THE CONVENTION OF THE LAW OF THE SEA AND THE APPLICATION OF ARTICLE 76 ON THE DELIMITATION OF THE SOUTH ATLANTIC OCEAN

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Abstract

The United Nations Convention on the Law of the Sea has defined various criteria in Article 76 to be used in the delineation of the outer limits of the extended continental shelf. South Atlantic Ocean coastal states between the Equator and latitude 60 degrees south were selected to demonstrate methods used and territory claimed by these states whilst complying with the recommendations and guidelines of the Commission on the Limits of the Continental Shelf. The importance of these submissions to coastal states is discussed with respect to current natural resources which can be claimed over the seabed and subsoil of the natural prolongation of its land mass. The conjugate nature of the sedimentary basins in South America and West Africa, together with the proven hydrocarbon reserves therein demonstrates the importance of claiming these territories through the authority of the United Nations for current and future generations. Mapping and analyses using OASIS MONTAJ software together with public domain satellite bathymetry, sediment thickness and submission data from Brazil, Uruguay, Argentina, the Falkland Islands, Gabon, Namibia and Ascension Island have been combined on GIS software. Thus, by integrating geological and political aspects, this work expects to be used as a contribution to the understanding, even partially, of the scope of the new geopolitical map of the South Atlantic according to the application by coastal States of Article 76 of the Convention.

All opinions expressed in this work are solemnly authors' responsibility and do not necessarily reflect the opinions of their governments.

1. Introduction

The United Nations Convention on the Law of the Sea (UNCLOS), hereinafter referred to as the Convention, established the concepts and limits of oceanic spaces and introduced the concept of the legal continental shelf as the natural prolongation of continental land mass and provided a way to demonstrate that it may extend beyond the 200M limit. Article 76 of the Convention establishes the definitions and criteria that coastal states can use

to establish the extent of the continental shelf up to 350M from the baseline thus ensuring their legal rights to the seabed and subsoil of the ocean floor and access to marine natural resources such as oil, natural gas and other minerals, as well as access to sedentary organisms.

The Convention entered into force in 1994, when the 60th coastal state signed it. In 1999, the Scientific and Technical Guidelines was issued by the Commission of the Limits of the Continental Shelf (CLCS), hereinafter referred to as the Commission. According to 11th Meeting of States Party of the Law of the Sea (SPLOS), coastal states would have a term of 10 years from the date that the Guidelines was issued to ensure that technical and scientific data in support of each application were submitted.

By September 2012, nine of the twelve coastal states located in the South Atlantic Ocean between the Equator and the latitude of 60°S had deposited full or partial Submissions with the United Nations Secretary (CLCS, 2012). The goal of this work is to perform an analysis of seven of these coastal states and in addition, although the information in the Executive Summaries are very limited, the work speculates some comparison regarding the results proposed by the coastal states from public domain bathymetric and sediment thickness data and bibliographic references. The results are shown in Open Source GIS environment providing the effort dedicated by the respective coastal states in the implementation of Article 76 with a perspective of the future maritime boundaries in the study area.

The figure 1 shows the Executive Summaries available on the Commission website regarding Submissions from seven coastal states: Brazil, Uruguay, Argentina, the Falklands/Malvinas Islands, Gabon, Namibia and Ascension Island which were selected to demonstrate the methods used and the territory claimed by these states while complying with the recommendations and guidelines of the Commission.

