Attribute-Assisted Interpretation of Fractured Vuggy Carbonate in the Tarim Basin

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Ordovician-age carbonate reservoirs are one of most economic oil and gas producing formation in the Tarim Basin. The reservoirs are buried very deep (more than 5000 m), and include many different types of traps. Compression and strike-slip faulting vuggy and fractured carbonates form the most common reservoirs. Irregular fracture interaction between sinkhole and source formation gives rise to both vertical and lateral heterogeneity. Several papers have demonstrated the value of improved seismic resolution in the identification of fault damage zones, sinkhole, cracks, fault-and fracture-controlled karst, and unconformities that form components of these reservoirs. However, identification of small-scale karstification is difficult on conventional in seismic amplitude volumes.

Seismic attributes identify changes of reflection in amplitude, phase, frequency, and continuity, which in turn provide quantitative measures critical to reservoir modeling and characterization. Karst provides complex patterns in seismic amplitude and exhibits a specific expression on every attribute. Karst-related diagenetic products generate lateral changes in thickness and porosity. Inaccurate velocity would give rise to miss-migration of diffraction wave at edges of sinkhole or caverns. To address these issues, we first apply principal component structure-oriented filtering to sharpen the edges of karst and fractured zones. Structural dip and curvature, which are the first and second derivatives of seismic reflections, are computed to highlight flexures, collapse features, and remnant karst towers. However, more subtle karst structures, extending vertically less than a quarter wavelength, are not seen by traditional geometric attributes. In contrast, amplitude gradients and amplitude curvature are sensitive to lateral changes in tuning thickness. The amplitude gradients and amplitude curvatures are the energy-weighted derivatives of seismic amplitude, and delineate not only several overlooked features of structural curvatures

but also small radius amplitude anomalies that result in the well-recognized “string of pearls” pattern.

Integration of karst features with associated cracks, faults, fractures, and unconformities, is critical to understand the storage and mobility of hydrocarbon fluids and form a key component of the reservoir model.