ARTICLE 76: THE RIDGE ISSUE

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Abstract

The process by which the delineation of an extended legal continental shelf (LCS) for an oceanic island territory is made beyond its 200M LCS causes significant confusion for both commentators and coastal states' representatives interpreting the criteria set in Article 76 of UNCLOS and the Technical and Scientific Guidelines published by the CLCS. This report brings to light some of the problems responsible for this confusion and attempts to resolve the uncertainty associated with ridge issues with a practical and equitable delimitation proposal.
Paragraph 6 of Article 76 allows a constraint of 350M from the territorial sea baselines on submarine ridges, however the criteria set in paragraph 4a(i) or 4a(ii) of Article 76, which provide the means to extend a LCS beyond 200M, cannot be applied to oceanic island territories because of difficulties in determining a consistent and practical location of a foot of slope. Accordingly the advantages and disadvantages of several geophysical data types have been evaluated for their use under paragraph 4 (b) of Article 76(definition of the foot of the slope on "evidence to the contrary to the general rule."). Our proposed method of using the apex of the mid oceanic ridge, whether this may be the ridge line or spreading centre, as a representation of the foot of slope (based on evidence to the contrary), results in a simple, fair and consistent way of developing an area of extended LCS between the 200M and 350M limits.

Introduction

There are a variety of ridge-like submarine elevations which characterise both shallow and deep water parts of the world's oceans, and throughout a long history of marine exploration, they have been given a variety of names and descriptors by their discoverers with a striking degree of inconsistency. The legacy of this diverse and often *ad hoc* nomenclature now provides a significant problem to legal and technical experts interpreting and implementing maritime delimitation issues under the United Nations Convention on the Law of the Sea (UNCLOS). This paper studies the characteristics of, the definition of, and the possible implications for territorial claims of features described as "ridges" on the seafloor, and in particular, how UNCLOS has sought to include them into their statutory delimitation of coastal States sovereignty over continental shelf (CS) maritime space.

Definitions
In the light of the diversity of use of terms to describe seafloor features, we believe a useful starting place is to provide an overview of current definitions of seafloor features relevant to this analysis.

Ridges
At the most generic level, a ridge is defined in the authoritative Glossary of Geology (Bates and Jackson, 1987) as a general term for a long narrow elevation of the earth's surface, usually sharp-crested with steep sides, occurring either independently or as part of a larger mountain or hill.' The glossary of terms published by the International Hydrographic Organization, 1993) contains more specific, marine-oriented definitions of ridge-related features. It states that an oceanic ridge is defined as 'a long elevation of the deep ocean floor with irregular or smooth topography and steep sides' (IHO, 1993). A submarine ridge, which is considered a more generic term than oceanic ridge (DOALOS, 1993), is defined as 'an elongated elevation of the sea floor, with irregular or relatively smooth topography and steep sides' (IHO, 1993). There is, of course, no quantitative information regarding the descriptive terms 'long' or 'elongated', as applied to ridges.

Paragraph 6 of Article 76 of the UNCLOS limits the extent of the continental shelf on a submarine ridge to 350 nautical miles (M). This special constraint is the consequence of the introduction, by Russia, of text during the development of Article 76. The paragraph was eventually included due to the perceived requirement to allay fears of inordinate extension of CS beyond 200M by coastal states lying on the mid-ocean ridge system. The implication, therefore, is that the term submarine ridge in this context applies to seafloor ridges which are of the 'mid-ocean ridge' type (i.e., those ridges which form part of the continuous actively spreading plate boundary transecting 60,000 kilometres of the worlds oceans). In order to be consistent with this interpretation, we maintain here that in the context of Article 76, the use of the term 'submarine ridge' is synonymous with 'mid-ocean ridge'. Accepting this premise, therefore, and to avoid further confusion and unnecessary duplication of nomenclature, we will use the term 'submarine ridge' to describe that particular type of feature of the seafloor throughout the rest of this paper.

Significantly, Article 76 states explicitly that paragraph 6 does not apply to submarine elevations. While the term submarine elevation is not usefully defined in any standard technical dictionary, intuitively we consider that the word 'elevation' is even more of a general (dimensionless, and without aspect information) descriptor than 'ridge', and thus must collectively include features which are specifically not submarine ridges, and which are therefore subject to either, or both, of the constraints provided for in paragraph 5 of Article 76.

Islands
It is important to consider the status of sub-aerial island land masses and their relationship to ridges. The term oceanic island is a general one which refers to island masses which occur in the ocean. The specific type of oceanic island which is of interest to this paper is that which has been rendered subaerial by reason of anomalous, local, thermal activity in the interior of the earth near to, or beneath a mid-ocean spreading ridge system. Excess thermal activity in the earths interior

locally leads to large amounts of volcanism, which accumulates to form the sub aerial elevations we recognise as mid-ocean ridge islands. The best known and largest example of such an island is Iceland, located on the Mid-Atlantic Ridge, but there are many others we have identified and which we refer to below. It is to these land masses that, we consider Article 76 paragraph 6 applies. These land masses have a demonstrable and wholly natural prolongation formed by the mid-ocean ridge system, which is synonymous with the submarine ridges as mentioned in Article 76.

