A Practical Overview of Article 76 of the United Nations Convention on the Law of the Sea

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Abstract

The United Nations Convention for the Law of the Sea, adopted in 1982, is the legal framework that sets out the rights and duties of States in the use and exploitation of the oceans. Article 76 through to article 85 in Part VI of the Convention is dedicated to provisions related to the continental shelf such as the determination and delineation of the outer limits of the extended continental shelf beyond 200 nautical miles and other rights of States over the continental shelf. The determination of the foot of the continental slope is one of the major features in the establishment of the outer limits of the juridical continental shelf under Article 76 of the Convention. It is the intention through this paper to provide an overview along with the basic information for a better understanding of the key issues of article 76 of the Convention. In this attempt, the important issues in the preparation of a submission for an extended continental shelf have been addressed through a review of the numerous publications on the subject, including the Scientific and Technical Guidelines from the Commission on the Limits of the Continental Shelf. The paper first gives a brief of the history of the Convention along with the difficulties in drafting article 76 during the negotiation stage. The provisions and implications of article 76 have been discussed with the different techniques that can be used in determining the foot of the slope and addresses the various criteria and data required for determining as accurately as possible the foot of the slope including geology and geomorphology. The importance of the resources of the continental shelf in the preparation of a submission and boundary delimitations have also been addressed.

Key words: Article 76, Law of the Sea, foot of the slope, sediment thickness and bathymetry.

Disclaimer

The views expressed herein are those of the author and do not necessarily reflect the views of the United Nations, The Nippon Foundation of Japan or the Government of Mauritius.

Introduction

The United Nations Convention for the Law of the Sea (UNCLOS, hereafter referred to as the Convention) of 1982 is the international legal framework that provides the basis for States in the exercise of their rights and duties in the use of the ocean and in the exploitation of its resources. The Convention was acclaimed when it was finally adopted after nine years of negotiations and was even hailed as ‘A Constitution for the Ocean’ by the President of the Third United Nations Conference on the Law of the Sea (Koh, T. 1982). The Convention codifies and develops customary international law as well as creating new rules and institutions. The Convention provides specific and precise rules over certain issues while at the same time deal with other issues in a more general manner. It relies much on bilateral and multilateral international agreement for its proper implementation.

The Convention comprises of 17 Parts, 320 articles, 9 annexes and a final act. The major features of the Convention relate to the definition and regulation of the different maritime zones that coastal States are entitled to, such as, territorial sea, contiguous zone, archipelagic waters, exclusive economic zone and continental shelf. Other maritime zones like the high seas and international seabed area are also defined. The Convention also sets the basis for the preservation of the marine environment, conduct of marine scientific research and development and transfer of marine technology. The part dealing with the deep seabed area and its resources was considerably amended and led to the Agreement of July 28, 1994. The Convention entered into force on November 16, 1994, for those states which deposited instruments of ratification. However, for a couple of reasons, later discussed in this paper, the agreed date of entry into force of the Convention has been set as May 13, 1999.

The continents and the oceans are the two types of morphological figures that are most prominent on the Earth's surface. The oceans is however the most significant with a total cover of around 71% of the total surface. The continental margin is the zone separating the thin oceanic crust of the deep ocean basins from the thick continental crust. Continental margins underlie about 28% of the oceans, with the transition from continental to oceanic crust commonly occurring beneath the outer part of continental margins. The boundary between these crustal provinces marks the real physical outer edge of the prolongation of the continent beneath the ocean.

At the time of preparation of this paper, in August 2005, 4 countries have produced and submitted their submission for an extended continental shelf as per the provisions of article 76 to the Commission on the Limits of the Continental Shelf (CLCS, hereafter referred to as the Commission), namely the Russian Federation, Brazil, Australia and Ireland.

Historical Perspective

The major advances regarding the laws of the sea came around the turn of the twentieth century. In those times, a coastal State had only sovereign rights over the seabed within their 3 M territorial sea. During the first decades, States started declaring sovereign rights for the exploitation of sedentary species on the continental shelf, or even asserting rights of control over specific areas of the shelf. With technical advances, the interest in having control over the shelf resources beyond the territorial sea increased, and the development was rapid (Heidar, 2003).

The first clear assertion of the idea that the resources of the continental shelf belong to the coastal State was made by President Truman of the United States in 1945. Following the, what is now known as, Truman Proclamation, several similar claims were made by other States and within a decade, a consistent and general State practice had developed in this field (Heidar, 2003). Some South American countries, including Chile, Ecuador and Peru made the Santiago Declaration in 1952 whereby they claimed full sovereignty over the seabed and subsoil for a distance of 200 M from their coasts and also declared sovereignty over the superjacent water and the air space above. This declaration would eventually have a great impact on the development of the law of the sea with regards to the breadth of the exclusive economic zone and the continental shelf, even though the declaration was being opposed by other States.

After the World War II and the creation of the United Nations (UN) in 1945, the International Law Commission was requested to consider the codification of existing customary International Law relating to the Oceans. Four separate draft conventions were prepared and adopted at the first UN Conference on the Law of the sea in 1958. The conventions dealt with the territorial sea and the contiguous zone, the high seas, fisheries and the conservation of the biological resources of the high seas and the continental shelf. These conventions had limited impacts as it did not reflect the current State practice of law related to the sea and they did not establish an agreed maximum breadth of the territorial sea. The second law of the sea conference, as well did not succeed in meeting the expectations of the States. There was still no agreement on the breadth of the territorial sea and the conference had failed to address fisheries jurisdictional issues (Levy, 2000).

At the United Nations General Assembly of 1967, it was proposed that the legal status of the seabed and the ocean floor beyond the national jurisdiction be looked into. Following this proposal, a committee was set up and after six years of work the Third United Nations Conference for the Law of the Sea was convened. This conference worked from 1973 to 1982 and eventually the Convention was approved on April 30, 1982 and was open for signature on December 10, 1982 where it was signed by 159 States.

The Drafting of Article 76

During the drafting of the Informal Composite Negotiating Text (ICNT), later to become the UNCLOS, several different legal areas were recognized beyond coastal or archipelagic baselines. These were the territorial sea, the contiguous zone, the exclusive economic zone, the continental shelf, the high seas and the (International Seabed) Area. It was also recognized that the continental shelf remained the most vexatious given that it concerns mineral resources with consequent socio-economic implications while at the same time it is a physical entity more of the domain of a scientist rather than a jurist and also because the outer boundary will be the boundary of the international Area and thus sensitive to encroachment by coastal States.

At the times of the negotiations, there were two types of continental margins that were defined. The first type comprised of a broad continental shelf, a steeper continental slope and a gently sloping continental rise which consists of a broad wedge or fan of sediments which taper oceanwards towards the deep abyssal plain. The sediments comprising the continental rise are derived from the adjacent continent. This would be the type typically found bordering the Atlantic Ocean. The second type of continental margin does not contain as simple pattern as the previous. In this second type, seismic activity and block fragmentation of the continental crust is common and there may be an array of small deformed sediment filled basins or a narrow continental shelf, bordered to seaward by steep slope leading to deep trench, this second type is commonly found in the Pacific.

During the negotiations various limits for the legal continental shelf have been put forward. These were based on water depth, natural boundaries and crustal boundaries but no agreement could be settled based on these parameters.

Large amount of what was known and published about margins, at the time, was dominated by Wood's Hole Oceanographic Institution and Lamont Doherty Geophysical Observatory. Those involved in the formulation of article 76 were provided with diagrams of the continental shelf, that were profiles with large vertical exaggeration showing slope descending at 30 to 45 degrees with the rise sloping at 15 degrees. Carleton *et al.,* 2000 are of the opinion that that this may have created an early impression in the framer's minds that (i) all continental margins were of this type, (ii) the transitions from one zone to another were clearly delineated and thus would be relatively simple to map any of the features shown. Two persons namely, Hedberg and Gardiner, were among the rare people to understand the complexity of the margin and thus made different proposals for setting the outer limits.

Prof. Hedberg suggested the use of the base of the continental slope approximated to the boundary between oceanic and continental crust. The formulation proposed would be to utilise a boundary zone of an internationally accepted width seaward from the base of the slope, within which the coastal state could draw straight lines boundaries between fixed geographical coordinates. According to Gardiner, 1978, this proposition would have been inconsistent with the accepted scientific definition and the concept of natural prolongation of the landmass and that great variations in the width of margins that extend beyond the 200 M would make it impracticable. However, if based on the true geological sense, the natural boundary of the continental margin would be logically the outer limit of the continental rise and so the sediment thickness boundary.

The sediment thickness formula is based on the recognition that the continental rises of Atlantic type of margins are composed of a wedge of sediment that thin seawards at the foot of the continental slope. The formulation proposed in March 1976, states that the distance cut-off point would be directly proportional to the thickness of rise sediments. Thus the outer limit of the rise at any point, for the purpose of the Convention, would be where the thickness of sediment is at least 1% of the shortest distance between it and the foot of the slope. This was known as the Gardiner formula. This formula is directly related to a natural geological feature and it takes into account the physical reality of global variations in the geographical breadth and thickness of continental rises. In such way, coastal states would be bounded by a natural feature. The 1% figure was chosen so that coastal states would retain under their jurisdiction a significant part of the continental rise.

Following the above propositions, amendments, consisting basically of the addition of 6 paragraphs, to the then, Article 76 of the ICNT covering 5 major points, were made. This was known as the Irish Amendments and includes:

1. The term 'continental margin' is defined in its natural scientific sense and is specified as including the continental shelf, slope and rise.
2. Two methods were offered whereby the outer limit of the continental margin can be precisely located.
   (a) The Gardiner formula (1% sediment thickness)
   (b) A modified version of the Hedberg proposal (60 M from the foot of slope)
3. Using simple mathematical exercise to determine the foot of the slope as the point of maximum change in gradient by considering the length and angle of slope.
4. The manner in which a coastal State can fix the limits of its continental shelf jurisdiction on a chart or map.
5. The requirement of an international boundary commission to act as 'watchdog' to prevent excessive coastal State claims.

A study was undertaken by the United Nations in view of assessing certain specific parameters which was discussed and upon which the coastal States relied on during the further negotiations.

Provisions of Article 76 of the Convention

To better understand the provisions of Article 76, it is opportune to review and discuss the paragraphs in turn.

Paragraphs 1 and 3 give the basic definition of the continental shelf.

Paragraph 1

> The continental shelf of a coastal State comprises the seabed and subsoil of the submarine areas that extend beyond its territorial sea throughout the natural prolongation of 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.

Paragraph 3

> The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the seabed and 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.

A coastal State will be entitled to exercise sovereign rights to the outer edge of the continental margin, which comprises of the seabed and subsoil of the shelf, slope and rise provided that it extends as the natural prolongation of the land territory or to a distance of 200 nautical miles from the baselines, from which the breadth of the territorial sea is measured, if the continental margin does not extend to that distance. The deep ocean floor along with the oceanic ridges are however excluded from being part of the continental margin.

The term ‘continental shelf’ as used here has a strictly legal connotation and is used as a juridical term. The United Nations study on continental shelf confirm the legal concept of the continental shelf and its link with the physical fact of the natural prolongation, enunciated in 1969 by the International Court of Justice in the North Sea continental shelf cases (United Nations, 1993, Smith & Taft, 2000).

It is good to point out that the term ‘continental shelf’ as used by geologists, and hence in the scientific jargon, generally mean that part of the continental margin which is between the shoreline and the shelf break or, where there is no noticeable slope, between the shoreline and the point where the depth of the superjacent water is approximately between 100 and 200 meters (United Nations Web Page). It is understood from the term ‘natural prolongation’ that the continental margin should be continuous and unbroken from the shoreline to its outer edge.

The deep ocean floor outside the 200 M from the baseline from which the breadth of the territorial sea is measured is considered under the Convention as the Area and no State shall claim jurisdiction over these areas according to the provisions of article 137.

The definition of the continental margin is based mostly on the geomorphology, or submarine landscape, and it is neutral in respect to crustal type, in the sense of ‘continental’ and ‘oceanic’ crust (Heidar, 2003). This implies that the submerged prolongation of the landmass of a coastal State, regardless of its characteristics, comprises its continental margin and creates its entitlement to a continental shelf. Symonds *et al.*, 2000, also point to the fact that article 76 does not contain geological terms and acknowledge that article 76 can be viewed in a variety of ways depending on whether it is approached from a legal, geomorphological or geological perspective, however, these approaches are not independent of each other. The geological considerations may be important when considering ‘evidence to the contrary’ as an alternative approach to defining the foot of the slope.

