Zn-Pb deposits as a clue for recognising reactivated structures in the Picos de Europa area (NW Spain)

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The Picos de Europa Region constitutes one of the outermost areas of the Cantabrian Zone, the foreland and thrust belt of the Variscan orogen in NW Iberia. It constitutes a thrust imbricate formed of Carboniferous limestones that was emplaced towards the S-SW during the latest Pennsylvanian. During the Permian and throughout the Mesozoic, the area was subjected to extension, as attested by the scarce remnants of contemporary sedimentary successions. During the N-S Cenozoic Alpine convergence between Iberia and Eurasia, the Picos de Europa Massif was deformed under shallow crustal conditions through the reactivation of previous structures.

Zn-Pb ores, in the form of sphalerite and galena, are abundant in the central and eastern sections of the Picos de Europa Massif, where they formed as Mississippi Valley-type deposits. Although a direct dating of the minerals has not been performed to date, indirect attempts have been made based on field observations and paleomagnetic studies that have resulted in a broad span of age estimations comprised between Permian and Cenozoic times. Our ongoing research includes the study of Pb isotopes within galena samples in several localities in the Picos de Europa. The measured Pb isotopic ratios (206Pb/204Pb = 18.604–18.771, and 207Pb/204Pb = 15.686–15.707) are comparable to those of other Mississippi-Valley-type and Sedex-type ore deposits situated further east in the Basque-Cantabrian Basin. This basin was formed throughout the Mesozoic as an extensional basin, and the associated ores have been dated through ore-typology (syn-sedimentary Sedex-type deposits), metallogenic data, and other geological criteria. The similarity of the isotopic ratios in these deposits and our samples from the Picos de Europa Massif suggests a similar ore formation age, around the Lower Cretaceous, based on the interpretation of a comparable Pb crustal source.

The ores from Picos de Europa are largely associated with kilometre-scale faults that have acted simultaneously as fluid conduits and zones of preferential mineralisation. Many of the studied localities display significant deformation of the ore deposits, suggesting subsequent fault reactivation events following precipitation. Thus, the age of the deposits is useful for determining the relative timing of fault reactivation. There are two main mineralised fault systems: faults trending W-E with a variable dip, and a subvertical NW-SE-trending set. Faults from the first system were originally developed as Variscan thrusts and in some cases reactivated as normal and/or, subsequently, reverse faults during the Alpine orogenic cycle (e.g. the Cabuérniga Fault System). In contrast, the age and kinematics of the second fault system are more debated. Zn-Pb deposits
from the Ándara and Liordes mining districts constitute illustrative examples of ore precipitation and subsequent brittle deformation along the San Carlos N118E-trending subvertical fault and the Liordes N117E-trending high-angle fault. While the San Carlos Fault accommodated an oblique but mainly dextral strike-slip displacement during ore deformation, the Liordes Fault acted as a dextral oblique fault with a larger reverse component, likely as a result of its slightly different dip angle. The last activity on these structures post-dates the Lower Cretaceous, suggesting a clear linkage with the Alpine orogeny.