Evolving Subduction-Related Basins Control the Formation of VMS Deposits in the Iberian Pyrite Belt

Fernando Tornos,[1*] Carmen Conde,[2] Massimo Chiaradia,[3] and Francisco Velasco[4]

[1]Centro de Astrobiología (CSIC-INTA), 28850 Torrejon, Spain
[2]C/ Vilar Formoso 66, 37008 Salamanca, Spain
[3]University of Geneva, rue des Maraîchers 13, Switzerland
[4]Universidad del Pais Vasco, 48080 Leioa, Spain

*E-mail, f.tornos@csic.es

The volcanogenic massive sulfide deposits (VMS) of the Iberian Pyrite Belt (IPB) are here interpreted to have formed during two separate events in an evolving back-arc continental basin formed during the southward oblique subduction of Rheic ocean beneath the current South Portuguese zone during Variscan times (≈360–305 Ma); this model is at odds with current interpretations that propose that the IPB formed in a pull-apart basin within a continental passive margin synchronously with northward subduction and later collision between Avalonia and Gondwana. The IPB includes two well-defined domains.

In the Northern Domain, the sequence includes a thick volcanic unit dominated by calc-alkaline andesite domes followed by tholeiitic to alkaline basalt intercalated with shale and at least two dacite (crypto-)dome units dated at ca. 352 and 347–345 Ma; here, the VMS mineralization occurs as replacive deposits just in the uppermost Zr-poor dacite units; the andesite hosts abundant inherited zircon of 540 to 470 Ma age, indicating the existence of early Paleozoic igneous rocks beneath the cropping out IPB. Conversely, in the Southern Domain the sequence is somewhat different and includes a thick basal sequence of shale with two superimposed dacite dome complexes and discontinuous basaltic subvolcanic intrusions and flows. Here, the mineralization is dominantly exhalative and is hosted by a specific anoxic horizon that strictly marks the onset of the volcanism at the Devonian-Carboniferous limit. Sr and Nd isotopes are consistent with the existence of a thick continental crust.

The higher thickness of the volcanic sequence and the abundance of andesite in the northern IPB suggest that this area was closer to the magmatic arc while the Southern Domain likely represented a marginal shale basin with minor volcanism. The mineralization in the Southern Domain was related with the onset of volcanism, hydrothermal venting of fluids equilibrated with the underlying continental sequence and the likely input in the anoxic basin of large amounts of organic matter. This produced widespread biogenic reduction of seawater sulfate and formation of large stratiform bodies of massive sulfides. This horizon is barren in the northern IPB, suggesting that here the basin was likely oxic or the very active volcanism inhibited the formation of exhalative massive sulfides. During Tournaisian times the hydrothermal activity likely migrated to the north; the massive sulfides here formed by replacement by the mixing of deep fluids with modified seawater along hydrothermal aquifers developed in the most glassy and reactive facies of volcanic domes. The direct relationship of the mineralization with a specific volcanic unit strongly suggests that the mineralizing fluids were magmatic-hydrothermal in origin.

The later continental collision during the late Visean ended with the volcanism and widened the basin, which was filled with up to 3,000 m of flysch deposits. These synorogenic deposits and the earlier volcanic rocks were later affected by widespread thrusting, low temperature metamorphism and plutonism and the likely magmatic arc, hypothetically located northwards of the suture that limits the South Portuguese zone and the autochthonous Iberian Massif, was tectonically eroded.