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# A chronological constraint on ancient hydrothermal activity using zircon inclusion ages

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It is necessary to understand ore-genesis processes throughout the Earth's history in the framework of differentiation of Earth system in order to establish genetic models of ore bodies. In addition, such understandings are essential not only to estimate the potentials of the oceanic resources but also to explore efficiently. Standing on such viewpoints, chronological and geochemical constraints are very important for the critical geological events in the early stages of the Earth's history, e.g. the crustal formation and petrological characteristics, initiation of the plate tectonics, formation of the hydrothermal deposits. However, the Hadean geological edifices within 0.5 Gyr do not remain on the Earth's surface. Thus, such chronological and geochemical investigations have been performed by using remnant zircon mineral and its inclusion. In particular, the existence of granitic crust as the host rock of such Hadean zircon (4.0-4.4Ga) has been hypothesized from the inclusion occurrences of quartz, muscovite, monazite, apatite and so on.

Regardless of such importance of inclusion of zircon, skepsis on the formation processes and origin of such inclusions have recently raised. Recent discoveries of Fe-hydroxides as the remarkable low temperature phase that could not form under or survive through the igneous activity are one reason. Further, the monazite inclusions having younger ages are also challenges the usability of zircon inclusions. Thus, the reliable ages of zircon and thermal history estimation are essential to solve such arguments. In this study, the local analysis performed as laser fused Ar-Ar dating with step-heating technique were applied. Muscovite and feldspar were chosen as the important index mineral of in situ component inclusions.

The Hadean zircon grains have some muscovite and fluid inclusion as an in-situ material. We separated the flesh zircon grains from host rock according to the comparison among non-irradiated grains. The samples have been irradiated in the KUR (Kyoto University Research Reactor Institute), and have been analyzed using the custom made mass spectrometer in Okayama University of Sciences. It was quite difficult to determine the procedure of the localized inclusion analysis in the zircon, the result of Ar analysis indicated the significant excess Ar in it some cases.

As the result of Ar measurement, plateau-like spectra were obtained. One of which indicated 1) the formation age of zircon (approx. 4.4 Ga) and, other two patterns of age spectra were 2) inherited $^{40}$Ar from the deep Earth (e.g excess $^{40}$Ar derived from magma) and 3) the $^{40}$Ar accumulation (= $^{40}$K decayed to radiogenic $^{40}$Ar) in inclusion itself. The second case shows significant releases of $^{40}$Ar in high temperature fraction (~ the 1000 ℃) regardless of the little release of $^{39}$Ar transformed from $^{39}$K by (n, p) reaction. Then, the apparent ages becomes unlikely old ones regardless of the less-disturbed age spectrum. In the third case, the calculated mean age was possible to be older than the alteration age at the formation of inclusions. On the other hand, the U-Pb age of zircon is also altered to be younger by Pb-loss, or to be older by disturbance of Pb diffusion in the zircon. Thus we plan further sample analyses and investigations on the formation ages coupled with the geological settings.

Keywords: Hadean, zircon, Ar-Ar dating, inclusion, Laser fusion