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Supporting Information for

**Nature And Origin of Magnetic Lineations Within Valdivia Bank: Ocean Plateau Formation by Complex Seafloor Spreading**

S. Thoram1, W.W. Sager1, K. Gaastra2, S.M. Tikoo3,4, C. Carvallo5, A. Avery6, A. Del Gaudio7, Y. Huang8, and Expedition 391 Scientists9

1Department of Earth and Atmospheric Sciences, University of Houston, Houston, TX 77204

2Department of Earth, Environmental and Planetary Sciences, Rice University, Houston, TX 77005

3Department of Geophysics, Stanford University, Stanford, CA, USA

4Department of Geological Sciences, Stanford University, Stanford, CA, USA

5Sorbonne Université, MNHN, CNRS, UMR 7590, Institut de Minéralogie, de Physique des Matériaux et de Cosmochimie, F-75005 Paris, France

6 School of Geosciences, University of South Florida, Tampa, FL 33620, USA

7Institute of Earth Sciences, University of Graz, 8010 Graz, Austria

8Key Laboratory of Exploration Technologies for Oil and Gas Resources (Yangtze University), Ministry of Education, Wuhan, China

9 International Ocean Discovery Program (IODP) Expedition 391 Scientists (2022) \*

**Contents of this file**

Text S1

Text S2

Figures S1 to S5

Table S1

**Text S1.** **Summary of Biostratigraphy analysis and overview of the key findings from Sites U1577 and U1576 drilled during IODP Expedition 391**

Standard Biostratigraphic analysis (e.g., Reagan et al., 2015) have been done aboard JOIDES Resolution during Expedition 391 to determine the age and age range of rock formations that have been recovered from ocean drilling sites.

Calcareous nannofossils were examined using smear slides prepared from unprocessed samples. The slides were viewed under plane-polarized light (PPL) and cross-polarized light (XPL) with a ZEISS Axiophot microscope at 1000x magnification, and 100 fields of view were counted to estimate relative abundance. Photomicrographs were taken using the Spot RTS system. Biostratigraphic zonation was determined using standard zonations, and age datums from the Geologic Time Scale were used for precise age dating. Identification of calcareous nannofossils followed the taxonomy of Perch-Nielsen, Bown, and Young. Core catcher samples and additional samples from working-half sections were examined to refine the biostratigraphy.

Planktonic foraminifera were prepared and analyzed from core catcher samples sieved over 63 μm, using hydrogen peroxide solution (30%) for more lithified samples. Material from the 500 μm, 250 μm, and 125 μm size fractions were scanned using a ZEISS SteREO Discovery V8 stereo microscope to detect planktonic foraminifera biostratigraphic markers. A Spot RTS system with the IODP Image Capture and Spot commercial software was used to image them, and SEM imaging was done to obtain pictures of major foraminifera taxa. Only relative abundance data for biostratigraphic markers was obtained.

**Site U1577 results**

Calcareous nannofossils were examined from 15 core catcher samples, two toothpick samples, and a mudline sample from Hole U1577A. Results indicate nearly continuous sedimentation from the Paleocene to the Upper Cretaceous. Since the mudline sediments showed calcareous nannofossils of Recent age, the lack of younger sediments at the top of the column is likely indicative of an erosional boundary, supported by the seismic profile.

Sections 8R-CC to 17R-CC contain a continuous Campanian section with the highest occurrence (T) of *Eiffellithus eximius* (77.00 Ma), T *Lithastrinus grillii* (79.00 Ma), lowest occurrence of (B) *Broinsonia parca constricta* (81.38 Ma), and B *Broinsonia parca parca* (81.43 Ma). Toothpick Sample 391-U1577A-18R-1, 58 cm suggests a Santonian age based on magnetostratigraphy data. The disappearance of *Arkhangelskiella* *cymbiformis*suggests that the basement age is older than this species’ lowest occurrence (B) at 83.20 Ma. However, without deeper sediments recovered it is difficult to determine if this true stratigraphic base of this species.

