Figure F1. Bathymetry map of Valdivia Bank. Bathymetry data are from the satellite altimetry–based SRTM15+ predicted depth grid (Tozer et al., 2019). Contour interval = 500 m.

Figure F2. Walvis Ridge (WR) bathymetry (Smith and Sandwell, 1997), fixed hotspot age models, previous DSDP and Ocean Drilling Program (ODP) drill sites (squares), and Expedition 391 proposed sites and drilled sites (red dots). Solid line = central plume track of the O'Connor and Le Roex (1992) hotspot model with dots every 10 Ma. Dashed line = Torsvik et al. (2008) fixed hotspot model with dots every 10 Ma. Yellow stars and dashed line = moving hotspot model of Doubrovine et al. (2012). Small bold numbers = ages in Ma. MAR = Mid-Atlantic Ridge.

Figure F3. Walvis Ridge age progression from radiometrically dated igneous rocks. Samples with EMI-type composition follow a tight linear trend. Most exceptions are samples with HIMU-type composition that yield ages ~30–40 My younger than the underlying basement with an EMI-type geochemical composition (see Homrighausen et al., 2019, for sources of age data).

Figure F4. Magnetization of Valdivia Bank and environs. Map shows output of a magnetization inversion (Parker and Huestis, 1974) from a magnetic anomaly compilation (Thoram, 2021). Red = positive (normal) magnetization, blue = negative (reversed) magnetization. Thin lines = ship track control of magnetic anomalies, heavy line = 4000 m bathymetry contour around Valdivia Bank.

Figure F5. Predicted paleolatitude drift of the TGW hotspot, hotspot models, and true polar wander. Expedition 391 sites are shown. Bottom: paleolatitude estimates. Red line with red 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 blue circles = same paleolatitude curve for a fixed hotspot model (Torsvik et al., 2008). Pink square = paleolatitude determined for 60–75 Ma sediments 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). Inverted black triangle (NPB), open square (CPB), and purple diamond (SPB) = paleolatitudes from the north, central, and south Paraná flood basalts (Ernesto et al., 1990, 1999), respectively. Red 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 true polar wander. Red line with circles = paleolatitudes estimated from paleomagnetic data (same as lower plot). Black line = northward drift of a seamount over time if formed at the Tristan hotspot location, assuming fixed hotspot model (Torsvik et al., 2008). Blue line = same as black line but for 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 Ma. 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 true polar wander (purple curve) (Doubrovine et al., 2012).

Figure F6. Bathymetry map, Site U1577. 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 are labeled in kilometers. Blue line = Seismic Line TN373-VB05. Heavy blue line = portion of the seismic line shown in Figure F7.

Figure F7. Seismic Line TN373-VB05. Top: seismic profile. Bottom: interpretation. Box shows the location and approximate depth of Site U1577 coring. TWT = two-way traveltime, CMP = common midpoint, VE = vertical exaggeration, SF = seafloor, B = basement.

Figure F8. Lithostratigraphic synthesis, Site U1577.

Figure F9. Bioturbated clayey nannofossil chalk (Lithofacies 1), Hole U1577A. A. Ferromanganese crust disrupted by drilling in the lower part of Unit I (5R-3, 1–16 cm). B. White fragments of inoceramid shells and laminae in the upper part of Subunit IIIA (8R-4, 1–16 cm). Gray color along some laminae and in some burrows may be due to cryptic tephra material. The apparent cross-bedding is a drilling artifact caused by biscuiting. C. Spectacular ichnofossils and dark green tephra material dispersed by burrowing in the upper part of Subunit IIIB (10R-5, 34–49 cm). D. Cyclical layering in Subunit IIIC (16R-3, 68–83 cm).

Figure F10. Tephra layers (Lithofacies 2) and primary volcaniclastic deposits, Hole U1577A. A. Black bioturbated vitric tephra in Subunit IIIB; most of the glass is palagonized (14R-3, 42–57 cm). B. Brown graded tephra layer in Unit II; vitric components are entirely altered to clays (6R-5, 125–140 cm). C. Gray laminated bed in Subunit IIIA interpreted to reflect a possible dilute tephra component in the clayey nannofossil chalk (10R-1, 10–25 cm). D. Layered hyaloclastite with partly palagonized glass close to the base of the sedimentary cover in Subunit IIIC (17R-3, 20–35 cm).

Figure F11. Tilted sharp sedimentary contacts observed in Lithostratigraphic Units II and III, Hole U1577A.

