Figure F1. Bathymetry map of Valdivia Bank showing the location of Sites U1575–U1577. 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 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. Dashed yellow line with yellow stars = 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. Expedition 391 proposed and drilled sites have estimated ages of 55–65 (U1578), 80–85 (U1576 and U1577), and 100–105 Ma (U1575) (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 on horizontal axis. 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 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 (MC) 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 U1576. Detailed multibeam bathymetry around Seismic Line TN373-VB13 is merged with the SRTM15+ bathymetry grid (Tozer et al., 2019). Contours are plotted at 10 m intervals and labeled in kilometers. Blue line = Seismic Line TN373-VB08. Heavy blue line = portion of the line shown in Figure F7.

Figure F7. Short portion of Seismic Line TN373-VB08 over Site U1576. Top: uninterpreted profile. Bottom: interpretation. TWT = two-way traveltime, CMP = common midpoint, VE = vertical exaggeration, SF = seafloor reflector, B = igneous basement reflector. R_1, R_2, etc. = seismic reflectors.

Figure F8. Longer portion of Seismic Line TN373-VB08. TWT = two-way traveltime, CMP = common midpoint, VE = vertical exaggeration, SF = seafloor reflector, B = igneous basement reflector.

Figure F9. Lithostratigraphic summary, Hole U1576A.

Figure F10. Ooze in Unit I, Hole U1576A. A. Very pale brown nannofossil-foraminifera ooze with minor radiolarians and clay in Subunit IA (1R-1, 120 cm). B. White nannofossil ooze with foraminifera and minor radiolarians in Subunit IB (3R-4, 50 cm). C. Brown foraminifera-nannofossil ooze with clay and minor radiolarians in Subunit IC (10R-1, 81 cm).

Figure F11. Selection of 50 cm thick intervals of cyclical chalk lithofacies at Hole U1576A. A. Pale brown and brown foraminifera-nannofossil chalk with clay in Unit II, here also including hardened, dark ferromanganese patches (13R-2, 70–120 cm). B. Pinkish white and reddish brown foraminifera-nannofossil chalk with clay in Subunit IIIA (22R-3, 30–80 cm). C. Pinkish gray, light gray, and darker gray foraminifera-nannofossil chalk with clay in Subunit IIIB (30R-4, 65–115 cm). D. Greenish gray to light gray foraminifera-nannofossil chalk with clay in Unit IV (40R-2A, 5–55 cm).

Figure F12. Stratigraphic boundaries between Units II/III, Subunits IIIA/IIIB, and Units III/IV, Hole U1576A. A. Ferromanganese layer between Units II and III (14R-1, 40–75 cm). B. Distinctive dark green clayey interval with reduction aureole between Subunits IIIA and IIIB (29R-4, 50–85 cm). C. First appearance downhole of siliceous chalk at the boundary between Units III and IV (34R-3, 85–120 cm).

Figure F13. Volcaniclastic facies in Unit III, Hole U1576A. A. Graded sand to silt rich in ferromagnesian minerals with bioturbated top (15R-1, 95–120 cm). B. Lenses of sandy ferromagnesian minerals in burrowed chalk (15R-2, 55–70 cm). C. Laminae of green clay in red clayey chalk, interpreted as altered layers of ash (19R-4, 50–70 cm).

Figure F14. Calcareous sandy-volcaniclastic facies in Unit IV. A. Amalgamated turbidites with normal grading, and parallel and cross-lamination (391-U1576A-38R-2, 59–74 cm). B. Amalgamated turbidites with normal grading, parallel and cross-lamination, and cross-bedding (391-U1576B-2R-1, 17–22 cm). C. Base of matrix-supported conglomerate with contorted bedding (2R-4, 2–17 cm). This sedimentary rock includes a chalk matrix with larger clasts of white chalk and possible black-green metalliferous sediment. This sedimentary rock is interpreted as a hyperconcentrated flow deposit and forms a distinctive stratigraphic interval between Holes U1575A and U1575B. D. Matrix-supported conglomerate with lenses of larger clasts of white chalk and possible black-green metalliferous sediment (391-U1576A-38R-3, 60–85 cm). This sedimentary rock is interpreted as a hyperconcentrated flow deposit and forms a distinctive stratigraphic marker between Holes U1575A and U1575B.

Figure F15. Layered metalliferous (Ti and V-rich) sediment (umber) preserved in Sedimentary Interbed S5 immediately below Massive Flow 7 (391-U1576B-12R-2, 85–107 cm). Note disturbed sediment and microfracturing thought to be caused by later flow loading and thermal fluxing following subsequent flow emplacement at this locality.

