

PALEOGEOGRAPHY OF THE BADENIAN SALT BASIN (CARPATHIAN FOREDEEP, POLAND AND UKRAINE)

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Abstract: During the Early to Middle Miocene evolution of the Carpathian Foredeep Basin two salinity crises were recorded—the Early Burdigalian and Late Badenian ones. The Late Badenia salts developed in two separate an echelon-like sub-basins, the western and eastern Carpathian ones. During the Late Miocene movement a substantial part of the salt deposits were incorporated in the folded zone in front of the Carpathians –Zgłobice Unit in the west and the Sambir and sub-Carpathian units in the east (Ukraine and Romania respectively).

Key words: Carpathian Foredeep, paleogeography, salt basin

Introduction

The Early to Middle Miocene Carpathian Foredeep Basin (CFB) developed on the southern edge of the European Platform at the front of the overriding Carpathian accretionary wedge. It was caused both by the loading effect of the Carpathians stack of nappes and of the deep subcrustal load of the downgoing plate (Krzywiec & Jochym, 1997, Oszczypko 1998). That flexural depression migrated in front of the advancing pile of nappes The CFB can be subdivided into two sub-basins, the inner and the outer ones (Oszczypko, 1998). The inner sub-basin, located beneath the Carpathian nappes, is composed of Lower to Middle Miocene terrestrial and marine deposits, whereas the outer sub-basin is filled with Middle Miocene marine deposits up to 3 500 m thick. The Carpathian Foredeep Basin was affected by two salinity crisis, the first more local of the Early Burdigalian age and second more general of the Late Badenian age (Andreyeva-Grigorovich et al., 1999, Marunteanu et al., 1999). During the latter crisis throughout most of the foreland basin, the eavaporites are in the form of gypsum, whereas in the more internal, isolated areas halite and sporadically potash evaporates were deposited.

Main stages of the Carpathian Foredeep evolution

At the turn of Early Burdigalian the Late Krosno (Polyanytsa) terminal flysch basin shifted towards the northern part of the Outer Carpathian domain (Ždanice unit - Czech Rep., Boryslav-Pokuttya unit - Ukraine, and Marginal Folds unit - Romania), and eventually this basin underwent dessication [(Krepice Fm. in Moravia, evaporite of the Vorotysche Fm in Ukraine (Andreeva-Grigorovich et al., 1997) and the Salt Fm in Romania)]. In the Western Carpathians the dessication event was followed by the Intra Burdigalian phase (Otnagian compressive tectonic event), when the marginal part of the Outer Carpathians (Silesian, Sub-Silesian and Skole units) was folded, overthrust and uplifted (Oszczypko, 1998). The Carpathians overrode the platform and caused flexural depression of the foreland. The flysch olistoplaque, recognised by boreholes in the Sucha Beskidzka-Cieszyn area in Poland, probably records that period of overthrusting (Oszczypko & Lucińska-Anczkiewicz, 2000). In the Ukrainian Carpathians this period of compression can be represented by the Truskawiec olistolite in the Vorotysche Fm.

The Late Burdigalian (Karpatian) molasse basin (inner foredeep), that partly developed on the top of the advancing Carpathian front and on the platform, was dominated by the terrestrial deposition. This basin was filled up mostly with sediments derived from the emerged platform and from the front of the Carpathians [(Stryzawa Fm (Poland), Dobrotiv and Stebnyk formations (Ukraine) and red beds in Romania (Magiresti and Hirja beds) (Oszczypko, 1998, Ślącza 1977, Burov et al., 1974).

At the beginning of the Early Badenian (Langhian) the axes of subsidence migrated towards the north. This enabled new marine transgression onto the foreland plate and marginal part of the Carpathians. The sedimentation started generally by conglomerates which in the western part of the foredeep pass upward into a series of claystones and mudstones with rare interbedded sandstones whose thickness reaches 1000 metres (Skawina Fm.). Towards the north and east the thickness of these sediments markedly decrease to tens of metres or to several metres. In the Sambir zone the Stebnyk Fm, pass upward into grey marly shales with sandstones intercalations (Balych Fm) and grey-greenish marly clays and marls (Bohorodchany Fm.). The latter deposits lay directly on the Meso-Paleozoic rocks of the more external part of the platform. At least the upper portion of the Stebnyk Fm as well as Balych Fm. represent the Early Badenian age, and are an equivalent of the Skawina Fm. On the turn of the Early Badenian basin became more shallow..

