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Sedimentology of Karpatian evaporites in the East-Slovakian Neogene basin (Slovakia)

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Abstract: After a deep-water sedimentation during the Lower Karpatian the communication between the East-Slovakian Neogene Basin and the Carpathian Foredeep was interrupted. This period is recorded by deposits of Soľná Baňa Formation containing high amount of evaporites. The Soľná Baňa Formation is subdivided into five lithofacies units. Unit I represents the period of gypsum precipitation on the coastal plain and its subsequent redeposition as well as the period of nodular anhydrite precipitation in the subaquoeous environment. Halite, occurring in the unit II, has been most likely originated in salt pans. Unit III was a period of increased subsidence controlling a deposition of coarse-grained sediments. During this period the halite of unit II had been dissolved along NW-SE faults giving rise to solution-collapse breccias. Unit IV represents a typical salt-pan cycle with desiccation rip-up breccias. Unit V, lithofacially resembling unit I, marked a gradual retreat to a normal, open-marine regime. The deposition of Soľná Baňa Formation, and especially of evaporites, reflects a function of a tectonic sill between the East Slovakian Basin and Carpathian Foredeep. This sill was most likely located in the outer flysch area.

Key Words: halite, sollution-collapse breccias, desiccation breccias, tectonic sill

Introduction

The East Slovakian Neogene Basin is the only basin of the Inner West Carpathians comprising economically important Miocene evaporites. The opening of the basin, located south-west of the Klippen Belt (Fig. 1), reflected the subduction of the flysch externides (European platform) below the Carpathian - Pannonian Block (Royden et al., 1983; Tomek, 1993) and the crust extension resulting from the uplift of the Pannonian asthenolit (Horváth, 1993). From the Eggenburgian to the Pliocene more than 6 000 m of mollase sediments have been deposited in the basin. The style, time and spatial distribution of deposits has been controlled by global palaeogeographic and palaeoclimatic changes as well as by tectonic regime of the basin during its evolution. Two etapes, differing by palaeogeographic evolution and depositional character, are divided in the sedimentary history of the basin. During the first phase (Eggenburgian - Middle Badenian) the deposition has been restricted to the relatively narrow WNW - ESE oriented graben opened to the Carpathian Foredeep in the northeast. The graben was separated to the Pannonian Basin in the south.

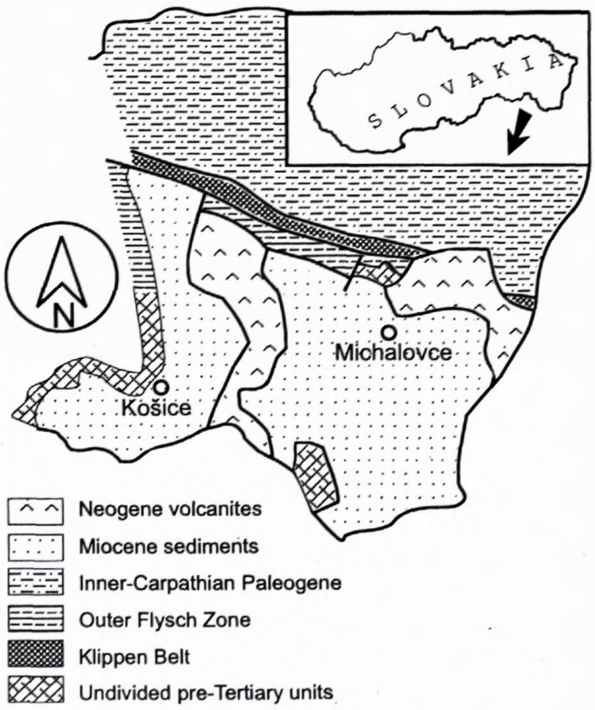


Fig. 1 Location of the East Slovakian Neogene Basin

Marine, mainly pelitic deposition prevailed during this phase. Deltaic deposition and shallow shelf deposition in the brackish-lacustrine environment dominated in the second phase (Upper Badennian - Pontian). It was established a communication to the Pannonian Basin in the south and the Mukachevo Basin in the southeast.

The sedimentary fill of the East Slovakian Neogene Basin comprises two evaporitic, halite-dominated formations. They were deposited during the middle part of the Karpatian and Middle Badenian. The deposit of the Badenian salt in the Zbudza Formation has been prepared for exploitation in 1997. The existing knowledge about its origin has been summarized by Galamay and Karoli (1997). The salt from the Karpatian Soľná Baňa (Salt Mine) Formation has been exploited since the 13th century. Until 1572, when the Leopold shaft was opened, salt was obtained by boiling of natural brine coming from a salt spring. After a construction of the shaft the underground exploitation lasted until 1752, when the shaft has been flooded. From this time the salt was again obtained by the boiling of natural brine getting from the former shaft (Butkovič, 1978). After 1950 the brine has been exploited by salt dissolution by a system of drillings.

