The submerged prolongation of Islands' land masses. The particular case of islands located in active spreading mid-oceanic ridges settings.

Monaco, 8 October 2019

Pedro Madureira
Mariana Neves
Luísa Pinto Ribeiro
Frederico Dias
Isabel Leal
& EMEPC Team

Task Group for the
Extension of the Continental Shelf

DISCLAIMER

The views expressed are the authors' own, and not necessarily those of the Portuguese Government

10th ABLOS CONFERENCE

Monaco, 8th October 2019

1. Introduction
2. The challenge
3. The case of ocean islands in active spreading ridge settings
   - 3.1 Ascension Island
   - 3.2 Iceland
   - 3.3 Bouvet Island
4. Conclusions

3

1. Introduction

10th ABLOS CONFERENCE

Monaco, 8th October 2019

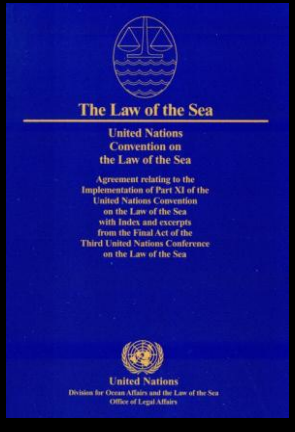
Article 76
Definition of the continental shelf

Continental margin

⇩

Submerged prolongation of the land mass

(Paragraph 3)



Base of the continental slope ⇨ Foot of the continental slope ⇨ Gardiner or Hedberg rules ⇨ Outer edge of the continental margin

Paragraph 4

5

Article 121 of UNCLOS - Regime of islands

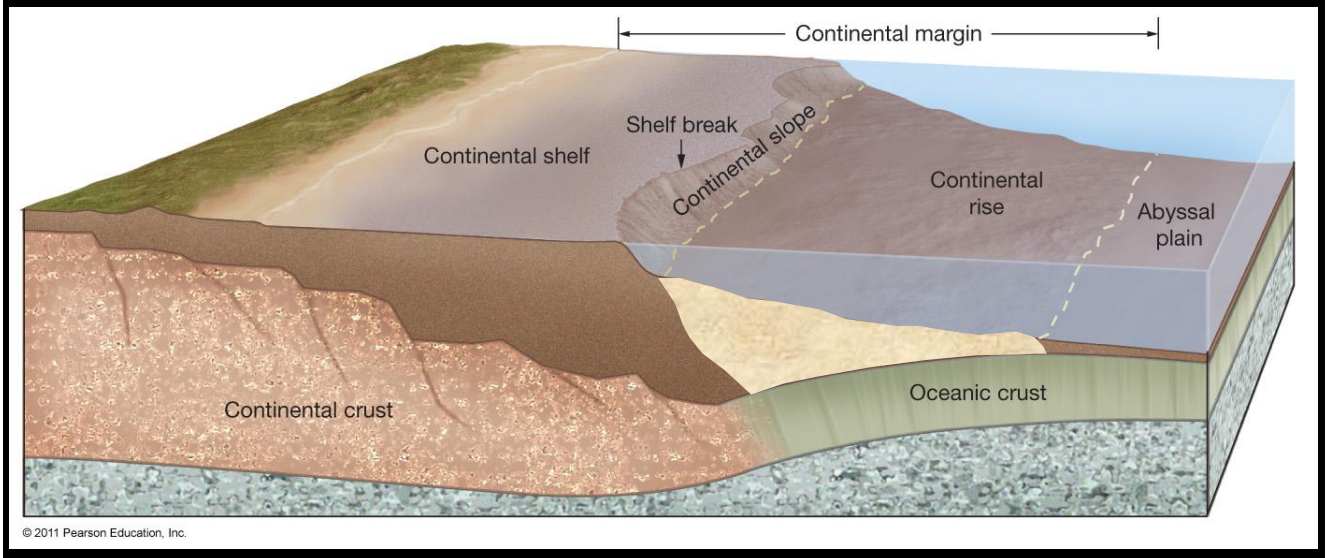
«2. […] the territorial sea, the contiguous zone, the exclusive economic zone and the continental shelf of an island are determined in accordance with the provisions of this Convention applicable to other land territory.»

2. The challenge

10th ABLOS CONFERENCE

Monaco, 8th October 2019

The ideal picture of a continental margin



8

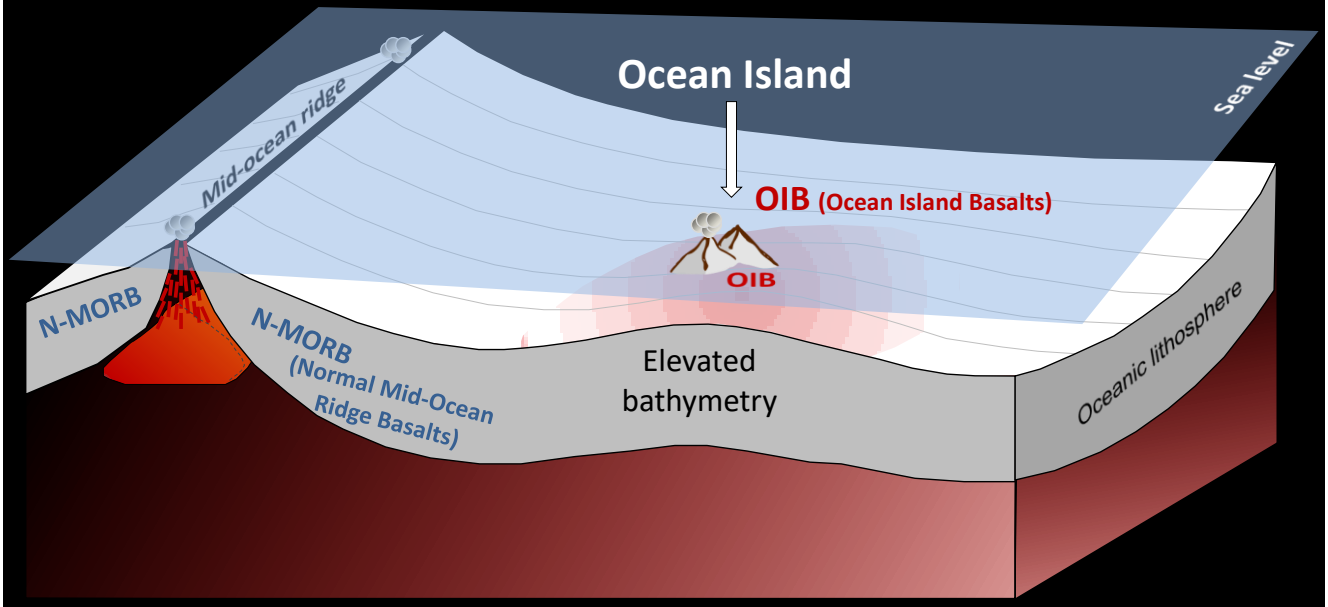
Scientific and Technical Guidelines – S&TG

