

Geothermometry of oxidized Zn-Pb ores: oxygen isotope systematics and a new femtosecond laser technique on monophasic fluid inclusions

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We studied the ¹⁸O/¹⁶O systematics of carbonate minerals from supergene oxidized Zn-Pb deposits and from submarine alteration of ancient slags to constrain oxygen isotope fractionation factors for smithsonite, cerussite, and phosgenite. The temperature dependence of oxygen isotope fractionation between Pb and Zn carbonate minerals and water below 100°C can be expressed as

$$\begin{aligned}1000 \ln \alpha_{\text{cerussite-water}} &= 2.29 (10^6/T[\text{K}]^2) - 3.56 \\1000 \ln \alpha_{\text{smithsonite-water}} &= 3.10 (10^6/T[\text{K}]^2) - 3.50 \\1000 \ln \alpha_{\text{phosgenite-water}} &= 2.55 (10^6/T[\text{K}]^2) - 3.50\end{aligned}$$

Average formation temperatures of the studied supergene deposits (SW Sardinia, E Belgium, Broken Hill district, Australia, and others) are calculated to be $20 \pm 5^\circ\text{C}$ using the estimated isotope compositions of local paleometeoric waters.

We also applied a new technique using a femtosecond laser to nucleate the vapor bubble in monophasic fluid inclusions. Homogenization temperatures of inclusions in cerussite and hemimorphite from the same deposits range from +6.1 to +25.5°C and confirm our stable isotope results.

New fluid inclusion and oxygen isotope data from willemite-bearing oxidized Pb-Zn ores from E Belgium and S Portugal, however, suggest that certain mineralization stages in these districts were formed by distinct low-temperature (<50°C) hydrothermal systems involving saline fluids.

Thus, oxygen isotope and fluid inclusion data for base metal carbonate minerals can be used to distinguish ores produced by weathering from very-low-temperature hydrothermal ores. They may also provide valuable paleoclimatic information.