Figure F1. Bathymetry of Walvis Ridge with feature names. Red dots = Expedition 391 cored drill sites, white dots = Expedition 397T cored drill sites. Base map is satellite-altimetry predicted depths (Smith and Sandwell, 1994).

Figure F2. Lithostratigraphic summary of sediments, Holes U1575A, U1576A, U1577A, U1578A, U1584A, and U1585A.

Figure F3. Lithostratigraphic summary of igneous rock, Holes U1575A, U1576A, U1576B, U1577A, U1578A, and U1585A.

Figure F4. Bathymetry of the South Atlantic Ocean, features of Rio Grande Rise and Walvis Ridge, Expedition 391 and 397T drill sites, geochemical trends, and ages. Colored symbols = dredge sites in different provinces (Hoernle et al., 2015). Numbers = radiometric ages in Ma (Rohde et al., 2013b; O'Connor and Jokat, 2015a, 2015b; Homrighausen et al., 2018, 2019). Red dots = cored drill sites. Inset shows the broader region and location of Paraná and Etendeka continental flood basalts (CFBs) and the post–70 Ma split of Walvis Ridge.

Figure F5. Walvis Ridge bathymetry (Smith and Sandwell, 1997), fixed hotspot age models, previous drill sites, and Expedition 391 and 397T drill sites. Solid line = central plume track of O'Connor and le Roex (1992) hotspot model, with black dots every 10 Ma. Dashed line = Torsvik et al. (2008) fixed hotspot model, with white dots every 10 Ma. Dashed line with yellow stars = moving hotspot model of Doubrovine et al. (2012). Small bold numbers = ages (Ma). Squares = DSDP and ODP holes drilled along Walvis Ridge (WR). Red dots = Expedition 391 and 397T cored drill sites. MAR = Mid-Atlantic Ridge.

Figure F6. Walvis Ridge age progression from radiometrically dated igneous rocks. Samples with EMI composition follow a tight linear trend. Exceptions are samples with HIMU-type composition that yield ages ~30–40 My younger than the underlying basement with an EMI-type geochemical composition. Vertical blue bands = Expedition 391 and 397T cored sites (see Homrighausen et al. [2019] for sources of age data). EMORB = enriched mid-ocean-ridge basalt.

Figure F7. Bathymetry reconstruction of Rio Grande Rise and Valdivia Bank at 88, 83, and 78 Ma. At 88 Ma, the main Rio Grande Rise and Valdivia Bank formed at the Mid-Atlantic Ridge. Around 83 Ma, Rio Grande Rise, Valdivia Bank, and part of East Rio Grande Rise formed a volcanic ring surrounding a small basin that may have contained a microplate (Thoram et al., 2019; Sager et al., 2021). White line = location of the Mid-Atlantic Ridge inferred from existing age models (Müller et al., 2008). This reconstruction shows bathymetry by crustal age, so features that postdate crustal formation appear too early. For this reason, guyots younger than the seafloor are masked. (From Sager et al., 2021.)

Figure F8. Tectonic sketch of the proposed microplate that briefly existed between Rio Grande Rise (RGR) and Valdivia Bank (VB) at 80 Ma (end of Chron 33r). Heavy lines = spreading ridges, arrows = spreading direction, gray lines = outlines of RGR and VB bathymetric highs, gray shaded area = positive magnetic anomaly zone, dashed line = rifts in RGR and VB. SA = South American plate, AF = African plate, CB = Centaurus Basin. (From Sager et al., 2021.)