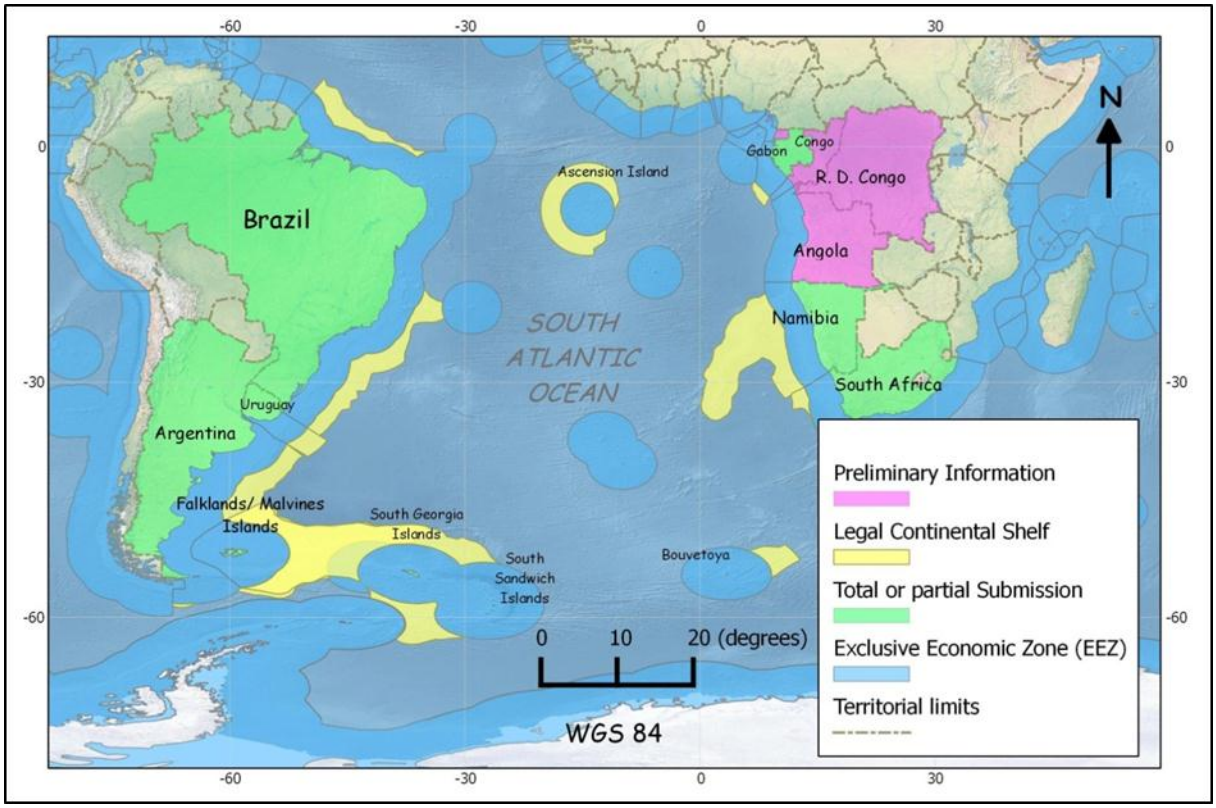

Figure 1. South Atlantic Ocean coastal states that deposited their legal continental shelf Submission or Preliminary Information with the United Nations Secretary by September 2012 (CLCS,2012).

2. Location, geology and resources

The Atlantic Ocean between the Equator and latitude 60ºS has been selected for the study because of its extensive marine reserves and its important role in the ongoing global energy supply. Some of the biggest oil fields discovered lie in its sedimentary basins.

The South Atlantic Ocean was formed by the intercontinental rifting and divergence of what are now the continents of South America and Africa. The South American and West African continental margins have similar stratigraphic units due to their proximity before and during the breakup of the Gondwana supercontinent. As a result, sedimentary basins of both margins can be correlated. Lacustrine oils of the southern Congo basin and Kwanza basin located in West Africa were generated from brackish and lacustrine rocks and can be correlated with those generated in the Reconcavo and Camamu-Almada basins of Brazil. (BROWNFIELD; CHARPENTIER, 2006).

The West African margin is divided into two distinct regions by the Walvis Ridge. South of the ridge, a largely unexplored volcanic continental margin extends from Namibia to South Africa. The region north of the Walvis Ridge, stretching from Angola to Cameroon, is characterized by post rift evaporite formations (DUPRÉ et al., 2007). According to Mello et al. (2011), two types of oil were discovered in the Orange Bowl south of the Walvis Ridge by comparing biological and geochemical data of rocks from the Northern elevation of the Rio Grande in the Brazilian continental margin, further demonstrating the conjugate nature of the basins and the reciprocity of knowledge.

The continental margin of Uruguay is relatively poorly surveyed. The margin consists of three sedimentary basins formed during the opening of the South Atlantic Ocean and extends beyond the limit of the 200M EEZ. Currently, the continental margin of Uruguay has a large volume of 2-D seismic data and various interpretations have already been carried out and compared with Brazilian data from sites with geological similarities. These data were also compared with the Kudu field seismic data in Namibia, which also has a high geological similarity with Uruguay (MORALES, 2011).

