Identifying and Assessing Autogenic Cycles in Alluvial Stratigraphy

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Abstract

Autogenic processes in fluvio-deltaic systems have long been considered background noise in stratigraphy, whereas allogenic processes produce larger-scale cyclicity and structure. However, recent studies have found large-scale autogenic processes associated with channel avulsion and compensational deposition can be described as behaving deterministically. Though it is not currently understood if these autogenic patterns are preserved within stratigraphy. If present, these patterns could be exploited to predictably describe reservoir characteristics or, if absent, they could simplify some stratigraphic models. Historically, bed-scale patterns have been a qualitative study with some application of more quantitative techniques such as Markov chain analysis. One challenge has been producing large and detailed enough field datasets to identify long-term (i.e., 100-1,000 kyrs) bed-scale variability, but core with exceptional recovery completeness and physical stratigraphic experiments offer an opportunity. In this study we apply time series analysis to an unusually complete core record through early Paleogene alluvial strata of the Bighorn Basin, Wyoming and purely aggradational, fluvio-deltaic experimental stratigraphy to test the presence of autogenic cyclic signatures. Of particular importance, is a newly identified autogenic process, the compensation timescale, that captures the time necessary for the channel of a fluvio-deltaic system to visit and deposit across the basin and for subsidence to remove the deposits from the reworking zone. This is a deterministic phenomenon arising from the convolution of subsidence and self-generated geomorphic topography creating accommodation in the basin. Our results reveal autogenic cycles within the experimental stratigraphy and

early Paleogene strata. However, these cycles vary in frequency and are sporadic and spatially inconsistent across the basin. This suggests the cycles may be spurious in both cases. Our results also indicate little evidence of cyclicity of the compensation timescale. Furthermore, the core analyses identify statistically significant cycles at frequencies different than the previously identified precessional-scale allogenic signatures from soil morphology. We interpret these results to indicate that large-scale autogenic processes do not impose organized cyclicity and that climatic effects can be recorded independently of the bed-scale structure of stratigraphy. This suggests that caution should be taken when statistically interpreting stratigraphic allogenic signatures using a limited sample size or number of sections. Indeed, bed-scale cycles observed in one location cannot be applied to other locations within a basin, and reservoir models that incorporate stochastic bed-scale patterns are accurate even in simple, well-behaved systems subject to no external forcings.