basin in the area of the village of Smolinské the Klape or Manín unit occur as well as the earlier determined units - Czorstyn and Kysuca. This idea was confirmed by findings of Na-blue amphiboles and chloritoid in the analysed section of the drill-core. These minerals occur in the Klape or Manín unit close to Považská Bystrica and in the Súľov window (see introduction of this paper). The biostratigraphical results from the studied drill-core (interval 1559.0 - 1561.0 m) and the state of preservation of the rocks allow us to suppose tectonic disturbance of this formation. In the four metre long extent of the core sediments of the Aptian, Lower, Middle, Upper Albian age were identified. They are arranged chaotically. Heavy minerals were obtained from the undisturbed parts of the drill-core (1559.0 - 1561.0 m) and the biostratigraphic data in this interval indicated the Lower Albian age. This is in agreement with biostratigraphical results sensu (Mišík, 1985; Kullmanová, 1988; Samuel, 1988).

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Modré amfiboly a mikrofosílie z mezozoického podložia viedenskej panvy (vrt Smolinské 27)

Mezozoické podložie viedenskej panvy v oblasti Smolinské - Štefanov - Koválov a dvora Bištava sa od 50. rokov pokladá za súčasť bradlového pásma. Horniny v tejto časti podložia sa litologicky a stratigraficky podobajú na sedimenty jednotiek bradlového pásma - czorsztynskej, kysuckej, resp. klapskej. Táto elevačná štruktúra sa zistila vrtnými prácami a je priamym pokračovaním bradlového pásma, ktoré sa ponára pod egenburské sedimenty pri obci Podbranč. Mišík (1985) ako prvý opticky určil klastické zrná modrého amfibolu a chloritoidu v jadre vrtu Smolinské 27 (interval 1560 - 1561 m). Tieto ťažké minerály sa vyskytujú v ílovitom vápenci, resp. vápnitom ílovci, v ktorých autor (l. c.) určil albské foraminifery.

Ako je známe, horniny fácií modrých bridlíc a klastické modré amfiboly sa vyskytujú ako súčasť albsko-cenomanských flyšových súvrství v klapskej, ale aj v manínskej jednotke (súľovské okno).

Pretože rozliční autori horniny jadra vrtu SM-27 stratigraficky nezaraďujú jednoznačne, urobili sme novú stratigrafickú analýzu. Na zvyšku vrtného jadra je zjavné tektonické postihnutie v krehkej duktilnej zóne, čo je zrejme príčinou disproporcií medzi stratigrafickými analýzami. V horninách jadra dĺžky 4 m (interval 1558 - 1562 m), ktoré nemá znaky prerušenia sedimentácie, sa zistil aptský až vrchnoalbský vek. Opakovaná analýza sa vykonala na neporušenej časti horniny (1559 - 1561 m). V jadre z hĺbky 1559 - 1560 m sa určila asociácia foraminifer aptského veku a z intervalu 1560 - 1561 m spodnoalbského veku, čo je v zhode aj s výsledkami štúdia vápnitého nanoplanktónu.

Z intervalu 1560 - 1561 m sa zistili tieto ťažké minerály: modrý amfibol, chlorit, chloritoid, granát, Cr spinel, zirkón a turmalín. V asociácii prevláda modrý amfibol (39 %). Rtg elektrónovou mikroanalýzou sa určil Fe glaukofán a crossit. Predpokladáme, že súvrstvie kriedového veku (apt až alb) v podloží sedimentov viedenskej panvy v mieste vrtu Smolinské 27 patrí do klapskej, resp. manínskej jednotky.

Mineralia Slovaca, 29 (1997), 234 - 236

Cicavce (Mammalia) a ulitníky (Gastropoda) vrchného pleistocénu mladopaleolitického táboriska v Trenčianskych Bohuslaviciach

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Late Pleistocene Mammals (Vertebrata, Mammalia) and Gastropods (Mollusca, Gastropoda) in Young Paleolitic site from Trenčianske Bohuslavice

In paleontological investigation of the locality Trenčianske Bohuslavice a fauna of mammals and gastropods was found. From the mammals *Rangifer tarandus* L., *Mammuthus primigenius* (Blumenbach) and *Equus caballus* L. are dominanting. They indicate late Pleistocene age. Gastropods fauna is psychrophyllic and loessic. Index loess species *Pupilla muscorum densegyrata* Lžk., *Valonia tenuilabris* (A. Br.) and loessic species *Pupilla muscorum* (L.) prevailed. More humid environments is indicated by predominating occurrence of the species *Succinea oblonga* Drap. The age of archeological artefacts is Gravettien. Radiometric analysis of the mammoth tusk determinate age 20 000 ± 1000 years.

Key words: Mammalia, Gastropoda, Late Pleistocene, archeological site

Úvod

Pri archeologickom výskume lokality Trenčianske Bohuslavice, ktorý viedol J. Bárta z Archeologického ústavu v Nitre, sa v spraši našlo väčšie množstvo zvyškov (kostí a zubov) cicavcov. J. Bárta nám ich poskytol na paleontologické spracovanie. Okrem zvyškov cicavcov sa tu našlo aj mnoho ulitníkov. Zvyšky cicavcov spracoval P. Holec a ulitníky J. Kernátsová. Navyše sme fragment kla mamuta, ktorý sa rozpadol na množstvo „triesok", poslali na zistenie rádiometrického veku metódou ^{14}C prof. Chrapanovi do Liptovského Mikuláša (Vysoká vojenská technická škola). Výsledok je 20 000 ± 1000 rokov.

Lokalita je na začiatku Bošáckej doliny na južnom okraji Trenčianskych Bohuslavíc v chotárnej časti Pod Tureckom na pravom brehu potoka Bošáčka na nízkej sprašovej tabuli (pozri obr. 1). Po odstránení asi 180 - 200 cm vysokej nadložnej vrstvy buldozérom sa roku 1981 začal archeologický výskum. Šiestimi 2 m širokými sondami sa odkryla plocha 111 m^2 a okrem toho bola v blízkom cestnom úvoze vyhĺbená aj 7 m hlboká a 1,5 m široká stratigrafická sonda, v ktorej sa zistila poloha hlavnej nálezovej vrstvy. Z artefaktov, ktoré určoval J. Bárta, tu prevládajú čepele, rydlá a škrabadlá. Zastúpené sú aj čepieľky s otupeným bokom a gravettské hroty, ktoré datujú kolekciu do súboru gravettienu, studenej fázy posledného würmského zaľadnenia (Bárta, 1982).

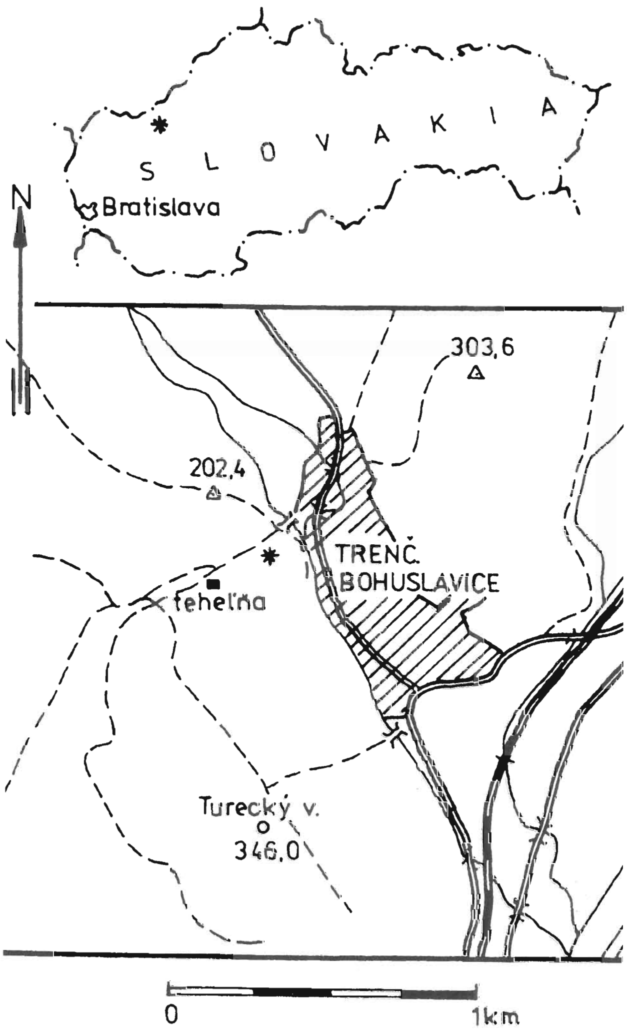
Fauna cicavcov

Pri terénnych prácach sa získala dosť veľká kolekcia kostí a zubov cicavcov, ktoré sa sčasti na mieste, ale väčšinou v laboratóriu katedry geológie a paleontológie Prírodovedeckej fakulty UK čistili a potom konzervovali zriedeným disperzným lepidlom Hercules. Išlo o spodné a vrchné zuby, články prstov, fragmenty dlhých kostí a pod. Na väčšine kostí sú známky po orezávaní svalov a šliach, mnohé boli roztrieštené, akoby sa z nich bol vyberal špik. To nás vedie k domnienke, že v prevažnej miere ide o zvyšky lovných zvierat vtedajších ľudí. Zo zubov prevažujú črenové a stoličky. Najmä pri sobích zvyškoch chýbajú rezáky. Zistené druhy uvádza tab. 1.

Zdá sa, že sa v tom čase najčastejšie lovil sob, lebo sobie zvyšky sú v našom materiáli výrazne najpočetnejšie (pozri tab. 1). Už Kafka (1916) vyslovil názor, že azda už v tom čase človek choval soby polodivým spôsobom. Zdá sa, že vo W3, keď v celej Európe pomerne rýchlo ubudlo mamutov, sa človek musel preorientovať na soby.

Ako vidno z tab. 1, najpočetnejšie sú zastúpené zvyšky prvých troch druhov, kým ostatné sú zriedkavé. Zaujímavý je nález zvyškov bobra, ktorý indikuje blízkosť vodného toku. Vzácne sú aj nálezy zvyškov človeka. Našli sme kamennú čepieľku medzi dvoma krčnými stavcami soba, ale nepodarilo sa nám určiť, či bola naozaj zabodnutá v krčnej časti pri love, alebo sa tam dostala až neskôr.

Naša lokalita je mladšia ako lokalita v Pavlove na Morave. Kultúrna vrstva tam leží v spodnej časti spraše W3 nad interštadiálnou hnedozemou W2-3, podľa typologického rozboru predstavuje samostatný stupeň gravettienu (Musil, 1959) a na rozdiel od našej lokality obsahuje prevažne mamutiu faunu ako hlavnú lovnú zver.



Obr. 1. Situačný náčrtok obce Trenčianske Bohuslavice, lokalita je vyznačená čiernou hviezdičkou.

Fig. 1. Situational sketch of the area of the Trenčianske Bohuslavice village, the locality is designated by the black star.

Aj lokalita v Dolných Věstoniciach je staršia ako naša (24 000 - 29 000 rokov). Musil (1959) podľa množstva zoradil nájdené druhy takto: mamut, líška, zajac, vlk, kôň, sob; s menším výskytom: rosomák, lev, nosorožec, tur, rys a vtáky. Výskumy Klímu (1983) ukázali, že v Dolných Věstoniciach ide najmenej o päť postupne zakladaných, a teda samostatných sídlisk. Zdá sa, že aj táborisko v Trenčianskych Bohuslaviciach sa osídľovalo viackrát po sebe. Na lokalite v Trenčianskych Bohuslaviciach sme našli aj zvyšky mamutov, ale úplne chýba medveď, nosorožec a hyena. V absolútnej prevahe je sob.

Fauna ulitníkov

Prevažná väčšina ulitníkov - kvantitatívna aj podľa počtu druhov (pozri tab. 2) - patrí do hlavnej ekologickej skupiny B - bezlesie (podľa Ložeka, 1955). Z 15 zistených druhov (neurčený druh *Pupilla* sp. tu nezaratúvame) sem patrí 9, t.j. 60 %, do skupiny A - les iba 2 druhy, t.j. 13,3 %, a do skupiny B - les aj bezlesie 4 druhy, t.j. 26,6 % zo všetkých tu zistených druhov. Kvantitatívne vysoko prevládajú *Pupilla muscorum* (L.) - sprašový druh

Tab. 1
Fauna cicavcov
Mammals fauna

Rangifer tarandus L.	veľmi hojné
Equus caballus L. Mammuthus primigenius (Blumenbach)	menej početné
Homo sapiens sapiens L. Castor fiber (L.) Alopex lagopus (L.) Canis lupus (L.) Megaloceros sp. Bos? Bison? sp.	zriedkavé

Tab. 2
Fauna ulitníkov
Gastropods fauna

Číslo vzorky					1	2	
Hĺbka					1,8	2,7	
č.	Druh	Bú	Es	HEs			Σ
1	Trichia striolata (C.Pfr.)	(+)	L(M)	A	1		1
2	Vitrea cristallina (Müll.)	(+)	L(V)	A		5	5
3	Pupilla sterri (Vth.)	+	S	B	2	11	13
4	Pupilla triplicata (Vth.)	+	S	B		39	39
5	Pupilla muscorum (L.)	+	O	B	440	100	540
6	P. m. densegyrata Lžk.	++	O	B	223	180	403
7	Pupilla loessica Lžk.	++	O	B	27	46	73
8	Columella columella (Mart.)	++	O	B	29	43	72
9	Vallonia tenuilabris (A.Br.)	+I	O	B	150	56	206
10	Vertigo parcedentata Sand.	++	O	B		20	20
11	Euomphalia strigella (Drap.)	(I)	XS	B	9		9
12	Trichia hispida (L.)	+	M	C	2	17	19
13	Cochlicopa lubrica (Müll.)	(+)	M	C		2	2
14	Clausilia dubia Drap.	(+)	RL	C		10	10
15	Succinea oblonga Drap.	+	VS	C	170	165	335
16	Pupilla sp.				20		20
Spolu					1073	694	1767

Biostratigrafické údaje (Bú): - + - sprašové druhy, (+) - miestne alebo príležitostné sprašové druhy, ++ - indexové sprašové druhy, (I) - eurytermné druhy teplých období. Ekologické skupiny (Es): L - les, L (M) - les, miestami aj stredne vlhké nelesné stanovište, L(V) - les, miestami aj vlhké nelesné stanovište, S - step a xerotermné skaly, O - otvorené stanovište, XS - suchšie lesné aj nelesné stanovište, M - stredne alebo nerovnako vlhké lesné aj nelesné stanovište, RL - stredne vlhké skaly, kmene stromov v lese, VS - vlhšie lesné aj nelesné stanovište.
Hlavné ekologické skupiny (HEs): A - les všeobecne, B - bezlesie všeobecne, C - les aj bezlesie.

(540 ks = 30,5 %), *Pupilla muscorum densegyrata* Lžk. - indexový sprašový druh (403 ks = 22,8 %) a *Vallonia tenuilabris* (A. Br.) - ďalší indexový sprašový druh (206 ks = 11,6 %). Tieto tri druhy predstavujú 64,7 % všetkých nájdených jedincov. Ešte pomerne hojne je zastúpený druh *Succinea oblonga* Drap. (335 ks = 18,9 %). Ten obýva najmä nivné biotopy, indikuje teda skôr vlhší biotop, čo dobre korešponduje s nálezom zvyškov bobra. Nezriedka žije aj na suchších miestach - na úpätí skál, ojedinele aj na miestach xereotermného rázu v spoločenstve stepných druhov. Neobyčajne početný býva práve v mladšej spraši (Kernátsová, 1991). Ostatné druhy sú zastúpené slabo.

Ako vyplýva z tab. 2, prevládajú ulitníky spraše, a to od indexových druhov až po príležitostné. Biotop podľa fauny ulitníkov charakterizujeme ako otvorený, bez drevín. Jeho najpočetnejším reprezentanom je druh *Pupilla muscorum* (L.), *Pupilla muscorum densegyrata* Lžk. a *Vallonia tenuilabris* (A. Br.). Vlhší biotop je vo väčšej miere zastúpený druhom *Succinea oblonga* Drap., ktorý - vzhľadom na prítomnosť ďaľších druhov s vyššími nárokmi na vlhko - indikuje mierne vlhšie podnebie. Slabšie sú zastúpené druhy indikujúce suché a stepné stanovište, stredne vlhké stanovište a rozličné lesné stanovištia.

Druh *Euomphalia strigella* (Drap.) je eurytermný mladoholocénny až recentný druh teplých oblastí a do tohto sprašového spoločenstva nepatrí. Bol sem zrejme splavený z nadložia. Výrazne prevažujú druhy chladného boreoalpínskeho spoločenstva. V malej miere sú zastúpené aj druhy stredne teplých sprašových spoločenstiev. Prítomnosť druhu *Vallonia tanuilabris* (A. Br.) a najmä *Columella columella* (Mart.) jednoznačne zaraďuje sedimentáciu spraše do obdobia najmladšieho glaciálu W3.

Záver

1. Podľa nájdených kamenných nástrojov sa lokalita zaraďuje do gravettienu.

2. Rádiometricky stanovený vek je 20 000 ± 1000 rokov.

3. Na základe fauny cicavcov bol určený vek W3, azda jeho vrcholiaca časť s ústupom mamuta.

4. Fauna ulitníkov dokumentuje paleoekologické podmienky - studenú klímu s možnosťou vlhších stanovíšť (*Succinea oblonga* Drap.).

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Zlatonosný tetraedrit zo Striebornej žily (baňa Mária, Rožňava)

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Au bearing tetrahedrite from the Strieborná vein (Mária mine, Rožňava, Slovakia)

Gold leaves of micrometer size were found in Ag tetrahedrite from the Strieborná vein, Mária mine, Rožňava ore field. Two types of gold leaves in composition are present - native gold in tetrahedrite I - and younger Au-Hg-Ag alloy in tetrahedrite II. The distribution trends of Ag, Cu, and Sb, Au, Bi, Hg, respectively, and thickness in course of the Strieborná vein proved a new economically significant ore reserves.

Key words: epigenetic, mineralization, siderite, Ag-tetrahedrite, gold, deformation, textures, Strieborná vein, Rožňava, Slovakia

Úvod

Popri siderite, ekonomicky hlavnej zložky v minulosti exploatovaných rožňavských kremeňovo-sideritovo-polysulfidických žíl, sa od 50., resp. 60. rokov pozornosť postupne sústreďovala na sprievodnú polysulfidickú mineralizáciu, najmä na tetraedrit, ktorý je jej hlavným minerálom. Zároveň s charakteristikou mineralogických pomerov (paragenéza, sukcesia vývoja mineralizácie, identifikácia minerálov v pestrej asociácii) žíl v západnej a východnej časti rudného poľa (Varček, a 1959; Novák, 1960,; Trdlička, 1963; Rozložník, 1981; Mesarčík, 1980 a 1994; Mesarčík et al., 1991 a iní) viacerí autori geochemicky intenzívne skúmali aj tetraedrit (zmeny v distribúcii, koncentrácii, mineralogickej charakteristike a obsahu stopových prvkov).

Suma mineralogických a geochemických poznatkov o tetraedrite, ktorý v žilných štruktúrach asociuje s prevažnou väčšinou minerálov, sa postupne zväčšila. Vzhľadom na jeho celkovú koncentráciu a variáciu v distribúcii sa konštatovalo, že obsah viacerých prvkov v tetraedrite (Cu, Ag, Sb, resp. Bi, As a Zn) je ekonomicky významný, avšak technológiu spracovania a extrakcie prvkov z tetraedritového koncentrátu sa podarilo vyriešiť iba nedávno.

Hoci prítomnosť Au v žilách rožňavského rudného poľa bola známa už v minulosti (pozri excerpovanú súhrnnú asociáciu minerálov z práce Zimányia, 1907; Pappa, 1919, in Bartalský et al., 1973, v ktorej sa Au uvádza zo žily Bernardy-Rudník a Rákoš-Volárska zo západnej časti rudného poľa, ako aj z východnej časti žily Mária, in Mesarčík et al., 1991), sledovanie obsahu Au od konca 50. rokov viac-menej konvergovalo s postupne rastúcim záujmom o tetraedrit.

Varček (1959) zistil drobné inklúzie Au v tetraedrite žily Mária. Začiatkom 60. rokov sa obsah a distribúcia Au už sledovali v komplexnej žilovine z vyšších úrovní žilnej štruktúry Mária a Aurélia, ako aj v separovanom tetraedrite (Novák, 1960; Trdlička, 1963). Napriek negatívnym výsledkom Novák (1960) konštatoval, že obsah Au v tetraedrite postupne s hĺbkou rastie. Trdlička (1963) však predpokladal Au aj/hlavne v kobellite, chalkopyrite, pyrite a arzenopyrite.

Tieto poznatky sa akceptovali do polovice 70. rokov, keď sa začal viac-menej systematicky skúmať obsah Au v komplexnej žilnej výplni z viacerých úrovní žilných štruktúr Mária I-II, ako aj forma výskytu Au v separovaných monominerálnych sulfidických frakciách (Rozložník, 1981).

Geochemicko-mineralogický výskum exploatovanej žily Mária I-II poskytol nové poznatky (Rozložník, 1981). Napriek tomu, že v niektorých aspektoch boli kontroverzné, potvrdili reálnosť viacerých predpokladov. Konštatovalo sa, že sa Au vyskytuje prevažne v tetraedrite (v úrovni 8. až 13. horizontu žily Mária I-II obsah Au varíroval od 2,78 do 6,92 ppm, v priemere 5,71, resp. 3,48 ppm). Výskyt Au sa predpokladal aj v mineráloch s vysokým obsahom As, ktoré sú prevažne inkludované v tetraedrite (arzenopyrit a gersdorffit, v ktorom sa v jednej vzorke z 10. horizontu žily Mária I zistil obsah 4,85 ppm Au). Konštatoval sa aj trend pozitívnej korelácie Au s As, ako aj to, že obsah Au v tetraedrite s hĺbkou smerom na SV rastie (o cca 0,5 ppm) a smerom na JZ klesá (o 2 ppm). V chalkopyrite sa zistil priemerný obsah 0,33 ppm Au a v komplexnej žilovine obsah Au varíroval od 0,05 do 0,28 ppm.

Napriek relevantnosti poznatkov z relatívne systematického sledovania obsahu, zmeny v distribúcii a forme výskytu Au sa Au v tetraedrite (ani v iných mineráloch), resp. v komplexnej žilnej výplni mikroskopicky nezistilo.

Rozsiahly prieskum a mineralogicko-geochemický výskum žily Strieborná koncom 80. a začiatkom 90. rokov (Mesarčík et al., 1991; Mesarčík, 1994) potvrdil nielen ekonomicky významnú zásobu tetraedritu s obsahom Ag (resp. aj ďalších prvkov, napr. Cu, Sb, Bi), ale aj obsah Au v tetraedrite od 1,6 do 7,2 ppm. Z viacerých analýz sa zistil pomerne vysoký priemerný obsah Au v tetraedrite z 10. (3,43 ppm Au) a 13. horizontu (3,15 ppm Au) Striebornej žily. V pyrite sa zistil priemerný obsah 0,53 ppm Au a iba jedna analýza chalkopyritu mala 0,2 ppm Au. V rozsahu Striebornej žily sa jednoznačne konštatovala prítomnosť Au v tetraedrite a slabší trend rastu obsahu Au smerom na 13. horizont. V skutočnosti sa však ani pri výskume Striebornej žily Au v tetraedrite (ani v iných mineráloch), resp. v komplexnej žilnej výplni mikroskopicky nezistilo.

