material. During development of these bands, the pore pressures were much higher than during DBC formation. They might have reached values close to the lithostatic pressure related to the ice-sheet loading. According to the experimental studies of Arch et. al. (1988) confirmed the positive correlation between the width of deformation bands with dilatancy and the pore-water content within sheared sediment, the DDBD might have developed after significant dewatering of the mélange matrix. The pore-water content during development of the DBD was much higher than during formation of the DDBD. The comparison of the pore-water content during formation of the DBD and the DBC is not possible without information about primary porosity of the mélange matrix material when this later band developed.

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The Structure of the Gypsum-Anhydrite Dome at Alsótelekes

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The Rudabánya Mountains is a SW-NE striking elongated chain of hills in the NE part of Hungary. It lies in the Darnó Zone, a major sinistral strike-slip fault zone of Lower Miocene age (Zelenka et al. 1983), which is about 4–5 km wide here. The Mezozoic rocks of the Rudabánya Mts. belong to the Silica nappe system. These nappes were detached from their original basement in the gypsum-anhydrite containing, incompetent material of the Upper Permian Perkupa Anhydrite Formation acting as décollement horizon (Less 2000). These strata are on several sites in a near-surface position. The Alsótelekes occurrence was explored in 1968 when the At-478 borehole penetrated a gypsum-anhydrite body with more than 400 m thickness. In the ’80s 230 exploration boreholes and ground geoelectric surveys prepared the start of the mining. The open pit works since 1987 and it offers unique opportunity for studying the structural features of the evaporite body. Our surveys aimed to get a picture about the structural details of the gypsum-anhydrite body based on the geological documentation of the drill cores and the pit walls with structural measurements, and to build up a model for the formation of them with respect to the regional tectonics.

The Darnó Zone consists of several individual fault blocks. The open pit lies some 100 metres away NW from the Telekes Valley indicating a fault parallel with the main strike of the zone. On the SE side of this fault Gutenstein Dolomite crops out, on the NW side the Perkupa Anhydrite Formation (Fülöp 1994) is covered by Neogene sediments. This evaporitic formation is a typical lagoon facies sediment with sabkha-like conditions on the higher and reductive conditions on the deeper parts. In the tidal zone there are three textural types of gypsum layers: brecciated, selenitic (coarse-grained) and laminitic. The strata formed beneath the tidal zone are dark, sometimes bituminous shales, sulphates and carbonates with fine scattered pyrite grains. Anhydrite occurs either with shale and sandstone inclusions or with dolomite interlayering. The microlayering of the dolomitic anhydrite and the lamination of the gypsum indicates (probably seasonal) changes in temperature. The direct cover of the evaporite is a red clayish continental sediment with debris and lenticular bodies of limestone breccia and resedimented black or purple clay of the evaporite. This sediment can be classified by its facies and material in the Lower Miocene Zagyvapálfalva Clay Formation. There are 10m-scale blocks of dark and bright limestone enclosed in or thrusted upon on the continental sediments or the evaporites. The bright limestone with rich fossil content comes from the Steinalm Limestone F. of the Silica Nappes. The uppermost beds are Pannonian fine-grained lacustric and limnic sediments with several lignite beds.

The present open pit explores the western side of a NE-SW elongated dome structure. The formation of the dome started in the Lower Miocene with the opening of a pull-apart basin, elongated parallel to the NNE-SSW striking Telekes Valley fault. The incompetent evaporite material was moving toward this zone by ductile flow under the load of the overlying Mezozoic rocks and produced an anticline by its thickening. The lamination of sedimentary origin became wholly transposed containing isoclinal or nearly isoclinal, dm-scale conical sheath folds and 10m-scale diapir structures. The remnants of the Mezozoic cover were uplifted and partly embedded in the evaporite while other blocks slipped aside. As the anhydrite became the outcropping layer on the surface, it was partly transformed into gypsum with karst features on the top. Meanwhile in the basin thick continental debris was accumulated, burying step by step the dome.

