Fluid geochemistry of an ancient analog to the modern seafloor polymetallic massive sulfides -- Yongping super-large copper deposit, Jiangxi province , China

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Yongping super large copper deposit, occuring in middle-Carboniferous marine sedimentary rocks, is located in Jiangxi, south China. It is composed of stratiform orebody and stringer vein type orebody. Fluid geochemistry data record a typical submarine hydrothermal origin for the ore formation.

Fluid geochemistry data

This study provides first time lots of fluid geochemistry data on fluid inclusion microthemometry, REE contents , and C, H, O isotope. REE pattern of the fluid preserved in fluid inclusions in the stringer vein type ores shows clearly that it was an analog to modern submarine hydrothermal fluids. Lots of microthemometric determination of fluid inclusions indicate the ore-forming fluid have the same salinity and temperature as modern submarine hydrothermal fluid., but have been experienced a boiling event. C, H, O isotope data suggest that the ore-forming fluid have originated from seawater and joined with little magmatic fluid at the main mineralization stage.

Conclusions and discussions

Geological and fluid geochemical features of Yongping copper deposit show that it was a typical MSD type deposit The ore formation mechanism is similar to the modern polymetallic massive sulfides in spreading zones and on top of seamounts. However, the happening of fluid boiling observed in fluid inclusions indicate that the water depth during the forming of Yongping copper deposit is much more shallower than that of most modern seafloor polymetallic massive sulfides deposits. The relative shallower environment of Yongping Copper deposit is consistent with the ore occurring tectonic environment—Hercynian-Indosinian Fault Depression in south China.

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Cw and pulse EPR: a way to gather structural information

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Introduction

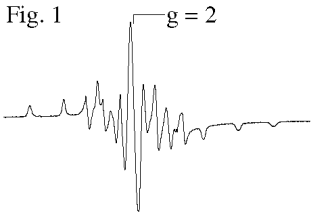
Electron paramagnetic resonance (EPR) spectroscopy is a powerful method to analyze binding properties, symmetry, concentration, and structural vicinity of transition metal complexes. The following two examples give an insight into the potential of EPR application.

Continuous wave (cw) EPR technique

The spectrum of V(IV) in muscovite exhibited an eight-line hyperfine-split (hfs) signal with g = 1.939 and A = 18.6mT. Dehydroxilation of the muscovite upon heating at 650°C revealed a narrowing of the spectrum (A = 17.5mT). This change can be explained by a transformation from octahedral into tetragonal-pyramidal co-ordination of V(IV).

Pulsed EPR technique

Electron spin echo envelope modulation (ESEEM) can give information on the nuclear spin environment of paramagnetic centers. V(IV) in vermiculite revealed a well resolved hfs signal (Fig. 1). The ESEEM with 20 and 40 ns pulses obtained from the central V(IV) feature near g = 2 position showed little modulation.



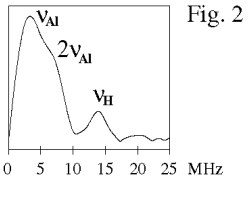


Fig. 1: cw EPR spectrum of V(IV) in vermiculite
Fig. 2: Fourier transformed ESEEM magnitude spectrum

The magnitude spectrum after Fourier transformation consisted of a broad peak at 3.4±0.5 MHz with a shoulder at about 6.5 MHz, and a weaker peak at 13.9±0.5 MHz (Fig. 2). The peaks indicated two different nuclear Zeeman frequencies (ν). The weak line leading to a nuclear g factor ($|g_N|$) of 5.46±0.2 was characteristic of protons (g_N = 5.5854, natural abundance 99.985%). The maximum of the intense line corresponded to a $|g_N|$ value of 1.35±0.2 which was close to those for weakly coupled nuclei of diamagnetic ^{27}Al (I=5/2, 100% natural abundance, g_N = 1.4554). These EPR data suggest that V(IV) replaces Al(III) in the octahedral sites of vermiculite.

Further studies will show if cw and pulse EPR are an analytical tool with broad application in geochemistry.