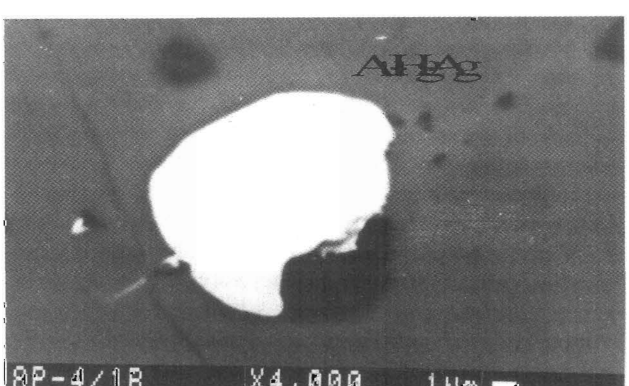
Roku 1994 a 1995 sa v tetraedrite dvoch generácií z 8., 9. a 13. horizontu Striebornej žily na základe chemického zloženia identifikovali dva typy Au minerálov - Au a Au-Hg-Ag intermetalická zliatina. Zlatinky tvoria v tetraedrite inklúzie (ojedinele zhluky inklúzií), ktoré sú veľké niekoľko mikrometrov.

V príspevku informujeme o zložení zlatiniek v tetraedrite I a II identifikovaných mikroskopicky a elektrónovým mikroanalyzátorom.

Vzorkovanie a analytika

Na mineralogické a geochemické hodnotenie mineralizácie sa počas spolupráce s anglickou spoločnosťou SAMAX Ltd odobrali vzorky s hmotnosťou cca 5 kg z 8. až 13. horizontu Striebornej žily. Zloženie viacerých minerálov - vrátane Au - Au-Hg-Ag intermetalickej zliatiny - sa určilo v stredisku elektrónovej mikroanalýzy Geologickej služby SR v Bratislave (LSEM GS SR), kde sa elektrónovým mikroanalyzátorom JEOL 733 Superprobe analyzovalo zloženie minerálnych fáz za podmienok: urýchľovacie napätie 20 KV, prúd 2-3.10^{-8}, štandardy - rumelka (Hg), chalkopyrit (Cu) a rýdze kovy Sb, Ag, Bi, Au a Te; a v stredisku elektrónovej mikroanalýzy Prírodovedeckej fakulty UK v Bratislave pomocou JEOL JXA-840 Superprobe s (EMP) za podmienok: urýchľovacie napätie 20 kV, prúd 15-20 nA a štandardy - rumelka (Hg), chalkopyrit (Cu) a rýdze kovy - Bi, Sb, Ag a Au. Analytická presnosť bola vyššia ako 0,2 %.

Skanová mikrofotodokumentácia vzťahu minerálnych fáz sa zhotovila pomocou SEM (JEOL 840 JSM v LSEM GS SR v Bratislave).



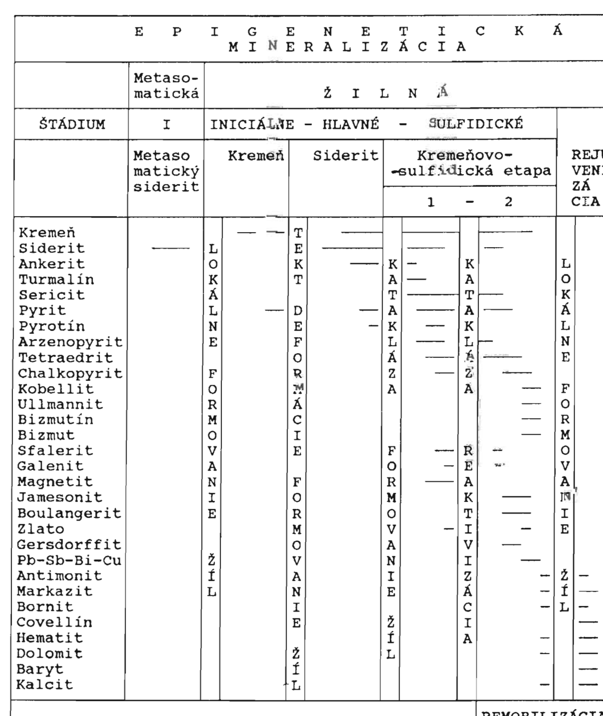
Obr. 1. Au-Hg-Ag intermetalická zliatina inkludovaná v tetraedrite II z 8. horizontu Striebornej žily baňa Mária, Rožňava.

Fig. 1. Photomicrograph of the Au-Hg-Ag alloy included in the tetrahedrite II, 8th level of the Strieborná vein, Mária mine, Rožňava ore district.

Výskyt a zloženie Au

Roku 1994 sa v spolupráci s anglickou spoločnosťou SAMAX Ltd znovu podrobne zdokumentovali banské prieskumné diela v úrovni 8., 9., 10. a 13. horizontu Striebornej žily s cieľom prehodnotiť vypočítanú zásobu tetraedritu a obsah Ag. Kremeňovo-sideritová žilná výplň so zvýšenou koncentráciou tetraedritu (spolu s asociujúcimi sulfidmi - sulfosoľami) sa v prevažnej časti banských diel systematicky ovzorkovala a väčší počet vzo-riek sa postupne geochemicky a mineralogicky zhodnotil. Okrem kvantitatívneho stanovenia obsahu Ag, Cu, As a čiastočne aj Hg sa analyzovalo aj Au, ktorého priemerný obsah v Striebornej žile bol > 3 g/t. Celkový obsah Au bol v intenciách uvedeného intervalu (Mesarčík et al., 1991).

Tab. 1
Schéma sukcesie mineralizácie a tektonických udalostí v rozsahu Striebornej žily (baňa Mária, Rožňava; prevzaté a upravené podľa Sasváriho a Maťa, 1996)
Succession scheme of mineralization and deformation events on the Strieborná vein, Mária mine, Rožňava ore district (adapted and modified after Sasvári and Maťo, 1996)



Tab. 2
Vybrané reprezentatívne mikrosondové analýzy Au-Hg-Ag intermetalickej zliatiny a Au s vysokou rýdzosťou, 8., 9. a 13. horizont Striebornej žily (baňa Mária, Rožňava)
Selected representative microprobe analyses of the Au-Hg-Ag alloy and gold of high fineness, 8th, 9th and 13th levels of the Strieborná vein, Mária mine, Rožňava ore district

Typ	Au	Ag	Hg	Cu	Sb	Bi	Suma
	63,61	12,64	21,49	2,05	n.d.	n.d.	99,79
	64,75	11,23	21,08	2,45	0,05	n.d.	99,56
I.	66,16	10,78	20,16	2,90	n.d.	n.d.	100,03
	68,37	9,63	19,72	1,89	0,11	n.d.	99,72
	93,97	4,63	n.d.	0,17	0,08	0,11	98,96
	94,37	4,21	n.d.	0,23	0,12	0,19	99,12
II.	97,36	2,17	n.d.	0,06	0,08	0,07	99,74
	97,48	2,08	n.d.	0,12	0,18	0,13	99,99

n. d. - nestanovené

Okrem pestrej asociácie minerálov (tab. 1) vrátane tetraedritu dvoch generácií (Td I a II) sa vo viacerých vzorkách s vysokou koncentráciou polysulfidického zrudnenia (zo systému a okolia reaktivizovaných subvertikálnych zlomov a z asymetrických sideritovo-polysulfidických šošoviek budinovanej Striebornej žily z 8., 9. a 13. horizontu; Maťo, 1994; Sasvári, 1994; Sasvári a Maťo, 1996; Sasvári et al., 1996) a obsahu Au > 5 g/t mikroskopicky pozorovali zlatinky.

Oválne a okrúhle zlatinky tvoria inklúzie (veľké 1 - - 20 mm) iba v tetraedrite. Najčastejšie sa nachádzali vo vzorkách z 8. horizontu, redšie z 9. a ojedinele z 13. horizontu. V agregátoch až masívnych akumuláciách tetraedritu sú zvyčajne 1 - 2 zlatinky (len ojedinele sa zisťovali zhluky 5 - 6 zlatiniek veľkých do 10 mm). Svetložlté okrúhle zlatinky relatívne väčších rozmerov (10 - - 20 mm) sa zvyčajne vyskytujú v takmer monominerálnych agregátoch tetraedritu II (obr. 1). Sýtožlté a menšie (1 - 10 mm) zlatinky sú v agregátoch tetraedritu I, ktorý sa zrastá, resp. je zatláčaný staršou a mladšou generáciou sulfidov a sulfosolí (pyrit, arzenopyrit, chalkopyrit, ullmannit, bizmutín, kobellit, jamesonit, boulangerit, markazit, bornit a doteraz bližšie neidentifikované Pb-Sb-Bi-Cu sulfosoli; pozri obr. 43 in Sasvári a Maťo, 1996).

Viaceré zlatinky sa analyzovali elektrónovým mikroanalyzátorom a výsledky potvrdili dva typy Au minerálov, ktoré sa výrazne odlišujú zložením (tab. 2), ale sú homogénne. Väčšie okrúhle svetložlté inklúzie v monominerálnych agregátoch tetraedritu II zložením zodpovedajú Au-Hg-Ag intermetalickej zliatine (1. typ). Pozorovali sa v tetraedrite II iba z úrovne 8., menej často 9. horizontu a nezistili sa vo vzorkách z 10. a 13. horizontu Striebornej žily. Sýtožlté menšie inklúzie v tetraedrite I (2. typ), ktoré tiež tvoria zhluky, zložením zodpovedajú Au s vysokou rýdzosťou. Len ojedinele sa nachádzali vo vzorkách z 8. horizontu, ale zvyčajne sa pozorovali vo vzorkách z úrovne 13. horizontu.

Celkove z obsahu Au zo vzoriek horizontov Striebornej žily vyplýva, že priemerný obsah Au je relatívne vyšší v úrovni 8. a 9. horizontu. V celom rozsahu Striebornej žily sa nezistila pozitívna korelácia medzi As a Au, skôr sa ako pozitívna ukazuje korelácia medzi Au a Hg vo vyšších úrovniach.

Záver

Po viac ako 35 rokoch (Varček, 1959) sa mikroskopicky v tetraedrite zo Striebornej žily v rožňavskom rudnom poli opäť identifikovalo Au. Potvrdil sa niekoľko desiatok rokov trvajúci predpoklad, že sa Au vyskytuje v tetraedrite a že sa neviaže v izomorfnej forme v arzenopyrite, pyrite alebo chalkopyrite. Mikroskopicky a elektrónovým mikroanalyzátorom sa identifikovali dva typy Au minerálov, ktoré sa výrazne odlišujú zložením: - (1. typ) Au-Hg-Ag intermetalická zliatina, - (2. typ) Au s vysokou rýdzosťou. Zlatinky v tetraedrite I a II sa najčastejšie zisťovali vo vzorkách z 8. horizontu, menej často z 9. a ojedinele z 13. horizontu.

Obsah Au a potvrdenie formy výskytu - identifikácia mikroskopických inklúzií v tetraedrite - sú v súčasnosti ekonomicky relevantné jednak pre celkovú hodnotu striebronosného tetraedritového koncentrátu (+ Cu, Sb, Bi), jednak pre finalizáciu technológie spracovania a úpravy tohto koncentrátu, a to aj napriek neadekvátnemu prístupu k tomuto dnes u nás ojedinelému a bohatému ložisku.

Poďakovanie. Táto práca vznikla aj vďaka čiastočnej finančnej podpory grantu GA 1083. Ďakujeme všetkým, ktorí nám akoukoľvek formou pomohli pri výskume. Za konštruktívne pripomienky ďakujeme recenzentom.

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Chemické zloženie hydrotermálneho lazulitu a gorceixitu v kremenci pohoria Tríbeč

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Chemical composition of hydrothermal lazulite and gorceixite in quartzite of the Tríbeč Mts. (SW Slovakia)

Lazulite $MgAl_2(PO_4)_2(OH)_2$ is a widespread low-temperature hydrothermal mineral of the quartz-muscovite-chlorite-hematite-baryte-pyrite-cinnabarite assemblage in Lower Triassic quartzites of the Tríbeč Mts. Microprobe analyses of lazulite from 3 localities show a relatively homogeneous composi-tion with at. Mg/(Mg+Fe) = 0.85 - 0.93 and none to trace Si, Mn, Zn, Ca, Sr, Ba, F and Cl contents. A calculated Fe^{3+} content (up to 0.07 p. f. u.) indicates some oxidation and alteration of lazulite. Gor-ceixite $BaAl_3(PO_4)(PO_3OH)(OH)_6$ forms microscopis fracture-fillings and replacement zones in lazulite; it shows some isomorphic admixture of Si, Fe, Ca, Sr and F. There are the first 3 occurrences of gorceixite in the Slovakia.

Key words: lazulite, gorceixite, phosphates, hydrothermal mineralization, Tríbeč, Slovakia

Úvod

Lazulit zo Slovenska po prvý raz opísal Sekanina (1957), a to z kameňolomu Lupka pri Nitre. Neskôr pribudli jeho početné nálezy v asociácii s barytom, rumelkou, hematitom a ostatnými minerálmi z ďalších 16 lokalít Tríbeča (Jahn, 1976, 1977, 1978a, 1978b, 1979a, 1979b, 1985; Doubek a Jahn, 1987, 1993). Aj keď sa identita minerálu nepopierateľne preukázala na základe rtg,. indexu lomu, hustoty a semikvantitatívnej spektrálnej analýzy (Sekanina, l. c.), jeho chemická analýza doteraz chýbala.

Geologické pomery a lokalizácia vzoriek

Študované minerály sa vyskytujú v neveľkých nepravidelných kremenných žilách, resp. žilníkoch a hniezdach spodnotriasového kremenca lúžňanského súvrstvia, bazálneho člena tríbečskej obalovej jednotky tatrika (cf. Maheľ, 1986). Lazulit sa vyskytuje vo forme nepravidelných agregátov, očiek a žiliek tmavomodrej až svetlomodrej farby s plochou až 7 x 4 cm v bielom hrubokryštalickom kremeni. V paragenéze s lazulitom sa vyskytuje jemnošupinkovitý muskovit (odroda sericit a zrejme aj fengit a fuchsit), bližšie nešpecifikovaný chlorit, mastenec, baryt, hematit (spolu s odrodami spekularit), pyrit a cinabarit, na lokalite Velčice aj galenit a sfalerit (Jahn, l. c.), často spolu so sekundárnym kaolinitom, goethitom, limonitom a bližšie neurčeným oxidom - hydroxidom mangánu („wadom").

Na geochemický výskum lazulitu sme vybrali nasledu-júce lokality:

1) Nitra-kóta Pyramída, 500 m na JZ od kóty Zobor (587 m n. m.),
2) Jelenec-lom Plieška, 700 m na V od kóty Plieška (375 m n. m.),
3) Zlatno-kóta Člnok (439 m n. m.), 2 km na JV od obce Zlatno.

Chemické zloženie

Mikrosondové analýzy sa vykonali vlnovodisperznou elektrónovou mikrosondou CAMECA SX50 na katedre geologických vied Univerzity v Manitobe (Winnipeg, Kanada). Použilo sa urýchľovacie napätie 15 kV, prúd 20 nA, priemer elektrónového lúča 1 - 2 μm, čas merania 20 s na vzorke a 10 s na pozadí. Použili sa prírodné aj syntetické štandardy. Dovedna sme získali 10 analýz lazulitu a 5 gorceixitu.

Lazulit, $MgAl_2(PO_4)_2(OH)_2$, sa na všetkých študovaných lokalitách prejavuje ako chemicky relatívne homogénny, nezonálny (tab. 1). Má výraznú prevahu Mg nad Fe; atómový pomer Mg/(Mg+Fe) dosahuje na sledovaných lokalitách nasledujúce hodnoty: 0,90 - 0,91 Nitra-Pyramída, 0,92 - 0,93 Jelenec-Plieška a 0,85 - 0,86 Zlatno-Člnok. Lazulit z lokality Zlatno-Člnok je výraznejšie železnatý. Prepočet chemických analýz lazulitu na ideálne stechiometrické vzorce indikuje prítomnosť časti sumárneho Fe^{3+}, pričom pomer $Fe^{3+}/(Fe^{3+} + Fe^{2+})$ široko varíruje od 0 po 90 atómových %, resp. 0 - 0,073 Fe^{3+} v 1 vzorcovej jednotke (p. f. u.), a to v závislosti od stupňa oxidácie, príp. alterácie minerálu. Ale exaktnejšie stanoviť Fe^{3+} možno len na základe chemickej analýzy mokrou cestou alebo Mössbauerovou spektrometriou. Obsah Mn, Zn, Ca, Sr, Ba, F a Cl je vo všetkých analýzach pod medzou stanoviteľnosti alebo v jej blízkosti, čiže pod 0,1 hm. %.

Gorceixit, $BaAl_3(PO_4)(PO_3OH)(OH)_6$, sa zistil ako výrazne svetlá fáza v porovnaní s okolitým lazulitom v kompozíciách odrazených elektrónov (BSE; obr. 1). Tvorí nepravidelnú maximálne 0,5 mm veľkú výplň trhlín v lazulite, príp. ho zatláča v nepravidelných zónach. Gorceixit je vždy mikroskopický a v množstve nedostatočnom na identifikáciu práškovou difrakčnou metódou (rtg.). Jediným, ale jednoznačným dôkazom jeho existencie v Tríbeči sú preto bodové mikrosondové analýzy. Doteraz nie je známy nijaký minerál s identickým chemickým zložením (polymorfná modifikácia). Gor-ceixit sa pre vysoký obsah (OH)-skupín analyzuje na mikrosonde pomerne ťažko, pretože sa miesto analýzy nadmerne vypaľuje, a tak len tri analýzy poskytli relatívne uspokojivú stechiometriu, hoci so zníženou sumou oxidov pri dopočítaní H_2O, resp. (OH) v stechiometrickom pomere (tab. 1). Zloženie minerálu podľa lokalít silnejšie varíruje a možno konštatovať mierne zvýšený obsah niektorých izomorfne sa viažucich prvkov, a to Si (Zlatno), Fe, Ca, Sr a F.

Diskusia a záver

Geochemické štúdium lazulitu z troch lokalít v pohorí Tríbeč poukázalo na existenciu relatívne homogénneho vysokohorečnatého člena s obsahom 85 - 93 % molekuly lazulitu s. s. a len 7 - 15 % scorzalitovej molekuly $Fe^{2+}Al_2(PO_4)_2OH)_2$. Tento výsledok je nižší ako odhad na základe závislosti hustoty od indexu lomu, pri ktorom sa pre lokalitu Nitra-Lupka predpokladalo až 20 % scorzalitovej molekuly (Sekanina, 1957). Na druhej strane treba uviesť, že sa tento prvý opísaný výskyt lazulitu geochemicky neštudoval. Chemické zloženie vzoriek tríbečského lazulitu, najmä pomer Mg : Fe, je oproti

Tab. 1
Reprezentatívne mikrosondové analýzy lazulitu (L) a gorceixitu (G) z Tríbeča (v hmot. %)
Representative compositions of lazulite (L) and gorceixite (G) from the Tríbeč Mts. (in wt. %)

	L-N	L-J	L-Z	G-N	G-J	G-Z
P_2O_5	46,34	46,34	45,82	28,42	26,67	26,73
SiO_2	0,00	0,00	0,05	0,13	0,14	1,16
Al_2O_3	33,16	33,47	31,80	28,20	30,32	29,95
Fe_2O_3	0,23	0,00	1,30	1,49	0,00	0,23
FeO	1,83	1,71	2,27	0,00	0,44	0,69
MnO	0,00	0,00	0,00	0,00	0,00	0,00
MgO	12,21	12,35	11,32	0,00	0,02	0,03
ZnO	0,00	0,00	0,01	0,00	0,10	0,12
CaO	0,00	0,00	0,01	1,52	0,80	1,27
SrO	0,03	0,00	0,07	2,49	1,83	1,68
BaO	0,00	0,00	0,00	21,67	23,67	23,06
Na_2O	0,00	0,00	0,00	0,00	0,00	0,03
K_2O	0,00	0,00	0,00	0,03	0,03	0,06
H_2O	5,88	5,90	5,77	11,90	11,73	11,97
F	0,00	0,00	0,00	0,81	0,97	0,91
Cl	0,00	0,00	0,00	0,01	0,02	0,04
Σ	99,71	99,77	98,42	96,33	96,33	97,54
P^{5+}	1,999	1,994	2,017	2,054	1,943	1,914
Si^{4+}	0,000	0,000	0,003	0,011	0,012	0,098
ΣC	1,999	1,994	2,020	2,065	1,955	2,012
Al^{3+}	1,991	2,005	1,949	2,838	3,075	2,985
Fe^{3+}	0,009	0,000	0,051	0,096	0,000	0,015
ΣB	2,000	2,005	2,000	2,934	3,075	3,000
Fe^{2+}	0,078	0,073	0,099	0,000	0,032	0,049
Mn^{2+}	0,000	0,000	0,000	0,000	0,000	0,000
Mg^{2+}	0,927	0,936	0,877	0,000	0,003	0,004
Zn^{2+}	0,000	0,000	0,000	0,000	0,006	0,007
Ca^{2+}	0,000	0,000	0,001	0,139	0,074	0,115
Sr^{2+}	0,001	0,000	0,002	0,123	0,091	0,082
Ba^{2+}	0,001	0,000	0,000	0,725	0,798	0,764
Na^{+}	0,000	0,000	0,000	0,000	0,000	0,005
K^{+}	0,000	0,000	0,000	0,003	0,003	0,006
ΣA	1,007	1,009	0,979	0,900	1,007	1,032
OH^{-}	2,000	2,000	2,000	6,780	6,733	6,751
F^{-}	0,000	0,000	0,000	0,219	0,264	0,243
Cl	0,000	0,000	0,000	0,001	0,003	0,006
ΣX	2,000	2,000	2,000	7,000	7,000	7,000

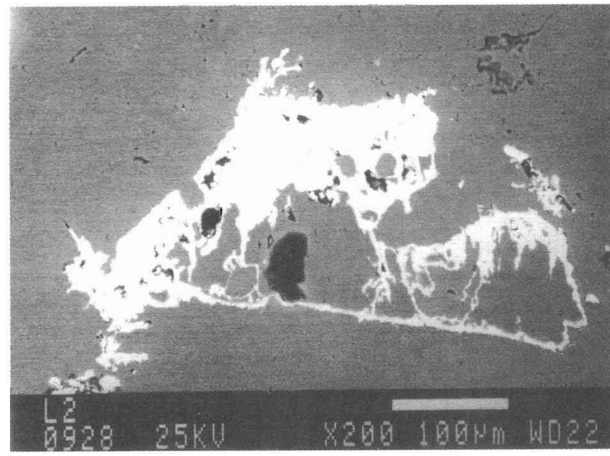
Sumy: -F, Cl = O. Kryštalochemické vzorce lazulitu - na 10 aniónov, gorceixitu - na 14 aniónov (obidva na 1 vzorcovú jednotku). Obsah Fe_2O_3 a H_2O vypočítaný na základe ideálnej stechiometrie. Lokality: N - Nitra, J - Jelenec, Z - Zlatno.

Totals: -F, Cl = O. Formulae based on 10 anions (lazulite) or 14 anions (gorceixite), both 1 formula unit. The Fe_2O_3 and H_2O contents on the basis of ideal stoichiometry. Localities: N - Nitra, J - Jelenec, Z - Zlatno.

tomu podobné lazulitu zo sideritovo-barytovo-sulfidickej mineralizácie v Jaklovciach-Baniskách (cf. Bajaník, 1979).

