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Hydrothermal Fluid Evolution and Polymetallic Mineralization of the Roc Blanc Pb-Zn-Ag-Au Vein Deposit, Jebilet Massif, Variscan Belt, Morocco

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INTRODUCTION & AIM

The Roc Blanc deposit is a Pb-Zn-Ag-Au vein-type deposit located in the central part of the Jebilet Hercynian massif, about 20 km northwest of Marrakech, within the Jebilet Pb-Zn-Ag-Au metallogenic province (Fig. 1). It is one of numerous Pb-Zn-Ag-Au ± Sb ± Cu ± F ± Ba vein-type deposits widely distributed within the Paleozoic inliers of Morocco. The mineralization occurs along the N- to NNW-trending Marrakech Shear Zone and is hosted by Visean-Namurian metamorphic shales (spotted schists) belonging to a succession of organic-rich black shales with interbedded sandstone, quartzite, and carbonate, metamorphosed under greenschist- to amphibolite-facies conditions (Huvelin 1977; Huvelin et al., 1978; El Arbaoui et al., 2019). The deposit is located within the contact metamorphic aureole of the Bramram-Tabouchennt-Bamega (BTB) granodioritic plutons.

The ore assemblage mainly consists of galena, sphalerite, native silver, and Ag-bearing sulfosalts hosted in a gangue of ferroan dolomite, ankerite, Mg-siderite, calcite, and quartz (Fig. 2 & 3). Mineralization forms a complex network of transtensional subvertical veins, veinlets, and en echelon tension gashes trending mainly NNW-NNE.

