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Evolution and architecture of a large, basin-bounding normal fault zone in Mesozoic platform carbonates of central Italy

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We studied the mechanisms and intensity of deformation across a large, active, basin-bounding normal fault zone in low porosity Mesozoic platform carbonates of central Italy. Based on the nature, orientation, crosscutting and abutting relationships of the different structural elements preserved within the fault zone and surroundings, we propose a conceptual model of normal fault growth under an extensional tectonic regime that follows an earlier contractional regime. Normal faulting initiated at depths of 1-2 km by shearing of the preexisting structural elements (predominantly pressure solution seams) of the platform carbonates, and formation and subsequent shearing of seams and joints/veins. This hierarchical process led to the localization of pods of fragmented carbonates within the individual mechanical layers, which eventually coalesced to form two sets of conjugate small normal faults within the emerging normal fault zone. The latest stages of deformation, at near surface conditions, were characterized primarily by opening mode mechanisms. The end result is a mature fault zone with $\sim$600m of throw that includes deformed basinal sediments in the hanging wall, 1m thick fault core and $\sim$100m thick damage zone in the footwall. The fault core is made up of low porosity and permeability matrix/cement-supported fault rocks and major slip surfaces. The damage zone consists of small faults with offsets between few centimetres and 10's of meters, and three domains of fragmented carbonate matrices whose porosity, permeability, and degree of deformation increases towards the fault hanging wall. The normal fault zone forms a combined barrier-conduit permeability structure to subsurface fluid flow.