The continental shelf of Argentina is particularly wide, extending beyond 400km from the coastline. However, exploration offshore Argentina is still in the preliminary stage, no well has been drilled in waters deeper than 1000m. Most hydrocarbon exploratory activities are concentrated in the Southern Basin, but extensive margin areas still need to be analysed (DAVISON, 2007).

Moving to the East and beyond the elevation of the Rio Chico, the Southern Basin becomes the Falkland Basin, one of the four basins around the Falklands/Malvinas Islands. Of the four basins, the North Falklands basin is structurally isolated by the Falklands Plateau and is recognized to contain one of the richest source rocks in the world, capable of generating up to 70kg/HC tons of rock and that could expel about 60 billion barrels of oil (RICHARDS, 2000). To the East of the Falklands Plateau are the volcanic South Sandwich Islands. These island arcs are formed by subduction of the South American plate beneath the small Sandwich plate (LARTER et al., 2003).

Away from continental margins, Ascension Island is a British territory located about 90km west of the Mid-Atlantic Ridge. Bathymetric studies show two underwater seamounts which rise 800m and 1500m from the seabed and that are connected by submarine elevations to Ascension Island (FANEROS; ARNOLD, 2003). It is believed that one of the seamounts

was formed at the same time and in a manner similar to Ascension Island through hotspot volcanism. The other seamount originated by volcanic processes associated with the Mid-Atlantic Ridge and is part of the ocean floor with its oceanic ridges which are specifically excluded from the definitions on Article 76.

One of the main reasons for a coastal State to submit for extension of the continental shelf is to ensure rights of sovereignty over the marine mineral resources available in the adjacent continental margin. Hydrocarbon exploration is continuing on both sides of the Atlantic and recent discoveries in the ultra-deep waters of Brazil serve to solidify the importance of delineation of the outer limit of the continental shelf. In the last 5 years, giant fields in the Santos basin of Brazil, with estimated reserves of more than 20 billion barrels of oil have been discovered; including 4.5 billion on Franco, 5.7 billion on Lula and 7.9 billion on the Libra field (ANP, 2010).

In 2006, the United States Geological Survey concluded that the Midwest province of the West African coast, a region that runs from Cameroon in the North to the South of Angola has undiscovered estimated reserves of 29.7 billion barrels of oil, 88.0 trillion cubic feet of gas and 4.2 billion barrels of liquid natural gas. Most of these reserves, which do not include those of Namibia, will occur offshore and in ultra-deep waters (BROWNFIELD; CHARPENTIER, 2006).

Other mineral reserves of interest are manganese nodules, alluvial diamonds, gold and methane hydrates. The search for methane hydrates is starting to reach the continental slope and go beyond the EEZ (RENNIE, 2011). The interest in marine mining has increased recently and commercial sulphide extractions will be held in the very near future (SCHOOLMEESTER; BAKER, 2011).

The interest in carbon capture and storage has grown intensely. It originated in the late 1990's with the injection of CO2 into producing oil fields in an attempt to increase production volumes. Since then, a new concept has developed for the storage of frozen CO2 directly into the Seabed (SCHOOLMEESTER; BAKER, *op.cit*).

3. Methodology

OASIS MONTAJ software from Geosoft and Open Source Quantum Geographic Information System were used to process, map and analyse public domain satellite bathymetry ETOPO1 and sediment thickness data from National Geophysical Data Center (NGDC) together with submission data from Brazil, Uruguay, Argentina, the Falkland Islands, Gabon, Namibia and Ascension Island Executives Summaries available on the Commission website (CLCS, 2012). Profiles of bathymetry and their second derivatives were used to demonstrate various types of continental margins and simulate the various criteria of Article 76 used by coastal States on the delimitation of the legal continental shelf. The profiles were selected from the bathymetry map and plotted to show elevation versus distance. The first and second derivatives of this elevation profile were then calculated and plotted to the same scale. Maxima in the second derivative generally coincide with rapid changes of gradient and can therefore be used to delineate the foot of the continental slope.

4. Results

The geomorphology of the Brazilian continental margin is highly varied and this is reflected in the different methods used to define the outer limit of the continental shelf

(Figure 2). To the north around the Amazon Delta, the outer limit is defined using a combination of fixed points based upon 60M distance from the foot of the continental slope (Hedberg formula), on the sediment thickness formula (where the thickness of sedimentary rocks is at least 1% of the shortest distance from the foot of the continental slope) and on the 350M distance from the baseline criteria. The profile on figure 3 shows a wide shelf and long concave slope suggesting the 350M distance from the baseline criteria was used and similarly further south the profile across the Santos Basin suggests likewise (Figure 4). The Vitoria-Trindade Ridge extends out from the continental land mass and the Brazilian Executive Summary indicates the use of the Hedberg and sediment thickness formulas at the north of the ridge and similarly at the south together with the 350M criteria.

