PSAn Integrated Workflow for Mapping Stratigraphic Features: Identification and Characterization of Channelized Debris Flows Within the Lower Wolfcamp Shale of the Midland Basin*

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Abstract

The Spraberry and Wolfcamp formations in the Midland Basin of west Texas have been heavily logged in numerous vertical wells. Localized stratigraphic features, however, remain difficult to predict and/or correlate. In this study we focus on the identification and delineation of an extensive (> 20-mile long) channelized debris flow complex, identified within the Lower Wolfcamp shale. Originally observed as an amplitude anomaly of unknown origin in a 3D seismic volume, the mapping of different seismic attributes and use of advanced visualization techniques show that the feature contains the unmistakable form of a meandering submarine channel system. Integration of available well logs and a fortuitously placed whole core located in the center of the anomaly confirm the channelized debris flow interpretation. The vertical sequence of facies seen in the core indicate the presence of a stacked succession of multiple individual flows, suggesting the channel was actively constrained to the same location for an extended period of time. Similar features have been noted in the Monterrey Basin, offshore California, and in the Amazon Fan, offshore Brazil, which provide modern analogs in terms of process and scale. Results of this work not only provide information on the debris flow architecture present in the Lower Wolfcamp shale but utilize techniques which apply to other deep-water units of the greater Permian Basin and elsewhere. These techniques have traditionally been used for conventional exploration; however, when utilized in resource plays, they can influence targeting, drilling and completions.

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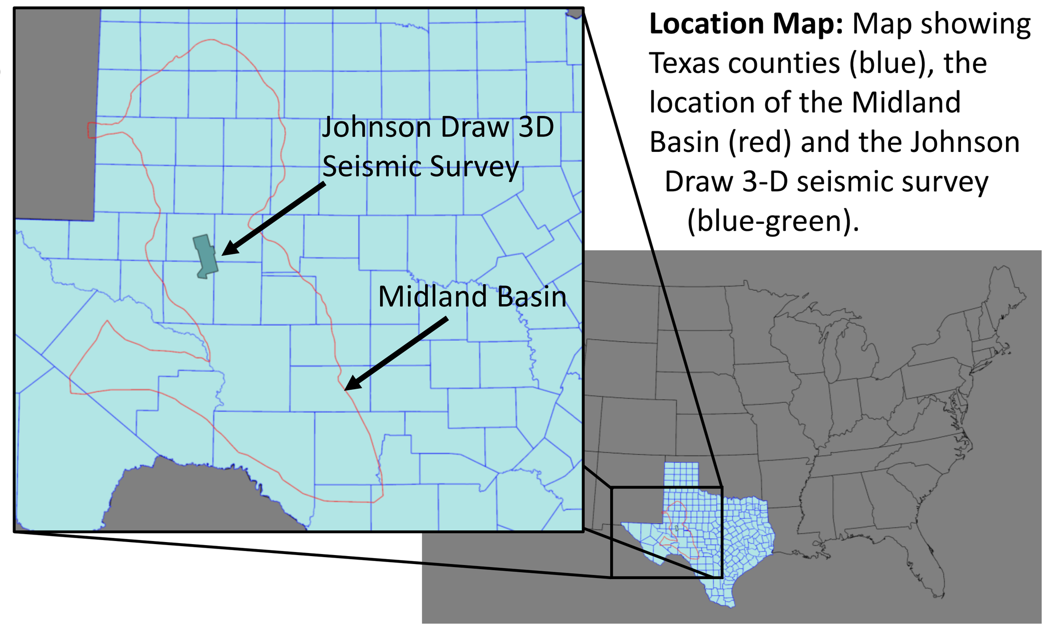
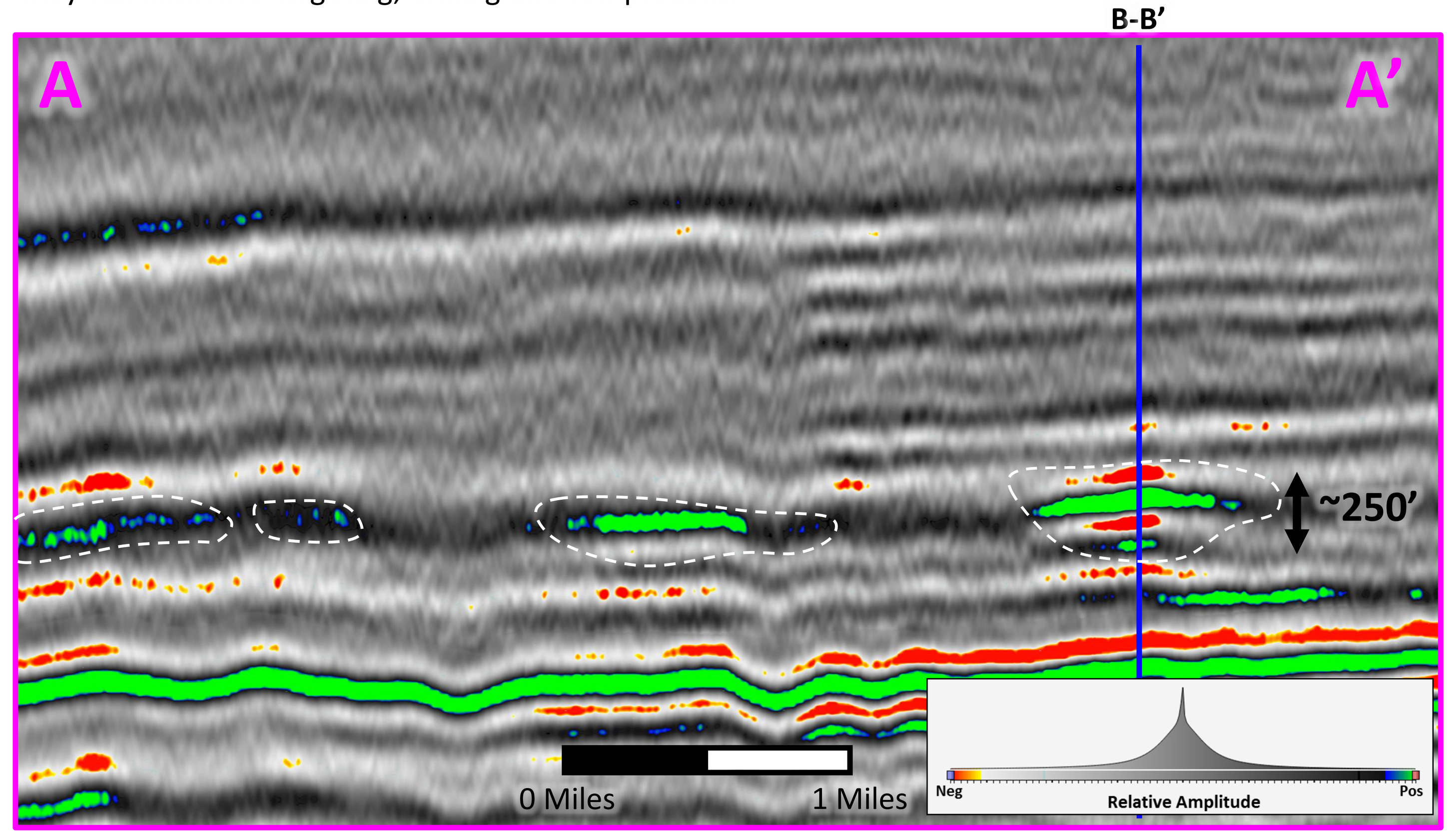
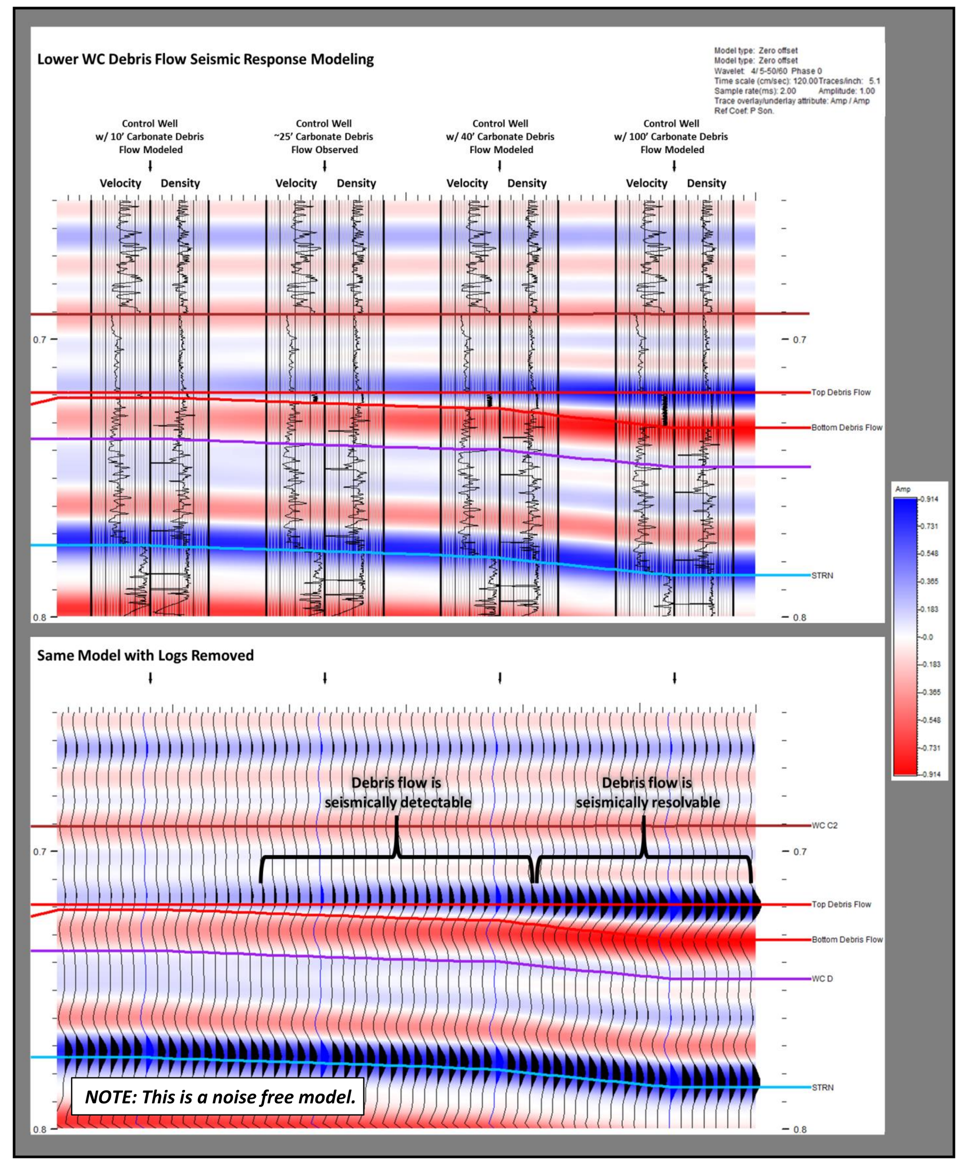


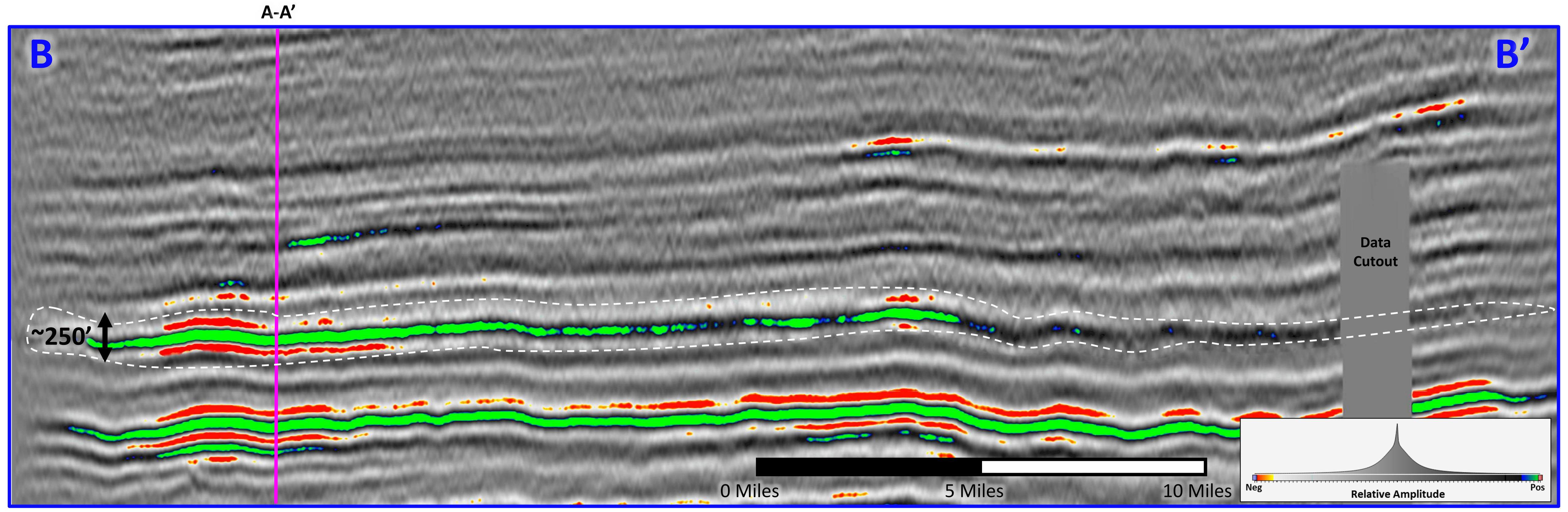
Location Map: Map showing Texas counties (blue), the location of the Midland Basin (red) and the Johnson Draw 3-D seismic survey (blue-green).



