

Earth Science and the Law of the Sea: Keys to Canada's Offshore Energy and Mineral Resources beyond 200 Nautical Miles

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SUMMARY

Article 76 of the United Nations Convention on the Law of the Sea allows Canada to establish sovereignty over resources of the seabed beyond the customary 200 nautical mile limit, when certain bathymetric and geological criteria are satisfied. This paper outlines the procedures for meeting those criteria, and describes the mutual benefits that can accrue to the earth sciences and the Law of the Sea through programs for collecting and analyzing the necessary data. In the Atlantic and Arctic oceans, this work could allow Canada to extend energy and mineral jurisdiction into seabed areas that approach the size of the three Prairie Provinces combined.

RÉSUMÉ

L'article 76 de la Convention des Nations Unies sur le droit de la mer permet au

Canada d'établir sa souveraineté sur les ressources des fonds marins au-delà de la limite bien connue des 200 miles nautiques, sous réserve de certains critères bathymétriques et géologiques. Le présent article décrit les procédures auxquelles il faut se plier, de même que les retombées positives qui découlent de la cueillette et l'analyse des données nécessaires, autant pour les sciences de la Terre que pour le droit de la mer. En ce qui a trait aux océans Atlantique et Arctique, le Canada pourrait voir sa juridiction s'appliquer à un territoire dont la dimension correspondrait à peu près à l'étendue des trois provinces des Prairies ensemble.

INTRODUCTION

This paper has a three-fold objective: 1) to review the main provisions of the Law of the Sea where it relates to maritime zones, and to the jurisdiction that may be exercised by a coastal state with a wide continental margin over the energy and mineral resources of the seabed beyond the customary limits of national sovereignty; 2) to describe the role of earth science in achieving this extended seabed jurisdiction through the implementation of the relevant provisions of the Law of the Sea; and 3) to outline the implications of this extended jurisdiction for Canada.

MAIN PROVISIONS OF THE LAW OF THE SEA

Table 1 outlines the main provisions of the Law of the Sea. For more details, the reader is referred to the official text of the UN Convention on the Law of the Sea (UNCLOS, United Nations, 1997a). The focus of the discussion that follows will be on the Articles in UNCLOS that pertain to the *continental shelf*, and to *resources of the seabed and subsoil beyond the Exclusive Economic Zones (EEZs)*.

Article 76 of UNCLOS defines the continental margin as the *submerged prolongation of a coastal state's land mass* that consists of the seabed and subsoil of the continental shelf, slope, and rise. The margin does not include the deep ocean floor, nor oceanic ridges. This definition relates only to the **physiographic components** of the seabed of the continental margin, as illustrated in the upper part of Figure 1.

Article 76 and other Articles of UNCLOS also refer to **juridical compo-**

nents of the continental margin, as illustrated in the lower part of Figure 1. Some components apply to the seabed, to the subsoil, and to the superjacent waters, *i.e., the territorial sea, the contiguous zone, the exclusive economic zone, and the high seas*, whereas others apply only to the seabed and subsoil, *i.e., the continental shelf and the Area*. It is worth underscoring here that the juridical continental shelf is **not** the same as the physiographic continental shelf: the former is defined according to bathymetric and geological criteria that are defined in Article 76, while the latter relates strictly to the shape of that portion of the seabed that is adjacent to the coastline.

Article 76 serves as an instrument for extending beyond 200 nautical miles (nm) the sovereignty of a coastal state with a wide continental margin, provided certain bathymetric and geological criteria are satisfied. Article 77 defines that state's rights within the extended zone of sovereignty, with respect to mineral and other non-living resources of the seabed and subsoil, and to biological resources that are characterized as sedentary species. Matters that pertain to living resources of the seabed are beyond the scope of this paper, and will not be addressed here.

In 1970, the United Nations General Assembly issued Resolution 2749, which articulated among other

Table 1 Main provisions of the Law of the Sea.

