Melting processes beneath Mt. Cameroon: Constraints from U-Th-Ra and Sr-Nd-Pb isotope systematics

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Precise measurements of ^{238}U-^{230}Th-^{226}Ra disequilibria in historical lavas from Mt. Cameroon volcano, Cameroon, are presented together with major and trace elements, and Sr-Nd-Pb isotope ratios to unravel the source and processes of basaltic magmatism in intraplate tectonic settings. Mt. Cameroon is currently the only active volcano in the Cameroon Volcanic Line (CVL) which locates at the ocean/continent boundary of the CVL. The volcano has 4095 m elevation above sea level, and it has erupted seven times in the last 100 yr. Of these eruptions, we have collected fresh samples from six lava flows (1909, 1922, 1959, 1982, 1999 and 2000AD), and 25 samples were analyzed in this study.

All the rocks used in this study are classified as basanite in the TAS diagram (SiO_2 = 43.5-46.6%, Na2O+K2O = 4.8-6.4%). They have mineral assemblages of ol + cpx ± pl ± mt as phenocrysts except for 1982 samples which are almost aphyric. In the primitive mantle normalized trace element patterns, Mt. Cameroon samples show convex signature with a peak-top at Nb (Nb_{sample}/Nb_{PM} ~150), subtle negative Pb anomaly, and it gradually decreases toward HREE (Yb_{sample}/Yb_{PM} ~ 5). The variations of Sr-Nd-Pb isotope ratios are rather restricted ($^{87}Sr/^{86}Sr$ = 0.70318-0.70332; $^{143}Nd/^{144}Nd$ = 0.51277-0.51281, $^{206}Pb/^{204}Pb$ = 20.382-20.427; $^{207}Pb/^{204}Pb$ = 15.656-15.663; $^{208}Pb/^{204}Pb$ = 40.173-40.199), but Pb isotope ratios are distinctly different depending on individual eruption ages.

All samples possess ^{238}U-^{230}Th-^{226}Ra disequilibria with ^{230}Th (18-24%) and ^{226}Ra (9-21%) excesses, and there exists a positive correlation in the ($^{226}Ra/^{230}Th$)–($^{230}Th/^{238}U$) diagram (Fig. 1). No significant alteration after eruption is found because all samples are in ^{238}U-^{234}U equilibrium within analytical error. The extent of ^{238}U-^{230}Th-^{226}Ra disequilibria is markedly different for individual eruption ages, although ($^{230}Th/^{232}Th$) ratio is constant irrespective of eruption ages. When U-series results are combined with Pb isotope ratio, negative correlations are observed in the ($^{230}Th/^{238}U$)–($^{206}Pb/^{204}Pb$) and ($^{226}Ra/^{230}Th$)–($^{206}Pb/^{204}Pb$) diagrams (Fig.2). Fractional crystallization in a shallow magma chamber with decay of ^{230}Th and ^{226}Ra does not account for the correlations observed in Figs. 1 and 2. Crustal contamination is not the case because continental crust is considered to have extremely high Th/U ratio with ($^{230}Th/^{238}U$) = 1, which is clearly off from the trend of Mt. Cameroon in the U-Th equiline diagram (not shown). Different degree of melting in the source mantle cannot explain a negative trend in the La/Yb-($^{230}Th/^{238}U$) diagram. Consequently, the most plausible scenario to produce geochemical characteristics of Mt. Cameroon

is the interaction between rising plume and sub-continental lithospheric mantle (SCLM) which has high U/Th and ($^{206}Pb/^{204}Pb$) ratios owing to ancient metasomatism. The result would suggest that the HIMU signature of the CVL has derived from metasomatised SCLM rather than enriched recycled materials in the plume source deep in the mantle.

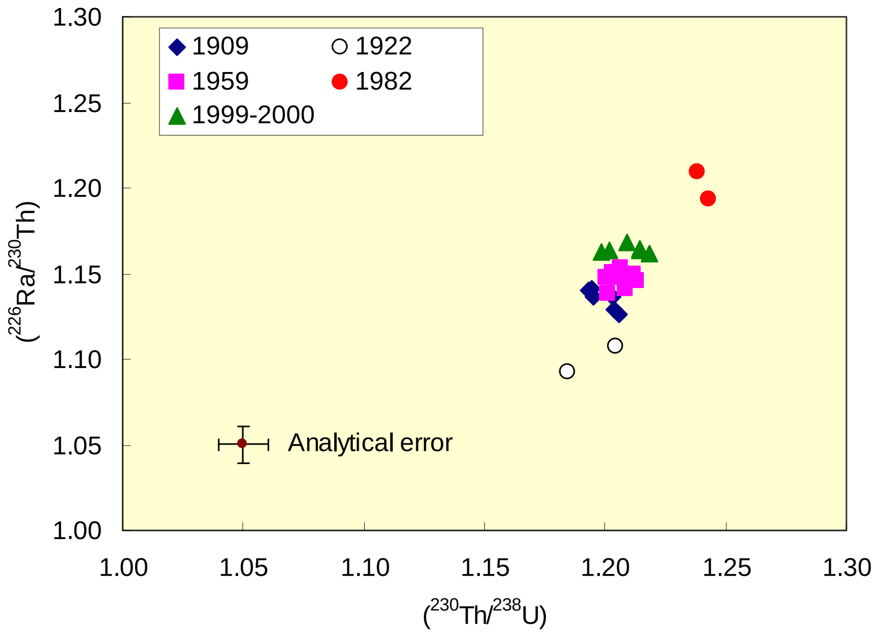

Fig. 1. ($^{226}Ra/^{230}Th$)–($^{230}Th/^{238}U$) diagram of Mt. Cameroon

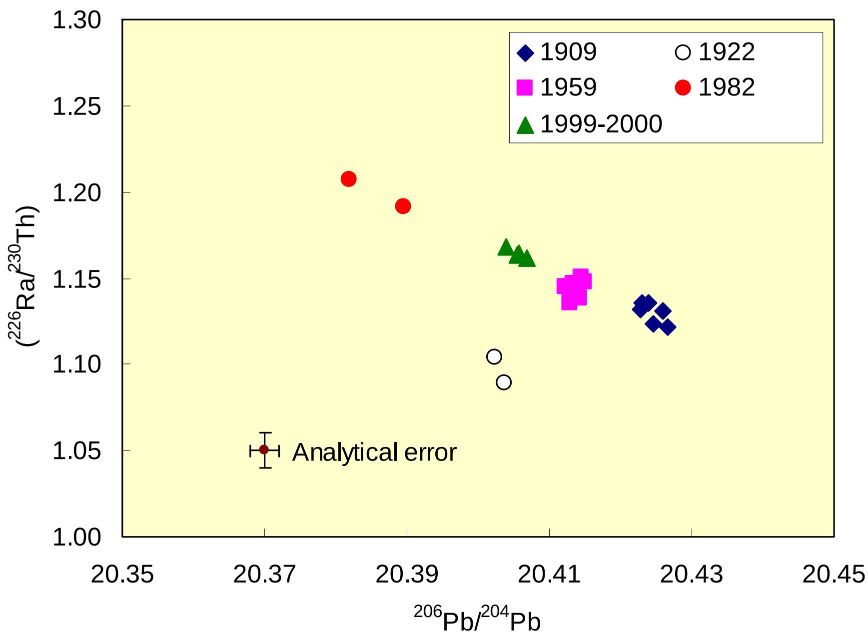

Fig. 2. ($^{226}Ra/^{230}Th$)–($^{206}Pb/^{204}Pb$) diagram of Mt. Cameroon