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

Tadeusz Marek Peryt*, Marek Jasionowski*, Stanislav Karoli, Oleg I. Petrichenko***, Andrey V. Poberegski***, Igor I. Turchinov******

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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 Kobeřice (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 intercala-

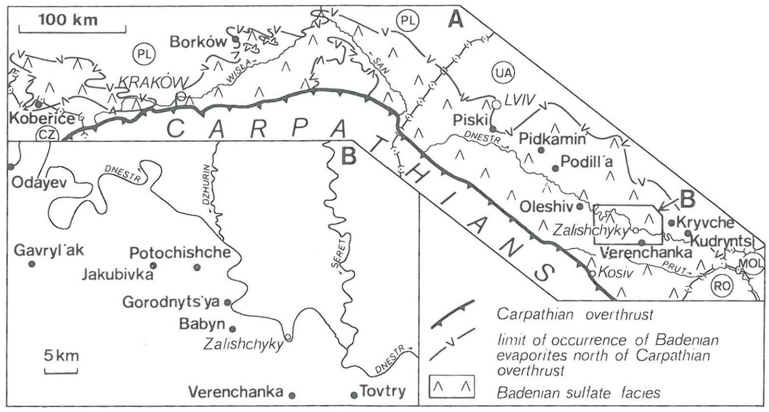

Fig. 1. Occurrence of the Badenian sulphate deposits in the Carpathian Foredeep (Czech Republic, Poland, Ukraine, and Moldova), showing the location of outcrops referred to in the text and shown on the cover photos

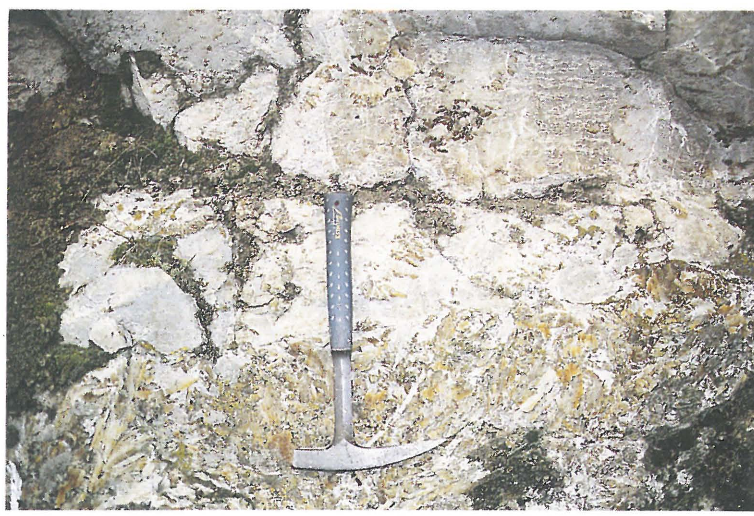

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Fig. 2. Crystalline gypsum overlain by stromatolitic gypsum, Gorodnyts'ya. All photos by T.M. Peryt

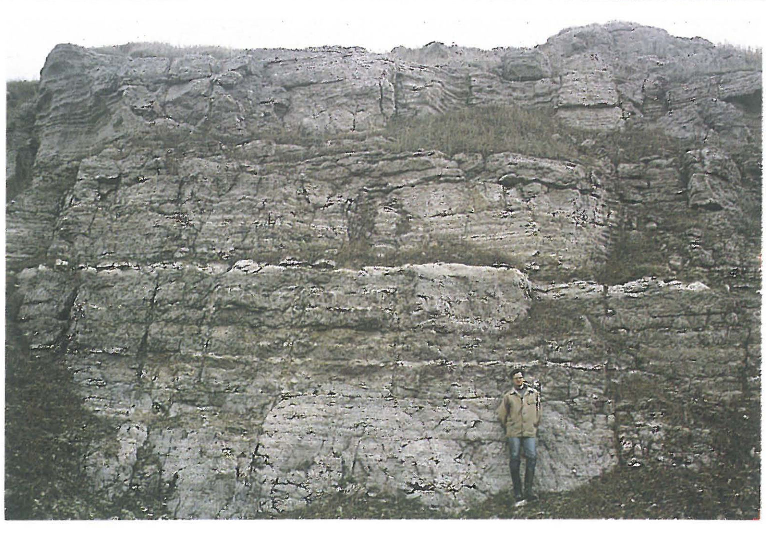

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Fig. 3. Marker bed of microcrystalline („alabastrine") gypsum seen in the middle of the outcrop, Oleshiv

*Państwowy Instytut Geologiczny, ul. Rakowiecka 4, 00-975 Warszawa, Poland, e-mail:tper@pgi.waw.pl