Paragraph 2

Paragraph 2 states specifically that the continental shelf as defined in paragraph 1, shall not extend beyond the limitations of paragraph 4 to 6 of article 76.

Paragraph 2 read as follows:

> The continental shelf of a coastal State shall not extend beyond the limits provided for in paragraphs 4 to 6.

Paragraphs 4 to 6 apply to the continental margin that extends beyond 200 M from the baseline from which the territorial sea is measured.

Paragraph 4

Paragraph 4. is as follows:

> (a) For the purposes of this Convention, the coastal State shall establish the outer edge of the continental margin wherever the margin extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by either:
>
> > (i) a line delineated in accordance with paragraph 7 by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is at least 1 per cent of the shortest distance from such point to the foot of the continental slope; or
> >
> > (ii) a line delineated in accordance with paragraph 7 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.
>
> (b) In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base.

Paragraph 4 provides 2 formulas by which the outer edge of the continental margin should be delineated. Either of the two formulas can be used in the delineation of the outer edge of the continental margin. Each formula can be applied in such way as to maximize the entitlement of a coastal State, that is the first formula can be used for a certain portions of the continental margin while the second formula can be used in other portions. The formulas can be applied alternatively.

The sediment thickness formula given in paragraph 4(a)(i) is measured by a line based on the determination of the outermost fixed points on the continental rise at which the thickness of the sedimentary rock is at least 1% of the shortest distance from such point to the foot of the continental slope. This formula was developed by P. R. Gardiner and was commonly referred to as the ‘Irish formula’ during the negotiations. If the formula is to be applied to a point at, say for example, 100 M from the foot of the slope, the sedimentary thickness at that point should be 1 M thick.

Figure 1 and figure 2 illustrate the sediment thickness formula and how it should be used in delineating the outer limit of the continental shelf.

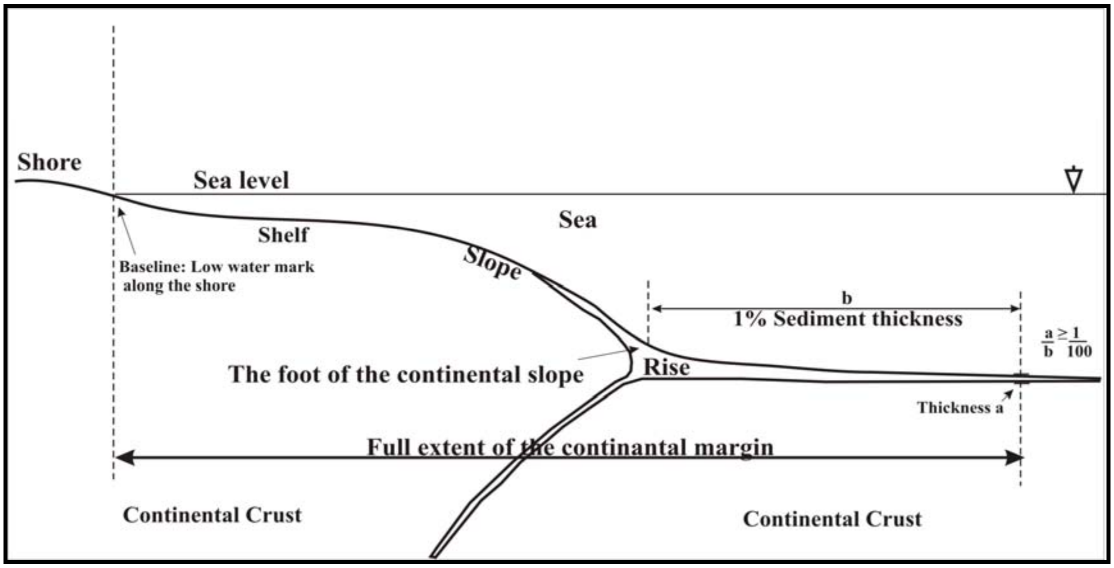

Figure 1: Illustration of the sediment thickness formula as given in paragraph 4(a)(i). The sediment thickness at a point delineating the outer limit of the continental shelf should be at least 1/100th of the distance from that point to the foot of the slope

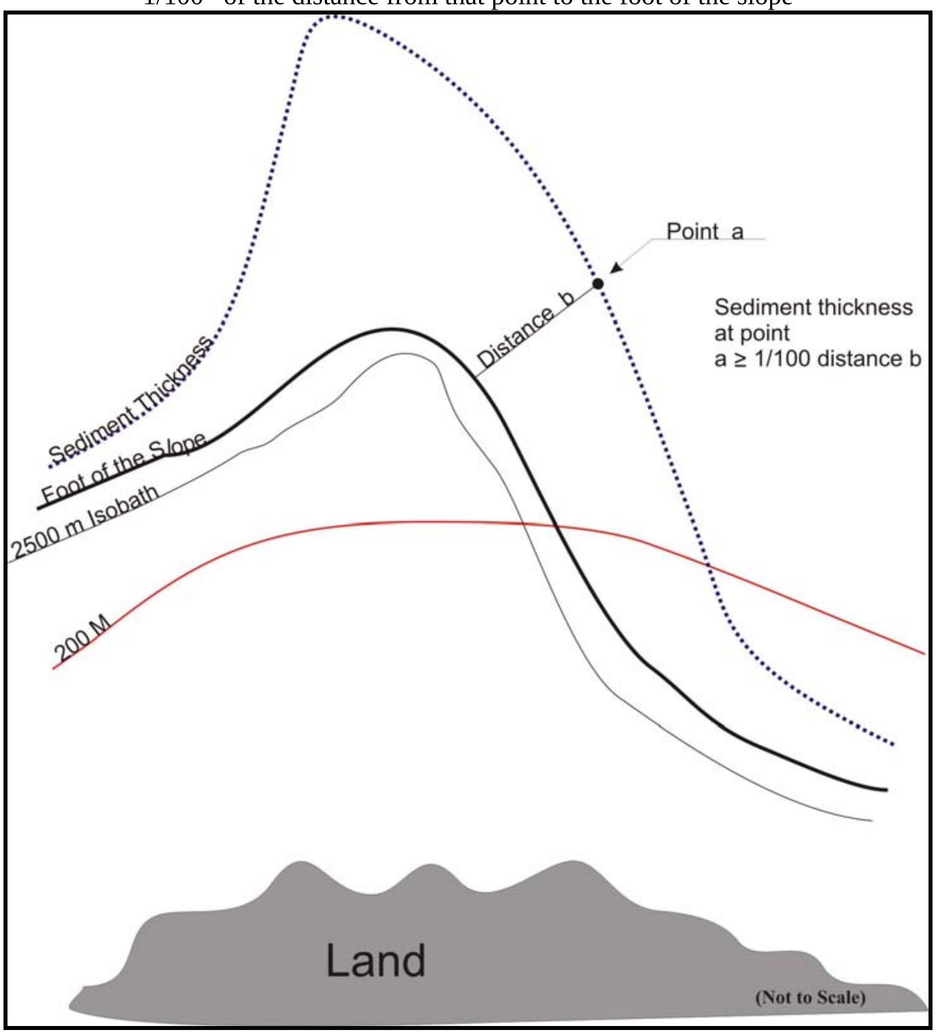

Figure 2: Illustration of the sediment thickness line as given in paragraph 4(a)(i)

The second formula as stated in paragraph 4(a)(ii) makes provision for the outer edge of the continental margin be established by a line based on fixed points which are not more than 60 M from the foot of the continental slope. This formula is commonly known as the Hedberg formula. Figure 3 shows the foot of the slope plus the 60 M line as provided for in paragraph 4(a)(ii).

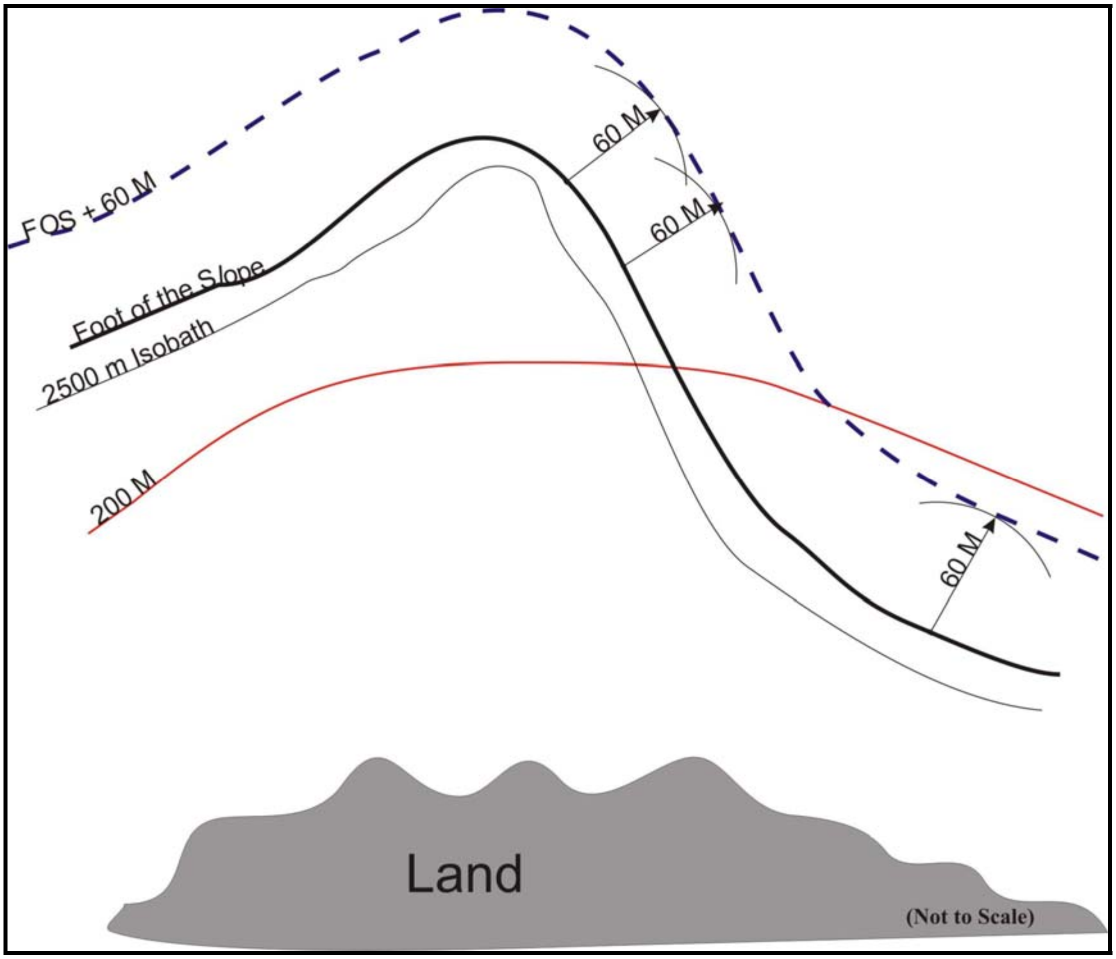

Figure 3: Illustration of the formula given in paragraph 4(a)(ii) with a line at a distance of 60 M from the foot of the slope.

The Scientific and Technical Guidelines of the Commission (hereafter referred to as the Guidelines), through paragraph 5.1.2., interprets that paragraph 4(b) provides a dual regime for the determination of the foot of the continental slope which requires the identification of the region defined as the base of the continental slope. Paragraph 5.4.5. of the Guidelines states that the Commission defines the base of the continental slope as a region where the lower part of the slope merges into the top of the continental rise, or into the top of the deep ocean floor where a continental rise does not exist. The Commission, through paragraph 5.2.1. of the Guidelines, further adds that bathymetric and geological data provide the evidence to be used in the geomorphological analysis conducted to identify the region defined as the base of the continental slope. However, the Commission emphasize, in the same paragraph, that only bathymetric information will be used to determine the location of the point of maximum change in the gradient at the base of the continental slope. Geological and geophysical data may be used to assist in identifying the region referred as the base of the continental shelf and these can be submitted by coastal States to supplement proof that the base of the continental slope is found at that location (paragraph 5.4.6. of the Guidelines).

Evidence to the contrary to the general rule is interpreted by the Commission, through paragraph 6.3.1. of the Guidelines, as a provision designed to allow coastal States to use the best geological and geophysical evidence available to them to locate the foot of the continental slope at its base when the geomorphological evidence given by the maximum change in the gradient does not or can not locate reliably the foot of the continental slope.