Scope and Limits of National Jurisdiction

- Territorial Sea: to 12 nautical miles (nm)
- Contiguous Zone: to 24 nm
- Exclusive Economic Zone (EEZ): to 200 nm
- *Continental Shelf: variable past 200 nm**

Rights of Passage for Ships and Aircraft

High Seas (water and air past EEZs)

- International Rights and Obligations
- Conservation and Management of Living Resources

The Area (seabed past EEZs and continental shelves)

- Common Heritage of Mankind
- *Resources of the Seabed and Subsoil**
- International Seabed Authority

Pollution Prevention

Scientific Research

* topics addressed in this paper

things a declaration of principle concerning the use of seabed resources beyond national jurisdiction:

the seabed and ocean floor, and the sub-soil thereof, beyond the limits of national jurisdiction ... as well as the resources of the Area, are **the common heritage of mankind** [and] shall not be subject to appropriation by any means by states or persons...

In recognition of that principle, Article 82 of UNCLOS establishes a framework for a system of royalties that will be delivered by coastal states to the International Seabed Authority (ISA), upon the extraction of resources from the seabeds of the juridical continental shelves that lie beyond 200 nm. These royalties are to take the form of payments or contributions, beginning at 1% of the value or volume of production at each production site after 5 years of operation, and increasing by 1% annually until the twelfth year (Fig. 2). These provisions are not applicable to states that are net importers of the resource(s) in question. Funds so collected by the ISA will be distributed on the basis of equitable sharing criteria to states that are party to the Convention, taking into account the interests and needs of under-developed and land-locked states.

EARTH SCIENCE AND THE IMPLEMENTATION OF ARTICLE 76

The implementation of Article 76 entails the analysis and interpretation of three classes of geoscientific information: the shape of the seabed, the depth of water, and the thickness of the underlying sedimentary material. It also requires geodetic computations for the accurate derivation of the horizontal co-ordinates of certain key features upon the ellipsoid of revolution. Table 2 outlines the operations and the classes of information that figure in this process. The following paragraphs provide an overview of these operations.

Natural Prolongation

For a given coastal state, the decision to proceed with the implementation of Article 76 depends almost entirely upon the perceived nature and dimension of the submerged component of its land mass, defined as the *natural prolongation of its land territory*. In most cases, a review