Continental Shelf

Paragraph 1 of Article 76 of UNCLOS defines the CS of a coastal State as 'the seabed and subsoil of the submarine areas that extend beyond its land territory to the outer edge of the continental margin, or to a distance of 200 nautical miles from the baselines from which the breadth of the territorial sea is measured where the outer edge of the continental margin does not extend up to that distance.' However Paragraph 3 of Article 76 states that the 'continental margin comprises the submerged prolongation of the landmass of the coastal state, and consists of the seabed and the subsoil of the shelf, the slope and the rise. It does not include the deep ocean floor with its oceanic ridges or the subsoil thereof. .' Which raises the question as to whether UNCLOS recognises that oceanic islands have a continental margin. It should be said that throughout the history of development of UNCLOS, and the subsequent readjustment and analysis of the subject, many commentators on UNCLOS, and on Article 76 in particular, question whether oceanic islands, by definition not possessing a continental margin, can extend their maritime space beyond 200M?

The Relevant Paragraphs of the Scientific and Technical Guidelines of the CLCS

Chapter 7 deals with the ridge issue.

7.2.6 The Commission feels that the provisions of paragraphs 3 and 6 may create some difficulties in defining ridges for which the criterion of 350 nautical miles in paragraph 6 may apply on the basis of the origin of the ridges and their composition.

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.

7.2.9 Article 76 makes no systematic reference to the different types of the earth's crust. Instead it makes reference to the two terms: "the natural prolongation of land territory" and "the submerged prolongation of the land mass" of coastal States as opposed to oceanic ridges of the deep ocean floor. The terms "land mass" and "land territory" are both neutral terms with regard to crustal types in the geological sense. Therefore, the Commission feels that geological crust types cannot be the sole qualifier in the classification of ridges and elevations of the sea floor into legal categories of paragraph 6 of article 76, even in the case of island States.

7.2.10 Therefore the Commission feels that in cases of ridges its view shall be based on such scientific and legal considerations as natural prolongation of land territory and land mass, morphology of ridges and their relation to the continental margin as defined in paragraph 4, and continuity of ridges.

7.2.11 As it is difficult to define the details concerning various conditions the Commission feels it appropriate that the issue of ridges be examined on a case-by-case basis.

Possible 'Ridge' Claims

There are 9 island States which potentially, have a claim of a continental shelf extending beyond 200 nautical miles along a submarine ridge or ridges which are natural prolongations of their land mass. Figure 1 illustrates the locations, and approximate extent, of each potential LCS extension. The coastal states are; Amsterdam and St Pauls Island (France); The Azores Islands (Portugal); Ascension Island (United Kingdom); Bouvet Island (Norway); The Galapagos Islands (Ecuador); Prince Edward Island (South Africa); Iceland (Iceland); Easter Island (Chile), Rodriguez (Mauritius).

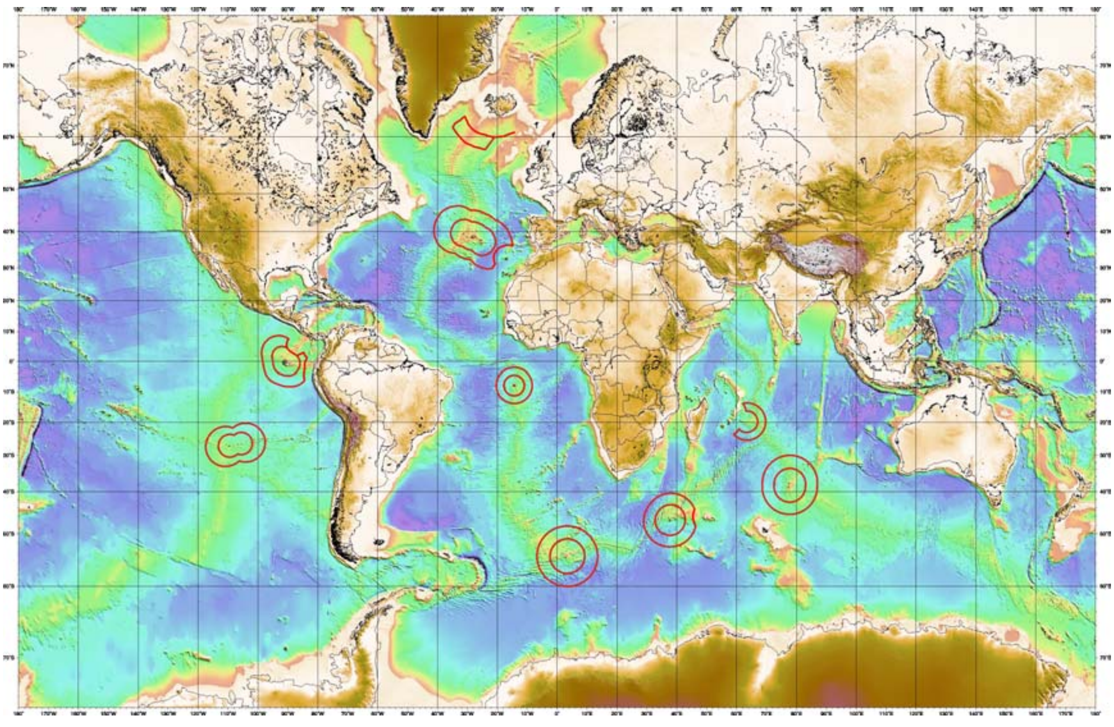


Figure 1. Locations of island states with a potential for a claim to continental shelf beyond 200M along a submarine ridge. For reference purposes, we have indicated both a 200M and 350M limit from baseline in each case.