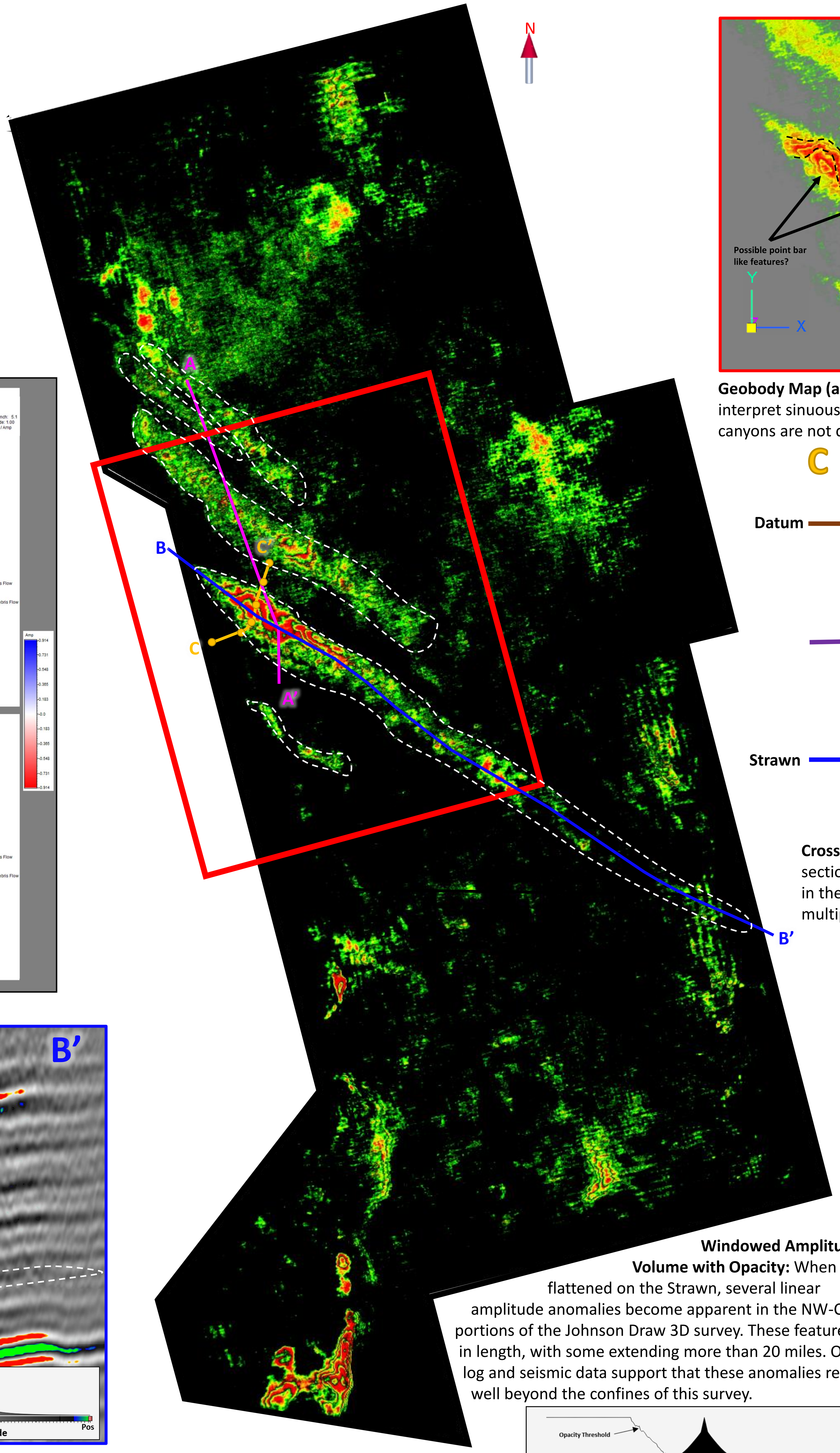
Cross section A-A' (above): Seismic amplitude (time) across multiple incised, debris flow filled channels. Because of the likely thinning and stratigraphic changes occurring on the edges of channel, the lateral extents are difficult to interpret without well control. Observation of these anomalies provided the catalyst for this study.



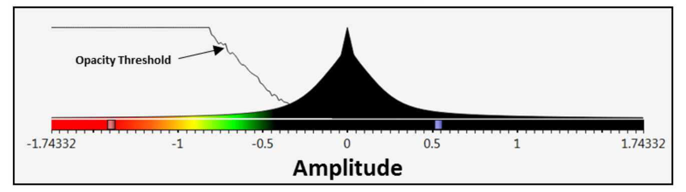
Debris Flow Modeled Seismic Response (right): Forward modeling of a debris flow of varying thickness showing amplitude development as the flow gets thicker. When the modeled flow is ~20' thick it becomes detectable, eventually becoming fully resolvable at ~50' thick.

