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Ocean Floor Boundaries

The base-of-slope boundary zone formula gives the most acceptable jurisdictional limit for mineral resources.

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Summary. The base of the continental slope, combined with the concepts of a boundary zone, a technical advisory boundary commission, and special treatment for restricted seas, offers a readily attainable, natural, practicable, and equitable boundary between national and international jurisdiction over the ocean floor. There is no point in bringing into the boundary formula the unnecessary added complication of thickness of sediments, as recently proposed. Review of the U.S. offshore brings out the critical importance with respect to energy resources of proper choice of boundary principles and proper determination of the base-of-continent line about our shores. The advice of the pertinent science and technology community should urgently be sought and contributed to decisions on offshore boundaries.

A major concern in Law of the Sea negotiations is the matter of boundaries on the ocean floor: What principles should control the position of the boundary between coastal state and international jurisdiction, and just where and how should this boundary be drawn? The resumed seventh session of the Third Conference on the Law of the Sea was concluded in New York City on 15 September 1978, with the matter still not conclusively resolved.

Ten years ago I proposed (*1*) that the national-international boundary should lie just oceanward of the continental (or insular) slope, within a zone of an internationally agreed width, and that within this boundary zone each coastal state should draw its own precise boundary (subject to the international guidelines) by means of straight lines connecting geographic coordinates of latitude and longitude. "Restricted seas" were to receive special treatment.

It appeared to me that the base of the slope (continental or insular) was not only the most prominent geomorphic marker worldwide on the ocean floor, but also that, as the outer edge of the continent or island, it was the most natural and appropriate line of division between the jurisdictional authority of the nations occupying the continents and islands and an international regime for the deep central oceans. I have continued to urge this basic procedure, elaborating it further from time to time [see (*2–6*)]. This proposal I refer to as the base-of-slope boundary-zone (base-slope-boundary-zone) formula.

National-International Boundary Problem: Current Status

The Third Conference on the Law of the Sea began in 1973, and very shortly thereafter the concept of a 200-nautical mile Exclusive Economic Zone came into favor, by which coastal state jurisdiction over natural resources would extend oceanward 200 n.m. from the baseline from which a country's territorial sea was measured (1 nautical mile = 1852 meters). This was strongly supported by the narrow-margin states, many of whom were principally interested in the extent of the boundary from the standpoint of fishing rights. However, those countries with broad shallow-water continental shelves extending out beyond 200 n.m. from shore (such as Argentina, Australia, the United States, the Soviet Union, and many others) were not happy with a plan that deprived them of large shallow-water shelf areas which they had always considered as their own.

Consequently, it was soon widely agreed at the conference that these broad-margin countries should have a special provision to extend their jurisdictional control over the ocean floor out beyond 200 n.m. "*to the outer edge of the continental margin.*"

Thus, although no final decision has yet been made by the conference on boundaries (or on anything else for that matter), the most authentic expression of conference attitude, the Informal Composite Negotiating Text of July 1977 (*7*), provides (articles 55 to 57) that the coastal state shall have sovereign rights over the seabed and superjacent waters in an Exclusive Economic Zone which "shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured." But it also provides (articles 76 and 77) that the coastal state shall have sovereign rights over the natural resources of the seabed of a "legal" continental shelf, which is defined as the seabed extending out from a coastal state "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."

Unfortunately, the Informal Composite Negotiating Text does not define the critical point of what is meant by "the continental margin" or by "the outer edge of the continental margin."

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Personally, I do not agree with the need for either an Exclusive Economic Zone or a "legal" continental shelf (which is no shelf at all and would include some of the greatest depths of the oceans). Also, I think that jurisdictional boundaries should have been dealt with separately for the ocean surface (navigation), for the ocean water body (fishing), and for the ocean floor (mineral resources) (5). Much confusion could have been avoided by a simple, single definition of the boundaries between coastal state and international jurisdiction for each of these realms and the rights and duties pertaining to both jurisdictional entities for each. For the ocean floor and its underlying mineral resources, I believe that the geomorphic base-slope-boundary-zone formula, which is explained below, could have adequately met all needs.