Considering that a submarine ridge system does not comprise a natural shelf, slope or rise, in order to pursue a LCS claim it is necessary to explore alternative methods to support a claim, given that paragraph 6 of Article 76 allows a 350M constraint. Paragraph 4b of Article 76 states that 'in the absence of evidence to the contrary, the foot of the continental slope (FOS) shall be determined as the point of maximum change in the gradient at the base of the slope.' Extensive, and rigorously peer-reviewed research has proven that the normal physiographic profile of a seafloor away from the mid-ocean ridge axis into deep water (i.e., as the seafloor 'ages' away from the zero-age of the axis of the spreading system) has a smooth decay curve. Irrespective of variation in spreading rate, this decay factor approximates closely to a mathematical relationship that the height of the sea floor scales proportionally with the square-root of age (Parsons and Sclater 1977). By definition the smooth curve cannot allow for a foot of slope identifiable as the point of maximum change of gradient at the base (of slope) along the submarine ridge. It is therefore necessary to use 'evidence to the contrary' to the general rule and formulate a robust and repeatable method of defining a FOS in a manner which is acceptable within both the statutory text of Article 76 and the Scientific and Technical Guidelines of the Commission on the Limits of the Continental Shelf (CLCS, 1999.)

Discussion

There are a number of geological and geomorphological parameters which are used by researchers to characterise and classify the seafloor in their studies of how oceans evolve. One or more of these may be useful to help us derive an acceptable FOS position. Magnetic anomalies, gravity anomalies and a selected isobath are probably the most readily available, easily and relatively cheaply acquired of these potentially useful data types . Each parameter has its advantages and disadvantages, and these are explored in some detail in the sections below.

Irregularity in magnetic strength along the ocean floor that reflects sea-floor spreading during periods of magnetic reversal (Shift of 180º in earth's magnetic field such that north-seeking needle of magnetic compass would point south rather than to north) are known as magnetic anomalies. Magnetic anomaly data could be used if a certain magnetic age was to be agreed. This method can be easily put into practice as there is now a broad understanding of this geophysical parameter, and how it can be acquired, processed and interpreted. Simple, ridge-orthogonal survey lines with appropriately spaced tracks could be occupied in the area between the 200M limit of the LCS and the 350M constraint. Having an understanding of the ridge would provide an approximate lateral extent of survey, knowing the spreading rate and distance from the ridge axis to a certain anomaly. Figure 2 illustrates how a lateral constraint could be achieved using this method.

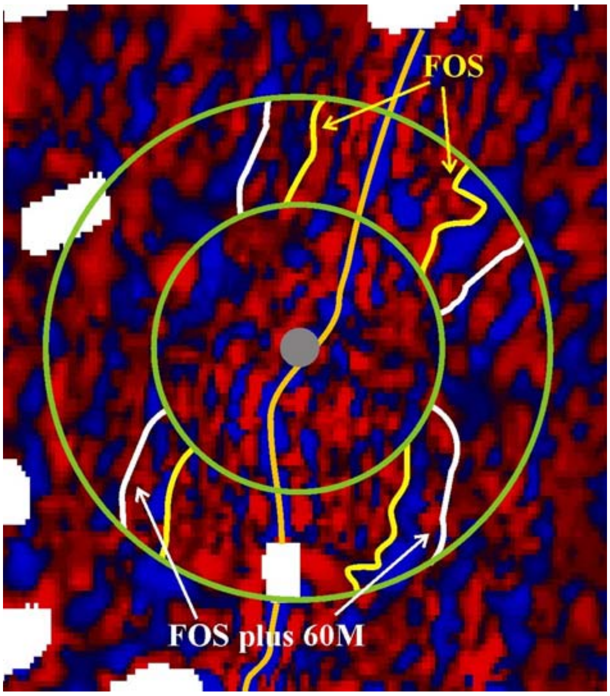


Figure 2. Schematic illustration of how an extended CS can be delimited using magnetic anomaly data. Blue and red areas represent the ageing seafloor, identified by magnetic anomalies, away from the zero age seafloor, orange line. Green lines are the 200M LCS and 350M constraint of a 'mock' island (grey).

