Hikurangi Plateau subduction a trigger for Vitiaz arc splitting and Havre Trough opening (southwestern Pacific)

K. Hoernle1,2, J. Gill3, C. Timm1,4, F. Hauff1, R. Werner1, D. Garbe-Schönberg2 and M. Gutjahr1
1GEOMAR Helmholtz Centre for Ocean Research Kiel, 24148 Kiel, Germany
2Institute of Geosciences, Kiel University, 24118 Kiel, Germany
3Department of Earth and Planetary Sciences, University of California, Santa Cruz, California 95064, USA
4GNS Science, PO Box 30-368, Lower Hutt 5040, New Zealand

ABSTRACT
Splitting of the Vitiaz arc formed the Tonga-Kermadec and Lau-Colville Ridges (southwestern Pacific Ocean), separated by the Lau Basin in the north and Havre Trough in the south. We present new trace element and Sr-Nd-Hf-Pb isotope geochemistry for the Kermadec and Colville Ridges extending ~900 km north of New Zealand (36°S–28°S) in order to (1) compare the composition of the arc remnants with Quaternary Kermadec arc volcanism, (2) constrain spatial geochemical variations in the arc remnants, (3) evaluate the effect of Hikurangi igneous plateau subduction on the geochemistry of the older arc lavas, and (4) elucidate what may have caused arc splitting. Compared to the Kermadec Ridge, the Colville Ridge has higher more-incompatible to less-incompatible immobile element ratios and largely overlapping isotope ratios, consistent with an origin through lower degrees of melting of more enriched upper mantle in the Vitiaz rear arc. Between ca. 8 and 3 Ma, both halves of the arc (~36°S–29°S) included a more enriched (EM1-type) composition (with lower 206Pb/204Pb and 208Pb/204Pb and higher Δ8/4 Pb [deviation of the measured 208Pb/204Pb ratio from a Northern Hemisphere basalt regression line] and 87Sr/86Sr) compared to older and younger arc lavas. High-Ti basalts from the Manihiki Plateau, once joined to the Hikurangi Plateau, could serve as the enriched Vitiaz arc end member. We propose that the enriched plateau signature, seen only in the isotope ratios of mobile elements, was transported by hydrous fluids from the western margin of the subducting Hikurangi Plateau or a Hikurangi Plateau fragment into the overlying mantle wedge. Our results are consistent with plate subduction triggering arc splitting and backarc opening.

INTRODUCTION
Volcanic arcs play a key role in the plate tectonic paradigm, being the surface expression of plate convergence. Nevertheless, little is known about the long-term tectonic and geochemical evolution of submarine remnant arc systems formed by arc splitting and backarc basin opening, largely due to their inaccessibility. Contemporaneous Neogene volcanism on the Tonga-Kermadec and Lau-Colville Ridges (southwestern Pacific Ocean; Fig. 1) supports the idea that the subparallel ridges were once part of a single volcanic arc (termed the Vitiaz arc), which split at ca. 5.5–3 Ma to form the Lau Basin and Havre Trough (e.g., Gill, 1976; Dun can et al., 1985; Wright et al., 1996; Timm et al., 2019; Caratori Tontini et al., 2019). Mechanisms for triggering arc splitting, however, are controversial (Sdrolias and Müller, 2006; Wallace et al., 2009).

Subduction of young igneous oceanic plateaus is unlikely due to their buoyancy, as demonstrated by the Hikurangi Plateau when it collided with and accreted to the Chatham Rise at ca. 105 Ma, becoming part of the Zealandia microcontinent. The present-day Hikurangi Plateau represents a rare example of an oceanic plateau being subducted into Earth’s mantle beneath the North Island of New Zealand and the southern Kermadec arc (Fig. 1) (Reyners et al., 2011). It formed at ca. 125 Ma as part of the Ontong Java–Manihiki–Hikurangi superplateau, which broke apart shortly after formation (e.g., Davy et al., 2008; Hoernle et al., 2010). The basement of the plateau fragments consists of two distinct geochemical types: (1) low-Ti basalts (Kroenke and Kwaimbaita groups on Ontong Java) have isotopically intermediate compositions similar to that of primitive mantle, and (2) high-Ti basalts (Singallo group on Ontong Java) have unradiogenic 204Pb/206Pb but radiogenic Sr isotope ratios (e.g., Tejada et al., 2004; Hoernle et al., 2010; Timm et al., 2011; Golowin et al., 2018). Where stratigraphic information is available, the high-Ti basalts overlie the low-Ti basalts. Between ca. 117 and 79 Ma, spreading along the Osbourn Trough paleo-spreading center, now located at ~25.5°S latitude, created ~3000 km of seafloor between the Hikurangi and Manihiki Plateaus (e.g., Mortimer et al., 2019). The northern tip of the subducting Hikurangi Plateau is presently located at ~36°S.