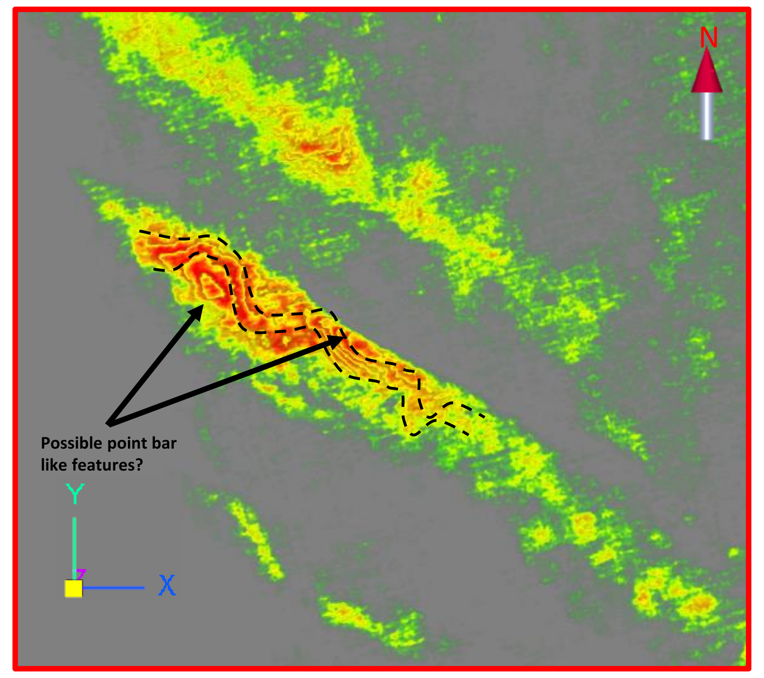


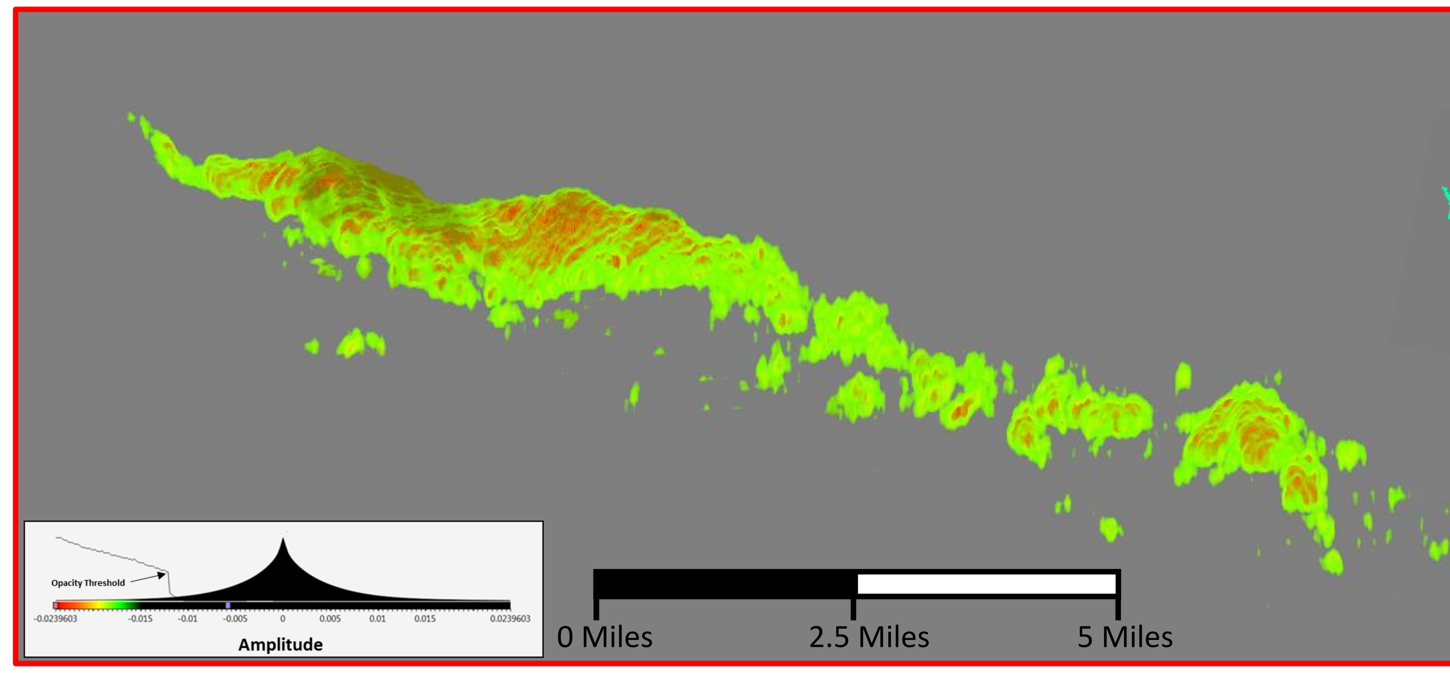
Cross section B-B': Seismic amplitude (time) along the southern-most incised, debris flow filled channel. Note, the zone in the middle of the inferred channel and it's diminished seismic response. This could be a result of a bypassed zone or a zone of thinning. See the modeled seismic response above for thickness requirements for seismic detection and resolution.



