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Miocene evaporites of the Carpathian foredeep basin and their role in contractional tectonics - 250 years of perspective

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The Carpathian foredeep basin developed in front of the advancing Carpathian orogenic wedge. Foredeep infill consists of the Miocene (Eggerian to Sarmatian) sedimentary sequence and includes important evaporitic formation. Presently, deformed foredeep sedimentary infill forms the most external thrust sheet (the Zgłobice unit) located in front of the main Outer Carpathian flysch (pre-Miocene) nappes. The foredeep evaporites have been continuously exploited in the Kraków region, in the Wieliczka and Bochnia salt mines, with the beginning of underground mining operations dating back to the turn of the 12th to 13th centuries.

Illustrations of tectonic structures of the Miocene evaporite sequence were first published by Christian Schober in 1750 and very clearly show complex folds and thrust deformations. Recent study showed that the large-scale intrasalt structure is dominated by north-vergent asymmetric folds and associated thrust/shear zones. This is repeated at smaller scales, where anhydrite-mudstone layers within the rock salt form folds with long, gently-moderately south-dipping backlimbs and short, steep to overturned forelimbs. Fold axes trend east-west but have highly variable plunges. Folded and thrusted boudins and folds cut by late extensional faults indicate complex spatial and temporal variations in the local stress field.

In late 18th and early 19th century, in the course of geological studies stimulated by intensified underground salt exploitation, the first more regional cross-sections showing the relationship between the deformed Miocene salt-bearing succession and the Carpathian orogenic belt were published by prominent geologists such as R. Townson, F.S. Beudant, G.G. Pusch, L. Zejszner and R.I. Murchison. A cross-section published by Hrdina in 1842 best captured much of what is accepted today for the overall internal geometry of the Wieliczka area, with three clearly defined tectonic slivers (contractional duplexes) developed within the evaporite-bearing Miocene succession.

Recently, due to the availability of high-quality 2D and 3D seismic data calibrated by numerous exploration wells, geological studies entered a new phase of imaging and analysis of contractional salt tectonics active along the Carpathian front in Miocene. The thick foredeep evaporites, present between Kraków (Wieliczka) in the west and Pilzno in the east, facilitated the development of wedge tectonics and partly syn-depositional backthrusting and formation of complex triangle zones with their cores filled by strongly deformed Miocene evaporites. Lateral variations in structural style of the frontal Carpathian orogenic wedge were controlled by thickness and facies variations of the evaporitic succession (rock salt vs. anhydrite) and the morphology of the pre-Miocene Meso-Paleozoic substratum (lower plate). Deep (> 1 km) erosional paleovalleys, incised following Paleogene inversion of the Permo-Mesozoic Polish Basin, controlled deposition of the Miocene foredeep evaporites. They also formed bounding morphological buttresses that led to local concentration of compressional stresses and thereby triggered the formation of complex fore- and backthrust zones detached within the Miocene evaporites. This frontal Miocene salt-related thrust system of the Carpathian wedge is mostly thin-skinned with some exceptions such as the Gdów tectonic “embayment” (east of Kraków) where thick-skinned thrusting coincides with a zone of reactivated deeper faults that also influenced deposition of the Miocene evaporites.