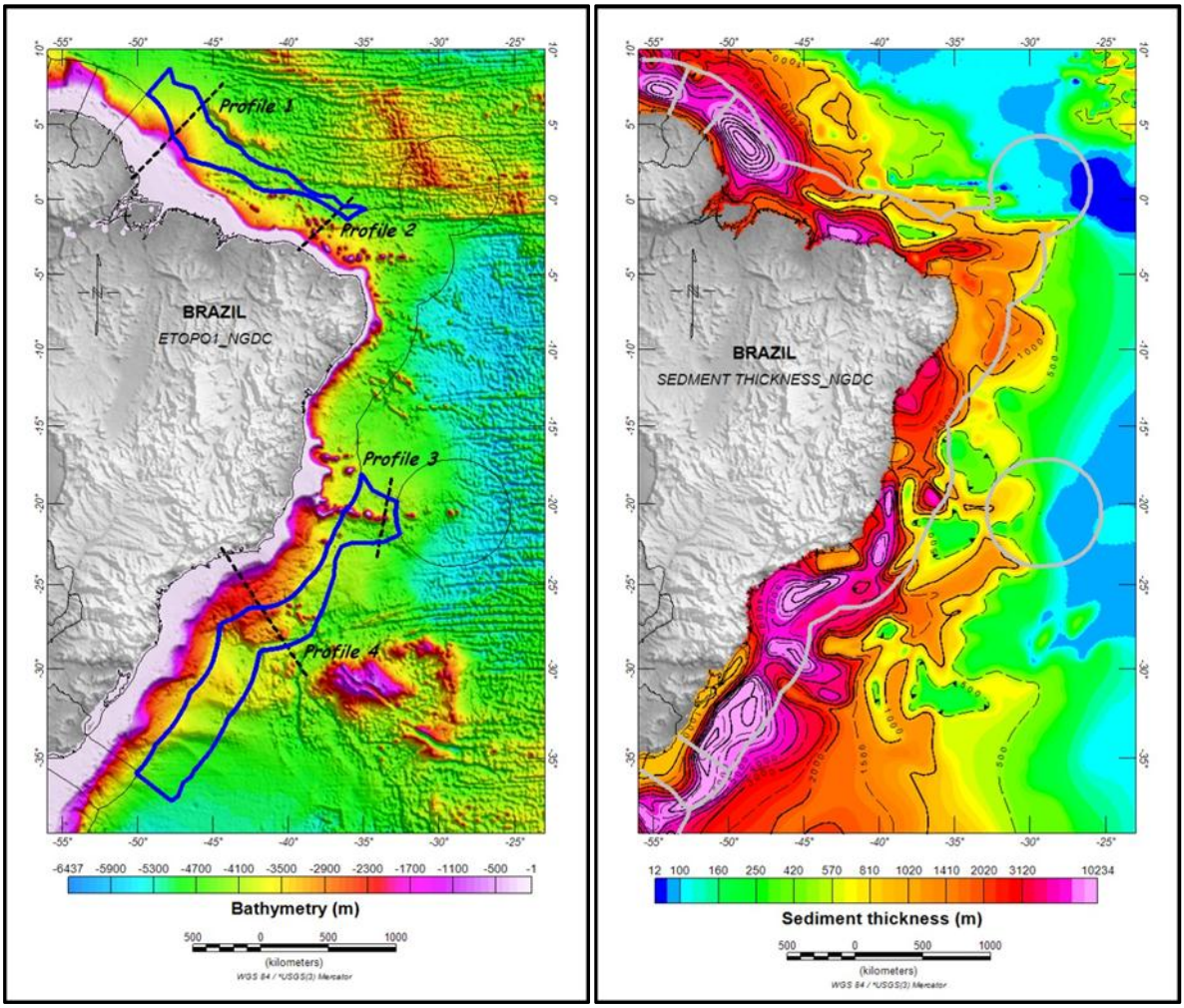

Figure 2. On the left, Brazilian continental margin bathymetry generated on OASIS MONTAJ from ETOPO1 satellite data integrated with GIS data of submitted extended legal continental shelf, the location where bathymetric profiles were selected and the EEZ. On the right, Brazilian continental margin generated of sediment thickness data from NGDC.

