Recrystallization Features in Rock Salt from Polish Zechstein Basin – Preliminary Results of Investigations

Stanisław BURLIGA

Institute of Geological Sciences, Wrocław University, pl. M. Borna 9, 50 – 204 Wrocław, Poland

Polish Zechstein Basin constituted the eastern part of European Zechstein Basin in which huge amount of evaporite deposits accumulated throughout the Late Permian. During subsequent geological periods, the deposits became covered by complex sedimentary sequence of variable thickness and, in places, strongly deformed. Zechstein sediments now occur both in flat-lying, apparently undisturbed settings as well as in the form of complicated salt structures piercing through the Mesozoic cover. This study presents preliminary results of microstructural investigation on rock salt in such two contrasting occurrences: almost flat-lying beds from the marginal part of the basin (Foresudetic Monocline), and a diapiric structure from the central part of the basin (Kłodawa salt structure). The observations were made on rock salt sampled directly in mine excavations, and the techniques applied included analyses of thin sections in transmitted light and of polished, etched sections in reflected light.

Rock salt at both localities shows variable grain size of halite, ranging from 2 mm to 2 cm in diameter. The size may vary at a sample scale as well as at a scale of a set of beds. A similar variation was observed in grain shape fabric: some samples possessed well developed fabric, other poorly visible fabric. The above features indicate that grain size and fabric are most likely controlled by tectonic deformation that affected rock salt. Besides halite, a variable amount of anhydrite and/or potash salt minerals is present in rock salt samples. Recrystallization processes in rock salt are evidenced by two main groups of features: grain shape geometry and its relation to mineral impurities, and internal grain structure.

Thin section study revealed that halite grains have mostly irregular boundaries with lobate interfingering of grains, although euhedral grains are also locally preserved. The boundaries are marked by impurity minerals (when present), which occur either in dispersed form or as relatively continuous films. Apart from intergranular position, anhydrite grains occasionally appear in trails within individual halite grains. The latter is interpreted as a “ghost” grain boundary, evidencing fast boundary migration during halite recrystallization.

Polishing and etching of sections enabled to visualize internal structure of halite grains, thus providing direct evidence for halite recrystallization. The analyses show that most grains contain subgrains of different size, shape and distribution across the grain. Some grains are constituted of very well defined polygonal subgrains and of subgrains with irregular boundaries developed only in a portion of a grain. Some grains do not reveal subgrain structure at all or have a very few subgrains. Grains without subgrains usually have convex shape at boundaries with subgrain-bearing grains, indicating that they are recrystallized phases.

The set of microstructures observed in thin and polished sections of rock salts from the Polish Zechstein Basin suggests that the salt was dynamically recrystallized in places, both in apparently undeformed salt beds and in a diapir structure. Subgrains, impurity trails in halite grains and dispersed potash minerals in rock salt evidence dislocation creep, grain boundary migration and solution transfer as the dominant recrystallization processes operating in salts. The recrystallization was of polyphase character and not uniform.

Decoupling of Deformation between Basement and Cover during Normal- to Reverse-slip Movement on a Basement Fault; Model Results

Stanisław BURLIGA[1], Hemin A. KOYI[2] and Piotr KRZYWIEC[3]

[1] Institute of Geological Sciences, Wrocław University, pl. M. Borna 9, 50 – 204 Wrocław, Poland
[2] Hans Ramberg Tectonic Laboratory, Department of Earth Sciences, Uppsala University, Villavägen 16, Uppsala, Sweden
[3] Polish Geological Institute, ul. Rakowiecka 4, 00 – 975 Warsaw, Poland

Many sedimentary basins show two-stage evolution history: an extensional phase followed by basin inversion due to which normal faults were reactivated as reverse faults. A set of sandbox models was built in order to study the geometry and kinematics of structures developed in an evaporite-bearing basin-fill undergoing subsequent extension-shortening events.

Each model consisted of a ductile layer overlain by layers of fine sand. These layers were placed on a rigid basement with an in-built, 60º-dipping fault, which was activated during extension and subsequent inversion. Additional, synextensional sedimentation of sand over the model led to cover thickness variation across the basement fault. During shortening part of the overburden was eroded. For comparison, one of models did not contain the ductile layer.