It may now indeed be too late to return to this simple, naturally based, logical approach applicable to all areas of the world, but I strongly urge that, at least, it be applied (i) to those states whose outer margins extend beyond 200 n.m. and (ii) to the world's "restricted seas."

In this connection I have recently discussed the vague term "continental margin" (*8*) and have concluded that the best definition of "the outer edge of the continental margin" is "the outer edge of the geomorphic continent," which usually translates exactly to "the base of the continental slope."

Base-Slope-Boundary-Zone Formula

The basic tenets of the geomorphic base-of-slope boundary zone formula I have proposed may be summarized briefly as follows:

Base-of-slope as a guideline. The general guide to the location of national-international boundaries on the ocean floor should be the base of the continental (or insular) slope, which forms the most distinctive and extensive natural division line between areas of the ocean floor appropriate for national jurisdiction and those appropriate for international jurisdiction.

Boundary zone. Because of the locally broad and imprecise nature of a geomorphic feature such as the base of the slope, it cannot be recognized everywhere as a line sharp enough to serve as a political boundary. Often it can be shown truly only as a belt—not a line—which may be several or even many kilometers in width, because often such is the limit of assurance with which it can be localized.

Consequently, in the use of the base-of-slope as a guide to a precise political boundary, this proposal recommends the device of a boundary zone—a zone extending out from the line best approximating the base of the slope, oceanward, for an internationally agreed and everywhere uniform distance. The precise boundary must then be drawn *within* this zone (see Fig. 1). In my opinion, the best width for the boundary zone is 100 kilometers (54 n.m.), although a larger figure might be used.

The reasons for an oceanward-extending boundary zone, rather than any attempt to utilize a precise *line*, are: (i) to allow for the fact that the base of the slope is generally too broad a feature to be identified as a line, (ii) to make certain that the coastal state receives as a minimum all of what it might reasonably claim as submerged geomorphic continent, (iii) to allow the eventual precise boundary to be drawn by the coastal state by a few simple straight lines, and (iv) to allow the community of nations latitude, by means of prescribing the width for the boundary zone, to determine the size of the residual central ocean area that they wish to leave under complete international control.

Technical advisory boundary commission. An international marine boundary commission, composed largely of oceanographers, geologists, geographers, and engineers, should be created. This commission should produce, on appropriate maps, an approximate base-of-slope line worldwide, according to its best judgment and extrapolating through areas where the feature is indistinctly developed or lacking. The boundary commission should then delineate on maps the boundary zone, using its approximate base-of-slope line as the inner limit and a line 100 (?) km oceanward from it as the outer limit of the zone.

Precise boundary to be drawn by coastal state. Within the boundary zone thus delimited, each coastal state should draw and mark its own precise linear boundary, consisting of straight lines connecting fixed points of latitude and longitude, subject only to the requirement that this precise boundary lie entirely within the internationally prescribed limits of the boundary zone (*9*).

Check by boundary commission. The international marine boundary commission would be expected to check the precise boundary proposed by a coastal state before recommending its acceptance to the international authority. (All recommendations of the international marine boundary commission would be subject to approval by both the international authority and the coastal state.)

Islands. Boundaries for oceanic islands (above high tide and with a potential of permanent habitability) beyond the base-of-slope should have the same rules as for continents, except that island