The importance of the concept of the foot of the continental slope should be stressed as it is the unique feature that will enable any coastal State whose continental margin extends beyond the 200 M from the baseline from which the territorial sea is measured, to delineate the outer edge of the continental margin as per the provisions discussed above. Both the Irish and Hedberg formulas make use of the foot of the continental slope as the starting point for measurements.

Paragraph 5

Paragraph 5 of article 76 sets the maximum limits of the entitlement of a country over the continental shelf. According to paragraph 5,

> The fixed points comprising the line of the outer limits of the continental shelf on the seabed, drawn in accordance with paragraph 4(a)(i) and (ii) shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured or shall not exceed 100 nautical miles from the 2,500 metre isobath, which is a line connecting the depth of 2,500 metres.

The Guidelines commonly calls these as the constraints. Paragraph 2.3.2 of the Guidelines states that whereas the application of at least one of the two formulae to determine a line beyond the 200 M suffices to provide the basis for entitlement to delineate the outer limits of an extended continental shelf, the application of all four rules may be necessary in order to actually delineate the outer limits of the continental shelf. It can be understood, and as discussed above, that either the Hedberg formula or the Irish formula can be used, or both alternately, to delineate the outer limit of the continental shelf, however these outer limits of the extended continental shelf should at no time go beyond the 350 M from the baseline from which the territorial sea is measured or 100 M from the 2500 meter isobath. It is good to point out that the 2500 meter isobath plus 100 M may result in a coastal State entitlement beyond 350 M from the baseline. In practice, a coastal State will have the possibility of choosing the constraint that will apply for a particular region and which is the most seaward and thus to its advantage, however the line delineating the outer limits of the extended continental shelf should at no time be further than that this chosen constraints. The eventuality of having more than one 2500-meter isobath off a coastal State's coast was enunciated by Smith & Taft, 2000, who said that nothing in the Convention precludes a state from using the 2500 meter isobath most advantageous to its interests.

Figure 4 shows the constraint lines as provided for in paragraph 5. The use of the formulas and constraints are shown in Figure 5. The formulas and the constraints have been applied alternately to show the several possibilities; however, not all the possibilities are shown.

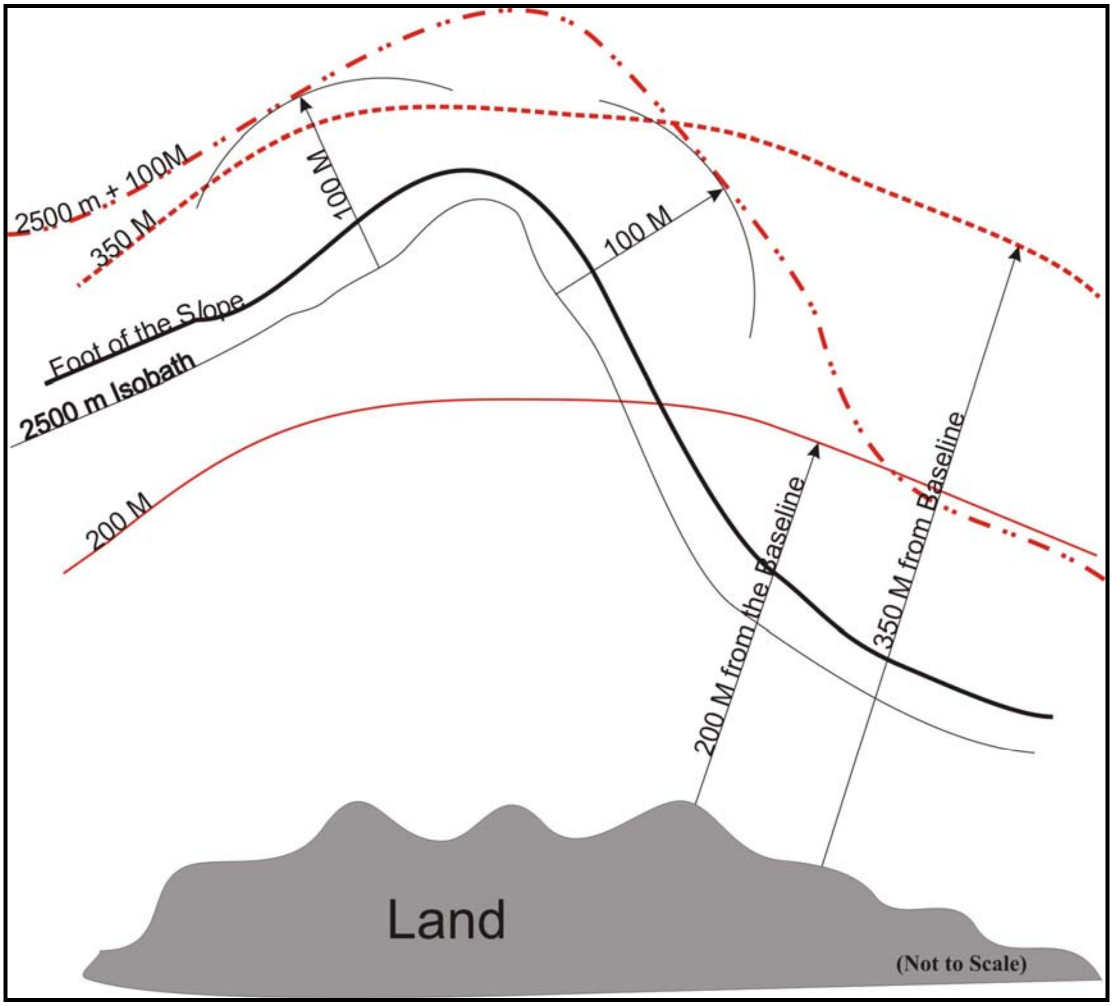

Figure 4: Illustration of the constraints as given in paragraph 5. The 350 M line from the baseline and the 2500 m + 100 M lines are shown.

Paragraph 6

Paragraph 6 states that

> Notwithstanding the provisions of paragraph 5, on submarine ridges, the outer limit of the continental shelf shall not exceed 350 nautical miles from the baselines from which the breadth of the territorial sea is measured. This paragraph does not apply to submarine elevations that are natural components of the continental margin, such as its plateaux, rises, caps, banks and spurs.

This paragraph, in addition to paragraph 5 provide another constraint that applies to submarine ridges whereby the outer limits of the continental shelf shall not be more than 350 M from the baseline. In the second phrase of this paragraph, the Convention differentiates the terms submarine ridges from submarine elevations. The latter are natural components of the continental margin such as its plateaux, rises, caps, banks and spurs.

The Commission acknowledge, through the paragraph 7.1.2. of the Guidelines, the existence of 3 types of sea floor highs namely

- Oceanic ridges of the deep ocean floor (paragraph 3)

- Submarine ridges (paragraph 6)
- Submarine elevations (paragraph 6)

Moreover the Commission acknowledges that the link between the terms 'oceanic ridges' of paragraph 3 and the 'submarine ridges' of paragraph 6 is unclear (paragraph 7.1.3. of the Guidelines). The 'submarine ridges' are subject to a maximum outer limit of 350 M from the baseline while the 'submarine elevation' can have an outer limits constrained by either the 350 M from the baseline or the 100 M from the 2500 meter isobath. On the other hand, 'oceanic ridges' do not provide any entitlement of extension beyond the 200 M from the baseline (paragraph 3). This shows that 'oceanic ridges' should be treated differently from 'submarine ridges'. The distinction between the 'submarine elevations' and 'submarine ridges' or 'oceanic ridges' should not be based on their geographical denominations and names used so far in the preparation of the published maps and charts and other relevant literature (paragraph 7.1.8. of the Guidelines).

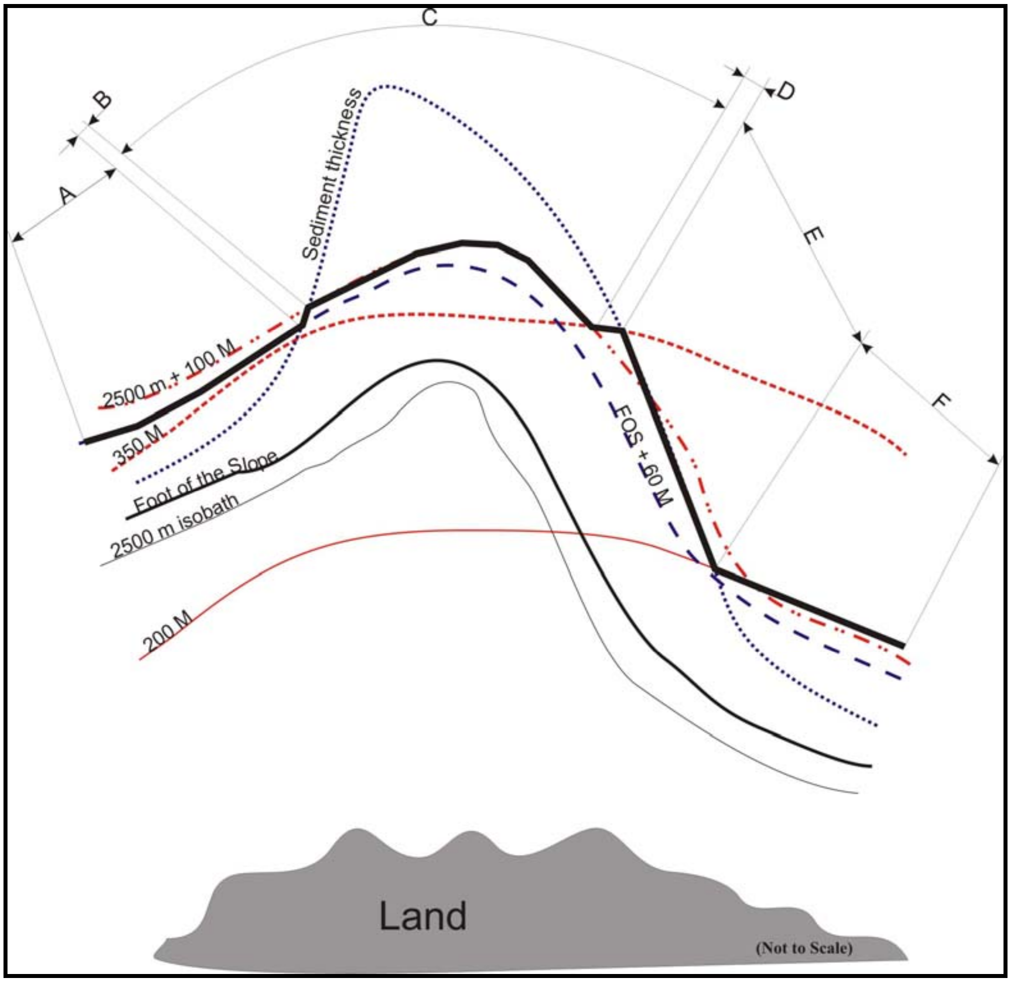

Figure 5: Illustration of the delineation of the outer limits of the continental shelf using the formulas of paragraph 4, the constraints of paragraph 5 and the general definition as given in paragraph 1.

A: The outer limit is delineated by the FOS + 60 M and constrained by the 2500 m + 100M limit
B: The outer limit is delineated by the sediment thickness line and constrained by 2500 + 100M limit
C: The outer limit is delineated by the 2500 m + 100M line as the sediment thickness line is beyond this limit.
D: The outer limit is delineated by the 350M line as the sediment thickness line is beyond this limit

E: The outer limit is delineated by the sediment thickness line and constrained by both the 2500 m + 100M and the 350M limits.

F: The outer limit is delineated by the 200M line as the FOS + 60M and the sediment thickness line lies within 200M

Paragraph 7

Paragraph 7 states that

> The coastal State shall delineate the outer limits of its continental shelf, where that shelf extends beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured, by straight lines not exceeding 60 nautical miles in length, connecting fixed points, defined by coordinates of latitude and longitude.

This paragraph allows the coastal State to join the fixed points delineating its outer limits of the continental shelf resulting from the application of the formulas cited in paragraph 3 by lines not exceeding 60 M in length. Smith and Taft, 2000, are of the opinion that the outer limits, through the application of paragraph 7 will not need to follow precisely particular features or follow all indentations in the features of the continental shelf.

Figure 6 illustrates the application of paragraph 7 in the delineation of the outer limits of the continental shelf.

