Structures due to Synsedimentary Deformations in Sediments of the Bílina Delta (Miocene, Most Basin, Czech Republic)

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The Bílina Delta is a clastic package deposited during the early Miocene at the SE margin of the Most Basin (part of the Eger Graben basin system, N Bohemia). The Bílina Delta formed at the mouth of a river which belonged to a large drainage system of NE and E Bohemia. This river entered the extensional basin across the Bílina Fault and drained into a fairly shallow lake surrounded by peat bogs. The Bílina Delta was a fluvial-dominated deltaic system with distributaries terminated by friction-dominated mouth bars, commonly with Gilbert-type profile (therefore called mouth fans). Within the Gilbert-type mouth fans, topsets represent sediments of subaerial and subaqueous delta plain, foresets represent sediments of steep delta front and bottomsets represent prodelta sediments. Locally, these fans have a shoal-water profile where foresets are missing.

A range of types of syndepositional, ductile and brittle deformation structures occur in the sediments of the Bílina Delta. These structures range in scale from centimetres to metres to tens of metres. It is possible to recognize small deformation structures which affect only parts of the mouth fans, and, on the other hand, large deformation structures affecting whole mouth fans or their packages. Some of the structures (e.g., growth faults) are described for the first time from the Eger Graben basins, and the significance of most of them has not been appreciated by previous studies. The syndepositional deformation structures could have been caused either by allogenic processes (e.g., seismicity), or by autogenic processes resulting from the evolution of sedimentation within the prograding delta system.

Growth faults are the largest syndepositional structures present. They are characterised by systematic stacking of mouth fans of a higher number and thickness on the hangingwall block. Growth faults occur only within the earliest delta bodies at the base of the Bílina Delta clastic package, underlain by a thick accumulation of clay, which, in turn, overlies a coal seam. The origin of growth faults is generally attributed to differential loading of easily deformable, mobile substrate. The formation of accomodation space needed for aggradation of the mouth fans was governed by high compaction rate of overpressured clays and their outward migration. The migration is revealed by the occurrence of ductile and brittle compressional structures , developed in prodelta heteroliths and shale diapirs. The main effects of growth faulting in the stratal architecture of the Gilbert-type mouth fans include (1) significant increase in thickness of the foreset packages in the subsiding hangingwall area, and (2) amalgamation of individual flooding surfaces towards the roll-over antiform portion of the rotated hangingwall block.

Ball-and-pillow structures occur in the heteroliths of subaqueous delta plain and prodelta. The basic mechanism of formation of these structures was strength loss in a relatively lower bulk density material loaded by material of higher bulk density. Convolute bedding of bottomsets represents plastic deformation of partially liquefied sediments, induced by seismic shocks or rapid sedimentation. The origin of convolute bedding of mouth fan foresets is explained by sediment liquefaction (potentially triggered by a seismic shock), combined with unequal confining load by an overlying sedimentary body. These deformation structures closely resemble those produced by experiments of Owen (1996), some of which were produced only by liquefaction-induced slope failure, without additional loading. Together with these structures, folded and fractured topsets occur, characterised by folding of thin clay layers to broad synclines and narrow anticlines, commonly breached due to fludization which followed sediment liquefaction, and resulting fluid escape. These structures are also interpreted as seismites (more likely in the cases presented) or structures formed by overpressuring. Simple concave flexures are due to loading of unconsolidated plastic sediment (lacustrine clays, prodelta sediments) by a sand body of a mouth fan or a distributary channel. Deformation affects both the overpressured substrate and the base of the sand body.

In the excellently exposed strata of the Bílina Delta clastic wedge, the study of synsedimentary deformations proved very useful for discriminating between the allogenic (tectonic-driven) and autogenic (sedimentation-driven) influences on depositional style. The size of outcrops in the Bílina coal mine makes this case a potentially useful outcrop analog for subsurface deltaic reservoirs in extensional basins, especially those affected by salt tectonics.

References

OWEN G., 1996. Experimental soft-sediment deformation: structures formed by the liquefaction of unconsolidated sands and some ancient examples. *Sedimentology*, 43, 279-293.