Figure F16. Stratigraphic column, Holes U1576A and U1576B.

Figure F17. Lava and glass pillows, Hole U1576B. A. Continuous core of massive lava (11R-1, 7–97 cm). B. Continuous core of massive lava (12R-1, 17–92 cm). C. Glass pillow rim on single pillow in Igneous Unit 1 (7R-1, 83–130 cm). Center interval was rotated 180° prior to splitting. D. Glass rims on two adjacent pillows in Unit 1 (6R-1, 11–28 cm). E. Carbonate filling pillow interstices along with adjacent glass pillow rim (6R-2, 0–7 cm).

Figure F18. Massive lavas and sheet flows. A, B. Massive lava with a glomeroporphyritic texture, altered olivine phenocrysts, plagioclase glomerocrysts, and zoned plagioclase (391-U1576A-40R-4, 117–120 cm; A = cross-polarized light (XPL), B = plane-polarized light [PPL]). C, D. Sheet flow with a seriate texture of plagioclase and clinopyroxene (391-U1576B-14R-2, 0–3 cm; C = XPL, D = PPL). E, F. Mesostasis melt globule (red circle) containing skeletal groundmass crystals and glass between phenocrysts; note plagioclase laths clustered along outer margin of the globule (391-U1576A-40R-4, 117–120 cm; E = PPL, F = reflected light).

Figure F19. Pillow lavas. A, B. Pillow lava rim with clinopyroxene and plagioclase microlites set in altered glass; clay-filled vein on right margin (391-U1576B-7R-1, 125–128 cm; A = XPL, B = PPL). C, D. Pillow lava interior with plagioclase and clinopyroxene glomerocrysts and a fine-grained groundmass (391-U1576A-41R-2, 16–19 cm; C = XPL, D = PPL). E. Pillow interior with labradorescent plagioclase (white arrows) and secondary pyrite crystals (orange arrows) (391-U1576B-6R-1, 113–116 cm; reflected light). F. Reflected light image of a pillow rim with cryptocrystalline groundmass around plagioclase (Plag) and clinopyroxene (CPX) microlites (7R-1, 125–128 cm).

Figure F20. Alteration of basalt. A. Alteration front showing intense pistachio-green alteration toward the top of the flow (in contact with green sediment) that stops abruptly around 61 cm (391-U1576A-40R-4, 51–71 cm). Below this gray-green basalt, the basalt is largely unaltered. B. Flow top alteration (intense gray-green) that fades gradually toward flow interior (pale gray) (391-U1576B-13R-2, 34–148 cm). Vesicle fill also decreases downward. C. Flow base alteration: dark gray of flow interior fades into intense gray-green alteration at the base of a flow (14R-2, 0–114 cm). D. Alteration of interpillow sediment and adjacent pillow rim glass (7R-1, 120–129 cm).

Figure F21. Correlated lithostratigraphy and biostratigraphy, Site U1576. ? = uncertainty that requires more detailed examination and more samples to increase accuracy and resolution.

Figure F22. Age-depth model, Hole U1576A. Interbedded sediment ages are not plotted.

Figure F23. Magnetization intensity and inclination for Sections (A) 391-U1576A-11R-1 through 21R-1, (B) 21R-2 through 31R-3, and (C) 31R-4 through 41R-2. Inclinations for the SRM are shown for the middle demagnetization step of 10 mT and the highest demagnetization step of 20 mT, whereas discrete data show the ChRM inclination from PCA of both 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 are based on the timescale of Ogg (2020) and recovered biostratigraphic markers (see Biostratigraphy).

Figure F24. Distributions of inclination values for SRM 20 mT data and discrete PCA data. A. Hole U1576A. B. Hole U1576B. Blue and orange bars = inclinations for discrete AF demagnetized and thermally demagnetized samples, respectively. Black lines = positive and negative inclination averages from the method of McFadden and Reed (1982), dashed black line = zero inclination.

Figure F25. AF demagnetization result for a representative sediment sample, Hole U1576A. 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 F26. Thermal demagnetization result for a representative sediment sample, Hole U1576A. 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 thermal demagnetization step, normalized by the maximum magnetization strength, M_{max}.

Figure F27. Magnetization intensity and inclination, Hole U1576B. Inclinations for the SRM are shown for the middle demagnetization step of 10 mT and the highest demagnetization step of 20 mT, and discrete data points show the ChRM inclination from PCA of both 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. 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.

Figure F28. IRM acquisition curves for four discrete sediment samples, Hole U1576A. Samples 14R-3, 57–59 cm, and 18R-5, 44–46 cm, are from the red sediments. Samples 29R-1, 19–21 cm, and 32R-3, 85–87 cm, are from the gray sediments.