Mikrosondovými analýzami sa zistil fosfát - gorceixit, ktorý sa na Slovensku zistil po prvý raz. Gorceixit je jednoznačne mladší minerál ako lazulit, ale problematický zostáva jeho genetický vzťah k ostatným minerálom lazulitovej paragenézy, najmä k ďalšiemu minerálu Ba - barytu.

Možno zhrnúť, že tríbečské výskyty lazulitu a gor-ceixitu spolu so sprievodnými minerálmi indikujú nízkoteplotnú hydrotermálnu mineralizáciu generovanú zrejme v súvislosti s tektonotermálnym účinkom slabšej regionálnej metamorfózy alpínskeho (kriedového?) veku. Metamorfné postihnutie obalového mezozoika Tríbeča, zreteľne výraznejšie ako v severnejších tatrických jednotkách, je všeobecne známe (cf. Maheľ, 1986) a pravdepodobne dosahuje až fáciu zelených bridlíc, čo indikuje aj prítomnosť chloritu a muskovitu (sericitu) v lazulitovej paragenéze. Napokon hydrotermálnometamorfný lazulit v kremenných žilách je typický aj pre svetové lokality, napr. metapsamity a metakonglomeráty pri Giogo di Toirano v Taliansku (Cortesogno et al., 1987), muskovitovo-kyanitové metakvarcity v Passo di Vizze v Taliansku (Morteani a Ackermand, 1996), ílovité bridlice v okolí Werfenu (Rakúsko), kyanitový kvarcit v Horrsjöbergu (Švédsko), viaceré lokality metakvarcitu v Brazílii a v USA (Bernard, Rost et al., 1992).



Obr. 1. Gorceixit (svetlý) tvoriaci výplň trhlín v lazulite. Lok. Jelenec-Plieška. BSE, foto Horák.

Fig. 1. Gorceixite (light) as a fracture-filling in lazulite. Loc. Jelenec-Plieška. BSE, photo by Horák.

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GeOvestník

Informačný spravodajca pre geológiu, baníctvo, úpravníctvo a životné prostredie

Príloha časopisu Mineralia Slovaca, roč. 29, č. 3

Obsah

Minulosť a budúcnosť ložiskovej geológie

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Roku 2000 bude Zem obývať takmer sedem biliónov ľudí. Ak priemerná spotreba nerastných surovín na osobu zostane na súčasnej úrovni, ich ťažba sa bude musieť za 30 rokov zdvojnásobiť. Ak spotreba v USA zostane na dnešnej úrovni, ale v rozvojových krajinách vzrastie, bude treba ťažbu nerastných surovín zvýšiť 30 ráz.

V ostatných tridsiatich rokoch USA spotrebovali viac nerastných surovín a fosílneho paliva ako ľudstvo od začiatku svojej histórie. Už roku 1970 spotreba USA predstavovala 40 % celkovej produkcie Al, 30 % Cu, 24 % ropy a 21 % uhlia. Do konca 20. stor. spotreba nerastných surovín v USA porastie o 3,4 až 5,5 % ročne. Od roku 1900 sa celková požiadavka na ropu a prírodný plyn zdvojnásobovala každých desať rokov a zvyšovanie bude nepochybne ešte vyššie (World Resources, 1990 - 1991, s. 86).

Ložiskoví geológovia USA boli a sú najdôležitejšími aktérmi pri vyhľadávaní, geologickom prieskume a ťažbe nerastných surovín, a preto je prirodzené, že nás ich náhľad na zabezpečenie ľudstva nerastnými surovinami v budúcnosti zaujíma.

Programy vyhľadávania a geologického prieskumu rudných ložísk sa majú radšej zakladať na pozorovaniach a skúsenostiach ako na genetických teóriách, keď nie pre iné, tak aspoň preto, že teórie majú tú zlú vlastnosť, že po preverení sú v najlepšom prípade iba polopravdami. Paul Gilmour

Nedávna minulosť ložiskovej geológie

Roky 1950 až 1975 boli obdobím významných a nebývalých úspechov rudnej ložiskovej geológie, obdobím objavov, najmä etapou zaisťovania veľkého množstva Cu z ložísk medenoporfýrových rúd. Veľa geologických poznatkov sa získalo aj o pôvode ložísk. Podľa R. L. Nielsena (1997) to bolo obdobie klasického výskumu medenoporfýrových ložísk a ich veľkých objavov.

Vyhľadávanie a geologický prieskum medenoporfýrových ložísk vrcholili v 50. rokoch 20. stor. a v 60. rokoch geologickoprieskumné a ťažobné akcie začalo postupne silne obmedzovať úsilie o ochranu životného prostredia, ako aj rad vyhlášok a predpisov.

Najmä ťažba medených rúd sa opäť stala celosvetovou potrebou, a tak tlak rastúceho obyvateľstva a priemyselnej činnosti posúvajú kyvadlo späť na stranu racionálneho prieskumu a produkcie nerastných surovín. Na prahu 21. stor. stoja ložiskoví geológovia tvárou v tvár pred novými výzvami a príležitosťami. Nevyhnutne sa musí vytvoriť „nová", citlivejšia organizácia ložiskových geológov, ktorá bude slúžiť potrebám tejto profesie a ľudstva.

H. Brown roku 1952 v diele Výzva k budúcnosti ľudstva odhadol preskúmanú zásobu Cu rúd dostupných baní a povrchových ložísk USA na 25 miliónov t a overenú zásobu Cu inde vo svete na 100 miliónov t.

Hospodárske, kultúrne a sociálne faktory

Stimuly významného prieskumného úspechu s medenoporfýrovými rudami boli rozličné. Do roku 1950 sa svet zotavoval z druhej svetovej vojny. Japonsko a Európa sa prebudúvali. USA sa pozerali vpred, smerovali k dekáde silnej hospodárskej aktivity a rastu obyvateľstva a k výraznej požiadavke na spotrebné produkty. Nedostatok kovov a rúd sa výrazne prejavil v 50. rokoch, čo potvrdila aj federálna vláda USA a rozhodnou mierou sa zaangažovala do politiky nerastných surovín. Prezident H. Truman, vláda i demokratmi ovládaný Kongres USA potvrdili kritický nedostatok nerastných surovín a prísne kontrolovali ceny nerastných surovín získaných banskou cestou. Išlo o kontrolu, ktorú bolo možno pokladať aj za dedičstvo z druhej svetovej vojny. Na svetovom trhu nerastných surovín vzniklo aj viac ťažko pochopiteľných porúch. Napríklad kým banskí producenti v Chile dostávali za libru (453,6 g) svojej Cu 35 až 36 centov, producentov USA držali pri 22 až 24 centoch. Kongres USA roku 1950 schválil štátny účet, ktorý zvýšil dane banských spoločností, a tak spoločnosti produkujúce Cu rudy platili za tzv. krajné zisky až 77 % z hrubého produktu. Je paradoxné, že táto dokázateľne nespravodlivá daň motivovala banské spoločnosti zvýšiť investície do prieskumu a výskumu.

Geologický prieskum rudných ložísk si vyžaduje multidisciplinárnu tímovú prácu robenú sústredene, cieľavedome a vysoko odborne - nazýva sa to tiež ako prieskumné umenie

Univerzity a technické školy v tom čase obsadzovali mladí ľudia na účet vlády. Spoločnosti, ako je Hughes, North American a Lockheed, podporovali stovky študentov plným štipendiom a mzdami v internátoch. Dobre vyškolení a vycvičení absolventi škôl išli do zamestnania a pomohli nevídane rozkrútiť americký priemysel (vrátane tzv. prúdového leteckého, čo viedlo až k letom na Mesiac). Situáciu správne pochopili aj banské spoločnosti a veľkoryso podporovali absolventov univerzít, v lete zamestnávali aj študentov, podporovali získavanie akademických postov, budovali posluchárne a laboratóriá, a to všetko za tzv. 23-centové doláre.

Rozvoj leteckého snímkovania v 2. svetovej vojne umožnil moderný regionálny geologický prieskum a výskum. Koncepcie mineralogické, geochemický výskum ložísk, rtg. difrakcia a skonštruovanie aparátov na syntézu hydrotermálnych minerálov zas viedli k modernému štúdiu hydrotermálnych premien hornín. Takýto vývoj položil základy veľmi produktívnej súčinnosti, a tak sa výskum ložísk nerastných surovín stal dôležitým partnerom geologického prieskumu rudných akumulácií.

Na začiatku 50. rokov bol geologický prieskum medenoporfýrových ložísk v USA spätý s dobre vyškolenými a skúsenými geológmi väčšinou z veľkých banských spoločností. Ich vzťah k spoločnostiam bol veľmi dobrý, a preto bola aj fluktuácia geológov medzi spoločnosťami malá. Geologický výcvik v ložiskovej geológii dopĺňala výchova geologickej etiky. Tak sa do rozličných častí sveta vydali plniť geologickoprieskumné úlohy vysoko kvalifikovaní a na terénnu prácu dokonale vyškolení geológovia, čo sa potom prejavilo nezvyčajne cennými objavmi rudných ložísk a veľkej zásoby rúd v krajinách, ako je Chile a Peru.

Spoločnosť ASARCO objavila rudné ložiská v Arizone, a to Silver Bell, Misson a Sacaton. Iné Cu ložiská sa zistili v Peru. Spoločnosť Phelps Dodge rozšírila zásoby medenoporfýrových rúd s pomocou banských inžinierov a použitím tzv. vírivého vŕtania.

Výrazne iný ako v USA, ale v mnohých smeroch analogický bol vývoj ložiskovej geológie po 2. svetovej vojne na Slovensku. Aj tu nastal rozvoj geologickoprieskumných prác s cieľom zistiť najmä rudný potenciál hlavných ťažobných rajónov, rudných revírov a žíl. Vytvoril sa na to Východoslovenský rudný prieskum, zameraný hlavne na spišsko-gemerskú časť Slovenského rudohoria, a Západoslovenský rudný prieskum, orientujúci sa najmä na stredoslovenské neovulkanity. Ich pokračovateľom sa roku 1958 stal Geologický prieskum. Preverovania nádejnosti rudných ložísk na základe geologických poznatkov z predchádzajúceho obdobia sa skončilo okolo roku 1965, keď sa zistilo, že ďalší prieskum ložísk možno vykonávať a nové rudné zásoby na rozvoj ťažby získať iba po komplexnom geologicko-montanistickom zhodnotení najmä hlavných ťažobných rajónov Spišsko-gemerského rudohoria, stredoslovenských neovulkanitov, Malých Karpát a iných oblastí Slovenska, ktoré budujú neovulkanity okolo 120 pracovníkov zo slovenských geologických a ťažobných organizácií, univerzít a SAV pripravilo v rokoch 1967 až 1975 geologicko-ložiskovú štúdiu Spišsko-gemerského rudohoria (Grecula, 1995).

Komplexné geologicko-ložiskové a prognózne zhodnotenie neovulkanických oblastí Slovenska z hľadiska nerastných surovín vo forme monografie pripravil bývalý Geologický prieskum a bývalý Geologický ústav Dionýza Štúra (Burian, Slavkay, Štohl, Tözsér a i.).

Tak sa zo Spišsko-gemerského rudohoria, ako aj z ložiskovo veľmi dôležitých neovulkanitov Slovenska po prvý raz zhromaždil podrobný a komplexný materiál o geológii, ložiskových pomeroch, baníctve, ekonomickom a prognóznom hodnotení rudných a nerudných ložísk. Na tomto základe pokračoval intenzívny prieskum rudných a nerudných ložísk, ako aj ťažba nerastných surovín do roku 1991, keď sa prieskum a ťažba obmedzili a potom skončili. Začiatkom roku 1996 sa ťažilo už iba Au v Hodruši (žila Svetozár), mastenec pri Hnúšti, baryt v Rudňanoch, siderit v Nižnej Slanej a magnezit v Košiciach, Jelšave a v Lubeníku, kým geologický prieskum rudných ložísk - okrem Nižnej Slanej a menších akcií vo veporiku a v Nízkych Tatrách - sa skončil alebo doznieval. Tým sa uzavrelo 50-ročné obdobie mimoriadnej intenzívnej geologickej, prieskumnej a ťažobnej aktivity zo štátnych prostriedkov, hlavne v neovulkanitoch Slovenska, v spišskej a gemerskej oblasti Slovenského rudohoria, ale aj v iných častiach Slovenska (v Nízkych Tatrách, vo Veporských vrchoch a v Malých Karpatoch).

Treba zdôrazniť, že úspešný geologický prieskum najmä rudných nerastných surovín bol vždy veľmi osobnou, individuálnou a podnikateľskou činnosťou. V USA ho vždy vykonávali súťaženieschopné spoločnosti. Vyhľadávanie a geologický prieskum nerastných surovín požaduje veľké geologické individuality, nálezcov rudných ložísk. Banské spoločnosti a skupiny, ktoré to vedia a konajú podľa toho, robia dobre.

Nedávno sa veľa písalo a hovorilo o geologickom prieskume rudných ložísk ako o činnosti vyžadujúcej multidisciplinárnu tímovú prácu. Úspešný vyhľadávací a prieskumný tím sa prirovnáva k futbalovému mužstvu, v ktorom všetci plnia úlohy s maximálnym nasadením a úspech sa vyjadruje gólmi. Analógia dobre ilustruje stanovisko úspešných amerických ložiskových geológov. Úlohou vedúceho tímu je dať dohromady schopných a skúsených hráčov s výbornou futbalovou zručnosťou. Analógia podmienok úspechu tímu futbalovej jedenástky a geologickoprieskumnej skupiny je zrejmá a podčiarkuje axiómu, podľa ktorej je kľúčom k úspechu obidvoch veľmi odlišných tímov sústredene cieľavedomé vedenie a individuálne a podnikateľské kvality, ktoré ťažko definovať, ale zhruba možno zhrnúť vetou: V prvom prípade treba mať futbalové a v druhom geologické a prieskumné UMENIE.

Prieskumná spoločnosť Kennecott prišla na to, že úspešný geologický prieskum musí byť podoprený aplikovaným výskumom, a tak sa zorganizovali skupiny vhodné na doplnenie geologického prieskumu. Keď sa stala dosiahnuteľná počítačová technológia, tzv. geofyzikálna zložka zahŕňala posádky prieskumných terénnych geofyzikov a osoby vyvíjajúce nové geofyzikálne prístroje a metódy interpretácie výsledkov geofyziky. Geochemické laboratóriá sa doplnili skupinou geologického výskumu a všetok výskum bol organizovaný ako služba osôb vo forme vnútroorganizačných konzultantov.

Strategickým cieľom prieskumného a výskumného úsilia bolo vyvinúť a odskúšať novú vyhľadávacoprieskumnú technológiu na odkrytie najmä medenoporfýrových ložísk pod postminerálnou a postvulkanickou skrývkou v miestach možného významného supergénneho chalkozínového (Cu_2S) obohatenia Osobitný dôraz sa kládol na zistenie minerálnej metasomatózy v komínových brekciách a vo vápenci, t. j. na miestach s relatívne vysokým obsahom Cu.

Zefektívňovanie jestvujúcich geologickoprieskumných technológií

Jednou z úloh bolo zdokonaliť interpretáciu leteckých a družicových snímok, ako aj radarových obrazov (satelitné zobrazovanie sa roku 1960 ešte nedalo využívať) na skvalitnenie a spresnenie regionálneho ložiskového výskumu. Významné úsilie sa sústredilo na interpretáciu okysličených a vylúhovaných východov hornín nad rudnými mineralizáciami a na vývoj tzv. semikvantitatívno-predpovednej interpretácie mineralogických a geochemických údajov získaných z okysličených odkryvov. Cieľom bolo predpovedať primárny rudný obsah Cu na odhad množstva vylúhovanej Cu a zistenie stupňa supergénneho medeného obohatenia. Základný geochemický program dokumentoval geochemické vzorové (modelové) prípady okolo medenoporfýrových centier a nad nimi. Cieľom bolo vyvinúť „vektory" ukazujúce smer k najbližšiemu vrtu v zóne geochemickej aureoly obklopujúcej ložisko, ako aj vzdialenosť k nemu. Táto technológia sa potom často používala pri hľadaní objektov (terčov) pod aluviálnou pokrývkou.

Vývoj nových geologickoprieskumných technológií

Geochemici robili pokusy s využitím geochémie podzemnej vody ako detektora pochovaných medenoporfýrových centier. Sľubná „ortuťová stopárska technika" (mercury sniffer) sa skúšala pri lokalizácii sulfidných ložísk pochovaných pod štrkom. Azda najúspešnejší bol vývoj geofyzikálnej vybudenej polarizácie (VP), ktorá umožnila vonkajšiu rekognoskáciu a v niektorých prípadoch minimalizovala efekt vysokovodivého nadložia, ktoré je v aluviálnych dolinách bežné.

Výsledky zdokonalených počítačových modelov poukazujú na chmúrnu budúcnosť ľudstva. Medzná hranica rastu počtu obyvateľstva sa dosiahne približne o 100 rokov. Objavenie nových zdrojov nerastných surovín môže tento hrozivý scenár posunúť, ale ľudstvo musí ihneď začať hľadať nevyhnutné zdroje surovín

Zdokonaľovanie pohľadu na rudotvorné procesy

Cieľom štúdia bolo lepšie definovať prostredie rudného ložiska. Veľký záujem o výsledky tohto druhu geológovia mali a zostavovatelia programov regionálneho geologického prieskumu. Osobitný program mala výskumná skupina zostavujúca a interpretujúca geologické, geochemické a geofyzikálne údaje v špecifických geografických regiónoch. Ich syntézou vznikali geologickoprieskumné koncepcie a myšlienky, ktoré prieskumný geológ poskytoval závodom regionálneho geologického prieskumu a spracúval do podoby cieľových objektov. Výskumné aj prieskumné skupiny spolupracovali s geochemikmi izotopistami na spoločných projektoch, ktorých cieľom bolo zisťovať pôvod a vývoj hydrotermálnych roztokov v medenoporfýrových systémoch. (Sheppard et al. 1969, 1971 a Sheppard a Gustafson 1976). Geochemici spoločnosti Kennecott v spolupráci s H. Hegelsonom z univerzity v Berkeley (Kalifornia) vytvorili numericky alebo počítačom modely zobrazujúce chladnutie intrúzií a vývoj alteračných zón (Norton, 1979). Spoločnosť Kennecott využila aj výhodu málo známeho federálneho vládneho programu USA, ktorého cieľom bolo zapojiť vedcov z univerzít do práce výskumných skupín banských spoločností na zlepšenie komunikácie a tvorbu spoločných výsledkov. Tak napr. vedci z Arizonskej univerzity dostali granty na spoluprácu s výskumníkmi spoločnosti Kennecott pri štúdiu tektonických deformácií a tvorbe tektonických modelov nádejných rudných ložísk v Arizone a v Novom Mexiku (Davis, 1979). To pomohlo definovať objekty krajiny s vyššou pravdepodobnosťou výskytu rudných ložísk.

Príprava prieskumníkov, výmena výskumných výsledkov a koncepcií. Modely ako významná časť programu

Praktické školenia a krátkodobé kurzy geofyzikálnej techniky, medenoporfýrovej geológie a regionálnej tektoniky boli pravidelnou súčasťou prieskumných akcií.

Novátorské úsilie spoločnosti Kennecott a metódy jej výskumnej skupiny boli prehľadne spracované z viacerých dôvodov. Toto výskumné úsilie bolo jedným z prvých tohto druhu v rámci banského priemyslu. Nezvyčajný bol najmä tesný vzťah medzi výskumnými úlohami a prieskumnou činnosťou. Ľudia vstupovali do skupín, pripravovali projekty a vracali sa späť do geologického prieskumu. Decentralizácia prieskumu tak vytvorila nový model v priemysle a stala sa nápadným znakom programu Kennecottu. Podľa tohto modelu sa aj vývoj iných veľkých organizácií geologického prieskumu uberal cestou decentralizácie.

Geologická služba USA mala aktívny a živý program výskumu zdrojov nerastných surovín a jej podiel na ich objavovaní je veľmi významný. Počas druhej svetovej vojny budovala impozantný a vedecky kompetentný štáb a program, ktorý zahŕňal aj pokračovanie geologického mapovania banských rajónov. V záujme optimálneho riešenia úloh Geologická služba USA a spoločnosť Kennecott pri výskume vzájomného záujmu tesne spolupracovali.

Osobitne treba zdôrazniť, že geologický výskum USA spätý s prieskumným podnikaním za 25 rokov (1950-1975) zväčšil dosiahnuteľnú zásobu medenoporfýrových ložísk takmer desať ráz. Produktívnosť tohto klasického obdobia bola výsledkom vysokej základnej daňovej sadzby (poskytovala viac dolárov na výskum a prieskum) a všeobecného zmyslu pre nevyhnutnosť udržiavať nezávislosť USA v oblasti nerastných surovín.

Na porovnanie situácie v USA a u nás uvádzame stav zásob a ložísk nerastných surovín v 80. rokoch na Slovensku.

Podľa M. Ťapáka sa roku 1987 na Slovensku ťažilo viac ako 30 druhov nerastných surovín, z toho viac ako 20 zo skupiny nerudných a tri zo skupiny energetických surovín. Ich súhrnná ťažba dosiahla roku 1985 56 miliónov t. Ťažilo sa zo 432 ložísk, z toho bolo 238 ložísk nerastov a stavebných materiálov. Na celkovej ťažbe sa roku 1987 objemovo zúčastňovali energetické suroviny 9, rudy 2, ušľachtilé nerudy 32 a stavebné hmoty 52 %. Hodnotové zastúpenie tých istých skupín nerastných surovín na celkovej hodnote vyťažených surovín roku 1985 bolo takéto: energetické suroviny 34 %, rudy 21 %, ušľachtilé nerudy 30 % a stavebné hmoty 15 %. V rokoch 1977-1987 objem ťažby energetických a stavebných surovín poklesol. Z energetických surovín sa znížila ťažba ropy a zemného plynu, ale celková bilancia zásob na rok 1985 naopak dokumentovala možnosti rastu.

Súčasné stanovisko vlády USA, ktoré podporuje aj Kongres USA, sa prejavuje krátením federálnych výdavkov, pričom sa vychádza z toho, že pre USA nie sú v súčasnosti nedosiahnuteľné nerastné suroviny. Americký banský úrad (The U. S. Bureau of Mines) bol zrušený a program zdrojov nerastných surovín Geologickej služby USA drasticky zredukovaný. Vládna finančná podpora sa poskytuje iba úlohám súvisiacim so životným prostredím, s tým spätou prípravou rozličných predpisov a nariadení a otázkam plánovaného využívania krajiny.

Geologické práce sa zo štátneho rozpočtu Slovenskej republiky financujú dvoma kanálmi. Ide najmä o štátne geologické organizácie, akou je napr. Geologická služba SR. Obmedzenia sú ešte drastickejšie ako napr. v USA. Súčasný tok financií na geologické práce spôsobuje, že sa prostriedky z poplatkov za geologické informácie v širšom slova zmysle nevracajú v adekvátnom podiele do štátneho rozpočtu a už vôbec nie do oblasti geológie (Tözsér, 1994). Podľa Tözséra (l. c.) sa objavujú aj názory, že vstupom zahraničného kapitálu do geológie nastáva výpredaj našej surovinovej základne, ktorá je majetkom štátu. Je to pravda, pretože zahraničné spoločnosti platia za prieskumné územia iba „almužnu" a nie sú zaviazané, aby napr. na každý štvorcový kilometer prieskumného územia preinvestovali ročne napr. 10 až 20 tisíc Sk, hoci takýto systém je v mnohých štátoch sveta samozrejmý (napr. v Zambii fungoval už v rokoch 1970 až 1980). Tak je potom na Slovensku bežné, že zahraničné spoločnosti zneužívajú lacné prieskumné územia na špekulatívnu blokáciu rozsiahlych nádejných území Slovenska na výskyt rúd bez toho, že by sa pustili do vážnejších a nákladnejších prieskumných prác.