At the nannoplankton boundary between zones NN5 and NN6 or in the lower part of NN6 zone (Andreyeva-Grigorovic et al., 1999, 2002, Crihan M., 1999 Marunteanu., 1999, Marunteanu et al., 1999) the open marine conditions in the CFB evolved into a restricted evaporite environment. The new evaporite basin developed in the area between Upper Silesia in the NW and the Danube River in the SE. The broad, shallow-water parts of the evaporite basin, both on the platform as well as on the Carpathian fold and thrust belt, were dominated by sulphate and carbonate facies, whereas the narrow and deeper, basinal part, located along the Carpathian front, was occupied by chloride-sulphate facies. At that time probably several halite sub-basins partly independent developed. Salt sedimentation took place in the outer sub-basins in the western (Polish) part of the CBF, between the Rybnik, Kraków and Przemyśl, further to the east (Ukraine)- in the outer and inner sub-basins, while in Romania both in the inner sub-basin as well as on the Tarcau Nappe (Romania). This was the effect of more advanced Carpathian thrusting onto the platform in the western part of the CFB.

The main sub-basins were situated in front of advancing Carpathians - Wieliczka - Bochnia sub-basin with halite in the West and Kalush sub-basin with halite and potash evaporites in the East. The direct connection between them is still controversial. Hitherto observed data suggests rather that the Kalush sub-basin occupied more internal position (Djinoridze, 1980) than Wieliczka-Bochnia sub-basin (comp. Garlicki, 1979). The other small basins were situated in more outer positions, Kolomya sub-basin in the SE part of Ukrainian Foredeep (Turchinov, 1999), and Rybnik sub-basin in the NE part of the Polish one. There is a possibility that halite deposit encountered in several boreholes, like Bochnia 1 and Kłaj 1 from Bochnia created a small separate basin similar to the previous one or it was a part of the main Wieliczka-Bochnia Basin.

The deposition of the Badenian evaporites were strongly influenced by tectonic activity, especially near the Carpathian front in the halite sub-basins. During the quiet period rock salt precipitated forming layered salt, whereas during more active tectonic periods redepositional processes and large scale gravity mass movements took place (Ślącza & Kolasa, 1997). In Wieliczka and Bochnia area saltstones, salt breccia and olistostromes were deposited by density currents and mass-movements. The clastic material was derived from southern margin of the salt sub-basin and/or from the front of the Carpathians. In the more distal areas eg. Kłaj or Rybnik sub-

basins redeposition also took place but resedimented deposits are represented by pebbly mudstones with salt grains (Zuber type deposits) only and deposited by high concentrated turbidity currents. Also in the eastern part of the foredeep basin, in Kalush sub-basin, the influence of tectonic activity is visible although not so strong as in the western part. In Kalush salt mine precipitated salt prevail over redeposited saltstones and pebbly mudstones (see Chlebowski, 1947). However, locally as in borehole 304 near Kalush redeposited sediments prevailed. The anhydrites redeposited by mass flows, triggered by earthquakes, were recognized even in the central part of the Polish Carpathian Foredeep by (Peryt, 2000).

The Badenian salinary crisis terminated during the upper part of the Late Badenian (higher part of NN6 zone) and open marine conditions were established. The open marine deposits (Chodenice and Grabowiec beds in Poland and Kossiv Fm. in Ukraine) are represented by clayey shales, clays, and mudstones interbedded by sandstones. At the same time depocenters shifted towards north-east. The sedimentation terminated during the Sarmatian (Krakowiec beds in Poland and Dashava Fm. in Ukraine).

During the Sarmatian time the main halite sub-basin was striped out together with a part of the underlying barren deposits (Skawina and Balych/Stebnyk fms.) from the platformian substratum by advancing Carpathian orogen and pushed towards the north in its front on more external Badenian and Sarmatian deposits. As an effect two folded unit in front of the Carpathian was developed - Zgłobice Unit along the northern Carpathians and Sambir- Rozniativ and Sub-Carpathian units in Ukraine and Romania respectively

Occurrence at the top of the Zgłobice and Sambir-Rozniativ succession the deposits of similar age represent by nannoplankton zone NN6/7 (Andreeva-Grigorovich et al., 2002) suggest that both units were formed by the tectonic processes generally in similar time.