Here we present new trace element and Sr-Nd-Hf-Pb isotopic data from 40 locations on the Kermadec (KR) and Colville (CR) Ridges between ~28°S and 36°S (Fig. S1 in the Supplemental Material), recovered primarily on the R/V Sonne cruise SO255. We show that geochemical variations along both ridges are nearly identical, confirming that they once formed a single arc, and that differences between the ridges reflect the KR having been the frontal arc and the CR the rear arc of the Neogene Vitiaz arc. Some of the late Neogene (8–3 Ma) Vitiaz arc had an enriched composition distinct from...
that of the Quaternary Kermadec volcanic arc, consistent with subduction of the Hikurangi Plateau or a plateau fragment. The enriched lavas occur along a segment of the arc where part of the forearc is missing, consistent with removal by plateau subduction. Plateau collision and subduction is a possible mechanism for causing arc splitting and backarc basin opening.

RESULTS

We report analytical methods in the Supplemental Material, trace element and isotope data in Table S1, and replicate materials and replicates in Table S2, for lavas of the KR and CR (together designated "KCR lavas"). Compared to the primarily tholeiitic KR samples, the primarily calcalkaline CR samples (no adakites or boninites were found) have higher more-incompatible to less incompatible immobile element ratios (Ta/Yb, Nb/Yb, Th/Yb, La/Yb, and La/Sm). KCR lavas also have low Nb/Tb (<3.4), low Ce/Pb (≤12, with two exceptions), and low Nb/U (<10 when loss on ignition [LOI] ≤4 wt%). Although the KR and CR lavas largely overlap in isotopic composition (Fig. 2), each can be divided into isotopically depleted and enriched groups. The depleted KCR lavas between ~28°S and 37°S largely overlap with the Quaternary Kermadec arc and Havre Trough backarc lavas isotopically (Fig. 2). Compared to the depleted KCR lavas, the enriched KCR lavas extend to higher K₂O and incompatible element contents for a given MgO content, and to lower ⁸⁷Sr/⁸⁶Sr (≤ 18.37) and ²⁰⁶Pb/²⁰⁴Pb (≤ 15.53) and higher ⁸⁷Sr/⁸⁶Sr (≥ 0.7047) at similar ²⁰⁶Pb/²⁰⁴Pb, Nd, and Hf isotope ratios, indicating an enriched mantle (EM1)-type component in the source of the KCR lavas (between ~29.5°S and 36.5°S), not yet found in the Quaternary lavas.

Alkaline seamounts behind and late-stage cones on the CR (designated "intraplate CR") have higher Nb/Tb (4.3, 9.5–15.5), Ce/Pb (3–32), Nb/U (9–50, LOI <4 wt%) and ²⁰⁶Pb/²⁰⁴Pb, and lower ⁸⁷Sr/⁸⁶Sr, suggesting a similar intraplate source as for seamounts in the South Fiji Basin (Mortimer et al., 2007; Todd et al., 2011).

DISCUSSION AND CONCLUSIONS

Origin of Enriched End Member

Published age data can be used to constrain the duration of the enriched volcanism (Fig. S1). Six ⁴⁰Ar-⁴⁰Ar ages published from enriched lavas range from 7.5 ± 2.0 to 2.63 ± 0.23 Ma (three from the KR, 4.4–4.8 Ma; three from the CR, 7.5–2.6 Ma; Timm et al., 2019). Depleted lavas yielded ⁴⁰Ar-⁴⁰Ar ages of 3.40 ± 0.24 Ma from the KR (Timm et al., 2019) and 16.7 ± 0.1 Ma from the CR (Mortimer et al., 2010). Samples classified as depleted based on K content (0.17–0.29 wt%) from the KR have K-Ar ages of 1.25–2.04 Ma (n = 8, ~32.3°S) and 7.84 ± 0.69 Ma (31.6°S) (Balance et al., 1999). In summary, volcanism on the KR (1.2–7.8 Ma) and CR (2.6–16.7 Ma) extends into the early Miocene, with enriched volcanism being restricted conservatively to ca. 8–3 Ma and depleted volcanism perhaps continuously since the early Miocene.

