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A fluid inclusion and in-situ LA-MC-ICP-MS sulfur isotope study of the Wusihe lead-zinc deposit in Sichuan Province of southwest China: implications for ore genesis

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The most productive lead-zinc region in southwest China includes Sichuan, Yunnan, and Guizhou provinces. The Wusihe lead-zinc deposit, in the Sichuan Province, is the typical one with 3.7 million tons (Mt) of Pb and Zn metals. Most of the ore bodies are stratoid in shape that hosted in the Neoproterozoic carbonate rocks. The ore texture mainly includes lamellar, impregnated, stockwork and breccia. In addition, it is noteworthy that a special orbicule structure of sphalerite is also observed (*Figure 1a*). Ore minerals contain sphalerite, galena, pyrite, chalcopyrite and pyrrhotite. Gangue minerals include dolomite, calcite, quartz, and fluorite. Abundant bitumens are also present in the ores.

A detailed fluid inclusion study in minerals of dolomite, quartz, calcite, fluorite and sphalerite indicates that the majority type of fluid inclusion is Liquid–Vapour (L+V) inclusions. The Laser Raman spectroscopy study shows that the vapour phase contains a certain amount of CH_4, H_2S, C_2H_6, C_2H_2, N_2 and NH_3. Microthermometric data show a homogenization temperature range of 120°C to 260°C, and an average salinity of 10.0 wt.% NaCl equiv.

In this study, we carried out in-situ LA-MC-ICP-MS sulfur isotope analyses on sulfide minerals of sphalerite, galena, and pyrite. The $\delta^{34}S$ are characterized by positive values with a peak around +13‰, with a decreasing trend from pyrite, sphalerite to galena ($\delta^{34}S_{pyrite}>\delta^{34}S_{sphalerite}>\delta^{34}S_{galena}$). A detailed sulfur isotope profile for the orbicule sphalerite reveals a decreasing trend from core to rim with a $\delta^{34}S$ range from +15.9‰ to +11.6‰ (*Figure 1b*). It is suggested that reduced sulfur may have derived from SO_4^{2-} of the host Neoproterozoic carbonate rocks and/or entrained coeval seawater by thermochemical sulfate reduction (TSR). TSR is likely the key factor for sulfur isotope fractionation in the sulfides and the orbicule sphalerite records the TSR process during the ore formation.

In summary, we suggest that ore-forming fluids of the Wusihe lead-zinc deposit are possibly basin brines with a multicomponent system involving organic-rich fluids. The mixing process of ore-forming fluids provoked TSR and resulted in ore deposition at a low/moderate temperature and salinity.

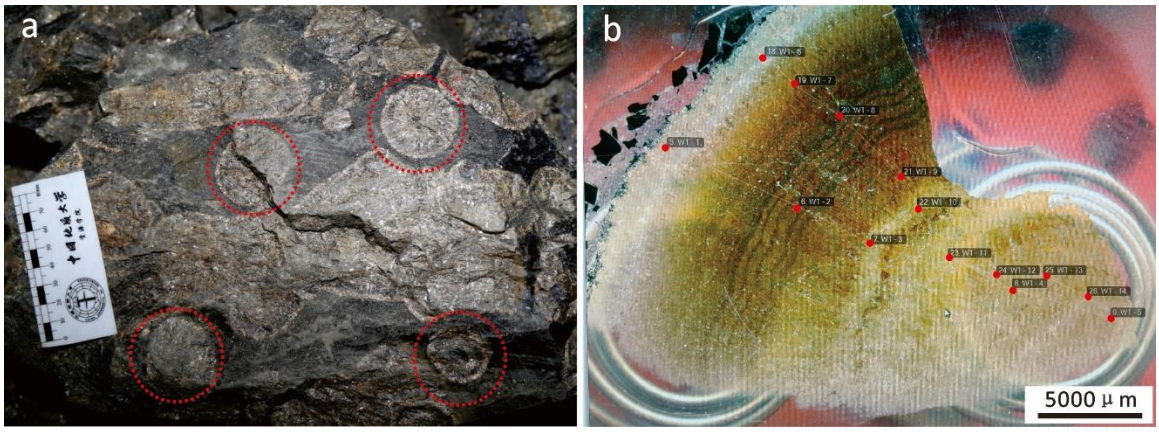

Figure 1: Photographs from the Wusihe lead-zinc deposit, Sichuan Province, southwest China.

(a) Red open circles represent the particular ore texture of orbicule sphalerite.

(b) Red dots represent spots where LA-MC-ICP-MS data were obtained with $\delta^{34}S$ values.