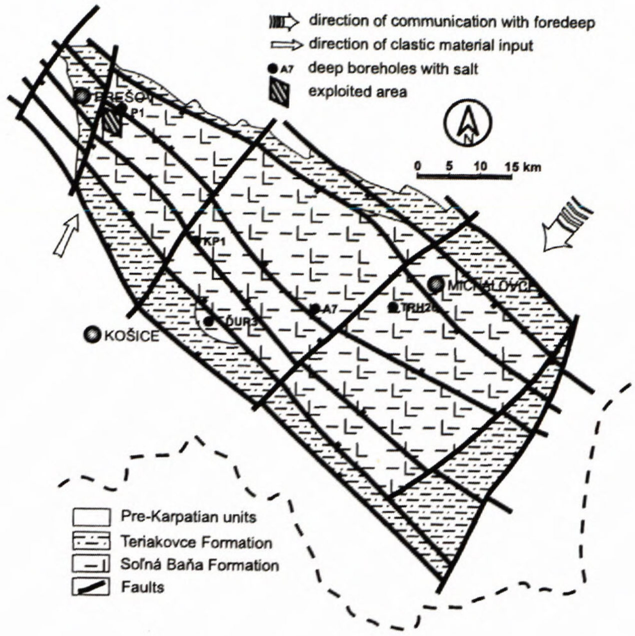


Fig. 2 Palaeogeographic reconstruction of the Lower (Teriakovce Fm.) and Middle (Soľná Baňa Fm.) Karpatian.

Geological setting

After a hiatus in the Ottnangian, the commencement of the Karpatian deposition in the East Slovakian Neogene Basin is the time of marine transgression. The communication to the Carpathian Foredeep was in the northeast, the deposition occurred in the elongated, transversely segmented WNW-ESE graben (Fig. 2). The ocean transgressed over the Eggenburgian and Paleogene deposits in the north and pre-Tertiary basement in the south. The graben originated by a simple NE-SW extension in the Lower Karpatian, from the Upper Karpatian the pull-apart mechanism in the transtension regime controlled the opening of the basin (Kováč *et al.*, 1995).

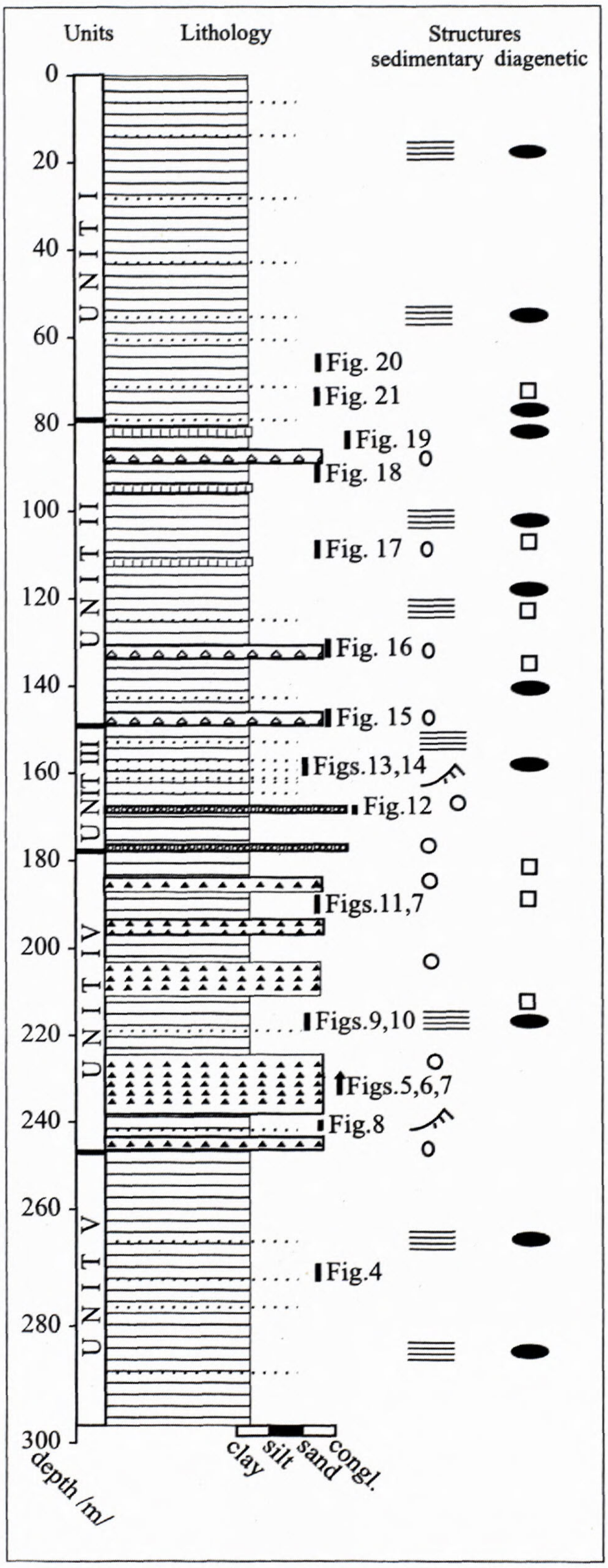
Three formations are being distinguished in the Karpatian (Vass & Čverčko, 1985): the evaporite bearing Soľná Baňa Formation is sandwiched by the lower Teriakovce and upper Kladzany Formations.

The lower **Teriakovce Formation** has a distinct coarse-detritic base evidencing a Karpatian transgression. The lower part of formation is 100 - 150 m thick and consists of conglomerates on the base passing upward to fine sandstones and siltstones. The upper part of formation is mainly composed of alternation of siltstones and claystones. Along the northern margin of the basin montmorillonitic products of the former volcanism and schlier occur. A rich foraminiferal fauna, often with pyritized tests, occur in the formation. The foraminifera indicate an environment of deeper neritic zone and shallow bathyal zone (Cícha & Kheil, 1962; Zlinská, 1992). The thickness of the formation is500 m.

