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Structurally controlled kaolinite-alunite mineralization in the lithocap of a fossil geothermal system

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Geothermal heat is a crucial source of renewable energy. Its present and future exploitation can be enhanced by the understanding of the in–situ structural and mineralogical processes and of how these processes may change the reservoir productivity. Fossil hydrothermal system may thus be used as analogues to study in-situ fluid-rock interaction processes in active geothermal systems.

We present the results of a structural-mineralogical study carried out in the lithocap of the Allumiere high-sulphidation epithermal system (Tolfa Mountains district, northern Latium, Italy). We integrated measurements of attitude of faults and fractures from field analysis with a virtual outcrop model constructed from drone imagery to model the distribution of major faults at the scale of the entire quarry. We then characterized the textures and mineralogical compositions of the alteration facies using optical petrography, Scanning Electron Microscope (SEM), X-ray diffraction analysis and field-based short-wave infrared (SWIR) spectrometer and we mapped their distribution in relation to major faults orientation.

We interpreted that initial argillization was promoted by circulation of highly reactive fluid(s) along a major fluid conduit, probably in the form of a network of fault and fractures. Fluid circulation promotes hydrolytic alteration of the Plio-Quaternary pyroclastic rocks, forming a highly silicified carapace at the immediate vicinity of conduits. Enrichment in alunite and kaolinite increases towards distal areas, which in turn fades out into illite-smectite-bearing zone, where the country rock appears less altered. Latest fracturing and fluid circulation occurs along two major sets of faults, oriented NE-SW and NW-SE that sharply put in contact different mineralogical facies.

We propose that initial alteration induces a mineralogical-mechanical zonation that control latest reactivations of the system. Strain localization promotes a massive mineralization of alunite and kaolinite by continuous dissolution and precipitation along major faults.