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Micro-scale Observations and Global Trends in Carbonate Diagenesis at the Great Bahama Bank

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We examined the petrographic, textural, elemental, and mineralogical characteristics of sediments from the slope of the Great Bahama Bank recovered by Ocean Drilling Program (ODP) Leg 166 to better constrain the diagenesis of marine carbonates. Based on measured pore fluid chemical composition, temperature, and pressure, we calculated the saturation state (Ω) of aragonite and calcite in the subsurface of the Great Bahama Bank and in a number of other, globally distributed, carbonate dominated ODP/IODP sites. Our data from the Great Bahama Bank suggest the occurrence of a number of important diagenetic processes including the dissolution, precipitation, and stabilization (i.e., neomorphism) of carbonate minerals. The depth at which these processes are occurring is dictated by pore fluid Ω. For example, in the upper ~ 25 m of the sediment column at site 1003, pore fluids are undersaturated with respect to aragonite and at equilibrium with calcite. At the same depth interval, textural observations provide evidence for dissolution without authigenic carbonate formation. We document the presence of authigenic carbonate phases deeper in the sediment column, once pore fluids become supersaturated with respect to aragonite and calcite. Using X-ray diffraction, Raman spectroscopy, and electron microprobe analysis, we constrain the mineralogy and Mg/Ca of these authigenic phases. The mineralogy appears consistent with saturation state predictions of stable phases. The Mg/Ca of authigenic carbonate phases can be accurately predicted using an empirical partition coefficient of Mg in calcite, which implies that the formation of these authigenic phases is controlled by kinetic rather than thermodynamic processes. Collectively, these results provide the basis for a process-based framework and suggest that diagenesis, although more complicated than generally assumed, appears to be predictable, at least on the slope of the Great Bahama Bank. We contextualized the chemical and diagenetic environment of the Great Bahama Bank through an analysis of pore fluid saturation state in globally distributed ODP/IODP sites spanning a wide range of geographic locations, depositional environments, sediment geologic age, sediment mineralogy, and water depths.