Analysis of Axial Valley Width at the Bight Transform Fault, North Atlantic

Mallory McCormack and Dr. Leslie Sautter
Department of Geology and Environmental Geosciences, College of Charleston

Abstract

The Bight Transform Fault (BTF) is the first transform fault on the Mid-Atlantic Ridge (MAR) south of Iceland and marks the reorganization from the obliquely spreading Reykjanes Ridge north of the BTF to the prominently perpendicular spreading of the MAR immediately south of the BTF. The objective of this study was to measure and analyze the axial valley width just north, south, and directly on the fault zone. Bathymetric data were acquired aboard the Lamont-Doherty Earth Observatory's ship *R/V Marcus G. Langseth* in August-September of 2013 using the Kongsberg EM-122 and post-processed in CARIS HIPS and SIPS 9.1.

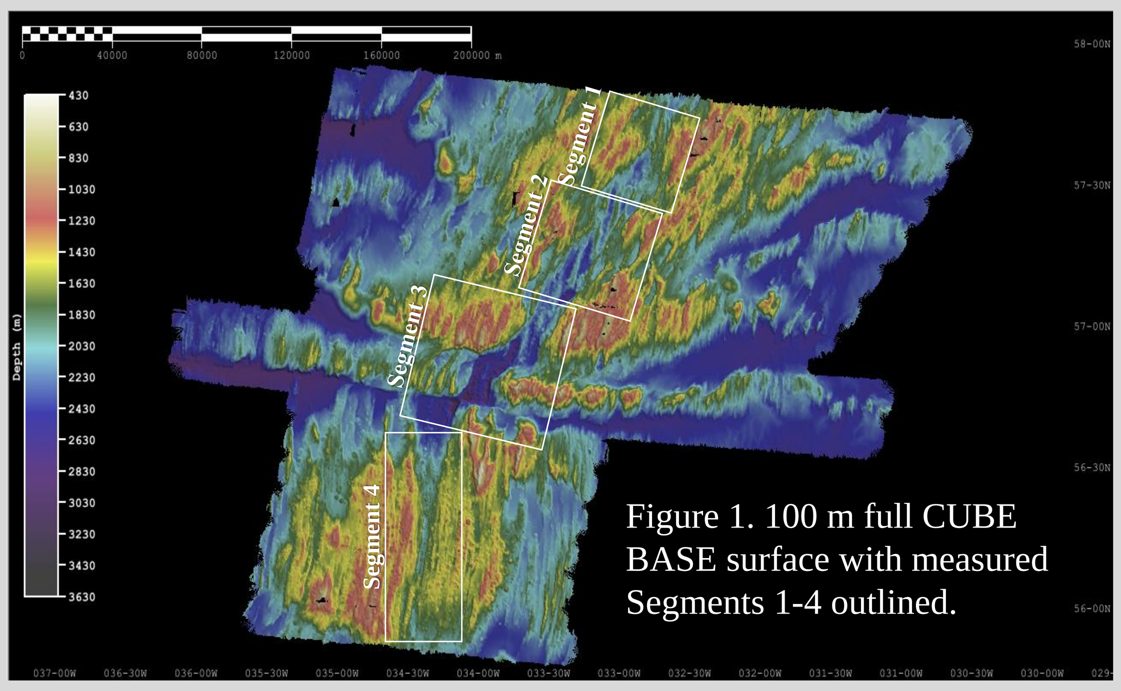

Figure 1. 100 m full CUBE BASE surface with measured Segments 1-4 outlined.

Background

Extending ~15 to 17 km in length, the Bight Transform Fault (BTF) is the location of the reorganization that started on the Reykjanes Ridge at ~40 Ma (Benediktsdóttir et al. 2016). North of the BTF the spreading is oblique, 30° from perpendicular to the ridge (Hey et al. 2015). Directly south of the fault zone, the spreading becomes nearly orthogonal to the trend of the ridge, which is common for the MAR (Hey et al. 2015). There are two models for explaining the reorganization from axial ridge to axial valley. The first theory proposes that the change is of thermal origin, which alters the oceanic lithosphere from brittle to ductile, producing the oblique unsegmented ridge pattern (Hey et al. 2015). This "pulsing plume" model is believed to create the V-shaped ridges, and marks the Reykjanes Ridge as the most hotspot-influenced area along the MAR (RR, 2013). The second theory suggests that the V-shaped ridges are a product of rift propagation. Propagating rifts cause mid-ocean ridges to change locations or orientation (RR 2013), in this case moving eastward toward the Iceland hotspot. This process forms a new ridge segment, offset of the original, then propagates parallel to existing rift system, which is destroyed when the new system takes over (RR 2013).

