Evidence from the Acasta zircons for consistent occurrence of magmas with moderately elevated d^{18}O throughout the Eoarchean

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Oxygen isotope ratio of undamaged zircon is a refractory signature and useful to infer petrogenesis of its host rock [1,2]. The d^{18}O values of zircons from primitive magmas are 5.3±0.6‰ (2 SD)[3]. Occurrence of 'supracrustal' d^{18}O values (>6.3‰) in >4 Ga zircons from the Jack Hills, Western Australia indicates existence of hydrated crustal rocks and chemically differentiated crust by 4.3 Ga [4]. However, because Jack Hills zircons are detrital and no host rock is known, it is difficult to reconstruct crustal evolution in the early Earth. The Acasta Gneiss Complex (AGC) in the Slave Province, Canada is one of the best places to study early crustal evolution because multiple generations of Eoarchean rocks are preserved [5].

In this study, oxygen isotope ratios (d^{18}O) of zircons from six felsic gneisses and one pegmatite of the AGC [5] were measured with an ion microprobe, CAMECA IMS 1280-HR at Kochi Institute, JAMSTEC. We selected zircons which exhibit concordant U-Pb age (mostly with 0±2% discordance) [5] and the samples can be classified into three groups based on their crystallization ages, >3.9 Ga, ca. 3.75 Ga, and ca. 3.6 Ga zircons, respectively. A new kimberlite zircon standard: KC-KLV-Zrc1 from Kaalvallei, South Africa (d^{18}O=5.43±0.14‰ VSMOW, 2 SD, determined by a laser fluorination and gas-source mass spectrometry at University of Wisconsin-Madison) was used as a running standard for SIMS analysis. Typical spot-to-spot reproducibility of d^{18}O values was ±0.26‰ (2 SD). The $^{16}OH^{-}/^{16}O^{-}$ ratios of zircons, which is an indicator of radiation damage [6], were monitored during oxygen isotope analysis and analysis pits were examined by SEM after the analyses to identify disturbed d^{18}O values by later alteration. We use oxygen isotope data from zircons with no evidence for later alteration.

Multiple oxygen isotope analyses within individual zircon grains showed that some AGC zircons have variable oxygen isotope ratios by ca. 0.5‰ correlated with growth zoning layers recognized by Cathodoluminescence (CL). The studied AGC zircons commonly have moderately elevated d^{18}O values (6.0 to 6.5‰) with a few exceptions of lower d^{18}O values (down to 5.0‰) in >3.9 Ga zircons. No low d^{18}O values (<4.7‰), which were recognized in ca. 4.0 Ga zircons from Idiwhaa tonalitic gneiss in the AGC [7] are observed from the samples in this study. Consistent occurrence of zircons with moderately elevated d^{18}O values (6.0 to 6.5‰) from ca. 4.0 Ga to 3.5 Ga indicates that production of sediment and incorporation of sediment to magma sources consistently occurred in the Acasta region in this period. Since zircons with low d^{18}O values are recognized in a tonalitic gneiss at ca. 4.0 Ga [7], interaction of crustal rocks with fluid at high temperatures would have occurred at an earlier stage of felsic rock formation. Oxygen isotopic characteristics of AGC zircons, moderately elevated with a narrow range of d^{18}O values (6.0 to 6.5‰), is distinct from that of zircons from West Greenland (<6.0‰ at ca. 3.8-3.9Ga) [8]. In addition, higher d^{18}O values are recognized in >4.0 Ga zircons from Jack Hills [e.g., 3,4]. The distinct O isotope evolution among the terranes indicate that crust-forming processes have been already established by Eoarchean.
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