Depleted mantle wedge and sediment fingerprint in unusual basalts from the Manihiki plateau, central Pacific Ocean: Comment and Reply

COMMENT: doi: 10.1130/G24829C.1

Ajoy K. Baksi*
Department of Geology and Geophysics, Louisiana State University, Baton Rouge, Louisiana 70803, USA

Ingle et al. (2007) reported $^{40}$Ar/$^{39}$Ar ages for Manihiki plateau rocks and suggested some of them were contemporaneous (~120 Ma) with lavas from the Ontong Java and Hikurangi plateaus, each some 2500 km distant (Ingle et al., 2007, their Fig. 1). Critical examination of the radiometric data suggests that widespread volcanism in the central-western Pacific at ~120 Ma is questionable.

All $^{40}$Ar/$^{39}$Ar results need to be evaluated for (1) statistical validity of plateau segments (Baksi, 2005), and (2) the state of alteration of splits used for dating purposes. The alteration index (AI) (Baksi, 2007a, 2007b) quantitatively evaluates the freshness of samples by monitoring the quantity of $^{36}$Ar seen in the various steps of the $^{40}$Ar/$^{39}$Ar incremental heating work. These tests are applied to the results of Ingle et al. (2007); errors are quoted at the 1σ level.

For tholeiitic sample D2–1, steps 3–6 define the best plateau; steps 7–9 are left out as they have very large associated errors (Ingle et al., 2007, their Fig. 3A). The plateau age is 117.8 ± 1.5 Ma; the mean square of weighted deviates (MSWD) value is 0.028, and the corresponding probability value is 0.994; the step age errors have been overestimated by a factor of ~5. Using these smaller error estimates yields a more “precise” plateau age of 117.83 ± 0.30 Ma, with a probability of occurrence of ~0.55. The average AI ($^{40}$Ar/$^{39}$Ar) of the plateau steps is four times higher than the cutoff value for fresh samples of <0.0006 (Baksi, 2007a). For sample D3–1 (alkalic lava), Ingle et al. selected steps 3–6 as yielding a plateau age. Step 6 is measurably younger than the others and should not be included in the plateau (Ingle et al., 2007, their Fig. 3C). The MSWD value (5.3) for steps 3–5 shows a probability of occurrence of ~0.005. This is unacceptable and the age cannot be taken to reflect the time of crystallization of sample D3–1. Further, the AI of the three plateau steps average >10 times the cutoff for fresh samples. No (proper) age was recovered for sample D3–1 and, at best, a minimum age was recovered for D2–1.

Ingle et al. compared their 117.9 ± 1.8 Ma age on sample D2–1 to the 121.8 ± 2.6 Ma ($^{40}$Ar/$^{39}$Ar age) reported for the Ontong Java plateau by Mahoney et al. (1993) (see Baksi 2007b, their Fig. 11A). The latter specimen has been shown to be altered (Baksi, 2007b, Fig. 11B) and unlikely to yield a proper estimate of its time of crystallization. The age of the Hikurangi plateau is reported in an abstract (Hoernle et al., 2005); no isotopic data are available for statistical inspection and/or the AI test. It is premature to equate (in time) lavas from the Manihiki, Ontong Java, and Hikurangi plateaus.

The dangers associated with the unquestioning use of $^{40}$Ar/$^{39}$Ar “ages” for oceanic rocks has been detailed elsewhere (Baksi, 1999, 2005, 2007b). This is illustrated by estimates for the age of the Bend in the Hawaiian-Emperor Chain, which are included in all introductory geoscience textbooks. Earlier work on whole-rock basalts suggested an age of 43 Ma (Dalrymple and Clague, 1976). More recent work on mineral separates (Sharp and Clague, 2006) indicates an age of 50 Ma. Sharp and Clague (2006) suggested that the earlier ages were based on dating of post-shield material and thus underestimated the age of the main shield-building phase at each seamount. This is unlikely, because the difference in age at each seamount is ~5–7 m.y., much larger than that estimated for shield–post-shield volcanism (~2 m.y.). As suggested elsewhere (Baksi, 2007b), the discrepancy in the ages results from the dating of altered material over three decades ago. The AI of the whole-rock samples dated by Dalrymple and Clague (1976) are >10 times the cutoff value ($^{40}$Ar/$^{39}$Ar < 0.0006). AI values ($^{40}$Ar/$^{39}$Ar) for the plagioclase samples of Sharp and Clague (2006) average ~0.00006, the cutoff for fresh samples. These (HF) acid-leached mineral separates yielded ages close to the crystallization value; the age of the Bend in the Chain is ~50 Ma.

Seafloor rocks are prone to alteration; this leads to considerable loss of $^{40}$Ar from the component silicate phases. It is critical that all $^{40}$Ar/$^{39}$Ar ages obtained on submarine rocks be critically assessed for statistical validity, as well as by the AI method. In the absence of high quality radiometric data for such rocks, speculation on immense volcanic events (plumes?), making up large sections of the seafloor such as in the central-western Pacific Ocean, is premature.

REFERENCES CITED

The validity of two $^{40}$Ar/$^{39}$Ar ages presented in our recent paper on the Manihiki Plateau (Ingle et al., 2007) is questioned by Baksi (2008). We welcome the opportunity to clarify the strengths and weaknesses of the data underpinning these ages.

Very little is known about the geochemistry, age, and origin of the Manihiki Plateau, one of several Early Cretaceous large igneous provinces (LIPs) present in the western Pacific Ocean. Several recent papers addressing the origin of the giant Ontong Java Plateau (e.g., Fitton et al., 2004; Ingle and Coffin, 2004), ~2500 km to the west of Manihiki, have stimulated renewed interest and debate about relationships among these LIPs (e.g., Taylor, 2006). The primary purpose of our paper was to analyze and interpret rocks of unusual composition that are not represented in LIPs (e.g., Taylor, 2006). The isotope composition of tholeiites is difficult, and large analytical uncertainties resulting from the low concentration of argon in these rocks and minerals I: Water, chemical weathering and atmospheric argon, in Foulger, G.R., and Judy, D.M., eds., Plates, plumes, and planetary processes: Boulder, Colorado, Geological Society of America Special Paper 430, p. 285–303.