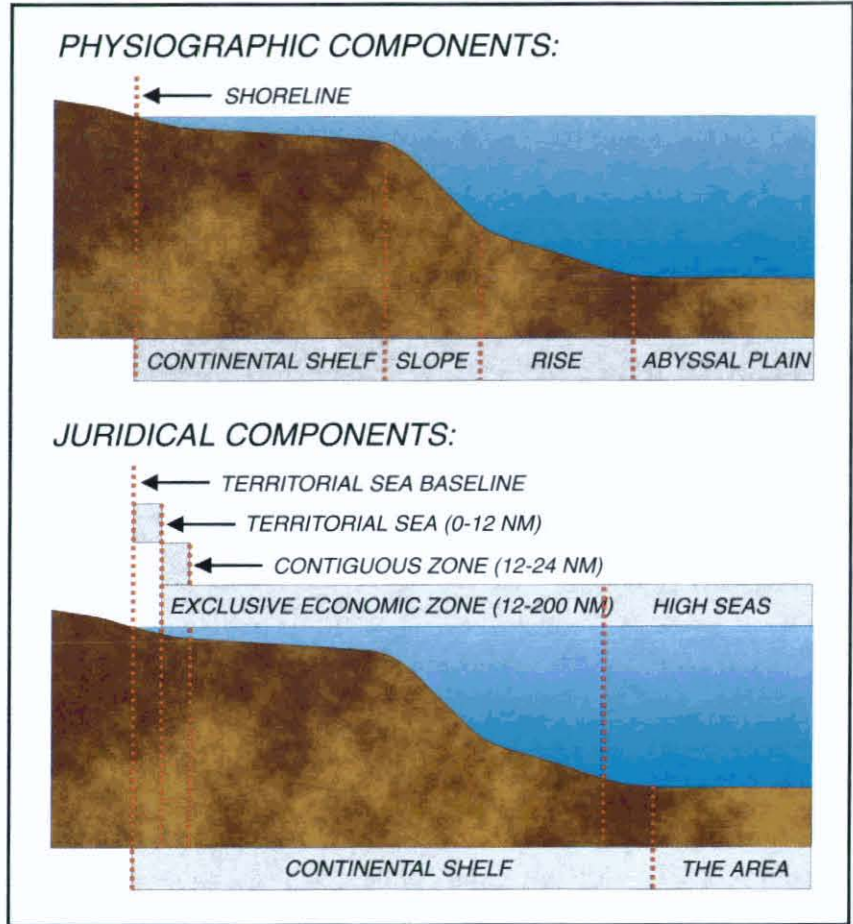


Figure 1 Using physiographic nomenclature, the three components of the continental margin consist of the continental shelf, the slope, and the rise, forming a transition zone between land and the abyssal plain. The juridical nomenclature of UNCLOS defines components that pertain to the seabed and superjacent waters: the *territorial sea*, the *contiguous zone*, the *exclusive economic zone*, and the *high seas*. UNCLOS also defines components that pertain only to the seabed: the *continental shelf* and *the Area*. *Note that the Juridical Continental Shelf is not the same as the Physiographic Continental Shelf.*

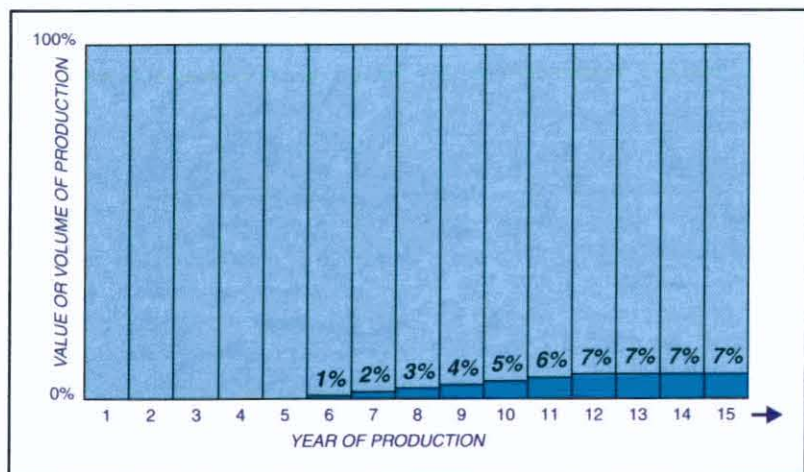


Figure 2 Schedule of royalties paid to the International Seabed Authority, as a percentage of the value of a non-living resource extracted from the seabed beyond 200 nm. Funds so collected are distributed to states party to UNCLOS, taking into account the interests of under-developed and land-locked states.

of the relevant morphological and geological factors will be undertaken to identify the seabed features beyond 200 nm that the coastal state proposes to include within the new outer limit of its continental shelf. This assessment should seek to determine whether a geological or morphological continuity exists between the terrestrial framework and distant seabed features.

Delineating the Foot of the Slope

Article 76 states that *the foot of the continental slope is defined as the point of maximum change in the gradient at its base*. This feature provides a point of departure for subsequent procedures; errors at this stage can propagate into the interpretations and derivations that follow, with a significant effect upon the determination of the outer limit of the continental shelf, and hence upon the size of the area enclosed by this limit.

The most direct technique for determining the location of the foot of the slope is to analyze a series of bathymetric profiles perpendicular to the edge of the continental shelf, with a view to identifying and joining the points of maximum change of seabed gradient in adjacent profiles. This approach evaluates relative changes of depth and hence does not require absolute bathymetric accuracy; however, the geographic co-ordinates of the bathymetric observations must be well known because their position in a horizontal frame of reference is significant. The outcome of this analysis depends heavily upon the quantity and distribution of profiles, the accuracy and resolution of the sounding equipment (wide-beam *versus* narrow-beam, single-beam *versus* multibeam), the processing that has been applied to the

data, the criteria applied in their interpretation, and the nature of the sea floor in this particular zone.

Software tools have been developed for making consistent determinations of the foot of the slope through the application of well-defined mathematical and geometric criteria to digital depth information. These procedures may operate directly upon original or synthetic bathymetric profiles (Fig. 3) or upon digital models that use regularly spaced grid points to describe the shape and depth of the sea floor (Ou and Vanicek, 1996).

Applying the Formulae of Article 76

Following the delineation of the foot of the continental slope, the next operation involves the construction of at least one and perhaps two distinct lines, the locations of which are determined with respect to the foot of the continental slope, in accordance with the two formulae explained in the following paragraphs: the *distance formula* and the *sediment thickness formula*.

