Re-Os evidence for the origin of Fe-oxide-(Cu-Au) deposits in SW Iberia at the Frasnian-Famennian boundary

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To investigate the origin of economically important but poorly understood Fe-oxide-(Cu-Au) deposits, we collected three samples from the operating Cala mine (Spain) in the Ossa Morena Zone (OMZ) of SW Iberia. The OMZ is an accretionary magmatic arc that records the Variscan collision of the South Portuguese zone with the autochthonous Iberian terrane. Thick sequences of Neoproterozoic dark shale form the pre-Variscan basement in the OMZ. Cala Fe-oxide-(Cu-Au) ore is associated with a small pull-apart structure in a 200 m wide sinistral shear zone containing very low grade Early Cambrian carbonate and clastic rocks and a few small diorite porphyry dikes, all displaying a complex polyphase brittle-ductile deformation history. Juxtaposed to the immediate north is the granodiorite-monzogranite Cala stock, a presumed source for mineralizing fluids. The stock introduced a pyroxene-garnet skarn overprint on an earlier magnetite-rich mineralization. The Cala stock is presumed to be part of the nearby Santa Olalla pluton inprecisely dated at 350-330 Ma. Our dated samples are from the NW wall of the open pit where the early banded magnetite massively replaces hydrothermally altered limestone. The fine-grained magnetite ore is locally brecciated and pyrite (± chalcopyrite and minor gold) penetrates and infills crackle zones.

Here we report the first magnetite-pyrite isochron for an Fe-oxide-(Cu-Au) deposit. Three pairs of magnetite-pyrite plus one magnetite replicate precisely define a 7-point 374 ± 3 Ma isochron with an unequivocally crustal initial $^{187}Os/^{188}Os$ of 0.592 ± 0.043 (MSWD = 1.4). Re and Os concentrations are in the low ppb to ppt and ppt range, respectively. We attribute the high precision of our result to sampling strategy and to strict analytical protocol, particularly for blank corrections. The Re-Os age for the deposition of Fe-oxide-(Cu-Au) at Cala places the onset of mineralization in the Early Variscan, ~20 m.y. older than previous estimates. We suggest that prior to the widespread appearance of intrusions in the OMZ, dilational zones within deep transpressional shear zones served as channels for vapor-dominated upward transport of Fe and other ore components. The metals may have been liberated from Neoproterozoic basement shales as they were heated and dehydrated by underplating magma that later accessed higher crustal levels. As such, our initial Os ratio implies an $^{187}Os/^{188}Os$ for Neoproterozoic seawater that is less than 0.6.