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Structural architecture and paleofluid evolution of the Compione fault, Northern Apennines

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The Compione fault (CF) is part of the basin boundary East Lunigiana extensional fault system, active since Early Pliocene. This system is composed of three main fault segments, striking almost NW-SE and dipping 60-70° to the SW. The offset of the CF exceeds 1 km and caused the tectonic juxtaposition of turbiditic sandstones of the Late Oligocene-Early Miocene Macigno Fm. in the footwall, against the calcareous pelites, siltites and fine sandstones of the Ottone Fm. (a Late Cretaceous Ligurian Helminthoid Flysch) in the hangingwall. The CF overprints the previously-formed contractional tectonic stack where the Ottone Fm. overthrusted the Macigno Fm. during Miocene times. We performed a detailed structural analysis along a cross-section perpendicular to the CF in its central part, coupled with laboratory analyses including standard and cold cathodoluminescence petrography, microtermometric and stable isotope analysis of vein cements, and particle size analysis of fault core rocks. Field data show that the architecture of the CF is formed by an about 1.5 km wide asymmetric damage domain, composed of an up to 1 km wide footwall damage zone, an almost 500 m wide hangingwall damage zone and a core domain with variable thickness, up to some tens of meters, mostly composed of cataclastic sandstones and gouge layers, which typically incorporates one or more shear lenses of Macigno sandstones. In the footwall, extensional deformation affecting very thick and coarse sandstone strata caused intense fracturing, mostly by low-displacement conjugate extensional faulting. Hangingwall rocks are less fractured than footwall rocks due to their different composition and rheology, which favoured abundant dissolution-cementation processes and extensional faulting along less numerous, higher displacement shear zones. We propose an evolutionary model of the CF that starts with upward propagation as a blind extensional fault dissecting the previously formed thrust-related anticline. Intense fracturing in the footwall sandstones occurred in the very early fault propagation stages, mostly in the process zone ahead of the fault tip. With increasing displacement, extensional fault-propagation folding caused passive rotation of both footwall and hangingwall rocks, and of previously-formed fracture patterns, up to 55-60° to the SW. Eventually, fault breakthrough caused deformation localization within a thick cataclastic fault core.