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Relay Ramp Style in Massive Limestone: Examples from the Sierra Del Carmen, West Texas

Relay ramps and breached relay ramps are important locations of enhanced fracture permeability in fractured reservoirs. The spectrum of relay ramp geometries includes relay ramps where displacement is partially accommodated by development of synthetic dip or several parallel normal faults within the relay ramp. Relay ramps that accommodate fault system displacement by development of synthetic dip or smaller scale faulting are recognizable as displacement minima on cumulative displacement profiles of the bounding faults. The Sierra Del Carmen in west Texas provides excellent exposure of a normal fault system in the thick, massive Cretaceous Santa Elena Limestone. Displacement maxima are on the order of tens to hundreds of meters and are in the size range of structures resolvable using seismic methods. Remote sensing and field analysis of the Sierra Del Carmen fault system reveals that fault linkage by connecting fault formation is rare or absent. Rather, fault linkage developed by curved lateral propagation of overlapping fault tips. Detailed analysis of relay ramps in various stages of development shows that relay ramps commonly contain smaller displacement normal faults parallel or at a low angle to the bounding faults, producing nested relay ramps. In each case, these relay ramps correspond to displacement minima on cumulative displacement profiles of the bounding faults. This relay ramp style may reflect early distributed faulting between underlapping faults. Prediction of analogous subseismic faults in production settings may be possible by identifying displacement minima on cumulative displacement profiles of seismically imaged faults.