«5.4.4. For the purpose of identifying the region defined as the base, the Commission defines the continental slope as the outer portion of the continental margin that extends from the shelf edge to the upper part of the rise or to the deep ocean floor where a rise is not developed. The rise, in turn, is the wedge-shaped sedimentary body having a smaller gradient than the continental slope. Many continental margins, however, depart from this ideal picture (see chap. 6, sect. 6.2, and figs. 6.1A-6.1F), and in such cases geological and geophysical data may be used to assist in identifying the region referred to here as the base of the continental slope.»

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Volcanic ocean islands' margins also depart from the ideal picture



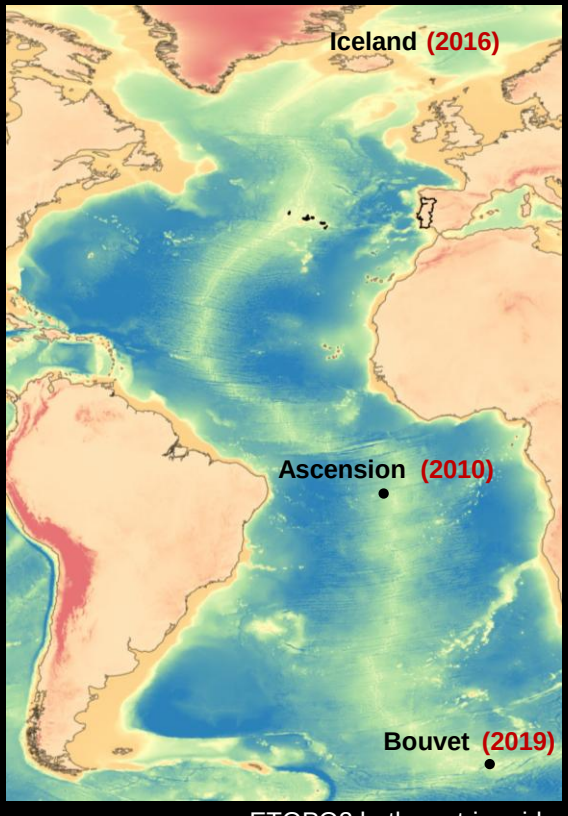
Adapted from Winterbourne et al., 2014

10

3. The case of ocean islands in active spreading ridge settings

10th ABLOS CONFERENCE

Monaco, 8th October 2019

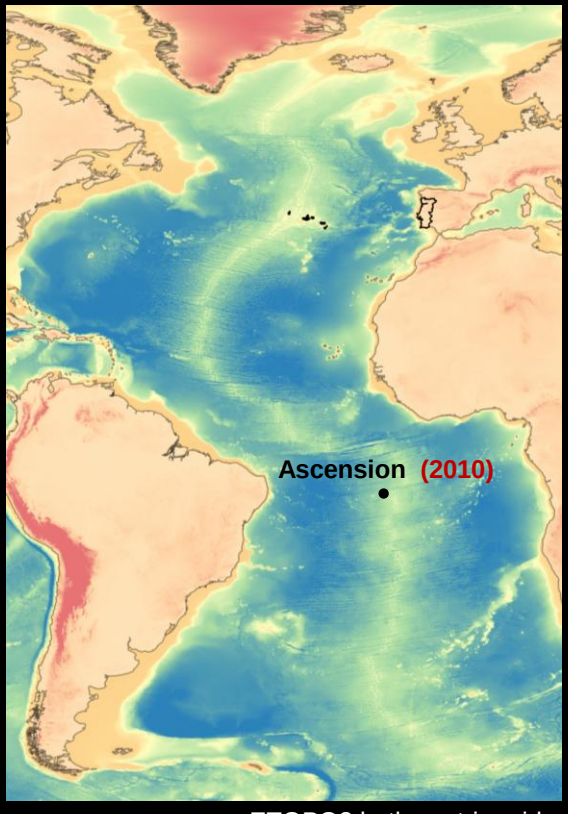


ETOPO2 bathymetric grid

S&TG

«7.2.8. Some ridges (including active spreading ridges) may have islands on them. In such cases it would be difficult to consider that those parts of the ridge belong to the deep ocean floor.»

