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Soft-sediment deformations (convolute lamination and load structures) in turbidites as indicators of flow reflections against bounding slopes

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Soft-sediment deformations, such as convolute laminations, load structures and water escapes are very rapid deformations that occur in unconsolidated sediments near the depositional surface during or shortly after deposition and before significant diagenesis. These types of deformations develop when primary stratifications are deformed by a system of driving forces, while the sediment is temporarily in a weakened state due to the action of a deformation mechanism know as liquidization. This deformation occurs if the applied stress exceeds the sediment strength, either through an increase in the applied stress or through a temporary reduction in sediment strength.
Liquidization mechanisms can be triggered by several agents, such as seismic shaking, rapid sedimentation with high-fallout rates or cyclic-pressure variations associated with storm waves or breaking waves. Consequently, soft-sediment deformations can be produced by different processes and form ubiquitous sedimentary structures characterizing many sedimentary environments. However, even though these types of structures are relatively well-known in terms of geometry and sedimentary characteristics, many doubts arise when the understanding of deformation and trigger mechanisms is attempted. As stressed also by the recent literature, the main problem lies in the fact that the existing approaches for the identification of triggering agents rely on criteria that are not diagnostic or not applicable to outcrop-based studies, because they are not always based on detailed facies analysis related to a paleoenvironmental-context approach.
For this reason, this work discusses the significance of particular types of soft-sediment deformations that are very common in turbidite deposits, namely convolute laminations and load structures, especially on the basis of a deep knowledge of the stratigraphic framework and geological setting in which these structures are inserted. More precisely, detailed facies analyses of the turbidites containing these deformative structures show that they are genetically linked to contained-reflected beds in structurally-confined basins, suggesting a trigger mechanism associated with the cyclic-wave loading produced by flow impacts or reflected bores and internal waves related to ponded turbidity currents. The data that can demonstrate this hypothesis come from the foredeep turbidites of the Marnoso-arenacea Formation (northern Italy) and Annot Sandstones (southwestern France), where a basin scale high-resolution stratigraphic framework with bed-by-bed correlations is now available. These data show that the lateral and vertical distribution of convolute laminae and load structures is not random but has an evident depositional logic related to reflection processes against bounding slopes.
Therefore, the main objectives of this work are: 1) to show that convolute laminae and load structures are strictly associated with other sedimentary structures that are unequivocally related to reflection and rebound processes of turbidity currents against morphological obstacles; 2) to show that their lateral and vertical distribution increases concomitantly with the number of contained-reflected beds in the proximity of structurally-controlled morphological highs; 3) to show that the increase in contained-reflected beds with convolute laminae is strictly related to the increase in the synsedimentary-structural uplifts producing more pronounced morphologic highs; 4) to discuss the processes that link soft-sediment deformations with cyclic-wave loading related to internal waves and bores produced by reflection processes.