Figure F12. Representative intervals of units and subunits, Hole U1577A. A. Unit I unconsolidated pale brown to white bioturbated nannofossil ooze, here with clay and a brown layer of graded volcanic ash (4R-2, 10–60 cm). B. Unit II poorly consolidated, bioturbated pinkish brown to pale brown clayey nannofossil chalk, here with a layer of brown graded volcanic ash (8R-2, 15–65 cm). C. Subunit IIIA inoceramid-bearing, pinkish brown to pale brown bioturbated clayey nannofossil chalk, here interbedded with three grayish beds possibly including a component of volcanic ash (9R-3, 55–105 cm). D. Subunit IIIB greenish gray bioturbated clayey nannofossil chalk, here interbedded with a layer of black graded vitric tuff (12R-5, 35–85 cm). E. Subunit IIIC inoceramid-bearing, pinkish brown to pale brown bioturbated clayey nannofossil chalk, here interbedded with a bioturbated layer of brown vitric tuff (6R-4, 30–80 cm).

Figure F13. Unit and subunit boundaries, Hole U1577A. A. Unit II/III boundary (8R-3, 131 cm), which corresponds to a possible ~3 My biostratigraphic gap between these units. B. Apparent Subunit IIIA/IIIB boundary (10R-5, 23 cm). Frequent biscuiting in the interval and along the apparent boundary suggests that the original boundary was lost to drilling disturbance. C. Subunit IIIB/IIIC boundary (14R-6, 92 cm), which marks disappearance of green colors downhole and a gradual change to more pinkish brown clayey nannofossil chalk in Subunit IIIC. D. Boundary between the sedimentary cover (Unit III/Subunit IIIC) and the igneous basement (Unit IV) (18R-1, 60 cm). A 0.5 cm thick layer of greenish, palagonized hyaloclastite occurs at the contact.

Figure F14. Stratigraphic column illustrating the recovery of igneous basement, Hole U1577A.

Figure F15. Basalt, Hole U1577A. A. The top of Igneous Subunit 1a preserves the 1 cm glassy margin of the basalt flow in contact with the basal pelagic sediment. Palagonite shards were trapped and preserved in the basal sediment (18R-1A, 58–59 cm). The massive flow continues into the underlying section (18R-2A, 0–150 cm). B. Massive basalt found in Subunit 1b (21R-5A). Some of the basalt is more fragmented with patchy alteration. C. A long, continuous core of massive basalt that fills most of two sections (23R-1A and 23R-2A).

Figure F16. Representative textures found in Igneous Unit 1, Hole U1577A. A, B. Flow margin with plagioclase ± clinopyroxene glomerocrysts in a mesostasis of microcrystalline plagioclase + clinopyroxene + Fe-Ti oxide (18R-2, 0–4 cm; TS 59;

Subunit 1a; A = plane-polarized light [PPL], B = cross-polarized light [XPL]). C, D. Olivine-plagioclase glomerocryst with equilibrium grain boundaries interpreted to represent a magma chamber cumulate (23R-3, 0–4 cm; TS 60; Subunit 1c; C = PPL, D = XPL). E. Plagioclase microlites with granular clinopyroxene and Fe-Ti oxides forming mesostasis in a massive flow interior (23R-3, 0–4 cm; TS 60; Subunit 1c; XPL). F. Skeletal Fe-Ti oxides formed in a massive flow interior (21R-1, 98–102 cm; TS 61; Subunit 1c; reflected light).

Figure F17. Long subvertical joints in basalt filled with calcite and iron oxide, Hole U1577A.

Figure F18. Copper-bearing mineral vein (391-U1577A-20R-4, 110–114 cm). (A) Exposed surface of a thin, diagonal green mineral vein showing (B) Cu-bearing hydroxides and clay (green). C. Detail of bright native copper metal.

Figure F19. A. Two sets of inclined veins (391-U1577A-21R-4). Upper vein is consistent with postemplacement compressional brittle fracturing and calcite infill, whereas lower vein is a composite of two vein systems. B. Box highlights composite vein structure consisting of a steep vein with irregular margins interpreted as a cooling fracture passing into/exploiting a pipe vesicle zone and a low-angle calcite vein crosscutting into the steep vein and representing later compressional brittle fracture. C. Close-up of crosscutting. Note that the irregular vein has a zoned infill with thin outer margins of green clay (chlorite?) and later calcite. The vein has only calcite infill.