12



ETOPO2 bathymetric grid

Ascension Island

(United Kingdom of Great Britain and Northern Ireland)

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Ascension Island – Summary of CLCS's Recommendations

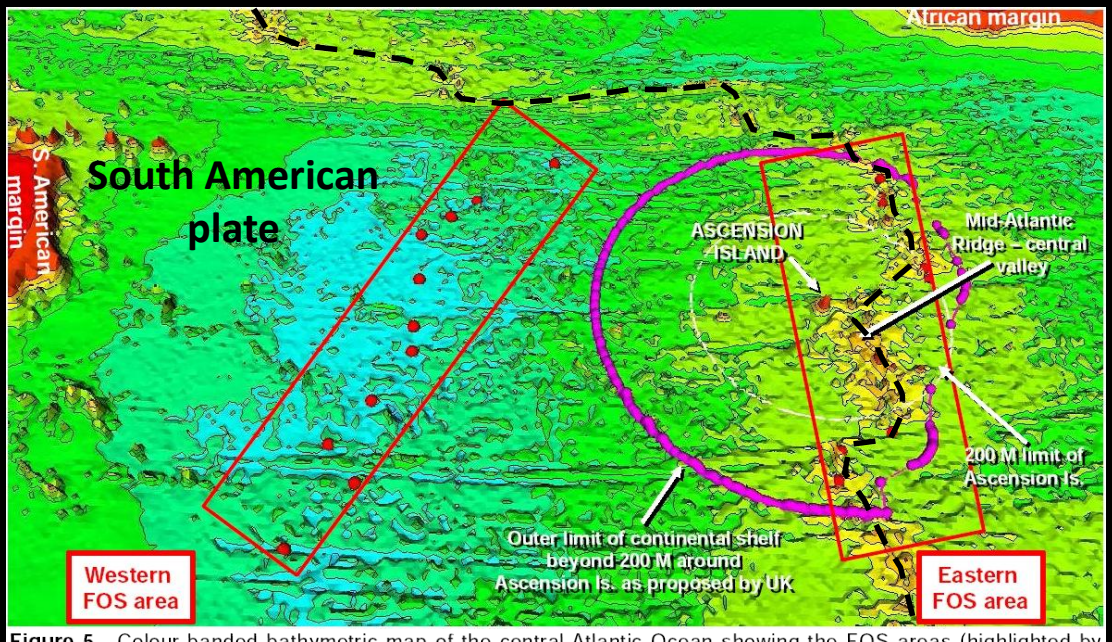


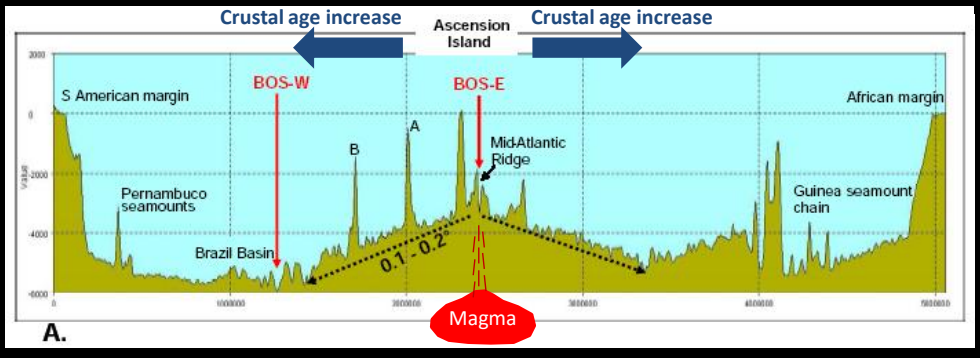
Figure 5. Colour-banded bathymetric map of the central Atlantic Ocean showing the FOS areas (highlighted by red boxes) containing the FOS points proposed by the United Kingdom (red spheres) on the ocean basin floor to the west of the Mid-Atlantic Ridge (MAR) and within the central valley of the MAR to the east of Ascension Island.

14

Ascension Island – Summary of CLCS's Recommendations

The Commission considered that the «*[…] seafloor gradients away from the axis of the MAR are related to the normal cooling and subsidence of oceanic lithosphere formed by seafloor spreading. In this part of the Atlantic, the seafloor depth/age relationship is broadly consistent with that predicted by the theoretical cooling models.*» (Paragraph 17)

Geophysical data



10th ABLOS CONFERENCE

Monaco, 8th October 2019

Ascension Island – Summary of CLCS's Recommendations

«[…] in the view of the Commission, ocean spreading structures, which are normally part of the deep ocean floor, can only form the continental slopes of island landmasses in cases where such structures form part of the discrete seafloor highs from which the island edifices rise. This is not the case for Ascension Island […] (Figure 6).»

(Paragraph 45)

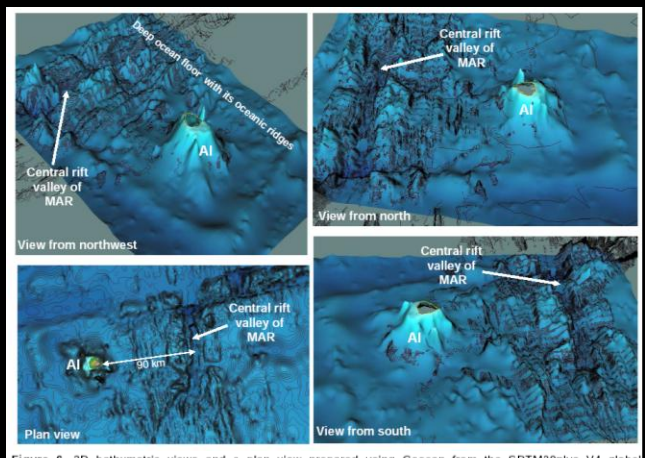


Figure 6. 3D bathymetric views and a plan view prepared using Geocap from the SRTM30plus_V4 global bathymetry grid overlain by bathymetric contours derived from the composite multibeam grid (mbes_250m) provided by the United Kingdom. Shows the restricted nature of the Ascension Island volcanic pedestal (AI) that rises directly from the normal deep ocean floor around it. The 3D views indicate that the pedestal is not connected to any other discrete morphological feature that rises above the general "ruggedness" of the surrounding seafloor.