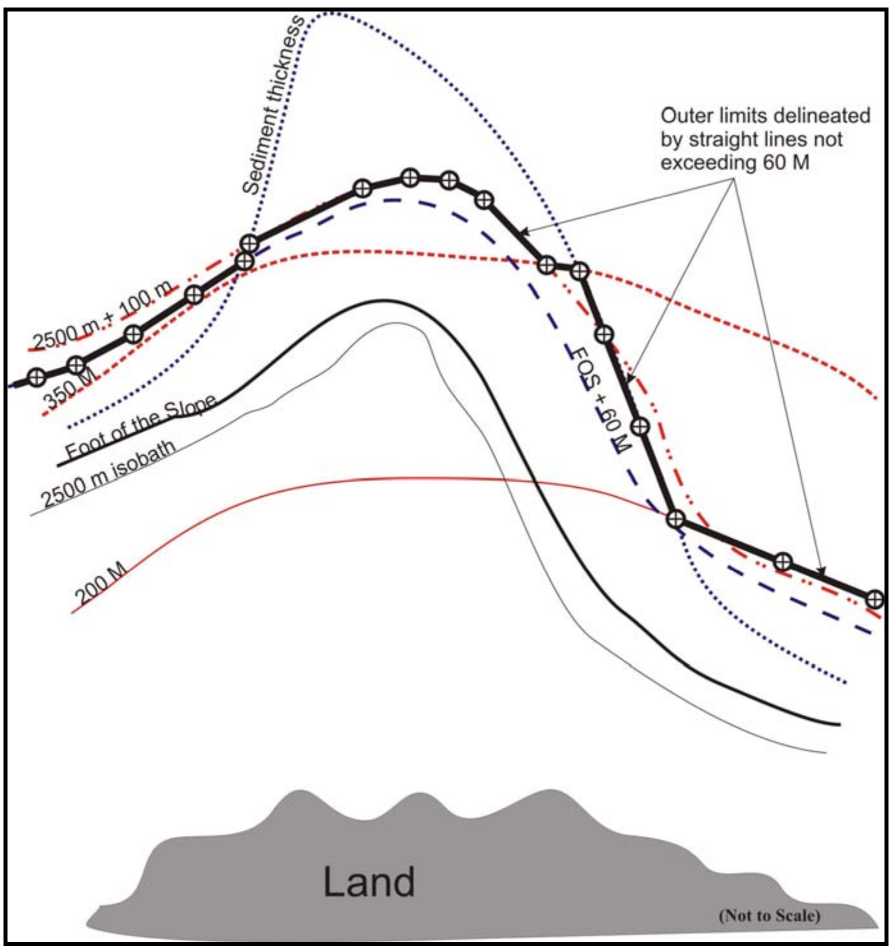

Figure 6: Illustration of the provision of paragraph 7 with the outer limits being delineated with straight lines not exceeding 60 M

Paragraph 8

Paragraph 8 states that

> Information on the limits of the continental shelf beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured shall be submitted by the coastal State to the Commission on the Limits of the Continental Shelf set up under Annex II on the basis of equitable geographical representation. The Commission shall make recommendations to coastal States on matters related to the establishment of the outer limits of their continental shelf. The limits of the shelf established by a coastal State on the basis of these recommendations shall be final and binding.

The Conference negotiators during the drafting of the Convention decided to create a Commission that would have recommendatory powers. It is good to point out that the Commission does not establish the outer limits of the continental shelf as this remains the function and responsibility of the coastal State. The Commission will make recommendations following the submission of information pertaining to the definition of the outer limits of the continental shelf by a coastal State. If the recommendations of the Commission are accepted by the coastal State, then the coastal State may establish the outer limits according to the recommendations of the Commission. These limits would be final and binding.

Paragraph 9

Paragraph 9 read as follows:

> The coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limits of its continental shelf. The Secretary-General shall give due publicity thereto.

This provision ensures that other States and institutions have access to information pertaining to the extent of the outer limits of the continental shelf of a coastal State. In addition to the relevant information to be submitted to the Secretary General of the United Nations, such as geodetic data, a coastal state shall also provide, according to article 83 and 84 charts of appropriate scale ascertaining the positions of the outer limits of the continental shelf or a list of geographical coordinates of those points.

Paragraph 10

Paragraph 10 states that

> The provisions of this article are without prejudice to the question of delimitation of the continental shelf between States with opposite or adjacent coasts.

The delimitation of the continental shelf between States with opposite or adjacent coasts are dealt with in article 83. The delimitation between coastal States should be effected by agreement on the basis of international law, as referred to in Article 38 of the Statute of the International Court of Justice, in order to achieve an equitable solution. The coastal States concerned should in a spirit of understanding and cooperation and pending an agreement, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation.

Annex II of the Convention

Annex II of the Convention elaborates the particulars of the Commission on the Limits of the Continental Shelf as provided for in article 76.

Article 4 of Annex II provides a time frame for a coastal State to make a submission to the Commission. According to the article, a coastal State which intends to establish, in accordance with article 76, the outer limits of the continental shelf beyond the 200 M, shall submit particulars of such limits to the Commission along with supporting scientific and technical data as soon as possible but in any case within 10 years of the entry into force of this Convention for that State.

As mentioned previously, the Convention entered into force on November 16, 1994, for those States which were already signatories to the Convention. This would give a deadline of November 15, 2004, for the submission of an extended continental shelf along with the supporting scientific and technical data, by those countries that have ratified the Convention prior to it entering into force. However, representations were made by States Parties, particularly developing States and small island developing States to the fact that significant resources, capacity and expertise were required to carry out the necessary activities such as the collection, collation and analysis of a large amount of bathymetric, seismic and geophysical data for the purpose of defining and submitting the outer limits of the continental shelf. The point was also made that a crucial theme of the Convention was that developing States should not, through lack of resources or capacity, be disadvantaged in respect of access to or use of their resources (SPLOS/73, United Nations Document, 2001). Further to discussions about the legality of extending the deadline or the commencement of the entry into force of the Convention, it was decided, through general agreement, for a State for which the Convention entered into force before 13 May 1999, the date of commencement of the 10-year time period for making submissions to the Commission shall be May 13, 1999. It is good to point that the date of May 13, 1999 is the date of the publication of the Scientific and Technical Guidelines of the Commission. This will thus give a deadline of May 12, 2009 for State Parties who have ratified the Convention before May 13, 1999.

The Foot of the Slope

The foot of the slope is one of the major features of article 76 that a coastal State needs to determine in view of preparing a submission for an extended continental shelf. It should be highlighted that both formulas mentioned in paragraph 4(a) of article 76 make use of the foot of continental slope as the starting point or point of reference. One may however ask, what is the foot of the continental slope or how may one determine to the foot of the continental slope. Paragraph 4(b) of article 76 provides a basic definition of the foot of the continental slope by stating ‘In the absence of evidence to the contrary, the foot of the continental slope shall be determined as the point of maximum change in the gradient at its base’. It is good to point that, from the Convention, only the point of the maximum change in the gradient at the base is required. There is no quantification of the gradients involved nor is there any specific depth associated to the foot of the continental slope. From the same paragraph, it is understood that the foot of the continental slope should be at the base or the deeper part of the slope. According to Carleton *et al*, 2000, the ‘evidence to the contrary’ is not defined, but appears that other arguments may be entertained that can overrule the morphometric gradient determination. They further add that there may not exist an exact foot of the slope and so coastal States need to look for a zone in which judgement must be applied to determine the most likely location of the feature which is taken to mark the edge of the continent.

The Commission is aware of the difficulties arising from the determination of the foot of the continental slope and the edge of the continental margin from a geological perspective. Continental crust is compositionally distinct from oceanic crust, but the boundary between these two crustal types may not be clearly defined. Simple subdivision of margins into shelf, slope and rise may not always exist owing to the variety of geological and geomorphological continental margin types resulting from different tectonic and geological settings (paragraph 6.2.4. of the Guidelines).

The Commission acknowledges that different scenarios might exist from which the general rule to locate the foot of the slope by means of the maximum change in the gradient at its base may be unsuccessful. In the case of irregular seabed topography, numerous local maxima might be revealed in the change of the gradient at the base of the continental slope and it is possible that the maximum *maximorum* may not be indicative of the location of its foot (paragraph 6.3.3. of the Guidelines). In such exceptional cases, geological and geophysical evidence may be introduced as an alternative for determining the location of the foot of the continental slope at its base.

Carleton *et al.*, 2000, acknowledge that determining of the foot of the slope can be quite challenging in some places. They provided an approach that may help detect and map the foot of the slope and these are given and briefly discussed below.

(a) Determining the change in slope from contour maps and/or profiles derived from them
Contoured bathymetric maps provide a layered or stepped view of the seafloor. The gradient from the contours can be determined by scaling the horizontal distance between them on the map and dividing that distance into the vertical distance depicted by the contour interval. On these maps, when the contours are closer together, means that there is a steep gradient, and so the foot of the slope should lie at the place where the closely spaced contours of the slope starts widening, as this depict the rise or the abyssal plain. It is very important that the foot of the slope can be determined to some degree of precision and consistency.

The major advantage of using contoured bathymetry maps is that they are readily available and are in widespread use for most continental margin. Some international series (e.g. GEBCO) have global coverage. On the other hand, locating the foot of the slope is limited by the contour interval selected by the map's author and this may have an uncertainty of the order of 10 M. The distribution of data over a map varies and so the contours are not of uniform quality. Contour maps are also vulnerable to interpretative bias in their construction and this may have for effect that the resulting foot of the slope line may have some degree of uncertainty.

(b) Selection of candidate foot of the slope points on profiles measured directly by echo-sounding and seismic profiling techniques
Echo sounders and seismic profilers produce a digital and/or analogue profile of the signal returned to them from the seafloor. This data can be used in conjunction with mathematical techniques or algorithm and some degree of human intervention such as visual inspection to pick changes in the slope and thus pick the foot of the slope. It should be pointed out that echograms usually provide continuous data, while digitized records are usually sampled over some fixed intervals. If these intervals are short, the effect of the sampling would be negligible, while if there is a big gap between the data, the resolution will be degraded.

The main advantage of using echograms and digital data is that the information is crude and has not been subject to any filtering and/or smoothing. The disadvantage is that the data has been collected, in most cases, at random following ship tracks, without prior knowledge of the slope and for the purpose of computing the foot of the slope, the profile should be perpendicular to the slope. The resolving power of the instruments used should be given due consideration and depending on the beam width, smaller features might be masked.

(c) Production of slope maps from multibeam surveys

The main advantage of using data from multibeam surveys is that they provide complete coverage of the area. The foot of the slope will be apparent in some places while at other place, different techniques might be used to determine its location. Multibeam data could also ensure that the identified feature is indeed the break in the slope and could confirm that it is continuous.

The main disadvantage of using such data is that there is not yet an extensive coverage available on a worldwide scale. These data should be collected from ships and multibeam data are expensive to collect and process. Another disadvantage is that multibeam data at times can be too detailed and or localized and so making the determination of the foot of the slope difficult.

(d) Use statistical techniques based on raw sounding, on gridded data, or on contour maps.

Mathematical and statistical techniques can be used to determine the foot of the slope as the sounding are numerical values and can form the basic data. The data should be arranged spatially such that a regular grid of derived water depth values is created. In the computation of the grid, several factors need to be taken into consideration such as the density of the data, the contribution of distance from grid point to real soundings, isolation or clustering of data points and the curve fitting method to be used to real soundings and candidate grid point. Grids can also be constructed from contour maps, in such cases, the contour values will be used rather than the actual sounding.

The construction of the grid sizes should be in relation to the density of the actual soundings. Grid size must be selected with care, based on what the data will support while at the same time minimizing the risk of introducing false wavelength (or aliasing).

The principal advantage is that they can be applied in instances where no other approach offers much chances of success, either because data is too sparse or else there is no discernible foot of the slope within the area being studied, for example in region with rough seafloor. Carleton *et al.*, 2000, are of the opinion that statistical techniques do not usually give exact values and do not give the impression of producing good results and these may make their acceptance by the Commission problematic, despite the fact that they can be very powerful devices in situations where other methods have proved unsatisfactory.

Sediment Thickness

Paragraph 4(a)(i) of article 76 states that the outer edge of the continental margin shall be identified by a line delineated at the outermost fixed points where the thickness of the sedimentary rocks is at least 1% of the shortest distance from such point to the foot of the continental slope. In the practical implementation of this paragraph, a coastal State will require information on (a) the variation in the sediment thickness seaward of the foot of the slope and (b) the distance of the closest portion of the foot of slope line at each of the points at which the sediment thickness is known.