Figure F9. Predicted paleolatitude drift of the TGW hotspot, hotspot models, and TPW. Bottom: paleolatitude estimates. Red line with dots = estimated paleolatitudes calculated from the global average African plate apparent polar wander path (Torsvik et al., 2008) based on a plate motion model with moving hotspots (Doubrovine et al., 2012). Thin vertical lines = 95% confidence limits based on paleomagnetic data scatter only. This polar wander path was constructed with a 20 My window length, averaged every 10 Ma. Blue line with circles = same paleolatitude curve for a fixed hotspot model (Torsvik et al., 2008). Pink square = paleolatitude determined for 60–75 Ma sediments (sed) from Site 525 (Chave, 1984). Its departure from the paleolatitude curve may be a result of inclination shallowing that is common for sediments (Verosub, 1977). Black triangle (NPB), open square (CPB), and purple diamond (SPB) = paleolatitudes from the north, central, and south Paraná flood basalts, respectively (Ernesto et al., 1990, 1999). Orange star (MC) = paleolatitude of Messum gabbros in the Etendeka province (Renne et al., 2002). Blue band (VK92) = hotspot drift estimated by Van Fossen and Kent (1992). Blue arrows = estimated ages of proposed drill sites from an age progression model (Homrighausen et al., 2019, 2020). Top: northward drift and TPW. Red line = paleolatitudes estimated from paleomagnetic data (same as lower plot). Black line = northward drift of a seamount with time if formed at the Tristan hotspot location (Schlömer et al., 2017), assuming a fixed hotspot model (Torsvik et al., 2008). Blue line = a moving hotspot model (Doubrovine et al., 2012). Green line = paleolatitudes of the Tristan hotspot from a mantle flow model (Doubrovine et al., 2012), indicating ~7° southward motion in 120 My. Orange line = northward drift of the African plate in the moving hotspot model (Doubrovine et al., 2012). It is less than the fixed hotspot model because the Tristan hotspot is modeled as moving south. Adding the hotspot motion to the moving hotspot model absolute motion equals the total northward motion indicated by the morphology of the TGW chain and the fixed hotspot model. All absolute motion models indicate that the African plate moved nearly monotonically northward, so they do not explain the rapid southward shift in paleolatitudes during the Late Cretaceous or the northward offset of paleolatitudes during the early Cenozoic. The difference between modeled and observed paleolatitudes implies significant TPW (purple curve) (Doubrovine et al., 2012).

Figure F10. 3-D plot of the Pb isotopic composition of TGW hotspot track samples. Spatial geochemical zonation indicates a triple-zoned plume (Class et al., 2015) where new data from dredge samples extend the previously identified dual zonation (Rohde et al., 2013a; Hoernle et al., 2015). Gough track = red, orange, purple; Tristan track = blue; Center track = green. Only high-precision Pb isotope data are shown, and uncertainty is smaller than the symbol size. Samples from the Tristan track with added depleted component with high Hf, high Nd, and low Sr isotopic composition are not shown for clarity (Figure F13). Data sources: Salters and Sachi-Kocher (2010), Rohde et al. (2013a), Hoernle et al. (2015), and Homrighausen et al. (2019). New data on Gough, Tristan, and Inaccessible Islands as well as seamounts sampled by MV1203 and older dredge samples from McNish and RSA by C. Class (unpubl. data).

Figure F11. Spatial geochemical zonation of the Tristan-Gough hotspot track since 70 Ma. Symbols = locations of dredge samples with high-precision Pb and Sr-Nd-Hf isotope data. Gough track = red, purple; Tristan track = blue, turquoise (depleted), yellow (plume-ridge); Center track = green. The three tracks are highlighted with transparent lines (that do not reflect plate motion) that connect most of the samples of each compositional zone and demonstrate the mostly spatially well separated zones (though there is some overlap). Only the north prong of the TGW chain after the split shows geochemical evidence for interaction of the plume with the Mid-Atlantic Ridge. In contrast, Tristan track samples with depleted compositions can be found over the entire length of the Tristan track. The older Walvis Ridge (red circles) shows no chemical zonation but extends the Gough track signature (Hoernle et al., 2015; Homrighausen et al., 2019). Data sources: Salters and Sachi-Kocher (2010), Rohde et al. (2013a), Hoernle et al. (2015), and Homrighausen et al. (2019).

Figure F12. Spatial geochemical zonation of the TGW hotspot track in $^{206}Pb/^{204}Pb$ vs. $^{207}Pb/^{204}Pb$ space, justifying the need for drilling. The compositional range is described as linear mixing arrays, and 95% confidence belts are shown. Highlighted are DSDP 527 and 528, Tristan Island group, and Gough Island samples, which show that the islands and drill sites show compositional variability that define mixing arrays. In contrast, dredge locations generally give only one compositional point. The few dredge locations that gave a compositional range are outlined and generally follow mixing arrays. Drilling can help test the triple-zoned plume model; a drill site in each of the three zones should give arrays that are parallel to the proposed mixing arrays. If the Center zone instead shows mixing between the Gough and Tristan end-members (compositional array perpendicular to the Center track), this will support the current model that zoned plumes sample the LLSVP margin and the ambient mantle outside of the LLSVP. Gough track = orange, red, purple; Center track = green, purple; Tristan track = blue, purple; DSDP Site 525A = purple dots. Samples from the Tristan track with added depleted component with high Hf, high Nd, and low Sr isotopic composition are not shown for clarity and not included for confidence belt calculations. All three tracks share the DSDP Site 525 end-member.

