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HYDROGRAPHIC AND GEOLOGIC CONCERNS OF IMPLEMENTING ARTICLE 76

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INTRODUCTION

You will recall that Miranda said to her father, Prospero, "If by your art, my dearest father, you have put the wild waters in this roar, allay them." This is surely a suitable start to a discussion of technical matters concerning the Law of the Sea. The Third Conference has finally completed its huge task of attempting to legally control the wild waters, and it is now up to the lawyers, the scientists, and technicians, to interpret many of the complex articles. The long-drawn-out debate, which attempted to reach a political consensus amongst many nations with many interests, has resulted in a high degree of compromise which is reflected in the complicated nature of many of the articles, particularly those concerning the delimitation of boundaries. One such article is 76. In the drafting of this article the negotiators attempted to satisfy the conflicting requirements of wide-margin and narrow-margin States. During the Conference various technical formulae were proposed, but, as when an architect designs a building using the most rigorous mathematical formulae, it is only when the construction is started that many of the weaknesses of the design begin to show themselves. In the Law of the Sea Treaty it is only now that hydrographers and geologists involved in delimiting the boundaries of their own countries can truly appreciate the scientific and technical difficulties and costs that must be faced.

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Note : The views contained in this paper are the personal ones of the authors and do not represent those of their respective organizations.

BACKGROUND

The definition of the outer boundary of the Continental Shelf under the provisions of the 1958 Geneva Convention on the Continental Shelf has long been recognized as unsatisfactory in the light of modern technology. Much has been written criticizing the ideas of adjacency and exploitability included in its Article 1 but it was Dr. PARDO, in 1967, who focused attention on the social consequences of a limit that had such elastic qualities that "the common heritage for all mankind would be destroyed". The Third Law of the Sea Conference, amongst its many other jobs, set about the task of redefining marine boundaries, but finding a formula that would define the outer limit of national jurisdiction to the satisfaction of all States proved to be difficult. The world and its oceans are far from homogeneous. Both the geography and the natural resources of the sea vary greatly from place to place. The TRUMAN Proclamation of 1945 spelt out the idea that the submerged part of the land contiguous to the coasts is a natural prolongation of the continents and the natural resources of the sub-soil and sea-bed are subject to the jurisdiction and control of the adjacent State. One of the many problems for the Third Law of the Sea Conference was to define the outer limit of coastal State jurisdiction.

Some States favoured a limit defined by distance, since their continental margins fell rapidly away to great depths, while others preferred to use a limitation of depth. There were questions of whether one boundary could be used to cover jurisdiction over different resources and different matters. The Conference was under pressure from day-to-day events and the consequent development of the customary law. Claims to 200-mile fishery limits which had earlier been contested by many States had become internationally accepted. The coincidence of the North Sea oil boom with the Conference and a general expansion of offshore oil exploration also had its effect on the thinking of the Conference. One of the most dramatic developments that took place during the Conference was the awakening of the realization of the economic potential of large quantities of "manganese" nodules on the floor of the oceans and the development of an ability to recover them. This economic potential may have been oversold, but in any event other mineral deposits were found during the Conference itself — the "polymetallic sulphides" of the crestal regions of mid-ocean ridges. All these matters affected the deliberations and added urgency to the need to firmly define the boundary between areas under national and areas under international jurisdiction.

EARLIER DEVELOPMENTS IN DEFINING THE BOUNDARY

Earlier proposals for a definition that would satisfy all States were relatively simple. One proposal included either 200 miles in terms of distance or 200 metres in terms of water depth with some percentage of the revenue beyond the 200-mile limit going to an international fund. For the hydrographer and geodesist this

definition would have been relatively straightforward to implement and administer but it did not satisfy all interests and other proposals were made. Several of these concerned the use of depth limits but these were generally unsatisfactory to coastal States with a narrow continental shelf even though some proposals suggested depth limits as deep as 3,000 metres. Some consideration was given to natural boundaries either in the form of a physiographic delimitation or a crustal or tectonic feature. This line of thinking stemmed mainly from the work of geologists. The fact that the earth's crust of the continents is thick and of a "granitic" nature while that beneath the oceans is thin and "basaltic" in composition suggested that their meeting point could be the boundary and it would be in line with the concept of natural prolongation. It was unfortunately found that there is not in fact a neat division between the two features but there is rather a zone where it is quite difficult to say with certainty "this" is oceanic, and "that" is continental.

