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The impact of mechanical layering on fracture propagation in faulted heterolithic siliciclastic succession

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Fracture type, geometry, distribution and dimensional properties play a significant role in the containment and migration of fluids in underground natural reservoirs. These properties are functions of the host rock rheology, which hence affect the modalities of fracture propagation within rock multilayers. In order to gain new insights on this topic, we study two heterolithic successions in siliciclastic rocks, which provide a unique opportunity to study fracture propagation in sedimentary beds: 1) the Miocene Cilento group, located along the Tyrrhenian side of southern Italy; 2) the Miocene - late Oligocene Macigno Formation, which outcrops in southern Tuscany, Italy. The Cilento group is made up of sandstone-pelitic and marly-calcarenite turbidites, with conglomerate intervals that are generally deposited unevenly throughout the study sites. There, faults with offsets up to ca. 50 m are investigated. The Macigno Formation includes siliciclastic turbiditic sandstones with minor siltstones, mudstones, marls and shales. There, faults with offsets up to 20 m are investigated. The comprehensive study of the two localities provides the chance to study fracture propagation in beds characterized by dissimilar lithologies and thicknesses. These outcrops also offer the opportunity to document the deformation mechanisms associated to fault nucleation and fault development across the multilayers. Results are consistent with the bed thickness, lithology and character (evenly vs. unevenly distributed beds) governing the fault evolution. Small- and medium-scale faults (0 - 10 m offset) exhibit flat-ramp geometries in correspondence of changing lithologies, which are hence interpreted as due to contrasting mechanical properties of the host rock. As a result, these faults show a pronounced variation of the dip angle throughout the multilayers. Conversely, large-scale (>10 m offset) faults exhibit straighter geometry, with volumes of cohesive and uncohesive cataclastic rocks localized into vertically persistent fault cores. Within the fault damage zones, preliminary data indicate that the fracture distribution is not dependent upon the bed thickness, but it is rather controlled by the grain size distribution of the rock. By comparing multiscale fault architecture in these two siliciclastic successions, this study can contribute to a better understanding of underground fluid flow in natural reservoirs.