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Imaging fault zones using 3D seismic image processing techniques

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Significant advances in structural analysis of deep water structure, salt tectonic and extensional rift basin come from the descriptions of fault system geometries imaged in 3D seismic data. However, even where seismic data are excellent, in most cases the trajectory of thrust faults is highly conjectural and still significant uncertainty exists as to the patterns of deformation that develop between the main faults segments, and even of the fault architectures themselves. Moreover structural interpretations that conventionally define faults by breaks and apparent offsets of seismic reflectors are commonly conditioned by a narrow range of theoretical models of fault behavior. For example, almost all interpretations of thrust geometries on seismic data rely on theoretical "end-member" behaviors where concepts as strain localization or multilayer mechanics are simply avoided. Yet analogue outcrop studies confirm that such descriptions are commonly unsatisfactory and incomplete. In order to fill these gaps and improve the 3D visualization of deformation in the subsurface, seismic attribute methods are developed here in conjunction with conventional mapping of reflector amplitudes (Marfurt & Chopra, 2007)). These signal processing techniques recently developed and applied especially by the oil industry use variations in the amplitude and phase of the seismic wavelet. These seismic attributes improve the signal interpretation and are calculated and applied to the entire 3D seismic dataset. In this contribution we will show 3D seismic examples of fault structures from gravity-driven deep-water thrust structures and extensional basin systems to indicate how 3D seismic image processing methods can not only build better the geometrical interpretations of the faults but also begin to map both strain and damage through amplitude/phase properties of the seismic signal. This is done by quantifying and delineating the short-range anomalies on the intensity of reflector amplitudes and collecting these into "disturbance geobodies". These seismic image processing methods represents a first efficient step toward a construction of a robust technique to investigate sub-seismic strain, mapping noisy deformed zones and displacement within subsurface geology (Dutzer et al.,2011; Iacopini et al.,2012). In all these cases, accurate fault interpretation is critical in applied geology to building a robust and reliable reservoir model, and is essential for further study of fault seal behavior, and reservoir compartmentalization. They are also fundamental for understanding how deformation localizes within sedimentary basins, including the processes associated with active seismogenetic faults and mega-thrust systems in subduction zones.

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