In the next phase, maybe still in the Lower Miocene (during the continuing sinistral strike-slip movement along the Telekes Valley fault) the basin was inverted and closed by a NNW-SSE transpression. This phase is characterized by SSE-vergent thrusting of the competent blocks with folding of the gypsum, forming an uplifted, imbricated structure. The area took up a geographically high position as younger sediments are missing up to the Pannonian and these lie on an irregular sedimentation surface.

The Upper Pannonian lignite-bearing formation is unaffected by the evaporite tectonics, though its layers show slight bending above the gypsum diapir due to later extensions. In a cm-scale view, this bending is realized by several microfaults. This subsidence can be derived either from solution processes or the slow ductile flow of the gypsum towards the Nagy Valley.

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Active Faults in Poland: An Overview

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Seismotectonic faults in Poland have developed in Neogene and Quaternary times due to reactivation of Laramian or older structures, or in the Quaternary due to reactivation of Neogene faults. The first group includes, i.a., faults bordering the lower Vistula River valley near Gniew (northern Poland), the escarpment zone of the Gorajec Roztocze region (south-eastern Poland), and many fault zones in the Sudetes and Fore-Sudetic Block (south-western Poland) of throws ranging from 100 m (Legnica - Chojnów fault), through 600 m (Paczków and Kedzierzyn grabens), to 800 m (Roztoka – Mokrzeszów graben). In NE Poland, manifestations of Quaternary reactivation of the Teisseyre-Tornquist zone and of faults perpendicular to it have been encountered. Most of these faults coincide well with the photolineaments identified on satellite images and topolineaments on digital evelation models.

The second group of faults includes those of Lower Silesia (Wroclaw–Ozimek, Przeworno–Wegliniec, Sudetic Marginal Fault, along the northern margin of the Karkonosze Mts.) and Upper Silesia regions, the NW-SE, N-S, NE-SW, E-W and ESE-WNW-orientated faults of the Lublin Upland and Roztocze region (SE Poland), the NNE-SSW and NE-SW-orientated faults in the northern part of the Carpathian Foredeep, as well as several oblique-slip, strike-slip, and thrust faults in the Carpathians (Ruzbachy fault, Bialka Tarzanska valley, faults cutting the middle part of the Dunajec drainage basin, Jelesnia Basin, Tarnów – Pilzno fault, southern part of the Jaslo – Sanok Depression, Dynów Foothills).

The size of throw of Quaternary faults changes from 40 to 50 m and >100 m in the Sudetes and the Lublin Upland, to several – several tens of metres in the Carpathians. The average rate of faulting during Quaternary times has been 0.02 to 0.05 mm/yr, what enables one to include these structures into the domains of inactive (D) or low-activity (C) faults. A similar conclusion can be drawn from the results of repeated precise levellings and GPS campaigns.

Strike-slip displacements have been postulated on some of these faults, including the Sudetic Marginal Fault (SW Poland) or Janowice fault (Lublin Upland). Isolated faults in Central Poland have shown middle Quaternary thrusting of the order of 40–50 m, and some of the Outer Carpathian overthrusts tend to reveal young Quaternary activity, as indicated, i.a., by concentrations of fractured pebbles within the thrust zones.

Episodes of increased intensity of faulting took place in the early Quaternary, in the Mazovian (Holsteinian) Interglacial, and during or shortly after the Odranian (Drenthe) glacial stage. Some of the faults have also been active in Holocene times (Karkonosze Mts., Roztocze region, Podhale Basin, Beskid Sadecki Mts., Jaslo-Sanok Depression).

The Quaternary faulting is reflected in increased thicknesses of young deposits on downthrown blocks (including stacks of colluvial-solifluction wedges), deformation of river terraces and alluvial fans, changes in the drainage pattern, as well as in the formation of cracks within Pleistocene icesheets, controlling the preferred orientation of glaciofluvial landforms.

The seismic activity is often related to strike-slip faults, which in the Carpathians trend ENE-WSW and NE-SW, whereas outside the Carpathians they are orientated parallel to the margin of the Easteuropean Platform and the Sudetic Marginal Fault.