Výskum a vývoj prieskumnej technológie nerastných surovín bude centrom ďalších geologických prác v budúcnosti. Hlavná pozornosť sa sústredí na tektoniku, stratigrafiu petroóogiu a horninové prostredie rúd. Vzrastie dôležitosť syntézy všeobecných geologických a geochemických informácií. Finančné prostriedky možno očakávať zo združených zdrojov, zo zlepšenej produktivity baní a z reálnych cien, ktoré pod tlakom požiadaviek spoločnosti rastú.

Geologický prieskum a výskum v 21. storočí

Keď bude rast obyvateľstva sveta naďalej exponenciálny, súčasný počet (okolo 6 biliónov) sa môže v nasledujúcich 40 alebo 50 rokov zdvojnásobiť.

Posledná publikácia tzv. Rímskeho klubu Mimo hraníc (Meadows, Meadows a Randers, 1992) sumarizuje výsledky zdokonalených počítačových modelov a predpovedá ľudstvu chmúrnu budúcnosť. Podľa nej sa hranica rastu ľudstva dosiahne približne o 100 rokov a potom bude nasledovať pokles počtu obyvateľov i priemyselnej kapacity. Zväčšenie dosiahnuteľnej základne surovín môže hrozivý scenár posunúť o niekoľko rokov, ale ľudstvo musí ihneď začať hľadať aspoň minimálne nevyhnutné zdroje surovín. Ako vidno, Rímsky klub s tvorivosťou človeka a s technologickým pokrokom vo svojom modeli veľmi nepočíta.

Demografia prezrádza, že priemyselné krajiny mali po druhej svetovej vojne 40 % svetového obyvateľstva. Dnes je to už iba 20 % ale 85 % svetových príjmov, a o niekoľko dekád to bude len 12 až 15 % svetového obyvateľstva. Robert D. Kaplan (1996) v publikácii Koniec sveta opisuje svoje cesty po preľudnenej a spustošenej západnej Afrike, Somálsku, Egypte a po potenciálne explozívnych krajinách Stredného východu, strednej Ázie, Indie, Pakistanu a západnej Číny. Nazdáva sa, že tieto regióny sú ilustráciou budúceho stavu trvale chudobných krajín. Jeho tézou je, že katastrofy, aké poznáme z Bosny, Čečenska, Rwandy a Somálska negatívne pretvoria svet zajtrajška.

Je jasné, že krajiny s bohatými prírodnými zdrojmi hľadia na vývoj ako na najlepšiu a azda poslednú šancu úniku zo sociálnej a hospodárskej dezintegrácie. Geologický prieskum zdrojov nerastných surovín bude dôležitým faktorom ekonomickej politiky v Latinskej Amerike, Ázii a v južnej Afrike, kde zatiaľ centralizované, ale viac-menej demokratické vzťahy stále existujú.

Americkí geológovia sa pozerajú na budúcnosť geologického prieskumu nerastných surovín, vývoj ich zásoby, ako aj na podnikanie s nimi s optimizmom. Predpokladá sa, že sa geologický prieskum nerastných surovín v nasledujúcich rokoch stane naliehavou nevyhnutnosťou. Aj výskum a vývoj prieskumnej technológie nerastných surovín, ktorý bol pri zisťovaní medenoporfýrových rúd v minulosti rozhodujúci, bude centrom ďalších geologických prác v budúcnosti.

V súčasnosti ustavične rastie význam diaľkového prieskumu geologickej stavby Zeme, premeny hornín a chemických údajov. Približne tretinu kontinentov pokrýva hlboko okysličený regolit a väčšina takýchto terénov pre nedostatok vhodnej technológie na detekciu a interpretáciu mineralogických a geochemických javov nedala primerane preskúmať. Výskum regolitového prostredia je prioritný v Austrálii, kde prieskumná technológia prekročila a priniesla objavy (Smith, 1996). Geochemické záznamy z podložných hornín a postmineralizačnej skrývky sa budú starostlivo študovať v záujme definície „sprievodcu" alebo „vektorov" na detekciu pochovaných a skrytých rudných zón. Zlepší sa technológia na zefektívnenie ťažby z vrtov používajúcich priebežnú geofyzikálnu a geochemickú karotáž. Geologické modelovanie geofyzikálnych údajov pomôže zlepšiť ich interpretáciu a všetko uľahčia počítače. Hlavná pozornosť sa sústredí na tektoniku, stratigrafiu a petrologické prostredie rúd. Vzrastie dôležitosť syntézy všeobecných geologických a geochemických informácií. Finančné prostriedky možno očakávať zo združených zdrojov, zo zlepšenej produktivity baní a z reálnych cien, ktoré pod tlakom požiadaviek spoločnosti rastú.

Čas výskumu a jeho realizátori

Ukazuje sa, že ani vláda USA ani vlády EÚ nebudú vo výskume nerastných surovín - aspoň nie v dohľadnom čase - pripisovať väčší význam. Takýto stav sa zrejme potvrdí až do chvíle, keď sa problém zásob nerastných surovín stane nápadným a dôležitým z hľadiska širokej verejnosti, čiže nie skôr, ako sa v USA prejaví krízový nedostatok nerastných surovín. V Geologickej službe USA zostalo iba relatívne malé jadro vedcov a práve ono azda v budúcnosti oživí výskumný program nerastných surovín.

Podobná, ba ešte horšia je situácia aj v Geologickej službe SR. Úloha SAV v budúcom výskume nerastných surovín je neistá, hoci niekoľko dôležitých otázok i mimoriadnych príležitostí jestvuje. Univerzity sú závislé od štátnych fondov, a preto veľmi citlivo reagujú na vládnu politiku. Veľká časť univerzitnej administrácie a študentov bola zatiahnutá do „politicky korektných" pohybov, a tak budúcnosť geológie vidí iba na počítačoch založených približných aplikáciách životného prostredia. Niektoré univerzity takmer vylúčili výchovu a výcvik v ložiskovej geológii vôbec, vynechali tradičnú terénnu geológiu a redukovali geologické kurzy z tektoniky a stratigrafie, hoci ide o základné predmety v príprave ložiskových geológov. Budúcnosť takýchto akademických oddelení vyzerá zle a aj študenti už spoznávajú, že zamestnať sa v oblasti životného prostredia je stále ťažšie.

Podľa Richarda Nielsena (1997) organizácie podporujúce vyvážený program a usilujúce sa perfektne vykonávať terénne orientovaný program geológie „tvrdých hornín" majú budúcnosť a požiadavky na absolventov s takýmto výcvikom budú rásť. Banské spoločnosti, geologické služby a vládne orgány, ktoré podporujú takýto typ vzdelávania a investujú doň svoje investície dobre zúročia. Úžitok budú mať univerzity aj študenti.

Rad západných univerzít spolupracujúce s organizáciami, aby podporili výskum v ložiskovej geológii a uľahčili aplikáciu výskumných výsledkov a výskumu technológie v priemysle, a to publikáciami, terénnym výcvikom a krátkymi kurzmi. Predstavitelia priemyslu a výskumníci geologických služieb sa stávajú členmi univerzitných poradenských a vedeckých rád, aby mohli navrhovať projekty výskumu nerastných surovín slúžiace potrebám priemyslu. Sami na to môžu poskytnúť finančnú podporu. Výskumné projekty tak realizujú geologické služby, univerzitní študenti a učitelia, ale dvere sú otvorené aj pre reprezentantov priemyslu. Austrálski a kanadskí ložiskoví geológovia v tomto smere predstihli svojich partnerov z USA. Napr. Austrálska výskumná asociácia banského priemyslu (AMIRA) podporuje výskum v austrálskych verejných a súkromných inštitúciách.

Spolupráca geologických služieb a univerzít bude úspešná, keď bude úsilie najmä zo strany univerzít úprimné, naozaj partnerské, keď nepôjde iba o získanie fondov na favorizované výskumné projekty. Aj priemysel musí takúto spoluprácu chápať ako dlhodobú väzbu a slobodnú výmenu výskumných výsledkov a myšlienok.

Demografické a hospodárske faktory potvrdzujú nevyhnutnosť geologického prieskumu na celom svete a na mnoho rokov. Rast obyvateľstva i ekonomická expanzia, najmä v Ázii, budú dôrazne zvyšovať požiadavky na nerastné suroviny. Chudobné krajiny nebudú schopné zúčastniť sa na ekonomickom raste, a preto im hrozí politický a sociálny chaos. Lokálne i občianske vojny sa môžu stať bežnými a aspoň dočasne môžu prerušiť zásobovanie nerastnými surovinami.

Napriek súčasným ťažkostiam sa o budúcnosť geologického prieskumu nerastných surovín netreba obávať. Výskum sa zameria na vývojové technológie vyhľadávania ložísk v zakrytých oblastiach, na presnejšie vytyčovanie budúcich cieľov ložiskovej geológie, ale aj na lepšie chápanie horninového prostredia rúd a genézy ložísk.

Veľké prieskumno-výskumné skupiny banských spoločností sú drahé a pravdepodobne už patria minulosti. Veľa tvorivej geologickoprieskumnej práce vykonali dobre financované mladé spoločnosti. A práve mládež potrebovala a žiadala si prístup k plodom geologického a technologického výskumu. Podľa R. Nielsena (1997) široká paleta výskumných prostriedkov a výskumných miest sa stane dosiahnuteľná aj pre pracovníkov geologického prieskumu ložísk napr. geológ z prieskumu bude mať prístup k výsledkom výskumu banskej spoločnosti ap. Niektoré výskumné projekty zrealizujú po dohode malé („butikové") výskumné skupiny.

Prieskumní geológovia spoločností sa budú zúčastňovať na poradách spolupracovníkov z univerzít, geologických služieb, priemyslu a vlády. Dôležitosť profesijných a technických organizácií bude rásť pri šírení výsledkov výskumu vo svete prostredníctvom publikácií, sympózií, praktického výcviku a terénnych konferencií.

Spoločnosť ložiskových geológov reaguje na globálnu výzvu spresnenou definíciou svojho poslania a stanovením dlhodobých i strategických cieľov.

Skupina strategického plánovania, ktorú vedie W. Hodder, dokončila štúdiu o strategických cieľoch. Správa predstavuje vidinu, podľa ktorej bude Americká asociácia ložiskových geológov (SEG) vedúcou medzinárodnou vedeckou organizáciou ložiskových geológov dokonale otvorenou na získavanie vybraných (hoci rôznorodých) poznatkov používaných pri vyhľadávaní nerastných surovín, pri ich hospodárskom a sociálnom využívaní.

Na dosiahnutie takéhoto cieľa musí SEG urýchlene plniť program zmien. Ide napr. o rozšírenie publikačného programu o geologické práce mimoriadneho záujmu, ktoré sú pri geologickom prieskume nerastných surovín veľmi efektívne. Rozvíjať sa budú aj programy podporujúce vzdelávanie a výskum, ako aj aktivita mimo Severnej Ameriky za aktívnej účasti zahraničných členov SEG a organizácií s podobnými cieľmi. Niektoré výsledky SEG nebudú publikované iba v angličtine. Pri sprostredkúvaní informácií a služieb bude rásť aj úloha elektronických médií. Na rozšírenie členstva v SEG - najmä medzi študentmi a medzinárodnou spoločnosťou - sa budú iniciovať priebojné informačné programy. SEG a jej vedenie sa budú modifikovať, aby lepšie slúžili členom, aby sa zlepšila komunikácia a poskytla publicita produktom a programom SEG a aby sa lepšie viedli dobrovoľníci - aktivisti, od ktorých je SEG závislí.

Kultúrna kvalita Severoameričanov, Európanov a Austrálčanov je základným predpokladom na to, aby SEG v ložiskovej aplikácii prieskumnej vedy vynikala. Každý z jej členov sa ako geologický profesionál zapojí do plnenia vedeckých, technických a výchovných úloh.

Každý člen SEG má vynaliezavosťou, časom, peniazmi, a najmä prácou a myšlienkami pomôcť pri napĺňaní jej vízie. Každý profesionál musí obnoviť záväzok - oddanosť dobrým vedeckým metódam v profesionálnej činnosti, a je jedno, či pracuje v geologických službách alebo ako jednotlivec, pre veľkú alebo malú spoločnosť, veď iba dobrá veda plodí dobrých profesionálov i zmysel pre povolanie.

Klasické štvrťstoročné obdobie (1950 - 1975) výskumu rúd a geologicko-ložiskových objavov sa už dávno skončilo. Pri pohľade do budúcnosti si treba uvedomiť nielen rastúcu populáciu, ale aj rozvoj priemyselnej kapacity, a preto bude geovedecké podnikanie a profesionálne geologické akcie veľmi potrebné. Podľa R. L. Nielsena (1997) bude nasledujúcich 25 rokov „periódou renesancie výskumu nerastných surovín a ich objavovania".

Budúcnosť ložiskovej geológie na Slovensku

Ložiskovo-hospodársku slávu Karpatom robil vyše 1000 rokov šírilo Au a Ag neogénnych magmatitov. Budúcnosť ložiskovej geológie Karpát v 21. stor. možno logicky a objektívne opäť vidieť v technologickom prehodnotení známych a overených typov nerastných surovín pre netradičné použitie (pripravuje sa projektový zámer), vo vyhľadávaní nových druhov, najmä nerudných nerastných surovín, a to tzv. industriálnych, ekologických pre farmaceutický, chemický a hutnícky priemysel, pre poľnohospodárstvo, ale aj v prieskume rúd, najmä drahých kovov.

Ekonomicky veľmi dôležitá Au-Ag mineralizácia Karpát sa koncentruje v troch ohniskových, ložiskových oblastiach. Sú to:

1. Stredoslovenské neogénne magmatity pri Banskej Štiavnici, Hodruši a Kremnici. Ekonomicky a metalogeneticky bolo najvýznamnejšou drahokovovou oblasťou Karpát oblasť Banskej Štiavnice už v 11. stor. Odtiaľ napr. pochádzajú aj strieborné denáre maďarského kráľa sv. Štefana (Balogh, 1993).

2. Gutínske neogénne magmatity pri meste Baia Mare (Slba, Sasar, Valea Rosie, Suiror, Baiut). Písané dokumenty o ťažbe Au v Gutínskych vrchoch pri Baia Mare sú od 13. stor.

3. Neogénne magmatity Apusenských vrchov, tzv. zlatý štvoruholník medzi obcami Brad, Sacarimb, Zalatna a Baia de Aries. Prvé vecné pamiatky o ťažbe Au-Ag rúd v Transylvánii, najmä od obce Rosie Montana, vo forme tzv. rímskych dobývok sú z dôb Rimanov (2. stor.).

V 13., 14. a 15. stor. boli tieto tri neogénne ložiskové a magmatické centrá Karpát hlavným producentom drahých kovov na svete, a to až do objavenia a otvorenia rozsiahlejších a bohatších baní na americkom kontinente. Karpaty v stredoveku ročne priemerne produkovali do 2500 kg Au a 10 000 kg Ag (Molnár a Hedenquest, 1996).

V ktorej časti Karpát bude mať ložisková geológia 21. stor. primát a kde bude rozkvitať drahokovové baníctvo, závisí od pochopenia a správnej aplikácie hlbokého zmyslu slov amerického ložiskového geológa P. Gilmoura (1977): „Programy vyhľadávania a geologického prieskumu rudných ložísk sa majú zakladať na pozorovaniach a skúsenostiach ...“

Triezvo sa pozorovania a skúsenosti v ložiskovej geológii v uplynulých 20 rokoch na Slovensku využili v prípade Au mineralizácie žily Svetozár v hodrušskom rudnom poli (Gavora, 1988), žily Strieborná v rožňavskom rudnom poli (Abonyi, 1980) a na polymetalickom a drahokovovom ložisku typu „kuroko" v rudnom poli Brehov - Zemplín na východnom Slovensku (Bacsó, 1995).

Dôsledné a na geologických pozorovaniach a skúsenostiach založené vyhľadávanie a geologický prieskum rudných ložísk vo všetkých troch uvedených prípadoch priniesol očakávané výsledky vo forme ekonomicky významných a nádejných rudných akumulácií.

Nielen v Amerike, ale aj v karpatskej horskej sústave v Európe, konkrétne na Slovensku, je budúcnosť ložiskovej (rudnej) geológie veľmi nádejná. Podmienkou však je sústrediť sa najmä na Au-Ag mineralizáciu neogénnych magmatitov tak, ako káže naša vyše tisícročná skúsenosť a rada dlhodobé vecné pozorovania v Karpatoch.

Druhou, kontrastnou a nie celkom pochopiteľnou stranou mince je, že hoci Slovensko má jednu z najdôležitejších drahokovových oblastí Karpát - stredoslovenské neovulkanity - v ťažbe Au-Ag rúd v porovnaní s podobne významnými rumunskými oblasťami zaostáva. V Gutínskych vrchoch je to okolie Baia Mare, Baia Sprie, Cavnic a v Apusenských vrchoch oblasť tzv. zlatého štvoruholníka Brad, Sacarimb, Zarand a Baia de Aires. V súlade so stanoviskom nášho najlepšieho súčasného znalca problematiky drahých kovov stredoslovenských neovulkanitov Böhmera (1987) to možno jednoznačne vysvetliť geologicko-ložiskovým zanedbávaním tejto oblasti prakticky od roku 1920 až po súčasnosť.

Poznámka: Príspevok vychádza z prác zahraničných členov americkej spoločnosti ložiskových geológov a bol z veľkej časti spracovaný na základe článku prezidenta SEG v rokoch 1996-1997 Richarda L. Nielsena The classic age of porphyry copper research and discovery (SEG NEWSLETTER, 1997, č. 5 s. 1 - 11, a Geotimes, č. 4/1977).

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Riešenie špecifických problémov abiotickej zložky životného prostredia a odpadového hospodárstva (Seminár, Bratislava 17. 4. 1997).

Potenciál Slovenska z hľadiska zdrojov ílovitých hornín do tesniacich jadier skládok odpadu

J. SCHWARZ

Poznanie distribúcie zdrojov ílovitých hornín vhodných na budovanie minerálnej tesniacej vrstvy najmä do skládok tuhého komunálneho odpadu (v zmysle nariadenia vlády č. 606/1992 Zb. skládky 3. stavebnej triedy) znižuje investičné nároky na budovanie takýchto zariadení, a tým stimuluje ich výstavbu.

Program odpadového hospodárstva (Ministerstvo životného prostredia SR, 1993) predpokladá, že do roku 2005 bude všetok komunálny odpad zlikvidovaný v zariadeniach vyhovujúcich legislatívnym požiadavkám. Preto sa vyvíja legislatívny tlak, aby si pôvodcovia väčšieho množstva odpadu, predovšetkým mestá a priemyselné podniky, takéto zariadenia vybudovali.

Alternatívny odhad potrebného počtu skládok vybudovaných na území Slovenska v rokoch 1990 - 2005 je minimálne 48 nových regionálnych skládok 3. stavebnej triedy, ale maximálne až 71 skládok. Preto Ministerstvo životného prostredia SR vyhlásilo úlohu Potenciál Slovenska z hľadiska zdrojov ílovitých hornín do tesniacich jadier skládok odpadu, ktorú na základe konkurzu plní firma EnviGeo, s. r. o., Banská Bystrica. Úloha sa rieši a skončí sa v októbri 1997.

obsah zŕn pod 0,002 mm (ílovina)	min. 20 %
obsah zŕn do 32 mm	max. 30 %
obsah zŕn nad 32 mm	0 %
index plasticity ($I_p = w_L - w_P$)	10 - 30 %
obsah organických látok	max. 5 %
koeficient filtrácie (k_f) pri optimálnom zhutnení	max. 5.10^{-10} m.s^{-1}

Na potreby úlohy sa definovali kvantitatívne a kvalitatívne požiadavky na tesniaci íl. Tesniace ílovité horniny musia spĺňať najmä tieto kvalitatívne požiadavky:

Uvedené kritériá sa vzťahujú na hlinu a íl, ktoré sa podľa STN 73 1001 označujú CL, Cl, CH, ML, MI, SM a SC.

Predmetom výskumu je najmä kvartérny a terciérny polyminerálny íl, ale nie bentonit, ktorého vyhľadávaním a prieskumom sa zaoberajú iné štúdie.

Úloha má dve etapy. V prvej sa ovzorkovali činné alebo opustené ťažobne tehliarskych surovín. Vychádzalo sa z faktu, že takéto ťažobne sú rozložené rovnomerne po celom území Slovenska, surovinovo sú späté s jemnozrnnými zeminami, teda poznanie ich fyzikálno-mechanických vlastností, vzhľadom na tesniaci účinok bude dobrým podkladom pre ďalšiu etapu - vyčlenenie nádejných geologických štruktúr a vyčíslenie prognóznych zdrojov.

Zo všetkých overených ťažobní tehliarskej hliny sa spracúvajú pasporty, ktoré budú prílohou záverečnej správy. Pasportizovať sa budú aj lokality tesniaceho ílu spĺňajúceho podmienky prognóznych zdrojov v kategórii P_1.

Predpokladá sa, že konečná hustota overených lokalít bude asi jeden zdroj na 700 km^2, teda asi jeden až dva zdroje na okres.

Výstupom úlohy budú:

1. pasporty ložísk tehliarskych surovín zodpovedajúcich požiadavkám na tesniaci íl,
2. pasporty prognóznych zdrojov tesniaceho ílu,
3. mapa priaznivých geologických štruktúr s vyznačením prognóznych zdrojov tesniaceho ílu,
4. slovné zhodnotenie územných celkov Slovenska (okresy a kraje podľa administratívneho členenia) z hľadiska výskytu tesniaceho ílu, rozčlenenie na dostatkové a nedostatkové oblasti, odporúčanie alternatívnych zdrojov tesniacich surovín v nedostatkových oblastiach (napr. zdrojov jemnozrnných zemín do zmesí s bentonitom) v textovej časti.

Všetky grafické výstupy budú digitalizované a ich súčasťou bude databáza technologických údajov.

V záujme rovnomerného pokrytia územia Slovenska geologickými prácami sa nadviazala spolupráca s organizáciami vykonávajúcimi geologickú činnosť v sledovaných oblastiach. Okrem firmy EnviGeo, s. r. o., Banská Bystrica ako nositeľa úlohy je to Progeo, s. r. o., Žilina, Geologia, s. r. o., Spišská Nová Ves, Maseva, s. r. o., Košice a Prírodovedecká fakulta UK Bratislava, katedra ložiskovej geológie (zastúpená združením Gemini).

Náročné laboratórne práce pre všetky spolupracujúce organizácie zabezpečuje laboratórne stredisko DMZH firmy Ingeo, a. s., Žilina.

V čase písania tohto príspevku prebiehali práce 2. etapy, takže k dispozícii boli čiastkové výsledky 1. etapy - overovanie potenciálu Slovenska z hľadiska vhodnosti ílovitých hornín do tesniacich prvkov na základe vzoriek z ťažobní tehliarskych surovín.

Z celkového počtu 63 vzoriek ílovitých hornín 32 vzoriek spĺňalo požiadavku na koeficient filtrácie maximálne 5.10^{-10} m.s^{-1} pri optimálnom zhutnení. Z toho je zrejmé, že asi 50 % overených ťažobní tehliarskych surovín možno použiť ako alternatívny zdroj tesniaceho ílu (tento odhad berie do úvahy len hodnotu koeficienta filtrácie ako rozhodujúcej vlastnosti z hľadiska tesniacich účinkov).