The conventional rock type classification separates sedimentary rocks, example those derived from physical and chemical weathering and transportation or from biological processes, from igneous rocks of intrusive and extrusive origin and metamorphic rocks which are originally igneous or sedimentary rocks that were subsequently changed by the effect of temperature or pressure or both. The deposition of sedimentary rocks on the seafloor in the vicinity of the foot of the slope may be significantly different from that of the classical oceanward-thinning wedge sequence. The geological processes which contribute to the deposition of sedimentary section is complex and relies on several factors such as morphology of the oceanic basement surface, the rate of supply of sediment, the stability of the margin and the degree of stability of the bottom current system.

The most accurate method of determining of total sediment thickness is to drill deep enough to reach the basement and directly measure sediment layers and the depth of the top of the basement. However, a deep borehole is very expensive and in offshore areas, closely spaced drilling is almost unthinkable expect for production well. The majority of data on sediment thickness are based on seismic reflection profiles. To convert the reflection time collected in the seismic reflection profiles into depth or thickness of sediment layers, it is necessary to know the average velocities of the formation lying between the various reflecting interfaces. Velocity information is mainly obtained by the velocity analysis of the multi-channel seismic reflection data. Prior to the determination of sediment thickness, identification of the sediment/basement interface is required. Basement may be identified either qualitatively, according to its character on seismic reflection records, or quantitatively, according to the velocity with which the seismic waves travel within it (Kasuga *et al.* 2000).

The Commission acknowledge, through paragraph 8.1.4. of the Guidelines, that a series of technical issues might arise during the implementation of paragraph 4(a)(i). These issues would relate the identification of the sediment/basement interface, the calculation of sediment thickness and the variability of the sediment distribution. The Commission further gives their understanding of the term sediment thickness as used in the Convention. The sediment thickness at any location on the continental margin is the vertical distance from the sea floor to the top of the basement at the base of the sediments, regardless of the slope of the sea floor or the slope of the top basement surface (paragraph 8.1.8. of the Guidelines). The measurement and determination of the sediment thickness would require the application of methods to establish the position and shape of the seabed relative to the top of the basement. The most relevant combined data sets for these purposes are those derived from bathymetric and seismic reflection and refraction measurements. The calculation of the vertical distance between the basement and seabed surfaces involves the conversion of the two-way travel times of the seismic wavelet in depth in meters (paragraph 8.1.10. of the Guidelines).

A practical procedure in the determination of sediment thickness over the basement involves three steps.

(a) The production of contour map of two-way travel time to each sedimentary horizon and velocity contour maps and depths conversion.
(b) The production of a contour map of average velocities between formations, which is in general derived from stacking velocities available along the seismic lines
(c) Undertake the depth conversion in which the two-way travel time map is converted into a depth map, using the average velocity distribution of each layer over the area.

Once maps of two-way travel time to various horizons and average velocities between the formations are established, depth values or isopach maps contoured in meters instead of two-way travel time in seconds can be constructed by multiplying travel times and velocities. Depth conversion should be carried out in such a way as to ensure consistency of values at line ties and near wells. Total thickness of sediment layer over the basement is established by integrating the thickness of each layer. In practice the amount of computation required is formidable, if several horizons are to be mapped over large areas.

The basement of the sediment wedge can be oceanic, continental or a combination of both. In the simplest cases, the sediments of the rise rest on oceanic basement all the way from the foot of the continental slope. The oceanic basement generally forms at an oceanic spreading ridge and consists of a peridotitic and gabbroic root complex, an intermediate zone of basaltic dyke intrusions and a thick series of submarine basalt lavas on top. Normally the formation of oceanic crust at the spreading ridge is in the range of a few centimetres per year in an environment of moderate sediment input. This means that it is possible to regard to top to the uppermost lava flow as the top of the basement (paragraph 8.2.15. of the Guidelines).

The top of the oceanic and continental basements represents a sharp increase in seismic velocities and gives high acoustic impedance contrast relative to the overlying sediments. Much of the energy will be reflected from this surface, and the penetration of energy into the underlying basement is significantly reduced. This result in a very low signal-to-noise ratio of the energy reflected within the basement and the internal signature of the basement will be that of random noise. Hence, on a seismic reflection profile, the top of the basement will stand out as a prominent reflector between the well-defined reflectors of an overlying bedded sedimentary sequence and an underlying, high velocity ‘noisy’ section of the basement (paragraph 8.2.17. of the Guidelines).

Methods for the Computation of the Foot of the Slope

The Commission has made it clear as to how the foot of the slope should be determined through the paragraph 5.4.7. of the Guidelines which state that the determination of the location of the points of maximum change in the gradient at the base of the continental slope will be conducted by means of the mathematical analyses of two-dimensional profiles, three-dimensional bathymetric models and preferably both. Methods of purely visual perception of bathymetric data will not be accepted by the Commission.

The purely mathematical method can be envisaged by a coastal State in the preparation of a submission for an extension of the continental shelf. The pure mathematical approach assumes that all that can ever be known about the real world surface being mapped is contained in the data points of the type being modelled. However, it will be rare that such a mathematical model would be able to incorporate different types of data. As an example, a mathematical model for the foot of the slope will probably be based on the soundings only and not on sediment data which may be just as important. Furthermore, the model would assume that the data is sufficient to describe the real world and that the phenomenon is continuous between data points (Monahan, 2003).

In practice and during the preparation of a submission for an extended continental shelf, there would be both the mathematical techniques and the visual perception that would be used in order to determine the foot of the slope. Even though visual perception cannot be used on its own for the determination of the foot of the slope, nothing prevent a coastal State to use partly some mathematical techniques and also some visual interpretation in view of arriving to results which would maximize the jurisdiction of the coastal State. However, the point chosen as the foot of the slope should be a point at which the change in gradient is a maximum, even though it is a local maximum and not necessarily the maximum *maximorum* as stipulated in paragraph 6.3.3. of the Guidelines. The techniques used along with the detailed mathematical algorithm in determining the foot of the slope should be provided to the Commission.

The simplest mathematical approach that is commonly used is the regression analysis where curves, of known characteristics, are fitted to the data points. A general approach to this mathematical analysis would be to fit a variety of curves to the data points and determine the best fit mathematically and the curve that offers the best degree of explanation of the object being studied. With the curve being represented by a mathematical formula, it is possible to find the gradient or slope of that curve. The gradient would be the first derivative of the mathematical formula. Since it is the maximum change in the gradient that is required under the Convention, then by finding the second derivative of the mathematical formula representing the curve, and thus the data points representing the continental slope, one would satisfy the requirement of the Convention. Ideally, it would be expected that the results of the second derivative would provide a single maximum or peak which would represent the foot of the slope. However, this would very rarely be the case as the resulting second derivative would most likely contain several local maximum or peaks. Even the maximum *maximorum* as highlighted in paragraph 6.3.3. of the Guidelines may not be indicative of the foot of slope. It is the opinion of the present author that it is at this stage that the visual perception and human intervention and interpretation should come into play to finalise the foot of the slope that would maximize the submission for an extended continental shelf for a coastal State. The human intervention and visual interpretation part would most likely be limited to choosing which of the local maximum satisfies the other requirements of the Convention and thus to be used as representing the foot of the slope. It should be reminded that both geological and geophysical data may be used in conjunction with the gradient of the slope in view of better assessing the relevance of the local maximum and in identifying the foot of the slope.

The Commission will not prescribe the use of a single mathematical methodology based on the bathymetric data for the identification of the region defined as base of the continental slope. It will make recommendations based on the mathematical methodology applied on a case-by-case basis, and in view of all other geological and geophysical evidence presented by the coastal State (paragraph 5.4.3. of the Guidelines). The methodology used to determine the foot of the continental slope by means of the point of maximum change in the gradient at its base can be regarded also as a two- or three-dimensional problem. This mathematical methodology has some similarities to the second derivative technique employed in the enhancement of potential field maps produced routinely in gravity and magnetic geophysical prospecting. The Commission recognizes the usefulness and complementarity of the use of both two- or three-dimensional approaches (paragraph 5.4.1. of the Guidelines).

The determination of the location of the point of maximum change in the gradient was envisaged originally as a two-dimensional problem based on the mathematical analyses of the two-dimensional bathymetric profiles. This methodology is acceptable to the Commission with the provision that their three-dimensional location on a bathymetric map or nautical chart is provided at all times. The Commission recommends that the orientation of this profile be such that it runs in a perpendicular direction to the isobaths located at the point of maximum change in the gradient at the base of the continental slope (paragraph 5.4.8. of the Guidelines).

The mathematical analysis of the two-dimensional bathymetric profiles is a very simple way of finding the foot of the slope. Simple mathematical programs can be written to undertake such analysis in view of determining the foot of the slope. The data points representing the bathymetry of the profile can be fitted with curves or else with a spline function (de Boor, 1978) and the first and second derivatives can be computed. Other method of computing the second derivative using numerical techniques such as the difference method can provide satisfactory results in the search of the foot of the slope (Persand, 2005).

There have been several attempts to develop other mathematical methods of fitting surfaces that would produce the foot of the slope. The second derivative can also be derived in three-dimension. Hughes Clarke, 2000, calculated the surface of the second derivative through several thousand points. Vanicek et al., 1994, used least square to fit surfaces of various orders to sounding data. Bennett, 1998, used maximum curvature applied to a smoothed ETOPO 5 grid. Other methods have no doubt been developed but not yet published.

Data Inventory

A coastal State should begin the implementation of article 76 by assembling and reviewing all available information that is relevant for determining the outer limit of the continental shelf. Data compilation activities tend to be labour intensive and the amount of time needed for their successful execution depends to a large extent upon the quantity and condition of the data sets, the skill and experience of the compilation staff and the data handling facilities at their disposal. However, almost any data compilation of existing data will turn out to be less expensive than mobilizing and executing a field program for collecting new data.

It is likely that the data sources would be dispersed across many bodies and organizations involved in their collection, analysis and custodianship. National and historical practices have resulted in a significant difference between the responsibilities and therefore data holdings of otherwise similar organizations. Many valuable data continue to reside with individual researchers in universities, research laboratories, military establishments, libraries and private collection from where they are normally unavailable other than through personal or chance connections (Holcombe and Moore, 2000).

Two types of information dominate the needs of addressing article 76: bathymetric and sediment thickness data. Bathymetric information is the basis for determining the foot of the continental slope and the 2500 m isobath, both of which parameters are specifically mentioned in article 76.

A typical bathymetric compilation would include the following general tasks (Holcombe and Moore, 2000):

- Identification and accumulation of all relevant sounding data within and adjacent to the study region
- Assessment of the general quality of these data sets, including the accuracy of positioning
- Conversion, where warranted, of analogue records to digital form
- Incorporation of all digital data sets into an efficient data management system
- Construction of plots to portray, at appropriate scales and projections, the distribution of observations within the study area
- Correction of obvious data errors and elimination of bad data sets

- Reduction of all data observations to a consistent set of processing parameters (velocity of sound in seawater, seasonal variation of sound velocity)

Sediment thickness information is needed if a coastal State wishes to invoke paragraph 4(a)(i) of article 76 which permits the definition of the outer limits of the continental shelf as the location at which the thickness of sedimentary rock is equal to 1% of the distance back to the foot of the slope.

A typical compilation for sediment thickness data would include the following general activities (Holcombe and Moore, 2000).

- Identification, accumulation, evaluation and cataloguing of all reflection records within and adjacent to the study area
- Assemble, evaluation and cataloguing of all available velocity-depth profiles from the study area
- Analysis and interpretation of reflection records to identify the base of sedimentary material
- Conversion of observations of two way travel times to true depths on selected seismic reflection records
- Construction of plots to portray, at appropriate scales and projections, the distribution of reflection observations and velocity-depth profiles within the study area.
- Construction of maps portraying the thickness of sedimentary materials.

These compilations of data will provide a coastal State with the basic information of what is already available and will assist in identifying the type, quality and extent of the new data that would be required. Moreover, planning of field surveys for data collection would be intricately linked to this data compilation.

Bathymetric Data

Bathymetric data are needed to derive the morphological criteria that define the extent of the juridical continental shelf. Article 76 contains two features that directly relate to the depths and they are the ‘foot of the slope’ and the 2500 m contour. Bathymetric data are required for depth ranging from 200 m to over 5000 m so as to satisfy the demands of the Convention. Shallower depths are useful for demonstrating the morphology of the physical continental shelf but do not bear any relevance in the delineation of the juridical continental shelf boundaries, other than where they are required to establish the baselines. The Commission makes it clear that only bathymetric information will be used to determine the location of the point of maximum change in the gradient at the base of the continental slope (paragraph 5.2.1. of the Guidelines).

