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3-D Carbonate Stratigraphic Model based on Energy and Sediment Flux

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We have written a 3-D forward carbonate stratigraphic model based on energy (potential, kinetic and biological) and sediment flux (biologic production, redistribution and accumulation) concepts. Kinetic energy is derived by landward-directed sea swell which dissipates via friction with the seafloor, and from storms on the shelf or platform. The wider the platform the greater the increase in hydrodynamic energy. Carbonate productivity is determined by a function that incorporates water depth, hydrodynamic energy and distance from shore. These parameters collectively account for photic, nutrient, oxygen, temperature, and salinity. Incorporation of hydrodynamic energy into carbonate productivity simulates observed differences in carbonate production and grain type between reefs and shoals, and lagoon/bay environments with similar water depth. Sediment erosion, transportation and redeposition are controlled by the potential energy (topographic gradient) and the kinetic (hydrodynamic) energy on the seafloor. Sediment flux at any time and point is proportional to kinetic energy and potential energy gradient, and sediment mass is conserved within the model. Grain-size distribution is approximately by the hydrodynamic energy. Using these concepts, we formulate a nonlinear parabolic partial differential equation system that relates topography, tectonic movement, sea level, carbonate productivity, sediment erosion, transportation and deposition, and potential and kinetic energy to each other in three dimensions. We discretize the equations with the Crank-Nicholson method in simulation space and solve numerically the resultant equation system with multigrid and Newton methods. Sensitivity analysis indicates the model behaves realistically, and close simulations to published data were achieved without inversion. The model is applicable for stratigraphic prediction and petrophysical simulations at exploration and reservoir scales.