16

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Ascension Island – Summary of CLCS's Recommendations

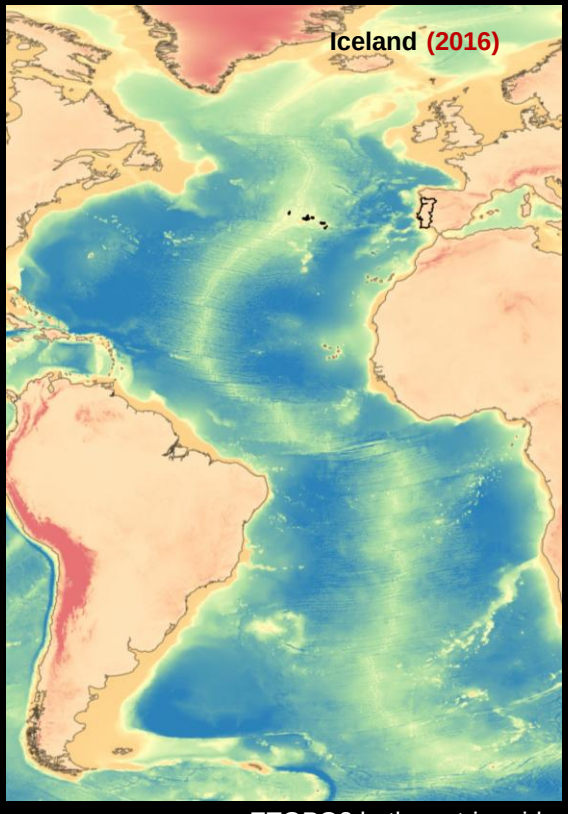
«Based on the data and material submitted by the United Kingdom, the Commission considers that the crustal structure of Ascension Island differs from the surrounding ocean floor that is composed of normal oceanic crust. […]. The Commission is of the view that Ascension Island is distinct from the surrounding ocean floor, morphologically, geologically, geophysically and geochemically [...].» (Paragraph 47)

Geological data

«Based on the Submission, and the additional data and material provided by the United Kingdom, the Commission does not agree with the approach adopted by the United Kingdom to define the base of the continental slope associated with Ascension Island and, in particular, the proposed locations of any of the FOS points […].»

(Paragraph 50)

17



ETOPO2 bathymetric grid

Iceland

(Ægir Basin Area and in the Western and Southern Parts of Reykjanes Ridge)

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Iceland (Western and Southern Reykjanes Ridge) Summary of CLCS's Recommendations

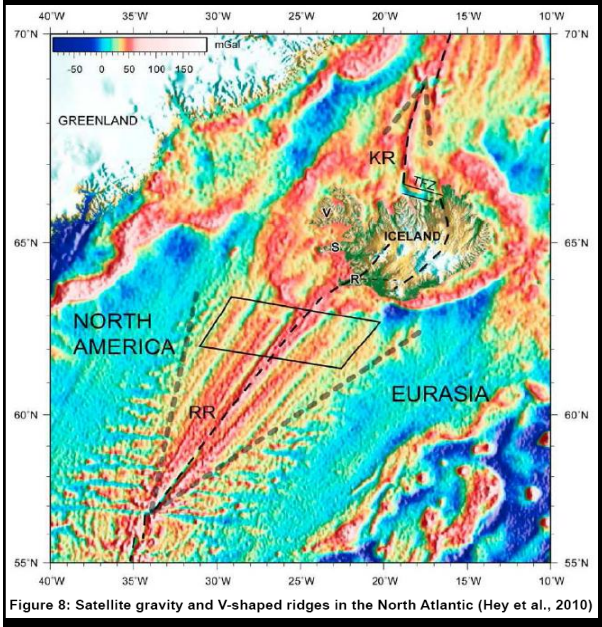


Figure 8: Satellite gravity and V-shaped ridges in the North Atlantic (Hey et al., 2010)

According to Iceland:

- The V-shaped area is well connected to Iceland, both morphologically and geologically, and related with the upwelling of anomalously hot mantle (mantle plume);

- The crustal composition of the V-shaped area is distinguishable from that of the surrounding mid-ocean ridge flanks.

(Paragraph 47)

19

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Iceland (Western and Southern Reykjanes Ridge) Summary of CLCS's Recommendations

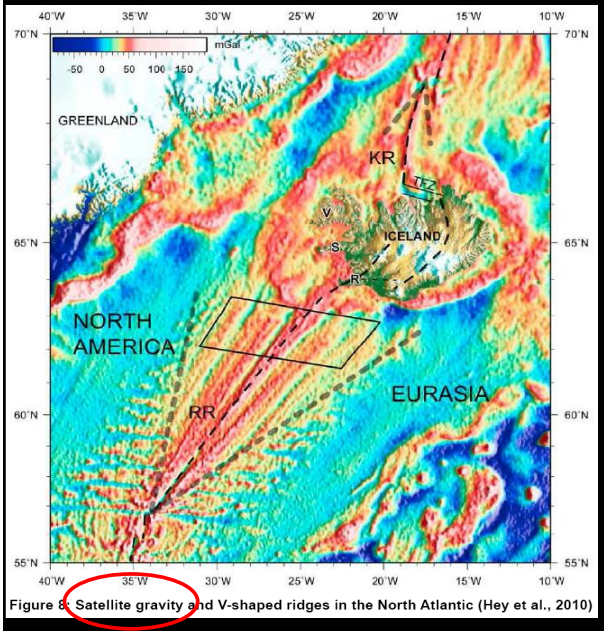


Figure 8: Satellite gravity and V-shaped ridges in the North Atlantic (Hey et al., 2010)