**Geological Survey of Slovak Republic, Werferova 1, 040 11 Košice, Slovakia

***Institute of Geology and Geochemistry of Combustible Minerals, NANU, Naukova 3A, 290053 Lviv, Ukraine

****Lviv Geological Survey Expedition, Turgeneva 33, 290018 Lviv, Ukraine

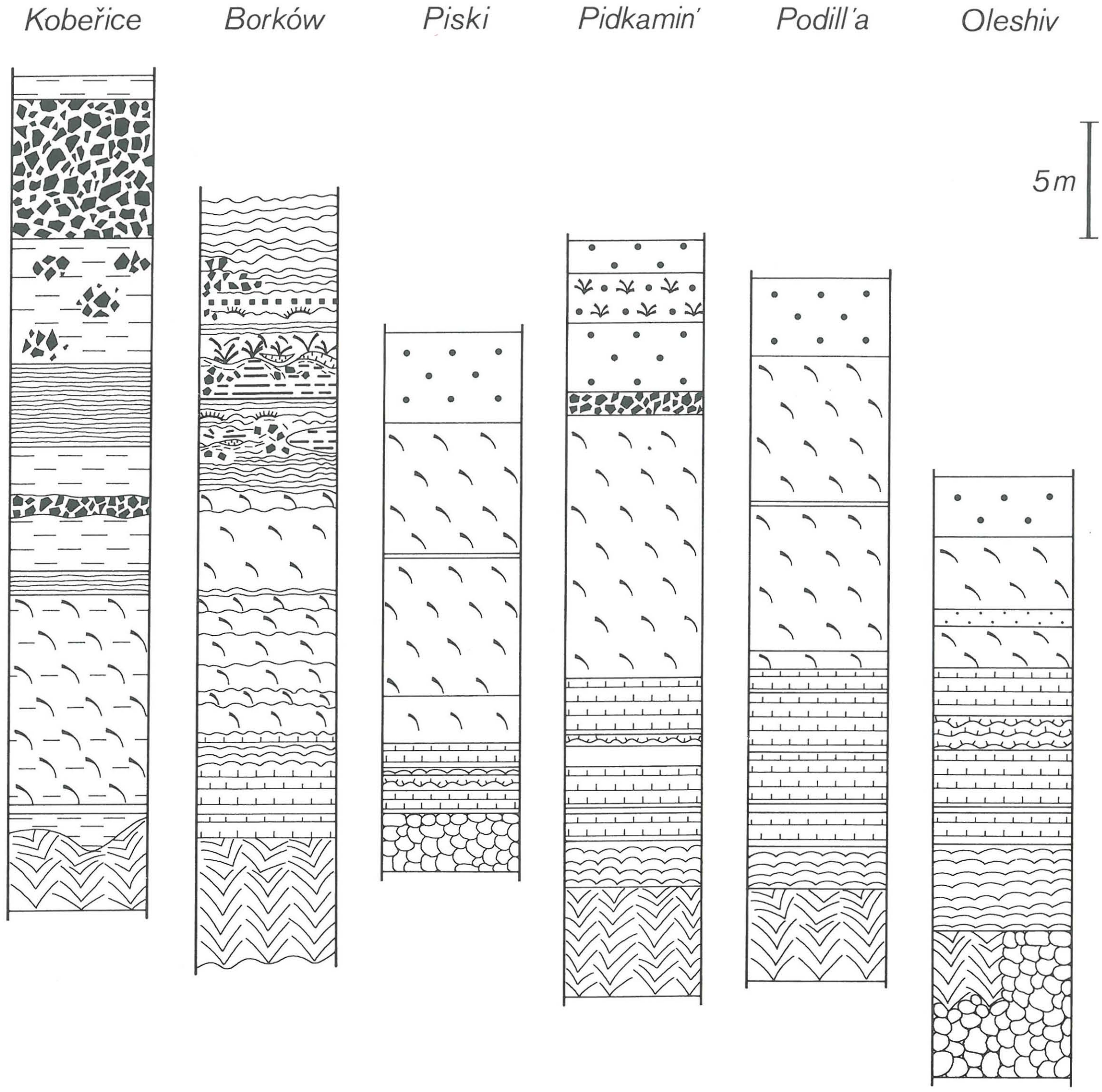

Fig. 4. Examples of gypsum sections

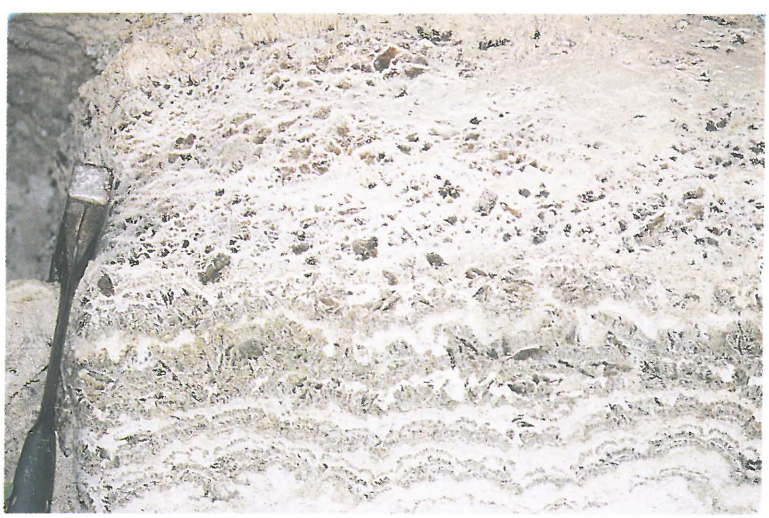

Fig. 5. Marker bed of microcrystalline gypsum, Tovtry

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

Above, a characteristic, thin (10–40 cm) bed of characteristic microcrystalline („alabastrine") 