The upper **Kladzany Formation**, representing the uppermost part of Karpatian deposits, is lithologically monotonous complex of silty claystones and clayey siltstones with thin, only occasionally up to 1 m thick, beds of fine sandstones. Typically, the deposits are violetish-red smudged in the lower part and yellowish-brown in the upper part. They contain scarce microfauna. Microscopic gypsum and anhydrite frequently occur in the lower part of the formation. The secondary fibrous gypsum sometimes fills interbed spaces and fissures; veins are mm to cm in thickness. The thickness of the formation is up to 1,300 m.

The Soľná Baňa Formation represents the middle part of the Karpatian deposits. After a long period of presumption that the salt occurrence is only restricted to the northeastern part of the East Slovakian basin, the deep boreholes during hydrocarbon prospection revealed the Karpatian deposits containing brine even in the southern and central part of the basin (Janáček et al., 1975; Rudinec, 1978). The palaeogeographic reconstruction (Fig. 2), based on the stratigraphic and tectonic analysis of the area, shows the occurrence of evaporites in the entire basin. Contrary to the underlying Teriakovce Formation, the sediments of Soľná Baňa Formation were deposited during a regression.

Laminated and thin-bedded gypsum and anhydrites occur in the lowermost part of the 230 - 340 m thick Soľná Baňa Formation. There is typical an abrupt disappearence of a rich microfauna of the underlying formation (Cícha & Kheil, 1962). Very scarce *is Uvigerina*



graciliformis, Uvigerina semiornata, Bulimina elongata, Bulimina dilatata, Robulus inornatus, Globigerina bulloides in claystone and *siltstone* layers (Beroušek in Polák *et al.,* 1955). The overlying deposits comprises salt breccias with matrix-supported structure. The matrix consists of halite, clasts are composed of claystone, siltstone and occasionally of sandstone. In the uppermost part of the formation laminae and beds of gypsum and anhydrite in the pelitic and siliciclastic sediments occur again. Pollen are very scarce and non-significant; pollen association indicating cold and arid climate are known from the underlying formation (Planderová, 1988).

Soľná Baňa Formation is typical by a lithofacies variability, especially in salt breccias. Tens of prospection and exploitation boreholes have been drilled in the exploited area nearby Prešov town (Fig. 2). Although there are not preserved cores showing a continuous profile of the formation, the description of cores from many boreholes and archive samples enabled to subdivide the formation into five lithologic units on the basis of evaporite facies (Fig. 3).

Description of Soľná Baňa Formation

Unit I

Unit I is 40 - 100 m thick. Its thickness increases toward north. The deposits consist of alternating siltstones and claystones and thin layers of fine sandstones. They

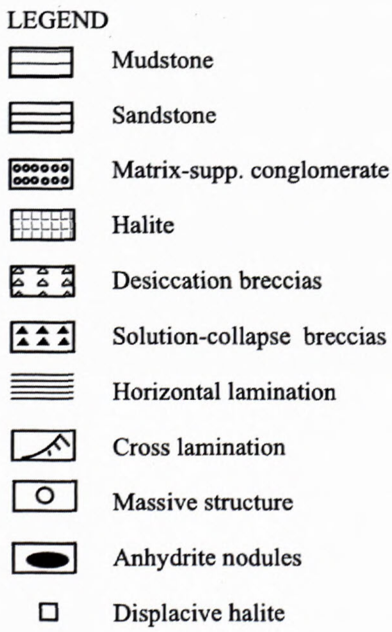


Fig. 3 Composite log showing the deposits of Soľná Baňa Fm. in the exploitation area. Note the location of close-up figures.

contain 0.5 - 2 mm thick laminae and beds of gypsum. They occur as either individual laminae in claystones and siltstones or laminae set formed by alternation of gypsum siltstone and gypsum sandstone. The deposits consist of prismatic crystals of gypsum and their fragments without preferred orientation. The longest axis of larger selenite crystals is sometimes elongated with lamination. Siliciclastics, mainly quartz, feldspar, mica, and glauconite grains, are very common as accessories. In some boreholes the frequency of evaporite laminae increases toward the top of the unit. If the laminae occur in thicker intervals, the surrounding deposit is often gypsum- or mixed gypsum-siliciclastic siltstone (Fig. 4). The siltstones are cross-laminated occasionally. A nodular anhydrite of cm size occurs irregularly in the entire unit.

Fig. 4 Alternation of laminated gypsum (lighter laminae) and gypsum siltstone (darker laminae) of unit I. The bar for a scale is 1 cm long.

