

Geochemistry and mantle source characteristics of the Woranso-Mille Pliocene basalts, west-central Afar rift, Ethiopia

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The Woranso-Mille area in the west-central Afar rift of Ethiopia contains numerous Pliocene volcanic emplacement units, including basalt flows, ignimbrites, fall-out tuffs, and reworked fossiliferous volcanoclastic horizons. We present whole rock major- and trace-element data including REE, and Sr-Nd-Pb isotope ratios from a suite of basalts to better characterize their geochemistry and mantle sources. Six basalt groups (I-VI) are distinguished in the Woranso-Mille area. ⁴⁰Ar/³⁹Ar dating of the basalts and associated tuffs constrain the age of Group I to >3.78 Ma, Group II to between 3.57 and ~3.8 Ma, Group III to >3.57 Ma, Group IV to between 3.4 and 3.6 Ma, Group V to >3.4 Ma and Group VI to <3.4 Ma. Group I and V basalts show intermediate concentrations of elements such as Nb, Zr, Ba, Y, TiO₂, P₂O₅ and K₂O. Group II and VI and Group III and IV basalts have higher and lower concentrations, respectively. The geochemistry of Group I and V basalts is similar to E-type MORB whereas that of the Group II and VI basalts is akin to within-plate basalts. Group III and IV basalts have compositions most similar to N-type MORB. Chondrite-normalized REE patterns vary from relatively flat with (La/Lu)_N of 1.6 in the NMORB-like Group III and IV basalts to LREE enriched with (La/Lu)_N of 5.6 in the within-plate type Group II and VI basalts. Accordingly, the ΣREE varies between 76-94 ppm for the Group I and V basalts, 136-172 ppm for the Group II and VI and 45-50 ppm for the Group III and IV. Initial ⁸⁷Sr/⁸⁶Sr ratios for the Woranso-Mille basalts vary from 0.70354 (Group I) to 0.70509 (Group VI) and display a typical inverse relationship with ¹⁴³Nd/¹⁴⁴Nd ratios that range from 0.512902 to 0.512793 for all but one outlier from Group III (0.70447 and 0.512677). Pb isotope ratios display limited ranges (e.g. ²⁰⁶Pb/²⁰⁴Pb = 18.36-18.74; ²⁰⁶Pb/²⁰⁸Pb = 0.479-0.483) with subtle between group variations. The previously mentioned Nd isotope outlier also possesses a distinct ²⁰⁶Pb/²⁰⁸Pb ratio of 0.451.

The Woranso-Mille basalt elemental and isotopic data support assertions that Pliocene basalt magmatism in west-central Afar resulted from variable contributions from Afar plume, depleted mantle, and continental lithospheric sources.