The *distance formula* is the more straightforward of the two formulae, involving a simple projection of the foot of the slope seaward for a distance of 60 nm. This is best accomplished numerically, using geodetic software that automatically calculates a series of co-ordinates that define a series of intersecting arcs centred upon a succession of points located along the line that delineates the foot of the slope (Fig. 4).

Applying the *sediment thickness formula* is potentially a more complex and expensive operation: depending on the suitability of existing data, this option could entail a costly field program for measuring the thickness of sedimentary rock beneath the ocean floor, coupled

with an analysis for determining the point where this thickness equals 1% of the distance back to the foot of the slope (Fig. 4). The limit defined by a succession of such points is known colloquially as the *Gardiner Line*, after one of its principal architects (Gardiner, 1978). Uncertainties in measurement and interpretation may give rise to significant ambiguities in the application of this formula; however, once the interpreter has made some reasonable assumptions about the nature and distribution of the sedimentary material, the determination of the 1% line should be relatively straightforward.

It is not mandatory to apply uniquely the distance formula or the sediment thickness formula throughout the study area, and in any particular location, the coastal state may apply the formula that is most advantageous to its interests. A coastal state may therefore opt initially to apply both formulae in some or all areas, developing one line segment with the distance formula, and another segment with the sediment thickness formula. The two lines may then be compared to determine which single line, or which combination of segments from both lines, encloses the largest possible area beyond 200 nm. The process of developing a composite line is illustrated in Figure 4. For convenience and to acknowledge the technique of its derivation, the term *formula line* is sometimes used to describe this line.

Determining the Cutoff Limits

Regardless of the method chosen for its delineation, the outer limit cannot in general extend beyond a maximum of 350 nm from the state's territorial sea baselines, or 100 nm beyond the 2500 m isobath, whichever is greater.

Table 2 Technical procedures for determining the outer limit of the juridical continental shelf.

OPERATION	COMPUTE		ANALYZE/INTERPRET	
	Geodesic (horizontal distance)	Bathymetry (depth of water)	Geology (sediment/bedrock)	Morphology (shape of seabed)
A Does a <i>natural prolongation</i> exist?				
B Locate the <i>foot of the slope</i>		✓	✓	✓
C Apply the <i>distance formula</i>	✓		✓	
D Apply <i>sediment thickness formula</i>	✓		✓	
E Combine C & D: the <i>formula line</i>				
F Construct the <i>350 nm limit</i>	✓			
G Project <i>2500 m isobath 100 nm</i>	✓			
H Combine F & G: the <i>cutoff line</i>		✓		
I Combine E & H: the <i>outer limit</i>				

The 350 nm limit consists of a series of circular arcs centred upon the coastal state's Territorial Sea Baseline (Fig. 5). It is recommended that this limit be constructed numerically by means of geodetic computations. In addition to its accuracy, this approach has the added advantage of creating a series of co-ordinates in digital form that can be saved for later use in portraying this feature on charts at a variety of scales and projections.

The location of the 2500 m isobath plus 100 nm is more problematic because it necessitates the measurement of absolute water depths with the utmost accuracy, which current international specifications require to be $\pm 2.3\%$ of the water depth. Again, it is left to the interpreter to make reasonable assumptions about the location of this feature, after which the 100 nm projection can be constructed in a manner that is entirely analogous to the method applied when applying the distance formula (Fig. 5).

To simplify their use, segments of the two limits constructed above may be combined into a single *cutoff line* that encloses the largest possible area beyond tal shelf. The process of developing this line is illustrated in Figure 5.

Determining the Outer Limit of the Juridical Continental Shelf

This step begins with a comparison of the formula and cutoff lines. If the formula line is located entirely inside the cutoff line, then the former will be used to define the outer limit of the continental shelf. Conversely, if the formula line is everywhere outside the cutoff line, then the latter will be used to define the outer limit.

As is often the case, some segments of the formula line are likely to be situated within the cutoff line while others extend beyond the cutoff line. The final outer limit will therefore consist of a composite line, where outlying segments of the formula line are discarded and replaced by intervening segments of the cutoff line, as shown in Figure 6. Note that the final outer limit cannot be a curved line, but that it must be defined by a succession of straight line segments not exceeding 60 nm in length.