The use of the outer limit of the geological continental shelf as a boundary has been criticized as being insufficiently definite, for the limit characteristics vary from place to place. Some continental shelves end with clear definition but others, notably those on Atlantic-type margins, lack clear definition and tend to slope away gently to the ocean depths. HEDBERG, one of the leading proponents of the "scientific method" proposed that the bottom or base of the slope was the most distinctive and extensive natural division. However, he went on to say that it was locally a broad and imprecise feature and should not be used firmly as a line, but as a boundary zone within which a State could firmly define its boundary line by a series of a few short lines. He felt that the boundary zone should be at least 100 km wide.

The concept of an international commission of scientists to supervise the drawing of boundaries had been proposed earlier at the Conference and HEDBERG supported this idea. The commission would define the boundary zone and after the coastal State had drawn the precise line it would be checked by the commission and recommended to the international authority.

Although the HEDBERG proposals introduced a new way of considering how the boundary might be defined, it still did not satisfy all States and GARDINER introduced yet another "scientific approach". He noted that proposals included 200-nautical-mile, 500-metre, 2,500-metre, or 3,000-metre limit, the seaward limit of the continental crust, the base of the continental slope (HEDBERG) and the continental slope. He felt that the sediments extending past the foot of the continental slope should be considered as an element of natural prolongation. Over many parts of the continental rise, particularly those with Atlantic-type margins, there is a broad wedge or fan of sediments tapering towards the deep abyssal plain. The difficulty that was met was where precisely to limit the boundary on this sediment wedge. Various arbitrary thicknesses were suggested, but GARDINER proposed that the boundary be determined by a ratio of thickness to distance from the foot of the slope. A sediment depth of 1 % of the distance from the base of the slope was chosen in what became known as the Irish Formula. There was considerable debate on the technical difficulty of determining the thickness of the sediments as the seismic methods primarily used for this task were in themselves open to assumptions concerning the density of the rocks and to general interpretation. GARDINER met these various questions with scientific arguments and the Irish Formula was an element of the final deliberations on defining the boundary.

FINAL MOVES TO ESTABLISH A BOUNDARY

In the final negotiations both the HEDBERG and GARDINER proposals have had considerable effect on the drafting of Article 76, which is reproduced below :

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Article 76

Definition of the continental shelf

1. The continental shelf of a coastal State comprises the sea-bed 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.

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

3. The continental margin comprises the submerged prolongation of the land mass of the coastal State, and consists of the sea-bed 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.

4. (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.

5. The fixed points comprising the line of the outer limits of the continental shelf on the sea-bed, drawn in accordance with paragraph 4 (a) (i) and (ii), either 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 depths of 2,500 metres.

6. 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.

7. 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 co-ordinates of latitude and longitude.

8. 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.

9. 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.

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

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Paragraph 1 is deceptively simple. A coastal State's "Shelf" is the "natural prolongation of its land territory to the outer edge of the continental margin...", and the key becomes the margin. This is defined in paragraph 3 in terms familiar to the geologist. It extends to the continental rise. It is the submerged prolongation of the land mass of the coastal State. It does not include the deep ocean floor with its oceanic ridges. Although it is easy to imagine discussion on what is a "submerged prolongation of the land mass" or what is an "oceanic ridge" where this is close to a coastal State, the first matter is to define the outer edge of the margin, and this is defined in paragraphs 4, 5, and 6.

An interpretation of paragraphs 4, 5, and 6 is given in Table 1.

The outer edge of the margin is defined in paragraph 4 with reference to the foot of the continental slope, which is the "point of maximum change in the gradient of its base", unless a coastal State presents evidence to the contrary. The nature of any contrary evidence is not stated. The Convention attempts to prevent creeping nationalism in paragraph 5. Whichever technical approach is taken by the coastal State to define the boundary, it cannot extend beyond the 350-nautical-mile limit or beyond 100 nautical miles from the 2,500-m bathymetric contour. Finally paragraph 6 provides an exemption to paragraph 5 when submarine elevations are natural components of the margin such as plateaux, rises, caps, banks, and spurs.

TABLE 1

The juridical Shelf Edge : the outer limit of the Continental Margin
An interpretation of paragraphs 4, 5, and 6 of Article 76

Determine :

Baselines (the low-water line as marked on large-scale charts).

200- and 350-nautical-mile lines from the baselines.

2,500-metre bathymetric contour.

100 nautical miles beyond the 2,500-m contour.

Foot of the slope : the point of maximum change in gradient at its base.

60 nautical miles beyond the foot of the slope.

The points where the ratio $x = \frac{\text{Sediment thickness}}{\text{Distance to foot of slope}} = 0.01$

Then a coastal State may claim the furthest of :

200-nautical-mile line.

60 nautical miles beyond the foot of the slope.

The points where $x = 0.01$

Which are within :

350-nautical-mile line.

or

100 nautical miles beyond the foot of the slope.

Unless :

A submarine elevation is a natural component of the continental margin, in which case the 350-nautical-mile limit does not apply.