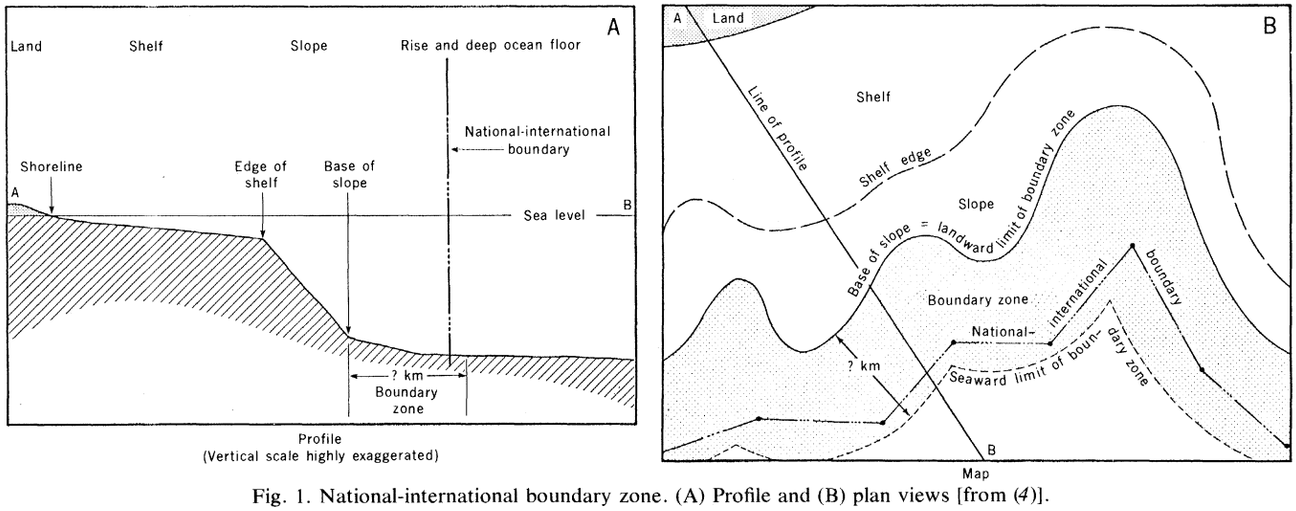

Fig. 1. National-international boundary zone. (A) Profile and (B) plan views [from (*4*)].

boundaries would be measured from the base of the insular slope rather than the continental slope. The influence of continental shelf or slope islands on boundaries would not extend to the international domain beyond the base of the continental slope and would have to be largely controlled by treaties between states. Boundaries for archipelagoes should be peripheral to such island groups as a whole. Islands and archipelagoes would be officially designated as such after study and recommendation by the international marine boundary commission.

Special treatment for restricted seas. In restricted seas [small enclosed or semienclosed seas, as contrasted with the major oceans (Fig. 2)], areas seaward of the base-of-slope should be divided in their entirety between the bordering countries on an equitable—usually median line—basis [see (*1*, p. 92; *2*, p. 166)]. Seas of this sort are shown in crosshatching in Fig. 2. Examples are the Caspian Sea, Black Sea, Caribbean Sea, Mediterranean Sea, Labrador Sea, Bay of Bengal, Gulf of Mexico, Sea of Okhotsk, Bering Sea, and Barents Sea.

The purpose of special treatment for small restricted seas is principally the practical one of avoiding the complication of having small, irregular, isolated, central "nuisance" areas of international jurisdiction within them. Restricted seas would be officially designated as such after study and recommendation by the international marine boundary commission.

This proposed base-slope-boundary-zone formula does not aim to secure areas of favorable petroleum prospects, manganese nodules, or other resources either to coastal state or international jurisdiction. It simply tries to provide the most natural, logical, appropriate, and feasible boundary between the two—let the mineral resources fall where they may.

The primary guideline is the base of the continental (or insular) slope, but in a larger sense it is really the geomorphic base of the continent or base of the island. The general criterion to be used for the position of the base of the slope is "the foot of the seawardmost major course of downward inclination in the generally descending profile of the slope, beyond which the gradient either flattens very gently to merge eventually with the abyssal plain, *or* reverses to form the other side of an oceanic trench" (*8*).

Irish Sediment-Thickness Boundary Proposal

The lack of an officially agreed upon definition for the expression "to the outer edge of the continental margin" in the Informal Composite Negotiating Text (*7*) and its predecessors has recently brought forth another proposal as to how the boundary should be defined for states whose margins extend beyond 200 n.m. This is the so-called "Irish proposal" (see Fig. 3) submitted to the Law of the Sea Conference by the delegation from Ireland under the date of 15 April 1976 [see a discussion of this proposal by its authors in (*10*, *11*)].

