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沈み込み帯の火山岩における U-Th 放射非平衡の起源
Origin of U-Th disequilibrium in subduction zone volcanic rocks

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Subduction zone magmatism is induced by the addition of slab derived fluids to the mantle wedge [1]. Chemical compositions of subduction zone volcanic rocks are largely controlled by the chemical and physical properties of the slab fluid. The nature of slab fluids have been extensively studied by geochemical approach utilizing trace element abundances and isotope compositions in arc basalts [2]. U-series disequilibrim in arc volcanic rocks is a useful tracer to understand the origin of arc magmas as well as the timescales of fluid/melt migration in subduction zones. However, detail of the process that producing ^{238}U-^{230}Th disequilibrium in primary melts in the mantle wedge is still poorly constrained.

In this study, we determined ^{238}U-^{230}Th disequilibrium in volcanic rocks from the Northeast Japan Arc (Iwate, Akitakoma, Yakeyama, Hachimantai, and Kampu). In addition, we performed a numerical simulation that reproduced (^{238}U/^{232}Th) and (^{230}Th/^{232}Th) ratios in primary melts in a subduction zone, by simultaneously calculating mantle dynamics, hydro phase reactions and trace elements transport. To discuss the origin of U-Th disequilibrium in arc volcanic rocks, the new data and previously published U-Th data around Japan were evaluated based on the result of the numerical simulation. The numerical simulation performed in this study

Most of arc volcanic rocks possess ^{238}U-^{230}Th disequilibrium with 238U excesses, suggesting the addition to the mantle wedge of slab fluid enriched in U relative to Th. The feature of ^{238}U enrichment is well reproduced by the numerical simulation. Interestingly, the simulation produced two positive trends in the U-Th diagram; the shallow trend matches data from the Izu-Mariana arc, while the steep slope is consistent with data from the Kamchatka arc. This strongly suggests that the positive trend in the U-Th diagram for a single arc samples simply reflects the variation of (^{238}U/^{232}Th) and (^{230}Th/^{232}Th) ratios in primary melts produced in the mantle wedge, and the slope does not have any age significance. Thus, as discussed in [3], the decoupling of U-Th and Th-Ra ages for arc samples would be explained by assuming that the slab derived fluid have (^{230}Th/^{232}Th) ratios higher than the mantle wedge composition.

Although the NEJ frontal-arc lavas (Iwate) possess ^{238}U-^{230}Th disequilibrium with ^{238}U excesses, the extent of 238U enrichment is moderate ($<$10%) compared to the other frontal-arc samples. In addition, Iwate lavas have relatively low (^{230}Th/^{232}Th) ratios that cannot be explained by the numerical simulation. This implies that the (^{230}Th/^{232}Th) in mantle wedge beneath Iwate volcano is lower than that in the depleted MORB mantle (DMM), due presumably to ancient mantle metasomatism by Th-enriched fluids derived from sediments.

In contrast to the frontal arc samples, the extent of ^{238}U enrichment in the NEJ samples decreases as the slab depth increases, and the rear-arc lavas (Kampu) show 230Th enrichments relative to ^{238}U ($<$10%). This generally reflects gradual decrease of the amount of slab derived fluid mixed into the wedge mantle. The ^{230}Th excesses in rear-arc lavas would be produced by the melting of garnet-bearing upwelling mantle, as reproduced by the simulation. However, our data for Kampu show 230Th excesses with an extremely low (^{230}Th/^{232}Th) ratio (~0.8) that plots outside the simulation data. This is explained by assuming the existence of metasomatised mantle beneath the NE Japan as discussed above, although the possibility of direct addition of Th-enriched fluid to the DMM-like mantle cannot be ruled out for the generation of rear-arc magmas.

References: [1] Iwamori (1998) *EPSL* 160, 65. [2] Nakamura et al. (2008) *Nature Geosci*. 1 380. [3] Yokoyama et al. (2003) *JGR* doi: 10.1029/2002JB002103.

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