Sample 391-U1577A-11R-CC contains *Globotruncana ventricosa, Pseudoguembelina costulata* and *Pseudoguembelina costellifera*, suggesting an age younger than 81.96 Ma. Sample 391-U1576A-17R-CC *contains Marginotruncana coronata, Whiteinella baltica and Globotruncanita elevata,* indicating a possible age between 82.89 and 83.64 Ma.

**Site U1576 results**

Samples from Sections U1576B-7R-CC, 8R-CC, 12R-CC, and 15R-CC were analyzed and yielded a Late Cretaceous age of the Campanian stage with an age range tentatively set at 81.2-81.38 Ma based on the occurrence of *Eprolithus floralis* in Section U1576B-12R-CC and the persistence of *Broinsonia parca constricta* into the deepest sample. The youngest possible age was determined to be ca. 79.00 Ma based on the occurrence of *Lithastrinus grillii* in Section U1576B-14R-CC.

**Text S2.** **Overview of Paleomagnetic analysis done during IODP Expedition 391**

Paleomagnetic and rock magnetic experiments were conducted on Expedition 391 aboard the *JOIDES Resolution*. Remanent magnetization was measured on archive section halves and cube samples; all archive halves were demagnetized using alternating field (AF), while discrete samples were subjected to either AF or thermal demagnetization. The magnetization of archive half sections was measured on the Superconducting Rock Magnetometer (SRM) whereas an Agico JR-6A spinner magnetometer was used to measure discrete, 8 cm3 cube samples. Sediment archive halves were typically demagnetized with AF steps of 10 and 20 mT, whereas igneous rock pieces were demagnetized using 5, 10, 15, and 20 mT. Discrete samples were either with AF up to 200 mT or thermally up to 700 °C. Magnetic susceptibility was measured after every heating step to monitor alteration of magnetic minerals.

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**Figure S1.** Magnetic anomaly model for South Atlantic. Polarity sequence (Ogg, 2020) is shown at the bottom and the calculated anomaly model is shown above. All anomaly ages shown correspond to the young end of the normal polarity interval except for C33r, which corresponds to the young end of the reversed polarity interval. The model has been generated assuming a half spreading rate of 35 kmMyr-1, an oceanic crust magnetic layer thickness of 1 km (top: 3 km and bottom: 4 km) and magnetization of 10Am-1. The direction of the current magnetic field is calculated at 25°N, 6°E using IGRF13. The present Inclination is -66.5° and the present declination is -16.94°. Remanent field directions (Inclination = -42.9°, Declination = -6.0°) were calculated from the Africa paleomagnetic pole for 80 Ma (Torsvik et al., 2012). The lineation azimuth is 164°.

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**Figure S2.** Magnetic anomaly map for WR and vicinity. Black dashed lines show fracture zones (Sager et al., 2021). Red (blue) zones show areas of positive (negative) magnetic anomaly. Thin black line is the 3000 m bathymetry contour. The colored isochron lines correspond to reversals but they are labeled by intervals of constant polarity. Dashed green line shows the older boundary of the C34n polarity block transferred from SAM. Question marks show area with missing magnetic anomalies. AFR = Africa, SAM = South America, FZ=Fracture Zone.

A close-up of a mountain

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**Figure S3.** Multi-channel seismic profile showing the basement structure of the VB eastern rift graben. Seismic section displays two-way travel-time in seconds (vertical axis) versus distance in km (horizontal axis). Seismic profile is section of line VB07 collected during cruise TN373 (2019). Profile location is shown in Figure 2C. Vertical scale assumes 1,500 m/s p-wave velocity. Vertical Exaggeration (VE) is 12. The rift graben labelled is interpreted as fossil MAR abandoned at ~81 Ma.