Skúmané vzorky boli zo 40 % (25 ks) z kvartérnych sedimentov a z 22 % (14 ks) z neogénnych sedimentov. 35 % (22 ks) tvorili vzorky z lokalít, kde sa ako tehliarska surovina využívajú sedimenty kvartéru aj neogénu (najčastejšie kvartérne zvetraniny a svahové sedimenty na terciérnych jemnozrnných sedimentoch). Len 3 % (2 vzorky) boli z iných hornín (paleogénny prachovec, kriedový ílovec).

Tab. 1

Vlastnosť (jednotka)	Vlhkosť (%)	Merná hmotnosť (kg.m^{-3})	Koeficient filtrácie (m.s^{-1})	Medza tekutosti (%)	Medza tvárlivosti (%)
Minimum	9,0	2460	1,99 10^{-11}	25	14
Maximum	42,4	2920	6,84 10^{-9}	93	46
Priemer	20,86	2682,38	8,62 10^{-10}	46,17	21,44

Tab. 2

Vlastnosť (jednotka)	Obsah organ.látok (%)	Číslo plast.	Proctor-w_{opt} (%)	Proctor-r_d^{max} (g.cm^{-3})	Ílová aktivita
Minimum	0,00	9	10,6	1,23	0,4
Maximum	5,36	50	37,5	1,96	22.0
Priemer	1,31	24,73	17,65	1,72	1,4

Hodnotenie a riadenie rizík vo svete a na Slovensku

M. MALOVESKÝ

V nasledujúcich tabuľkách sú minimálne, priemerné a maximálne hodnoty vybraných fyzikálno-mechanických vlastností zo 63 vzoriek ílovitých hornín odobratých v ťažobných tehliarskych surovín.

Úloha je príkladom konkrétnej pomoci štátnej správy podnikateľským subjektom, v tomto prípade firmách budujúcich zariadenia na zneškodňovanie komunálneho odpadu.

V oblasti ochrany životného prostredia je ekologická záťaž pomerne vážnou, ale často obchádzanou otázkou. Znečistenie prírodného prostredia predstavuje zdroj rizík pre zdravie ľudí, ako aj pre životné prostredie. V rade prípadov sa riziká uvedomujú, resp. sa o nich vie, ale pre nedostatočné legislatívne nástroje, nevhodnú metodiku a napokon aj pre nedostatok financií zastávajú neraz naďalej problémom.

Hodnotenie rizík sa skladá z niekoľkých krokov.

1. Určenie nebezpečnosti

Pri hodnotení treba v prvom rade vedieť, aké látky sú príčinou zvýšeného rizika. Prvým krokom je identifikácia látok potenciálneho záujmu. V ňom sa identifikujú zdroje znečistenia, technologické postupy, pri ktorých znečistenie vzniká, fyzikálno-chemické vlastnosti látky a jej toxicita. Ďalej treba určiť transportné cesty takýchto látok, ako aj faktory, ktoré transport ovplyvňujú. Potom sa zisťuje plošný a priestorový rozsah kontaminácie v súvislosti s geologickými, hydrogeologickými, hydrologickými, pedologickými, klimatickými a poveternostnými podmienkami lokality, stavom fauny, flóry a vegetácie, a to vzhľadom na spôsob manipulácie s kontaminovanými zložkami, blízkosť ľudských obydlí alebo vzácnych biotopov, ich pozícia k smeru prúdenia znečistenia atď. Odstrániť vplyv všetkých znečisťujúcich látok vo väčšine prípadov nemožno, a preto je cieľom hodnotenia aj určenie postupnosti v ich odstraňovaní. Aj to sa robí na základe fyzikálno-chemických a toxikologických vlastností príslušnej látky.

2. Hodnotenie šírenia sa znečistenia

Pri hodnotení šírenia sa znečistenia sa zisťuje aktuálny stav kontaminácie a robí sa predpoveď jeho ďalšieho vývoja. Pri predikcii treba poznať charakteristiku parametrov nesaturovanej a saturovanej zóny. Predpoveď časopriestorového správania sa kontaminantov je nevyhnutná pri posudzovaní rizika ohrozenia podzemných vôd. Odhad šírenia sa znečistenia potom možno získať aplikáciou matematických modelov, ale najmä pri menších lokalitách treba zvážiť ich opodstatnenosť.

3. Hodnotenie rizika

Hodnotenie rizika je komplexný proces umožňujúci kvantitatívne a kvalitatívne zhodnotiť nebezpečnosť rizikových látok vzhľadom na zdravie obyvateľstva (health risk assessment) alebo biotu (ecological risk assessment).

Riziko sa hodnotí v troch krokoch, a to je

1. určenie vzťahu dávka - odpoveď, 2. zhodnotenie expozície a 3. charakterizácia rizika.

Určenie vzťahu dávka - účinok. Východiskom na určenie tohto vzťahu je štúdium dostupných zdrojov informácií o možnom negatívnom vplyve znečisťujúcej látky pri rôznych formách jej výskytu a pri rozličných expozičných cestách. Výsledkom tejto fázy je zistenie základných vplyvov znečisťujúcej látky (toxicita, jej druh, karcinogenita) a určenie základných hodnôt na hodnotenie rizika (Rfd - referenčná dávka, NOAEL - najnižšia hodnota dávky, pri ktorej sa nezaznamenali nepriaznivé účinky, atď.).

Hodnotenie expozície. Je to jedna z najdôležitejších fáz hodnotenia rizika. Zaoberá sa cestou vstupu škodliviny do ľudského organizmu alebo zástupcov živočíšnej a rastlinnej ríše, ako aj odhadom množstva vniknutej látky. Dôležité je zmapovať všetky možné cesty expozície, všetky cieľové skupiny a určiť ich postavenie vo vzťahu k pohybu kontaminantu.

Charakterizácia rizika. Je to záverečná fáza, v ktorej sa využitím získaných údajov hodnotí riziko jednotlivých škodlivín. Výsledok môže byť kvantitatívny (napr. riziko rakoviny pre obyvateľov oblasti z emisií As je $5{,}3.10^{-4}$) alebo kvalitatívny, teda s opisom všetkých rizík vyplývajúcich z výskytu danej škodliviny. Zároveň obsahuje hodnotenie všetkých neistôt, zjednodušení použitých pri riešení a ich možný vplyv na kvalitu výsledku.

Výsledky hodnotenia rizík sú podkladom pre tzv. rizikový manažment (risk management), ktorý na základe tohto hodnotenia a vykonaných analýz (napr. cost-benefit analysis) stanovuje ďalšie kroky (napr. sanácie), ktoré treba urobiť na nápravu situácie, časový postup a podľa možností aj zdroje financovania.

Ak z predchádzajúceho postupu vychodí, že je riziko väčšie ako *prijateľná miera rizika,* treba ako nasledujúci krok odporučiť sanáciu. Odporúčané cieľové parametre sanácie možno odvodiť spätným postupom, keď sa identifikujú prijateľné hodnoty koncentrácie škodlivých látok.

V súvislosti s metodikou určovania sanačných parametrov je užitočné vysvetliť princípy sanácie pôdy v Holandsku, ktoré berú do úvahy nové normy kvality pôdy založené na ekotoxikologických kritériách, ako aj kritériách toxicity vzhľadom na ľudský organizmus. V týchto princípoch sú definované dve základné limitné hodnoty kvality pôdy, a to cieľová a intervenčná hodnota. Cieľová hodnota (target value) je horným limitom pre multifunkcionálnu kvalitu pôdy. Hodnota je odvodená od hodnoty maximálneho tolerovateľného rizika - MTR. Intervenčná hodnota (intervention value) je dolným limitom neakceptovateľnej kvality pôdy. Hodnota I je odvodená od prípustnej dennej dávky (accetable daily intake - ADI).

Podľa najnovších prístupov treba pri určovaní cieľových hodnôt sanácie brať do úvahy budúce využitie sanovaného územia (napr. priemysel, obytná zóna, obchod, poľnohospodárska výroba a pod.), pretože spomenuté normy sa pokladajú za nepružné, lebo neprihliadajú na rozdielnosť napr. vo veľkosti rizikovej časti populácie, čas expozície a pod.

Hodnotenie dnových sedimentov z hľadiska súčasnej legislatívy

M. MUDRÁKOVÁ

Slovensko už niekoľko desaťročí využíva rad vodohospodárskych diel. Za ten čas sa v mnohých prípadoch uložilo toľko dnových sedimentov, že ich treba odťažiť a získaný materiál zneškodniť.

Pred schválením niektorých environmentálnych zákonov sa dnové sedimenty priamo využívali na hnojenie a rekultiváciu pôdy bez ohľadu na jej využívanie.

Podľa zákona č. 238/1991 Zb. o odpade a naň nadväzujúcich vyhlášok a nariadení je materiál usadený prirodzenou cestou pre využívateľa vodohospodárskeho diela, niečím, čoho sa chce zbaviť, teda odpadom. Pri jeho zneškodňovaní treba brať do úvahy zdravé životné podmienky a ochranu životného prostredia a podľa § 5 citovaného zákona, odseku 1, písmena e ho pôvodca musí využívať ako zdroj druhotných surovín.

Firma EnviGeo, s. r. o., Banská Bystrica v posledných rokoch riešila otázky využívania dnových sedimentov 1. vodnej nádrže Bátovce, 2. vodnej nádrže Želovce, 3. vodnej nádrže Môťová, 4. vodnej nádrže Kozmálovce a 5. potoka Podlužianka v Leviciach.

Laboratórnym rozborom sa vo vzorkách dnových sedimentov stanovil a zhodnotil absolútny obsah v rozsahu stanovenom Metodickým pokynom Ministerstva pre správu a privatizáciu národného majetku SR a Slovenskej komisie pre životné prostredie zo dňa 14. 7. 1992 č. 130-1992/I k postupu pri vyhodnocovaní záväzkov podniku z hľadiska ochrany životného prostredia v privatizačnom projekte predkladanom podnikom v rámci II. vlny veľkej privatizácie, ktorého príloha 2 Odporučenia Slovenskej komisie životného prostredia na uplatňovanie ukazovateľov a normatívov pre asanáciu znečistenej zeminy a podzemných vôd (ďalej len Odporučenia ...) zaraďuje zistené znečistenie do troch kategórií, a tým určuje aj spôsob nakladania s týmto materiálom. Vo vodnom výluhu sa zisťovala koncentrácia látok rozhodujúcich z hľadiska zaraďovania hodnoteného materiálu do tried vylúhovateľnosti (príloha 4 nariadenia vlády SR č. 606/92 Zb. Tieto dve zákonné normy hodnotia dnové sedimenty ako odpad, a preto na jeho druhotné využitie nie sú celkom vhodným kritériom.

Na hodnotenie dnových sedimentov ako druhotnej suroviny pokladáme za oveľa vhodnejší pripravovaný Záväzný právny predpis o podmienkach priamej aplikácie kalov z čističiek odpadovej vody a dnových sedimentov, ktorý vychádza z § 4 zákona SNR č. 307/1992 Zb. o ochrane poľnohospodárskeho pôdneho fondu. Metodika priamej aplikácie kálu z komunálnych čističiek odpadovej vody a dnových sedimentov ako neoddeliteľná súčasť Záväzného právneho predpisu ... umožní širšie využitie kalu v nadväznosti na jeho charakter, teda nie iba jeho zatriedenie a zneškodnenie ako odpadu.

Dnové sedimenty sú výrazne heterogénne, čo spôsobuje ich chemické, fyzikálne a mechanické zloženie, ktoré je funkciou geologickej stavby územia a ľudských aktivít v danej oblasti. Obsah makroživín v dnových sedimentoch je veľmi nevyrovnaný. V zmysle Záväzného právneho predpisu ... možno uvažovať o ich abiotickom a biotickom využití.

Na abiotické využitie (budovanie podložia ciest, v tehliarskom a keramickom priemysle, na humusovanie častí cestných telies) sa odporúča aplikovať dnové sedimenty, v ktorých obsah rizikových prvkov neprekračuje celkový maximálny obsah vybraných kontaminantov v dnových sedimentoch vodných tokov, vodných nádrží a rybníkov v $mg.kg^{-1}$.

Biotické využitie dnových sedimentov je priamou aplikáciou dnových sedimentov do pôdy po ročnej depónii na dočasnej skládke na

a) tvorbu novej poľnohospodárskej pôdy,

b) rekultiváciu skládok priemyselného a energetického odpadu a pevného komunálneho odpadu,

c) rekultiváciu vysoko kontaminovanej až devastovanej poľnohospodárskej pôdy,

d) zúrodňovanie defektnej poľnohospodárskej pôdy,

e) výrobu antropickej zeminy.

Vyzretý dnový sediment sa aplikuje podľa spracovaného projektu a ďalších administratívnych a kontrolných opatrení.

1. Podľa analýz sušiny a výluhu z dnových sedimentov, a posudzovania využiteľnosti pokladáme za postačujúce hodnotiť výsledky chemických analýz sušiny.

2. Hodnotenie dnových sedimentov ako odpadu podľa prílohy 2 Metodického pokynu Ministerstva pre správu a privatizáciu národného majetku SR a Slovenskej komisie pre životné prostredie zo dňa 14. 7. 1992 č. 130-1992/I, ako aj ich výluhov podľa Nariadenia vlády č. 606/92 považujeme skôr za informatívne, pretože v mnohých prípadoch nelogické a zneškodňovanie neekonomické. Záväzný právny predpis o podmienkach priamej aplikácie kalov ČOV a dnových sedimentov k § 4 zákona SNR č. 307/1992 Zb. odporúčame čím skôr schváliť, pretože umožňuje oveľa širšie praktické využitie dnových sedimentov a kalu z čističiek odpadovej vody, čo má aj ekonomický efekt.

Kontaminácia abiotických zložiek životného prostredia v areáli Rudných baní Vajsková a spôsob jej sanácie

A. ILKANIČ

Areál bývalých Kovohút Vajsková, resp. zariadenie v ňom, sa viac ako 100 rokov využívalo na výrobu kovov, najmä Sb, z privezených koncentrátov a rudy. Nakladanie s odpadom vznikajúcim pri spracúvaní rudy, manipulácia so vstupnými reagenciami a s finálnymi výrobkami zodpovedala stupňu technickej vyspelosti a technologickej disciplíny. S materiálmi a s odpadom sa nakladalo spôsobom neprijateľným z hľadiska požiadaviek dnešnej legislatívy a zistená kvalita abiotickej zložky životného prostredia je toho priamym dôsledkom.

Tab. 1

Obsah Sb	Maximálna zistená hodnota	Násobok limitu kategórie C*
Horninové prostredie	102 000 mg/kg	1020 x
Podzemná voda	23,03 mg/l	115 x
Povrchová voda	14,17 mg/l	71 x

*Kontaminácia prekračujúca limit kategórie C predstavuje úroveň znečistenia, pri ktorej v zmysle Odporučenia ... treba prikročiť k sanačným prácam.

Prevádzka huty bola po prechode do vlastníctva Rudných baní Banská Bystrica roku 1992 zastavená.

Prieskumnými prácami sa v horninovom prostredí identifikovala anomálna koncentrácia najmä Sb, As, sulfidickej S, v menšej miere Cu a lokálne aj nepolárnych extrahovateľných látok.

Hodnotením kontaminácie horninového prostredia a podzemnej vody podľa Odporučenia Slovenskej komisie pre životné prostredie k uplatňovaniu ukazovateľov a normatív pre asanáciu znečistenej zeminy a podzemných vôd č. 130-1992/I sa zistila mimoriadne vysoká koncentrácia As, Sb, Mo, resp. NH_4 v podzemnej a povrchovej vode, v horninovom prostredí a v pôde.

Práce na zistenie stupňa znečistenia pokryli celkovú plochu 400 640 m^2, z čoho bola plocha skládky 12 982 m^2. Znečistenie horninového prostredia sa zistilo v kategórii B na 8 % plochy Sb (10 % As) a v kategórii C na 85 % Sb (23 % As), pritom 16 % plochy je znečistených Sb viac ako 10-násobným prekročením limitu kategórie C.

Zdrojom kontaminácie podzemnej vody je najmä materiál haldy, ale identifikovali sa aj iné zdroje v areáli závodu. Významným zdrojom kontaminácie bol aj prašný spád, ovplyvňujúci kvalitu pôdy v širšom okolí závodu.

Areál závodu (horninové prostredie, pôda, halda, objekty, kontaminovaná podzemná a povrchová voda) predstavuje priame toxikologické nebezpečenstvo.

Prieskumnými prácami (júl 1996) v areáli závodu a v jeho okolí sa podrobne zistil plošný a hĺbkový rozsah znečistenia zeminy, rozsah znečistenia podzemnej a povrchovej vody, pôdy rastlín, riečnych sedimentov a kvality stavebného materiálu objektov. Využitím takto získaných poznatkov bolo možno podrobne identifikovať zdroje znečistenia a vypracovať návrh opatrení na zabezpečenie areálu.

Návrh zabezpečenia areálu zahŕňa:

- zabezpečenie jestvujúcej haldy proti prieniku zrážkovej vody (prekrytie nepriepustnou ílovou vrstvou)
- vybudovanie povrchovej drenáže umožňujúcej odvádzanie povrchovej vody mimo telesa haldy do Vajskovského potoka
- zabezpečenie ochrany telesa haldy proti prieniku podzemnej vody (vybudovanie odvodňovacieho prvku - odvodňovacej štôlne)
- vybudovanie podzemnej drenáže na odvedenie zvyškovej vody, ktorá zostane v telese, príp. prenikne do telesa haldy aj po jeho izolovaní - výtok takejto vody sa v prípade kontaminácie musí čistiť
- vybudovanie tesniacej steny zabraňujúcej prieniku vody potoka do telesa haldy
- odstránenie zeminy a antropogénnych uložením z plochy, kde zistená koncentrácia jedného zo sledovaných kontaminantov prekračuje hodnotu stanovenú legislatívne (na trvalé uloženie časti takto vzniknutého materiálu možno využiť haldu)
- priestor vzniknutý po odstránení kontaminovanej zeminy a antropogénnych navážok nahradiť neznečisteným materiálom a zabezpečiť minimálnu infiltráciu zrážkovej vody do tohto priestoru (inštalácia ílového tesnenia, rekonštrukcia vnútrozávodnej kanalizácie)

sledovať spôsob opráv, úprav a demolácie objektov, spôsob depónie tohto materiálu a jeho trvalé zneškodnenie

pokračovať v monitoringu kvality podzemnej a povrchovej vody v pozorovacích objektoch.

Halda priemyselného odpadu železiarní Podbrezová - príklad komplexného riešenia environmentálneho problému

P. TUPÝ

Novodobá tradícia vo výrobe železa pod vrchom Brezová pri Hrone (dnešná Podbrezová) siaha až do roku 1840. Okrem neodškriepiteľného ekonomického prínosu, ktorý pre túto oblasť znamenala prevádzka železiarní v minulosti a značí aj dnes, nemožno prehliadnuť ostatné, nie vždy priaznivé a želateľné vplyvy. Jedným z nich je produkcia odpadu a potreba zneškodňovať ho v súlade s platnou legislatívou. Táto úloha sa najmä v posledných rokoch dostala do pozornosti aj neodbornej verejnosti. Ekonomické nástroje využívané pri zneškodňovaní odpadu podobne ako investičná náročnosť novobudovaných zariadení na jeho zneškodňovanie (skládky, spaľovne, recyklačné zariadenia) sa premietajú do ceny výrobkov a služieb a pociťuje ich každý občan. Odpad, ktorý platná legislatíva často označuje ako nebezpečný, je vážnym ekonomickým a environmentálnym problémom manažmentu dnešných firiem aj štátnej správy.

Činnosť firiem orientovaná na oblasť odpadového hospodárstva by sa mala zamerať na:

- identifikáciu, kvantifikáciu a sledovanie vplyvov zariadení (skládok) na zložky životného prostredia
- hodnotenie únosnosti prípadného negatívneho vplyvu na zložky životného prostredia (hodnotenie zdravotného, environmentálneho rizika)
- návrh a realizáciu opatrení na zníženie, resp. odstránenie negatívneho vplyvu na environmentálne prijateľnú mieru vo väzbe na ekonomické a technické možnosti (riadenie rizika, technicko-ekonomická štúdia sanácie poškodeného prostredia)

Návod na opatrenia vo výrobe a v nakladaní s odpadom, ktorý by minimalizoval produkciu energeticky, resp. materiálovo nevyužiteľného odpadu, zahŕňa:

- sledovanie, kontrolu realizácie navrhnutých opatrení a aplikáciu nových poznatkov vo výrobe a toku materiálov a energie vyúsťujúcich do environmentálne prijateľnejšej výroby (recyklácia materiálov, energetické a materiálové zhodnotenie odpadu, znižovanie spotreby energie, minimalizácia tvorby odpadu, znižovanie negatívneho vplyvu výroby na životné a pracovné prostredie).

Služby poskytované firmou EnviGeo, s. r. o., Banská Bystrica Železiarňam Podbrezová, a. s., by mohli byť príkladom úsilia o systematickú a komplexnú spoluprácu výrobnej spoločnosti a environmentálne orientovanej firmy.

Príkladom na takúto spoluprácu sú úlohy zamerané na:

1. hodnotenie a monitorovanie vplyvu skládky odpadu Železiarní Podbrezová, a. s., na zložky životného prostredia,
2. hodnotenie využiteľnosti odpadu produkovaného v minulosti a v súčasnosti z pohľadu technologickej vhodnosti a environmentálnej akceptovateľnosti jednotlivých spôsobov využitia,
3. technické a projekčné služby pri zneškodňovaní nevyužiteľného odpadu vznikajúceho pri súčasnej výrobe,
4. technické a projekčné služby pri ťažbe, prepracúvaní, opätovnom zhodnocovaní, resp. opätovnom skládkovaní v minulosti vzniknutého odpadu (oceliarenská troska), uzatváraní a pri rekultivácii skládky.

V súvislosti s prvou úlohou sa vyhĺbilo päť monitorovacích vrtov, takže dnes sú údaje o takmer 5-ročnom sledovaní kvality podzemnej vody. Odber a kvalita vo vybraných ukazovateľoch sa hodnotí štvrťročne a celkové výsledky na konci roka.

Spomenutými prácami sa monitoruje kvalita podzemnej vody v najkritickejších (najznečistenejších) častiach skládky. Po skončení skládkovania, uzavretí skládky a skončení rekultivačných prác sa budú vybrané objekty ďalej sledovať. Vplyv doterajšej činnosti na ostatné zložky životného prostredia (biotickú, ovzdušie, horninové prostredie, pôdu, obyvateľstvo) zhodnotila environmentálna štúdia, ktorou sa skúmal vplyv na Železiarne Podbrezová pri ďalšom prevádzkovaní skládky a súčasnom prepracúvaní a hodnotení na nej uloženého materiálu.

Druhou zo spomenutých úloh je hodnotenie využiteľnosti veľkoobjemového odpadu, ktorý produkujú Železiarne Podbrezová. Ide o 30 000 $t.rok^{-1}$ oceliarenskej trosky. Ekonomický efekt spätý s minimálnou, t. j. nijakou produkciou odpadu tohto druhu, s tým súvisiacim šetrením poplatkov za uloženie na skládke, resp. príjem z možného predaja trosky ako umelého kameniva je evidentný. Ak sa k tomuприráta aj zisk z metalického Fe získaného z podrvenej trosky viacstupňovou magnetickou separáciou, je takéto riešenie ešte ekonomickejšie.