In this example an arbitrary age of crust of anomaly 3 has been selected (5 million years old) to define a foot of slope on evidence to the contrary. Points of 60M distance from this foot of slope have been constructed, according to Article 76 paragraph 4 (a) ii. Paragraph 4a (i) has not been applied for two reasons. Firstly, it is recognised that on very 'young' ocean crust, such as that encompassed by the anomaly here selected, sediment accumulation is likely to be of a very low level, and impracticable to record satisfactorily. The second, and much more fundamental reason is that as crust ages away from the axis of the mid-ocean ridge system, so will its thickness of sediment cover increase - thereby negating the rational to identify the part of thinning of sequence to the Gardiner Line (1%), which cannot, by definition, ever be reached.

Aside from the practical difficulties referred to above, there are a number of other issues which deem this method somewhat unfavourable. Magnetic signatures from specific areas on the globe can be inconsistent. Near the magnetic equator, for instance, or at the magnetic poles, anomaly values may be misleading and difficult to correlate satisfactorily. Furthermore, the natural diversity of ridge spreading rates would also add another inconsistency. Anomaly-based territorial selections of those island territories located on ultra/slow spreading rate ridges would be at a huge disadvantage (in some cases up to 200 times difference) relative to those located on a faster spreading rate ridge.

The earth has an external gravity field that arises from its distribution of mass. Deviations, or gravity anomalies, provide important information on the distribution of density in the earths outer layers. In order to compare gravity anomalies measured at different locations, it is necessary to correct them to some common datum - sea level. This correction is called the free-air, or altitude, correction. A widely available dataset is a compilation of free air gravity anomalies generated from combining marine measurements and satellite altimetry data (Sandwell and Smith, 1997). One of the main advantages of this dataset is that as well as being free (downloadable from the Internet) it has at least a uniform level of data control lines - and thereby does not suffer from the local extreme differences in data density controlling bathymetric compilations, for example.

It is possible to consider ways of using these gravity anomaly data sets to derive an estimate of crustal thickness - and thus present an alternative parameter which might be used to define a foot of slope on evidence to the contrary. Variations in crustal thickness are known to be pronounced in the vicinity of the thermal anomalies which are believed to be direct contributors to sub aerial islands on submarine ridges. Due to their localised nature, these thermal anomalies are often referred to as 'hotspots'. Crustal thickness estimates, however, are only achieved following a complex process of modelling, which in turn requires a number of assumptions to be made, rather than direct measurement. Gravity models and the 'solutions' produced are notoriously non-unique, and as such are unlikely to be useful to define as critical a feature as a foot of slope based on evidence to the contrary. Assumptions aside, again, as in magnetic anomaly studies, it would be necessary to select an arbitrary thickness value at which to place the foot of slope - arguments to support such a selected value would have to be well supported.

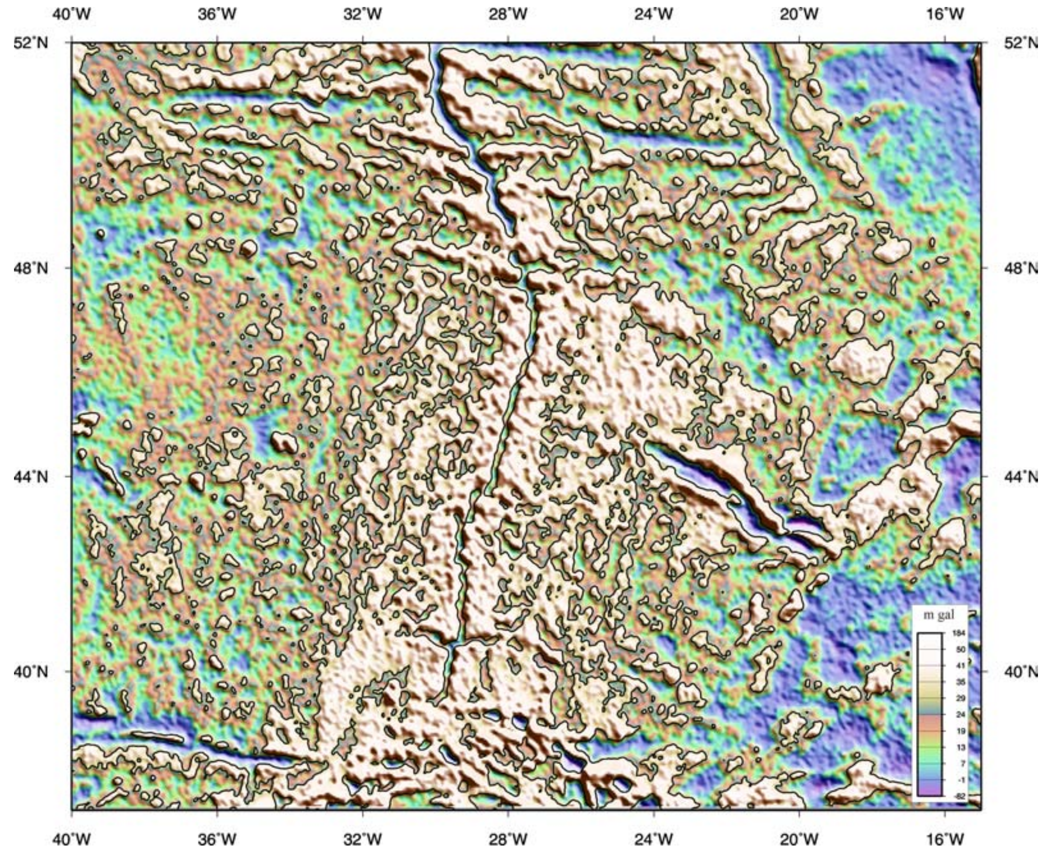


Figure 3 illustrates free air gravity anomaly values extracted from the Sandwell and Smith (1997) dataset. The 30mgal isogal is highlighted. Also evident is the mid oceanic ridge (MOR), clearly visible, flanked either side by higher gravity anomaly values, implying thicker crust. However in order to generate crustal thickness values a number of very complex modelling functions would need to be performed.