Geophysical data

«The Subcommission examined the test of appurtenance and concluded that hotspot-ridge interaction has significantly changed the seafloor spreading process and morphology of parts of the Reykjanes Ridge. […] the Subcommission considered that the region defined by the Iceland hotspot interaction with the seafloor spreading […], is part of the continental margin of Iceland for the purposes of article 76.» (Paragraph 52)

20

10th ABLOS CONFERENCE Monaco, 8th October 2019

Iceland (Western and Southern Reykjanes Ridge) Summary of CLCS's Recommendations

«*The Subcommission was of the view that water depth alone is not sufficient to define the complex boundary region between the continental slope and the deep ocean floor, which is located on the adjacent flanks of the Reykjanes Ridge, as part of the Mid-Atlantic ridge system, and in the surrounding abyssal plain. In accordance with paragraph 5.4.4 of the Guidelines, in this case, geological and geophysical information should be used to support the determination of the base of the continental slope.*»

(Paragraph 54) (emphasis added)

21

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Iceland (Western and Southern Reykjanes Ridge) Summary of CLCS's Recommendations

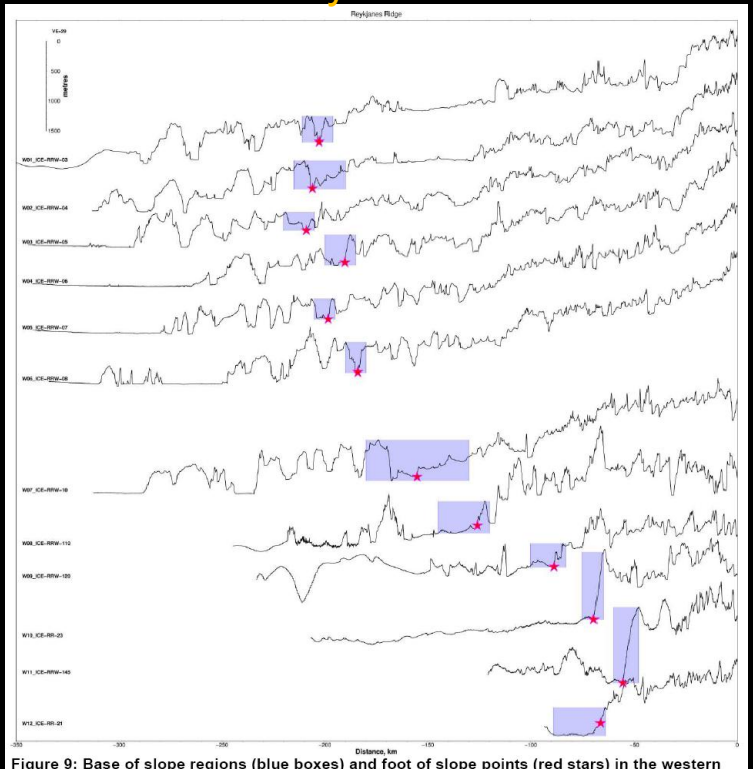


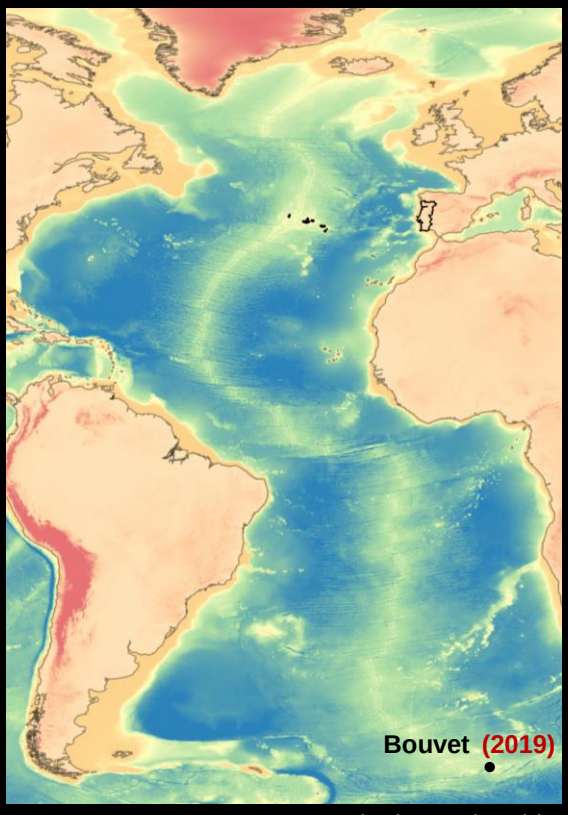
Figure 9: Base of slope regions (blue boxes) and foot of slope points (red stars) in the western and southern parts of Reykjanes Ridge shown on bathymetric profiles as amended by Iceland.

BOS and FOS points accepted unanimously by the Subcommission and by the Commission

22

10th ABLOS CONFERENCE

Monaco, 8th October 2019



ETOPO2 bathymetric grid

Bouvet Island

(Norway)

23

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Bouvet Island – Summary of CLCS's Recommendations

Norway considers that Bouvetøya is the surface expression of magmatism related to the long-lived Bouvet Hot Spot. (Paragraph 33)