This proposal requires particular attention because it is said to be currently favored by the delegations of many countries and is even being strongly sup-

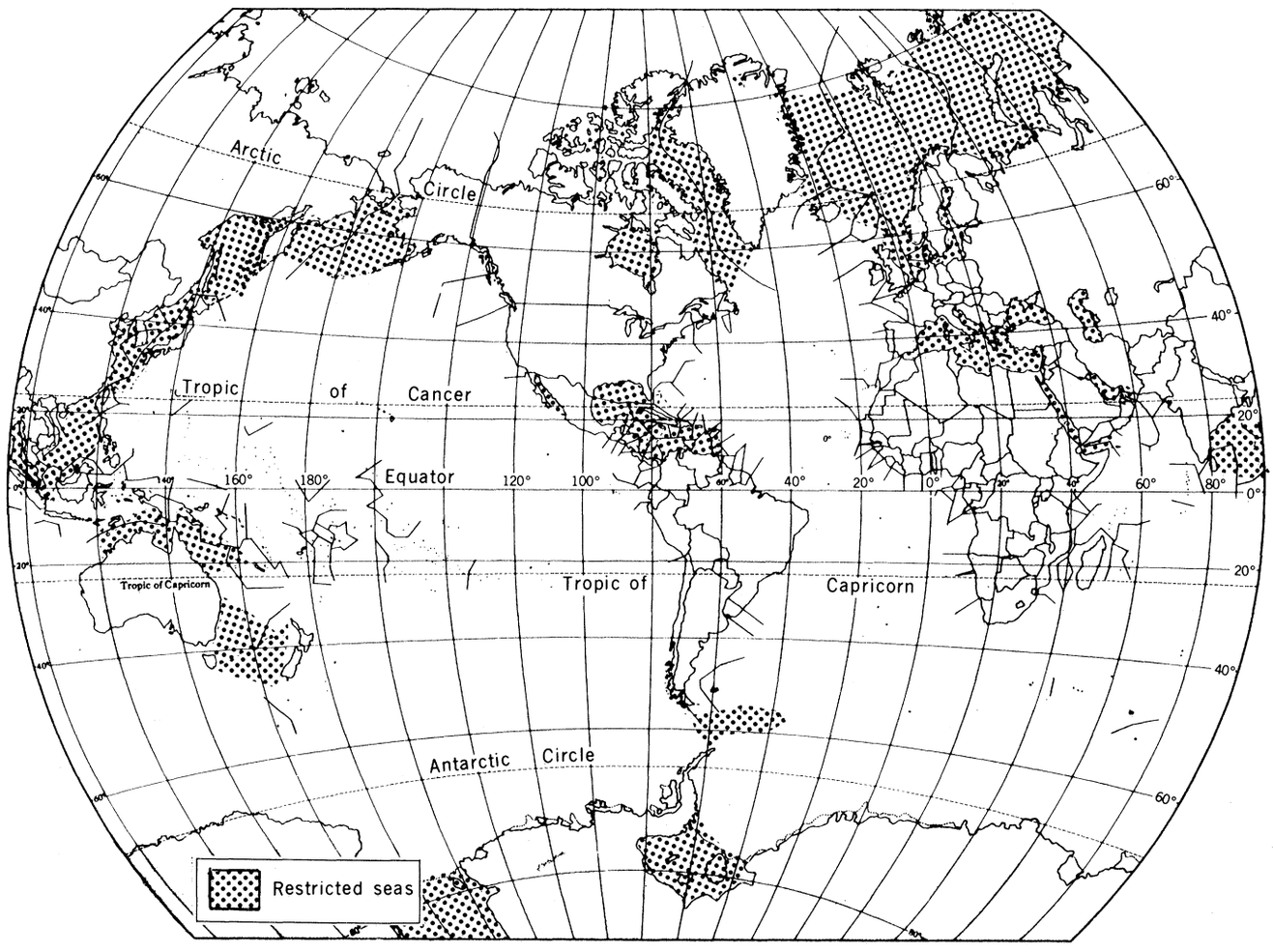

Fig. 2. Restricted seas of the world.

ported by the United States delegation (*12*). This proposal should be weighed carefully by U.S. scientists before any official decision is made as to whether it should become a part of the Law of the Sea.

The Irish proposal adopts many of the cardinal points of my much earlier base-slope-boundary-zone proposal: the use of the base of the slope as a guide to the boundary, the use of straight lines connecting fixed points of latitude and longitude for the precise boundary, the establishment of a technical international marine boundary commission, recognition of the futility of trying to put a political boundary at the outer limit of the continental rise, provision that the precise boundary be drawn by the coastal state itself within internationally established guidelines, the placing of the boundary at about 50 to 60 n.m. oceanward from the base of the slope, and so on.