The idea of using a certain isobath to define a FOS based on evidence to the contrary could be viable. In the sense of requiring an arbitrary choice of isobath value, this procedure is not too far removed from either of the two potential field methods described above. The only isobath value to be referred to in Article 76 is that of 2500 metres, which is specifically referred to in the context of identifying a constraint position to a continental shelf claim in paragraph 5. As an example of what this isobath might define, figure 4 is a predicted bathymetric summary for a section of the central equatorial Atlantic illustrating the distribution of seafloor topography shallower than 2500 metres.

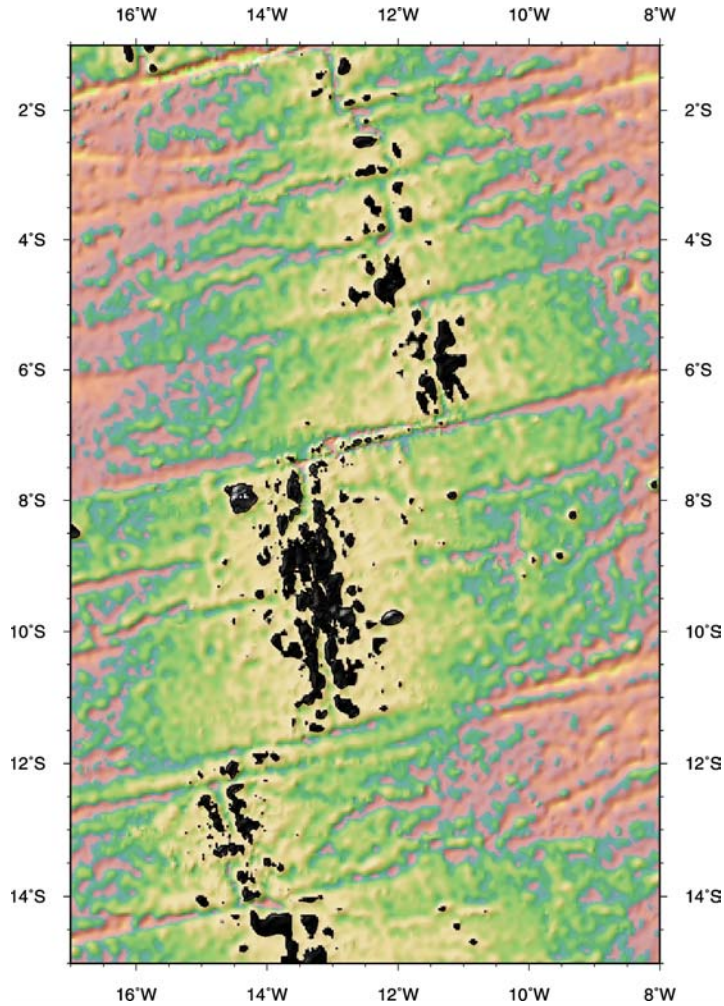


Figure 4 is an illustration of gridded bathymetry in the equatorial Atlantic. The blackened areas identify those parts of the sea floor which are 2500m or shallower.

However, again there are difficulties encountered from using such a method. Firstly not all oceanic island territories will necessarily have prolongations of their territory which are 2500m and shallower beyond 200M. Secondly, the inherently discontinuous nature of a certain depth value (due to the highly irregular relief of mid-ocean ridge terrain) would make it difficult to identify areas with which to construct a FOS region based on this evidence to the contrary. Although the region between the 200M LCS and 350M constraint narrows the region requiring investigation to establish the above, nonetheless in order to deliver a consistent and robust case to the CLCS, an inordinate amount of surveying may be required.

An alternative procedure to the selection of a specific isobath examined above would be to identify a point of maximum change in the gradient of the sea floor, directly following Article 76 paragraph 4(b). Submarine ridges do not, by definition (and by the arguments rehearsed above following studies of the natural and smooth decay of the topographic profile) have a slope region which would naturally contain a FOS. There may be exceptional circumstances, however, where by reason of geological conditions, they may have a morphological break at which a foot of ridge (FOR) may be apparent. In order to test the frequency that such features may occur, and the feasibility of such an approach, the authors analysed all available single beam echo sounding data transects across the mid-ocean ridge system in the southern and equatorial Atlantic Ocean, to try and establish if 'a point of maximum change in gradient' could be identified.