Unit II

The deposits of unit II are being exploited today. They contain the maximum accumulation of salt. The unit is from 30 to 100 m thick, it is separated by sandstone dominated unit III from overlying, another salt-bearing unit IV. Salt breccias are dominant deposits in this unit, they are separated from each other by a few metres thick claystones, siltstones and thin beds of sandstones. They are lenticular, very irregular bodies which are concentrated in horizons schematicaly shown in Fig. 3. The individual lenses pinch out after tens or hundreds of metres and it is almost impossible to correlate them between individual boreholes. The thickness of the breccias usually range from 3 to 7 m, occasionally it is up to 25 m. The maximum thickness of salt breccias is according to Barkáč and Grech (1988) about 40 m. The clast size of breccias varies from gravelites to boulders. The halite matrix, forming 20 - 80 per cent of deposits, consists of grey, transparent grains. The 1 to 5 mm big angular halite grains are dispersed in the halite matrix. The basis of breccias is sharp. Deposits overlying salt breccias are fissured. The fissures are filled by fibrous salt (Figs. 6, 7 and 8). The character of the breccias is best documented by archive photos from the Leopold shaft (Figs. 5, 6 and 7) which has been flooded (and conserved) a long time ago.

The sandstones most frequently form thin interlayers in claystones and siltstones. Sometimes, if they immediately underlie salt breccias, they have thickness of several metres. Sandstones are massive, rarely cross-laminated (Fig. 8), occasionally contain laminae of gypsum and anhydrite. Claystones and siltstones are laminated, rarely massive, especially if they immediately underlie breccias. Gypsum and anhydrite laminae are common throughout the entire unit.They have the same features as in unit I (see above). Intrasedimentary cubic halite laminae of several mm size occur often in siltstones and claystones. Halite crystals are rarely 1 - 1.5 cm across (Fig. 9). This type of halite is often restricted to laminae and thin beds of sandstone (Fig. 10). Individual anhydrite nodules are very sporadic in the unit. They form 5 - 7 cm thick beds, more common in the upper part of the unit. Nodules several mm across, arranged in laminae, often occur together with salt beds. Individual nodules 6 cm across are found in association with gypsum laminae. Occasional cavernous beds of kidney-shaped anhydrite are typical for this unit (Fig. 11).

Unit III

The unit is typical by beds of medium and coarse-grained sandstone interfingering with claystone and siltstone. The occurrence of sandstone decreases upward in the unit. Thick beds of conglomerate with clasts of gravelite size occur in the lower, basal part of the unit, which is *ca.* 25 - 45 m thick. The conglomerate is mostly matrix-supported, only occasionally clast-supported conglomerate occurs (Fig. 12). The conglomerate is fining upward to fine-grained sandstone and siltstone in some beds (Fig. 13). Beds of gypsum identical to those described in unit I are common. Usually they are from 1 to 2 cm thick and they are associated with 5 -15 cm thick beds of medium and coarse sandstone (Fig. 13). The sandstones are occasionally flaser bedded (Fig. 14). Gypsum selenites or their fragments are very common in these beds. The basal part is overlain by massive silstones containing gypsum laminae. The upper part of the unit is characteristical by a decrease in number of sandstone beds and anhydrite laminae frequency. The thickness of the whole unit as well as the occurrence of coarse-grained deposits decrease toward the north.

Fig. 5 Salt breccias of unit II containing irregular claystone and siltstone clasts in claystone matrix. The length of the corridor is ca. 1.8 m. Photo by Kalvoda in Polak et al., 1955.

Unit IV

Unit IV consists of alternating claystone and siltstone beds. Occasionally thin beds of fine and medium-grained sandstone occur. The deposits comprise salt breccias and halite layers 0.1 - 0.6 m thick, occasionally they form beds with thickness 1- 2 m (Fig. 16). Salt breccias are more common in the lower part of the unit. They contain claystone and siltstone clasts or fragments of their laminae (Fig. 15). Only rarely they are underlain by halite beds alternating with siltstone and claystone. Halite occurs more frequently in the upper part of the unit. Grey, transparent, cubic halite crystals are from 2 to 15 mm long. For both halite and salt breccias are typical milky-clouded crystals of halite, which are often concentrated on the top of beds (Fig. 17). Milky-clouded center zones of halite crystals have a form of cube corners and plates. Four-sided crystals occur occasionally in layers with extreme accumulation of these crystals. Gypsum and nodular anhydrite are also common in the unit. The nodular anhydrite is often arranged in laminae (Fig. 16) and thin enterolithic beds (Figs. 18 and 19). In the upper part of the unit these laminae are sometimes sandwiching halite layers.

Unit V

Unit V is composed of alternating claystones and siltstones. The difference between this unit and unit IV is in absence of salt and salt breccias. Gypsum laminae are common (Fig. 20) and nodular anhydrite similar like in the underlying units. The nodular anhydrites are prevailingly in the lower part of the unit concentrated into enterolithic beds with tightly-packed nodules (Fig. 21). The frequency of nodules and sulphates decreases upward. The thickness of the unit is from 60 to 110 m; the unit overlain by the Kladzany Formation formed by claystones with redish-violet smudges.

Interpretation of depositional environment

The sediment description shows that all the described units but unit III consist mostly of alternation of massive and laminated claystones and siltstones. Occasionally, they comprise thin beds of massive and flaser bedded sandstone. The facies association indicates fluctuation of sediment input into the basin and prevailing deposition from suspension clouds. Thin beds of flaser bedded

Fig. 6 Contact of salt breccias and overlying deposits, unit II. The deformed parts are filled by white fibrous salt. The length of the mine adit is ca. 1 m. Photo by Kalvoda in Polak et al., 1955.

sandstone probably represent a deposition by traction current. The dominance of sandstone in unit III may be related to a higher input of coarser sediment. A more detailed interpretation of depositional environment is rendered by evaporite facies.

