Analysis of a Discontinuity Surface within Point Bar Deposits of False River, Louisiana

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EXTENDED ABSTRACT

Discontinuity or major reorientation surfaces found within point bar complexes of meandering rivers are bounding stratigraphic surfaces (4th or 5th order) useful for detecting major changes in the flow characteristics of ancient fluvial systems. The significance of discontinuity surfaces in modern systems is not well known, even for the well-studied Holocene False River Point Bar complex (Fisk, 1947) of the Lower Mississippi Valley. A two-dimensional characterization of these systems is needed, with particular focus on the internal structure of the point bar complex, including the dip angle as well as the downward trajectory of the discontinuity surface into the subsurface.

We expect a discontinuity surface in a point bar complex to separate sediment classes of different grain sizes. A large shift in the orientation of a meander may generate the discontinuity surface. Seismic methods may characterize the discontinuity surface, as well as the bounding sediments. If the sediment impedance change across the discontinuity surface is not large enough to detect seismically, we may still infer its position by considering changes in dips of overlying and underlying units across this boundary.

Discontinuity surfaces imply episodic point bar growth (Allen and Friend, 1968). Four causes of this episodicity include (1) exceptional flooding, (2) a lack of deposition for an extended period of time, (3) resistance to further migration of the meander because of resistance by a vegetated outerbank, and (4) a channel reaching its minimum radius of curvature. A channel with a larger radius of curvature is more stable and less prone to bank erosion; as the meander's radius shrinks, so does the channel's stability, up to a point.

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LiDAR data (U.S. Army Corps of Engineers, 2001) allow the ridge-swale topography that exists above the point bar deposits to be readily mapped (Fig. 1); this ridge-swale topography gives clues to the relative history of the meander bend. Seismic methods allow us to map the internal structure of the deposit, something that LiDAR cannot do. A sediment core has also been collected directly along the seismic profile, as well as gamma ray and electrical conductivity data in the well. These will be correlated with the seismic data in order to assist with the interpretation.

We collected, processed, and interpreted a two-dimensional, 150-m-long common midpoint (CMP) seismic reflection profile that cuts perpendicularly across a major discontinuity surface in the False River point bar complex, using 24 horizontal component geophones at 1-m spacing. The seismic source consisted of a ground recoil device that fires a shotgun shell horizontally, producing shear waves. Horizontally polarized shear waves (SH) encounter less attenuation than P-waves and produce a better signal with a clearer response, leading to a higher-quality image than P-waves. The point bar sediments in our study area do not exceed 40 m thicknesses (Fig. 2). Multiple field experiments demonstrated which type of source and receiver provided the least amount of noise, with the most coherent incoming signal from reflections.

The seismic processing workflow we use is typical of a reflection seismology survey. Surface waves are removed with f–k filtering. Love waves were especially strong in our data because we collected the profile along a dirt road between two trenches, which act as a waveguide. Additionally, we removed traces that contain diffraction effects produced by a metal culvert that runs perpendicularly underneath our line. We collected shotpoint gathers, which were converted to CMP gathers and then stacked, in order to improve our signal-noise ratio.

Investigating the structure and formation of discontinuity surfaces will allow us to better understand the permeability of these deposits. Permeability in point bar deposits is useful for groundwater management (Raju, 2007), as well as for economic extraction of oil and gas (Strobl, 2013). In addition, this study provides valuable insight into the evolution of fine-grained river systems, both modern and ancient.

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