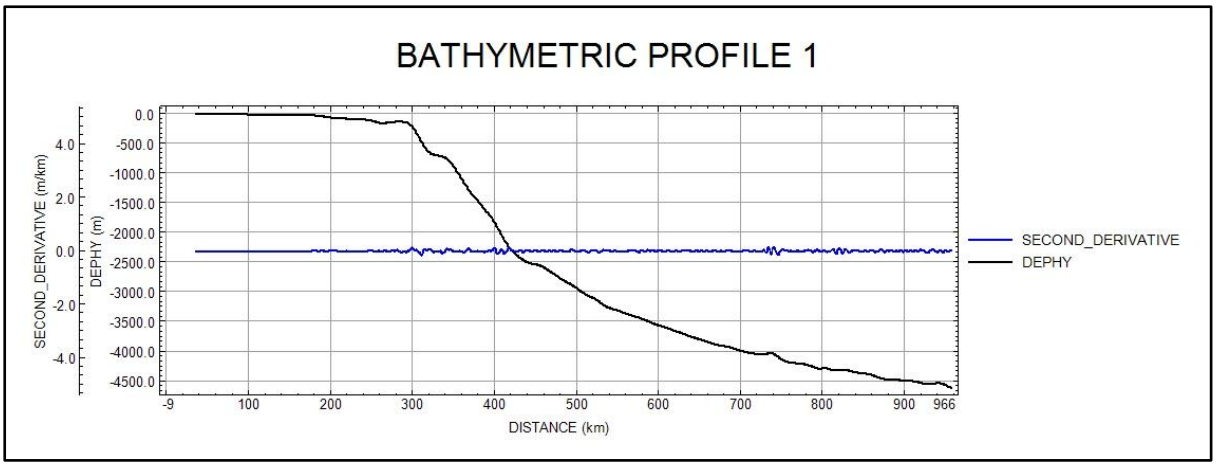

Figure 3. Brazilian Bathymetric profile 1 from Amazon Fan showing a wide continental shelf and concave slope. The second derivative of the elevation remains almost stable.

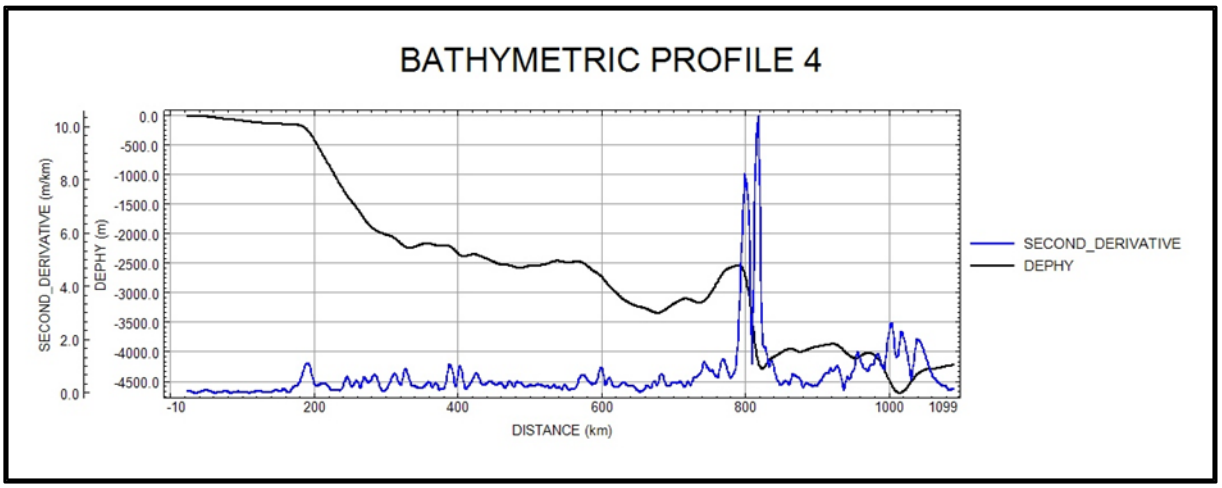

Figure 4. Brazilian Bathymetric profile 4 from Santos Basin showing the maxima on the second derivative of the elevation at 800km distant from the beginning of the profile.