Horizontal laminae and beds of gypsum, occurring in all units, originated by a redeposition of a primary gypsum. The deposits forming these laminae and beds may be termed as fine- and medium-grained gypsarenites and gypslutites. Regularly laminated evaporites are thought to be deposited in a shallow water in a low-energy shelf environment. Described laminated and thin-bedded gypsum has probably originated by suspension fall-out. There is only scarce information about the source of primary gypsum. An irregular and sometimes deformed gypsum laminae have been only recovered in 0.7 m thick interval (Fig. 22) in the borehole at the margin of the basin southerly from Prešov town. The gypsum is composed of 2 - 5 mm large selenite crystals without preferred orientation. This facies, representing the entire range of Soľná Baňa Formation, is not known from another boreholes and probably represents a relic of primary gypsum precipitating mostly in subaqueous environment on a coastal plain.

Nodular anhydrites, especially from recent and ancient deposits of supratidal and intertidal zones, were described by many authors (e.g. Kendall, 1984; Warren, 1991). Their formation in this environment requires short-time sea level oscillation governing the type of deposition on shelf (laminated gypsum) and evaporite mud flats. The character of nodular anhydrites in Soľná Baňa Formation suggests a different genesis explained by an intrasedimentary grow of nodules by a coalescence from residual brine in subaqueous environment. The heavier, sulphate brine probably entered the basin together with clastic gypsum and it was accumulated in non-lithified sediments.

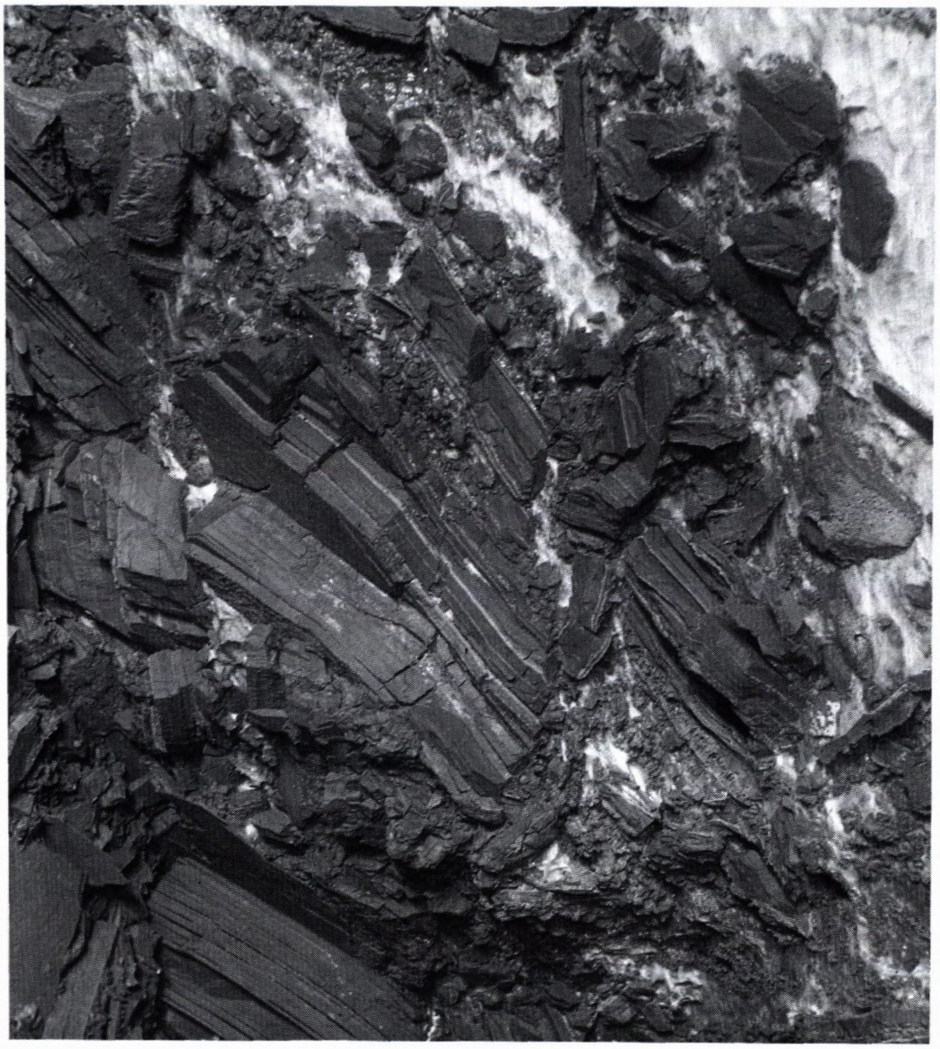


Fig. 7 Brecciated claystones and siltstones containing gypsum laminae overlying salt breccias, unit II. The fissures are filled by secondary fibrous salt. The length of the corridor is ca. 1 m.

Enterolithic layers of anhydrite (Figs. 18 and 19) with tightly packed nodules (Fig. 21) suggest short-period emergence of deposits and precipitation of nodules in salina mud flats (*sensu* Kendall, 1992). The origin of anhydrite enterolith, underlain and overlain by siltstone or claystone containing gypsum laminae without desiccation features, is explained by intrasedimentary, early diagenetic grow in extremely sulphate brine-soaked host sediments in subaqueous conditions. Both enterolithic layers of anhydrite immediately overlying halites from unit IV (Figs. 18 and 19) and laminae of small nodules are thought to be originated by an abrupt sea flooding. Sea water contained high amount of clay and silt in suspension. Their fast deposition formed a basal layer. The basal layer contained low-concentrated sulphate brine giving a rise to anhydrite nodules. This mechanism could operate during the precipitation of halite in both subaqueous and terrestrial environments.

