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The Role of Sediment Transport and Sea-Level Fluctuations on the Sequestration of Offshore Freshwater in Passive Continental Margin Environments

Mark Person, Kerry Key, Michael Steckler, Chris Paola, Vaughan Voller, Susan Stadler, Aaron Micallef, Celine Grall, Chloe Gustafson, Rob Evans, John Wilson, and Denis Cohen

New Mexico Tech, Hydrology Program, Socorro NM, USA mark.person@nmt.edu

Vast quantities (> 100,000 cubic kilometers) of freshwater are sequestered within continental shelf clastic and limestone formations around the world up to 100 km offshore. We hypothesize that evolving stratigraphy, dynamically changing bathymetry, and sea level fluctuations during the Pleistocene have had an important impact on the distribution of offshore freshwater. Sediment deposition and the stratigraphic evolution of continental shelf deposits are controlled by a variety of tectonic, climate, and geomorphic processes. We illustrate the importance of these coupled processes on fresh water sequestration by presenting results from a simple numerical experiment in which we have reconstructed the stratigraphic and sedimentological evolution of offshore New Jersey, USA over the past 5 million years. Using published permeability data from IODP Expedition 313, we considered two scenarios. In one (dynamic) scenario, we allowed the Plio-Pleistocene stratigraphy to evolve over the past 5 million years. A series of permeable, laterally continuous sand and silt/clay units were deposited over this time interval. In the second scenario, we used the modern stratigraphy in a "static" sense. That is, the stratigraphy considered did not evolve during the simulation. In both scenarios, we allowed sea level to fluctuate along the top boundary. We assumed that the land surface above sea level was exposed to fresh meteoric recharge. We compared computed salinity conditions from these two scenarios to salinity profiles from legacy boreholes as well as recently completed electromagnetic surveys. The salinity distribution in the dynamic scenario more closely mimics observed conditions; the lateral extent of shallow sequestered freshwater extends about 50 km offshore. The lateral extent of freshwater is restricted to 10km from the modern coastline in the static simulation. These differences are likely due to the deposition of shallow confining layers that were not present during recent sea-level low stands.