Without doubt this paragraph will be open to broad interpretation in the number of cases where it may have application.

The influence of HEDBERG's proposals is evident in paragraph 7 which states that coastal States should delineate the boundary, when it extends beyond 200 nautical miles, by straight lines not exceeding 60 nautical miles in length, connecting fixed points defined by coordinates of latitude and longitude.

Returning to paragraph 4, apart from the use of the base of the slope, probably the most contentious part of the entire article is to be found in paragraph 4(i) which provides that the thickness of sedimentary rocks and their distance from the foot of the continental slope may be used to define the boundary. This follows directly from GARDINER's or the "Irish" proposal.

Finally the International Commission is to make recommendations to coastal States on matters related to the establishment of the boundary. Once the boundary is established under these recommendations it is to be final and binding.

HYDROGRAPHIC AND GEOLOGIC CONSIDERATIONS

To arrive at a solution that satisfies all parties requires a considerable measure of compromise and qualification of statements. This is very much the case in the Third Law of the Sea Treaty with respect to boundary delimitation. Throughout the history of debate on Law of the Sea issues it can be seen that the geographers have tried to establish geographically precise, if arbitrary, formulae for delimiting boundaries while the lawyers seem to prefer a more flexible definition than can accommodate the differing circumstances of each case. In the debate over Article 76, pressure from the various interests has resulted in an extremely complex definition that will be demanding on the resources of coastal States to define.

The delimitation of a 200-nautical-mile boundary is not seen as a problem apart from defining the baseline from which it is measured. The use of straight baselines has been discussed at great length. The use of these baselines appears to be a matter of decision for the coastal State and seldom open for criticism by other States or by the international community, unless they affect bilateral delimitations. It remains to be seen if the Commission examining the boundary defined by Article 76 has a right to examine the baselines themselves. When the baseline is to be the normal baseline defined by the low-water line as stated in Article 5, we must be concerned about the general state of world knowledge. In many parts of the world the configuration of the coastline is imprecisely known, particularly the position of off-lying islands and rocks. This situation may be aggravated where there are large tidal ranges, pack ice, and even rough seas which obscure the precise position or elevation of the low-water line. The matter of vertical datum has been a matter for dispute in several cases including the Anglo-French Arbitration with respect to the Eddystone Rock. The above matters are not unsolvable but may require the extensive use of precise geodetic control and photogrammetry and the establishment of a common vertical datum and definition of low water. In all cases where boundaries are to be defined in terms of geographic coordinates, they must be referred to a horizontal datum, and ideally this should be a world-wide datum. It has yet to be decided if the acceptability of baselines is in the domain of the Commission's authority.

If the outer edge of the continental margin extends beyond 200 nautical miles, a key feature of the delimitation will be the foot or the base of the continental slope. It will be recalled that HEDBERG claimed that this was an imprecise feature and should be used only to determine the position for a belt at least 100 kilometres wide. Yet in Article 76 the base of the slope is considered to be a firm line. To assist in precisely determining its position, sub-section 4(b) of Article 76 allows that the foot of the slope be determined at the point of maximum change in the gradient at its base. In an examination of eleven detailed profiles samples along the eastern Canadian continental margin, it was found that this method did not allow the base of the slope to be determined without ambiguity. The transition from the slope to the flat ocean floor was in most of the samples quite gradual. Furthermore, in four of the samples there were points where the bottom rose again before falling off. The use of maximum change of gradient as a criterion tended to place the foot of the slope considerably closer to the land than in the profiles of the eastern United

States and Canada discussed by HEDBERG. In his discussion he refers to a "notch" that comes visible separating the very steep upper part of the slope from the lower part. This feature cannot be identified on the profiles that have been referred to here. For these reasons it is easy to see why HEDBERG proposed a broad geographic definition for the base of the slope, and the comment by GARDINER, to quote, "In addition, it is now recognized that the base of the slope can be accurately located for those margins that extend beyond 200 n.m." must surely be questioned. While it is true that neither the profiles provided by HEDBERG nor the Canadian profiles that have been referred to here provide a completely representative sample, they do provide evidence that the use of the base of the slope as a firm feature for delimitation should be examined very carefully with regard to its implementation. In a study by an ad hoc working group of scientists representing the Intergovernmental Oceanographic Commission (IOC) and the International Hydrographic Organization (IHO) prepared for the Third United Nations Conference on Law of the Sea, on the implication of preparing large-scale maps for the Conference, it was noted that drafting of foot-of-slope lines on a world map raises a variety of difficulties. It must be cautioned that the bathymetric maps in some parts of the world have been interpreted from sparse data and that ideally the base of the slope should be determined from measured profiles and that the bathymetric maps will normally provide only an approximate position for this keystone of the boundary delimitation.