However, there are a few alarming differences. Among these are: (i) the provision in article 3-a of the Irish formula for an optional alternative boundary procedure in which thickness of sediment in relation to distance from the slope becomes a controlling factor, (ii) the lack of a boundary zone concept, so necessary to allow for uncertainties in the exact position of the base-of-slope, and (iii) the lack of any special provision for small restricted seas.

If these drawbacks could be eliminated, the Irish proposal would seem very satisfactory, although it would then of course be an almost exact duplicate of the base-slope-boundary-zone proposal.

The major flaw in the Irish proposal is its provision for the use of sediment thickness as an optional alternative to a simple location of the boundary with respect to the base of the slope. With this alternative, the boundary, according to the Irish formula, would be "a line delineated . . . by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is at least 1% of the shortest distance from such point to the foot of the continental slope."

I do not believe that this alternative to the base-slope-boundary-zone formula is either desirable or practicable, and since no final decision has yet been made by the nations, it seems a duty to call attention to the defects, dangers, and difficulties in this alternative "thickness-of-sediments" proposal, and, particularly, to the lack of any real need for it. Among practical difficulties in its application would be the following:

1) Available quantitative information on sediment thicknesses in the oceans is far too meager at present to allow the drawing of a precise and reliable linear boundary on this basis.

2) The spottiness and irregularity in distribution of sediment thickness in many oceanic areas would make the linear representation of a specific thickness relation to the base of the slope extremely complex and difficult.

3) The gradual nature and directional variability of change in sediment thickness in many oceanic areas would also make it very difficult to portray, by a specific line on the ocean floor, the precise limits of any sediment-thickness relation to distance from the slope.

4) The interbedding of igneous and sedimentary rocks, as demonstrated by a number of JOIDES (*13*) Deep Sea Drilling Project (DSDP) holes (118, 138, 152), would make it difficult or impossible in many areas for one to be sure when true igneous basement had been reached and hence to determine the true total thickness of sediments at a given locality.

5) The presence in some areas of deep seismic reflections far below generally presumed "basement" depths suggests the possibility of deep underlying sedimentary strata and hence leaves doubt as to the true thickness of sediments in such areas.

6) Although it is not popularly appre-

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.

2 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 nor the subsoil thereof.

3 For the purpose 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:

(a) A line delineated in accordance with paragraph 4 by reference to the outermost fixed points at each of which the thickness of sedimentary rocks is at least 1% of the shortest distance from such point to the foot of the continental slope; or,

(b) A line delineated in accordance with paragraph 4 by reference to fixed points not more than 60 nautical miles from the foot of the continental slope.

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.

4 The coastal State shall delineate the seaward boundary 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, such points to be defined by co-ordinates of latitude and longitude.

5 Every delineation pursuant to this Article shall be submitted to the Continental Shelf Boundary Commission for certification in accordance with Annex __. Acceptance by the Commission of a delineation so submitted in accordance with Annex __ and the seaward boundary so fixed, shall be final and binding.

6 The coastal State shall deposit with the Secretary General of the United Nations charts and relevant information, including geodetic data, permanently describing the outer limit of its Continental Shelf. The Secretary General shall give due publicity thereto.

7 The provisions of this Article are without prejudice to the question of delimitation of the Continental Shelf between opposite or adjacent States.

Fig. 3. Text of the Irish proposal [from Gardiner and Robinson (*10*)].

ciated, there are numerous technical impediments to precise depth determinations and thickness measurements by reflection seismic work; in particular, there is the difficulty of getting a sufficiently accurate picture of the velocity of transmission of seismic waves in a sedimentary section of variable and uncertain character. Practicing marine geophysicists suggest that a 5 to 10 percent error may reasonably be expected in estimating depth to basement in an uncontrolled oceanic area. Thus, where water depth was approximately 5000 feet (1 foot = 0.3048 meter) and sediment thickness approximately 5000 feet, the seismic determination might be able to show the sediment thickness no more accurately than somewhere between 4750 and 5250 feet—a range in possible error in sediment thickness of about 500 feet, which is hardly sharp enough for drawing a precise political boundary.