Conclusions

In the Early/ Middle Miocene Carpathian Foredeep two salinary crises took place: the Early Burdigalian connected with dessication of residual flysch basin (Eastern Carpathians) and younger (Late Badenian), which embraced whole Carpathian Foredeep in Poland, Ukraine I Romania. During the both crises in the deeper part saline sub-basins developed at the front of the Carpathians. During the younger crisis two main saline sub-basins along the advancing Carpathian orogen developed – in

the Eastern Carpathians Kalush sub-basin and in the Western Carpathians Wieliczka - Bochnia sub-basin. The both basins were separated in the Przemyśl area, and the Wieliczka-Bochnia salt sub-basin occupied more external position than the other one. However the both sub-basins passed through similar environmental and tectonic stages: terrestrial-brackish, open marine, hypersaline, open-marine, and brackish during the Middle Miocene (Badenian and Sarmatian) evolution. Biostratigraphical investigation shows that sedimentation of salt in the both younger sub-basins took place during the Late Badenian (nannoplankton zone NN6). Apart of precipitated salt, in all salt sub-basins also redeposited sediments occur marking strong tectonic activity. During Sarmatian both main younger sub-basins were striped off from the substratum, folded and overthrust on the autochthonous Badenian sediments. The present work was supported by Polish Scientific Research Fund (KBN) Project 4461/T12.