Figure F13. Plume-ridge interaction in Walvis Ridge samples. A. Tristan track samples extend to depleted compositions as shown by their high $^{143}Nd/^{144}Nd$ and $^{176}Hf/^{177}Hf$ isotopic compositions. Tristan track samples form a distinct trend from Gough track and Center track samples in this projection. B. All TGW chain samples overlap in $^{206}Pb/^{204}Pb$ vs. $^{208}Pb/^{204}Pb$ isotopic compositions (gray area). Only the most depleted samples (yellow) are displaced toward South Atlantic MORB compositions (orange = MORB 30°–55°S; black = MORB 0°–30°S), providing geochemical evidence for plume-ridge interaction (also MORB-type depleted trace element patterns, not shown here). Data sources: Salters and Sachi-Kocher (2010), Rohde et al. (2013a), Hoernle et al. (2015), and Homrighausen et al. (2019).

Figure F14. Seismic Line GeoB01-25. Top: seismic profile. Bottom: seismic line interpretation. TWT = two-way traveltime, VE = vertical exaggeration.

Figure F15. Detail of Seismic Line TN373-VB13 illustrating the section cored at Site U1575. Top: uninterpreted data. Bottom: interpretation of layering in seismic section. TWT = two-way traveltime, VE = vertical exaggeration.

Figure F16. Lithostratigraphic summary, Hole U1575A.

Figure F17. Stratigraphic column for the volcanic succession in Lithostratigraphic Unit IV, Hole U1575A.

Figure F18. Bathymetry of Site U1576 and environs. Detailed multibeam bathymetry around Seismic Line TN373-VB08 is merged with the SRTM15+ bathymetry grid (Tozer et al., 2019). Contours are plotted at 10 m intervals and labeled in kilometers. Blue line represents Seismic Line TN373-VB08. Heavy blue line shows the portion of the line shown by Figure F19.

Figure F19. Detail of Seismic Line TN373-VB08 and locations of Holes U1576A and U1576B. Top: uninterpreted seismic data. Bottom: seismic line interpretation. SF = seafloor reflector, B = basement reflector. R1, R2, etc., = seismic reflectors. TWT = two-way traveltime, VE = vertical exaggeration.

Figure F20. Regional section of Seismic Line TN373-VB08. TWT = two-way traveltime, VE = vertical exaggeration, SF = seafloor reflector, B = igneous basement reflector.

Figure F21. Lithostratigraphic summary, Hole U1576A.

Figure F22. Igneous stratigraphic column, Holes U1576A and U1576B. Sed = sedimentary.

Figure F23. Bathymetry of Site U1577 and environs. Detailed multibeam bathymetry around Seismic Line TN373-VB05 is merged with the SRTM15+ bathymetry grid (Tozer et al., 2019). Contours are plotted at 50 m intervals and labeled in kilometers. Blue line = Seismic Line TN373-VB05, heavy blue line = portion of the seismic line shown in Figure F24.

Figure F24. Seismic Line TN373-VB05 over Site U1577. Top: uninterpreted seismic data. Bottom: seismic line interpretation. Box = location and approximate depth of Site U1577. Seismic line location shown in Figure F23. TWT = two-way traveltime, VE = vertical exaggeration.

Figure F25. Lithostratigraphic summary, Site U1577.

Figure F26. Stratigraphic column for igneous basement, Hole U1577A.

Figure F27. Seismic Line TN373-CT2B over Site U1578. Top: uninterpreted seismic profile. Arrow = location of Site U1578. Bottom: seismic line interpretation. TWT = two-way traveltime, VE = vertical exaggeration.

Figure F28. Bathymetry map of Site U1578 and environs. Detailed multibeam bathymetry around Seismic Line TN373-CT2B is merged with the SRTM15+ bathymetry grid (Tozer et al., 2019). Contours are plotted at 50 m intervals and labeled in kilometers.

Figure F29. Section of Seismic Line TN373-CT2B showing the northwest flank of the Center track guyot. Arrows = locations of Site U1578 and proposed alternate Sites CT-6A and CT-7A. VE = vertical exaggeration.

Figure F30. Lithostratigraphic summary, Hole U1578A.

Figure F31. Stratigraphic column for igneous basement, Hole U1578A.