Ale do úvahy treba vziať aj aspekty, ktoré realizáciu zámeru komplikujú. Okrem technických ťažkostí súvisiacich s mechanickým prepracúvaním (drvením) húževnatého materiálu, ako aj s účinnosťou viacstupňovej magnetickej separácie sa objavujú:

- Ťažkosti pri stanovovaní technologickej vhodnosti už podrveného materiálu (na hodnotenie tohto druhu kameniva nie je technická norma).
- Problémy pri hodnotení možného environmentálneho vplyvu výrobku - kameniva na zložky životného prostredia (niet "predpisu", ktorý by stanovoval metodiku skúšania, prípustné limity, resp. od toho sa odvíjajúce spôsoby využitia). Kritériá legislatívy platnej v odpadovom hospodárstve, t. j. nariadenie vlády SR č. 606/92 Zb., nie sú vhodné.
- Ťažkosti psychologického rázu, čiže nedôvera potenciálnych spotrebiteľov, zákazníkov a povoľujúcich orgánov štátnej správy k novému, doteraz neoverenému druhu materiálu. Nedôvera sa najmä pri absencii dvoch spomenutých normatívov bude prekonávať veľmi ťažko.

Služby poskytované pri riešení tretieho a štvrtého okruhu úloh vychádzajú z našich doterajších skúseností z projekčného aj technického zabezpečovania odťažovania, technickej a biologickej rekultizácie skládok priemyselného a komunálneho odpadu (Sereď, Žiar nad Hronom, Levice, Vajsková) a zo skúseností z projektovania nových skládok komunálneho odpadu (Kalná nad Hronom, Dolný Kubín, Banská Bystrica). Bohaté skúsenosti získané pri riešení týchto úloh sú zárukou technicky, environmentálne a ekonomicky optimálnych riešení.

Stavba a vývoj hercynýd (Seminár, Bratislava, 11. 3. 1997)

Stavba hercýnskeho orogénu Západných Karpát

V. BEZÁK

Doterajšie členenia stavby kryštalinika boli postavené buď iba na litologicko-stratigrafickom princípe bez prihliadnutia na tektonické vzťahy (Hovorka et al., 1993), alebo ich príliš ovplyvnilo alpínske tektonické prepracovanie kryštalinika (Putiš, 1992; Vozárová a Vozár, 1992). Náznaky hercýnskeho litotektonického prístupu má klasifikácia Putiša (1992), avšak dotýka sa len časti kryštalinika.

Základné princípy rekonštrukcie hercýnskej tektonickej stavby v Západných Karpatoch, ktoré navrhujeme, sú:

1. Odfiltrovanie účinkov alpínskej tektoniky (najmä skrátenia) a rekonštrukcia predalpínskej pozície komplexov kryštalického fundamentu.
2. Rekonštrukcia pozície komplexov kryštalického fundamentu na profiloch.
3. Korelácia štruktúrno-metamorfného vývoja jednotlivých komplexov.
4. Kombinácia obidvoch predchádzajúcich kritérií (t. j. pozície a štruktúrno-metamorfného charakteru), ktoré umožnil vyčleniť väčšie tektonické celky (hlavné hercýnske litotektonické jednotky).
5. Verifikácia základných jednotiek vo výstupoch fundamentu.
6. S pomocou dostupných geochronologických údajov rekonštrukcia vývoja štruktúry hercýnskeho orogénu, jeho polarity ap.

Na základe týchto kritérií sme v kryštaliniku Západných Karpát vyčlenili nasledujúce hlavné hercýnske litotektonické jednotky:

- epizonálne komplexy vo vrchnej tektonickej pozícii,
- vrchná litotektonická jednotka,
- stredná litotektonická jednotka,
- spodná litotektonická jednotka.

Zdokumentovali sa priestorové vzťahy týchto jednotiek a ich tektonometamorfný vývoj v jednotlivých štádiách hercýnskej orogenézy.

Hercýnske syntektonické až posttektonické granitoidy možno v závislosti od geotektonických podmienok ich vzniku rozdeliť do niekoľkých skupín.

Osobitné postavenie majú paleozoické komplexy vystupujúce v gemeriku. Ich paleotektonická pozícia je otázkou, ktorá čaká na riešenie podobne ako problém predpokladaného kadómskeho fundamentu na J od hercýnskych jednotiek Západných Karpát.

Ortoruly Nízkych Tatier a severného veporika - staronové pohľady

I. PETRÍK

Tri geneticky a vekovo odlišné horninové typy z Nízkych Tatier a severnej časti veporika, a to "oftalmity" Nízkych Tatier a ľubietovského pásma, granit hrončockého typu a porfyroidy ľubietovského pásma, majú spoločné to, že ich možno označiť ako ortoruly.

1. Pravdepodobne predvariské "oftalmity" považujeme za duktilné deformované veľkozrnné porfyrické granodiority s mineralogickými a geochemickými črtami typu S. Distribúcia Ba v megakrystoch K živca má zvonovitý tvar a interpretuje sa ako výsledok frakčnej kryštalizácie in situ. Ľubietovské ortoruly sú analogické horniny, avšak výrazne alpínsky diaftorizované.

2. Permský granit hrončockého typu, ktorý má geochemické znaky typu A, bol do podoby ortoruly deformovaný. Túto duktilnú deformáciu pokladáme za synintruzívnu. O dynamickom prostredí v strižnej zóne svedčia granitické mikrobrekcie tmelené aplitickou hmotou ("leptity"). V lokalizovaných zónach bol granit hrončockého typu intenzívne alpínsky mylonitizovaný. Výskyt grossulárových granátov, fengitov a rozsiahlej saussuritizácie svedčí o ponorení do značnej hĺbky (ca 800 MPa).

3. Porfyroidy ľubietovského pásma, pre ktoré je typický hojný porfyrický magmaticky korodovaný kremeň, boli intenzívne deformované a mylonitizované. Prítomnosťou mikrobrekcií a typológiou zirkónu (Broska et al., 1993) pripomínajú granit hrončockého typu, čo podporuje názor o ich permskom veku.

Postorogénne peraluminózne dvojsľudné granity a granitové porfýry klenoveckého typu v kohútskej zóne veporika

Ľ. HRAŠKO, V. BEZÁK a B. MOLÁK

V priestore rúl klenoveckého komplexu sa identifikovali pne dvojsľudného peraluminózneho granitu a granitového porfýru s granátom. Geochemicky a štruktúrnou pozíciou majú charakter postorogénneho granitu. Od granitoidov veporika (okrem granitu hrončockého typu) sa odlišujú zvýšeným obsahom K (3,06 - 5,4 %), Rb (194 - 228 ppm), B (11 - 224 ppm), Y (17 - 40 ppm), U (5,4 - 12,7 ppm), Be (2 - 10 ppm), Sn (8 - 15 ppm), W (3 - 83 ppm), F (do 0,17 %), nízkym obsahom CaO (priemerne 0,9 %), Sr (30 - 160 ppm, priemerne 54 ppm) a Ba (126 - 232 ppm) a vysokým pomerom Rb/Sr (3,7 - 6,5). Charakteristická pre ne je prítomnosť železitého biotitu (horečnatosť 0,206 - 0,274) a zmiešanej zirkónovej populácie typu A a S. Vodou nedosýtená tavenina granitu sa pravdepodobne derivovala nízkostupňovým tavením tonalitických ortorúl, čo bolo podporené modelovaním dávkového tavenia tonalitovej ortoruly z hybridného komplexu. Zvýšenie obsahu vody v magme spôsobila hlavne frakčná kryštalizácia K živca. Magma granitu vystúpila do vyšších úrovní prostredníctvom hlboko založených zlomov alebo strižných systémov. Granity a granitové porfýry klenoveckého typu sa najväčšmi podobajú granitoidom gemerika, pričom je častá turmalinizácia. Granity sa na základe geochemickej príbuznosti s permskými granitoidmi Západných Karpát pokladajú za permské.

Granitoidné horniny Žiaru - geochemické a petrotektonické implikácie

M. KOHÚT a O. MIKO

Pohorie Žiar vo forme priečneho hrastu smeru SZ - JV oddeľuje Hornonitriansku kotlinu od Turčianskej. Budujú ho prevažne horniny kryštalinika s prevládajúcimi granitoidmi viacerých typov. Výskyt jednotlivých variet hornín kryštalinika podmienilo rozsegmentovanie hrastu Žiaru na niekoľko blokov, ktorých pozícia vzhľadom na výzdvihové, resp. poklesové pohyby nie je rovnaká. V súčasnosti tu po výraznej denudácii vystupujú na povrch rôzne etáže granitoidného masívu aj so zvyškami jeho metamorfného obalu. Metamorfované horniny sa vyskytujú len v najjužnejšom bloku na SV od Ráztočna, resp. na Z od Skleného.

Magmatické až granitoidné horniny variského veku reprezentujú:
- hybridné biotitické granodiority až tonality,
- granity až granodiority, dvojsľudné, často porfyrické, tzv. žiarskeho typu,
- hrubozrnné granity až granodiority, miestami nevýrazne porfyrické,
- pegmatity a aplity,
- biotiticko-amfibolické kremité diority.

Geochemicky patria granitoidné horniny žiarskeho masívu medzi plutonické peraluminózne horniny strednodraselnej až vysokodraselnej vápenato-alkalickej granodioriticko-monzonitickej série (ASI = 1,0 ~ 1,6; Peacockov index celej série hornín je 58,5). Obsah SiO_2 s výnimkou dioritov varíruje od 62,5 po 78,3 hm. %. Pomer Na_2O versus K_2O v granitoch - granodioritoch je vyrovnaný a hodnota pomeru Rb/Sr 0,2 - 1,15 poukazuje na relatívnu diferencovanosť týchto granitoidov. Normalizované záznamy REE vykazujú vyrovnaný trend distribúcie s nevýraznou zápornou Eu anomáliou pri všetkých typoch granitoidov. $e_{Nd}(0)$ = -6,6 spolu s neodýmovým kôrovým indexom NCI = 0,75 poukazuje na výraznejšie uplatnenie sa kôrového zdroja pri tavení týchto granitoidov. Zdanlivo neodýmovo kôrovorezidenčný vek týchto granitov je v súlade s tvorbou kôry v Európe $t_{(DM)}$ = 1247 Ma, resp. t(DM2St) = 1347 Ma. V zmysle klasickej typológie I/S patria medzi granitoidy typu S. Podľa geotektonickej klasifikácie ich možno zaradiť medzi neskoro kolízne granitoidy so zdedeným geochemickým charakterom VAG, resp. CAG. Hercýnsky vek granitoidov Žiaru dokladá datovanie muskovitu Ar/Ar metódou t = 338,1 +- 1,7 Ma (Kráľ a Štarková, 1995), ktoré je identické ako obdobné datovanie z Veľkej Fatry.

Alpínske rozsegmentovanie plutónu a jeho exhumácia (pred 52 - 46 Ma, Kováč et al., 1994) spôsobili, že plutón extrémne erodoval, pričom sa v centrálnej časti obnažili až hrubozrnné porfyrické granitoidy. Tento typ granitoidov predstavuje v hypotetickom reze hercýnskych masívov jadrových pohorí Západných Karpát spodnú etáž. V porovnaní s inými jadrovými pohoriami (Tatry, Veľká Fatra) sa tu oderodovalo cca 2 - 2,3 km granitoidného plutónu, pričom viac ako 1 km masívu erodovalo od vrchnej kriedy po miocén pri pomalom výzdvihu 0,5 - 0,01 mm/rok.

Hlavné výsledky štruktúrneho výskumu hercýnskeho orogénu v tatroveporiku v II. etape projektu Geodynamický vývoj Západných Karpát

J. MADARÁS, M. PUTIŠ, J. HÓK, P. SIMAN, O. LEXA, V. BEZÁK a M. KOVÁČIK

Štruktúrny výskum hercýnskeho orogénu sa v rokoch 1994 - 1996 zameral na kryštalinikum veporika v Stolických a Veporských vrchoch a tatrika v ďumbierskych Nízkych Tatrách. Po odfiltrovaní účinkov alpínskeho orogénu vo veporiku sa relikty predalpínskej stavby preukázali vo vysokometamorfovaných komplexoch (v rulách, migmatitoch, ortorulách), ktoré možno interpretovať ako intrudované - plášťové horniny granitoidných masívov.

Horniny hybridnej zóny v jv. časti kohútskej zóny predstavujú úzky pás vynárajúci sa spod hlavných más hercýnskych granitoidov veporika. Hercýnsky tektonometamorfný vývoj prebiehal vo vysokostupňových metamorfných podmienkach s častými znakmi migmatitizácie a s neskoršími lokálnymi retrográdnymi zmenami súvisiacimi s umiestňovaním granitoidov v extenznom režime. V kompresnej fáze je evidentné silné preteplenie späté s tavením a plastickou deformáciou s násunmi generálne jv. smeru.

V sz. časti veporika (oblasť Čierneho Baloga, Pohronskej Polhory a Beňuša) sa študoval horninovo pestrý čiernobalocký komplex a novo definovaný komplex Veľkého Zeleného potoka. Reliktne zachovaná hercýnska magmatická foliácia má smer SV - JZ až VSV - ZJZ a strmý až stredný sklon na SZ a ZSZ. Minerálna lineácia smeru SZ - JV, podobne ako orientácia intrafoliačných vrások a duktilných strižných zón, poukazuje na predalpínsku (hercýnsku) kinematiku v smere SZ - JV s násunmi na J, resp. JV. Štúdium kryštalografickej prednostnej orientácie osí C kremeňa a plagioklasu preukázalo uplatnenie sa režimu jednoduchého strihu pri teplote 300 až 500 °C, ako aj čistého strihu vo vyššieteplotných podmienkach (nad 500 °C) podobne ako duktilná deformácia plagioklasu na strednokôrovú reológiu (teplota nad 500 °C). V prípade komplexu Veľkého Zeleného potoka (hlavne páskovaných metadioritov a gabrodioritov hercýnskeho veku) sa však naložená deformácia môže vzťahovať na strednokôrovú alpínsku vysokoteplotnú metamorfózu a deformáciu.

Poslednou študovanou oblasťou bolo tatrické kryštalinikum na južných svahoch ďumbierskych Nízkych Tatier. Komplexy kryštalických bridlíc, väčšinou migmatitizovaných do rôzneho stupňa, tvoria plášť granitoidov. Vysokoteplotná regionálna metamorfóza postihla komplexy kryštalických bridlíc skôr, ako sa penetrovali intrúziou ďumbierskych a prašivských granitoidov. Efekt granitoidnej intrúzie spôsobil mladšiu - naloženú termickú metamorfózu najmä v zóne bezprostredne priliehajúcej ku granitom. Retrográdna metamorfóza bola na tieto dva procesy naložená v záverečných fázach. Dnešný tektonický obraz južných svahov ďumbierskych Nízkych Tatier je najmä výsledkom uplatnenia sa alpínskych tektonických procesov. Staršie stavebné prvky (predhercýnske?, hercýnske) sa bez zvyšku včlenili do alpínskeho štruktúrneho plánu, ale zachovali sa v podobe reliktných blokov "plávajúcich" v alpínskych štruktúrnych zónach.

Na základe mezoštruktúrnych a mikroštruktúrnych meraní orientácie planárnych a lineárnych štruktúrnych prvkov, orientácie intrafoliačných vrások, ako aj orientácie duktilne deformovaných porfyroblastov živca predpokladáme zmysel tektonického transportu (hercýnskeho násunu) v plastických podmienkach v smere od SZ na JV.

Vek chladnutia v kryštaliniku Západných Karpát

J. KRÁĽ

Najnovšie geochronologické údaje (hlavne Ar/Ar, Rb/Sr a Pb/Pb zo sľudy, živca, amfibolu a zirkónu) z kryštalinika tatrika umožňujú lepšie precizovať nielen vek intrúzií granitoidných hornín a metamorfného obalu, ale aj ich tektonického vývoja spätého s kolíznym a extenzným vývojom v rozličných etapách hercýnskeho orogénu, ktorý spôsobil výzdvih hornín a potom chladnutie. Pokiaľ sa schladnutie tatrického kryštalinika na izotermu cca 300 oC odhadlo na 302 Ma (z klasických K/Ar údajov a s chybou vyše 10 %), datovanie zo sľudy hlavne z pohorí, z ktorých geochronologické údaje neboli donedávna k dispozícii (Strážovské vrchy, Veľká Fatra, Žiar), vychodí že v kryštaliniku tatrika možno vyčleniť aspoň dve domény s rozdielnym vekom chladnutia na izotermách 350 - 300 oC (muskovit, biotit).

Geofyzikálna interpretácia hlbinnej stavby východnej časti Západných Karpát

J. ŠEFARA, M. BIELIK, V. BEZÁK a P. KUBEŠ

Prednáška predstavila prvý variant riešenia hlbinnej stavby litosférického dosahu na profile C (Tisa a Przemysl) ako výsledok komplexného modelovania dostupných údajov zo seizmiky, seizmológie a MTS doplnený o hustotné modelovanie s princípom izostatickej rovnováhy a modelovaním hlbinných magnetických hmôt. Výsledky poukázali na možnosť viacfázovej kolízie. Subdukcia sa kombinovala s mechanizmom horizontálnych posunov. Výrazným javom v podloží transkarpatskej panvy je jej na povrchu ťažké magnetické podložie s pravdepodobným geologickým výkladom vo forme zvyškov oceánskej kôry alebo s relatívnym odkrytím ťažších hmôt pri extenzii.

Geológia južného Nórska

M. KOHÚT a V. BEZÁK

V júni 1996 zorganizovala Európska sieť granitoidných pracovísk (European Network of Laboratories "Granites") pod vedením profesora Bonina z Paríža pracovné terénne stretnutie v južnej časti Nórska. Transekt od Stavangera po Oslo, paralelný s pobrežím, poskytol možnosť študovať granitoidné, sprievodné - asociačné (anortosity), ako aj metamorfované horniny baltického štítu a oslovského riftu.

Sledované územie tvorí časť jz. škandidávskej domény baltického štítu, v rámci ktorej sú doložené dve orogénne udalosti (1,74 - 1,5 Ga, 1,25 - 0,9 Ga). Celkovo možno pozorovať mladnutie štruktúr západným smerom. Najstaršia izochróna v južnom Nórsku a U/Pb veky dávajú 1,5 - 1,6 Ga. V závere orogenézy sa umiestňoval značný počet posttektonických granitových plutónov datovaných okolo 850 - 1000 Ma.

V oblasti Moi sa študovali horniny sjelsetského magmatického komplexu - biotitické porfyrické granity spolu s pyroxenicko-fayalitickými charnockitmi, ako aj rogalandské anortosity a osumilitické migmatity z metamorfného plášťa. Na lokalite Storeknuten sa analyzovali aspekty vzniku bjerkreimsko-sokndalskej zvrsvenej magmatickej intrúzie, ktorú tvoria gabronoritické a "leukotroktolitické" horniny. Syntektonické a posttektonické prekambrické granitoidy (920 - 990 Ma) sektora Bamble na základe izotopických charakteristík (Sr, Nd +- Pb) dokumentujú výrazne kôrový charakter s príspevkom plášťovej magmy.

Osloský graben je charakteristický intenzívnou magmatickou a vulkanickou aktivitou od protoriftového (315 - 300 Ma) až po hlavný rift (295 - 275 Ma). Z magmatických hornín tejto oblasti sú najznámejšie hrubozrnné larvikity (syenity) označované aj ako "čierny labradorit", príp. lardality (nefelinické syenity) využívané ako dekoračný kameň. Zaujímavosťou dramenského batolitu sú permské ružové hrubozrnné granity s rapakivickou textúrou, ktoré sú o miliardu rokov mladšie ako známe wiborgity z Fínska.

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Ekológia halofytnej vegetácie

M. KOVÁČOVÁ:

Halofyty sú ekologicky jednou z najstarších skupín rastlinstva odkázaných na substráty presýtené soľami. Neviažu sa iba na istý druh soli, ale na vysoký obsah akejkoľvek soli. Neprezrádzajú nič o chemizme substrátu, iba dokazujú jeho znehodnotenie bez ohľadu na chemizmus, a preto sú v praxi dobre využiteľné ako všeobecný indikátor agresivity pôdnej vody, príp. minerálnej vody s vyššou mineralizáciou.

Slanomilná vegetácia obsahuje dva základné typy substrátov. Prvým typom sú pravé slaniská. Sú zriedkavé a viažu sa na zníženiny reliéfu v neveľkých oblastiach ílovito-slienitých hornín a zemín bohatých na sírany. Platí to však o vyslovene slaných typoch pôdy so zreteľne vyvinutou halofytnou vegetáciou. Druhým typom sú len mierne slané pôdy, neviažu sa na substrát s vysokým obsahom síranov, sú iba slabo indikované halofytnou vegetáciou, avšak signalizujú výskyt agresívnej vody.

Najčastejšie sa vyskytujú fakultatívne halofyty a vegetácia, ktorá akcesoricky sprevádza slané a rumoviskové miesta.

Sama slanobytná vegetácia sa rozdeľuje na dva typy. Sú to obligátne halofyty, vzťahujúce sa na miesta pravých slanísk (*Salicornia herbaceae*), a fakultatívne halofyty, ktoré sa vyskytujú na miestach s mierne slanou pôdou a na rumoviskách (*Chenopodium album*).

Zástupcovia halofytnej vegetácie (*Chenopodiaceae*) sú bežné aj v palynospektrách z neogénnych sedimentov. Pozoruhodný je ich veľmi hojný výskyt v sedimentoch s vekom určeným ako panón A v západnej časti slovenského úseku viedenskej panvy, čo svedčí o prítomnosti salinných výbežkov pozdĺž morského pobrežia. V súčinnosti s postupujúcou regresiou mora sa postupne transformovali na slané bažiny a šírili v smere regresie. Obdobný horizont je známy z dvoch vrtov v západnom Maďarsku (vrchný panón s. l.) a interpretuje sa ako sladkovodná fácia s akumuláciou *Chenopodiaceae*. Takáto akumulácia lokálne indikuje vznik slaných bažín sledujúcich postupujúcu regresiu mora. Podobný mimoriadny výskyt sa zistil v spodnom miocéne (egenburg) karpatskej predhlbne (Čejkovice).

NH_4 illity v karpatskej sústave

P. UHLÍK:

Touto a ďalšími prácami sa chceme zaoberať NH_4 illitmi nielen ako mineralogickou raritou, ale aj ako možným indikátorom geologických procesov.

Blízko Banskej Štiavnice na lokalite Červená studňa sme pomocou rtg. difrakčnej analýzy, chemickej analýzy a IČ spektrometrie identifikovali rektorit (illit/smektit s 50 % illitových a 50 % smektitových vrstiev). Illitové medzivrstvia v ňom obsahujú 11 % NH_4, 37 % Na a 52 % K, čo je nateraz jediný nález minerálu tohto druhu vo svete. Väčšinou obsahujú iba K alebo Na.

Po tomto zistení sa počet lokalít s amónnym illitom alebo illitom smektitom v karpatskej sústave zvýšil na štyri. Ich forma vzniku je jasná. Tri z nich sa viažu na hydrotermálne alterované oblasti neovulkanitov, a to Kapka (Vihorlat), Hargita (Rumunsko) a Červená studňa (Štiavnické vrchy) a štvrtým miestom výskytu je Veľká Tŕňa v zemplíniku NH_4 illit sa tu nachádza v karbónskych čiernych bridliciach v asociácii s čiernym uhlím a vznikol v podmienkach anchimetamorfózy. Zdroj NH_4^+ v tejto oblasti sa zdá byť jednoznačný. Je ním čierne uhlie, z ktorého sa pri prechode do antracitového typu (T = 200 - 270 oC) uvoľňuje NH_4^+. Problematický je zdroj NH_4^+ v neovulkanitoch. Prítomnosť NH_4 illitov v neovulkanitoch môže signalizovať existenciu karbónskych alebo iných bituminóznych bridlíc v podloží obsahujúcich NH_4 silikáty, z ktorých sa NH_4^+ uvoľňuje pri teplote 500 - 700 oC. Iným zdrojom môže byť organická hmota, z ktorej sa NH_4^+ uvoľňuje pôsobením hydrotermálnych fluid. Ďalším teoretickým zdrojom sú soľné diapíry, z ktorých unikajú fluidá obsahujúce N_2.

