Stratigraphic convergence of alluvial-shelf systems through steady base-level cycles: A "degradation-free" world suggested from the autostratigraphy theory and tank experiments

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A prevailing idea/assumption in the stratigraphy of alluvial-shelf systems growing under base level cycles (or relative sea level cycles) is that a particular segment of eustatic curve (or accommodation curve) is reflected in a particular sediment stacking pattern and thus the depositional system has no or insignificant hysteresis of the preceding base level cycles through which the system has been growing. The autostratigraphy theory claims that with base level cycles proceeding, the alluvial-shelf system can take different responses to a same base level condition, depending upon stages of the system’ s spatial growth and slope conditions, and eventually becomes free from global degradation, no matter how fast the base level changes with any large amplitude. The alluvial-shelf system inevitably becomes unable to retain non-equilibrium responses in the initial/early cycles, which, through continuing base level cycles, eventually converge to equilibrium responses that are characterized by alternations of nondeltaic transgression during base level rise and deltaic and aggradational regression during base level fall. These theoretical notions were examined by means of tank experiments at Nagasaki University. During each experimental run, base level (water level inside the tank) changed in a symmetrical pattern where through cycles, the rising and falling limbs had the same constant rate ($|R_{bl}|$), the same constant period, and thus the same constant amplitude (A_{bl}), but with no basin tectonism. Totally nine 2D runs and twelve 3D runs were designed to represent different combinations of $|R_{bl}|$ and A_{bl}, whereby the theoretical predictions were effectively tested. The comparative results of the runs clearly support the notions. In addition, the number of cycles elapsed prior to this phase-transition was proportional to the amplitude that is made dimensionless with autostratigraphic length scale. Long-term subsidence or uplift, while steady base-level cycles in a symmetrical pattern proceed, can seriously affect the non-equilibrium responses and their convergence to the equilibrium responses. Subsidence and uplift during base-level fall will tend to enhance alluvial degradation and aggradation, respectively.The experimentally-verified autostratigraphy theory can account for the geomorphology and stratigraphic architectures of natural alluvial-shelf systems.

Keywords: alluvial-shelf system, autogenesis, autostratigraphy, base level cycles, non-equilibrium response, tank experiment

