

Gold metallogeny of northwestern Iberia: Superimposed orogenic and intrusion-related mineralization in an evolving Variscan Orogen

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Northwestern Iberia was the most important single source of gold for the Roman Empire in the 1st and 2nd centuries, with several very large placer and paleoplacer (e.g., Las Médulas) and lode mines (e.g., Salave, Três Minas) in production, along with several thousand smaller operations. Both intrusion-related (IRG) and orogenic gold (OG) deposits are present in the region, and discriminating between these deposit types is important for designing regional exploration programs. U-Pb, Re-Os and Ar-Ar dating studies indicate that the IRG and OG deposits formed over a short interval between ~305 and 290 Ma, during the latter stages of collisional tectonism and oroclinal bending of the Variscan Orogen. IRG deposits include Au-Cu skarns of the Rio Narcea belt (El Valle-Boinás and Carlés; ~1 Moz gold produced prior to 2006; remaining M+I+I resource of 2.5 Moz), which are associated with quartz monzodiorite/monzogranite dated at 297-294 Ma (U-Pb). The Linares deposit, located in the Navelgas belt to the southwest, comprises disseminated IRG mineralization hosted by granitic intrusions (U-Pb ages of 298-293 Ma). Molybdenite associated with gold at Linares has a Re-Os age of 292 Ma. Intrusion-related W-Sn (\pm Mo) vein and W skarn mineralization are widespread in central and northern Portugal (e.g., Panasqueira, Carris, Tabuaço). Although some of these are locally anomalous for gold (e.g., Covas) no significant IRG resource has been identified thus far in Portugal.

Several styles of OG deposits are developed throughout the region, including gold-bearing sheeted quartz-arsenopyrite vein systems at Corcoesto (M+I+I resource of 1.5 Moz) and Tomiño in northwestern Spain, and at Limarinho and Grovelas in northern Portugal. Shear zone-hosted quartz-arsenopyrite-base metal OG veins are present at Jales (0.83 Moz past production) and Gralheira in northern Portugal, and disseminated gold and microfracture-hosted orogenic quartz veins occur at Três Minas. OG vein systems in the Valongo Belt and adjacent Castromil area in northern Portugal appear to be structurally related to the sinistral-oblique Douro-Beira shear zone. Previous Ar-Ar dating at Jales and Três Minas indicate mineralization at ~305 Ma, and gold mineralization at Castromil must be younger than the 305 Ma (U-Pb) host granites.

The Salave deposit in northwestern Spain (M+I+I resource of 1.05 Moz) is still enigmatic. Early molybdenite-bearing quartz veins (Re-Os age 307 Ma) are older than the main 295 Ma (U-Pb) Salave granodiorite that hosts most of the deposit. Molybdenite within the deposit was deformed prior to introduction of gold, and is dated at 293 Ma (Re-Os). Unaltered and apparently unmineralized gabbro in the immediate vicinity of the deposit is dated at 291 Ma (U-Pb). Textural

evidence therefore suggests an OG character; however, dating studies indicate a close temporal relationship to local intrusions.

Our on-going research in northwestern Iberia focuses on further characterizing the IRG and OG deposits in the region and examining the relationships, if any, between these deposit styles. We are also attempting to better understand the specific structural and lithological controls on OG systems and the nature and origin(s) of hydrothermal fluids (and contained metals) that produced these deposits.