The Commission will require a full technical description of the bathymetric database used in the implementation of the article 76. It will also determine the relative value from each of these sources of data in a manner that is consistent with that applied to the determination of the 2500 m isobath. The Commission will also consider as admissible evidence synthetic bathymetric data produced in the form of grids and profiles derived from cartographic and analogue sources officially recognized by the coastal State. These cartographic and analogue sources may only be based, in turn, on a combination of the bathymetric measurements as listed below. Synthetic bathymetric data will have to be accompanied by a detailed and complete technical description of the method applied and the bathymetric measurements used to produce the cartographic and analogue sources from which it stems (paragraph 5.2.4. of the Guidelines).

Data Sources

Several methods exist for deriving bathymetry amongst which the most widely used is the sonar. Airborne electromagnetic methods (for example electromagnetic induction, red-green lasers and inversion of sea surface radar) can rarely determine depth in excess of 40 m. The only other potentially useful method for deriving deeper water bathymetry is through the inversion of sea surface altimetry obtained from satellites.

The Commission states, through paragraph 5.2.2. of the Guidelines, that the bathymetric database used in the delineation of the foot of the slope in a submission may include only one, or a combination of the following data:

- Single-beam echo sounding measurements
- Multi-beam echo sounding measurements
- Hybrid side-scan sonar measurements
- Interferometric side-scan sonar measurements; and
- Seismic reflection-derived bathymetric measurements.

A brief of the different methods for measuring the bathymetry is given below and has been adapted from Hughes Clarke, 2000. For more detailed discussions on the measurements of bathymetry, the paper of Hughes Clarke, 2000 is recommended as well as that of Shipman and Laughton, 2000, and Monahan, 2000.

Single beam sounding

The majority of historic bathymetry has been collected using the single-beam sounding approach, however this method has three critical limitations which are:

1. Incomplete coverage
2. Uncertainty about the exact location of the first arrival of the acoustic pulse and
3. distortion of short-wavelength topography

Better methods have been devised to project the acoustic energy both within narrower solid angles and while deriving this information over angular sectors extending further out from the side of the survey vessel. This has the added advantages of giving a more complete coverage, better echo location and higher spatial resolutions.

Sidescan sonar

The sidescan sonar projects and receives the acoustic energy only within a narrow azimuth range. The time series of backscattered energy after the first arrival can be used to infer changes in either the topography or the lithology of the seafloor. The horizontal bearing and the slant range of the echo are confidently known, however no distinction can be made for echoes that are coming from different elevation angles and so the use of two separate arrays mounted facing in opposite direction so as to minimize the sensitivity of the echoes coming from the opposite sides. Sidescan sonar operates at discrete frequency bands for each side. The fluctuations in the backscatter strength can be qualitatively interpreted for changes in the seabed slope or changes in the seabed material. For the purpose of the Convention, the sidescan can suggest the strike and extent of abrupt depth changes seen in 2-D profiles obtained from single beam echosounder at nadir. However, sidescan images provide no quantitative information that can be used to directly support the claim of the location of relevant topographic features without further surveying.

Interferometric sonar

Interferometric sonar has the advantage that the elevation angle information is completely contained in the received backscattered signal. Thus, no extra phase information needs to be measured. However the interferometric sonar has the following limitations and uncertainties:

- It is difficult to distinguish an interference pattern from rapidly varying seabed backscatter strength
- It is difficult to confidently relate a particular null to a specific interference lobe
- Elevation angles can only be estimated as frequently as the angular spacing of the fringes
- Because of the broad receive beam pattern, there is no ability to distinguish between echoes coming from differing directions at the same time.

To get around the problem of simultaneous echoes from different direction and since the receive beam is sensitive only within a narrow angle of elevation angles, an alternative approach to measuring the elevation angle and making use of narrow beams is required. The multiple narrow beam method is very similar to the sidescan with the important difference that because the receive beams are steered across track and are discriminating in elevation angle, the transmit beam can be used for port and starboard. Using beam steering, multiple, simultaneous receive channels are formed at discrete angular sectors to discriminate time of arrival from the seafloor echo within narrow but finite solid angles. The multi beam sonar can obtain simultaneously echoes from differing directions because of separate angular discrimination for each of the narrow athwartship (across-ship) beam.

Multibeam sounding

The multibeam bathymetry has the advantage of being more accurate system for the purpose of determining the depth. However given that it is attached to the hull of a vessel, it is prone to errors arising from the motion of the vessel (roll, yaw and pitch) and also from high signal to noise ratio by being near the sea surface.

For accurate depth measurement, a number of effects and measures need to be taken into consideration such as:

- The positioning of the sensor and vessel
- The instrument orientation
- The effect of acoustic propagation in the ocean.
- The horizontal and vertical resolution
- The areal coverage provided by the sensors

Altimetry

Another way of determining depth is through bathymetry derived from sea surface satellite altimetry data. The approach combines existing historic soundings collected over the past 30 years and with high resolution marine gravity information provided by the GEOSAT, ERS 1,ERS 2, and TOPEX/ POSEIDON altimeters. The approach was to use the sparse depth soundings to constrain the long-wavelength depth variations while the shorter-wavelength topography is predicted from downward-continued satellite gravity measurement. Over the short-wavelength band, the topography-to-gravity ratio is regionally calibrated using available soundings. This method relies on a number of underlying assumptions or simplifications about the density structure of the seafloor and underlying crust and mantle. These assumptions are most easily violated as one move from relatively uniform oceanic crust onto highly homogeneous continental crust and its margin. Unfortunately, it is in these regions that bathymetric data are most required for the purpose of the Convention.

Geological and Geophysical data

Geophysical surveys, using seismic techniques, have been extensively used for mapping of subsurface geological structures. In seismic surveys, seismic waves are generated by near-surface artificial explosion at a series of sites, the resulting waves are then recorded digitally and as an analogue record. The regional geological structure and sediment thickness can then be deduced from analysis of the travel times of identifiable wave groups.

The Commission will regard data provided by seismic reflection and seismic refraction surveys as the primary source of evidence for mapping and determining the sediment thickness. Gravimetric and magnetic data may be provided at all times as complementary sources of evidence. These complementary forms of evidence are particularly relevant in instances where only a non-comprehensive seismic database may not be available (paragraph 8.2.1. of the Guidelines).

Numerous specialised geological or geophysical papers deal with data acquisition, processing and analysis in these particular fields. Only a brief on the different methods has been given in this present paper and the material has been adapted mostly from Kasuga *et al.*, 2000.

Seismic reflection survey

Seismic reflection surveys have been extensively used for mapping structures in sedimentary sequences, especially as part of exploration programs for oil and gas. Two seismic reflection methods are widely used, single-channel and multi-channel seismic profiling systems. Although the former typically used an analogue recording system with a single receiver, digital recording is now commonly employed. The single-channel method is often employed during shallow reconnaissance exploration or in offshore engineering surveys because it is relatively cheap. This advantage of the single-channel system is countered by the fact that the maximum depth of penetration of the single-channel system is rather shallow and it does not give information on the deep geological structure or on the seismic velocity of the sedimentary layers.

The multi-channel method is characterized by digital recording and multiple receivers in a long multi-channel streamer cable. Most marine seismic reflection profiling has now shifted from analogue single-channel data to digital recording of multi-channel data, largely because digital recording and processing of large amounts of data improve the signal to noise ratio and provide high quality seismic records.

Multi-channel reflection data form a much more comprehensive source of evidence than data collected by means of single-channel techniques. The overall greater quality and penetration of these multi-channel data offer many advantages for the delineation of the outer edge of the continental margin. Single-channel data are generally of poorer quality, shallower and without velocity information. They are less valuable and often are very randomly distributed (paragraph 8.2.3. of the Guidelines). The Commission will regard multi-channel reflection data as the most authoritative source of evidence for the determination of sediment thickness. Single-channel reflection data may also be provided at all times by coastal States as supplementary source of evidence (paragraph 8.2.4. of the Guidelines).

Seismic refraction survey

The marine seismic reflection method uses near-vertical reflected waves to determine reflectors in the crust. In contrast, the refraction method uses mostly horizontally propagated waves to accurately determine apparent velocity. In a reflection survey, the reflected signal is measured as a function of vertical travel time for a round trip from source to reflector to receiver. In a refraction survey, the arrival time of waves is measured as a function of distance from the source. Seismic refraction surveying is an effective method for obtaining information on the deep structures and seismic velocities of deep layers. On the other hand, reflection surveys have advantages in the acquisition of detailed shallower crust and in the detection of horizontal heterogeneity.

The refraction profile is obtained using the two-ship technique, where one ship provides the controlled explosive sources and the other records seismic signals via towed hydrophones sensors with pressure detectors. Since the 1960s, ocean bottom seismographs (OBS) and/or ocean bottom hydrophones (OBH) have been employed as receivers in refraction surveys, instead of the hydrophone towed beneath the surface.

Seismic refraction methods, including wide-angle reflection methods, give information on the transmission velocities and the nature of subsurface rock layers. The two main features of the wide angle method are that

(a) it employs rather low frequency sources
(b) the seismic rays are projected obliquely through the geological structures.

The low frequencies allow good penetration. The oblique angles allow the detection and measurement of velocity gradient zones as well as the more abrupt changes, which show up well on reflection profiles. In typical marine wide-angle reflection surveys on continental margins, the recording stations, ocean bottom seismographs, are placed typically 5 km to 10 km apart, providing a corresponding moderate accuracy of the ray trace modelling solutions, velocity and depths estimates. Full details of the sources of the data and the processing methods utilized are required in order to determine the validity of the interpretation presented (paragraph 8.2.7. of the Guidelines).

Planning a seismic survey to determine sediment thickness

The most practical and most efficient way to determine the thickness of sediments involves a combination of seismic reflection surveys, refraction surveys and if possible, down-hole seismic surveys. An economical and effective way to determine sediment thickness over a wide area may be to conduct different kinds of seismic surveys at various stages, first utilizing inexpensive methods for reconnaissance survey, and then proceeding to more costly and time consuming surveys for relatively limited and important areas.

Stage 1: Reconnaissance mapping of the subsurface

Broad-scale single-channel seismic reflection profiling in previously unexplored areas is one of the economical ways to obtain an overall picture of the distribution of sediments and determine where thick sedimentary sequences are located.

Stage 2: Estimation of sediment thickness at selected profile in areas of particular interest

Multi-channel seismic reflection profiling may be undertaken in key areas to provide more accurate information on sediment thickness. Refraction surveys or wide-angle reflection surveys are effective for determining velocities of the very deep and thick sedimentary sequences. The simultaneous implementation of multi-channel reflection surveys and refraction surveys using the same survey ship is an effective method for these areas.

Stage 3: Gathering more accurate information on sediment thickness at a key location

If deep drill holes are available in the survey area, down-hole seismic surveys using well-shooting and continuous velocity logging are very useful for determining the precise velocities of each sediment layer and for providing and accurate overall assessment of sediment thickness at selected points.

Coring

Cores and samples provide evidence of sediment or rock type and supply material for a variety of studies that include sedimentological and geochemical analyses, radiometric age determination, paleontological age, environment of deposition, postdepositional history, paleomagnetism and geotechnical properties. Individually or collectively, these various parameters can be used as basis for determining which provisions of the Convention can be applied, depending on whether the seafloor has continental or oceanic characteristics.

There are several types of corer that exist and which are used for the qualitative analysis of the sediment, but only a few can be used for the purpose of determining the sediment thickness. Powered corers would be better suited for such purposes. Coring can also be carried out from drillships. One such drillship, the Glomar Challenger, was used for the Deep Sea Drilling Program in the 1960s and for the Ocean Drilling Program. The drillship can core in water depths of 6500 m and to depths below seabed of 2500 m (Ardus *et al.*, 2000).

Filtering and Smoothing

The commission recognizes that filtering and smoothing of bathymetric data might be required in order to facilitate the identification of the location of the foot of the continental slope at the point of maximum change in the gradient at its base. This procedure might be required in some instances because the use of the second derivatives of the bathymetric surface produces an enhancement of all features which may obscure the exact location of the foot of the slope (paragraph 5.3.1. of the Guidelines).

The Commission defines filtering in signal theory as the differentiation between signal and noise, which is to be regarded as wanted or unwanted information. Filtering is usually applied to regularly spaced data and since bathymetric data is rarely collected in the field at equally spaced intervals, the Commission acknowledge that a coastal State might produce a regularly spaced data set from the irregularly spaced data. However, the Commission will pay close attention to the methodology employed in producing the regularly spaced data set and might request the original irregularly spaced data, details about the mathematical techniques employed and the output comprised of regularly spaced data (paragraph 5.3.3. of the Guidelines). Moreover, the Commission will pay special attention to the admittance function of the filters used in the wavelength or wave number domain which might be applied to two dimensional bathymetric profiles and three dimensional bathymetric surfaces (paragraph 5.3.4. of the Guidelines).

