How to differentiate hydrothermal zircons by determining their U, Th and Pb isotopic ratios: A case study from the Huangshaping polymetallic deposit, south China

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The Huangshaping polymetallic deposit is a large-scale deposit located in the central Nanling region, South China. The intense W-Sn-Pb-Zn mineralization is mainly associated with the latest magmatic event, the intrusion of granite porphyry. In this study, three types of zircons have been identified in this unit: early magmatic, late magmatic and hydrothermal zircons. Hydrothermal zircons have been differentiated from magmatic ones based on their internal structural and trace elemental characteristics, and further confirmed by their U, Th and Pb isotopic ratios. Generally, the hydrothermal zircons have higher $^{207}Pb/^{206}Pb$, $^{207}Pb/^{235}U$ and $^{208}Pb/^{232}Th$ ratios mainly ranging from 0.06 to 0.26, 0.26 to 1.55 and 0.012 to 0.15, respectively, compared to the magmatic zircons. On the other hand, the early magmatic zircons possess lowest $^{238}U/^{232}Th$ ratio ranging from 1.47 to 2.67. Additionally, the hydrothermal zircons have higher common Pb compositions (>20 ppm); and most hydrothermal zircons also have higher total Pb compositions mainly ranging from 550 ppm to 860 ppm.

The higher values of common Pb, $^{207}Pb/^{235}U$ and $^{208}Pb/^{232}Th$ ratios in hydrothermal zircons suggested that the primitive fluid was enriched in Pb, Th and U. The greater ratios of $^{207}Pb/^{206}Pb$ in hydrothermal zircons indicate that there were high concentrations of ^{235}U rather than ^{238}U in the original fluid, because ^{207}Pb is daughter from ^{235}U whereas ^{206}Pb is daughter of ^{238}U. The relative enrichment of ^{235}U in the fluid suggests an oxidation environment for the intense W-Sn mineralization. On the other hand, the relatively low $^{238}U/^{232}Th$ ratios and radioactive Pb concentrations in magmatic zircons reveal that the magmatic zircons were transformed by the hydrothermal fluid. The Pb, Th, U and other trace elements could have been assimilated and leached by the hydrothermal process, forming a high-concentrated Pb, Th and U-bearing fluid. This study shows that some U, Th and Pb isotopic ratios can be used as good tools to identify hydrothermal zircons in magmatic-hydrothermal system. What's more, there ratios are also helpful in determining the metallogenic environment of fluids and the genesis of hydrothermal zircons.