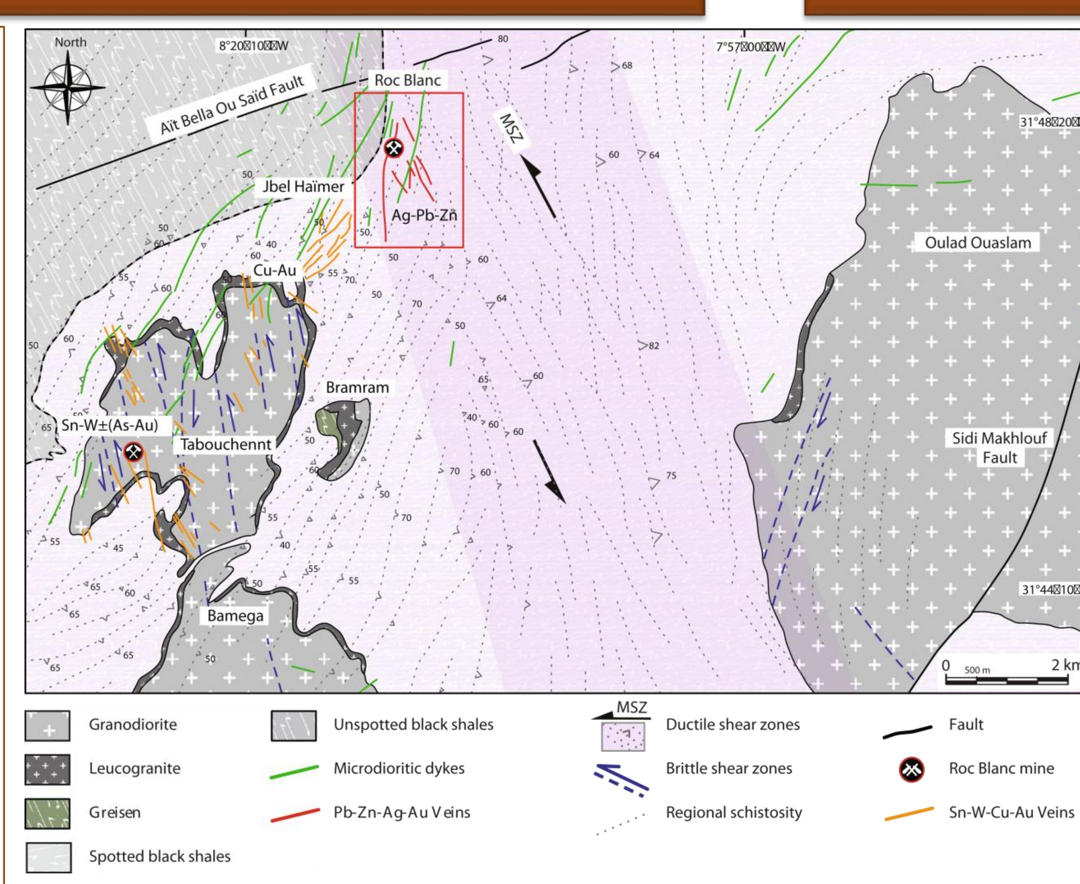
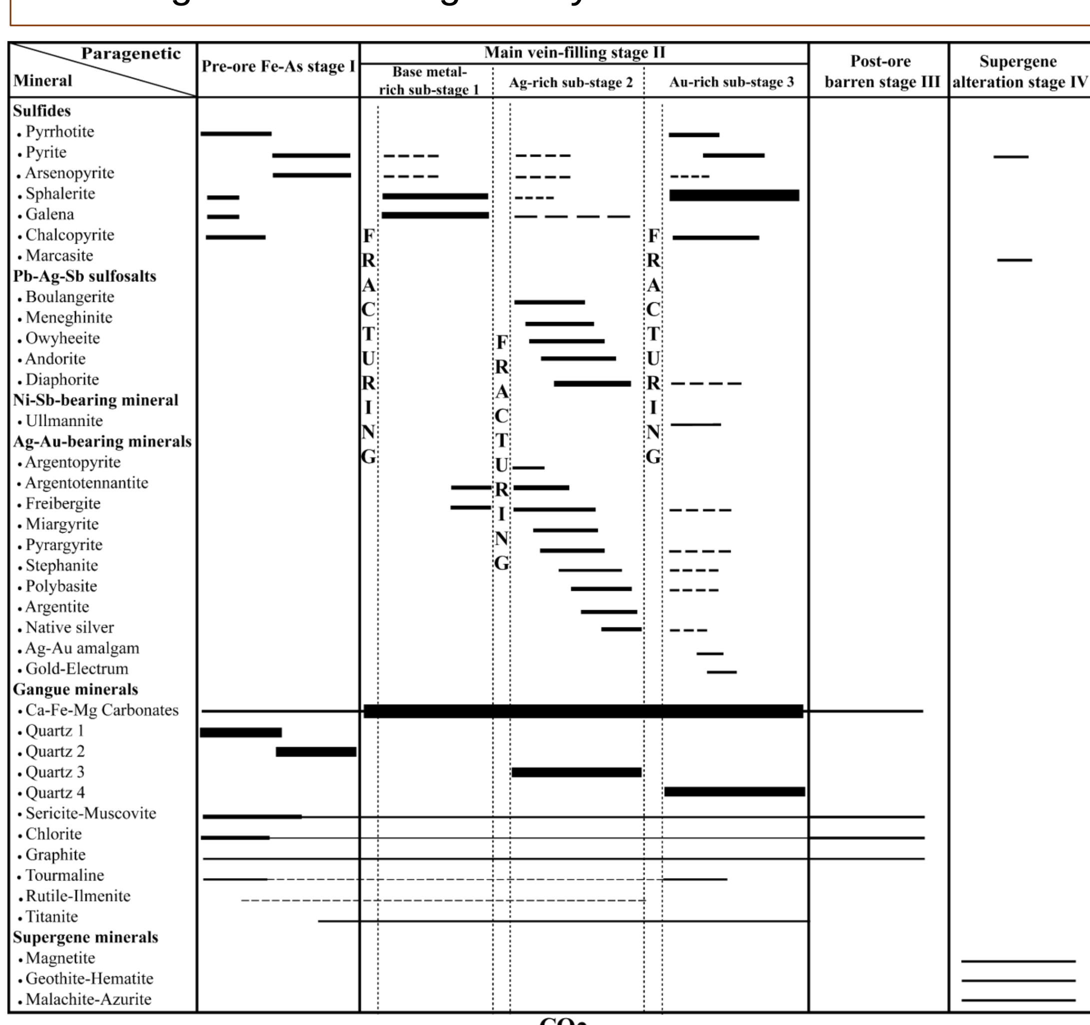


