Isotopic and Chemical Alteration of Zircon Crystals by Hydrothermal Fluids within the Horseshoe Greenstone Belt (Superior Province) Using Trace Element and U-Pb Depth-Profiling Techniques

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Abstract

Hydrothermal fluids play an important role in heat transfer, reaction kinetics, and act as a transporting medium for soluble material. New advances in zircon geochronology give the potential to date recrystallizing events of a rock through the analysis of submicron mineral domains caused by coupled dissolution-recrystallization of the mineral. Here we develop techniques to determine the timing and nature of crustal fluid flow. U-Pb isotopic and trace element analyses on unpolished zircon were conducted using laser ablation-inductively coupled plasma-mass spectrometer (LA-ICPMS) depth-profiling methods. Zircons were separated from lower greenschist facies Neoarchean metasediments from the Central Domain in the Horseshoe Greenstone Belt of the Western Superior Province. Metasediments preserve relict sedimentary structures and possess cross-cutting ca. 2730 Ma porphyritic plagioclase-rich felsic dikes. Chlorite and sericitization of feldspar are commonly observed in thin section and suggest post-metamorphic fluid alteration. The equant zircons (and quartz grains) are generally euhedral to subhedral, which suggests that sedimentary transport was minimal and the source of these sediments is proximal. U-Pb geochronology coupled with trace element depth-profiling techniques uncovered ≤3 μm thick distinct chemical domains preserved along the margins of zircon. Normalized zircon/chondrite versus REE (La-Lu) diagrams indicate the ultrathin domains are enriched in LREE. Also, isotopic analyses suggest that these chemical domains are enriched in U. In a third of the zircons analyzed, these chemically distinct zircon exteriors are ca. 100 m.y. younger than the zircon interior ages (ca. 2950 Ma vs. 3040 Ma, respectively). Surprisingly, our rim ages are dissimilar to the adjacent ca. 2730 Ma porphyritic plagioclase-rich dikes. The zircon's morphology and geochemical signatures infer that the alteration event may have occurred prior to deposition since the age of the greenstone belt is believed to be 2860 Ma. Therefore, Mesoarchean geological processes are responsible for the distinct chemical domain preserved in the zircon crystals.