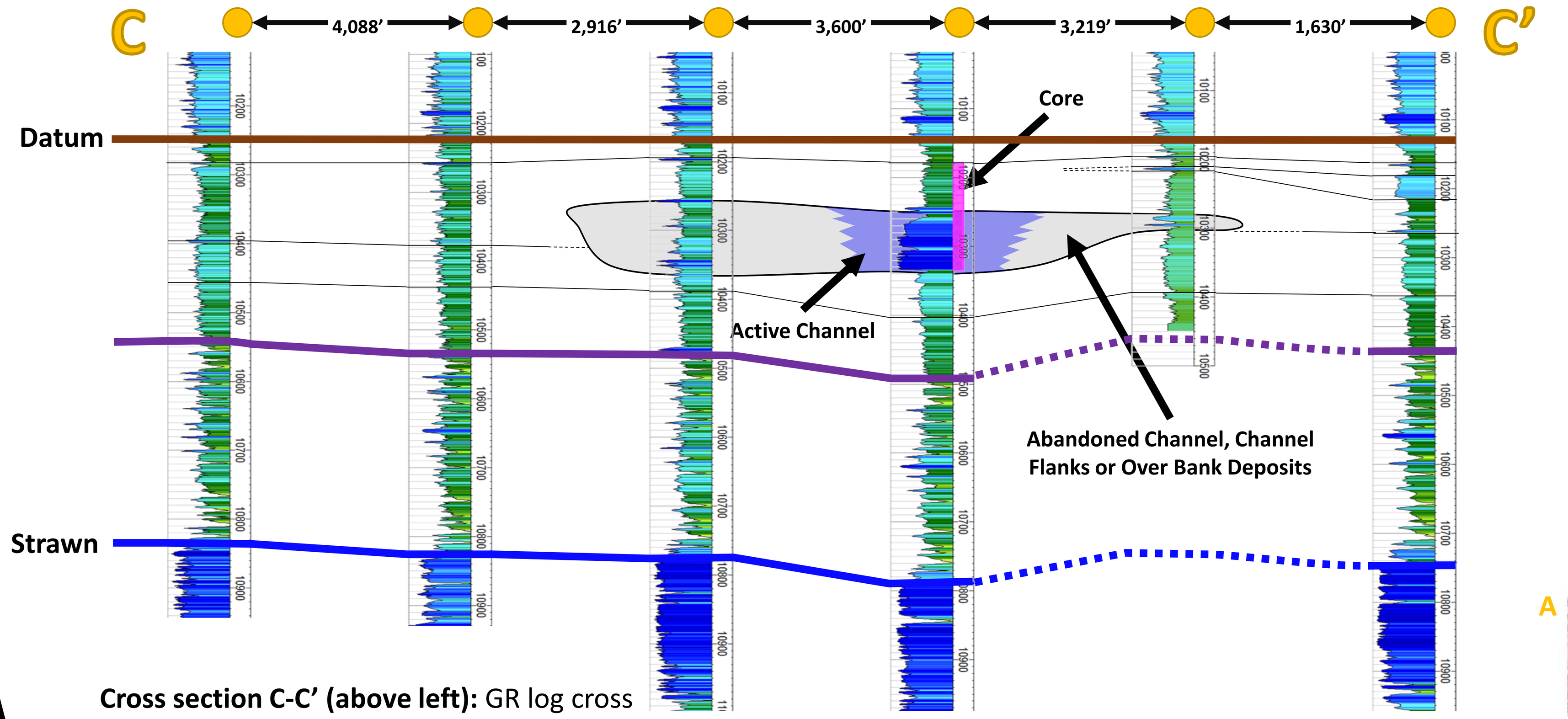
Windowed Amplitude Volume with Opacity: When flattened on the Strawn, several linear amplitude anomalies become apparent in the NW-Central portions of the Johnson Draw 3D survey. These features vary in length, with some extending more than 20 miles. Other log and seismic data support that these anomalies reach well beyond the confines of this survey.