During progressive extension of the sand-box a set of normal listric faults with conjugate antithetic counter listric faults bounding grabens developed in the sand layers. The number, geometry and location of these faults and grabens depended on: (i) thickness of the ductile layer, (ii) rate and amount of extension, and (iii) rate and amount of sedimentation. At small extension, the faults developed above the basement fault area; at higher extension, an additional set of faults developed on the footwall. The latter did not originate when ductile layer was missing.

Reverse movement on the basement fault reactivated only few of the normal faults in the footwall. The rest of the normal faults were left dormant during the entire inversion. In one of the models, inversion also resulted in formation of thrust faults in the footwall far way from the basement fault. Evolution of these tectonic structures during progressive shortening was controlled by amounts of shortening and erosion. Performed models illustrate that the ductile layer decouples the basement from the cover units. In contrast, in the model which lacked a ductile layer, deformation in the cover was coupled with that of the basement.

Dynamic Topography: A Key to Understanding how the Earth‘s Mantle works?

Ondřej ČADEK

Department of Geophysics, Faculty of Mathematics and Physics, Charles University, V Holešovičkách 2, 180 00 Prague, Czech Republic

The dynamic surface topography is defined as a topographic signal maintained by the viscous flow in a sublithospheric mantle. The dynamic topography should not be confused with the observed topography, which is mostly related to isostatic compensation of crustal thickness variations and tothermal cooling of the lithosphere (for a detailed discussion of the concept see Le Stunff and Ricard, 1995). The analysis of geological data suggests that the amplitudes of the long-wavelength dynamic topography are significantly smaller than the observed amplitudes. This fact has been a puzzling problem for many years since a small dynamic topography can hardly be explained by numerical simulations of the whole-mantle convection and it seems to be in contradiction with the long-wavelength gravitational signature of the Earth as well. The interpretation of the dynamic topography thus represents a challenging problem the solution of which can provide important information about the style of mantle convection.

The last decade has seen many attempts to constrain the amplitudes of thedynamic topography from geological data and/or geophysical modeling. The first-order estimates of the dynamic topography based on whole-mantle flow models with a free-slip upper boundary usually show large topographic depressions close to subduction zones and topographic elevations in the neighborhood of ridges and the regions of hotspot activity. This paradigm is intuitively acceptable since it apparently agrees with the observation: We indeed find topographic heights close to spreading centers while the convergent plate boundaries are accompanied by pronounced depressions. A careful analysis of the bathymetric data taking into account thermal models of the oceanic lithosphere (Colin and Fleitout, 1990; Panasyuk and Hager, 2000) indicates, however, that the above concept may be misleading: The topography of the Pacific ocean corrected for the cooling effects shows an increase of amplitudes from slightly negative values (shallow depression) in the neighborhood of the East-Pacific Rise to positive values in the West Pacific (pronounced elevation). This result, which cannot be explained on the basis of whole-mantle flow models with a free-slip upper boundary, suggests that the dynamic topography may be strongly influenced by a complex flow situation at the boundary between the upper and lower mantles and by the existence of stiff lithospheric plates. If the plates are mainly driven by mass heterogeneities near the boundaries (slab pull), then the lithosphere drags the underlying mantle, giving rise to a large-scale flow. This flow generates and a negative topography close to the spreading centers and a positive large-scale topography above the convergent plate boundaries. At a short distance from the trench, the positive large-scale topography is overprinted by a small-scale depression.

We test this hypothesis using a model of mantle flow with imposed plate velocities, partial layering at 660 km and strong lateral viscosity variations in the tectosphere (Čadek and Fleitout, 1999, 2003). The parameters of the model are tuned up to satisfy the observed long-wavelength gravitational signal as well as thebasic seismic and tectonic information (buoyancy forces proportional to seismic velocity anomalies, existence of subducted slabs in the upper mantle, changeable thickness of the oceanic lithosphere, existence of continental roots, etc.).For such a model we predict a dynamic surface topography and we compare it with the oceanic topography corrected for the cooling effects (=presumable dynamic topography). Our model shows reasonably small topographic amplitudes (200–600 m) provided that the mass flux across the 660-km interface is significantly (by a factor of 3) reduced in comparison with the whole-mantle flow. The partial layering together with the plate motion imposed on the top leads to a flow pattern which strongly differs from the usual whole-mantle flow models and which produces a strikingly different pattern of the dynamic topography. The predicted dynamic topography basically fits the main trends of the bathymetric data corrected for the effects of lithospheric cooling: It shows a large-scale elevation