7) The great cost of oceanic deepwater drilling precludes the determination of sediment thickness by an adequate number of drill holes to draw a precise boundary. At present, the density of holes in the deep oceans that supposedly have penetrated the entire sedimentary section is about one hole per 2.3 million km^2, or about four holes in an area the size of the United States! And most of these holes are in the central oceans where sediment thickness is only a few hundred meters. (Moreover, even drill holes often give erroneous thicknesses because of deviations of the hole from vertical.)

8) Finally, perhaps the greatest defect of the Irish 3-a formula as regards practical applicability, is its compounding of *two* uncertainties in arriving at a boundary line: (i) the uncertainty of correct total sediment-thickness determination and (ii) the uncertainty of precise location of the base of the slope. The Irish 3-a formula clearly indicates that the sediment-thickness provision can be used only *after* the base of the slope has first been determined, since the sediment-thickness requirement is stated as a percentage of the distance from the base of the slope. (Yet the Irish proposal lacks the boundary zone as a focusing device for reducing the imprecision of these features as a boundary line.)

Unfortunately, there are several misconceptions and erroneous assumptions in Gardiner's (*10*) discussion of supposed advantages of his formula over mine. Among these are the following:

1) The assumption (*10*, p. 158) that the term "the outer edge of the continental margin" must be interpreted uniquely to be "the outer edge of the continental rise" and that the outer edge of the rise can be satisfactorily defined on the basis of total thickness of sediments [see (*8*) for a variety of different definitions of the term "continental margin" which have appeared in the literature].

2) The unjustified implication (*10*, p. 156) that my proposal was founded on the idea that the base of the slope was precisely marked by the contact between oceanic and continental crust.

3) The assumption (*10*, pp. 156–157) that the "natural prolongation" oceanward of a continent must include all of the continental rise, whereas I would consider the continent as a geomorphic feature whose "natural prolongation" would extend only to the base of the slope.

4) The objection (*10*, p. 157) to the concept of a boundary zone on the grounds that it would unfairly exclude from coastal state domain parts of the rise adjacent to such countries as Norway, Argentina, Canada, and India, overlooking the fact that the only parts of the rise excluded would be in remote ultra-deep waters of little if any potential value and that the associated concepts of a boundary zone and of complete division of restricted seas between bordering countries would more than recompense them with additional and much more potentially valuable ocean floor.

5) The assumption (*10*, p. 159) that the mere existence of attempts to map sediment thickness in the Atlantic Ocean proves that the accurate determination of sediment thickness in the oceans for boundary purposes would not pose problems.

6) The assumption (*10*, p. 160) that errors in sediment-thickness estimates due to interbedding of igneous and sedimentary rocks would always act against the coastal state and that this would justify