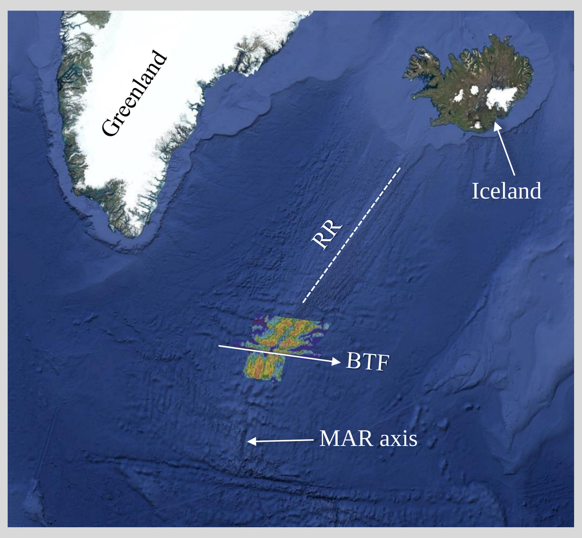

Figure 2. (Above) Google Earth image showing study site in the North Atlantic, southwest of Iceland.

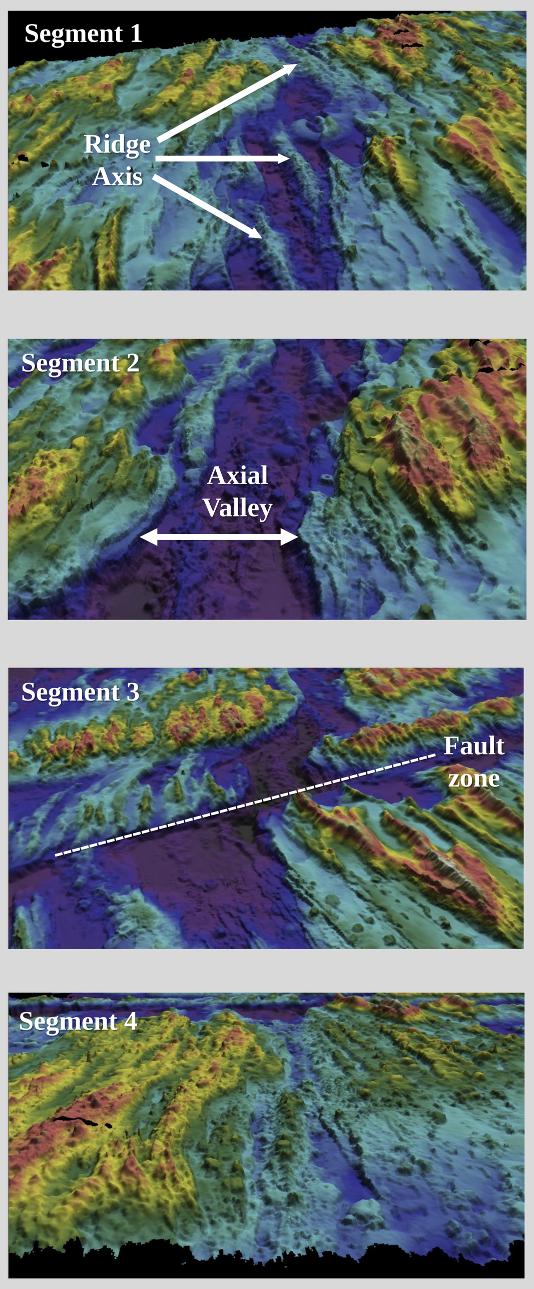

Figure 3. 3D images of each segment measured, with significant features labeled. Viewing north to south for Segments 1-3 and south to north for Segment 4.

Methods

The axial valley was interpreted as a surface that was traced along a band of oceanic lithosphere from an earlier stage of spreading and having similar slope. The green/blue areas represent the steepest slope.