Anhydrite in cavernous layers (Fig. 11) of unit II has a replacive character. Nodules are irregular and kidney-shaped. They were precipitated epigenetically after a dissolution of former evaporites, most likely halite.

Halite, which comprises individual layers and matrix of salt breccias, contains primary features (*sensu* Hardie et al., 1983). These features are represented by hopper crystals of halite (milky-clouded centres of crystals) precipitating on the brine - air interface (Arthuron ,1973). The crystals originate during the fast precipitation, best produced in wind-free days (Sonnenfeld ,1984). Thin salt layers overlying and underlying salt breccias of unit IV are interpreted as originated in the saline mud flat environment. Halite, containing claystone relics, probably precipitated intrasedimentary as salt crust.

Salt breccias of unit II are interpreted as solution-collapse breccias. This is supported by undisturbed bases, deformed overlying beds with fissures filled by

Fig. 8

Fig. 9

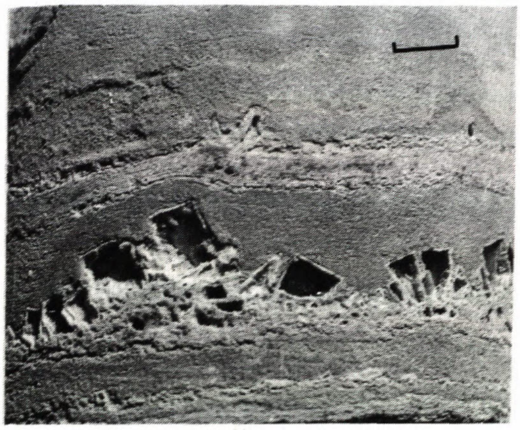


Fig. 10

Fig. 11

Fig. 12

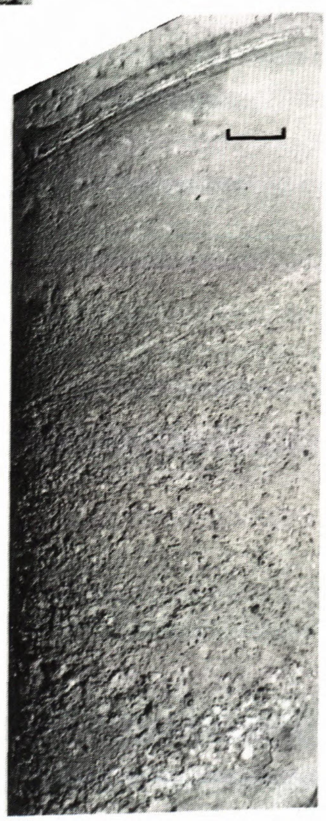


Fig. 13

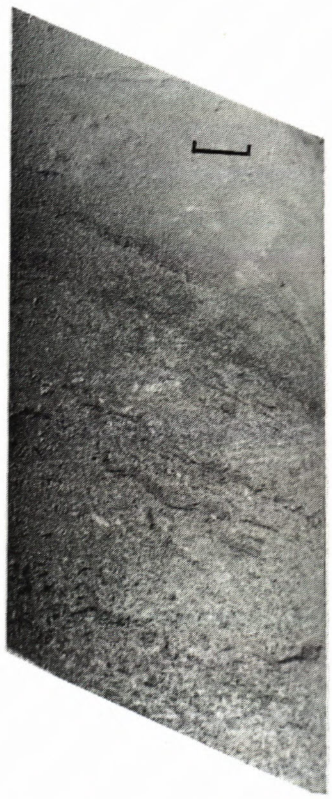


Fig. 14

fibrous salt and an absence of primary sedimentary features of halite. All these suggest to the origin of breccias by halite dissolution and collapse of non-evaporitic deposits. The dissolution by undersaturated water, which is confirmed by bromine content (14 to 32) ppm , began after the lithification of overlying beds or after the lithification of all unit II. During the collapse, the overlying beds sunk and were disturbed. As a result of lithostatic pressure the brine has been pressed into fissures, where it precipitated in form of fibrous halite oriented perpendicular to fissures. An equigranular structure of halite reflects its precipitation or crystalization during the condition of a fast mass grow. In case of more intensive sinking, the overlying beds have a character of after-collapse breccias with fissures filled by fibrous salt (Fig. 7). This type of breccias and mechanism of dissolution is also known from the Permian evaporates in the southwestern part of USA (Anderson, 1978; Johnson, 1981).

The character of breccias, the development of irregular lenses and a high lateral and vertical variability suggests that the original depositional environments were smaller coastal basins, most likely of salt pans type (*sensu* Kendall, 1992). The alternation of halite and non-evaporitic layers reflects a polycyclic development. One cycle includes a phase of flood, evaporation and most likely also a phase of desiccation as described Lowenstein and Hardie (1985).

Salt breccias of unit IV, containing fragments of siltstone and claystone laminae, are interpreted as desiccation breccias (rip-up breccias) forming in the last stage of salt-pan cycle (Lowenstein & Hardie, 1985).