Uruguay has a remarkable uniform bathymetric margin and was able to determine 4 foot of slope points between the northern border with Brazil and the southern border with Argentina and then define the outer limit of the continental shelf based on the Hedberg formula. Because the formula results falls beyond this limit, Uruguay has had to fall back to the maximum allowed limit of 350M from the baseline as shown in figure 5.

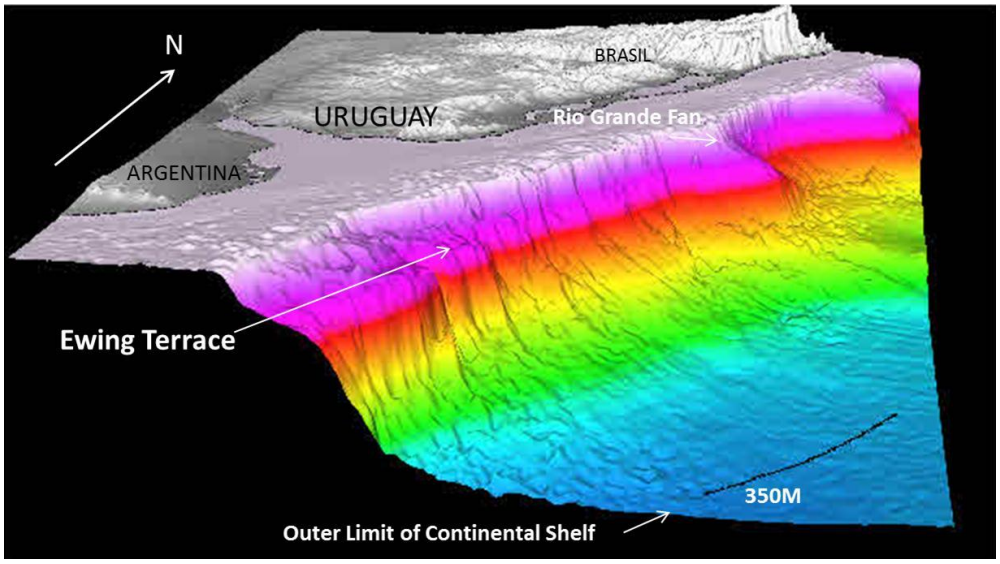

Figure 5. Uruguayan Bathymetry 3D map generated on OASIS MONTAJ and integrated with GIS data of the outer limit of continental shelf defined on 350M from the baseline.

Due to the complexity of the area being proposed and the variation of margin types therein, Argentina have utilized different methods proposed on Article 76 for different sections of margins. To the north across the volcanic passive margin, seismic data were used to determine the outer limits of the continental shelf complying with the sediment thickness formula. Further south, around the sheared continental margin adjacent to the Falklands Plateau, the Hedberg formula was used due to a clearly defined base of slope. A profile selected across the South Sandwich Island shows the bathymetry dropping rapidly into the South Sandwich Trench and here they declared on their Executive Summary that the outer limit be 200M.

The United Kingdom Submission in respect of Falklands/Malvinas, South Georgia and South Sandwich Islands only follows an extended continental shelf outline to the north where the Hedberg formula was used. In the east, it matches with Argentina submission and follows the boundaries of the South Sandwich EEZ which already lies over the abyssal plain. To the south, it recognizes Antarctic and EEZ around it accordingly whilst to the west and south the outer limit follows the internationally recognized boundary equidistant between Argentina and Falkland/Malvinas Islands.

On the African side of the South Atlantic Ocean, Gabon have fixed the outer limit of the continental shelf where the thickness of the sedimentary rocks is at least 1% of the distance from the foot of the continental slope apart from over the Congo Fan which is so large that the foot of the slope is beyond 350M from the baseline (Figure 6).

