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Hydrodynamic Fractionation of Minerals in Distributive Sedimentary Deposits: Implications for Reservoir Quality

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Fluid turbulence longitudinally fractionates, or sorts, grains on the basis of size. Does fluid turbulence fractionate grains on the basis of mineralogy? Each of the common sandstone-forming minerals such as quartz, feldspar, and mica has distinctive densities and shapes, which affect settling velocity of grains in a suspension. This study uses measurements from physical experiments and natural systems to document, for the first time, how fluid turbulence spatially fractionates minerals on the basis of density and shape.

1) Two physical experiments were conducted in the Tulane Deep-Water basin. Both experiments used engineered sediment with similar grain-size distributions. The first experiment examines how grains fractionate on the basis of density. The experimental turbidity current had equal proportions by volume of spherical ballotini (ρ=2.50 g/cm3) and spherical zirconia silicate (ρ=3.85 g/cm3). The abundance of high-density particles relative to low density particles decreases toward the lateral and distal margins of the deposit. At all locations, high-density particles are smaller than adjacent low-density particles. The second experiment examines how grains fractionate on the basis of shape. The experimental turbidity current had equal proportions by volume of spherical ballotini (ρ=2.50 g/cm3) and angular crushed glass (ρ=2.50 g/cm3). The abundance of angular particles relative to rounded particles increases toward the lateral and distal margins of the deposit.

2) The Upper Cretaceous Point Loma Formation, San Diego, California contains distributary lobes that compensationally stack to build a submarine fan. This study documents one turbidite bed within a lobe that is exposed over a lateral distance of ~ 2.5 km. There are discrete axis-to-margin changes in mineralogy of the bed. The abundance of k-feldspar, plagioclase, biotite, and terrestrially derived organic material increases relative to quartz toward the lateral and distal margin of the bed. These minerals are more angular and/or less dense than quartz. In contrast, the abundance of hornblende, which is denser than quartz, decreases relative to quartz toward the lateral and distal margin of the bed.

Results indicate turbidity currents spatially fractionate minerals on the basis of density and shape. This process explains spatial variations in mineralogical composition described in some submarine fans, and provides empirically derived patterns useful for prediction. Hydrodynamic fractionation of minerals has significant consequences on primary and secondary reservoir quality as abundance of angular and labile minerals changes spatially. Future research will focus on large-scale spatial patterns in submarine fans, shale basins, and river systems.

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