Public domain data available from the National Geophysical Data Centre (NGDC), Boulder, Colorado, were analysed to identify if the profile revealed a region where a foot of ridge (FOR) could be located. Once the profiles had been visually inspected a number of them were analysed using CARIS LOTS (an off-the-shelf software package designed to aid organizations as they submit their offshore territorial claims under the UN's Law of the Sea Guidelines) in an attempt to identify a point of maximum change in gradient. It became apparent that if such a technique were to be used in defining a point of maximum change in gradient, using the recommendation laid down by the CLCS in their Technical Guidelines (Paragraph 5.4.5; CLCS/11, 1999), the FOR points would lie a considerable distance from the submarine ridge, and certainly well beyond the constraints defined in paragraph 6 of Article 76,. It then becomes both impractical and expensive to secure long survey lines across all areas necessary to identify the maximum change in gradient. Figure 5 is an illustration of a profile crossing the south Atlantic and where in CARIS LOTS a point of maximum change of gradient could be identified.

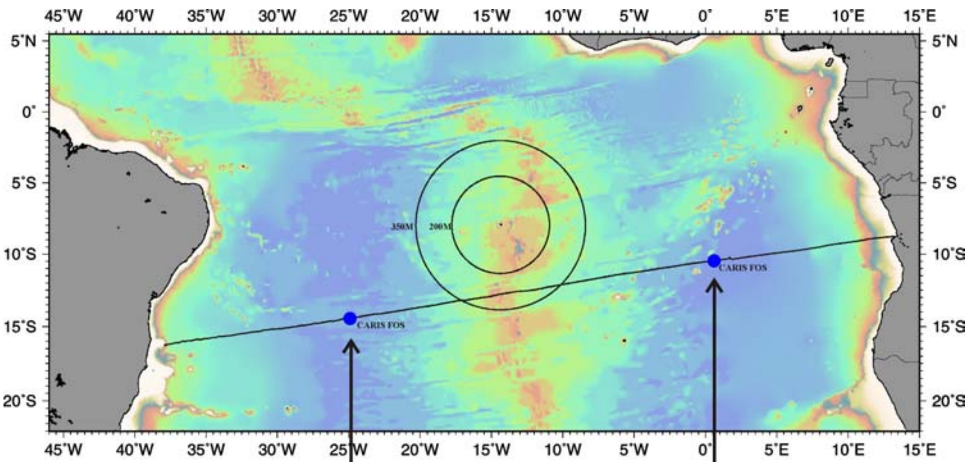


Figure 5a

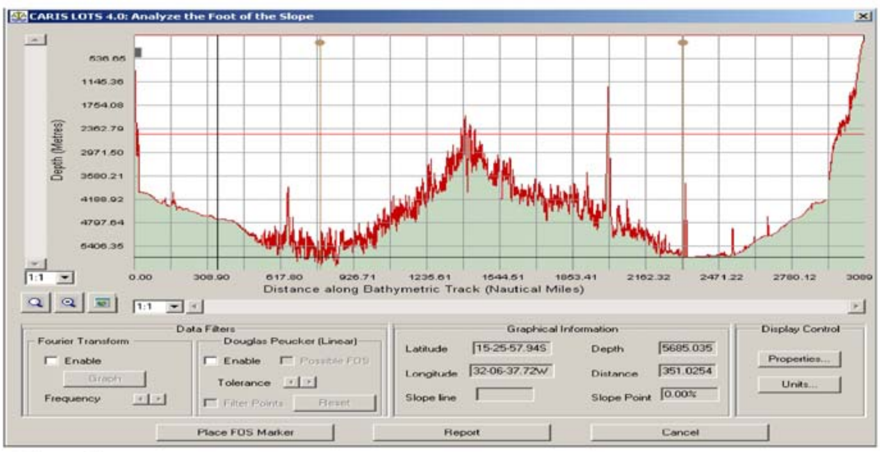


Figure 5b

Figure 5a is a gridded bathymetry map of the equatorial Atlantic. The navigation track of a single beam data file from South American to Africa has been overlaid, upon which, points of maximum change in the gradient of the sea floor, derived from analysis of the single beam file in CARIS Lots, figure 5b, have been placed, blue dots. Also illustrated are the 200M LCS and 350 constraint for Ascension Island.

What figure 5 demonstrates is how inefficient and expensive it would be to acquire the necessary data required for a submission, as even though the FOR would inevitably lie outside the paragraph 5 constraints, an outer limit would have to be defined. A great deal of public domain data is characterised by pre-GPS (Global Positioning System) navigation and minimal quality assurance information. It would therefore be likely that an island state would be obliged to acquire extensive new single beam or primary data such as swath bathymetry to define a FOR, despite the fact that it lies a significant distance outside of the constraint line.

Another Possible Solution would be to remove the necessity to use geophysical data and simply geodetically link the 200M LCS to the 350M constraint. A geodesic measurement on a flat plane, would be a straight line. On a surface of a sphere, a geodesic is a great circle (a great circle is defined as the intersection of a plane which passes through the centre of the circle and the sphere).

This method would alleviate the necessity to acquire any data (other than precise baseline data). It would be consistent for all claims of the same nature, simple to generate and extremely cost effective. Geodesics linking the 200M LCS to the 350M constraint down the ridge are purely pragmatic and not tied into any geological or geomorphological parameters.