Figure F29. AF demagnetization results for a representative basalt sample, Hole U1576B. 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 F30. Thermal demagnetization result for a representative basalt sample, Hole U1576B. 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 thermal demagnetization step, normalized by the maximum magnetization strength, M_{max}.

Figure F31. Partial ARM acquisition of four discrete samples from Hole U1576B. 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 in the 15–20 mT interval. Blue and red lines = fresh basalts, orange and green lines = altered basalts.

Figure F32. IW alkalinity, pH, chloride, phosphate, bromine, sulfate, sodium, strontium (including Sr/Ca value), magnesium, potassium, calcium, ammonium, barium, boron, iron, lithium, manganese, and silicon, Hole U1576A. Unit V represents the igneous basement.

Figure F33. TC, $CaCO_3$, and TOC, Hole U1576A. Unit V represents the igneous basement.

Figure F34. pXRF and ICP-AES results obtained on the same sample powder, Hole U1576A. Black dotted line = regression line for samples. Gray line = y = x line. Samples plot on this line if ICP-AES and pXRF contents are identical. ppm = µg/g.

Figure F35. Sawed section rock surface images of the samples for ICP-AES measurements, Site U1576. Samples are classified into two groups based on petrological observations. Three green samples are heavily altered. One oxidized brown with limited green sample is moderately altered. Eight gray samples with vesicles filled with gray minerals and/or secondary sulfides are slightly altered.

Figure F36. TiO_2 vs. major and some trace element compositions, Site U1576. Major element compositions are normalized to 100 wt% totals on a volatile-free basis. Blue circle = heavily altered Sample 396-U1576B-8R-3, 25–27 cm. In the other samples, SiO_2, CaO, Na_2O, P_2O_5, V, Zr, and Y are generally well correlated with TiO_2 and are consistent with a fractional crystallization trend, including the most altered samples (with few exceptions), suggesting that these elements are immobile during alteration. K_2O, however, shows more scatter when plotted against TiO_2, indicating that it is mobilized during alteration. Interestingly, in the TiO_2 vs. Zr diagram, the altered samples show a slightly distinct trend compared to the slightly altered samples.

Figure F37. A. Total alkali versus silica classification (Le Bas et al., 1986) with alkalic-tholeiitic division (MacDonald and Katsura, 1964). Blue circle = heavily altered Sample 396-U1576B-8R-3, 25–27 cm. Site U1576 samples are tholeiitic basalt and basaltic andesite, and their trend is consistent with fractional crystallization. Other samples from the same hotspot system from Gough Island, Gough guyot track, other Walvis Ridge dredge sites, and DSDP sites are variably fractionated from basalt to hawaiite and mugearite. Samples from the Tristan Island group are dominantly basanites fractionated to phonotephrites and phonolites (out of range). B. Ti vs. V classification diagram after Shervais (2022) shows that all basaltic lavas from Site U1576 lie within the MORB field and overlap the 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 same hotspot system, fall in the OIB and alkaline OIB fields. ppm = µg/g. 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 F38. MgO vs. major and some trace element compositions normalized to 100 wt% totals for major element concentrations. Arrows = individual fractionation trends of olivine + clinopyroxene and Ti-Fe oxides. Data from Hole U1576A and U1576B rocks generally lie within the compositional array of the previously reported rocks of the Tristan-Gough hotspot track. One highly altered sample (391-U1576B-8R-3, 25–27 cm) displays deviating CaO/Al_2O_3, Y, and Sr values (blue circle). Major and trace element variations are, in general, consistent with crystal fractionation of the phenocryst phases. ppm = µg/g. 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; Homrighausen et al., 2019.

Figure F39. Downhole chemical variations, Hole U1576A. Select elements measured using ICP-AES on rock powders in comparison to pXRF data on archive-section halves and rock powders. Blue circle = heavily altered Sample 396-U1576B-8R-3, 25–27 cm. The pink dotted line marks the boundary between greenish alteration in Igneous Unit 3 and the upper part of Igneous Unit 4 and relatively fresh igneous rocks below. ppm = µg/g.

Figure F40. Physical properties, Holes U1576A and U1576B. cps = counts per second.

Figure F41. Lithologic and MS correlation between Holes U1576A and U1576B.

Figure F42. Cyclicity displayed in reflectance, MS, SRM magnetization intensity, and NGR in Hole U1576A sediments.

Figure F43. Porosity and grain density vs. bulk density, Holes U1576A and U1576B.