

Constraining the redox states of Archean TTG magmas by sulfur-in- apatite

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Obtaining the redox states of magmatic systems is important for understanding magmatic evolution, mineralization, volatile composition of volcanism, and oxidative weathering of Earth's crust. Here we use sulfur-in-apatite to study the TTG samples from North China Craton and Kaapvaal Craton to semi-quantitatively constrain the redox states of the intermediate-acid magmas in the Archean Eon. Our results show that the apatite in these Archean TTGs can have sulfur contents exceeding 1000 ppm. Interestingly, high sulfur concentrations are typically seen in the cores of apatite crystals and likely preserve the magmatic signatures. These high sulfur concentrations require significant amounts of S⁶⁺ in the TTG magmas because S²⁻ is incompatible in apatite. Therefore, at least some of the TTG magmas may have had oxygen fugacities of > FMQ + 1. Before the Great Oxidation Event, the Earth's surface was extremely anoxic and seawater had low sulfate concentrations, so the incorporation of surface materials, which is widely thought to account for the high oxygen fugacities of modern arc magmas, could not oxidize the Archean magmas. We suggest that the oxidized compositions of Archean TTGs may result from the endogenic oxidation of magmas produced by the fractionation or retention of garnet under high pressure. Alternatively, the oxidized compositions of TTGs can also be explained by water dissociation and hydrogen incorporation in mantle orthopyroxene during the process of melt-mantle reaction.