**Diagram, schematic

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**Figure S4.** Downhole plot of paleomagnetic inclination for units recovered from Hole U1576B. The recovery bar represents the proportion of recovered core using a black bar to represent recovered core length and the total length of each core is denoted by each pair of black and white bars. Center plot shows inclination (in degrees) versus hole depth (mbsf). Inclinations for the superconducting rock magnetometer are shown for the highest demagnetization step of 20 mT (small orange dots), whereas discrete data points show the CHRM inclination from PCA of both thermal (red squares) and AF demagnetization (red circles). The red dashed lines show the expected GAD inclination, both normal and reversed, for the current location of the site. Lithology column shows lithographic units (see Sager et al.,2022).

**Diagram, schematic

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**Figure S5.** Downhole plot of inclination for units recovered from Hole U1577A. The recovery bar represents the proportion of recovered core using black bars black and the total length of each core by each pair of black and white bars. Center plot shows inclination (in degrees) versus hole depth (mbsf). Inclinations for the superconducting rock magnetometer are shown for the highest demagnetization step of 20 mT (small orange dots), whereas discrete data points show the CHRM inclination from PCA of both thermal (red squares) and AF demagnetization (red circles). The red dashed lines show the expected GAD inclination, both normal and reversed, for the current location of the site. Lithology column shows lithographic units (Sager et al.,2022).

**Table S1.** Cruises with Magnetic Anomaly Data Over VB

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Cruise ID** | **Year** | **Ship** | **Source Institute** | **Navi¶** |
| V1912 | 1963 | *Vema* | Lamont-Doherty Earth Observatory | C |
| V2011 | 1964 | *Vema* | Lamont-Doherty Earth Observatory | C |
| CIRC08AR | 1968 | *Argo* | Scripps Institute of Oceanography | D |
| CH099L04 | 1970 | *Chain* | Woods Hole Oceanographic Institute | U |
| RC1313 | 1970 | *Robert D. Conrad* | Lamont-Doherty Earth Observatory | D |
| 71003311 | 1971 | *Jean Charcot* | France CNEXO | U |
| A2060L05 | 1971 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| A2067L02 | 1972 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| A2067L05 | 1972 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| A2067L06 | 1972 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| V2906 | 1972 | *Vema* | Lamont-Doherty Earth Observatory | D/C |
| CH115L02 | 1973 | *Chain* | Woods Hole Oceanographic Institute | D |
| RC1703 | 1973 | *Robert D. Conrad* | Lamont-Doherty Earth Observatory | D |
| A2093L02 | 1975 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| A2093L03 | 1975 | *Atlantis II* | Woods Hole Oceanographic Institute | D |
| 78009911 | 1978 | *Jean Charcot* | France IFREMER | D |
| 79000211 | 1979 | *Jean Charcot* | France IFREMER | D |
| 79000212 | 1979 | *Jean Charcot* | France IFREMER | D |
| FM0102 | 1979 | *Fred H. Moore* | University of Texas | D |
| FM0103 | 1979 | *Fred H. Moore* | University of Texas | D |
| FM0104 | 1979 | *Fred H. Moore* | University of Texas | D |
| TD388 | 1979 | *Thomas B. Davie* | S Africa University of Cape Town | D |
| DSDP74GC | 1980 | *Glomar Challenger* | Scripps Institute of Oceanography | D |
| V3620 | 1981 | *Vema* | Lamont-Doherty Earth Observatory | U |
| RC2711 | 1986 | *Robert D. Conrad* | Lamont-Doherty Earth Observatory | G/D |
| ODP208JR‡ | 2003 | *JOIDES Resolution* | ODP/Texas A and M | G |
| TN373‡ | 2019 | *Thomas G. Thompson* | University of Washington | G |
| TN374‡ | 2019 | *Thomas G. Thompson* | University of Washington | G |

**¶**Navigation (Navi) types: C=Celestial navigation; D=Doppler satellite (NNSS); G=Global Positioning System (GPS); U=Unknown. ‡Data not used in previous compilations (Cande et al., 1988; Meyer et al., 2017).

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