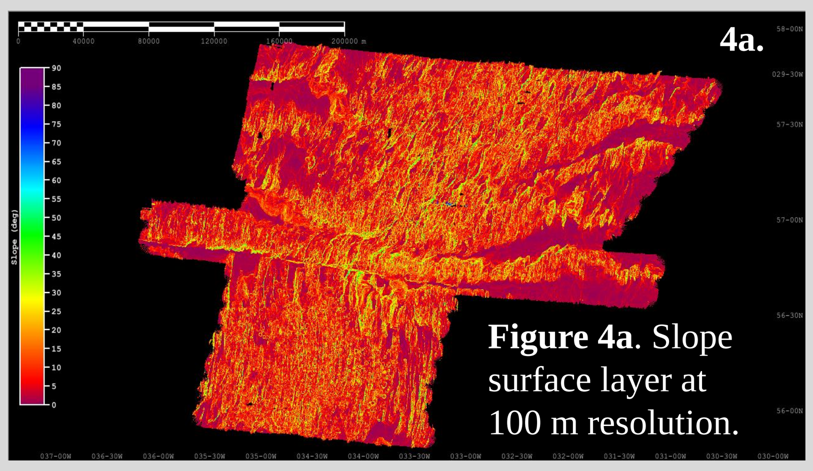

Figure 4a. Slope surface layer at 100 m resolution.

A slope layer was superimposed on a depth layer to determine a traceable surface for the axial valley.

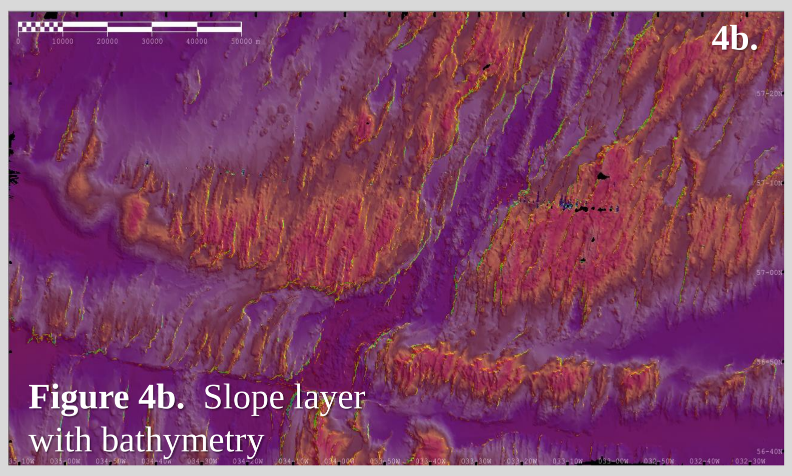

Figure 4b. Slope layer with bathymetry

Profiles were made perpendicular to the ridge segments to the north, south, and directly on the BTF. Refer to Figure 5 for cross-profile.

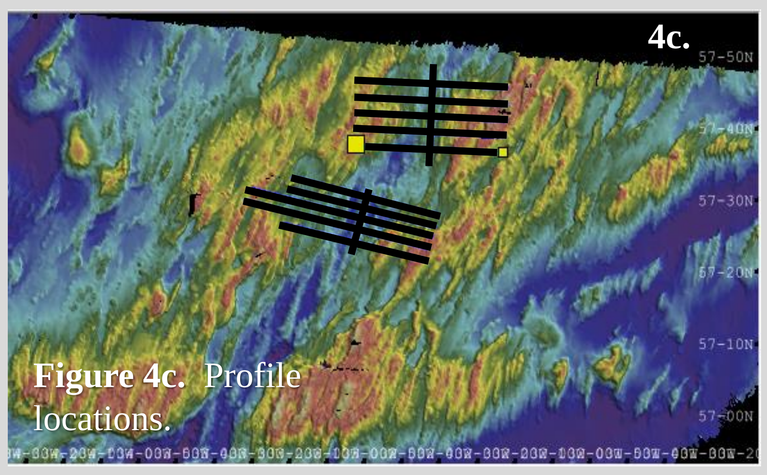

Figure 4c. Profile locations.

- Bight Transform Fault data were collected by the Lamont-Doherty Earth Observatory's ship the *R/V Marcus G. Langseth* using a Kongsberg EM-122
- Data post-processed using CARIS HIPS and SIPS 9.1

Table 1. Axial Valley widths for each segment studied.