Although this appears to be deceptively simple there may be problems meeting the requirement to delimit the outer limit by geographical co-ordinates. It does not fulfil any of Article 76's criteria, in that none of the conditions set in paragraph 4a or 4b of Article 76 have been satisfied, neither have the criteria of paragraph 7 of Article 76 been used, in that the straight lines which connect the fixed points delineating the claim area are more than 60M apart.

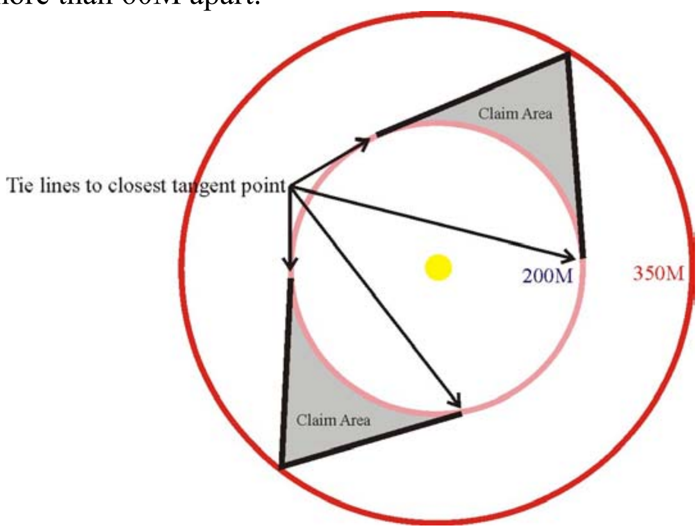


Figure 6 displays how a simple geodetic solution may resolve the ridge problem

A Proposed Solution

Having considered a number of ways of attempting to determine how best to construct a lateral limit for a ridge claim, and endeavoured to consider the merits of each method, it is evident from the content of this report that none of those previously mentioned would provide a feasible solution.

What we propose is that where an island lies on a ‘ridge’, evidence to the contrary is used as laid down in paragraph 4b of Article 76 to define the "foot of the slope"; Every ridge, of whatever geological composition, will have an apex, either a ridge line or a spreading centre. This can be determined by bathymetry alone, although supporting information such as magnetics and gravity would be useful accompaniments. From this apex a limit of 60M either side can be calculated in accordance with paragraph 4a(ii) of Article 76 along the ridge apex from the 200M to the 350M limit, calculated from the territorial sea baseline of the island.

The Advantages of this proposition are:

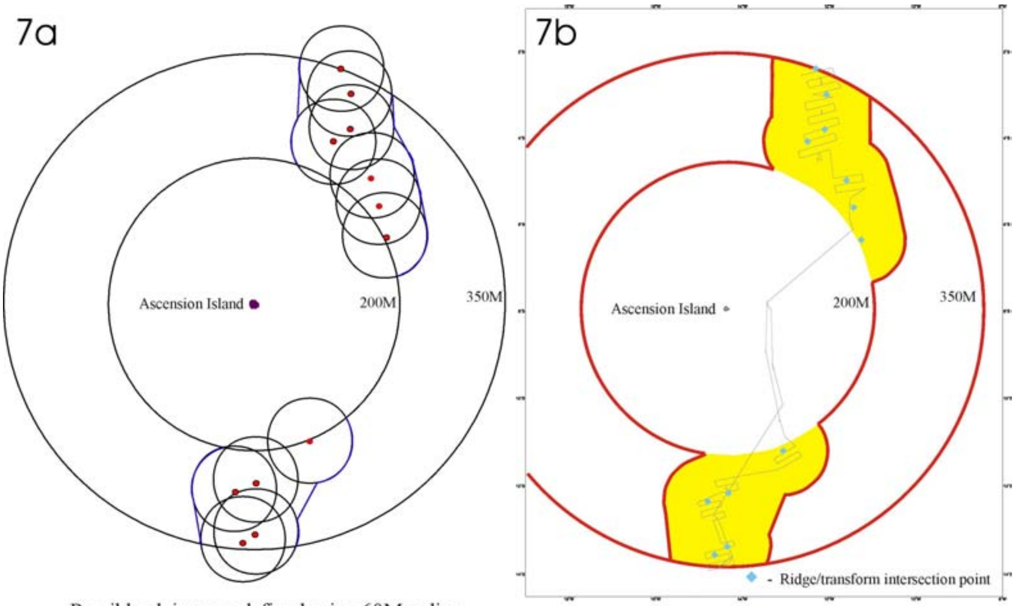
- That it is relatively simple to determine;
- It can apply to all types of ridges;
- The claim will not be unreasonable;
- the claim will not extend beyond 350M;
- it will define the lateral extent of a ridge claim consistently and fairly.

An Example

During September/October 2001 swath bathymetry data was acquired along the mid oceanic ridge, north and south of Ascension Island, to define where the ridge axis exists, in a programme to define an outer limit to CS based on the model solution proposed above.