Implementation Tasks and Time Frame for their Completion

Article 76 states that the tasks outlined

above need to be completed by a coastal state within 10 years of the entry into force of UNCLOS for that particular state. In principle, the 60 states that were among the original ratifiers of UNCLOS have until the year 2004 to carry out this work on their respective continental margins, if applicable, and to present a submission to the Commission on the Limits of the Continental Shelf (CLCS). In this context, it is worth noting that Canada, along with the United States and a few other states, has yet to ratify UNCLOS; for these non-ratifying nations, the time limit for continental shelf delimitation is not yet in effect.

A set of guidelines has been prepared by the CLCS (United Nations, 1999) to assist coastal states in the execution of the tasks described above, in the preparation of a submission, and in the organization of supporting material. In general, the implementation process consists of several successive steps,

beginning with an initial desk study that: 1) assembles all available geoscientific information (bathymetry, morphology, and geology); 2) analyzes that information to develop provisional outer limits; and 3) determines whether a requirement exists for more or better geoscientific information.

Depending on the outcome of the desk study, it may prove necessary to conduct fieldwork or to engage in a more exhaustive search for existing information, with a view to improving the data base in certain respects, *e.g.*, determining a definitive territorial sea baseline, upgrading the bathymetric map in certain areas, or defining sediment thickness on the basis of seismic reflection and refraction. New information that is acquired through fieldwork or through an expanded archival search needs to be assimilated into existing data bases. Previous interpretations then require revision and refinement in light of the new data, culminat-

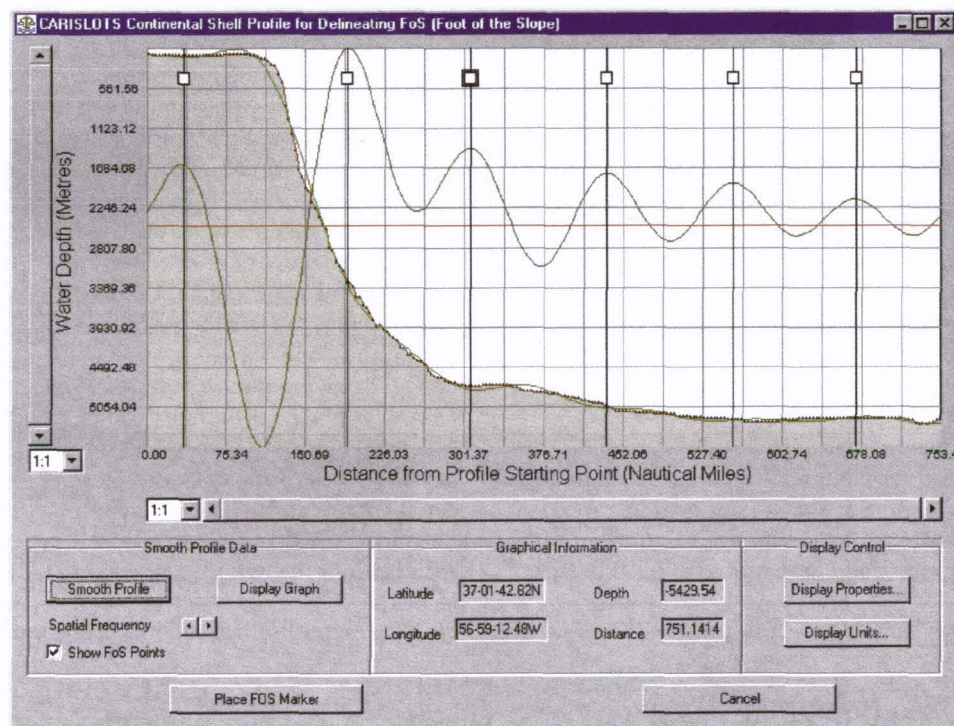


Figure 3 The *Foot of the Continental Slope*, defined by Article 76 as “the point of maximum change in the gradient at its base,” is a key element in determining the outer limit of the juridical continental shelf. It may be determined numerically as illustrated in the example above, where a mathematical curve (light green) is fitted to a series of original bathymetric observations along a profile perpendicular to the continental margin, or to a synthetic profile extracted from a digital bathymetric model. The quasi-sinusoidal second derivative of the mathematical curve (dark green) approximates the change of bottom gradient, and its positive peaks provide objective indicators for locating the points of maximum change (from van de Poll *et al.*, 2000).