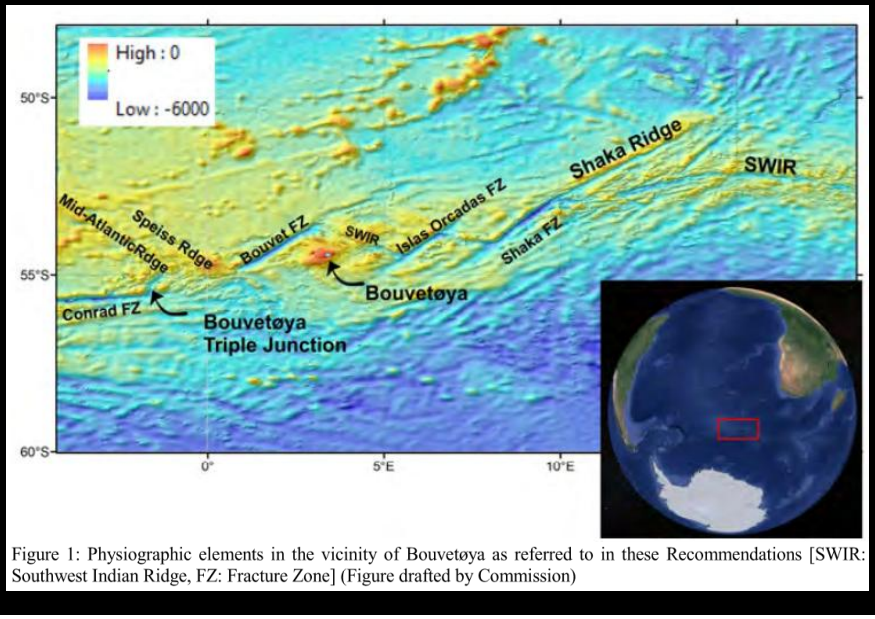


Figure 1: Physiographic elements in the vicinity of Bouvetøya as referred to in these Recommendations [SWIR: Southwest Indian Ridge, FZ: Fracture Zone] (Figure drafted by Commission)

24

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Bouvet Island – Summary of CLCS's Recommendations

According to Norway:

• The area of significant positive residual bathymetry is characterized by a thicker crust of different composition compared to the surrounding MORB-type oceanic crust of the abyssal plain. (Paragraph 38)

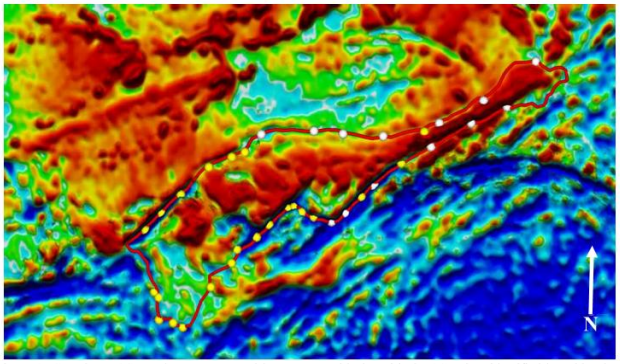


Figure 8: Complete FOS envelope as proposed by Norway with the critical FOS points identified by white dots (NOR1-DISC-16-12-11-2014, north arrow added by Subcommission)

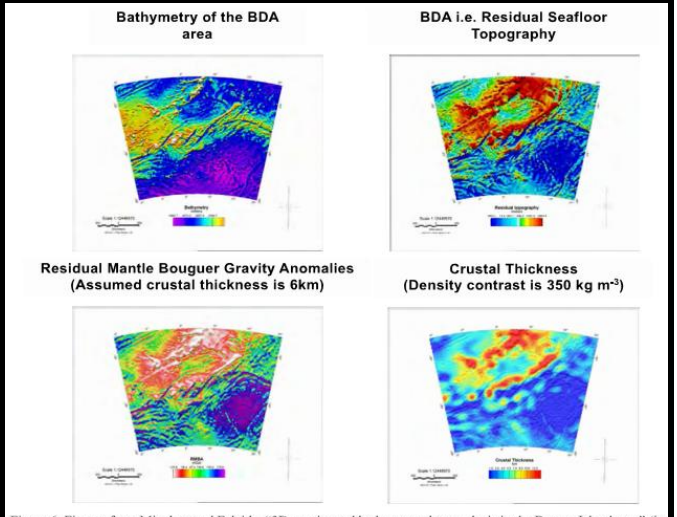


Figure 6: Figures from Minakov and Faleide: "3D gravity and bathymetry data analysis in the Bouvet Island area" (in NOR1-DISC-06-19-02-2014)

• This anomaly was used as a guide to the location of the BOS of this seafloor high. (Paragraph 39)

25

Bouvet Island – Summary of CLCS's Recommendations

«*In its consideration of the base of the continental slope presented in the Submission, the Subcommission examined each of the following elements: The morphology and its continuity between each of the constituent parts of the composite seafloor high […]; the nature of the proposed hot spot and migration of lithospheric plates over it; the nature of the depth anomaly; and the geology and geochemistry of the constituent parts.*»

(Paragraph 43)

Geophysical and Geological data

«*Based on all of the data and material submitted by Norway, the majority of the Subcommission agreed with the approach adopted by Norway to define the base of the continental slope associated with Bouvetøya […].*» (Paragraph 48)

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Bouvet Island – Summary of CLCS's Recommendations

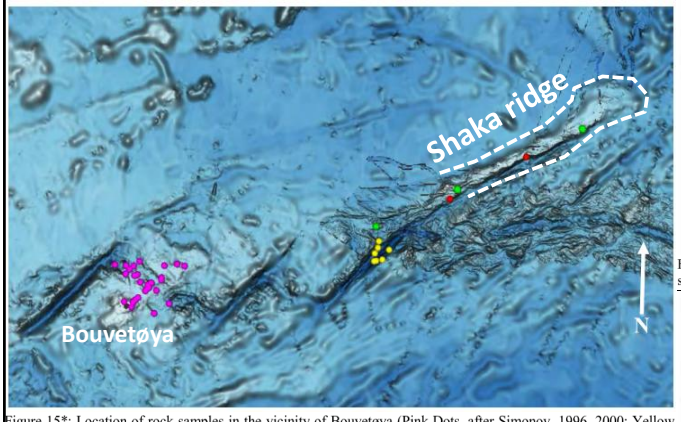


Figure 15*: Location of rock samples in the vicinity of Bouvetøya (Pink Dots, after Simonov, 1996, 2000; Yellow Dots after Dick, 1989; Red Dots after Lin et al. 2001 and Dick et al. 2003); and locations of 2016 dredge samples as Green Dots)