Discussion and conclusion

The sedimentation of Soľná Baňa Formation in the East Slovakian Negene Basin represented a phase of regression following transgression in the Lower Karpatian (Teriakovce Formation). The formation is subdivided into five lithofacies units in the NW margin of the basin. The units reflect different depositional environments.

During the deposition of unit I, a continual communication with the Carpathian Foredeep was interrupted. A semiclosed shallow basin with smaller depressions on coastal plain has been established. In this, climatically cool and arid, environment, a precipitation of gypsum occurred. The gypsum was mostly eroded and redeposited off the coast. Sulphate brine was also redeposited which made a source for a growth of nodular anhydrite by coalescence.

During the deposition of unit II, repeated interruptions of communication with the Carpathian Foredeep caused the precipitation of halite in salt pans. The repeated phases of floods, evaporation and most likely also desiccation of these depressions controlled the origin of typical lithofacies associations comprising halite, siltstone and claystone, occasionaly also sandstone.

Halite and nodular anhydrite precipitated in surrounding salina mud flats. After a lithification of overlying beds or the entire unit II, the halite was dissolved giving a rise to solution-collapse breccias.

Unit III is the phase of deposition in a semiclosed basin controlling the gypsum precipitation. Sandstone and occasional conglomerates were deposited during events of higher sediment input.

The deposition of unit IV was again determined by partial restriction of communication between the East Slovakian Basin and Carpathian Foredeep. The character of deposits is result of a typical salt-pan cycle. Halite interfingered with claystone and siltstone originated by repeated phases of floods and evaporation. These deposits were destructed when emerged and they give rise to desiccation (rip-up) breccias. Nodular anhydrites precipitated mostly in subaerial environment of saline mud flat.

In unit V, precipitation of sulphates and their redeposition continued. The deposition in the basin retroated back to a normal marine regime as indicated by a decreasing amount of syndepositional sulphates and finely their disappearance.

Salt deposition in the Karpatian is extraordinary in the Carpathian belt (both in Internides and Externides) (*e.g.* Seneš, 1989). The reasons of this sedimentation type are specific palaeogeographic conditions. Salt deposition has not been restricted to the marginal, coastal

Fig. 8 Cross-laminated medium-grained sandstone overlying salt breccias, unit II. The fissure is filled by fibrous halite. The bar for a scale is 1 cm long.

Fig. 9 Intrasedimentary cubic halite (dark) in siltstone, unit II. The bar for a scale is 1 cm long.

Fig. 10 Originally displacive, now replacive halite growing from sandstone laminae and deforming overlying deposits, unit II. The inner walls of halite crystals are coated by a white anhydrite. On the right-hand side of the photo cornet crystals occur. In the sandstone lamina overlying halite originally gypsum crystals are replaced by anhydrite (the middle part of the photo). The bar for a scale is 1 cm long.

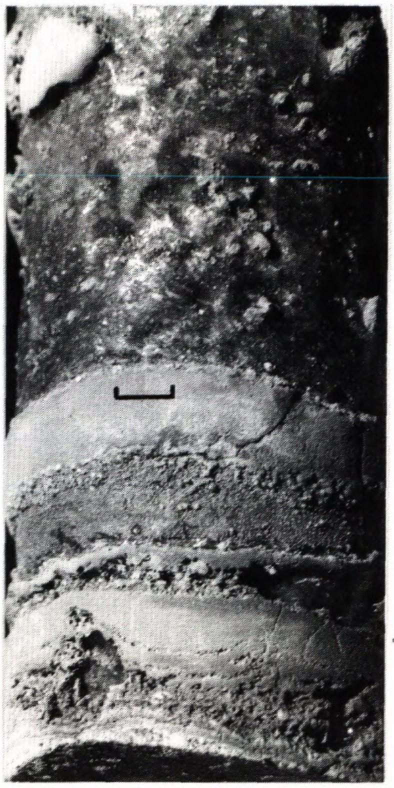
Fig. 11 The layer of cavernous, kidney-shaped nodular anhydrite, unit II. The bar for a scale is 1 cm long.

Fig. 12 Matrix-supported gravelite of unit III. Note the erosive base. The bar for a scale is 1 cm long.

Fig. 13 The upward-fining conglomerate passing into fine-grained sandstone overlain by siltstone, unit III. Gypsum laminae occur in the upper part of the siltstone bed. The bar for a scale is 1 cm long.

Fig. 14 Flaser bedded, upward-fining sandstone. The bar for a scale is 1 cm long.