Plots of isotope ratios versus latitude (with 1° latitude added to CR samples to compensate for northwest-southeast opening of the Havre Trough) show that isotopic variations are nearly identical along the KR and CR (Fig. 3), confirming that they once formed a single volcanic arc (Gill, 1976; Timm et al., 2019; Caratori Tontini et al., 2019). The shift to higher more-incompatible to less incompatible element ratios in the CR than the KR lavas at similar isotopic composition suggests derivation of CR lavas through lower degrees of melting beneath the rear arc. KCR lavas with enriched compositions were found between 29°S and 37°S (corrected CR; Fig. 3) with the strongest enriched signal being located at ~33°S, characterized by the lowest ²⁰⁶Pb/²⁰⁴Pb and ²⁰⁷Pb/²⁰⁴Pb and highest ⁸⁷Sr/⁸⁶Sr ratios. Therefore, the enriched arc signature appears to have been limited both temporally and spatially, although more geochronology is necessary to define its exact duration.

We now review possible origins of the enriched end member, beginning with the mantle wedge. Assuming corner flow, enriched intraplate mantle as found in South Fiji Basin seamounts and intraplate CR samples could have flowed from the backarc beneath the older arc. The South Fiji seamount and intraplate CR source, however, has higher ²⁰⁶Pb/²⁰⁴Pb and lower ⁸⁷Sr/⁸⁶Sr isotope ratios than the KCR lavas and therefore cannot explain the enriched (EM1-type) signature (Fig. 2). There is also no evidence of a plume beneath the arc, because the enriched lavas show typical subduction zone incompatible element abundances, e.g., low Ce/Pb (2.0–11.2, n = 74) and Nb/U (0.7–7.6, n = 74) ratios, well below typical mantle values of 25 ± 5 and 47 ± 10, respectively, in global intraplate lavas (Hofmann et al., 1986). There is also no geophysical (Bassett et al., 2016) or geochemical evidence that continental lithosphere underlies the KR and CR.

The enrichment of fluid-mobile elements relative to fluid-immobile elements is consistent with the enriched component coming from the subduction input. A decrease in Ce/Pb from 25 (average for global dry oceanic mantle, after Hofmann et al. [1986]) to 6 (average in enriched KCR lavas) represents a fourfold addition of fluid-mobile Pb compared to fluid-immobile Ce, implying enrichment of the mantle wedge primarily by hydrous fluids rather than melts. Enrichment by fluid addition can also explain why the isotope ratios of fluid-mobile elements (Pb and Sr) have been affected more than those of fluid-immobile Nd and Hf (Turner and Hawkesworth, 1998). There is, however, no evidence of an EM1-type hotspot track or seamounts being subducted along 900 km of this part of the arc that could
explain the enriched composition (Castillo et al., 2009; Hoernle et al., 2010).

The Hikurangi Plateau currently subducts south of 36°S, but isotopic evidence suggests that it may underlie the present arc as far north as ∼32°S (Timm et al., 2014). The enriched KCR isotopic signature, however, cannot be explained by the composition of the low-Ti Hikurangi basement, sampled along ∼50 km of the Rapuhia scarp (Hoernle et al., 2010).

Detailed sampling and geochemical studies have also been conducted on the Manihiki Plateau, which was once joined to the northern part of the Hikurangi Plateau. The high-Ti lavas from the Manihiki North Plateau have appropriate Pb and Sr isotopic compositions (Timm et al., 2011; Golowin et al., 2018) to serve as the EM1 component in the enriched KCR lavas (Fig. 2). Although estimates of the maximum size of the Hikurangi Plateau based on super-plateau reconstructions extend the plateau to ∼32°S (Timm et al., 2014), it is possible that a relatively thin finger of plateau material or plateau fragment, separated from the western edge of the Manihiki Plateau, may have extended as far north as 29°S. Alternatively, EM1 plateau material may have also been incorporated in the ocean lithosphere (crust and/or mantle) formed directly after plateau breakup at ca. 117 Ma (Fig. 4). We propose that between ca. 8 and 3 Ma, high-Ti plateau basalts with an EM1-type composition, similar to Manihiki North Plateau lavas, subducted beneath the southern Vitiaz arc possibly as far north as ∼29°S.

