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Magma and hydrothermal fluids exploiting similar crustal traps at Gavorrano (Tuscany)

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The 3D reconstruction of magmatic, metasomatic and/or ore bodies plays a major role in understanding the emplacement mechanisms for magmas and hydrothermal fluids in the upper crust.

The Gavorrano Intrusive-Hydrothermal Complex (GIHC, Tuscany, Italy) is an excellent case study in which intrusive and hydrothermal rocks, as well as sulphides ore bodies are spatially associated.

The evolution of the GIHC starts in the early Pliocene with the sequential emplacement, at the contact between the Paleozoic basement (metapelites) and the overlying Mesozoic limestone-dolostone formations, of a cordierite-biotite monzogranite and a tourmaline microgranite. The monzogranite is highly porphyritic with megacrysts of K-feldspar and phenocrysts of quartz, plagioclase, biotite, and cordierite. The microgranite is characterised by a huge number of euhedral microliths (10-500 μm) of black tourmaline set in a quartz-feldspars groundmass. The small size of the Gavorrano intrusion (ca. 3 x 1 km) and its shallow emplacement level (ca. 5 km) resulted in a thin contact aureole (< 100 m thick) made of phlogopite-olivine marble and biotite-andalusite pelitic hornfels. Isoclinal folds in marble are indicative of dynamic crystallization during contact metamorphism and point out an outward sense of movement of the aureole rocks with respect to the granite intrusion. At the contact with the intrusion, marbles were overprinted by a discontinuous (0.1-10 m thick) layer of vesuvianite-garnet exoskarn. Exoskarn, contact aureole and undisturbed host rocks, were subsequently affected by hydraulic brecciation. The closing stage of the evolution of the complex is characterized by mineralizing fluid circulation, producing widespread chloritization-silicification and decametric pyrite bodies (with adularia, fluorite, and base metal sulfides).

Surface and underground mapping integrated by mining reports and drill logs allow us gave way to the reconstruction of the attitude and shape of magmatic and hydrothermal bodies. The NW-SE elongated intrusion is characterised by a pronounced asymmetry: the eastern part is made of sub-horizontal multiple bodies, locally with both roof and bottom contacts exposed; the western part has an overall sub-vertical, west-dipping attitude. Such an asymmetry is shown by each of the two intrusive units and highlighted by second order features: the monzogranite unit reaches its maximum thickness (0.8 km) in the central-western subvertical zone while in the subhorizontal eastern branches is few hundred meters thick, and the subhorizontal microgranite bodies display steep west-dipping offshoots. The GIHC asymmetry is also exhibited by the hydrothermal system: the pyrite orebodies mantle the top and the western flank of the intrusion, with the two main masses displaying, in vertical section, a sigmoidal shape with a steep west-dipping thick portion connecting upper and lower tails gently dipping to the west.

The collected data indicate the west side of the GIHC as the focus zone for both magmas and hydrothermal fluids. The overall geometries of the intrusive units and pyrite bodies suggest a sense of movement top-down-to-the-west. This close spatial and shape relationship between intrusive rocks and hydrothermal bodies suggests a common extensional tectono-magmatic regime capable to produce asymmetric crustal traps (dilational structures) for magmas and fluids.