Fig. 15



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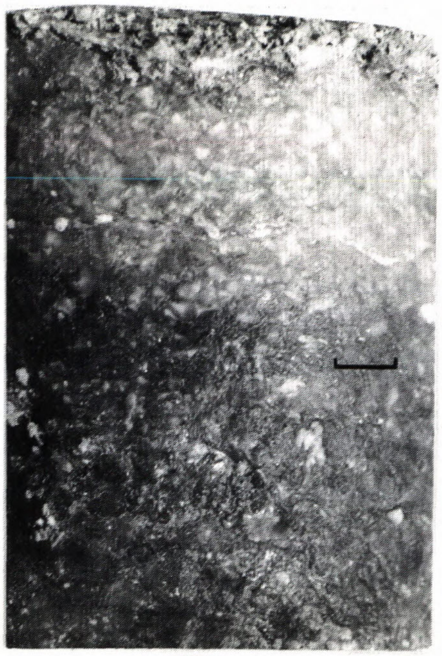
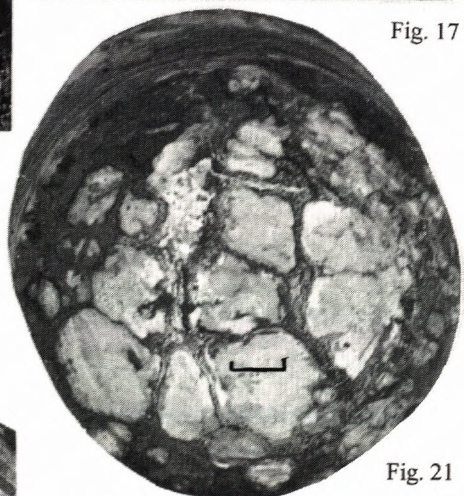


Fig. 17

Fig. 18



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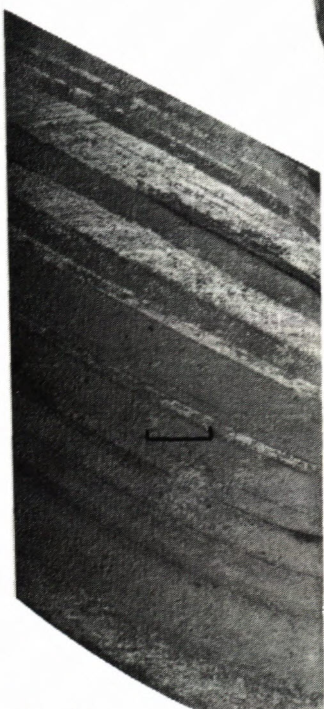

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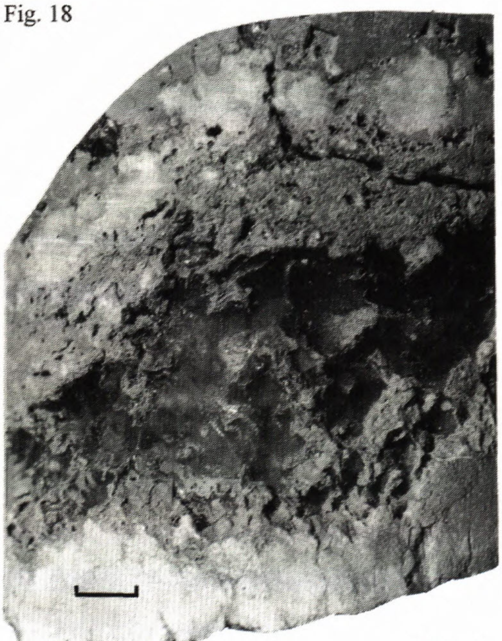

Fig. 19

Fig. 22

plain areas of the basin; on the contrary, the boreholes in the centre of the basin show that salt occurs in the whole basin area (Fig. 2). Unfortunately, even if salt occurrence is proved in the central areas, there are not enough of recovered sediment for sedimentological study. Thin layers of halite, described by Rudinec (1978) from the borehole Trhovište 26, may have been precipitated from both surface brine of deeper basin and brine in smaller depressions of salt pan type. The cause of evaporitic deposition was the existence of a barrier, which restricted a communication between East Slovakian Neogene Basin and Carpathian Foredeep. This barrier was most probably a tectonic sill located in the area of the outer flysch zone. We assume the partial restriction of communication (gypsum and anhydrite sedimentation) or entire isolation of the basin (halite precipitation) giving a shallow-water-deep-basin type (Kendall, 1992, Fig. 35). The origin of sollution-collapse breccias is related to the unit III. Coarse-grained deposits of this unit and their spatial distribution indicate an uplift of the SW basin margin and a subsidence along NW-SE faults. Undersaturated sea water or brackish water (caused by a drop in salinity due to fresh water input by flows distributing coarse-grained sediments) migrated along the system of these faults and caused the dissolution of halite from the underlying unit II.

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Fig. 15 Salt breccias composed of halite matrix, clasts and laminae fragments of claystone and siltstone, unit IV. The bar for a scale is 1 cm long.

Fig. 16 Salt breccias and halite sandwiched by laminated siltstone, unit IV. On the base and top of halite light nodules of anhydrite. The siltstone on the base contains a conspicuous displacive and replacive halite.

Fig. 17 Halite with accumulation of milky-clouded crystals, unit IV. The bar for a scale is 1 cm long.

Fig. 18 Halite overlain by enterolithic layer of nodular anhydrite, unit IV. Space between nodules filled by siltstone. The bar for horizontal scale is 1 cm.

Fig. 19 Paramorphosis of a clear halite cement after original displacive halite in the middle part of the photo, unit IV. The overlying and underlying beds are composed of light, enterolithic nodular anhydrite. The overlying bed is deformed by displacive halite. The bar for a scale is 1 cm long.

Fig. 20 Laminated siltstone composed of gypsum and siltstone laminae, unit IV. The bar for a scale is 1 cm long.

Fig. 21 Enterolithic layer of nodular anhydrite, bird-eye view. Unit V. The bar for horizontal scale is 1 cm.

Fig. 22 Irregularly laminated and soft-deformed gypsum as a relic of primary precipitating gypsum. The bar for a scale is 1 cm long.