Figure 2. 206Pb/204Pb versus 208Pb/204Pb (A), 207Pb/204Pb (B), 87Sr/86Sr (C), and 143Nd/144Nd (D) isotope diagrams for depleted and enriched (EM1-type; ca. 8–3 Ma) Kermadec Ridge and Colville Ridge lavas, Quaternary Kermadec volcanic arc (QKVA) lavas, Havre Trough backarc (HTBA) lavas, sediments data, and Manihiki North Plateau samples (Golowin et al., 2018; Timm et al., 2019, and references therein; Hauff et al., 2021; Gill et al., 2021). In C, the arrow labelled “Subducted sediments” points to the subducted sediment field, which plots above the range in the diagram. Pacific and Indian mid-oceanic ridge basalt (MORB) is from the PetDB (http://www.earthchem.org/petdb).

Figure 3. Plot of 206Pb/204Pb versus latitude, showing a peak in enrichment (lowest 206Pb/204Pb) at 33°S. One degree of latitude has been added to Colville Ridge samples to correct for the opening of the Havre Trough. References are as for Figure 2.
Causes of Arc Splitting and Backarc Basin Opening

The causes of splitting of the Vitiaz arc into the KR and CR and the formation of the Havre Trough backarc basin are enigmatic. Extension in the overriding plate can trigger backarc rifting and/or spreading (Karig, 1971). Rollback of the subducting slab causes trench retreat, resulting in extension in the overriding plate (Jurdy, 1979), but rollback is unlikely to be a major process during subduction of thickened plateau crust (e.g., as much as 35 km beneath the Hikurangi Plateau; Reyners et al., 2011).

Another mechanism for generating extension in the overriding plate is forearc rotation caused by collision of a buoyant indenter on the incoming plate (e.g., seamount province, hotspot track, or oceanic plateau) with the subduction margin. The collision “pins” the subduction zone, resulting in trenchward rotation of the forearc about the pinned pivot point, causing extension, arc splitting, and backarc rifting and/or spreading (McCabe, 1984). An important criterion for causing backarc opening by a collision is that the “indentor enter[s] the subduction margin just prior to the initiation of the back-arc rifting event” (Wallace et al., 2009, p. 9). Based on the presently available age and geochemical data, the first evidence for plateau subduction was at ca. 8 Ma, preceding the initial Havre Trough opening at 5.5–3 Ma (Caratori Tontini et al., 2019), consistent with a connection between (1) plateau subduction, and (2) Vitiaz arc splitting and Havre Trough opening.

Because there has been only minor clockwise rotation of the Kermadec forearc from 10 Ma to the present (Sdrolias and Müller, 2006), another possible mechanism is removal of forearc lithosphere (Wolf and Huismans, 2019). Subduction of a positive bathymetric anomaly on the downgoing plate, such as an aseismic ridge or plateau fragment, would enhance basal lithospheric erosion of the overriding plate, resulting in subsidence and extension of the margin (Clift et al., 2003). Between 29°S and 34°S, the lithosphere thickness beneath the forearc thins to ~10–11 km but reaches thicknesses of 16–17 km to the north (25°S–26°S) (Stratford et al., 2015; Bassett et al., 2016), which may reflect basal forearc removal by plateau subduction. In order to explain the absence of the ~110-km-wide Tonga Ridge (located ~160 km from the trench at ~25°S–26°S) in the forearc south of ~30.5°S, Collot and Davy (1998) proposed frontal forearc removal. Removal of a large block of the forearc could have resulted in extension as the overriding plate moved trenchward to compensate for forearc removal, and could explain migration of the arc westward away from the trench (Keppie et al., 2009) beginning at ~30°S and away from the KR into the eastern Havre Trough south of ~32°S (Bassett et al., 2016). Thus, lithospheric removal by plateau collision and subduction could also be an important mechanism contributing to arc splitting and backarc basin opening.

Finally, the enriched plateau signal disappears in the KR and CR volcanism at ca. 3 Ma, and normal oceanic crust is presently subducting in the region where the enriched signal was observed (29°S–36°S). Once the plateau fragment fully subducted and thinner “normal” Cretaceous oceanic crust started subducting again, some slab rollback would have been likely. This could also have been an important mechanism causing or contributing to backarc rifting and/or spreading. We need better constraints on the timing of Havre Trough opening and plateau subduction in order to constrain the exact mechanism further.

