Correlation and sedimentary history of the Badenian gypsum in the Carpathian Foredeep (Ukraine, Poland, and Czech Republic)


Key words: Badenian, evaporites, gypsum, sedimentary basins, correlation, Carpathian Foredeep, Ukraine, Poland, Czech Republic

In the middle Miocene Badenian evaporite basin of the Carpathian foreland basin, broad zones of sulphate deposits occur in the marginal parts, and narrow zones of chloride sediments are restricted to the basin center (Fig. 1). The origin of these evaporites is related to the salinity crisis at the end of Middle Badenian. The time and facies relations of evaporites occurring in marginal and central parts of the Carpathian foreland basin are still unclear and different correlation has been proposed for particular parts of the basin (Petrichenko et al., 1997). However, it is possible to correlate particular marker beds in both domains over a distance of hundreds of kilometers (e.g. Garlicki, 1994; Peryt et al., 1994, 1997) suggesting common controls of evaporite deposition regardless of the geological setting.

In the lower part of the gypsum section in the peripheral part of the basin, a unit built of blocky crystalline intergrowths occurs (see photo on the front page of this issue). It was recorded in major part of the Carpathian Foredeep, from Kobefice (Moravia, Czech Republic) in the west (see Peryt et al., 1997) to Odayev (eastern Galicia, West Ukraine) in the east. In some sections in eastern Galicia, the place of blocky crystalline intergrowths is taken by nodular, secondary gypsum (Fig. 4; Peryt, 1996), and further toward the east by a unit of stromatolitic gypsum. The transition between the unit of giant gypsum intergrowths and the unit of stromatolitic gypsum occurs in the area located between Odayev and Zalishchyky, and its expressed by the occurrence of intercalar...
Fig. 4. Example of gypsum section

Fig. 5. Marker bed of microcrystalline gypsum, Tovtry

tion (a few tens of cm thick) of crystalline gypsum within the stromatolite unit (Fig. 2).

Above, a characteristic, thin (10–40 cm) bed of characteristic microcrystalline ("alabastine") gypsum occurs (Figs 3–5); in many places this unit is preceded by a few thinner beds of microcrystalline and/or stromatolitic gypsum intercalated with selenitic gypsum (Fig. 6; cf. Kasprzyk, 1993). Higher up, a unit of sabre gypsum occurs (see also photos on page 795 of this issue, and the lower photo on the back of this issue). It contains, in its upper part, a thin (usually 10 cm thick) intercalation of clastic gypsum (Fig. 4).

Towards the basin margins, the stromatolitic gypsum replaces the sabre gypsum, and a possible counterpart of clastic gypsum intercalation in the latter is a lenticular layer/lamina of limestone occurring in some sections composed of stromatolitic gypsum (Fig. 7). This limestone has $\delta^{18}O$ and $\delta^{13}C$ values that are characteristic for contemporaneous marine limestones: between 0.19 and $-4.94\%e$ (except of Kudryntsi where they are $-5.91$ and $-7.93\%e$) and $0.85$ and $-2.55\%e$, respectively.

In the area located between Seret and Zbruch rivers in West Ukraine, vertically elongated dome structures, 5 to 10 m across, occur (Turczynow & Andrijczuk, 1995). The dome nuclei are composed of stromatolitic gypsum, and the dome peripheries are built of sabre gypsum crystals that differ from those earlier described from southern Poland (e.g. Bąbel, 1986; Kasprzyk, 1993) in that they are thinner, they are bent upward, and consist of many subcrystals (see the lower photo on p. 795
Odayev  Gavryl'ak  Babyn  Verenchanka

giant gypsum intergrowths  nodular gypsum  stromatolitic gypsum  alabastrine gypsum
grass-like gypsum with interbeds of alabastrine and/or stromatolitic gypsum  sabre gypsum  nucleation cones
stromatolitic gypsum with common intercalations of alabastrine gypsum  clastic laminated and redeposited gypsum  moulds of halite crystals  banded gypsum  druse aggregates of gypsum crystals  crystalline gypsum  crinkled laminated gypsum
clay  gypsum breccia  planar laminated gypsum

Fig. 7. Lenticular limestone bed in the upper part of the stromatolitic gypsum section at Kadryntsi; the top of limestone bed is below the elbow of right hand of A.V. Poberejiski

Fig. 6. Intercalations of selenitic gypsum and stromatolitic/alabastrine gypsum below the marker bed of microcrystalline gypsum, Verenchanka

and the upper photo on the back of this issue; Turchinov, 1997).