Fig. 1. Geology of the Roc Blanc Pb-Zn-Ag-Au deposit and its relationship to late Variscan granitoid intrusions and associated regional-scaleMarrakech Shear Zone (El Arbaoui et al., 2019)



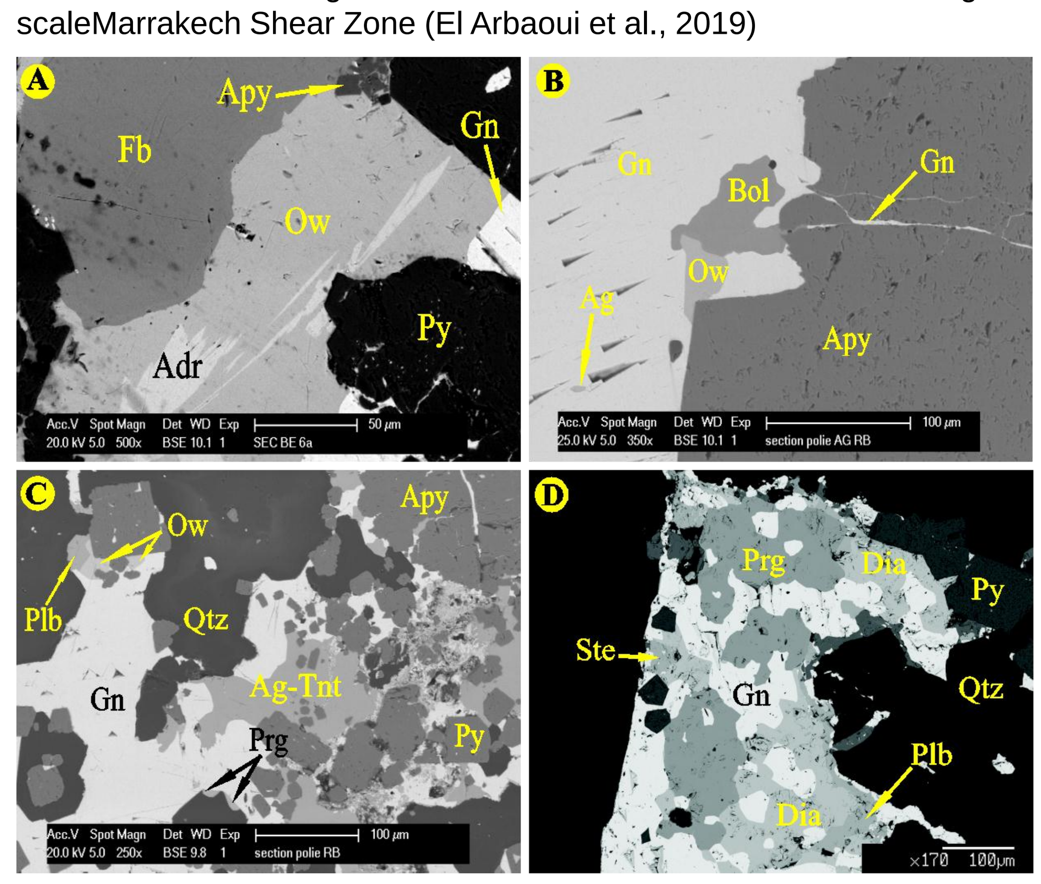
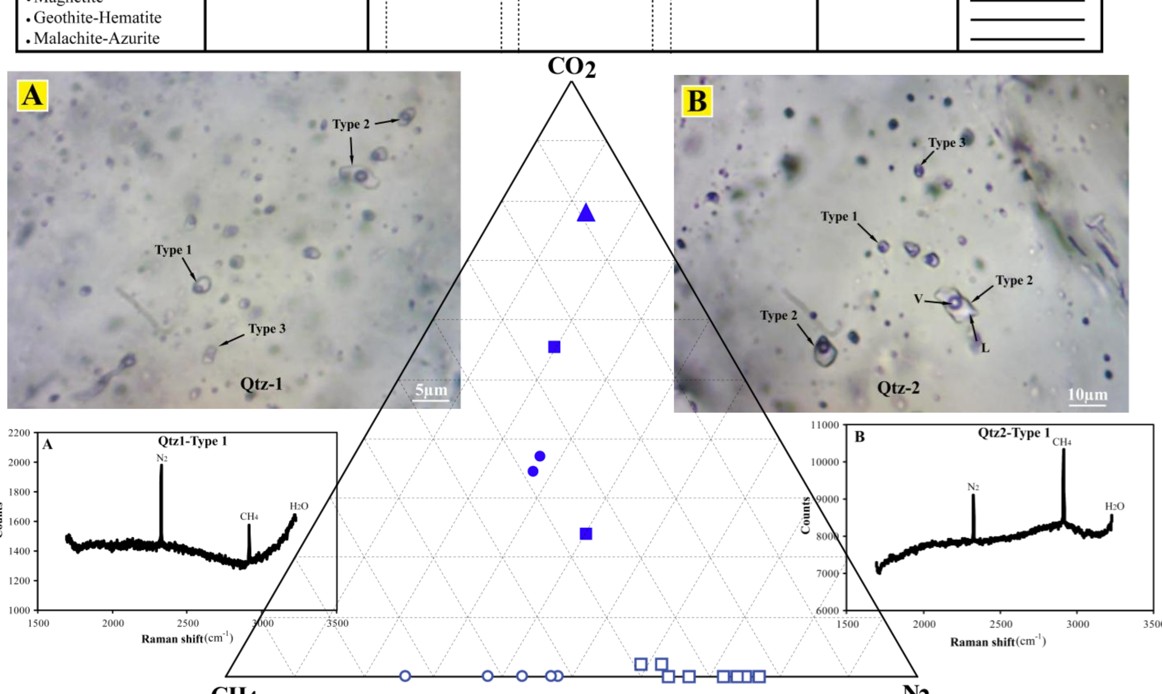
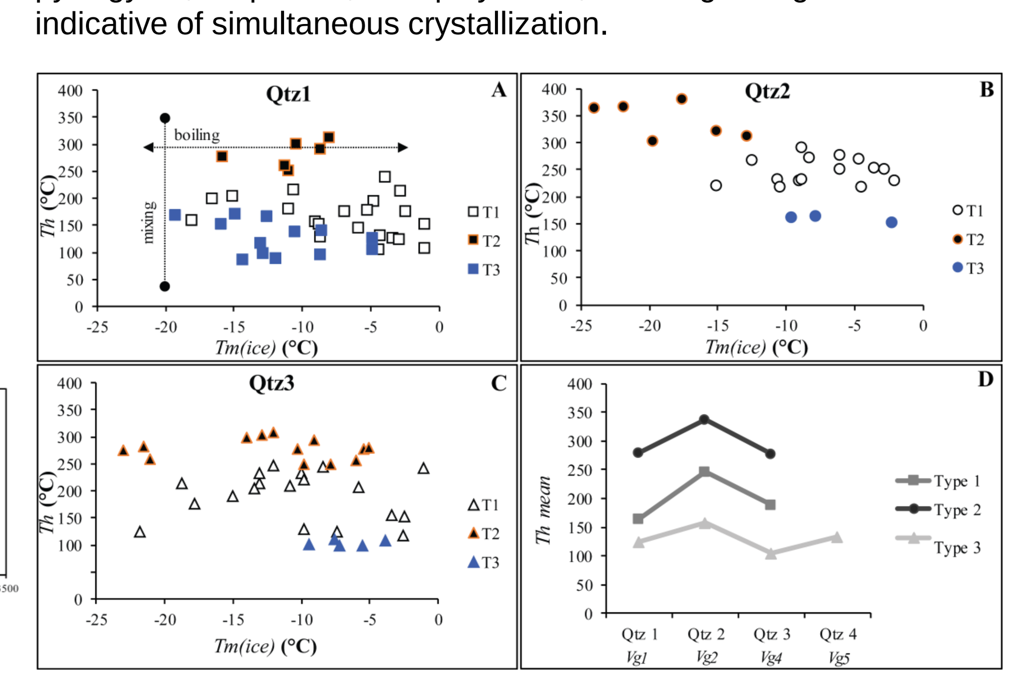