As is clear from Ontong Java, plateau collision with a subduction zone will not always result in arc splitting and backarc rifting. Due to its larger size, greater thickness, and younger age at collision than the Hikurangi plateau margin or plateau fragment when it collided with New Zealand, the Ontong Java Plateau was too buoyant and thick to subduct and clog the subduction zone, resulting in subduction polarity reversal, so that normal ocean crust could again subduct. In summary, there appears to be a continuum from collision and subduction of seamount clusters and hotspot tracks resulting in forearc rotation and backarc rifting (Wallace et al., 2009), to collision of older...
plateau fragments causing lithospheric removal (accompanied by arc splitting and backarc opening), to collision of large and thick plateaus over a long stretch of an arc that shuts down subduction, causing polarity reversal in oceanic subduction zones.

ACKNOWLEDGMENTS

We thank the shipboard and scientific crews of R/V Sonne for a successful SO255 cruise; S. Hauff, K. Junge, and U. Weström for analytical support; O. Ishizuka, B. Jich, and B. Stern for helpful formal reviews; I. Gregymeyer for helpful comments; and the German Federal Ministry of Education and Research (BMBF) (grant 03G0255A), GEOMAR Helmholtz Centre (Kiel, Germany), and GNS Science (New Zealand) for funding this project.

REFERENCES CITED

Duncan, R.A., Vallier, T.L., and Falvey, D.A., 1985, Collot, J.Y., and Davy, B., 1998, Forearc structures

Caratori Tontini, F., Bassett, D., de Ronde, C.E.J., Junge, and U. Westernströer for analytical support; We thank the shipboard and scientific crews of R/V

23 April 2021

Garbe-Schönberg, D., Gutjahr, M., and Jung, S., 2021, Basalt geochemistry and mantle flow during early backarc basin evolution: H Havre Trough and Kermadec Arc, southwestern Pacific: Geochemistry Geophysics Geosystems, https://doi.org/10.1029/2020GC009339 (in press).

Golowin, R., Pilet, I., Hoernle, K., Hauff, F., Werner, R., and Garbe-Schönb erg, D., 2018, Geochemistry of deep Manihiki Plateau crust: Implications for compositional diversity of large igneous provinces in the Western Pacific and their genetic link: Chemical Geology, v. 493, p. 553–573, https://doi.org/10.1016/j.chemgeo.2018.07.016.

Hauff, F., Hoernle, K., Gill, J., Werner, R., Timm, C., Schönb erg-Dan, Jutjahr, M., and Jung, S., 2021, R/V SONNE Cruise SO255 “VITIAZ”: An integrated major element, trace element and Sr-Nd-Pb-Hf isotope data set of volcanic rocks from the Colville and Kermadec Ridges, the Quaternary Kermadec volcanic front and the Havre Trough backarc basin (version 1.0): Interdisciplinary Earth Data Alliance (IEDA), https://doi.org/10.26022/IEDA/111723 (accessed October 2020).

Hooke, D., Hauff, F., van den Bogaard, P., Werner, R., Mortimer, N., Geldmacher, J., Garbe-Schönberg, D., and Davy, B., 2010, Age and geochemistry of volcanic rocks from the Hikurangi and Manihiki oceanic plateaus: Geochimica et Cosmochimica Acta, v. 74, p. 7196–7219, https://doi.org/10.1016/j.gca.2010.09.030.

Hofmann, A.W., Jochum, K.P., Seufert, M., and White, W.M., 1986, Nb and Pb in oceanic basalts: New petrologic evidence of the Leucite Plateau: Journal of Petrology, v. 27, p. 215–237, https://doi.org/10.1093/petrology/27.1.215.

Koppers, A., 2011, Age and geochemistry of the Ontong Java Plateau: Geological Society [London] Special Publication 299, p. 135–150, https://doi.org/10.1144/GSL.SP.2004.229.01.009.

Timm, C., Hoernle, K., Werner, R., Hauff, F., van den Bogaard, P., Michels, P., Morley, M.F., and Koppers, A., 2011, Age and geochemistry of the oceanic Manihiki Plateau, SW Pacific: New evidence for a plume origin: Earth and Planetary Science Letters, v. 304, p. 135–146, https://doi.org/10.1016/j.epsl.2011.01.025.

Timm, C. et al., 2014, Subduction of the oceanic Hikurangi Plateau and its impact on the Kermadec arc: Nature Communications, v. 5, 4923, https://doi.org/10.1038/ncomms5923.