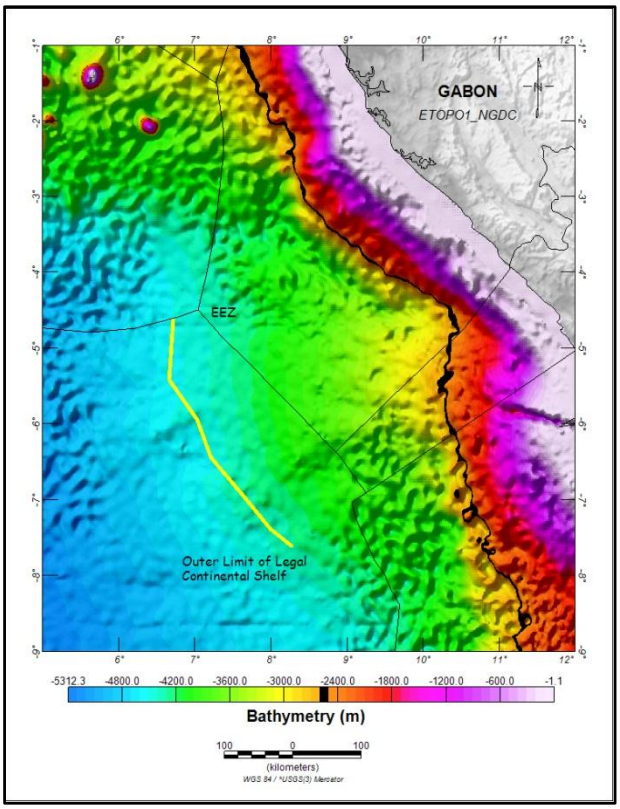

Figure 6. Gabon continental margin bathymetry generated from ETOPO1 satellite data integrated with GIS data of submitted extended legal continental shelf.

Further south, Namibia have been able to take advantage of the Walvis Ridge which is interpreted as being directly connected to the continent and is hence treated as part of the prolongation of the land mass of Namibia. In doing this, they have been able to extend the outer limit to over 1000km from the base line primarily using the Hedberg formula but along the Walvis Ridge they have also had to use the 2500m isobath constraint criteria.

The seamount of the Ascension Island is isolated from continental landmasses and exhibits no geomorphologic continental shelf. However, the Convention allows the definition of the legal continental shelf. On the western side the 350M limit was used as the foot of the slope is indiscernible. To the east, the Mid Atlantic Ridge enabled the United Kingdom to define several foot of slope points and therefore the extended legal continental shelf is actually narrower in the west, even been constrained by the 200M EEZ for one portion.

The total area proposed for the extension of the legal continental shelf of Brazil, Uruguay, Argentina (above the latitude 60°S), Namibia, Gabon, the Falkland/Malvinas, South Georgia and South Sandwich Islands and the Island of Ascension that were analysed in detail in the course of this work correspond to approximately 5,483,000km^2. The total area of the extended legal continental shelf proposed from all South Atlantic coastal states Submissions corresponds to approximately 6,343,000km^2.

The areas proposed in the Submissions of the United Kingdom and Argentina around the Falklands/Malvinas Islands, South Georgia and South Sandwich overlap by around 862,000km^2, as can be seen in the figure 7. This overlap arises from the current political impasse regarding the territorial sovereignty of the Islands.

