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Plumbotectonic Evolution of the Ossa Morena Zone, Iberian Peninsula: Tracing the Influence of Mantle-Crust Interaction in Ore-Forming Processes

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Abstract

The Ossa Morena zone in the Variscan belt of the Iberian Peninsula is characterized by a complex geotectonic evolution. It hosts a Neoproterozoic-Paleozoic sequence that records the existence of two orogenic events (Cadomian and Variscan) separated by rift and stable platform stages (Middle Cambrian to Late Devonian). Volcanogenic and sediment-hosted massive sulfides, skarns, magmatic Ni-(Cu) deposits, synmetamorphic and intragranitic and perigranitic veins, and replacement bodies are related to different magmatic-hydrothermal systems ranging in age from 650 Ma to about 250 Ma. The lead isotope signatures from 26 different mineral deposits show variable ratios of $^{206}Pb/^{204}Pb$ (17.49–18.44), $^{207}Pb/^{204}Pb$ (15.47–15.67) and $^{208}Pb/^{204}Pb$ (37.37–38.78) that have low average μ values (9.7) but high ω values (38.3). As a whole, the lead isotope data define an irregular cluster that plots around the Stacey and Kramers (1975) growth curve but clearly marks the existence of two main ore-forming events during Cadomian and Variscan times.

The most radiogenic samples are from some minor Zn-Pb stratiform (sedimentary exhalative) mineralization. They are interpreted as having a dominantly crustal derivation (μ >10.1) in which most of the lead was leached from a pre-Cadomian continental basement with a long crustal history. This basement has strong geochemical affinities with the oldest rocks of the Iberian terrane. However, most of the ore samples investigated plot below the Stacey and Kramers (1975) reference curve, indicating polyphase but variable mixing of lead from upper crustal and mantle lead reservoirs at the terrane scale. Clear mixing lines between the two end-member reservoirs are evident only in the oldest volcanic rock- and sedimentary rock-hosted massive sulfide deposits related to the Cadomian (late Neoproterozoic-Early Cambrian) magmatic arc; in the other deposit types lead isotopes have more restricted values. The crustal lead is interpreted as having been derived from ancient crust (2.1–2.5 Ga) and the derived shales (Montemolín Formation) that predated the Cadomian orogeny. The mantle-derived lead may have been derived from three different sources: Neoproterozoic tholeiitic orthoamphibolite, syn-Cadomian calc-alkaline andesite, or calc-alkaline metaluminous plutonic rocks intruded during the Variscan orogeny. The first two sources probably controlled the lead isotope signatures of the Cadomian massive sulfide deposits and the Variscan synmetamorphic veins.

The input of primitive lead is especially significant during Variscan times (350–300 Ma) and is interpreted as having been related to the existence of a large primitive reservoir that controlled the Variscan magmatic, metallogenic, and hydrothermal evolution of the Ossa Morena zone. This primitive lead is recognized in most of the magmatic-hydrothermal deposits, including the typically crust-derived W- and Pb-bearing perigranitic hydrothermal systems. Likewise, associated plutonic rocks have more primitive lead isotope signatures than their counterparts in other Iberian terranes. The lead isotope evolution of the region is consistent with recent geophysical data that suggest that a deep, large mafic sill was intruded below the Ossa Morena zone during Variscan times. This sill was a likely key factor in the different Pb isotope evolution of the Ossa Morena zone compared with the nearby Iberian terranes and the entire Western Mediterranean province, which are characterized by lengthy crustal histories with very little input of primitive lead. The extensive mantle-crust interaction probably explains the wide variety and the unusual metallogenic features of the Ossa Morena zone.

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