Figure F20. Crosscutting relationships of high- and low-angle veins representing two episodes of vein formation, Hole U1577A.

Figure F21. Inclined pipe vesicles in the interior region of massive flow Subunit 1c (391-U1577A-23R-2, 62–74 cm). Pipe vesicles are typically associated with slow degassing of near-stagnant flow interiors in the final stages of the inflation (eruption) process; inclination of this series suggests a small degree of internal magma flow immediately prior to the completion of flow crystallization.

Figure F22. Correlated lithostratigraphy and biostratigraphy, Hole U1577A.

Figure F23. Age-depth model, Hole U1577A.

Figure F24. SRM and discrete sample magnetic results from sediment sections, Hole U1577A. Intensity and inclination data for the SRM are shown for the middle demagnetization step of 10 mT and the highest demagnetization step of 20 mT, and discrete sample data show the ChRM inclinations from PCA of both thermal and AF demagnetization. Red dashed lines = normal and reversed expected GAD inclination for the current location of the site. Black dashed lines = section boundaries; section labels for black dashed lines are between the magnetization and inclination plots. Interpreted polarity: black = normal polarity (inclinations >20°), white = reversed polarity (inclinations <20°), gray = an inability to assign polarity (for inclinations between ±20° and regions in which no core was recovered). Polarity chron assignments are based on the timescale of Ogg (2020).

Figure F25. Distributions of inclination values from sediments, Hole U1577A. Top: SRM 20 mT data. Bottom: discrete PCA data. Blue and orange bars = inclinations for discrete AF demagnetized and thermally demagnetized samples, respectively. Black lines = positive and negative average inclinations from the method of McFadden and Reed (1982).

Figure F26. AF demagnetization results for a representative sediment sample, Hole U1577A. A. Equal area stereonet with direction of magnetization vector at different AF steps. B. Orthogonal vector (Zijderveld) plot with magnetization endpoints plotted on two orthogonal planes. C. Normalized magnetization strength, M, at a given AF field demagnetization, normalized by the maximum magnetization strength, M_{max}.

Figure F27. Thermal demagnetization results for a representative sediment sample, Hole U1577A. A. Equal area stereonet with direction of magnetization vector at different temperature steps. B. Orthogonal vector (Zijderveld) plot with magnetization endpoints plotted on two orthogonal planes. C. Normalized magnetization strength, M, at a given temperature, normalized by the maximum magnetization strength, M_{max}.

Figure F28. IRM acquisition curves for six discrete sediment samples, Hole U1577A.

Figure F29. SRM and discrete sample data from igneous units, Hole U1577A. Intensity and inclination data for the SRM are shown for the middle demagnetization step of 10 mT and the highest demagnetization step of 20 mT, and discrete data show the ChRM inclination from PCA of thermal and AF demagnetization. Red dashed lines = expected normal and reversed GAD inclination for the current location of the site. Black dashed lines = section boundaries; section labels for black dashed lines are between the magnetization and inclination plots. Interpreted polarity: black = normal polarity (inclinations >20°), white = reversed polarity (inclinations <20°), gray = inability to assign polarity (for inclinations between ±20° and regions in which no core was recovered). Polarity chron assignments based on the timescale of Ogg (2020).

Figure F30. Distributions of inclination values from igneous rocks, Hole U1577A. Top: SRM 20 mT data. Bottom: discrete PCA data. Blue and orange bars = inclinations for discrete AF demagnetized and thermally demagnetized samples, respectively. Black lines = positive and negative average inclinations from the method of McFadden and Reed (1982).

Figure F31. AF demagnetization results for a representative basalt sample, Hole U1577A. A. Equal area stereonet with direction of magnetization vector at different AF steps. B. Orthogonal vector (Zijderveld) plot with magnetization endpoints plotted on two orthogonal planes. C. Normalized magnetization strength, M, at a given AF demagnetization, normalized by the maximum magnetization strength, M_{max}.

Figure F32. Thermal demagnetization results for a representative basalt sample, Hole U1577A. Note the sharp decrease of magnetization with heating. A. Equal area stereonet with direction of magnetization vector at different temperature steps. B. Orthogonal vector (Zijderveld) plot with magnetization endpoints plotted on two orthogonal planes. C. Normalized magnetization strength, M, at a given temperature, normalized by the maximum magnetization strength, M_{max}.