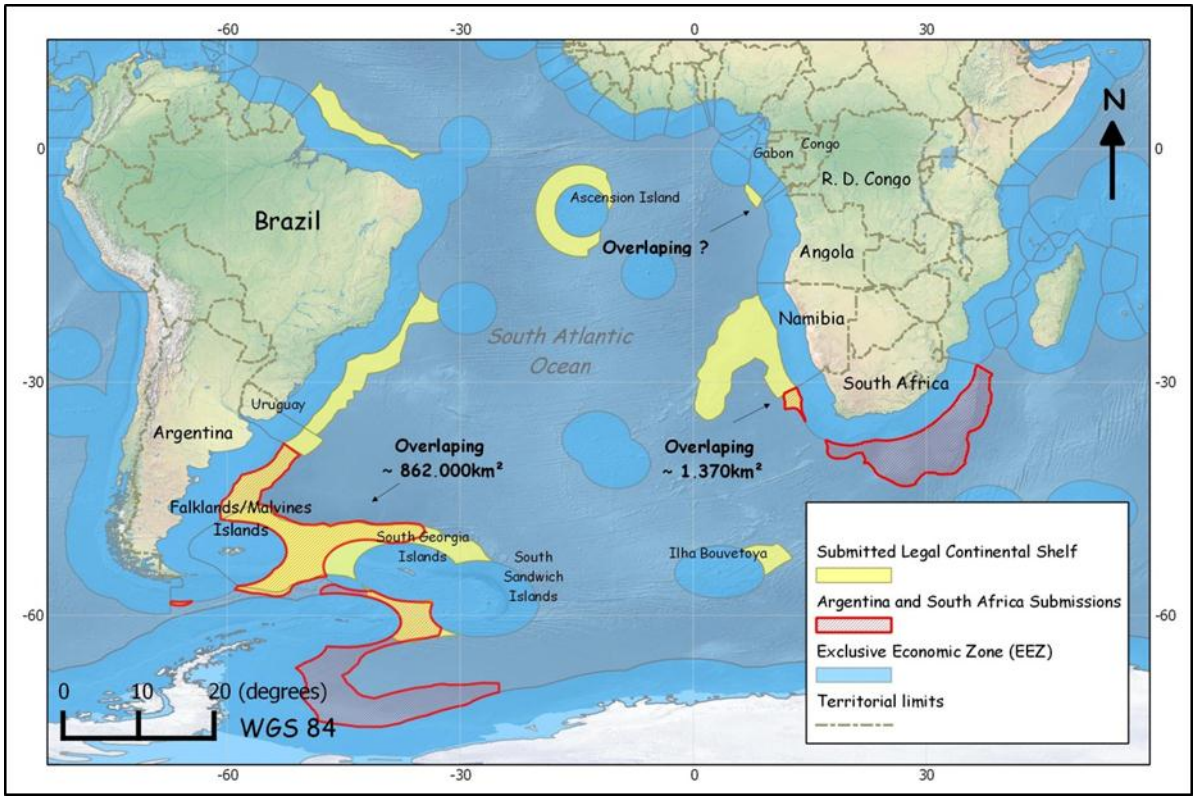

Figure 7. South Atlantic Ocean and all submitted legal continental shelf. The United Kingdom and Argentina Submissions overlap by approximately 862.000km² around the Falklands/Malvinas Islands on the South American coast, also the Namibian and South African Submissions overlap approximately 1.370km² on the West coast of Africa.

The areas proposed in the submissions of Namibia and South Africa overlap by approximately 1,370km^2 (Figure 7). The boundary between the two States is still the object of negotiation and according to their executive summaries, proposals for expansion of the legal continental shelf that have been deposited with the Secretary of the United Nations will not bring prejudice to the future establishment of the maritime boundary between them.

According to the analysis made in the Executive Summaries of Gabon and Preliminary Information of Angola, Congo and the Democratic Republic of the Congo, there is the possibility of overlapping areas of the continental shelf on the West African margin. The total of this overlap will be better understand only when those coastal States present their proposals for extension in the form of partial or total Submissions to the Commission through the Secretary of the United Nations.

5. Conclusion

The results obtained in the analysis conducted in this paper are highly affected by the limitations of data and information available in the coastal states Executive Summaries published on the Commission website and by the bathymetric and sediment thickness public domain data resolution.

This work is dedicated to the geological and geopolitical analysis of the various issues relating to Article 76 of the Convention and its application in the establishment of maritime boundaries of the coastal states of the South Atlantic Ocean while followed the recommendations and technical and scientific Guidelines issued by the Commission.

The coastal states located in the study area pay great effort and attention regarding the Convention and its implementation, in particular in relation to Article 76, allowing the incorporation of new maritime areas supported by legal and technical elements.

With the world population growing and the corresponding demand in reserves increasing, it is imperative that each coastal state should extend its legal continental shelf in an appropriate manner, complying with the legal provisions in order to reduce the risk of future disputes over these resources.

The new maritime areas represent the potential for extracting new mineral, biological and energy resources that could contribute to the social and economic development of coastal states. However, new areas also represent new social, economic and environmental responsibilities to these states. These responsibilities can be hampered by jurisdictional uncertainty caused by undefined maritime boundaries and disputes over these new boundaries.

Hydrocarbon exploration and extraction is expanding on both sides of the South Atlantic Ocean, where the nature of the conjugate margins and sedimentary basins between Brazil and Uruguay in the West and Gabon and Namibia in the East, show the benefits of cooperation and mutual agreements as well as the importance of the establishment of internationally recognised maritime limits.

The implementation of Article 76 of the Convention paved the way for the improvement of oceanographic sciences that are associated with the methods of collection and interpretation of data necessary for the establishment of the legal continental shelf, thus providing a better understanding of geological types and tectonic structures associated with margins.

Thus, by integrating geological and political aspects in the GIS system, this work expects to be used as a contribution to the understanding, even partially, of the scope of the new geopolitical map of the South Atlantic according to the application by coastal States of Article 76 of the Convention.

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