ben) basin system in Northern Bohemia. The delta formed at the mouth of a river that drained into a shallow lake and its deposits overlie the main coal seam in this part of the basin and a package of lacustrine clays. Close to the Bílina Fault, which is one of the major basin-bounding extensional faults, the internal architecture of the deltaic system reflects a significant influence of syndepositional tilting, recorded as basinward divergence of originally horizontal strata, thickening of stratal units in the same direction, and tilt-induced growth faulting.

The divergence of strata is pronounced in the architecture of individual Gilbert-type and shoal-water mouth bars, as well as in the overall architecture of the deltaic strata in the cross-section normal to the fault strike. Within the Gilbert-type mouth bars, originally horizontal topsets show a significant basinward divergence over a distance of tens of metres, with the dip angle increasing towards older strata (up to 30 degrees), attesting to deposition of the mouth bar during gradual tilting. These individual mouth bars show increasing amalgamation towards the fault.

Growth faults observed in the deltaic strata adjacent to the Bílina Fault are interpreted as caused by gravity sliding induced by basin-floor tilting, because their heave to throw ratios (Morley and Guerin 1996) are relatively high. The growth fault planes are strongly listric, flattening in shallow depths where they pass into prodelta heteroliths which functioned as the zone of detachment. Local accommodation space formed due to rotation of the subsiding hangingwall and resulted either in strong aggradation of topset strata, thickening (diverging) towards the growth fault plane, or in the formation of complete new mouth bars showing a basinward decrease in thickness.

With respect to the position of the observed phenomena relative to the Bílina Fault, two causes of syndepositional tilting are possible. The first possibility is growth folding related to the propagation of the Bílina Fault (cf. Gupta et al. 1999). Formation of a growth monocline above the tip of the propagating fault was caused by deformation of ductile material above the fault before the fault plane breached the surface. In this case, the ductile layer important for the formation of the monocline was represented by a thick bed of peat, clays and heterolithic strata underlying the proximal deltaic deposits.

The second possibility is syndepositional tilting caused by differential compaction of the peat underlying the deltaic clastics. In the study area, the peat accummulated on a pre-depositional topographic slope inclined basinwards (Dvořák and Mach 1999), which caused the thickness of peat to increase downslope. From this resulted a basinward increase in the potential compaction-induced subsidence that could induce basinward tilting of overlying strata. The resulting tilt of stratal units of dimension comparable to the slope itself would not exceed the topographic slope angle (max. 20 degrees).

The majority of observed tilt-induced phenomena – basinward divergence of topsets, growth faulting induced by gravity sliding – occur only in close vicinity (less than 250 m) of the Bílina Fault, although the area potentially affected by compactional tilting is larger (400–500 m). The amalgamation of the topsets takes place always basinward of the Bílina Fault and the tilt of these topsets and other originally horizontal strata in this narrow zone often exceeds 20 degrees determined by the topographical slope. Therefore, we interpret growth folding induced by fault propagation as the main cause of the **small-scale** tilt-induced phenomena (of mouth-bar scale) in the deltaic deposits. This is also supported by the occurrence of syndepositional compressional and extensional fractures, characteristic of forced folding (Withjack et al. 1990; Withjack and Callaway 2000), near the Bílina Fault, and on the other hand, by the absence of similar phenomena in areas in greater distance from the Bílina Fault that were affected only by compaction. The compactional tilting is interpreted as the cause of the overall, **large-scale**, basinward divergence of stratal units observed over the whole area of the pre-depositional topographic slope. The rate of compactional tilting was not fast enough to cause the tilting at the mouth bar scale, because the fastest compaction had already taken place during deposition of lacustrine and prodelta sediments on the main seam.

This research was partly supported by GAČR grant 205/01/0629.The authors are grateful to Severočeské doly a.s., for granting access to the Bílina Mine and help in obtaining data on the geology of this locality. In particular, we thank Mr. K. Mach for his assistance.

References

DVOŘÁK Z. and MACH K., 1999. Deltaic deposits in the Nort-Bohemian Brown Coal Basin and their documentation in the Bílina opencast mine. *Acta Universitatis Carolinae – – Geologica*, 43 (4): 633-641.

