

Hydrothermal titanite from the Chengchao iron skarn deposit: Temporal constraints on iron mineralization, and its potential as a reference material for titanite U–Pb dating

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Titanite incorporates moderate amounts of U and Th into its structure and has a high Pb diffusion closure temperature, making it an ideal mineral for U–Th–Pb dating. In the last decade, laser ablation inductively coupled plasma mass spectrometry has been increasingly used for the in situ analysis of U–Pb isotopes and trace elements in titanite samples from a wide range of formation environments, yielding significant insights into the timing and processes of magmatic, metamorphic, and hydrothermal events. However, recent studies have shown that using zircon as the calibrant material can significantly underestimate U–Pb titanite dates. Therefore, a matrix-matched titanite reference material with known high-precision age is required in order to study titanite U–Pb geochronology more reliably.

In this study, U–Pb isotopes and trace elements of titanite from the Chengchao iron skarn deposit (Daye district, Eastern China), were analyzed using laser ablation inductively coupled plasma mass spectrometry to provide temporal constraints on iron mineralization and to evaluate its potential as a reference material for titanite U–Pb geochronology. Titanite grains from mineralized endoskarn have simple growth zoning patterns, exhibit intergrowth with magnetite, diopside, K-feldspar, albite and actinolite, and typically contain abundant primary two-phase fluid inclusions. These paragenetic and textural features suggest that these titanite grains are of hydrothermal origin. Hydrothermal titanite is distinct from the magmatic variety from the ore-related granitic intrusion in that it contains unusually high concentrations of U (up to 2995 ppm), low levels of Th (12.5–453 ppm), and virtually no common Pb. The REE concentrations are much lower, as are the Th/U and Lu/Hf ratios. The hydrothermal titanite grains yield reproducible uncorrected U–Pb ages ranging from 129.7 ± 0.7 to 132.1 ± 2.7 Ma (2σ), with a weighted mean of 131.2 ± 0.2 Ma [mean standard weighted deviation (MSWD) = 1.7] that is interpreted as the timing of iron skarn mineralization. This age closely corresponds to the zircon U–Pb age of 131 ± 1 Ma (MSWD = 0.71) determined for the quartz diorite, and the U–Pb ages for zircon and titanite (130 ± 1 Ma and 131.3 ± 0.3 Ma) in the granite, confirming a close temporal and likely genetic relationship between granitic magmatism and iron mineralization. Different hydrothermal titanite grains have virtually identical uncorrected U–Pb ratios suggestive of negligible common Pb in the mineral. The homogeneous textures and U–Pb characteristics of Chengchao hydrothermal titanite suggest that the mineral might be a suitable internal reference material for U–Pb dating.

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