The Commission makes it clear that they will not accept the artificial amplification or enhancement of any information at wavelength at which the bathymetric information can be decomposed. Only the removal of unwanted noise at wavelength shorter than those relevant to the description of the shelf, the slope and the rise will be regarded as admissible (paragraph 5.3.5. of the Guidelines).

The Commission defines smoothing as an empirical procedure which might have an important role to play in facilitating the identification of the main features of the continental margin (paragraph 5.3.6. of the Guidelines). The Commission is aware that the full array of empirical data smoothing techniques is vast. The Commission will remain open to considering the application of any smoothing technique, but will examine closely the proper application of each one in this context. The Commission might require fill disclosure of the original data, the mathematical details of the smoothing algorithm and the output data (paragraph 5.3.7. of the Guidelines).

Geodetic Issues

In a submission for an extended Continental Shelf under article 76 of the Convention, coastal States need to establish baseline, locations of specific points, distances and water depth with a high degree of accuracy. The measurement and calculations relating to position on the surface of the earth, the geodetic principles underlying the concepts of coordinates and their reference systems, and the level of accuracy with which positions can be determined will be addressed briefly in the following paragraphs. For a more detailed discussion on the subject, the paper of Dodson and Moore, 2000, was found to be appropriate and much from what follows was adapted from the paper.

Coordinate Systems

Astronomical coordinates

When using astronomical coordinates, we need to define the astronomical latitude and longitude (ϕA and λA) and for that it is necessary to specify an equator and a zero meridian (see figure 7). The equator is a plane perpendicular to the spin axis of the Earth and passing through the Earth's centre of mass. The zero meridian is an arbitrary reference plane which contain the spin axis. The astronomical latitude of a point is given by the angle between the vertical at that point and the equatorial plane. The astronomical meridian is defined as the plane passing through the vertical at a point and to the spin axis of the Earth. This given definition is an oversimplified version and the following need to be considered.

(a) The instantaneous axis of the Earth is not fixed with respect to the solid mass of the earth but is in a state of continuous motion known as polar motion.

(b) The zero meridian does not pass through a particular point at Greenwich but is defined as the mean value of the adopted longitudes of a number of observatories around the world.

(c) Unlike Geodetic latitude and longitude, they are not proper measures of position on Earth, but indications of the inclination of the direction of the local vertical with respect to the instantaneous axis of rotation of the Earth and the International Earth Rotation Service zero longitude respectively.

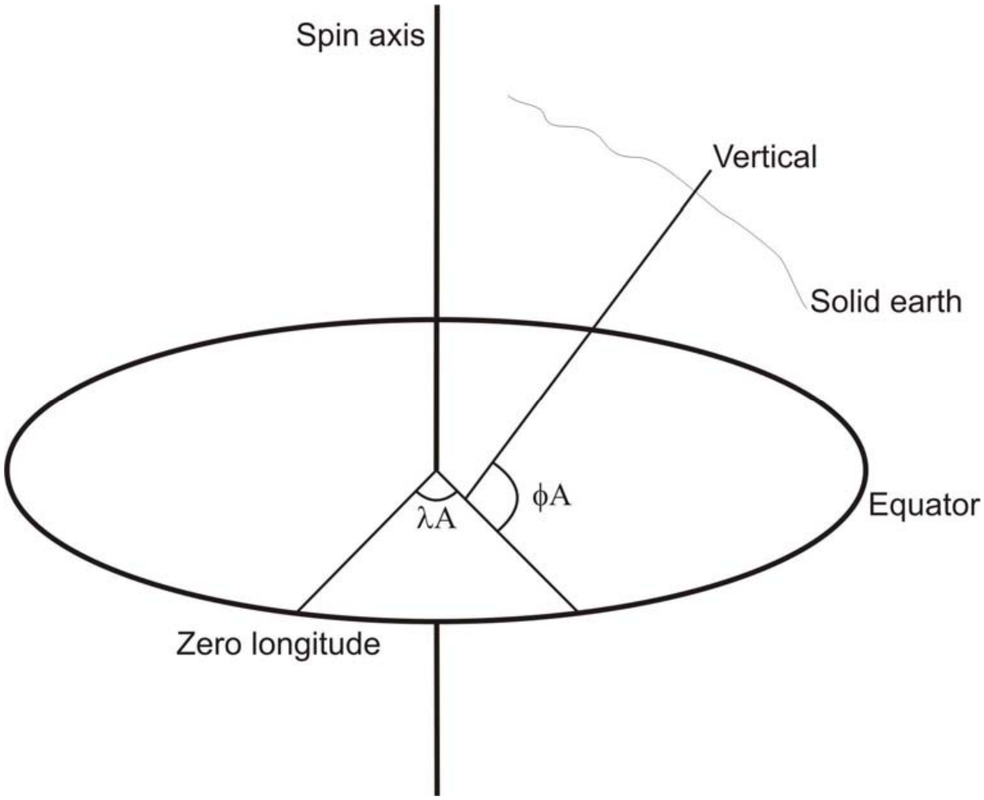

Figure 7: Astronomical coordinates, adapted from Dodson and Moore 2000

Geodetic (Ellipsoidal) coordinates

The geodetic position of a point on Earth is defined by the ellipsoidal coordinates of the projection of this point on to the surface of a reference ellipsoid, along the normal ellipsoid. Geodetic latitude (ϕG) is defined as the inclination of the normal to the ellipsoidal equatorial plane, and geodetic meridian as the plane through the normal and the minor axis of the reference ellipsoid. The geodetic longitude (λG) of a point is the angle between the geodetic meridonal plane and the arbitrary zero meridian (see figure 8).

No two projection points on the reference ellipsoid may have identical geodetic coordinates which is different from the astronomical coordinates. Mathematical formulas can be developed to compute the distances and azimuth between two points whose geodetic (ellipsoidal) coordinates are known. It is good to point that an ellipsoid of rotation is used as the geodetic reference surface as it is the closets regular geometrical shape to represent the figure of the Earth.

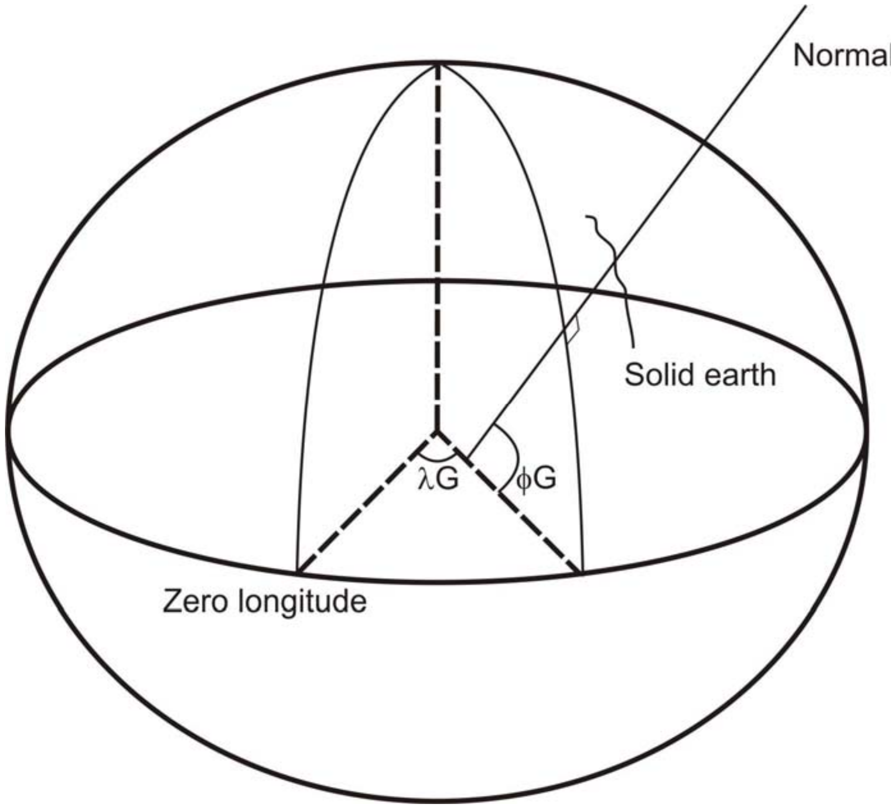

Figure 8: Geodetic (Ellipsoidal) coordinates, adapted from Dodson and Moore 2000

Cartesian coordinates

A more useful and more popular alternative to using the angular measurements of latitude and longitude is to describe the position of a point, or indeed above or below the Earth's surface in terms of Cartesian coordinates. Conventionally, the axes form a left hand triad; with the Z-axis in the direction perpendicular to the equator, the X-axis in the direction of the zero meridian and the Y-axis perpendicular to the other two (see figure 9). The origin of such a Cartesian system may be either the centre of the associated reference ellipsoid or the implied mass centre of the Earth (geocentric Cartesian coordinates).

The greatest advantage of the Cartesian coordinate system is that it is completely defined by the direction of the three axes and the position of the origin without the complications of the reference ellipsoid and projection grids. However, the simplicity of the concept of this system of coordinates is not matched by the convenience of use.

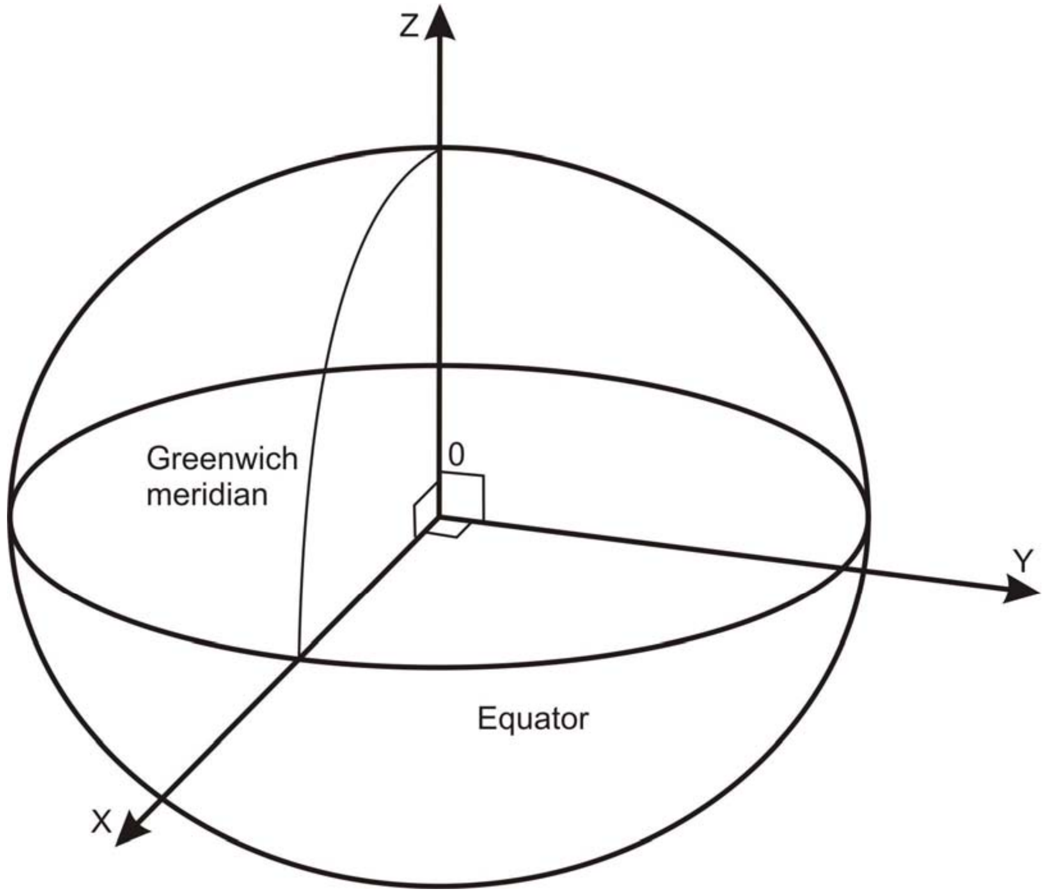

Figure 9: Cartesian coordinates, adapted from Dodson and Moore 2000

Datum transformations

A multitude of both local and global datums exist and are in use around the world. It is almost common practice to transform coordinates from one datum to another. A number of procedures are available for performing coordinate transformation. The merits and drawbacks of the available techniques should be considered with respect to accuracy requirements and computational simplicity. Of the many techniques used for datum transformation, three formulas are worth considering namely the Helmert transformations, the Molodenskii formulas and the Multiple-Regression formulas.