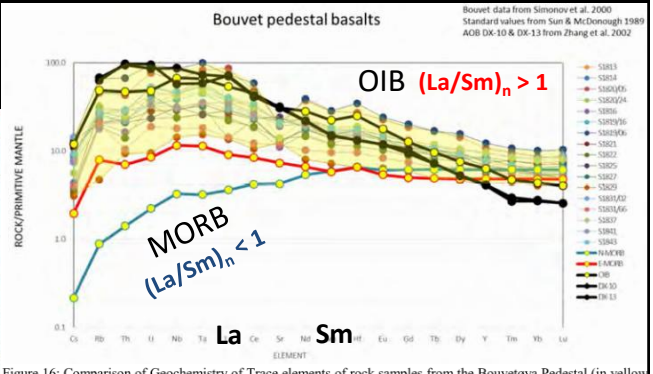


Figure 16: Comparison of Geochemistry of Trace elements of rock samples from the Bouvetøya Pedestal (in yellow shaded area) and MORB (blue line) (NOR1-DISC-22-28-07-2015 Presentation – Part 2, slide 25)

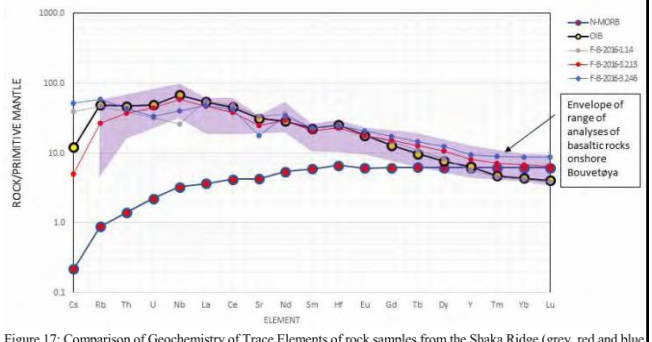
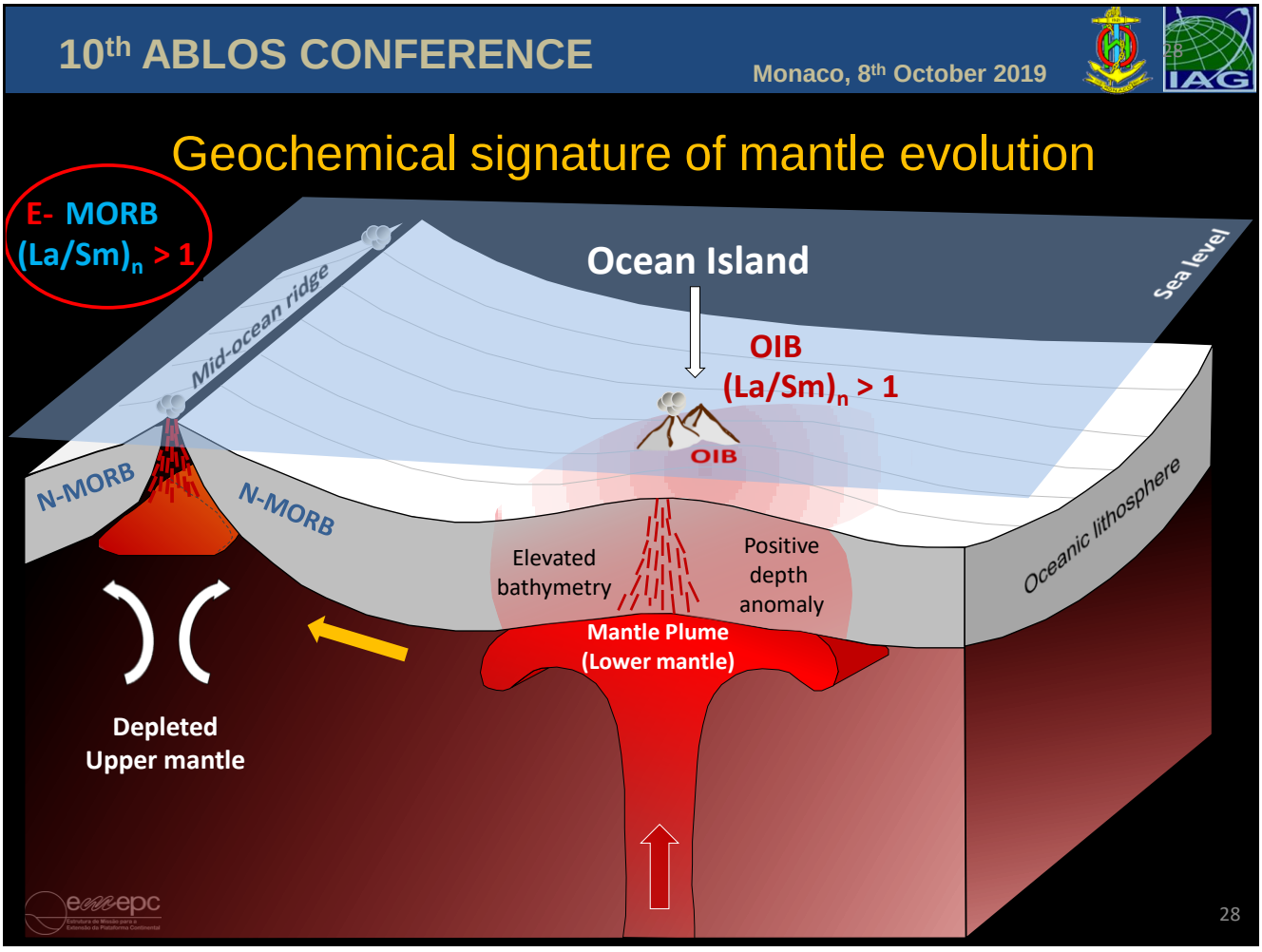


