Physical diagenesis: a neglected aspect in the reconstruction of ancient sedimentary environments

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In the study of clastic sedimentary rocks, physical diagenesis has received relatively little attention. This is unfortunate because recent work has indicated that physical diagenesis can considerably alter the primary character of sedimentary sequences, in particular of those that have been deposited in tectonically unstable regions.

As used here physical diagenesis embraces all post-depositional pre-metamorphic changes resulting from dewatering, compaction and sub-surface remobilization of sediments. Conditions governing physical diagenesis include high initial porosity, excessive pore-fluid pressures, rapid sediment accumulation, density inversion and differential viscosities. The principal processes involved are fluidization, liquifaction and elutriation.

A wide range of secondary sedimentary structures can form as a result of physical diagenesis including load deformation, sediment injection, sediment inflow, and sediment interflow structures as well as structures formed from rheoplasis and local fluidization and dilation of the sediments.

It is important to distinguish primary from secondary sedimentary structures. Primary sedimentary structures, as the name implies, reflect primary processes at the sedimentary interface involving sediment transport and deposition. In contrast, secondary sedimentary structures reflect dewatering and the post-depositional rheotropic behaviour of the sediments. They are related to groundwater conditions, subsurface drainage, rate of sediment accumulation and pre-consolidation movement of the sediments during compaction in response to unstable pore-fluid, density and viscosity gradients, and induced shear (earthquake movement). Primary and secondary sedimentary structures, therefore, represent separate aspects of the depositional environment, and for a more complete paleo-environmental reconstruction the information from both classes of structures should be integrated when possible. Recent work has indicated that physical diagenesis can overprint primary stratification, homogenize sediments, amalgamate beds and cause other major changes as a result of compaction and/or post-depositional redistribution of the sediment. It may lead to the development of pre-tectonic deformation structures, such as intrastratal slump-folds and soft sediment fissility and can significantly reduce primary porosity and permeability of potential reservoir rocks by post-depositional clay infiltration into the matrix of coarse-grained sediments.