Problém zdroja NH_4^+ by vyriešilo stanovenie stabilných izotopov N_2 v silikátoch, avšak touto metodikou sa doteraz nik nezaoberal. Vyriešenie tohto problému by pomohlo pri hľadaní odpovede na otázku, či prítomnosť NH_4 illitov v karpatskej sústave viac či menej spolu súvisí.

Databáza zlomov Západných Karpát na území Slovenska

J. OROSZLÁNY a P. SOBOTKOVÁ:

V súčasnosti sú technológie geoinformačných systémov stále rozšírenejšou a rozvíjajúcou sa oblasťou, s ktorou sa možno stretnúť aj pri každodennej práci. Metódy geoinformačných systémov sa dajú široko využiť pri riešení rozličných úloh aj v geológii a jej aplikácii.

Geoinformačné systémy sa vo veľkej miere zužitkúvajú pri zbere, spracúvaní, analýze a prezentácii údajov napríklad vo forme analytických a syntetických máp alebo slúžia ako vstupné údaje na ďalšie spracovanie inými metódami (napr. modelovaním). Ich štruktúra umožňuje prepojenie grafických údajov vektorového alebo rastrového charakteru so znakovými údajmi, čím možno získať komplexný údajový model, ktorý v digitálnej podobe odráža záujmové územie z hľadiska sledovaných charakteristík. Možnosti, ktoré spomenuté systémy ponúkajú, sme aplikovali pri spracúvaní zlomových porúch na území Slovenska.

Doteraz sa zlomové poruchy spracúvali archivovaním údajov vo forme správ, geologických a tektonických máp ako podkladu pri navrhovaní štruktúry databázy zlomov na území Slovenska. Príspevok približuje metodiku spracúvania údajov o zlomových poruchách, rozdelenie údajov do textovej a grafickej časti a ich vzájomné prepojenie. Využilo sa na to pracovné prostredie programu Topol a MapInfo.

Vytvorená komplexná databáza zlomov je uceleným súborom údajov o zlomových poruchách, ktorý poskytuje komplexný obraz o zlomovej tektonike Slovenska. Využitie databázy spočíva v archivácii, aktualizácii a ďalšom spracúvaní alebo pri tvorbe analytických a syntetických máp. Takto spracovaná komplexná databáza zlomov by sa mala všestranne využívať v geologickej praxi.

Vrchnobádenské Ostracoda z okolia Sekúľ

R. PIPÍK:

Ostracoda sú skupinou kôrovcov s mäkkým telom ukrytým v dvojlastúrkovej schránke. Dokážu obývať takmer každé vodné prostredie a na úrovni rodu sú ich ekologické požiadavky nemenné, čo možno veľmi výhodne využiť pri paleoekologickom výskume. A keďže sa rýchlo menia v čase, sú vhodné aj na biostratigrafiu sedimentov. Obidve spomenuté vlastnosti ich predurčujú aj na paleogeografické rekonštrukcie.

Prednosti ostrakód sa využili pri biostratigrafickom výskume jadier z vrtu Sekule-1. Jadro z dvoch tretín tvoril sivý jemnozrnný pieskovec až siltovec a z jednej tretiny sivý až zelenkavosivý vápnitý ílovec až prachovec. Horniny boli výrazne bioturbované, tektonicky neporušené a uložené vodorovne.

Vzorky sa preplavili štandardnými metódami. Zachovanie fosílií bolo veľmi dobré. Vo výplavoch sa našli tieto druhy ostrakód: *Cytheridea paracuminata* Kollmann, *Senesia vadaszi* (Zalányi), *Falunia plicatula* (Reuss), *Cyamocytheridea dertonensis* Ruggieri, *C. dérii* (Zalányi), *Callistocythere canaliculata* (Reuss) sp. juv., *Cythereta ornata* semiornata Brestenská, *Parakrithe dactylomorpha* Ruggieri, *Hemicytherideis gigantea G.* Carbonel, *Loxoconcha aff. schmidi* Cernajsek, *Leptocythere sp.* Cernajsek, *Semicytherura sp.*

Z hľadiska stratigrafického zaradenia vzoriek je najdôležitejší druh *Cyamocytheridea dertonensis* Ruggieri. Jeho stratigrafický rozsah je vrchný báden. Jiříček (1978) rozdelil vrchný báden podľa ostrakód na spodnú a vrchnú časť. Do spodnej zasahuje iba druh *Cytheridea paracuminata*, *Parakrithe dactylomorpha* a *Cythereta ornata semiornata*, a preto možno predpokladať, že sedimenty vekovo patria do spodnej časti vrchného bádenu.

Druhy nachádzajúce sa vo vzorkách žijú v morskom prostredí s normálnou salinitou a rody *Xestoleberis*, *Leptocythere* a *Loxoconcha* aj v brakickom prostredí. Z batymetrického hľadiska takéto rody obývajú epineritické až neritické prostredie. Prevaha epineritických foriem v počte jedincov aj rodov ukazuje na hĺbku sedimentačného prostredia v pásme epineritika.

Spomienka na RNDr. Jána Ilavského,DrSc.

30. apríla 1997 sme si pripomenuli nedožité 75. narodeniny popredného slovenského geológa metalogenetika RNDr. Jána Ilavského, DrSc., ktorý opustil naše rady 8. júla minulého roku. Pri hodnotení jeho životného diela hlavne v oblasti slovenskej ložiskovej geológie sa nemôžeme nestotožniť s myšlienkou, že bol hlavne zakladateľom modernej slovenskej metalogenéze a postavil jej základné piliere. Bol prvým a doteraz nenahradeným ložiskovým geológom, ktorý komplexne pokryl a syntetizoval celú problematiku metalogenézie Západných Karpát a svojou odbornou erudíciou a vecekými prácami významne prekročil aj hranice našej vlasti. Jeho pracovná aktivita, činorodosť, všestrannosť, a to počnúc vlastnou výskumnou a končiac vedecko-organizačnou prácou bola i v medzinárodnom meradle bezpríkladná. Patril medzi oduševnených geológov, bol hlboko oddaný práci, ktorej zasvätil celý svoj život. Ovládanie cudzích jazykov a časté pôsobenie v zahraničí sa výrazne podpísali pod jeho vysokú odbornosť. Vedomosti získané z mnohých krajín tvorivo aplikoval pri poznávaní metalogenézy Západných Karpát.

Ján Ilavský sa narodil 30. apríla 1922 vo Važci a tam navštevoval základnú školu. Po maturite na Gymnáziu v Liptovskom Svätom Mikuláši v rokoch 1941 až 1946 absolvoval štúdium prírodopisu a zemepisu na Prírodovedeckej fakulte Slovenskej univerzity. Doktorát z geológie získal roku 1948, kandidátom geologicko-mineralogických vied sa stal roku 1959 a doktorát vied obhájil na Vysokej škole technickej v Košiciach roku 1974.

Počas Slovenského národného povstania prerušil vysokoškolské štúdium, aktívne sa na ňom zúčastnil a neskôr vstúpil do radov I. československého armádneho sboru.

V rokoch 1946 - 1949 bol asistentom geologicko-paleontologického ústavu Prírodovedeckej fakulty UK. V rokoch 1949 až 1952 pôsobil ako vedúci prospekčného oddelenia Železorudných baní v Spišskej Novej Vsi. Táto práca zrejme predurčila jeho budúce odborné smerovanie. V rokoch 1952 až 1957 bol hlavným geológom novovzniknutého Východoslovenského rudného prieskumu. Od roku 1957 až do odchodu do dôchodku pracoval v Geologickom ústave D. Štúra v Bratislave s viacerými prerušeniami, počas ktorých pôsobil v zahraničí. Na GÚDŠ vykonával rad funkcií. Bol vedúcim oddelenia paleozoika (1952 - 1962), námestníkom riaditeľa (1964 - 1965) a vedúcim oddelenia nerastných surovín (1970 - 1980).

Často pôsobil v zahraničí. V rokoch 1965 - 1968 pracoval ako expert OSN v projekte na prieskum keramických surovín v Tunisku, v rokoch 1969 - 1970 ako vedúci projektu OSN na vyhľadávanie farebných kovov v Togu a v rokoch 1981 až 1984 prednášal na univerzite v Annábe, hlavne nerastné suroviny.

Okrem dlhodobých pobytov v zahraničí sa zúčastnil na viacerých krátkodobých expertízach v Turecku (1957), Guine (1959), Mali (1960), Afganistane (1961) a v Alžírsku (1963).

V slovenskej ložiskovej geológii, v prieskumnej a výskumnej praxi zanechala činnosť J. Ilavského hlboké stopy. Pracoval pre KKZ, v rozličných skúšobných komisiách, bol členom viacerých vedeckých rád, školiteľom vedeckých ašpirantov GÚDŠ a členom štátnej komisie pre udeľovanie vedeckých hodností v odbore ložisková geológia a úžitková geofyzika. Bol členom komisie UNESCO pre zostavenie metalogenetickej mapy Európy. Skúsenosti, ktoré tam získal, zužitkoval pri zostavovaní mapy a vysvetliviek k metalogenéze alpínsky zvrásnenej strednej a juhovýchodnej Európy. Táto mapa vyšla vo francúzštine pod názvom Metallogenese de L'Europe Alpine centrale et du Sud - Est (1979) vo vydavateľstve GÚDŠ.

Geologický výskum J. Ilavského na Slovensku aj v iných krajinách bol zameraný takmer na všetky typy ložísk či rúd alebo nerudných surovín vo všetkých geologických útvaroch. Na Slovensku mu osobitne prirástlo k srdcu Spišsko-gemerské rudohorie, kde svojimi prácami v danom čase a priestore položil základy modernej metalogenézy. Ešte viac priľnul k rudnej oblasti Smolníka. Tam od geologického mapovania, histórie baníctva až po detailné mineralogicko-geochemické práce urobil takmer všetko, čo bolo treba na charakteristiku rudného ložiska.

Pri výskume aplikoval moderné genetické princípy, zostavil viac metalogenetických modelov Západných Karpát, pričom sa opieral hlavne o francúzsku a ruskú metalogenetickú vedu. Ako novinky, ktoré sú dnes v metalogenetickej praxi vcelku bežné, začal prvý aplikovať princíp regenerácie rudných ložísk a zdôrazňovať stratiformný pôvod niektorých ložísk.

Z metalogenetických súborných mapových prác, ktorých bol hlavným autorom alebo spoluautorom, treba ako najzávažnejšie spomenúť nasledujúce: Metalogenetická mapa Československa 1:200 000 (1964), Metalogenetická mapa Československa 1:1 000 000 (1968), Mapa rudných ložísk Tuniska 1:500 000 (1969), Metalogenetická mapa Európy 1:25 000, list 5, Praha, UNESCO, Metalogenetická mapa karpatsko-balkánskych oblastí 1:1 000 000. Sofia, RVHP (1972 - 1980), Metalogenetická mapa Československa 1:500 000.

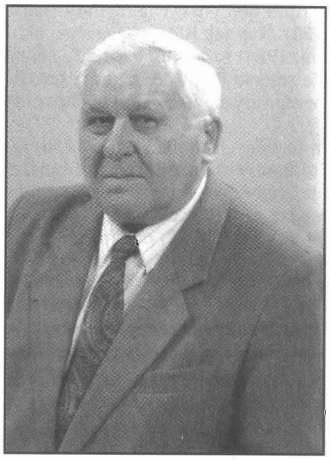
Na príprave spomenutých máp sa zúčastňoval spracúvaním oblasti Západných Karpát spolu s radom domácich a zahraničných spolupracovníkov.

Mimoriadne bohatá bola odborná publikačná činnosť J. Ilavského, ktorou sa natrvalo zapísal do slovenskej geologickej literatúry. Odchod do dôchodku nebol preňho hranicou výskumnej činnosti. Napriek narastajúcim zdravotným ťažkostiam bol literárne plodný až do konca svojho života. Na chodbách ústavu sme sa s ním často stretávali ešte nedávno. Navštevoval nás, odborne s nami diskutoval a spomínal. V posledných rokoch spracúval históriu rodného Važca a písal historickú štúdiu o počiatkoch baníctva na území Slovenska. Napísal viac ako sto závažných štúdií, príspevkov a monografií, z ktorých mnohé boli publikované v zahraničí, a to aj v takých uznávaných svetových časopisoch, ako je Economic Geology a Mineralia Deposita.

Pri hodnotení celoživotného diela RNDr. Jána Ilavského, DrSc., stojíme v pohnutí nad rozsahom jeho práce. Do slovenskej ložiskovej geológie vyoral hlbokú brázdu, ktorú nijaká erózia času neodstráni. Prácou i príkladným životom zostane navždy v našich spomienkach i v spomienkach budúcich generácií.

Jaroslav Štohl

K životnému jubileu prof. Ing. Miloslava Böhmera, CSc.



Mimoriadne významná osobnosť slovenskej geológie prof. Ing. M. Böhmer, CSc., sa 18. júna 1997 dožil sedemdesiatich rokov. Od roku 1951 až po odchod do dôchodku roku 1992 pracoval ako univerzitný učiteľ. Ako asistent pôsobil na katedre geológie a mineralógie bývalej Vysokej školy banskej v Bratislave a potom už iba na katedre nerastných surovín - terajšej katedre ložiskovej geológie - na Geologicko-geografickej a neskôr Prírodovedeckej fakulty Univerzity Komenského. A keďže činnosť človeka v mnohom ovplyvňuje už obdobie mladosti, začíname práve ním.

Prof. M. Böhmer sa narodil vo Vyšnej Boci v rodine učiteľa, ktorý tiež pochádzal z tohto kraja. Nižšie triedy gymnázia absolvoval v Liptovskom Mikuláši a vyššie v Novom Meste nad Váhom, kde aj zmaturoval. Potom sa rozhodol pre štúdium banského inžinierstva, a to aj pod vplyvom baníckych tradícií v rodisku. Vysokoškolské štúdiá začal na Slovenskej vysokej škole technickej v Bratislave (odbor špeciálnych náuk) roku 1947 a v rokoch 1949 - 1951 v nich pokračoval na Vysokej škole banskej v Ostrave. Už počas štúdia sa okrem baníctva vážne zaujímal o ložiskovú geológiu a ako študent sa zúčastnil na jednom z prvých komplexných výskumov ložísk v Banskej Štiavnici a v Rožňave. Z učiteľov ho usmerňovali najmä profesor R. Lukáč, B. Cambel, J. Šalát, J. Šuf, B. Růžička a ďalší.

Hneď po absolvovaní vysokej školy roku 1951 sa jubilant stal asistentom na Vysokej škole banskej, v tom čase ešte v Bratislave, roku 1952 asistentom na katedre nerastných surovín Geologicko-geografickej a po zlúčení Prírodovedeckej fakulty UK. Vedúcim katedry bol prof. Cambel.

Roku 1961 získal vedeckú hodnosť kandidáta geologicko-mineralogických vied, roku 1964 po obhájení habilitačnej práce ho vymenovali za docenta a roku 1973 za profesora v odbore geológia ložísk nerastných surovín.

Podľa potrieb katedry prof. M. Böhmer prednášal viaceré disciplíny ložiskovej geológie, ale hlavným smerom jeho pedagogickej činnosti boli metódy vyhľadávania, prieskumu a výpočet zásob, základy baníctva a neskôr ekonomika nerastných surovín. V spoluautorstve s prof. M. Kužvartom dosiahli veľký úspech viacerými vydaniami publikácie Vyhľadávanie a prieskum ložísk, ktorá vyšla v češtine, angličtine, slovenčine (roku 1972, 1978, 1986, 1993) a v zahraničí vo vydavateľstve Elsevier (roku 1978 a 1986). Išlo vždy o prepracované vydania. Uvedené dielo sa kladne hodnotilo a doma i v zahraničí a používalo ako vysokoškolská učebnica, ako aj príručka pre geológov v praxi. Prof. M. Böhmer okrem toho vydal aj dva tituly vysokoškolských skrípt.

Jubilant úspešne viedol desiatky diplomových prác a niekoľkých vedeckých ašpirantov.

Výskumná činnosť prof. M. Böhmera je rozsiahla a úspešná. Rudnú problematiku sledoval v oblasti Pezinok, Liptovská Dúbrava (Sb), Novoveská Huta, Kozie chrbty (Cu), Malá Magura (W, Au), stredoslovenské neovulkanity (Poľana, Javorie, Štiavnické vrchy, Kremnické vrchy - Au, Ag, polymetály). Spravidla išlo o komplexne zameraný výskum so spolupracovníkmi. Centrom jeho pozornosti zostala Kremnica, ktorú študoval viac ako 30 rokov.

Výsledky vedeckého výskumu publikoval v 90 publikáciách (časť v zahraničí) a sú výrazným prínosom z teoretického i praktického hľadiska.

Jubilant v priebehu rokov vykonával rad dôležitých funkcií. Bol riaditeľom Výskumného ústavu geologického PFUK (1964 - 1974), prodekanom, členom vedeckej rady PF a UK, členom Slovenskej geologickej rady, Česko-slovenského národného mineralogického komitétu a ložiskovej komisie KBGA, miestopredsedom Rady pre koordináciu ekonomického výskumu surovinovej politiky ČSSR, členom KKZ a členom akademického senátu PFUK.

Zo zahraničných aktivít prof. M. Böhmera treba uviesť napr. krátky prednáškový pobyt na niektorých univerzitách v Egypte, účasť v česko-slovenskej geologickej expedícii v Južnom Jemene (1983), profesúru na katedre geológie a baníctva Univerzity v Jose v Nigérii (1986 - 1987). Absolvoval aj niekoľko študijných pobytov v zahraničí a aktívne sa zúčastnil na viacerých kongresoch a sympóziách.

Medzi ocenenia za rozsiahlu a obetavú prácu prof. M. Böhmera patrí bronzová, strieborná a zlatá medaila PFUK (1982, 1980, 1987), bronzová a dve strieborné medaily UK (1969, 1982, 1987), pamätná medaila GÚDŠ (1980), pamätná medaila Vysokej školy banskej Ostrava (1975) a Košice (1977), Rudných baní, n. p., Kremnica (1978) a iné. Jubilant je aj čestným členom Slovenskej geologickej spoločnosti (1994).

Prof. M. Böhmer sa dožíva jubilejnej sedemdesiatky v dobrom zdraví a sviežosti a neopúšťa ho ani jemu príslovečný humor. Činnosť a celoživotné dielo oslávenca v pedagogickej a vedeckovýskumnej činnosti zostane trvalým vkladom do rozvoja

Ivan Kraus

Hercynidy versus variscidy

M. Suk, Přírodovědecká fakulta Masarykovy university, Kotlářská 2, 611 37 Brno

V geologických vedách sa možno často stretnúť s tým, že sa nerešpektuje priorita, a tak sa termínom, ktorých význam sa pôvodne definoval celkom jasne, z rozličných príčin dáva iný význam. Príkladom môže byť termín ofiolity (podľa Steinmanna, 1927, horizontálne asociácie spilitov, karbonátov a buližníkov; podľa Colemana, 1977, vertikálne asociácie spilitov s gabrami a ultrabázikami), termín internidy, ktorý sa dnes používa v inom význame, ako ho zaviedol Kober (1940), rozdielne chápanie termínu batolit v európskej a americkej literatúre, rovnako ako aj zámena termínu štruktúra a textúra. S rastúcim poznávaním významnej úlohy paleozoického orogénu v geologickom vývoji Západných Karpát sa zjavujú pochybnosti o termíne hercýnske vrásnenie, hercynidy a variské vrásnenie, variscidy.

Adjektívum hercýnsky terminologicky prvý raz použil L. von Buch (1807) v diskusii o príčinách vzniku vrásových pohorí na označenie systému porúch smeru JV - SZ. Vyšiel z latinského pomenovania lesnatých území medzi Dunajom a Sudetmi Hercynia silva (nešlo teda o Harc, ako sa mylne traduje v českej literatúre). V 19. stor. sa označenie hercýnsky používalo v Buchovom, ale aj v niektorých iných významoch. Roku 1847 nazval Zippe ako hercynit železnatý spinel a Kayser (1878) ako hercýnsky vápencový označoval vývoj spodného devónu v Harci, analogický barrandiénovému vývoju. Odtiaľ pochádza tzv. hercýnska otázka. V takom význame používal termín hercýnsky vývoj Chlupáč (in Svoboda et al., 1964). Ale termínom hercýnsky vývoj sa označoval aj litofaciálny vývoj kriedových sedimentov v stredoeurópskej oblasti primkýnajúci sa k tetydnému vývoju. Konečne roku 1887 (teda nie roku 1893, ako, pravdepodobne zámerne, uvádzajú niektorí autori) navrhol Bertrand používať termín hercynien na pomenovanie mladopaleozoického vrásnenia, aj keď si uvedomoval odlišnosť od jeho pôvodného významu. Jeho návrh sa medzi významnými bádateľmi ujal hneď.

Názov motivovaný germánskym kmeňom Variskov, ktorý sídlil v susedstve Markomanov v okolí dnešného bavorského mesta Hof (po latinsky Curia variscorum), ako prvý použil Breithaup roku 1937 na pomenovanie minerálu variscitu. Roku 1887 potom navrhol Suess termín Variszisch pre európske mladopaleozoické pásmo od Ardén a Vogéz na Z po Sudety na V. Neprehliadnuteľný je fakt, že mnohí nemeckí autori názov variscidy používajú v takomto význame dodnes, a to na odlíšenie od armorického pohoria vo Francúzsku, južnom Anglicku a Írsku. Aj Suess ešte roku 1909 použil označenie hercýnske horstvo v regionálnom význame. Ako celkový názov pre pohorie časovo zhodného veku s európskou mladopaleozoickou sústavou ("hercýnskou"), ako sú napr. Appalače a niektoré ázijské horstvá, navrhol názov altaidy.

Titul článku Über das Alter variszischen Gebirgsbildung svedčí o tom, že Stille rozjšíril termín variszisch, varistisch, variscisch i variskisch už roku 1920 (teda nie roku 1924). Nemeckí geológovia potom nepoužívali názov hercýnske vrásnenie, ale rozlišovali variské vrásnenie v strednej a armorické v západnej Európe (napr. aj Kosmat, 1927). Termíny variské vrásnenie, variscidy v nemeckej literatúre postupne nadobudli prevahu, kým vo všetkých ostatných krajinách sa používa termín hercýnsky, hercynidy (napr. Aubouin, 1984; Ellenberger, Tamain, 1986). Napriek istej propagačnej aktivite (napr. Murawski, 1980; IGC Moskva, 1984) sa termín variscidy neujal v ruskej ani v japonskej literatúre. Podľa rešerše PASCAL v praxi prevládajú termíny hercýnske vrásnenie a hercynidy nad termínom variscidy v pomere 10:1.