The upper part of the gypsum sequence consists of interbedded laminated gypsum, gypsiferous claystones and gypsum breccias (Petrichenko et al., 1997; Fig. 4). The redeposition phenomena are common in that part of the gypsum section (Peryt & Jasionowski, 1994; Peryt et al., 1997). In the central part of the basin, the place of gypsum is taken by anhydrite, and the redeposition features abound throughout the entire sulphate section that is built of laminated anhydrite intercalated with anhydrite breccia (Peryt et al., 1998).

The middle Miocene Badenian gypsum of Carpathian Foredeep was mostly deposited, in the lower part of the stratigraphic section, in a vast brine pan. This brine pan was characterised by a facies mosaic that reflects an interplay of concentrated brines from the central part of the evaporite basin and diluted brines, possibly due to the influx of continental meteoric waters (Peryt, 1996). Although individual depositional features and facies types in the Badenian may be explained by comparison with modern salinas (e.g. Orti Cabo et al., 1984), lateral persistence of thin beds over large areas with only minor changes in thickness and facies indicates that they formed on broad, very low relief areas which could be affected by rapid transgressions. A similarity of evaporite facies through the Badenian basin seems to be related to an extrabasinal
control that did not obscured important local and regional tectonics. Intrabasinal marker beds occurring in the evapo­rite sequences record distinct phases of brine body evolution (frequent refreshing episodes) or diagenesis related to sub­aerial exposure.

In the peripheral part of the basin, gypsum is overlain by marine limestone (Ratyn Limestone). The boundary between gypsum and limestone is the sequence boundary, and gypsum deposits prior to carbonate deposition underwent an important faulting phase and subsequent erosion.

References


Paleoecology and organic matter in the Late Badenian and Early Sarmatian marine basin of the Polish part of the Carpathian Foredeep

Iwona Czepiec*, Maciej J. Kotarba**

The studies aim to determine both the ecological and geochemical conditions of the Late Badenian and Early Sarmatian sedimentary basin located in the outer part of the Carpathian Foredeep. Particularly interesting are: depositional environment of organic matter, depth of the basin and water temperatures. The Late Badenian sea was presumably only slightly deeper than the outer shelf, i.e. about 200 meters. The warm climate resembling that of the warm temperate zone resulted in surface water temperatures 17–20°C. In the Sarmatian the sea depth was initially about 30–50 meters thus, the existence of submarine meadows was inferred. Then, progressing shallowing to about 10 meters took place. The Sarmatian sea was a warm basin with temperatures roughly corresponding to those of the Late Badenian ones. Organic matter deposited during both the Badenian and the Sarmatian reveals terrestrial origin. Organic matter in the Late Badenian and Early Sarmatian strata is immature or, at most, early matured but at depth below 3000 meters. Very low correlation of both the concentrations and the maturation degree of the organic matter with its depth of occurrence suggest the similarity of sedimentary environments in the whole Miocene succession and the lack of thermal transformation after deposition. Almost exclusive occurrence of the humic organic matter points to the fast and rhythmic supply of terrestrial clay matter to the deltaic environments in the shallow Miocene basin. A rapid sedimentation of terrestrial, deltaic sediments took place in the Miocene basin, therefore the humic organic matter (type III kerogen) prevailed there and the marine type II kerogen was hardly detectable.

Key words: areal geology, Badenian, Sarmatian, basin analysis, foraminifers, paleoecology, organic materials, Carpathian Foredeep, Poland

Introduction

The joint studies on microfossils and organic geochem­istry of the Late Badenian and Early Sarmatian sediments aim to determine both the ecological and organic matter deposition conditions in the sedimentary basin located in the outer part of the Carpathian Foredeep. Special attention was paid to depositional environment of the organic matter (OM), depth of the basin and water temperatures. These data are crucial for the reconstruction of generation and accumulation systems of natural gases (Szafran, 1990; Kotarba et al., 1998a). Such preliminary reconstruction has been based upon the results of routine geochemical analyses of hydrocarbons (Rock Eval and extraction) as well as upon the studies on microfossil assemblages with the reference to other fossil remains (particularly to their taxons composition and degree of preservation in the sediment).

The study has been undertaken as a part of research projects of the Carpathian Foredeep financed by the State Committee for Scientific Research in Warsaw (grant No. 9 9214 92.03) and National Fund for Environmental Protection and Water Management (grant No. 2.14.0100.00.0). Material and methods

The source materials were 85 core claystone/mudstone samples of autochthonous Late Badenian and Early Sarmatian sediments of the Carpathian Foredeep collected from the following 11 wells (Fig. 1): Brzóza Stadnicka 1 (BS 1), Czarny Las 3 (CL-3), Dobra 4 (Do-4), Jaksmance 257 (J-257), Jodłówka 4 (Jo-4), Komorów 2 (Km-2), Łazy 9