Geophysical Research Abstracts
Vol. 20, EGU2018-19613, 2018
EGU General Assembly 2018

Hydrous melt and fluid assimilation at ultraslow-spreading ridge: evidence from zircon and apatite in SWIR

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The mid-ocean ridges are considered the origins of the oceanic lithosphere. At ultraslow-spreading ridges, the lower crust can provide valuable clue to the magmatic and tectonic processes which reflects the melt input and the mantle flow pattern. Transform faults develop extensively at ultraslow-spreading ridges, serving as tunnels for successive intrusions of hydrothermal fluid. Thus, a logical explanation of the protolith's metasomatism by fluid-rock interaction might be the key to unraveling the puzzle in this region from deep dynamics to shallow tectonics.
With the promotion of the InterRidge, the Southwest Indian Ridge (SWIR) has become the most intensively investigated slow- and ultraslow- spreading ridge. Today the mechanism of the magma supply and modes of melt transport in SWIR is still on debate, e.g. whether the mantle source is incorporated into the shallow process and to what extent the fluid-rock interaction shapes the homogeneity in chemical and mineralogical composition on this site. The Expedition 360 of International Ocean Discovery Program (IODP) was aimed at solving these problems.
We examined the gabbroic rocks drilled from SWIR during IODP Expedition 360. We found the zircons with unique mosaic microstructure and conducted high-spatial resolution elemental and isotopic analysis. We obtained a high resolution U-Pb date (12.16$\pm$ 0.3 Ma, MSWD=1.5, n= 68) for the zircons by SIMS, as well as the oxygen and partial lithium isotopic data. The zircon U-Pb dating may constrain the initial phase of asymmetric expansion of SWIR, whereas the isotopic data may give clues to separating the contributions from deep magma and late added fluids.
Apatites in samples from SWIR exhibit distinct low fluorine (0.8$\sim$2.8 wt%), high chlorine (0$\sim$3.5 wt%) concentrations, which is opposite to high-F (1$\sim$3.5 wt%) low-Cl (0$\sim$0.5 wt%) apatites commonly observed from other mid-ocean ridges. This implies that late brine-rock interactions actually occur as long as the apatites formed by deep melt in SWIR is the same as those with high-F low-Cl observed in other MORs. In addition, the coherent relationship between REE and Cl in apatites suggests that different REE substitution reaction occur in apatites during the fluid metasomatic process. Moreover, the REE partition in apatites systematically displays slight variations in depth, which raises a new issue on whether and how the brine-rock interaction changes the REE characteristics over depth.