Do českej literatúry zaviedol obidva termíny Kettner (1927, 1956) vo významoch blížiacich sa pôvodným, a to hercynidy pre karbónske horstvá všeobecne, kým ich súčasťou v Európe je armorické, variské a iberské horstvo. Tak ich používajú v kompendiách Kodym a Bouček (1963), Svoboda et al. (1964) a Suk et al. (1984). Mísař et al. (1983, 1987) odporúča iba termín variscidy. V súčasnom období je v českej literatúre častejší názov variský a variscidy. Zrejme to súvisí so spoluúčasťou českých geológov na projekte Nemeckej spolkovej republiky KTB.

Na Slovensku je situácia pomerne jednoduchá. Andrusov (1938, 1958) dôsledne používal termín hercýnske vrásnenie a hercynidy rovnako ako neskôr Maheľ (1984). V novšej literatúre sa objavuje termín variské vrásnenie a variscidy len sporadicky a bez zdôvodnenia.

V európskych medzinárodných projektoch sa obidva termíny používajú podľa aktivity národných zástupcov. Napr. v tektonickej mape je adjektívum variský, ale v metamorfnej, metalogenetickej a v ďalších hercýnsky a substantívum hercynidy. Aj v zhrnutiach výsledkov korelačných programov sa paralelne objavujú obidva názvy (Ager, Brooks eds., 1976; Zoubek et al., 1987; Zwart eds., 1978).

Z prehľadu vychodí, že by sa podľa práva priority mal uprednostňovať termín hercýnske vrásnenie, hercynidy vo všeobecnom význame. Ale viditeľná je aj tendencia používať obidva termíny v rovnakom význame paralelne.

Angličtina a propriá v slovenských geologických textoch

Napísať túto poznámku nás priam vyzvalo niekoľko rukopisných (sčasti aj publikovaných) prác popredných slovenských geológov určených na zverejnenie v odbornom geologickom časopise a v jeho vedecko-populárnej prílohe. Podčiarkujeme, že išlo a ide iba o texty napísané v slovenčine.

Naša poznámka sa dotýka 1. anglickej transkribovanej podoby názvu hlavného mesta Čínskej ľudovej republiky **Beijing**, 2. anglickej transkripcie iných čínskych, ako aj japonských geografických názvov a 3. anglických viacslovných názvov rozličných spoločností, komisií, katedier, fondov ap.

Anglická transkribovaná podoba názvu hlavného mesta ČĽR **Beijing** sa v prácach viacerých autorov napísaných v slovenčine (to podčiarkujeme) objavila najmä v súvislosti s prípravou, ale potom aj s uskutočnením nedávneho svetového geologického kongresu viac ráz.

Takýto postup - čiže používanie názvu **Beijing** v slovenskom texte - treba bez akejkoľvek pochybnosti odmietnuť. V slovenčine totiž platí, že geografické jednoslovné propriá (vlastné mená) celkom rovnako ako jednoslovné propriá z iných oblastí, napr. mená a priezviská ľudí (**George, John, Karel, Shakespeare, Dumas, Bacon, Agricola, Beutell** ap.), majú v slovenčine povahu tzv. lexikálnych citátov, a preto sa v slovenskom texte zapisujú ako v pôvodnom jazyku a vyslovujú (aj keď nie hyperkorektne) podľa ortoepických pravidiel pôvodného jazyka, napr. **Washington, Marseille, Le Havre, Helsinki, Bologna** ap. Názov **Beijing** medzi ne, prirodzene, nepatrí, lebo ide iba o čínsky názov transkribovaný podľa platných pravidiel do angličtiny, nie do slovenčiny. Iba na ilustráciu uvádzame, že aj v angličtine funguje - azda ešte častejšie ako **Beijing** - názov **Peking** (pozri napr. Webster's New World Dictionary, 1984, s. 442).

Druhú skupinu sledovaných proprií tvoria názvy, ktoré majú jednak pôvodnú cudziu formu, ale popri nej v istých oblastiach funguje aj tzv. vžitá (paralelná) slovenská podoba. Do slovenských textov (hovorených aj písaných) patrí iba vžitá podoba, z ktorej sa spravidla bez ťažkostí tvoria aj potrebné deriváty. Tak má v slovenských textoch miesto iba **Rím** (pôvodná podoba **Roma**), **Viedeň** (**Wien**), **Budapešť** (**Budapest**), **Londýn** (**London**), **Berlín** (**Berlin**), **Debrecín** (**Debrecen**), **Rakúsko** (**Österreich**) ap. Je prirodzené, že sa napr. v kartografických dielach aj so slovenským textom na prvom mieste uvádza vždy pôvodná podoba.

Práve do predchádzajúcej skupiny treba zaradiť aj u nás vžitú (paralelnú) podobu **Peking**. V takejto forme je názov kodifikovaný napr. v 6. diele Slovníka slovenského jazyka (1968, s. 289), ale aj v najnovších Pravidlách slovenského pravopisu (1991, s. 295).

Do slovenčiny transkribovaný (prepísaný) čínsky názov, ktorý sa právom objavuje aj na našich mapách na prvom mieste, je **Pei-ťing** (nie *Beijing*).

Ako vidno, nie je ani najmenší dôvod, aby sa v slovenských textoch objavovala po anglicky transkribovaná podoba *Beijing*. A platí to v plnom rozsahu aj o odborných i populárno-vedeckých textoch. Všade tam musí byť **Peking**. (Úvahy o tom, či má byť v anglických textoch **Peking** alebo Beijing, patria do kompetencie anglistov.)

V slovenských textoch nemajú čo hľadať ani iné do angličtiny transkribované názvy, napr. čínskych provincií, riek ap., japonských geografických názvov atď. Preto môže v slovenskom texte byť napr. **Čching-chaj**, ale nie *Sinkiang*, **Jang-c'-ťiang**, ale nie *Yangtze*, **Tóno**, nie *Tono*, **Kamaiši**, nie *Kamaishi*, **Honšú**, nie *Honshu*, **Kjúšú**, nie *Kjushu* atď.

Do textu písaného v slovenčine nepatria ani po anglicky transkribované ruské mená, napr. *Shatalov*, lebo slovenský prepis je **Šatalov** ap.

Tretiu skupinu proprií, ktorými sa tu zaoberáme, tvoria viacslovné názvy rozličných spoločností, komisií, fondov ap. Aj keď jazyková kodifikácia na otázku, ako je to s prekladom, s prepisom či s rešpektovaním cudzej podoby, nedáva jednoznačnú odpoveď, k príkladom tohto druhu vypísaným zo spomenutých rukopisov možno zaujať dosť jednoznačné stanovisko.

Ak sa v texte písanom po anglicky oprávnene uvádza názov jednej maďarskej spoločnosti ako **Mecsek Ore Minig Co.** (maďarský názov nemáme k dispozícii), do slovenského textu patrí jej slovenský, nie anglický preklad. Pravdaže, proti tomu, aby pri slovenskom názve bol (najlepšie azda v zátvorke) aj pôvodný maďarský názov, nemožno nič namietať. Úplne rovnaký záver sa týka napríklad aj názvu **National Waste Disposal Program**, lebo aj ten je z Maďarska, nie z nejakej po anglicky hovoriacej krajiny.

Analogicky sa patrí uvažovať aj v iných prípadoch. Preto do slovenského textu mal autor textu, z ktorého vychádzame, dať namiesto anglického **Federal Office for Radiation Protection** slovenský preklad, napr. **Spolkový úrad pre radiačnú ochranu** a zátvorke uviesť východiskovú nemeckú (!) podobu.

Aj ďalšie príklady sú rovnakého druhu. **National Spanish Radioactive Waste Management Company** bolo treba preložiť do slovenčiny priamo zo španielčiny asi ako **Španielska národná spoločnosť na spracovanie rádioaktívneho odpadu** a rovnako v zátvorke uviesť pôvodný názov v španielčine (nepoznáme ho), z ktorého zrejme pochádza aj skratka **ENGRESA.**

Švédska spoločnosť pre spracovanie jadrového paliva a odpadu má skratku SKB, čo je zrejme v poriadku, ale v slovenskom texte ju nemožno označovať ako **Swedish Nuclear Fuel and Waste Management Co.**

Za najvhodnejšie, hoci nie povinné, treba pokladať uvedenie slovenského preloženého názvu a potom pôvodného názvu, príp. aj jeho skratku, napr. **Národné združenie pre ukladanie (skladovanie) rádioaktívneho odpadu (Nationale Genossenschaft für die Lagerung radioaktiver Abfälle - NAGRA).**

Z celkom rovnakých príčin, ako sme uviedli doteraz, ťažko obhájiť aj prípady typu *...analýzy sa vykonali na Department of Geological Sciences, University of Manitoba*, keď ide o **katedru geologických vied Manitobskej univerzity vo Winnipegu.**

Všetky doteraz kritizované prípady pôsobia na čitateľa viac-menej snobsky. Závery sa vonkoncom nedotýkajú iba textov geologických vied, ale majú oveľa širšiu platnosť. Na ilustráciu uvádzame, že aj v dennej tlači by bolo správnejšie a prirodzenejšie namiesto *S podporou Open Society Fondu pokračuje výučba*...alebo *Program Health Education Project (HEP)... sa rozhodli uplatňovať ponúknuť* na prvom mieste slovenský preklad fondu či programu, teda... **S podporou Otvoreného sociálneho fondu (Open Society Fond) pokračuje výučba** a podobne **Projekt zdravotnej výchovy (Health Education Project - HEP)... sa rozhodli uplatňovať....**

Na záver podčiarkujeme, že naše poznámky ani v najmenšej miere nespochybňujú spontánne získané alebo aj explicitne proklamované vedúce postavenie angličtiny vo vedeckej komunikácii. Ide naozaj iba o prirodzené fungovanie proprií rozličného typu v odborných, ale aj v iných slovenských textoch.

P. Kušnír

Nový projekt IGCP

Nový projekt IGCP č. 405 má názov Antropogénne vplyvy na procesy zvetrávania - človekom vyvolaná interakcia medzi atmosférou, vodami a pevnými fázami v globálnom až mikroskopickom meradle.

Jeho koordinátorom je P. Sulovský a J. Zeman z brnianskej Masarykovej univerzity. Projekt sa orientuje štúdiom interakcie minerálov (hornín) a vody, experimenty so zvetrávaním umelých anorganických materiálov, mikrobiologickú aktivitu, zvetrávanie ako príčinu mechanického rozpadu stavebných materiálov a na zvetrávanie ako zdroj znečisťovania.

Hlavným cieľom projektu je koordinácia teoretických, experimentálnych a aplikovaných štúdií zameraných na isté aspekty zvetrávania priemyselného odpadu rozličného druhu alebo zvetrávania indukovaného kyslými podmienkami.

Rapídne zmeny životného prostredia obklopujúceho zložky biosféry a neživé predmety okolo nás si vyžadujú riešenie podobných tém, aké sa u nás v minulosti často obchádzali.

Zvetrávanie - ako každý exogénny geologický fenomén - nepozná štátne, jazykové ani iné bariéry. Tomu zodpovedá i štruktúra projektu, ktorý sa delí na podskupinu 1. teoretického modelovania, 2. experimentálneho výskumu a 3. terénnej (aplikovanej) činnosti.

Cieľom podskupiny teoretického modelovania je rozbierať a zjednotiť termodynamické údaje zo svetovej literatúry tak, aby vznikla kompletná a komplexná databáza na tvorbu modelov degradácie materiálov vplyvom zmeneného životného prostredia.

Experimentálny výskum je orientovaný na lepšie spoznanie správania sa najbežnejších horninotvorných minerálov (kremeňa, živcov, pyroxénov, sľúd, ílových minerálov) a horninových typov (granitoidy, bazalty, pieskovce, bridlice) pri bežnej povrchovej teplote a tlaku, ale v podmienkach acidného zvetrávania či zvetrávania vyvolaného inými chemickými činidlami.

Aplikovanou činnosťou sa riešitelia pokúsia zhodnotiť stav, predpovedať správanie sa a navrhnúť na zachovanie prijateľný stav rozličných materiálov ovplyvňovaných zmeneným životným prostredím.

V čase 1. konferencie v závere roka 1996 bolo do projektu oficiálne zapojených viac ako 20 krajín Európy a sveta. Projekt je otvorený aj na Slovensku pre všetkých, ktorí majú záujem riešiť otázky späté so zvetrávaním sledovaných materiálov.

Vedúcim slovenskej národnej skupiny je V. Šucha, u ktorého sa môžu záujemcovia o účasť v projekte prihlásiť (V. Šucha, katedra ložiskovej geológie Prírodovedeckej fakulty UK, Mlynská dolina G, 842 15 Bratislava).

Ďalšie informácie možno nájsť na internetovej adrese http://www.sci.muni.cz/~sulovsky/igcp405.html

2. konferencia o projekte IGCP č. 405

bude 24. - 26. novembra 1997 na Prírodovedeckej fakulte UK v Bratislave. Organizuje sa po dobrých skúsenostiach z 1. konferencie, ktorá bola roku 1996 v Brne. Konferencia má dve hlavné témy:

- Zvetrávanie industriálneho odpadu
- Zvetrávanie v kyslých podmienkach

Témy sú aktuálne z hľadiska vedeckého výskumu a jeho výstupu do praxe a sú obsiahnuté aj v projekte IGCP č. 405. Cieľom konferencie je okrem širokej diskusie odborníkov z viacerých krajín obrátiť pozornosť aj na domáce problémy a vzbudiť záujem o ich riešenie.

Na konferencii sa budú prezentovať výsledky bádania zo všetkých troch oblastí, ktorými sa projekt IGCP zaoberá, a tak vznikne bohatý materiál pre odborníkov a záujemcov o podobný typ výskumu.

Pozývame vás na prvú konferenciu tohto druhu na Slovensku v nádeji, že odbornými príspevkami a účasťou prispejete k jej odbornej úrovni.

Záujemcovia môžu poslať prihlášku na adresu: Juraj Majzlan, katedra mineralógie a petrológie Prírodovedeckej fakulty UK, Mlynská dolina G, 842 15 Bratislava.

Juraj Majzlan

Plán odborných akcií Slovenskej geologickej spoločnosti na II. polrok 1997

V II. polroku 1997 usporiadajú pobočky Slovenskej geologickej spoločnosti a odborné skupiny tieto akcie:

Banskobystrická pobočka (predseda RNDr. M. Háber, CSc.)

26. - 28. 8. 1997
Seminár s terénnou exkurziou: Kolektív Ďumbier - montnisti Magurka v Nízkych Tatrách. Zabezpečuje M. Háber

20. 11. 1997
Seminár Problematika riešenia znečistenia životného prostredia a vyhľadávania zdrojov podzemných vôd. Miesto: GÚ SAV, Banská Bystrica, Severná 5, zasadačka, 13:00 hod. Zabezpečuje M. Galisová.

Bratislavská pobočka (predseda RNDr. J. Hók)

25. 9. 1997
M. Kováčik, P. Kováč a Š. Káčer: Environmentálne mapovanie Vysokých Tatier pomocou metód diaľkového prieskumu Zeme. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje M. Kováčik.

9. 10. 1997
J. Geczy a Ľ. Kucharič: Uplatnenie georadaru v geologickej praxi. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje M. Elečko.

Žilinská pobočka (predseda RNDr. M. Demian)

A. Záthurecký: Poznatky z prieskumu diaľničného tunela Branisko. Miesto a čas prednáškového popoludnia bude spresnený neskôr. Zabezpečuje M. Demian.

Košická pobočka (predseda prof. RNDr. F. Zábranský, CSc.)

2. - 5. 9. 1997
IX. Medzinárodná banícka konferencia, usporiadaná pri príležitosti 45. výročia Baníckej fakulty TU v Košiciach - sekcia geologická.

Október 1997
S. Karoli: Litofaciálny vývoj a sedimentačné prostredie evaporitov Slovenska. Miesto: Fakulta BERG (1. polovica októbra).

Kolektív autorov: Geologická a technická problematika výstavby tunela pod Braniskom. Prednáška spojená s exkurziou na tunelové teleso. Miesto: Košice - Branisko (2. polovica októbra).

November 1997
Fórum mladých: Prezentácia geologických výsledkov mladých pracovníkov (8 vystúpení). Miesto: Herľany. Miesto a čas konania budú spresnené na plagáte. Zabezpečuje výbor pobočky.

Spišskonovoveská pobočka (predseda Ing. M. Radvanec, CSc.)

Október 1997 (2. polovica)
M. Tréger: Nové pohľady na ekonomické hodnotenie - cena ložísk. Miesto: GS SR, Spišská Nová Ves, Markušovská cesta 1, zasadačka, 14:00 hod. Zabezpečuje M. Radvanec.

Geofyzikálna skupina (predseda doc. RNDr. J. Lanc, CSc.)

22. 10. 1997
J. Hricko: Medzinárodný projekt Košice-biotická a abiotická zložka životného prostredia. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje J. Lanc.

Geochemicko-mineralogická skupina (predseda doc. RNDr. M. Chovan, CSc.)

23. 10. 1997
Prednáškové popoludnie
Prednášatelia a prednášky budú spresnené v pozvánke na mesiac október a na plagáte. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje M. Chovan.

Hydrogeologická skupina (predseda RNDr. M. Benková)

6. 11. 1997
Prednáškové popoludnie
I. Mucha a kol.: Využitie numerického modelovania pri riešení praktických problémov v hydrogeológii.
Z. Hlavatý a kol.: Dekontaminácia podzemných vôd v Maďarskej republike.
Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje K. Benková.

4. 12. 1997
Prednáškové popoludnie
M. Fendek: Vysokoteplotné zdroje Islandu.
I. Šalaga: Povery a problémy so zabezpečovaním podzemnej vody v Afrike.
M. Fendeková a kol.: Hydrogeológia Holandska.
Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:00 hod.

Inžinierskogeologická skupina (predseda doc. RNDr. R. Holzer, CSc.)

Október 1997
Inžinierskogeologická exkurzia: Problematika líniových a tunelových stavieb na Považí, Kysuciach a Liptove. Zabezpečujú R. Holzer a Ľ. Iglárová.

13. 11. 1997
R. Holzer: Svahové deformácie a iné prírodné hazardy v Japonsku. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje R. Holzer.

18. 12. 1997
A. Klukanová a M. Ondrášik: Národné parky a chránené územia juhozápadu USA (Grand Canyon, Zion, Bryce, Death Valley, Petrified Forest, Red Rock, Sunset Crater a pod.). Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje Ľ. Iglárová.
Všetky akcie sú v spolupráci so Slovenskou asociáciou inžinierskych geológov.

Ložisková skupina

16. 10. 1997
J. Zuberec, Z. Hroncová a J. Kozač: Výskum netradičných nerudných surovín, ich úprava a využitie (metodika, dosiahnuté výsledky a ich ďalšia perspektíva). Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje J. Zuberec.

Paleontologická skupina (predseda doc. RNDr. J. Michalík, DrSc.)

29. 9. - 5. 10. 1997
Záverečná konferencia Projektu IGCP 362 v Starej Lesnej.

11. 12. 1997
Seminár Paleontológia v Európe
P. Holec: Ďalšie nálezy miocénnych stavovcov na území Slovenska.
K. Zágoršek: Eocénne machovky Maďarska a ich porovnanie s podobnými asociáciami u nás.
M. Kováčová: Niektoré nové poznatky zo štúdia palynoflóry miocénnych sedimentov vo Viedenskej panve.
L. Ožvoldová a L. Frantová: Nové údaje získané štúdiom jurskej/kriedovej rádioláriovej mikrofauny.
E. Halásová a A. Antalíková: Evolúcia vápnitého nanoplanktónu na stratotypových lokalitách Rochovica a Polomec.
Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:00 hod.
Zabezpečuje J. Michalík.

Skupina ropnej geológie (predseda P. Ostrolucký, CSc.)

10. 9. 1997
Viedenská panva - zabezpečenie terénnej exkurzie v rámci zjazdu SGS v spolupráci so sedimentologickou skupinou.

Sedimentologická skupina (predseda doc. RNDr. M. Kováč, CSc.)

20. 11. 1997
Seminár Oligo-Miocénny vývoj akrečnej prizmy na rozhraní Vonkajších a Centrálnych Západných Karpát (typy panvé, synsedimentárna tektonika, sedimentárne fácie a prostredie depozície ...).
Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:00 hod. Zabezpečujú J. Soták a M. Kováč.

Skupina štruktúrnej geológie (predseda doc. RNDr. D. Plašienka, CSc.)

27. 11. 1997
Prednáškové popoludnie
Program popoludnia sa spresní na poznávke na november, resp. na plagáte. Zabezpečuje I. Hók.

Vulkanologická skupina (predseda RNDr. L. Šimon)

30. 10. 1997
V. Konečný: Vulkanizmus v Mexiku. Miesto: GS SR, Mlynská dolina 1, Bratislava, zasadačka - 3. poschodie, 13:30 hod. Zabezpečuje L. Šimon.

Zberatelia nerastov a skamenelín (predseda RNDr. R. Ďuďa, CSc.)

6. 12. 1997
Burza
14. medzinárodné stretnutie zberateľov nerastov a skamenelín. Miesto: Slovenské národné múzeum, Vajanského nábrežie 2, 9:00 - 17:00 hod. Zabezpečuje O. Miko.

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1. Musia byť vysokej kvality. Majú dokumentovať a objasňovať text. Originál (pred zmenšením) môže mať rozmer najviac 340 x 210 mm. Maximálny rozmer ilustrácie vytlačený v časopise je 170 x 230 mm. Skladacie ilustrácie treba úplne vylúčiť.
   V prípade, že ide o počítačovo vytvorené ilustrácie, prosíme o ich zaslanie na diskete 3,5" vo formáte CorelDraw (PC), Adobe Illustrator (PC, Mac) alebo Aldus FreeHand (Mac).
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4. Obrázky popisovať šablónou, nie voľnou rukou.
5. Všetky ilustrácie včítane fotografií musia obsahovať grafickú (metrickú) mierku.
6. Zoskupené obrázky, napr.: fotografie, diagramy, musia byť pripravené (nalepené) ako jeden obrázok a jeho časti treba označiť písmenami (a, b, c atď.). Takto zoskupené obrázky sa citujú ako jeden obrázok. Zoskupené fotografie treba starostlivo upraviť a nalepiť na biely kriedový papier.
7. Fotografie musia byť ostré, čiernobiele, kontrastné a vyhotovené na lesklom papieri. Je vhodné, aby sa zmenšovali minimálne o 50 %.
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11. Všetky ilustrácie sa musia citovať v texte.
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Tabuľky

1. Tabuľky sa píšu na osobitný list. Rozsah a vnútornú úpravu tabuliek zvoľte tak, aby sa tabuľka umiestnila do stĺpca alebo na šírku strany. Rozsiahlejšie tabuľky sa neprijímajú.
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4. Vertikálne čiary v tabuľkách nepoužívať.
5. Tabuľky sa číslujú priebežne a uverejňujú sa v číselnom poradí.

Literatúra

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2. Používať nasledujúci spôsob uvádzania literatúry:
   Kniha
   Gazda, L. & Čech, M., 1988: Paleozoikum medzevského príkrovu. Alfa Bratislava, 155.
   Časopis
   Vrba, P., 1989: Strižné zóny v komplexoch metapelitov. Mineralia Slov., 21, 135 - 142.
   Zborník
   Návesný, D., 1987: Vysokodraselné ryolity. In: Romanov, V (red.): Stratiformné ložiská gemerika. Špec. publ. Slov. geol. spol., Košice, 203 - 215.
   Manuskript
   Radvanský, F., Slivka, B., Viktor, J. & Srnka, T., 1985: Žilné ložiská jedľoveckého príkrovu gemerika. Záverečná správa z úlohy SGR-geofyzika. Manuskript - archív GP Spišská Nová Ves, 28.
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