Internal Waves and Carbonate Systems

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ABSTRACT

A broad array of depositional processes control carbonate platform architecture, which in turn influence variability in the properties of carbonate reservoirs. Recognition of new or previously enigmatic stratigraphic details can induce a redesign of production strategies by promoting more realistic models of interwell heterogeneities; enhanced visualization of stratigraphic details can trigger renewed exploration interest even in mature reservoirs. Recognition of the role of internal waves in carbonate systems provides a new dimension in which to interpret carbonate reservoirs.

Internal waves, which propagate along the pycnocline, are ubiquitous in oceans and lakes. While they are well known by oceanographers and engineers, their influence on the sedimentary record remains largely unrecognized. Turbulence along pycnoclines can be a prime factor in shaping the sedimentary record where the pycnocline intersects the seafloor. In siliciclastic systems, the turbulence induced by breaking internal waves on sloping surfaces induces sediment remobilization on shelves and continental slopes. In carbonate systems, both the pycnocline and the associated turbulence shape carbonate production by influencing biological systems. Relatively high concentrations of phyto- and zooplankton typically occur at the nutricline, which coincides with the top of pycnocline. The nutricline generally begins in the lower part of the photic zone, where nutrient-rich (deeper) water can mix upward via upwelling or internal waves, and where available light energy, not nutrients, limits primary production.

A strong pycnocline is beneficial for plankton-feeding sessile organisms, e.g., corals, sponges, stromatoporoids, rudists, etc. This explains why most Phanerozoic metazoan mounds are in mid- or outer ramp settings. Moreover, low-light adapted coral-line algae can also thrive at the intersection of the pycnocline/nutricline with the seafloor; an oligophotic zone of coralline algal dominance wass common during the Cenozoic.

A weaker pycnocline, however, should be more beneficial for small and unattached mixotrophs such as the larger benthic foraminifers; the turbulence associated with strong internal waves would produce hydrodynamic instability. This may explain the dominance of LBF on the warm Tethyan shelves during the Paleogene and Miocene.