Stratigraphic Numerical Modeling: Contribution to Sequence Stratigraphy

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Sequence stratigraphy has made amazing strides since its inception several decades ago, and stratigraphic numerical modeling has progressed with it, but the relationship has not yet met early expectations. Much of the difficulty lies in the "upscaling problem." The stratigraphic record was produced by processes operating at time scales of seconds to days, but in a given basin, the resulting stratigraphic edifice typically represents tens of millions of years. The problem lies in retaining critical aspects of the physics of high frequency processes in models of long-term stratigraphic successions.

The STRATAFORM program of the Office of Naval Research, and its successor program, EuroSTRATAFORM, has for this purpose developed two converging families of models. The SEDFLUX family has as its greatest strength deep-water gravity processes, while the SEQUENCE family has stressed shallow water sedimentation and the upscaling process itself. A virtue of the STRATAFORM program has been its integrated nature. Modelers work directly with physical oceanographers and students of sediment transport, as well as with sedimentologists who collect cores and stratigraphers who collect seismic profiles, and the work has benefited by the interactions of observationists with modelers. As observations progressed in the west coast study area (northern California margin); the paradigm abruptly changed; The shelf muds have not simply settled out as storm currents waned; in at least some cases, fallout from the plumes of river floods has generated near-bottom fluid muds which slide seaward and deposit on the outer shelf, or bypass over the shelf edge. Working against real-time dynamical records, modelers were not only able to describe this process mathematically, but to show that it dominates over post-storm settling in the stratigraphic record of this tectonically active margin.

How to incorporate such insights into long-term stratigraphic models? Seismic methods record reflections from surfaces, and are notoriously uninformative with respect to lithology. Seismic stratigraphy, sequence stratigraphy, and sequence stratigraphic modeling have primarily been concerned with describing and predicting geometries. How to paint the facies colors between the lines? Ongoing work in the east coast study area (New Jersey Margin) suggests a three-fold approach. Deterministic sediment transport models can be embedded in probabilistic models of depositional systems (facies models), that parameterize driving forces (floods, waves and earthquakes) as probability density distributions. The facies models can in turn be embedded in models of stratigraphic successions that respond to global sea level changes, compaction, and lithospheric mechanics.