Fig.3. (A) Association of freibergite, owyheeite, and pyrite, with acicular andorite occurring within owyheeite. (B) Galena hosting inclusions of native silver, boulangerite, owyheeite, and stephanite. (C) Galena crosscutting or enclosing euhedral arsenopyrite and pyrite crystals and containing fine inclusions of polybasite, pyrargyrite, meneghinite, and owyheeite. (D) Galena replaced by pyrargyrite, diaphorite, and polybasite, showing intergrowth textures indicative of simultaneous crystallization.





Ore deposition at the Roc Blanc deposit occurred in two main stages: an early stage at ~350 ± 20 °C with a salinity of ~13.7 wt.% NaCl equiv., followed by the main argentiferous stage at ~150 °C with a salinity of ~12.1 wt.% NaCl equiv., under relatively low pressures (<1–1.1 kbar). Fluid inclusion data indicate that silver precipitation was mainly controlled by fluid cooling and dilution, involving mixing between metamorphic fluids (H_2O–CH_4–N_2–CO_2) and surface to subsurface aqueous fluids (H_2O–salt; meteoric or brine).

METHOD

- **Electron microprobe analysis (EPMA):** Chemical compositions of sulfide and sulfosalt minerals were determined using a JEOL JXA-8200 Superprobe (WDS–EDS) at the Department of Earth Sciences, University of Milano, Italy.
- **Carbon and oxygen isotopes:** $\delta^{13}C$ and $\delta^{18}O$ analyses of ore-related Ca–Fe–Mg carbonates were performed to constrain the origin of hydrothermal fluids and the conditions of carbonate precipitation.
- **Strontium isotopes:** $^{87}Sr/^{86}Sr$ ratios of hydrothermal carbonates and host rocks were measured to identify fluid sources and evaluate fluid–rock interactions during mineralization.
- **Lead isotopes:** Pb isotope compositions of galena were analyzed to constrain metal sources and trace hydrothermal fluid pathways during ore formation.
- **Fluid inclusion analysis:** Fluid inclusions in quartz were investigated using microthermometry (Linkam THMS-600 heating–freezing stage) and Raman spectroscopy to determine fluid composition, salinity, and P–T conditions of the mineralizing fluids

RESULTS & DISCUSSION

The Roc Blanc Pb–Zn–Ag–Au deposit occurs as N–S to NNW–SSE veins within the contact metamorphic aureole of the BTB intrusions. The mineralization developed in three stages: (I) a pre-ore stage with Fe–As–Zn–Cu mineralization, (II) the main ore stage characterized by Ag–Au–Pb–Zn–Cu–Sb minerals, and (III) a post-ore stage marked by unmineralized chlorite, sericite, and quartz.