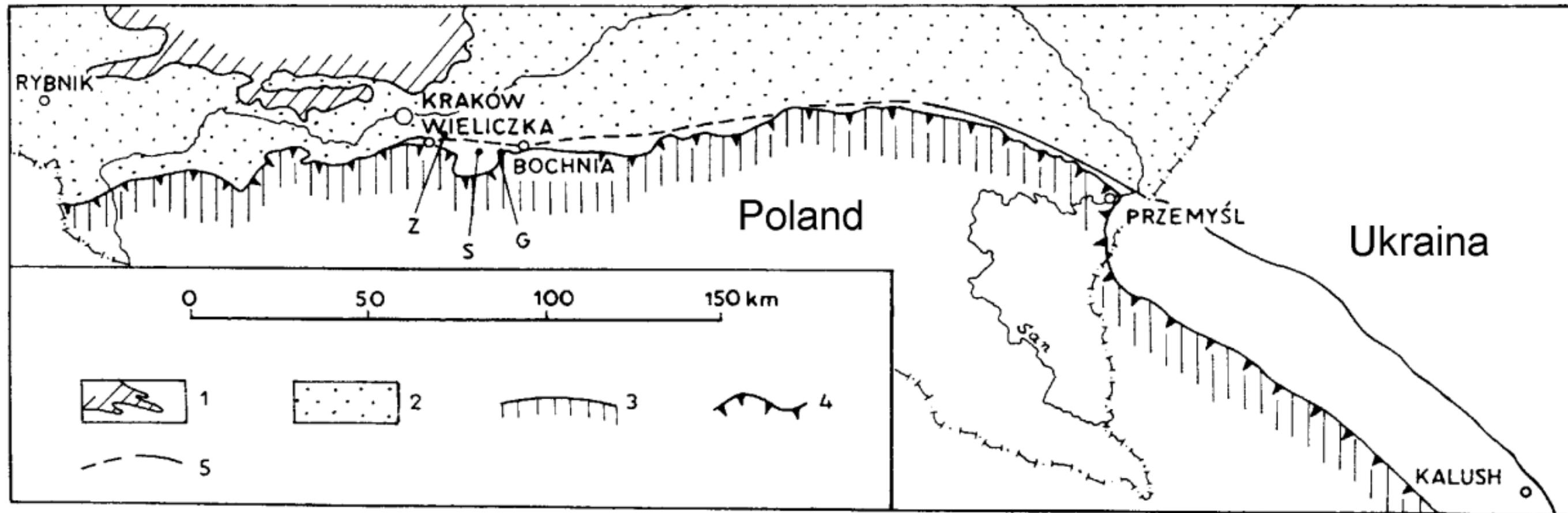
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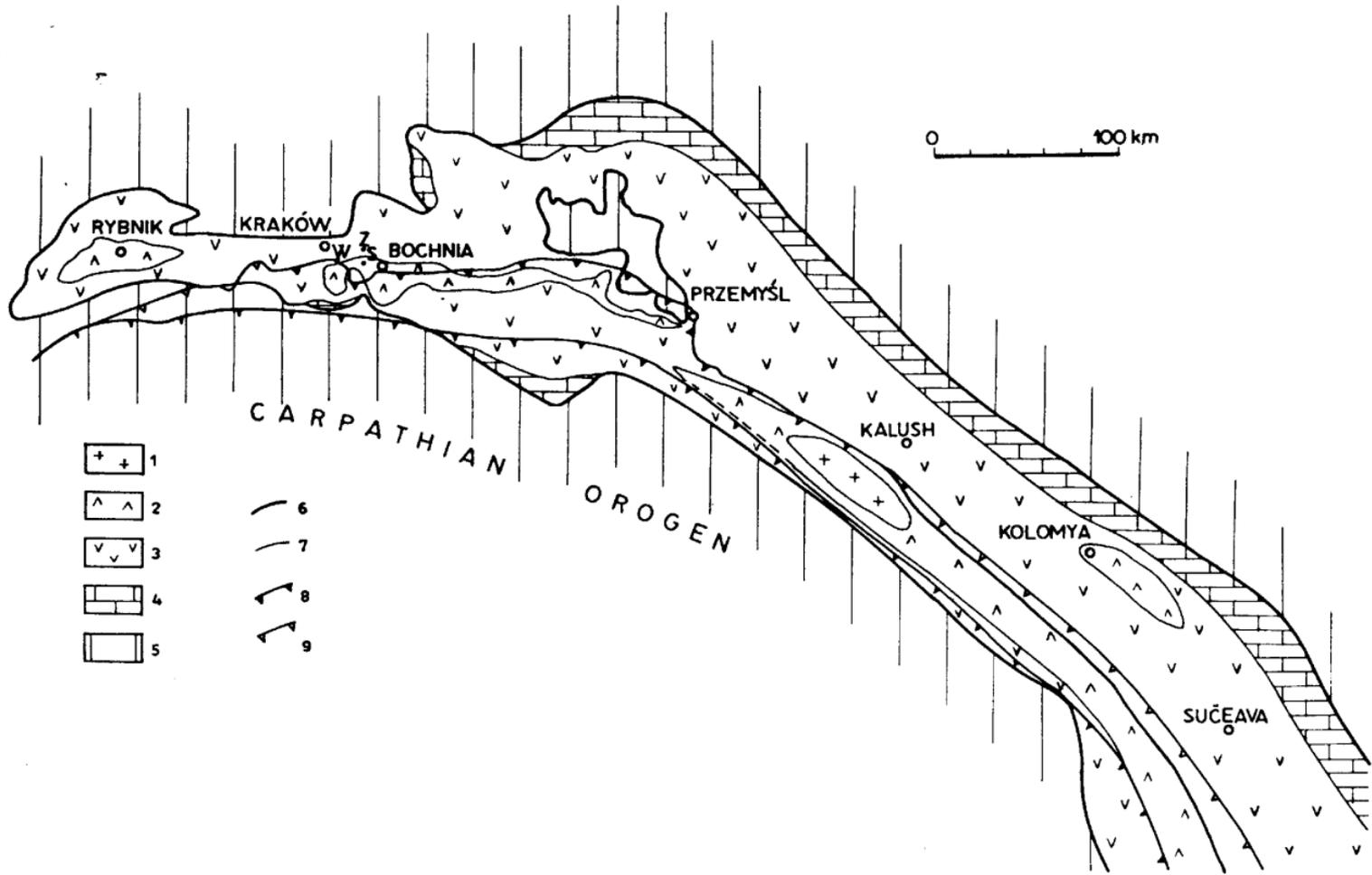
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Fig. 1. Paleogeographic map of the Late Badenian time.

1. Potash salt,
2. Halite,
3. Sulphate deposits,
4. Limestones,
5. Land,
6. Boundary of Foredeep basin.
7. Boundary of lithofacies,
8. Margin of the Carpathian orogen,
9. Present day margin of the Carpathians





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