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Lithium-tantalum-rich topaz-lepidolite granites as the most differentiated rocks in the solar system: whole rock Sr-Hf and zircon isotope constraints

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Topaz-bearing granite as highly evolved silicic magma is often associated with Li-Ta-Nb-Be-Sn-W mineralization. The topaz-lepidolite granite (TLG) near the city of Yichun, Jiangxi Province, southern China, is one of the most important lithium-tantalum deposits in China and is well-known for its "snowball" texture [1]. The Yichun topaz-lepidolite granite has super high $^{87}Sr/^{86}Sr$ ratios (up to 32.9), likely the highest $^{87}Sr/^{86}Sr$ values for Earth's rocks [2]. The Yichun TLG displays extreme enrichments in Li, Ta, Cs, Rb, F, strong depletions in Ba, Sr, Eu, and rare earth elements, and is characterized by extremely low Nb/Ta (0.44—0.74), Zr/Hf (5.1—6.8), and K/Rb (5.7—7.6) ratios. Whole-rock rare earth elements and zircon rare earth elements display pronounced lanthanide tetrad effect. Whole rock Hf isotopic compositions ($\varepsilon_{Hf}(t)$=-8.8 to -7.8) and zircon Hf isotopic compositions ($\varepsilon_{Hf}(t)$=-9.6 to -8.0) are consistent and reveal a dominant role of crustal melting. The whole rock samples yield a Rb-Sr isochron age of 139±3 Ma for the Yichun topaz-lepidolite granites, which represents the age of Rb/Sr system closure for the late stage of magmatic-hydrothermal transition. New trace element data for zircons from Yichun TLG show super high uranium (up to 100,000 ppm), hafnium (up to 80,000 ppm), and yttrium (up to 39,000 ppm) contents. New U-Pb ages for high uranium metamict zircons from Yichun TLG are highly variable ranging from 80 to 548 Ma. To obtain accurate and precise U-Pb ages for high uranium metamict zircons, I have developed a new method to identify meaningful analyses for metamict zircons. Applying this new method to Yichun TLG zircons, the selected metamict zircons yield a U-Pb age of 149±1 Ma, regardless of zircon uranium contents. The age difference (10±3 Ma) between high-uranium zircon age of 149 Ma and whole-rock Rb/Sr age of 139 Ma provides the duration of magmatic-hydrothermal system for the Yichun topaz-lepidolite granite. The Yichun topaz-lepidolite granite is the most highly differentiated granite in Earth and was formed by extreme magmatic fractionation followed by protracted magmatic-hydrothermal transition.

[1] Yin, L., Pollard, P.J., Hu, S.X., Taylor, R.G. (1995) *Economic Geology* 90, 577-585.

[2] Zou, H.B. (2026), *Journal of Asian Earth Sciences* 301, 107005.