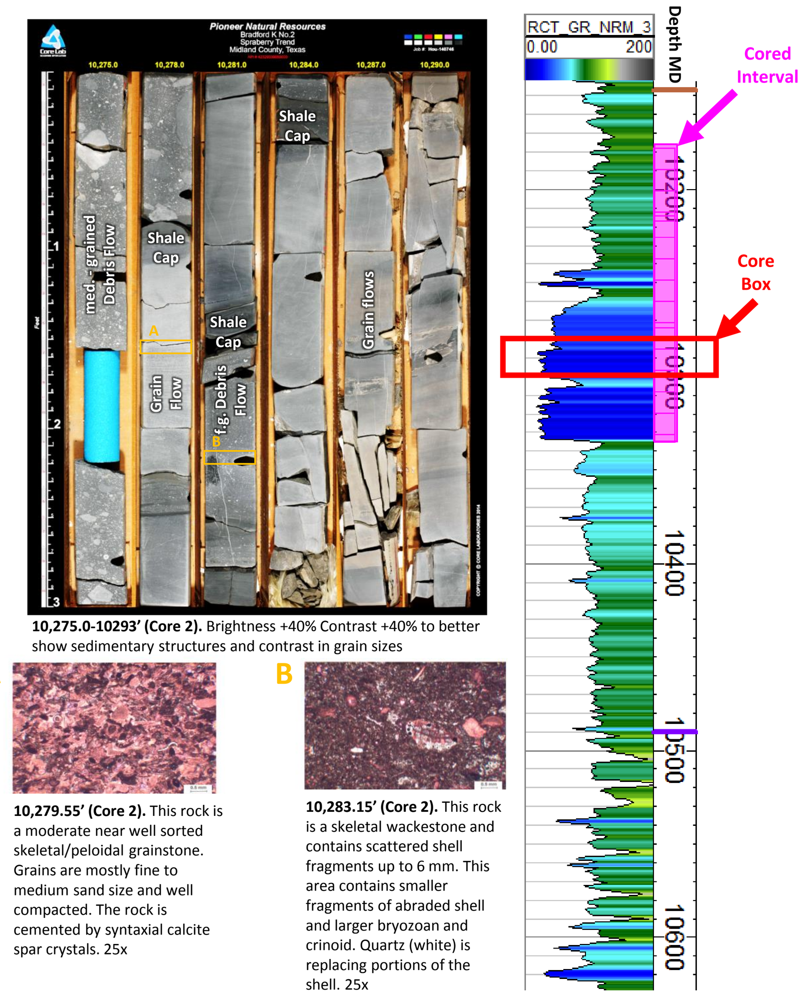




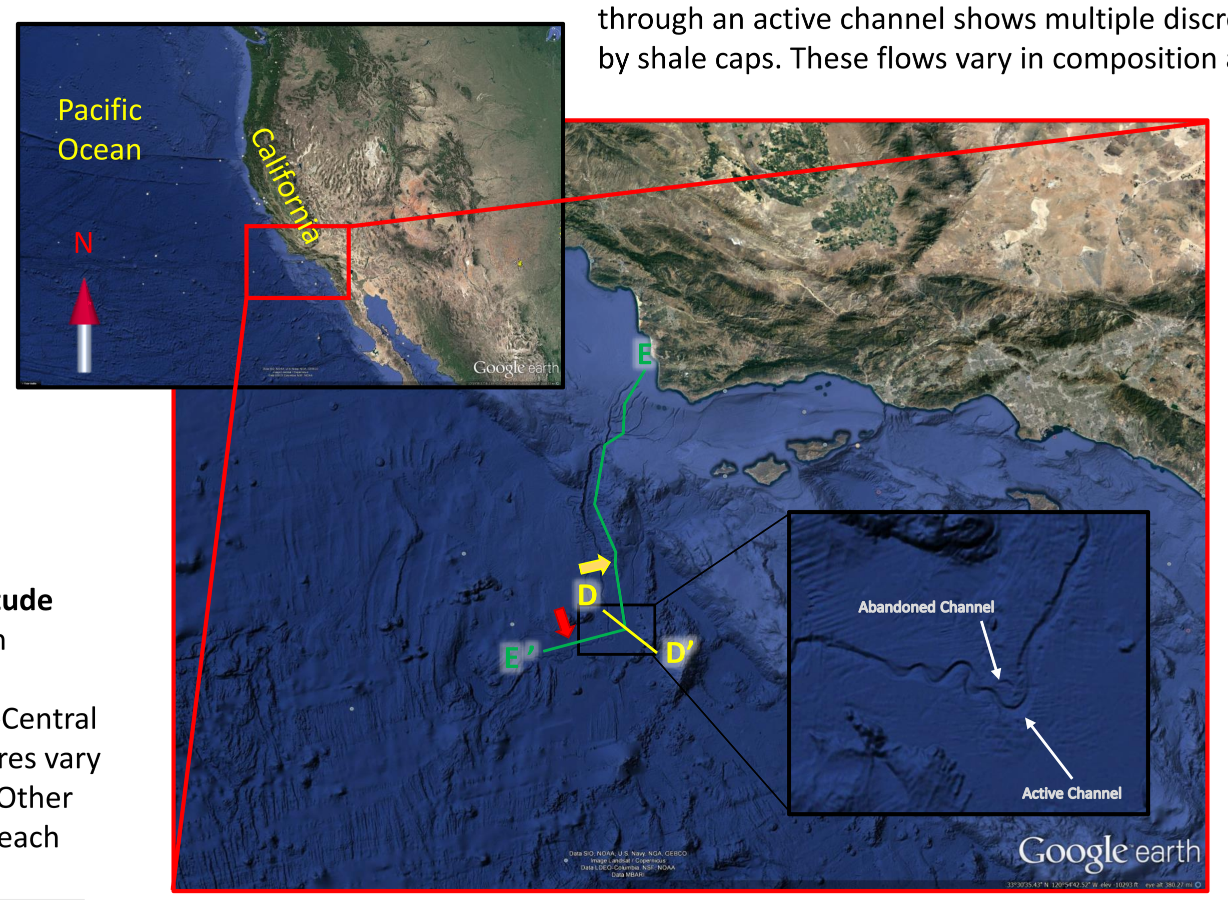


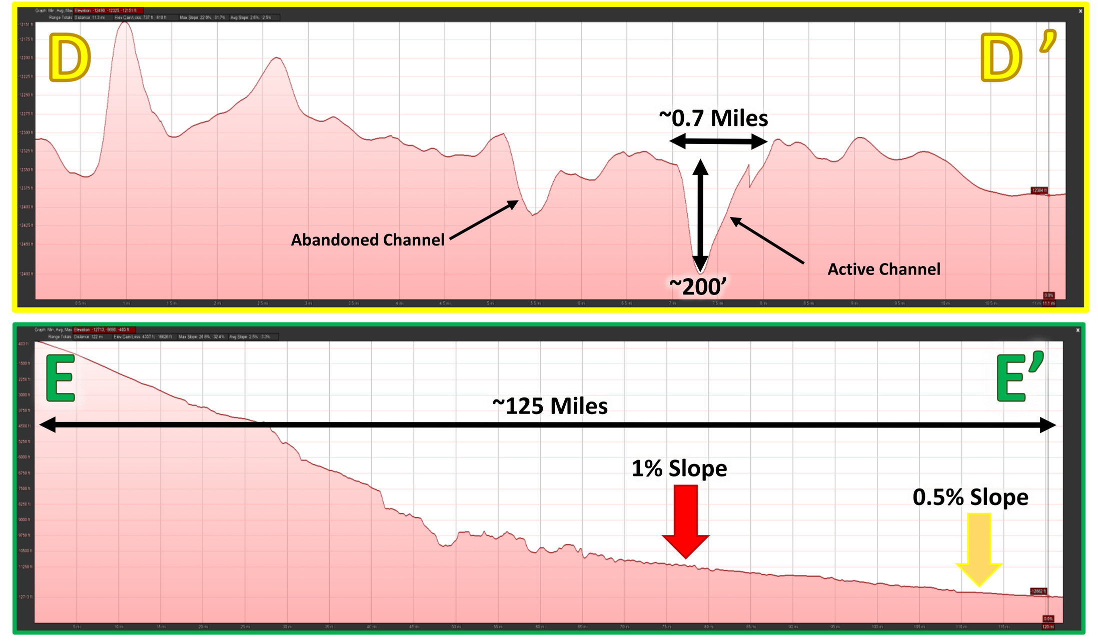
Geobody Map (above left): Filtering and opacity have been applied to windowed amplitude (time) volume to help define geobodies. Once filtering is applied it is possible to interpret sinuous channel forms within the larger incised submarine canyons. This geomorphology is supported by modern analogs. **Geobody 3D section (above right):** Incised canyons are not dipping uniformly, suggesting possible deformation, post-deposition.





Cross section C-C' (above left): GR log cross section though wells. These wells have been logged through one of the debris flow filled, incised channels observed in the seismic. Log signatures and interpretation support the theory of a long lived, active channel which contains multiple flows, abandoned channels, and overbank deposits. **Core Photos and Photomicrographs (above right):** Core through an active channel shows multiple discrete flows separated by shale caps. These flows vary in composition and texture.





Model Analog: Hydra sub-marine channel off of southern California, USA is used as a modern analog. This channel system is around 125 miles long and (where most applicable to this study) is around .75 miles across and around 200' deep. A close look at the bathymetry in Google earth reveals sinuous channels within the larger incised canyon. Similar channel features are seen in the 3D seismic data. **Cross Section D-D':** Strike section from Google earth, across the distal Hydra Submarine Canyon. Section shows active and abandoned channel features. The active channel has similar dimensions as the amplitude anomalies observed in seismic. **Cross Section E-E':** Dip section from Google earth, showing offshore bathymetry paralleling the main active channel of the Hydra Submarine canyon.