Timm, C., de Ronde, C.E., Hoernle, K., Cousens, B., Wartho, J.-A., Caratori Tontini, F., Wysockanski, R., Hauff, F., and Handler, M., 2019, New age and geochemical data from the Southern Colville and Kermadec Ridges, SW Pacific: Insights into the recent geological history and petrogenesis of the Proto-Kermadec (Vitiaz) Arc: Gondwana Research, v. 72, p. 169–193, https://doi.org/10.1016/j.gr.2019.02.008.

Timm, C., de Ronde, C.E., Hoernle, K., Fuhr, M., Wartho, J.A., Brown, J., Caratori Tontini, F., Wysockanski, R., Hauff, F., and Handler, M., 2019, New age and geochemical data from the Southern Colville and Kermadec Ridges, SW Pacific: Insights into the recent geological history and petrogenesis of the Proto-Kermadec (Vitiaz) Arc: Gondwana Research, v. 72, p. 169–193, https://doi.org/10.1016/j.gr.2019.02.008.

Todd, E., Gill, J.B., Wysockanski, R.J., Hergt, J.M., Wright, I.C., Leybourne, M.J., and Mortimer, N., 2019, Age and isotopic evidence for arc underplating in the Tonga-Kermadec region: Insights into the recent geological history and petrogenesis in the mode of mantle wedge enrichment: Southern Havre Trough and South Fiji Basin back arc: Geochimica Geosystemics, v. 12, Q09011, https://doi.org/10.1029/2019GC003683.

Turner, S.P., and Hawkesworth, C.J., 1998, Using geochemistry to map mantle flow beneath the Lau Basin: Geology, v. 26, p. 1019–1022, https://doi.org/10.1130/0091-7613(1998)026<1019:UGTMMF>2.3.CO;2.

Wallace, L.M., Ellis, S., and Mann, P., 2009, Collisonal model for rapid fore-arc block rotations, arc curvature, and episodic back-arc rifting in subduction setting: Ocean Geophysics Geosystems, v. 10, Q05001, https://doi.org/10.1029/2008GC002220.

Wolf, S.G., and Huismans, R.S., 2019, Mountain building or backarc extension in ocean-continent subduction systems: A function of backarc lithospheric strength and absolute plate velocities: Journal of Geophysical Research: Solid Earth, v. 124, p. 7461–7482, https://doi.org/10.1002/2018JB017171.

Wright, I.C., Parson, L.M., and Gamble, J.A., 1996, Evolution and interaction of migrating cross-arc volcanism and back-arc rifting: An example from the southern Havre Trough (55°20′–37°S): Journal of Geophysical Research, v. 101, p. 22071–22086, https://doi.org/10.1029/96JB01761.

Reyners, M., Eberhart-Phillips, D., and Bannister, S., 2011, Tracking repeated subduction of the Hikurangi Plateau beneath New Zealand: Earth and Planetary Science Letters, v. 311, p. 165–171, https://doi.org/10.1016/j.epsl.2011.09.011.

Sdrolias, M., and Müller, R.D., 2006, Controls on back-arc basin formation: Geology Geosystems, v. 7, 407–410, https://doi.org/10.1029/2005GC001099.

Stratford, W., Peirce, C., Funnell, M., Paulatto, M., Watts, A.B., Greveymeyer, I., and Bassett, D., 2015, Effect of Seamount subduction on forearc morphology and seismic structure of the Tonga-Kermadec subduction zone: Journal International, v. 200, p. 1503–1522, https://doi.org/10.1016/j.jisg475.

Tejada, M.L.G., Mahoney, J.J., Castillo, P.R., Ingle, S.P., Sheth, H.C., and Weis, D., 2004, Pin-planting the elephant: Evidence on the origin of the Ontong Java Plateau from Pb-Sr-Hf-Nd isotopic characteristics of ODP Leg 182 basaltas, in Fitton, J.G., et al., eds., Origin and Evolution of the Ontong Java Plateau: Geological Society [London] Special Publication 229, p. 133–150, https://doi.org/10.1144/GSL.SP.2004.229.01.009.

Timm, C., Hoernle, K., Werner, R., Hauff, F., van den Bogaard, P., Michels, P., Morley, M.F., and Koppers, A., 2011, Age and geochemistry of the oceanic Manihiki Plateau, SW Pacific: New evidence for a plume origin: Earth and Planetary Science Letters, v. 304, p. 135–146, https://doi.org/10.1016/j.epsl.2011.01.025.