SEGMENT 1	
Latitude (decimal-degrees)	Axial Valley Width (m)
57.76	7695.53
57.73	7793.35
57.71	7675.96
57.59	9782.45
57.50	8716.17
57.48	7977.26
57.47	8054.22
57.46	7618.57
57.45	7116.41
57.43	6286.20
57.38	5529.04
57.36	9209.20
57.33	9103.55
57.33	8812.03
57.30	7700.75
AVERAGE	7938.05

SEGMENT 2	
Latitude (decimal-degrees)	Axial Valley Width (m)
57.29	11885.68
57.25	12138.07
57.25	11993.29
57.23	10702.00
57.20	10017.23
57.13	13235.66
57.13	13493.92
57.11	13235.66
57.15	14742.16
57.15	13601.52
57.03	11008.52
57.01	10121.58
57.00	12025.90
56.96	14478.03
56.96	13695.43
AVERAGE	12424.98

SEGMENT 3	
Latitude (decimal-degrees)	Axial Valley Width(m)
56.88	18547.53
56.85	12795.45
56.83	10330.27
56.81	9303.11
56.80	11504.16
56.78	12736.75
56.75	19105.13
56.73	18400.79
56.71	17491.03
56.70	17080.16
56.66	17168.20
56.63	15407.36
56.61	13558.48
56.58	8843.34
56.55	8295.52
56.51	15599.75
AVERAGE	13444.41

SEGMENT 4	
Latitude (decimal-degrees)	Axial Valley Width (m)
56.48	10565.05
56.43	8634.64
56.40	8843.34
56.36	8008.57
56.35	8139.00
56.33	7199.89
56.30	5843.39
56.26	7252.06
56.25	7591.18
56.21	6078.16
56.16	7225.97
56.15	4304.28
AVERAGE	7473.79

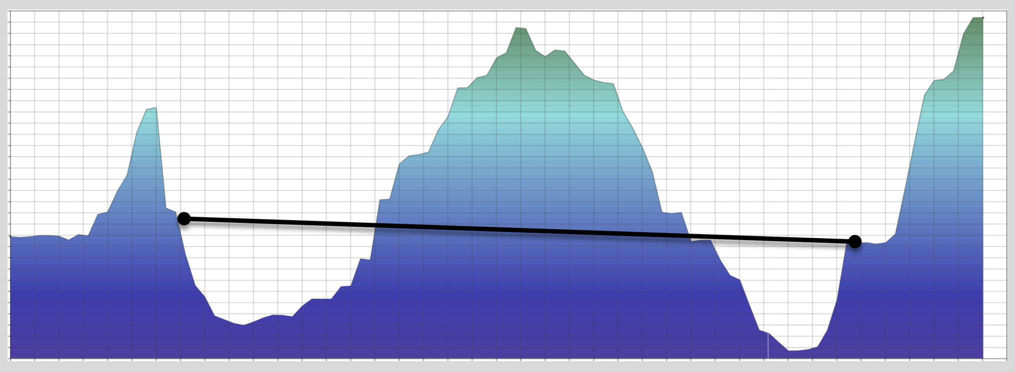

Figure 5. Example of a cross-profile of ridge segment 2 showing measuring technique. XY distance was measured at the point at which the greatest depth gave way to a traceable band of oceanic lithosphere.

