Slumping versus tectonic deformation: a case study in growth strata of the Upper Gosau Subgroup at Muttekopf (Lechtal Alps, Tyrol)

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The distinction between slump folds and folds formed due to tectonic forces has hitherto been problematic. A new research project will try to define valid criteria to distinguish the two fold types. 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. A pilot project was conducted in a very coarse clastic turbidite succession in the Cretaceous of the western Northern Calcareous Alps (Upper Gosau Subgroup), where growing of the underlying syncline-anticline system is documented by several progressive unconformities within the turbidite succession (Ortner, 2001; in press). The most important prerequisite to distinguish slump folds and tectonic folds is an understanding of the processes causing soft sediment deformation. Most early deformational structures in clastic sediments are related to water escape from water saturated sediment associated with partial liquidization of sediment, creating load casts and dish structures. Sediment instability can also lead to surficial gliding of sediment, creating deformed load casts. Increasing overburden goes along with increasing lithification of the sediment, and thick packages of sediment may glide downslope, causing plastic deformation. If rates of deposition are very high, pore water may be trapped in the sediment and sealed. In these cases, pore pressures may approach lithostatic pressure, and subsurface sediment mobilisation due to fluidization may result.

Following criteria can be used to distinguish slump folds from folds due to tectonic forces:

(1) Slumping and fluidization affects single or several beds, whereas axial planes of folds related to tectonic processes can be traced across sediment packages several 10s of meters thick.

(2) Fold axes in slump deposits and fluidized deposits scatter strongly about the transport direction of the unit or the strike of the slope. If folds are not isoclinal, they commonly face downslope. In contrast, axes of folds related to tectonic deformation tightly cluster in a direction perpendicular to tectonic transport. Folds are commonly asymmetric and consistently face in transport direction.

(3) During slumping, shortening is commonly associated with extensional deformation, whereas tectonic folding is not.
(4) Whereas slump folds form during the earliest stages of lithification, folds related to tectonic shortening form throughout lithification. Tectonic folds therefore display a much wider range of structures related to folding.

Ortner, H. (2001): Growing folds and sedimentation of the Gosau Group, Muttekopf, Northern Calcareous Alps, Austria.- Int. J. Earth Sci. (Geol. Rundsch.), 90, 727-739, Stuttgart.

Ortner, H. (in press): Styles of soft-sediment deformation on top of a growing fold system in the Gosau Group at Muttekopf, Northern Calcareous Alps, Austria: slumping versus tectonic deformation.- Sedimentary Geology.