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Styles of soft sediment deformation on top of a growing anticline-syncline system

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Soft sediment deformation occurs in unstable sedimentary environments. The reason for instability can be, for example, high sedimentation rate or seismic activity, among others. Sedimentary environments particularly vulnerable to instability are located on top on growing anticline-syncline systems, because there, the forelimb of the fold becomes steeper through time. In this paper, we study soft sediment deformation in a very coarse clastic turbidite succession in the Cretaceous of the western Northern Calcareous Alps, where growing of the underlying syncline-anticline system is documented by several progressive unconformities within the turbidite succession (Ortner, 2001). We observe different styles of deformation, the first two restricted to single layers and the third affecting thick sediment packages, which most probably also followed each other through time:

1) downslope creep of sediment packages

The base of conglomerate beds is often deformed by mullions of dm to m-size, whereas the top of the beds is flat. Mullions formed, where conglomerates are contact with cm-scale sand-mud couplets. Above a bedding-parallel detachment, these sand-mud couplets are deformed by boudinage and buckle folding. This association of structures indicates, that during deformation competency was ölowest in mud, higher in sand, and highest in conglomerate, and that all sediments behaved plastically. Deformation was most probably caused by downslope creep of sediment packages.

2) deformation within liquefied layers

The most common type of soft sediment deformation observed is open to isoclinal folding of disrupted sandstone beds, which float in a conglomerate matrix. Deformation within conglomerate beds was probably triggered by fluidization of conglomerate

beds as is indicated by conglomerate dykes and diapirs intruding the neighbouring beds. Locally also mullions at the top of the conglomerate beds were observed, where the overlying sandstones form the cusps. Fluidization did not affect sandstone beds within the conglomerate layer, which were deformed by flexural folding. Therefore, within the liquefied layers, the competency of conglomerates was lowest. The downslope ends of liquefied layers show ramps, where the base of the fluidized layer climbs upsection, and the overlying beds are folded above the ramp, indicating at least several meters of overburden at the time of fluidization. Fluidization of conglomerate layers was possibly promoted by high porosity.

3) Tectonic folding

In decametric folds affecting a sediment package of 200 m thickness, sand-mud couplets are deformed by flexural slip, indicating complete lithification of these layers, however conglomerate layers reacted by flow within the layers, which is indicated by thickened fold hinges. Therefore lithification of conglomerate layers was slow as compared to sandstone-mud couplets. Formation of these folds is attributed to tectonic forces.

Reference

Ortner, H. (2001): Growing folds and sedimentation of the Gosau Group, Muttekopf, Northern Calcareous Alps, Austria.- International Journal of Earth Sciences, 90, 727-739.