There has already been considerable debate on the ability to measure the thickness of the sediment wedge with sufficient accuracy to satisfy the requirement under sub-section 4(a)(i). GARDINER claims that this is not a problem and that by means of reflection and refraction seismics, detailed cross sections of the sediment can be obtained. He notes that the acoustic properties of the overlying sediments and the basement rock are markedly different and therefore the thickness of the sediments can be easily obtained. This factor has been consistently confirmed by drill holes.

However, in practice, several problems arise. (1) There must be many regions of the world where data are sparse. In the case of the east coast offshore Canada, although a lot of seismic reflection work has been done by oil companies or their contractors for hydrocarbon exploration, its geographical extent is very limited. The companies naturally have only seldom ventured beyond the upper part of the continental slope, and, with rare exceptions, the only reflection data in the region of interest beyond the 200-mile limit and the "foot of the slope" are those obtained by academic or government institutions. (2) Basement beneath sediments is often rough, and to say *this* is the 1 % point for sediment thickness will be hard. Errors in refraction velocities lead naturally to error in the sediment thickness; if the base of the sediment column is a relatively gradually sloping interface on average, this error in thickness is magnified and becomes a greater error in distance horizontally. The velocities of sediments and igneous rocks of "basement" overlap, so that thicknesses interpreted from refraction experiments alone may be uncertain. Sediments and igneous rocks may occur together, so that to say that *this* reflector on a reflection record marks the lower limit to the occurrence of sediments will be difficult to prove, in the absence of drilling. Therefore, a State wishing to precisely delimit its offshore boundary would have to plan on a considerable expenditure if it wished to make use of Section 4(a)(i).

The previously mentioned UNCLOS study points out that "although a considerable body of data exists, or is presumed to exist, that will permit identification of the base of the sediments in this manner, a considerable amount of processing and interpretation will be needed before they can be compiled in map form. Even so, there may be insufficient profiles in some areas to satisfy the need for data points at 60-mile intervals required by the formula."

Paragraph 5 of Article 76 includes a requirement for measuring either 350 nautical miles from the baselines or the 2,500-metre isobath. The former presents no particular difficulty and is similar to the measurement of the 200-nautical-mile boundary. The measurement of distance and the location of position many miles offshore has reached a high state of refinement using modern satellite positioning systems. The location of the position of drilling platforms using satellite methods can now be obtained to better than ± 10 metres and the position of moving vessels to ± 50 metres. The measurement of depths of 2,500 metres is a much more difficult matter as acoustical science has moved more slowly. Hydrographers consider that provided they have a reasonable knowledge of the density structure of the water column they can measure depths to ± 1 %. With considerable care in measuring the density during each echo sounding measurement, and by using narrow-beam echo sounding equipment, it is possible that figure could be improved to perhaps half the amount but such data is not generally available for the world's oceans. Although ± 1 % of 2,500 metres is only 50 metres it is to be realized that these depths normally occur in areas of the ocean where the slope of the sea floor is often less than one degree. This could result in a considerable horizontal offset in the position of the boundary in the order of several nautical miles.

Although the amount of possible displacement of the boundary may not at this time seem to be highly significant, it must be appreciated that economic interest in the outer limit of the margin is still in a speculative stage. Historically, it can be shown that as man advances his economic interests, the requirement to define boundaries more and more precisely becomes apparent. The surveying of rural land allows some relaxation of precision to be tolerated but, in the city centres, surveys to a matter of inches are essential. We must anticipate that such will eventually be the case in the world's oceans.

CONCLUSION

In this paper the authors have examined the scientific and technical problems involved in implementing Article 76. In doing so they are not criticizing the article which was developed under the spirit of give and take and eventual compromise which was the very essence of the Third Law of the Sea Conference. In Canada, as a country well advanced in hydrography and geology, it has been possible to examine the requirements of the article in detail. It is evident that a considerable quantity of data must be obtained if States are to take advantage of the clauses in Article 76 allowing the boundary to be extended beyond 200 nautical miles. Certain technical and administrative matters must be examined in detail by the Commis-

sion, such as whether their task involves scrutinizing the baselines from which the territorial sea is measured, the use of horizontal and vertical datums, the precision of depth measurements, the interpretation of the base of the slope, the exact definition of an undersea feature in terms of its generic nomenclature, the methods and accuracy of determining the thickness of sediments and the precision with which boundaries can be plotted on charts of different scales.

Fortunately, it appears that it will be some time before the exploitation of the outer edges of the continental margins takes place, but States should use this breathing space to secure the large amounts of bathymetric and geophysical data that will be required to carry out the task of delimitation properly.

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