Figure F33. Thermal demagnetization results for a representative basalt sample, Hole U1577A. Note the rapid decrease of demagnetization with increasing temperature. A. Equal area stereonet with direction of magnetization vector at different temperature steps. B. Orthogonal vector (Zijderveld) plot with magnetization endpoints plotted on two orthogonal planes. C. Normalized magnetization strength, M, at a given temperature, normalized by the maximum magnetization strength, M_{max}.

Figure F34. pARM acquisition curves for seven discrete samples, Hole U1577A. Samples were measured with a sliding window of 5 mT in a direct current field of 0.2 mT superimposed on an AF maximum field of 100 mT. Field (mT) = highest field in the interval in which ARM was applied (Jackson et al., 1988). For example, the point at 20 mT is the pARM acquired on the 15–20 mT interval.

Figure F35. IRM acquisition curves and backfield curves for three discrete igneous rock samples, Hole U1577A.

Figure F36. IW alkalinity, pH, chloride, phosphate, bromide, sulfate, sodium, strontium, magnesium, potassium, calcium, ammonium, barium, boron, iron, lithium, manganese, and silicon, Hole U1577A. Unit IV represents the igneous basement.

Figure F37. TC, $CaCO_3$, and TOC, Hole U1577A. Unit IV represents the igneous basement.

Figure F38. pXRF and ICP-AES results obtained on the same sample powder, Hole U1577A. ppm = µg/g. Dotted line = regression line for samples. Gray line is y = x line. Samples plot on this line if the ICP-AES and pXRF contents are identical.

Figure F39. A. Total alkali versus silica classification (Le Bas et al., 1986) showing that all Site U1577 samples measured using ICP-AES are tholeiitic basalts using the classification of MacDonald and Katsura (1964). The U1577 samples overlap in composition with the tholeiitic basalts of Site U1575 and lie at the mafic extension of Site U1576 tholeiitic basalts. B. Ti vs. V classification diagram after Shervais (2022) showing that all basaltic lavas from U1577 lie within the MORB field and overlapping field of ridge-centered OIB consistent with EMI-type dredge and DSDP drill sites from Walvis Ridge. In contrast, all island and Guyot Province samples, as well as HIMU-type samples, from the hotspot track fall in the OIB and alkaline OIB fields. Data sources: Le Maitre, 1962; Richardson et al., 1984; Weaver et al., 1987; Le Roex et al., 1990; Cliff et al., 1991; Gibson et al., 2005; Willbold and Stracke, 2006; Class and le Roex, 2008; Salters and Sachi-Kocher, 2010; Class and Lehnert, 2012; Rohde et al., 2013; Hoernle et al., 2015; Homrighausen et al., 2018, 2019.

Figure F40. Mg# vs. SiO_2, P_2O_5, Zr, Sr, Sc, and V, Site U1577 lavas. Major element compositions are normalized to 100 wt% totals. Data from Site U1577 overlap with the high Mg# part of the Site U1575 cluster as well as the mafic end-member of the Site U1576 trend. All Walvis Ridge drill sites (U1575, U1576, and U1577) lie generally within the compositional array of the previously reported rocks of the Tristan-Gough hotspot track. Data sources: Le Maitre, 1962; Richardson et al., 1984; Weaver et al., 1987; Le Roex et al., 1990; Cliff et al., 1991; Gibson et al., 2005; Willbold and Stracke, 2006; Class and le Roex, 2008; Salters and Sachi-Kocher, 2010; Class and Lehnert, 2012; Rohde et al., 2013; Hoernle et al., 2015; Homrighausen et al., 2018, 2019.

Figure F41. Downhole chemical variations, Hole U1577A. Select elements measured using ICP-AES in comparison to pXRF data on the same powders and on archive-half sections. Dashed arrows = similar trends downhole that show minimum values for Igneous Subunit 1b. Trends of elements that are compatible in olivine ± Cr-spinel (i.e., MgO, Mg#, Ni, and Cr) are consistent with the olivine-free layer in Igneous Subunit 1b being slightly more fractionated, although remarkably this is not reflected in elevated elements that are incompatible in olivine. Ba shows a marked increase in Igneous Subunit 1a, whereas most other incompatible elements display only a slight increase. Incompatible elements (TiO_2, Sr, Zr, and Ba) show slight decreases downhole.

Figure F42. Physical properties, Hole U1577A. cps = counts per second.

Figure F43. Lithostratigraphic, petrophysical, and paleomagnetic correlation of possible unconformity at ~70 mbsf, Hole U1577A. cps = counts per second.