Distance determination

Article 76 requires the delineation of outer limits in terms of distances from the baselines from which the breadth of the territorial sea is measured. Where such distances exceed 200 M, the delineation is to be by straight lines not exceeding 60 M in length connecting the fixed points, defined by coordinates of latitude and longitude. It is also required that the coastal State shall deposit with the Secretary-General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limits of its continental shelf.

These requirements necessitate an understanding of the definition of latitude and longitude and geodetic datums and also the definitions of units such as the meter and the nautical mile and also of what constitute a straight line.

The Guidelines, through paragraph 3.2.1., state that the current international definition of the meter as that used in the Convention is the definition adopted by the Conference Générale des

Poids et Mesures of 1983. This defines the meter as the length of the path travelled by light in a vacuum during a time interval of (1/299792458) of a second, noting that this value is the reciprocal of the accepted value for the speed of light in a vacuum. The same paragraph in the Guidelines, states that the international nautical mile is a unit of length defined by the identity 1M = 1852 m following the proposal adopted by the International Hydrographic Bureau.

The Commission, though paragraph 3.2.9. acknowledges the convergence of two separate realisations of an International Terrestrial Reference System (ITRS) into a single international Standard. One of the realisations is the International Terrestrial Reference Frames (ITRF94) recommended by the International Union of Geodesy and Geophysics and the other, the WGS84, recommended by the International Hydrographic Organization. The Commission notes that for all practical purposes involved in the determination of positions relating to a submission, both the ITRF94 and the WGS84 can be regarded as equivalent realizations of an ITRS. Geodetic coordinates referred to one system will be regarded by the commission as equivalent in the other (paragraph 3.2.13. of the Guidelines).

Distance computation

Paragraph 7 of article 76 mentions the use of straight lines, not exceeding 60 M in length, which connects the fixed points in the delineation of the outer limits of the continental shelf. The Commission acknowledges that this provision does not specify explicitly the geometric definition of these straight lines and that several definition could be conceivably adopted. The Commission further acknowledges that this provision implements a new norm of international law and that there is no precedent or State practice which might suggest the existence of a uniform and extended application of a particular geodetic methodology for this particular purpose (paragraph 2.3.6. of the Guidelines).

In view of the rigorous geometric definition of a straight line as the line of the shortest distance between two points, the Commission will employ geodesics on the surface of the official geodetic reference ellipsoid used by a State in each submission to define the path and distances of these specific straight lines (paragraph 2.3.7. of the Guidelines).

This will imply that all distances by definition would have to be geodesics and that a rigorous approach to the calculation of the length of a geodesic should be adopted. There exist several formulations of solutions for the computation of the length of geodesic between two given points. Most of these have been approximate solutions necessitated by earlier lack of computation power. With the advances in the computer technology and computer power, the computational approach using compact iterative formulas as proposed by Vincenty, 1975 will be appropriate for any length of line from a few centimetres to nearly 20000 km and it will give submillimeter accuracy.

Errors

All survey observations are subject to measurement uncertainty. The sources of error causing this uncertainty are numerous and diverse. They include such factors as physical instability of a measurement station, atmospheric variation along a line of observation, instrument malfunction and plain human fallibility. It is reasonable to classify errors into the following three types:

- Random errors which reflect the variability of repeated measurements due to sampling from statistical distributions.
- Systematic errors which can have a constant effect on repeated observations and therefore cannot be detected by repetitive measurements.

- Blunders which are an inevitable consequence of human fallibility, but the use of careful observational procedures and in particular the use of independent checks on observations should largely reduce their effect.

Precision, accuracy and reliability

The concepts of precision, accuracy and reliability have been a matter of debate for many years. They may be considered as directly relating to the types of error present in the observations. Precision is a quantity representing repeatability of a measurement and therefore only includes an assessment of random errors, whereas accuracy is considered to be an overall estimate of the error in a quantity, including the systematic effects. The ability of a measurement scheme to detect and hence eliminate blunders leads to the concept of reliability. An observation which is reliable is unlikely to contain undetected blunder, and conversely, a blunder is unlikely to be detected in an unreliable observation.

Given the limitations in collecting marine survey data and the potential ambiguity in their interpretation, it would be unrealistic in many, if not most, cases to expect that the accuracy and precision of the outer limit of the continental shelf will be comparable to those of boundaries that define the more conventional limits of national jurisdiction. The following table puts into perspective the potential levels of uncertainty that are inherent in each operation that is stipulated implicitly or explicitly by article 76 and which impact upon the final position of the outer limit (Macnab, 2000).

Operation	**Parameter**	**Techniques**	**Source(s) of uncertainty**	**Potential uncertainty**
Locate the foot of the slope	Seafloor morphology (primarily)	Acoustic measurement and interpretation	Measurement errors, interpretative criteria	10s of kilometres
Apply the distance formula	Horizontal distance	Graphical or geodetic	Graphical or computational errors	Low or none
Apply the sediment thickness formula	Sediment thickness	Acoustic measurement and interpretation	Measurement or interpretation errors	10s of kilometres
Construct the 350 M limit	Horizontal distance	Graphical or geodetic	Graphical or computational errors	Low or none
Locate of the 2500 m isobath	Water depth	Acoustic measurement	Measurement errors	100s of meters
Construct a line 100 M seaward of 2500 m isobath	Horizontal distance	Graphical or geodetic	Graphical or computational errors	Low or none

Resources

There is a need to attach some economic importance or some sense of economic value to the extended jurisdiction that can be obtained through article 76. It is also very important that the government of coastal States be informed of the resource potential of the region and this can be achieved through a desktop study or else through exploration of the region. Article 77 of the Convention defines the resources of the continental margin over which States exercise sovereign rights. The natural resources of the continental shelf consist of the minerals and other non-living resources of the seabed and subsoil together with living organisms belonging to sedentary species, that is to say, organisms which at the harvestable stage are either immobile on or under the seabed or are unable to move except in constant physical contact with the seabed and subsoil.

Information that describes the resources of the seabed and subsoil beyond the 200 M is not needed for determining the outer limit of the continental shelf but it is important to recognize that the essential purpose of article 77 is to define a procedure whereby a wide-margin state may claim sovereign rights over such resources (Macnab, 2000). Coastal States possessing little or no information on seabed resources may, in anticipation of improved techniques for extraction, especially in deepwater, undertake even a rudimentary appraisal of resources that could benefit future generations.

The oceans contain significant amount of energy and mineral resources that are becoming increasingly important as the availability of land-based resources diminishes. The outer continental shelf house different sources of energy, including oil and gas, and this is the main motivation for coastal States to make a submission for an extension of their continental shelf. Some coastal States have committed themselves to encourage the economically beneficial and environmentally sound expansion of these diverse resources (Kelly, 2003).

With the advent of new technologies, interest in the deeper water has intensified, particularly in the Atlantic Basin. The United States, oil production from the deepwater Gulf of Mexico is rising significantly with exploration expected to push beyond the exclusive economic zone in the not too distant future and product pipeline network extending well off the continental shelf and down the continental slope or with production being received by floating storage vessels positioned on the ocean surface above the well head (Kelly, 2003). Deepwater production (>305 m) first began in the United States around 1979 with the Shell Cognac Field and has been developing for two decades. During the last few years, there has been an increase in activity levels in the ultra-deepwater (> 1525 m) of the Gulf of Mexico. Similar trend has been observed in other Atlantic Basin areas such as Northwest Europe, Brazil, West Africa, North Africa and Southeast Asia (Kelly, 2003).

Other non-living resources, excluding hydrocarbons, can be obtained and exploited from the extended jurisdiction obtained through article 76. These non-living resources include placer deposits, phosphorites, evaporates, polymetallic sulphides, gas hydrates and manganese nodules and crusts. It is good to point that resources comprise of estimates of the potential occurrence and abundance of minerals regardless of the feasibility of the exploration. Parson, 2003, examines, through a desktop study, the non-living resources potential within areas of extended continental shelf. The study made an attempt to provide a prediction of the potential abundance of some non-living resources based on statistical analysis.

The type of animal marine organisms that fall under the category of sedentary species as defined in article 77 of the Convention include molluscs such as abalone, pearl oysters and scallops; crustaceans such as rock lobsters, bugs and mud crab; and echinoderms such as sea urchins, beche-de-mer, sponges and corals. The exploitable vegetable species include seaweed and sea grasses. Until recently, the main interest in sedentary species has been as a source of food, but increasingly, the interest and the future commercial promise lies in the discovery of new biochemicals and pharmaceuticals (Prescott, 2000).

A coastal state exploiting the non-living resources of the continental shelf beyond the 200 nautical miles from the baseline, from which the breadth of the territorial sea is measured, will have to make payments or contribution in kind as provided for under the provisions article 82 of the Convention. The payments and contributions shall be made annually with respect to all production at a site after the first five years of production at that site. For the sixth year, the rate of payment or contribution shall be 1 per cent of the value or volume of production at the site. The rate shall increase by 1 per cent for each subsequent year until the twelfth year and shall remain at 7 per cent thereafter. The payments or contributions shall be made through the Authority, which shall distribute them to States Parties to the Convention, on the basis of equitable sharing criteria, taking into account the interests and needs of developing States, particularly the least developed and the land-locked among them.

Article 82, paragraph 3 exempt developing States which are net importer of a mineral resource produced from its continental shelf from making such payments or contributions in respect of that mineral resource.

It is good to point that production as used in article 82 of the Convention does not include resources used in connection with exploitation.

Boundary Dispute and Delimitation

The Convention has made provisions for the Commission in dealing with submissions where there may be boundary dispute. The Commission is instructed that its actions following the submission from a coastal State shall not prejudice matters relating to the delimitation of boundaries between States with opposite or adjacent coasts (Annex II, article 9 of the Convention). While paragraph 10 of article 76 is concerned with the establishment of the outer limit of the continental shelf and not the delimitation of the overlapping entitlements between neighbouring States, article 9 of Annex II is specifically concerned with the procedure involving the Commission. The Commission recognizes, through paragraph 1 of Annex I of the Rules of Procedure, that the competence with respect to matters regarding disputes which may arise in connection with the establishment of the outer limits of the continental shelf rests with States. In case there is a dispute in the delimitation of the continental shelf between opposite or adjacent States, or in other cases of unresolved land or maritime disputes, related to the submission, the Commission shall be:

(a) Informed of such disputes by the coastal States making the submission; and

(b) Assured by the coastal States making the submission to the extent possible that the submission will not prejudice matters relating to the delimitation of boundaries between States.

Paragraph 4 of Annex I of the Rules of Procedure states that joint or separate submissions to the Commission requesting the Commission to make recommendations with respect to delineation made by two or more coastal States by agreement:

(a) Without regard to the delimitation of boundaries between those States; or

(b) Having indicated by means of geodetic coordinates the extent to which a submission is without prejudice to the matters relating to the delimitation of boundaries with another or other States Parties to this Agreement.

In cases where a land or maritime dispute exists, the Commission shall not consider and qualify a submission made by any of the States concerned in the dispute. However, the Commission may consider one or more submissions in the areas under dispute with prior consent given by all States that are parties to such a dispute. The submissions made before the Commission and the recommendations approved by the Commission thereon shall not prejudice the position of States which are parties to a land or maritime dispute (paragraph 5 of Annex I of the Rules of Procedure).

The case of disagreement between a coastal State and the Commission has been addressed in a paper by Eiriksson, 2003. Elferink, 2003, discusses the case where there exists a dispute between coastal States over a region which is subject to a claim for an extended continental shelf. The discussions in the two papers have been found appropriate and the avid reader is encouraged to go through them.

Summary

The present paper has attempted to provide an overview of the provisions of article 76 and associated articles of the United Nations Convention for the Law of the Sea. This was achieved through a review of the numerous publications on the subject. The key issues in the article have been discussed so as to give a general sense of the factors that need to be considered when preparing a submission to the Commission. A brief on the history of the Convention along with the difficulties in drafting article 76 during the negotiation stage was presented. The implications in the preparation of a submission for an extended continental shelf by a coastal State were discussed as well as the methods and techniques that can be used in the determination of the foot of the slope and the sediment thickness. The importance of the resources of the continental shelf in the preparation of a submission and boundary delimitation was also addressed.

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