Autogenic Organization of Channel Avulsions During Basin Filling

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The interplay of autogenic sedimentary processes and basin boundary conditions controls the distribution of coarse-grained channel-belt deposits within alluvial successions. Over basin filling time scales, intrinsic processes, including channel avulsion, are typically assumed to contribute depositional “noise” via relatively small-scale spatial and temporal variability. Consequently changes in stratigraphic architecture are commonly attributed to extrinsic controls, i.e. changes in climate, tectonics, or sea level. Here we present experimental and field evidence that large-scale stratigraphic patterns can arise spontaneously through autogenic processes in the absence of, and independent from, allogenic forcing. Both the Ferris Formation (Upper Cretaceous/Paleogene, Hanna Basin, Wyoming) and a physical experiment designed to highlight intrinsic variability in alluvial depositional systems show stratigraphic organization where clusters of closely spaced channel deposits are separated from other clusters by intervals dominated by overbank material. In the experiment this pattern developed under constant basin boundary conditions and resulted from a combination of relatively frequent, short avulsions and occasional longer avulsions. Over relatively long time scales, the depositional system shifted back and forth to compensationally fill the basin. Spatial statistics show that channel belt bodies in both the experiment and the Ferris Formation are statistically clustered on intermediate basin length scales, a similarity which raises the question of whether channel belt clustering in the ancient deposit is a product of intrinsic depositional processes. The Ferris Formation was deposited in a rapidly subsiding Laramide basin where boundary conditions cannot be assumed constant. In order to evaluate the role of external controls on deposition and determine the potential for self-organization in this ancient deposit, we analyzed the spatial patterns of key channel properties - sand-body aspect ratio, paleoflow depth, maximum clast size, paleocurrent direction, and sediment provenance. The study interval lacks strong spatial trends in sand-body properties. Consequently, channel-belt clustering in the Ferris Formation is interpreted to have resulted from autogenic organization of channel avulsions over basin-filling time scales.