This routine is relatively simple as the area is restricted by the 350M constraint and the established 200M LCS. Public domain data, Sandwell and Smith predicted bathymetry and the GEBCO contours, were used during the survey planning to identify the regional morphology and in peculiar probable locations of the ridge axis, hence narrowing down the work area.

The natural configuration of the geometry of mid oceanic ridge segments is one of stepped, offset character affected by lateral displacements of the ridge along transform fault zones or more minor tectonic features. The consequence of this is that when put into practice it became evident that the areas of most importance were the ridge-transform intersection points. By placing a FOS point here the claim area is somewhat increased due to the stepped nature of the geometry of the delimiting points, compared to a series of points which lay along a straight line. Figure 7a illustrates the construction process by which it is possible to generate an extended LCS, 7b.



Possible claim area defined using 60M radius from the ridge/transform intersection points.

Figure 7a illustrates the locations of the ridge-transform intersection points (RTI) from where 60M arcs are drawn, in accordance to paragraph 4a(ii) of Article 76, and connected by straight lines no more than 60M (paragraph 7 of Article 76). The resulting extended LCS area is shown in figure 7b in yellow. Also seen in figure 7b is the survey navigation track from which most of the RTI locations were derived.

The results of applying this method to other oceanic island territories can be seen in figure 8.

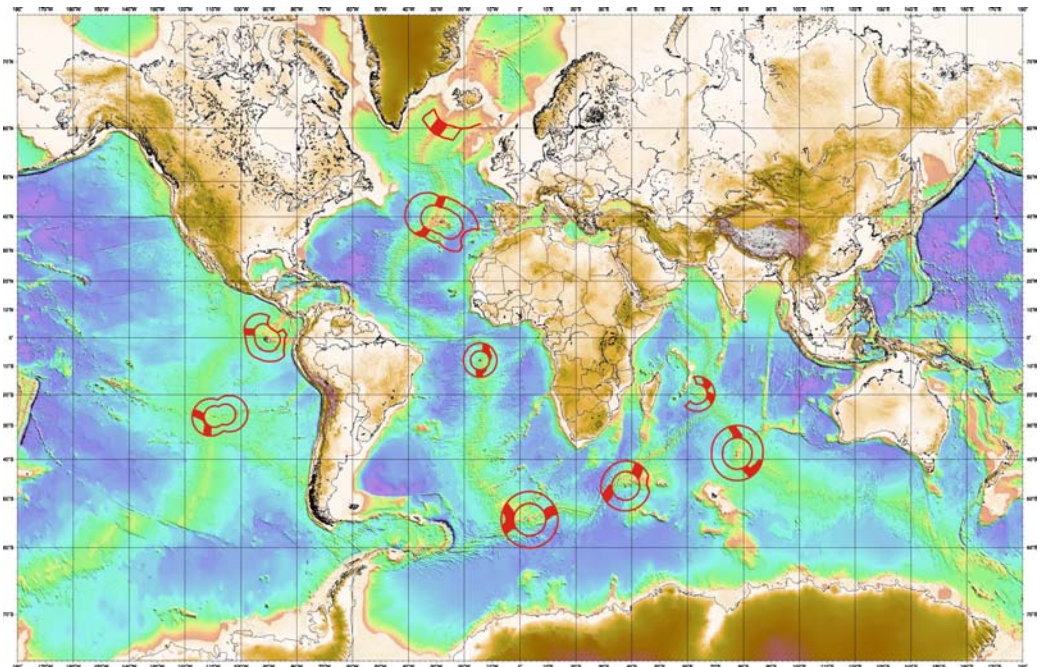


Figure 8 displays the approximate extent each territory would claim using the proposed solution. Seen here are the 200M LCS, the 350M constraints and the reddened areas of the potential extended LCS.

The issue concerning the natural prolongation of an oceanic island territory has not been discussed in this report. Iceland is only territory located directly on the MOR. However those territories, which are subaerial element of the ridge, offset to either one or both sides, can also be regarded as an integral part of the ridge, though there must be a limit to the distance by which they are offset before they are no longer considered a part of the ridge.

Conclusions

The Commission on the Limits of the Continental Shelf have considered the 'Ridge' issue in Chapter 7 of their Scientific and Technical Guidelines. However, to date they have found it impossible to give any guidance on the lateral extent of these potential claims.

It is clear that in most cases the implementation of paragraph 4a of Article 76 in a ridge situation will be either impossible or excessively expensive to achieve.

Without further guidance from the Commission, it is clear that the nine or so coastal States that have potential ridge claims will have to present their claims in an imaginative and as far as possible, practical way. It is considered that any such claims that are regarded to be too expansive will have difficulty in meeting the requirements of the Commission.

Serious consideration should be given to the proposed pragmatic solution outlined above. It would be relatively simple to delineate, cost-effective to gather the required data, not too expansive in its claim and can be applied consistently to all potential ridge claims thus meeting the stated aim of the Commission to be consistent with all their recommendations.

The opinions contained within this paper are those of the authors and are not necessarily those of the United Kingdom Hydrographic Office, Southampton Oceanography Centre or any Government Department.

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