Linking surface processes to subsurface architecture: Levee-floodplain and delta-bottomset building processes and their stratal records.

Wonsuck Kim, JeongYeon Han, Minsik Kim, Yonsei University

Part 1:
Linking levee construction with channel avulsion: insights from an advection settling model

A natural levee is a typical wedge-shaped deposit adjacent to a river channel. Given the location and distinctive features, levee can serve as a key to revealing depositional processes of the coupled channel to floodplain system preserved in the rock record. Levee-floodplain topographic evolution is also closely linked to river avulsion process which can spell a catastrophic flooding. Nonetheless, the levee geometry and its aggradation pattern on floodplain have not been fully incorporated in the study of avulsion. Here, we present a levee-building model using an advection settling of suspended sediment to reproduce the evolution of a fluvial levee over floods and to examine the effects of boundary conditions on levee geometry and grain-size trend. We further investigate river avulsion frequencies and styles (i.e., local vs. regional avulsion) associated with grain-size distribution of supplied sediment and overflow velocity into floodplain that control the levee geometry and especially the aggradation rate at the levee crest. In the modeling results, levee develops 1) a concave-up profile, 2) exponentially decreasing grain size in the deposits, and 3) a relatively steeper shape for coarser sediment supply with longer time for approaching to the equilibrium state in grain size. We find that the input grain size and levee profile slope are positively correlated with avulsion frequency, whereas the overflow velocity is inversely proportional to avulsion frequency. In connection with avulsion styles and levee geometry, our results suggest that steeper levee slopes tend to promote more local avulsions protecting abandoned channels from topographic healing, but gentler slopes of levee are likely to lead to regional avulsions as abandoned channels with gentler levees are more vulnerable to removal of topographic memory. The insights drawn from the current modeling work, may have potential implications for reconstructing paleoenvironments in regard of river sediment transport and flood processes via levee deposits. Based on roles of a levee on the avulsion frequency and style, the flood hazards triggered by river avulsion as well as the alluvial architectures in the sedimentary record can be better assessed.

Part 2:
The effect of bottomset on fluviodeltaic deltaic building process: Numerical modeling and physical experiment

Loss of coastal delta area is an emerging topic across the scientific community, as many countries have been suffering from land loss due to accelerating relative sea-level rise. Various methods have been attempted to mitigate the land loss. Among these methods, river diversion, which makes use of the natural river delta-building process, has been proposed and examined. Prior numerical models predicted possible ranges of new land-building rates and verified the feasibility of reduction in land loss by river diversions. These models, however, only considered the topset and foreset of the delta without incorporating the mud bottomset, as the subaerial portion of the delta mostly consists of sand, and mud was considered as washload. Since muddy bottomset deposits are observed in most coastal river deltas and less than 20% of the total sediment load is sand (while the rest is comprised of mud), it is critical to understand deposition of mud in deltas. Here, we show that mud retention in the bottomset has significant effects on land building using a new numerical model and flume experiment that includes an additional moving boundary at the foreset-bottomset break. We find that bottomset aggradation can accelerate the shoreline progradation as the bottomset aggradation decreases the foreset length. We also applied our model to a field scale based on parameters taken from the Wax Lake Delta. The results show that when the mud supplied from the river was retained more, delta-building area increases accordingly compared to that in non-bottomset delta. Our results show that even with a limited volume of supplied sand, abundantly available mud deposition in the bottomset can significantly improve the land-building rate. We suggest that bottomset is an important factor in delta progradation, therefore, we should consider bottomset in deltaic evolution to accurately interpret delta responses to external controls (e.g., sea level and sediment supply) using the stratigraphic records of shoreline migration.