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Fault fluid evolution at the outermost edges of the southern Apennines fold-and-thrust belt, Italy

Fabrizio Agosta (1), Claudia Belviso (2), Francesco Cavalcante (2), and Angela Vita Petrullo (3)

(1) University of Basilicata, Sciences, Potenza, Italy (fabrizio.agosta@unibas.it), (2) Istituto di Metodologie per l'Analisi Ambientale, National Research Council, Italy, (3) GeosmartItalia

This work focuses on the structural architecture and mineralization of a high-angle, extensional fault zone that crosscuts the Middle Pleistocene tuffs and pyroclastites of the Vulture Volcano, southern Italy. This fault zone is topped by a few m-thick travertine deposit formed by precipitation, in a typical lacustrine depositional environment, from a fault fluid that included a mixed, biogenic- and mantle-derived CO_2. The detailed analysis of its different mineralization can shed new lights into the shallow crustal fluid flow that took place during deformation of the outer edge of the southern Apennines fold-and-thrust belt. In fact, the study fault zone is interpreted as a shallow-seated, tear fault associated with a shallow thrust fault displacing the most inner portion of the Bradano foredeep basin infill, and was thus active during the latest stages of contractional deformation.

Far from the fault zone, the fracture network is made up of three high-angle joint sets striking N-S, E-W and NW-SE, respectively. The former two sets can be interpreted as the older structural elements that pre-dated the latter one, which is likely due to the current stress state that affects the whole Italian peninsula. In the vicinity of the fault zone, a fourth joint high-angle set striking NE-SW is also present, which becomes the most dominant fracture set within the study footwall fault damage zone. Detailed X-ray diffraction analysis of the powder obtained from hand specimens representative of the multiple mineralization present within the fault zone, and in the surrounding volcanites, are consistent with circulation of a fault fluid that modified its composition with time during the latest stages of volcanic activity and contractional deformation. Specifically, veins infilled with and slickenside coated by jarosite, Opal A and/or goethite are found in the footwall fault damage zone.

Based upon the relative timing of formation of the aforementioned joint sets, deciphered after an accurate analysis of their abutting and crosscutting relationships, we envision that the fault fluid was first likely derived from a deep-seated, acid fluid, which interacted with either Triassic or Messinian in age evaporitic rocks during its ascendance from depth. From such a fluid, jarosite precipitated within N-S and NE-SW joints and sheared joints located both away and within the fault damage zone. Then, very warm fluids similar to the lahars that were channeled along the eastern flank of the Vulture Volcano caused the precipitation of Opal A within the dense fracture network of the footwall damage zone, likely causing its hydraulic fracturing, and in the N-S striking veins present in the vicinity of the fault zone. Finally, gotheite coated the major slickensides and sealed the NE-SW fractures, postdating all previous mineralization. Gothetite precipitate from a fault fluid, meteoric in origin, which interacted with the volcanic aquifer causing oxidation of the iron-rich minerals.