GUPTA S., UNDERHILL J.R., SHARP I.R. and GAWTHORPE R.L., 1999. Rolo of Fault Interactions in controlling synrift sediment dispersal patterns: Miocene, Abu Alaqa Group, Suez Rift, Sinai, Egypt. *Basin Research*, 11: 167-189.

WITHJACK M.O., OLSON J. and PETERSON E., 1990. Experimental Models of Extensional Forced Folds. *AAPG Bulletin*, 74 (3):1038-1054.

WITHJACK M.O., and CALLAWAY S., 2000. Active Normal Faultig Beneath a Salt Layer: An Experimental Study of Deformation Patterns in the Cover Sequence. *AAPG Bulletin*, 84 (5): 627-651.

Moravian Jurassic Geodes and their Geological Significance

Dana RICHTEROVÁ, Antonín PŘICHYSTAL and Zdeněk LOSOS

Division of Earth Sciences, Masaryk University, Kotlářská 2, 611 37 Brno, Czech Republic

Moravian silica geodes occur “in situ” only in small relics of Jurassic platform silicified limestones near the village of Olomučany (the central part of the Moravian Karst). We know a few next localities of Jurassic limestones in the area of Brno but they do not contain geodes. Besides, the above mentioned primary occurrence, the largest geodes are already found in secondary position in younger sediments. The most attractive geodes come from the Rudice Formation – claystones with lenses of limonitic iron ores, quartz sandstones and chert gravels that originated by weathering especially of the Jurassic sediments under tropical conditions in the Lower Cretaceous. The Rudice Formation is situated just in the Jurassic limestones in the Moravian Karst. In addition to it, new finds of geodes have been ascertained in Neogene (Eggenburgian–Ottnangian) gravels of the Krumlovský les Upland. Their presence testifies to totally denudated Jurassic limestones in this part of the Bohemian Massif. Finally, it is possible to find the Jurassic geodes at many sites of Pleistocene terrace gravels in South Moravia.

Megascopically the geodes have usually globular shape, sometimes with a stalk-like prominence. As for their origin, since the beginning of their research in the second half of the 19th century it was believed they could represent especially silicified Porifera or other marine animals (Wankel 1882, Mejzlík 1977). The authors of this contribution prepared thin sections of such geodes resembling the sponges, examined them by means of microscope and they found no traces of organic textures. On the other hand, as a typical sign of Moravian Jurassic geodes their sculpted outer surface similar to a cauliflower has to be mentioned. Geodes with analogical shapes and surfaces have been described from various parts of the world. In addition to it, the authors found relics of sulphates (anhydrite, barite) in all studied geodes.

In thin sections it is possible within the geodes to distinguish a few zones differing in presence of some varieties of SiO_2. The margin of geodes is built of spherical or radial aggregates of probably quartzine (fibers of chalcedony having a positive crystallographic elongation) with relics of anhydrite textures showing brown coloration of central part of aggregates when we study the thin section only with polarizer. These marginal parts do not contain sulphate inclusions. The geode border passes continuously in the zone of coarse-grained subhedral quartz with undulatory extinction. The presence of sulphate inclusions is typical of this part of geodes. The EDX-analyses and XRD examination proved anhydrite in geodes from primary occurrence in Jurassic limestone at Klepačov (west of Olomučany in the Moravian Karst) and from secondary position in the Syrovice – – Ivaň Pleistocene terrace at Žabčice (South Moravia). The XRD analyses identified beside prevalent quartz unambiguously the two strongest x-ray diffractions of anhydrite – 3.499/100, 2.849/10 (d/I_r). Using the spot EDX-analyses inclusions of barite were found in a smaller amount as well. The inclusions of sulphates have usually lath or leaf shape with their dimensions in 0,X – 0,0X mm. It is possible to prove the parallel extinction to their elongation. The distribution of inclusions is prevalently irregular but they also form clusters in the central part of quartz crystals. The internal part of geodes is built of coarse-crystalline quartz forming druses of crystals absolutely without sulphate inclusions. Covers of chalcedony (having often the so- called zebra pattern in crossed polars) represent the innermost and youngest parts of the geodes.

