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Soft-sediment mullions

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In this contribution I describe the appearance, formation and significance of soft-sediment mullions. I use several examples from synorogenic turbidites of the Alps and the Pyrenees to show their appearance in the field.

Soft-sediment mullions are elongate, slightly irregular bulges at the base of coarse-grained clastic beds (sand to conglomerate), separated by narrow, elongate flames of fine-grained material (mud) protruding into the coarse-grained bed. Various processes may lead to the formation of such structures: (1) longitudinal furrows parallel to the sediment transport direction may form by spiral motion in flow rolls during sediment transport (Dzulinski, 1966; Dzulinski & Simpson, 1966). (2) Loading combined with downslope movement can produce elongate structures parallelling the dowslope direction (Anketell et al., 1970). (3) Soft-sediment mullions are oriented perpendicular or oblique to the downslope direction, and show evidence of bedding-parallel shortening. Thus, they resemble cuspate-lobate folds or mullions, which are well-known in ductile structural geology (e.g. Urai et al., 2001).

Soft-sediment mullions have been observed in two cases: Either bedding-parallel shortening can be achieved by slump processes, or by active tectonic shortening. Slumping is characterized by an alternation of stretching and shortening (e.g. Ortner, 2007; Alsop & Marco 2014), and therefore mullions do overprint or are overprinted by normal faults. In active depositional systems that are subject to tectonic shortening growth strata will form, but sediments already deposited will be shortened during lithification. In some cases, the formation of soft-sediment mullions predates folding, but the most widespread expression of syn-lithification shortening seems to be soft-sediment mullions, that form in the inner arcs of fold hinges.

In the examples documented so far, the size of soft-sediment mullions is dependent on the grain-size of the coarse-grained layer, in which the mullions form. In coarse conglomerates, meter-scale mullions were observed, in sandstones centimeter-scale mullions. There does not seem to exist a relationship to the rate of shortening, as the size of mullions is independent of their position in larger scale folds, or in slump complexes or tectonic folds.

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