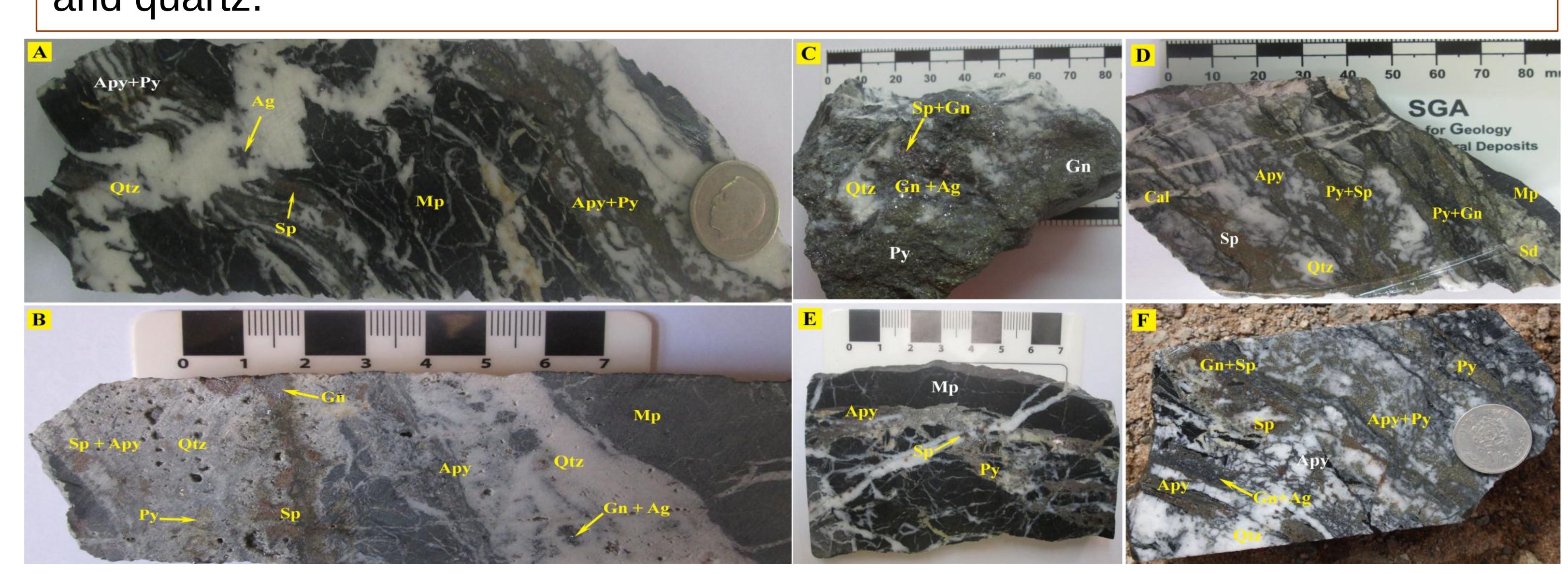
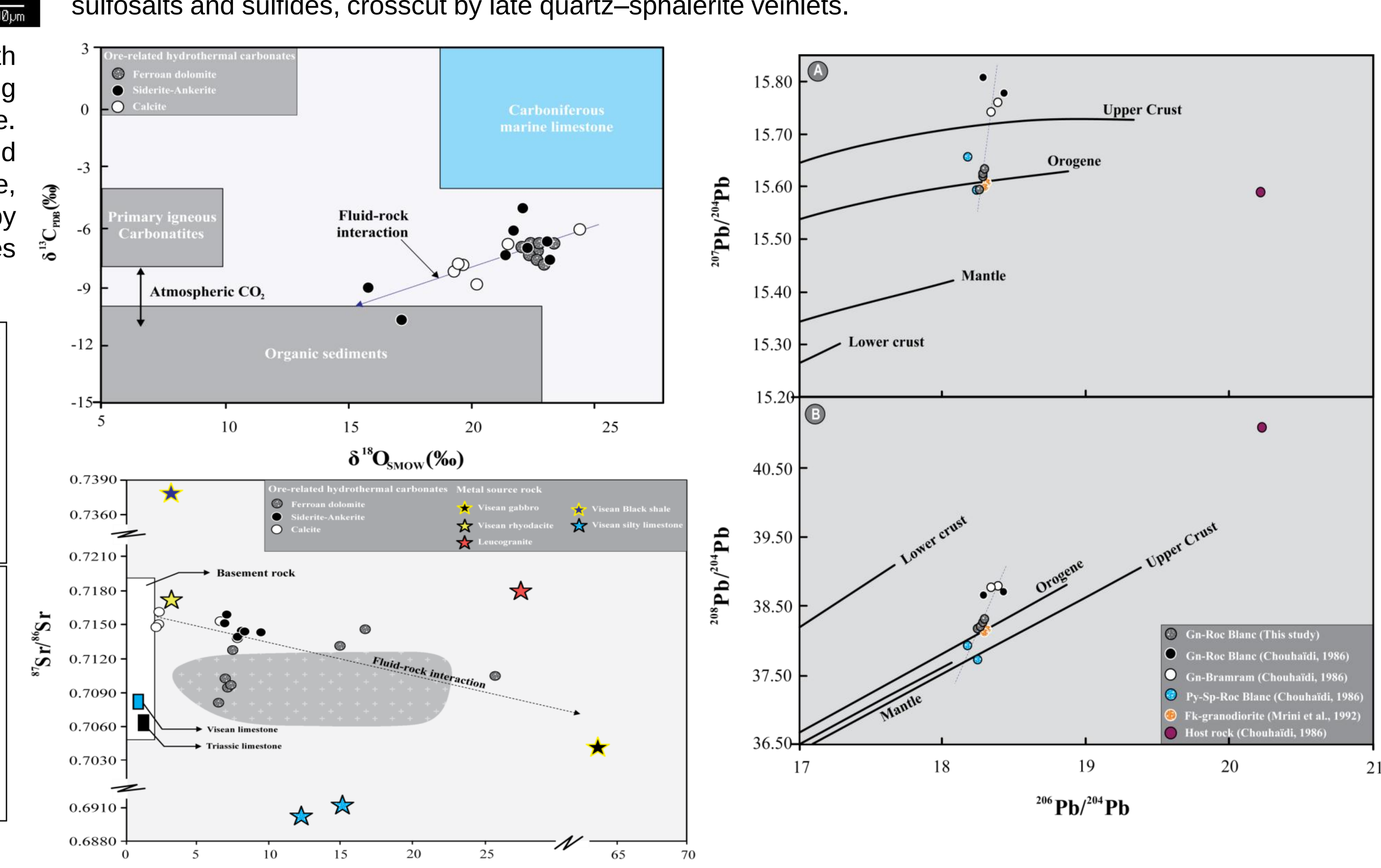