Conspicuous morphological similarity of Moravian Jurassic geodes with the geodes from Rutba in Iraq (Petránek et al. 1983) and from Triassic dolomite conglomerates in the surroundings of Bristol, UK (Tucker 1976) was noticed already by Petránek (1995). Our microscopical study of Moravian geodes has confirmed the similar genetic interpretation with the Iraqi and English geodes – siliceous pseudomorph after sulphate (prevalently anhydrite) concretions. This conclusion is based not only on the presence of sulphate inclusions but also on identification of SiO_2 varieties and other textural signs typical of pseudomorphosed sulphates (Siedlecka 1972; Milliken 1979). It is necessary to mention other occurrences with the same interpretation in the world – geodes from Lower Carboniferous dolomite formations in Tennessee and Kentucky, USA (Chowns and Elkins 1974, Milliken 1979) or from Upper Cretaceous dolomite sequences in northern Spain (Garcia-Garmilla and Elorza 1996; Bustillo et al. 1999).

The finds of numerous sulphate inclusions are important from the palaeoclimatic point of view. Origin of anhydrite concretions in carbonate rocks indicates a presence of hypersaline pore waters during early diagenesis in the sediments at the sea margin, probably under conditions of its regresion. The sedimentary environment has been often compared to the recent sabkhas in Persian Gulf. We suppose similar sedimentary setting at the end of the Upper Jurassic in the central part of the Moravian Karst and in the Krumlovský les Upland.

References

BUSTILLO M.A. et al.,1999. Unusual sedimentary geodes filled by gold-bearing hematite laths. *Geol. Mag.*, 136 (6): 671-679.

GARCIA-GARMILLA F. and ELORZA J., 1996. Dolomitization ad synsedimentary salt tectonics. The Upper Cretaceous Cueva Formation at El Ribero, nothern Spain. *Geol. Mag.*, 133 (6): 721-728.

CHOWNS T.M. and ELKINS J.E., 1974. The origin of quartz geodes and cauliflower cherts through the silicification of anhydrite nodules. *J. sed. Petrology*, 44 (3): 885-903.

MEJZLÍK Z., 1977. K rozšíření a genezi jurských geod ve střední části Moravského krasu. *Sbor. Okr. vlastivěd. Muzea v Blansku*, VI-VII: 137-146.

MILLIKEN K.L., 1979. The silicified evaporite syndrome – – two aspects of silicification history of former evaporite nodules from southern Kentucky and northern Tennessee. *J. sed. Petrology*, 49 (1): 245-256.

PETRÁNEK J., JASSIM S.Z. et al., (1983). Quartz geodes from Western Desert, Iraq. *Čas. Mineral. Geol.*, 28: 139-147.

PETRÁNEK J., 1995. Sedimentární acháty. *Bull. min.-petr. odd. NM v Praze*, 3: 100-103.

SIEDLECKA A., (1972). Length-slow chalcedony and relicts of sulphate-evidences of evaporitic environments in the Upper Carboniferous and Permian beds of Bear Island, Svalbard. *J. sed. Petrology*, 42 (4): 812-816.

TUCKER E.M., 1976. Quartz replaced anhydrite nodules (“ Bristol Diamonds”) from the Triassic of the Bristol District. *Geol. Mag.*, 113 (6): 569-574.

WANKEL H., 1882. Bilder aus der Mahrischen Schweiz und ihrer Vergangenheit. Wien.

Tectonometamorphic Evolution of the Stronie Series near Javorník

Markéta ROMANOVÁ and Pavla ŠTÍPSKÁ

Institute of Petrology and Structural Geology, Charles University, Albertov 6, 128 43, Prague, Czech Republic

The studied area occurs at the NE margin of the Orlica-Sneznik orogenic root which represents a deformed and metamorphosed Late Precambrian-Early Paleozoic basement-cover sequence composed of granites and volcano-sedimentary series. The present work is essentially focused on the description of structures and related metamorphic evolution of one part of the volcano-