Figure 17: Comparison of Geochemistry of Trace Elements of rock samples from the Shaka Ridge (grey, red and blue small solid circles) and the envelope of geochemical analyses of rock samples from onshore Bouvetøya. (Slide 42 of the 11072016 Presentation by Delegation)

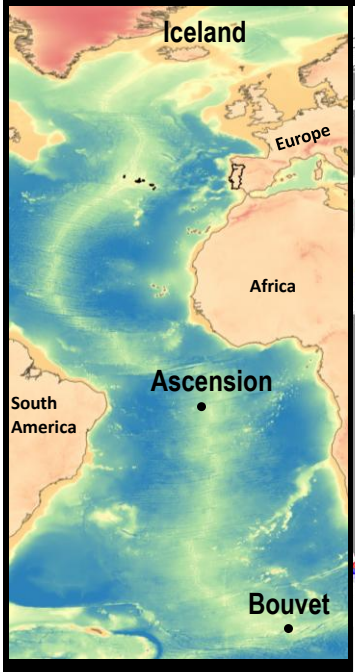

10th ABLOS CONFERENCE
Monaco, 8th October 2019
IAG
Geochemical signature of mantle evolution
E- MORB
(La/Sm)n > 1
Ocean Island
Sea level
Mid-ocean ridge
OIB
(La/Sm)n > 1
OIB
N-MORB
N-MORB
Elevated
bathymetry
Positive
depth
anomaly
Oceanic lithosphere
Mantle Plume
(Lower mantle)
Depleted
Upper mantle
28

10th ABLOS CONFERENCE

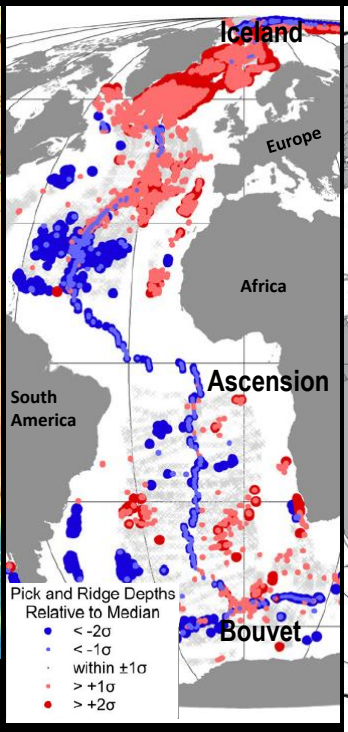
Monaco, 8th October 2019

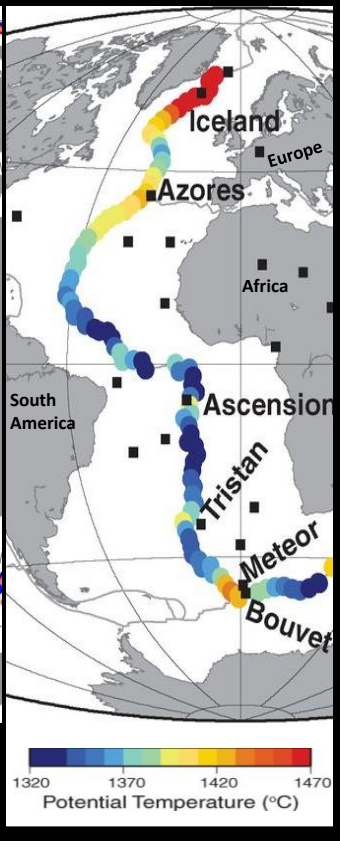
Adapted from Rowley (2018)

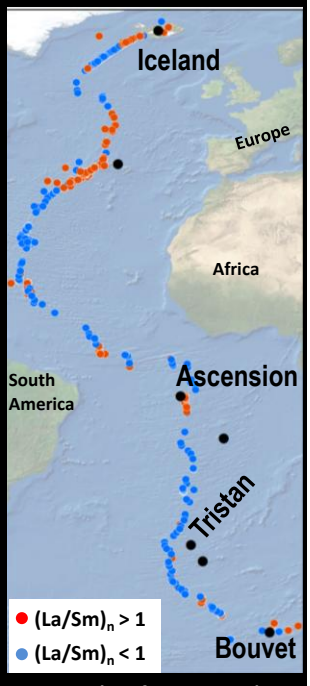
Adapted from Dalton et al. (2014)



ETOPO2 bathymetric grid







Samples from PetDb

29

4. Conclusions

10th ABLOS CONFERENCE

Monaco, 8th October 2019

1. The identification of the base of the continental slope (BOS) at the submerged prolongation of volcanic ocean islands in ridge settings is challenging;

2. Apart from morphological continuity, geological and geophysical data have been used in the referred Submissions and considered by the Commission in the recommendations to assist in identifying the base of the continental slope (in accordance with paragraph 5.4.4. of the S&TG) and to distinguish what is "anomalous", i.e. above the "normal" bathymetry of the mid-ocean ridge;

3. In the Bouvet Island case, the use of geochemical data was crucial for the final delineation of the outer limit of the continental shelf beyond 200 M.

31

10th ABLOS CONFERENCE

Monaco, 8th October 2019

Source: http://www.monacomania.com/musee-oceanographique-de-monaco/