Fig.2. (A–B) Milky white quartz veins mineralized with sulfides and sulfosalts displaying a banded texture. (C) Coarse-grained galena vein associated with massive pyrite. (D) Massive pyrite–arsenopyrite–sphalerite–galena mineralization crosscut by late calcite-filled fractures. (E–F) Quartz veins mineralized with Ag-bearing sulfosalts and sulfides, crosscut by late quartz–sphalerite veinlets.



Isotopic data provide key constraints on fluid and metal sources. Oxygen isotopes indicate a dominant metamorphic fluid component, likely related to devolatilization of carbonaceous host rocks during granite emplacement. Strontium and lead isotopes suggest that metals were mainly derived from the surrounding host rocks through fluid–rock interaction. These results indicate that the Roc Blanc mineralization formed in a post-collisional extensional setting associated with Variscan magmatism.

CONCLUSION

The Roc Blanc Pb–Zn–Ag ± Au vein system formed within the contact metamorphic aureole of the BTB granitic intrusions along the Marrakech Shear Zone in the Central Jebilet massif. Mineralization developed through several stages, with the main Ag-rich stage occurring during decreasing temperature and low-pressure conditions. Fluid inclusion data indicate that ore-forming fluids evolved from ~350 °C to ~150 °C, suggesting that cooling and fluid dilution were the main mechanisms controlling silver deposition.

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