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HIMU and high-precision Pb isotopes

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Thirty years ago, Zindler and Hart [1] described the observed isotopic variability in mantle-derived basalts in terms of the end-member components DMM, HIMU, EM1 and EM2. HIMU represents ocean island basalts whose Pb isotopic composition is extremely radiogenic ($^{206}Pb/^{204}Pb \geq 20.5$; $^{207}Pb/^{204}Pb \geq 15.7$ and $^{208}Pb/^{204}Pb \geq 40$). Only few islands in the world fall into the category: St Helena in the South Atlantic and Mangaia, Rurutu and Tubuai in the South Pacific [2l.

Here we report new high-precision MC-ICPMS Pb isotopic ratios for about 50 selected samples from Tubuai Island that cover its entire period of volcanic activity and range of rock compositions. While the previous and less precise Pb TIMS data defined a cloud at high $^{206\text{-}207\text{-}208}Pb/^{204}Pb$, the new data define two parallel trends. In contrast to the geographical arrays known in Hawaii, in Tubuai the trends have no link to location but relate to the timing of the eruptions on the island and the chemical characteristics of the lavas: the oldest group consists of basanites and alkali basalts while the younger group includes nephelinites followed by evolved phonolites. The older lavas erupted between 10 and 9.5 Ma have lower $^{208}Pb/^{204}Pb$ at any given $^{206}Pb/^{204}Pb$ than the younger group erupted between 9.5 and 8.8 Ma. The old alkali basalts and basanites also have higher Ce/Pb at 32.7±3.6 than the younger lavas (26.1±4.0) but similar Th/U ratios at 4.0±0.4. Finally, the older group has mantle-like Nb/Th ratios at 14.6±2.7 while the younger nephelinites have lower Nb/Th ratios at 10.3±0.9, a feature that might be due to the presence of accessory residual phases during formation of these unusual liquids produced by exceptionally low degree of melting.

The new high-precision Pb isotopes and the trace element data demonstrate that the isotopic composition of the rising plume changed at 9.5 Ma, when the composition of the lavas also changed from basanite to nephelinite suggesting that the isotopic heterogeneity is related to temporal variation in plume composition.

References: [1] Zindler, A., Hart, S., 1986. Ann. Rev. Earth Planet. Sci., 14: 493-571; [2l Stracke, A., Hofmann, A., and Hart, S.R. 2005. Geochem, Geophys. Geosys. 6, Q05007, doi:05010.01029/02004GC000824.