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‰ (except of Kudryntsi where they are –5.91 and –7.93‰) and 0.85 and –2.55‰, 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

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

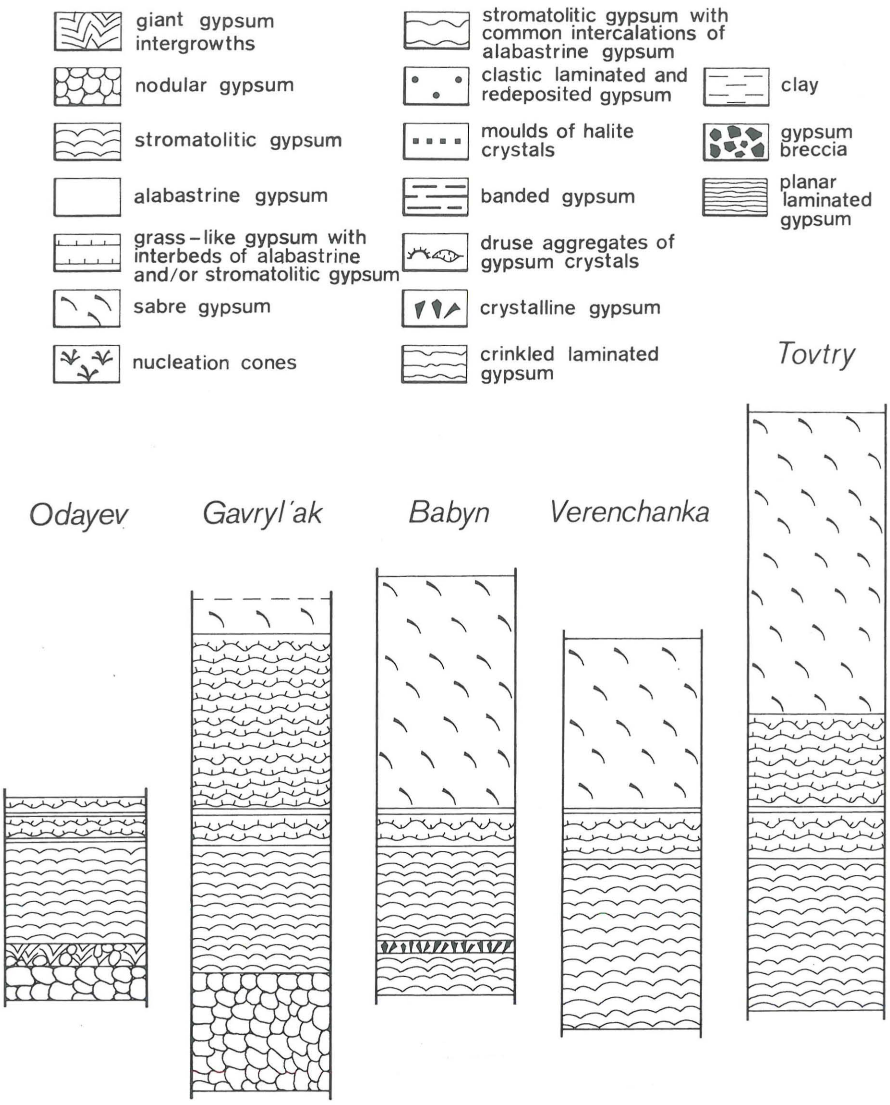

Fig. 7. Lenticular limestone bed in the upper part of the stromatolitic gypsum section at Kudryntsi; the top of limestone bed is below the elbow of right hand of A.V. Poberegski

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

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.

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