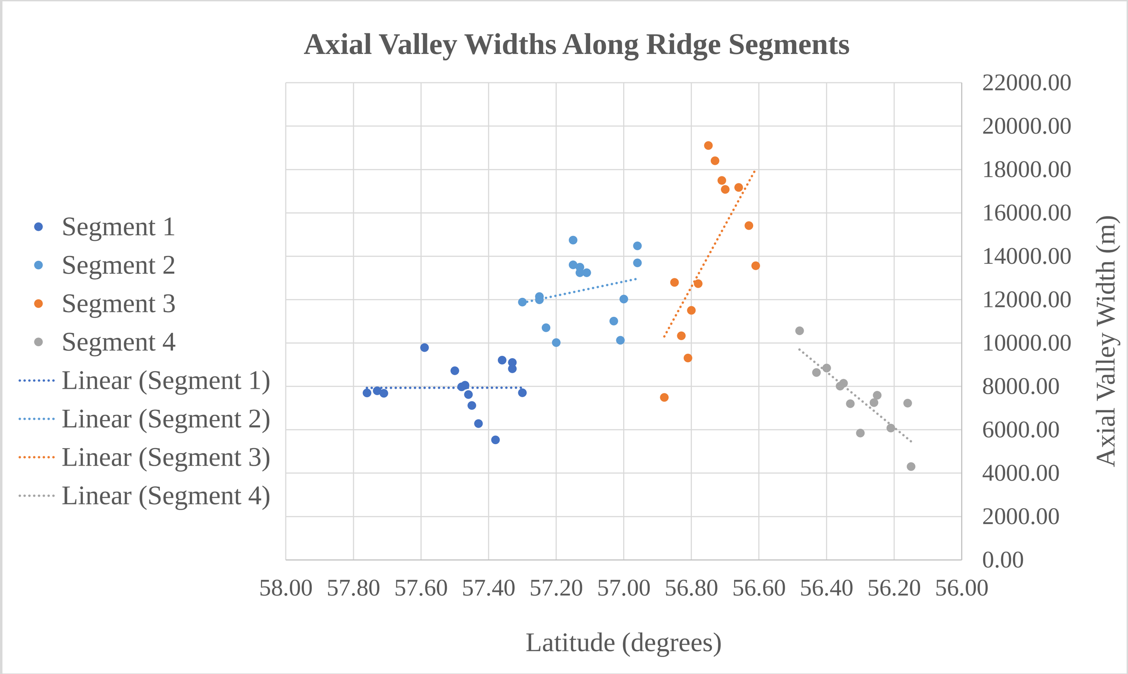

Figure 6. Axial valley widths along ridge segments from north to south. Refer to Figures 4(a-c) and Figure 5 for measuring technique and Table 1 for data.

Results

The axial valley within the study area, from 57.80°N to 56.15°N, fluctuates drastically from north to south. Segment 1 and 4 average at about 8000 meters in width, while Segment 2 and 3 are significantly wider, averaging about 12,500 meters and 13,500 meters respectively. The widest measured axial valley width of 19,105 meters occurs within Segment 3 at 56.75°N, which is just north of the fault zone. The narrowest axial valley measured at 4,304 meters lies within Segment 4 at the very southern portion of the study area. Segment 3 is particularly interesting due to the ~10,800 meter range which can easily be attributed to the fault zone.

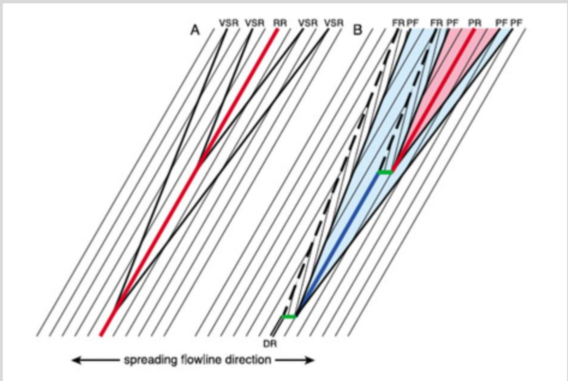

Figure 7. (From Hey et al., 2010). (A) Thermal 'rising plume' model predicts symmetry about the ridge axis. (B) Propagating ridge model predicts zone of transferred lithosphere and slight asymmetry. VSR = V-shaped ridges; PR= propagating rifts; PF = pseudofaults; FR = failed rifts

Discussion and Conclusion

The tectonic differences of the segments north and south of the Bight Transform Fault contribute to the fluctuation of the axial valley widths of each segment. Identifying the origin of the tectonic differences will contribute to the understanding of the Iceland hotspot. However, it is difficult to determine which theory is largely at play, or if it is possibly a combination of the two mechanisms. To the north, the thermal 'pulsing plume' theory is proposed to create symmetry about the ridge axis (Figure 7), which could explain the average ~5,000 meter difference between Segments 1 and 2, where the younger, ductile rheology produces the oblique unsegmented ridge pattern (Hey et al., 2015). The older, brittle rheology south of the BTF, mainly Segment 4, is characterized by the orthogonal, ridge-parallel pattern, causing the axial valley to narrow.

In regards to the propagating rift theory, the zone of transferred lithosphere is problematic to distinguish using axial valley widths. Additional magnetic and gravity data are needed to determine the reorganization boundaries. However, it is apparent that there is some mechanism causing the reorientation of the Reykjanes Ridge.

References

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Acknowledgements

Special thank you to the College of Charleston BEAMS Program for providing this learning opportunity; CARIS's Josh Mode for training; the crews and scientists of the R/V *Marcus G. Langseth*, the University of Hawaii and the University of Iceland for acquiring data used in this study; the College of Charleston Department of Geology and Environmental Geosciences.; and the College of Charleston School of Science and Mathematics.