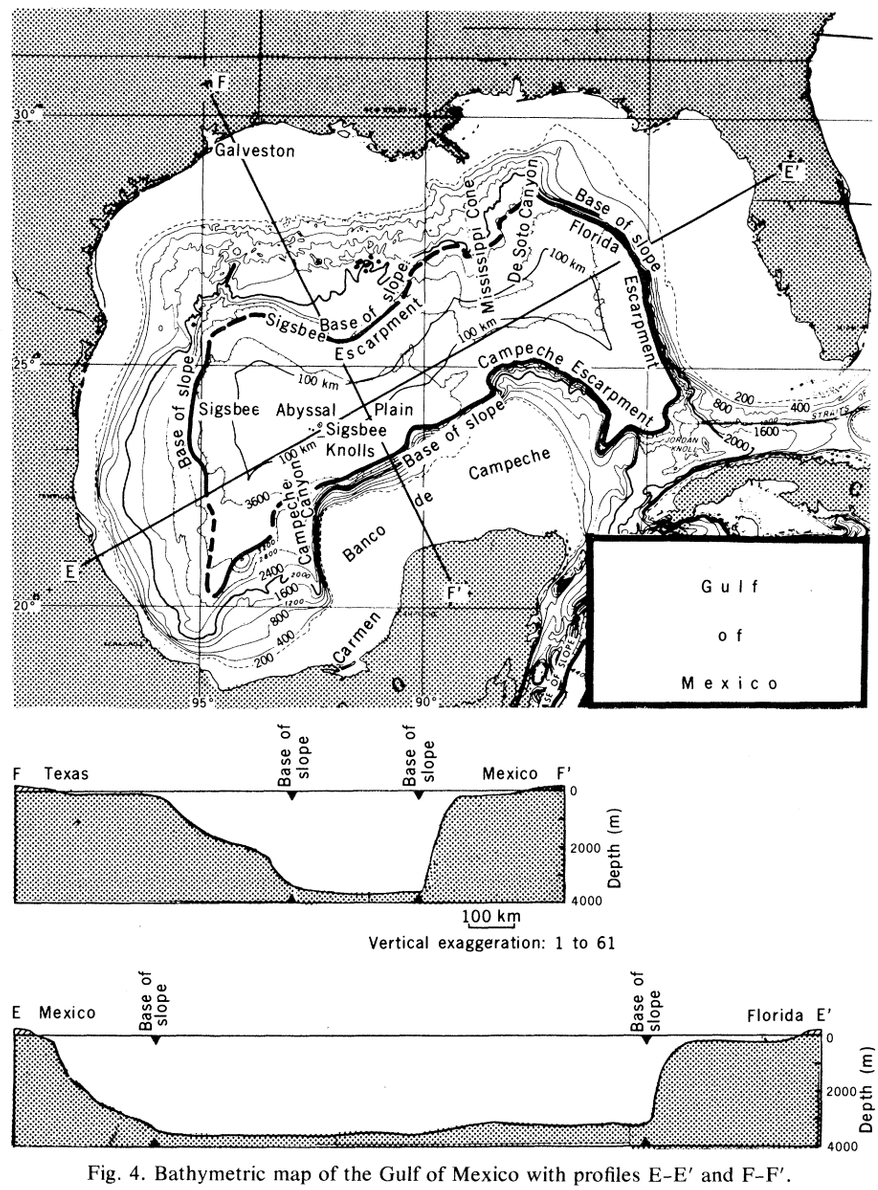

Fig. 4. Bathymetric map of the Gulf of Mexico with profiles E–E′ and F–F′.

considering such errors inconsequential.

7) The apparent unawareness (*10*, pp. 161 and 164) that the requirement of an international boundary commission, stated to be "one of the key elements of the Irish amendment," was first proposed by me in 1970 (*2*, p. 164) and has always been an integral part of all statements of my base-slope-boundary-zone formula.

It is hard to see any reason or need for tying national-international jurisdictional boundaries in the oceans to thickness of sediments, even if this were practically feasible. Why should the base-slope-boundary-zone formula be encumbered with such an additional burden involving a difficultly achievable mathematical calculation for its application? No one would recommend drawing boundaries between countries on land on the basis of thickness of sediments. Then why attempt to draw them on this basis under the far more difficult conditions under the oceans?

Considering the many difficulties in application and disadvantages of the Irish formula, one wonders what compensating advantages to the world it could possibly have to justify its adoption. I have been told that the Irish formula is attractive because it would give the coastal states more potential petroleum territory than would the base-slope-boundary-zone formula. This is said in spite of published protestations by Gardiner that the Irish proposal "demands a substantial concession on the part of wide margin states" (*10*, p. 159), ensures "that a substantial area with hydrocarbon potential remains outside national jurisdiction" (*10*, p. 159) and will result in coastal states "giving up some 25% of their margins as presently recognized under customary international law" (*10*, p. 165).

I think that along the continental margins of the great oceans the use of the boundary zone would assure to the coastal state essentially as much of any potentially valuable petroleum territory as would the Irish sediment-thickness formula and, moreover, by the base-slope-boundary-zone formula coastal states would appropriately have the added advantage of receiving all of the particularly promising petroleum territory of the some 40 restricted seas of the world.

Throughout Gardiner's discussion he repeatedly claims that his plan is the only one to receive approbation by the nations. This may indeed be true, but, if so, this could reflect not only the merit of many of the provisions it has borrowed from other proposals but also, with re-

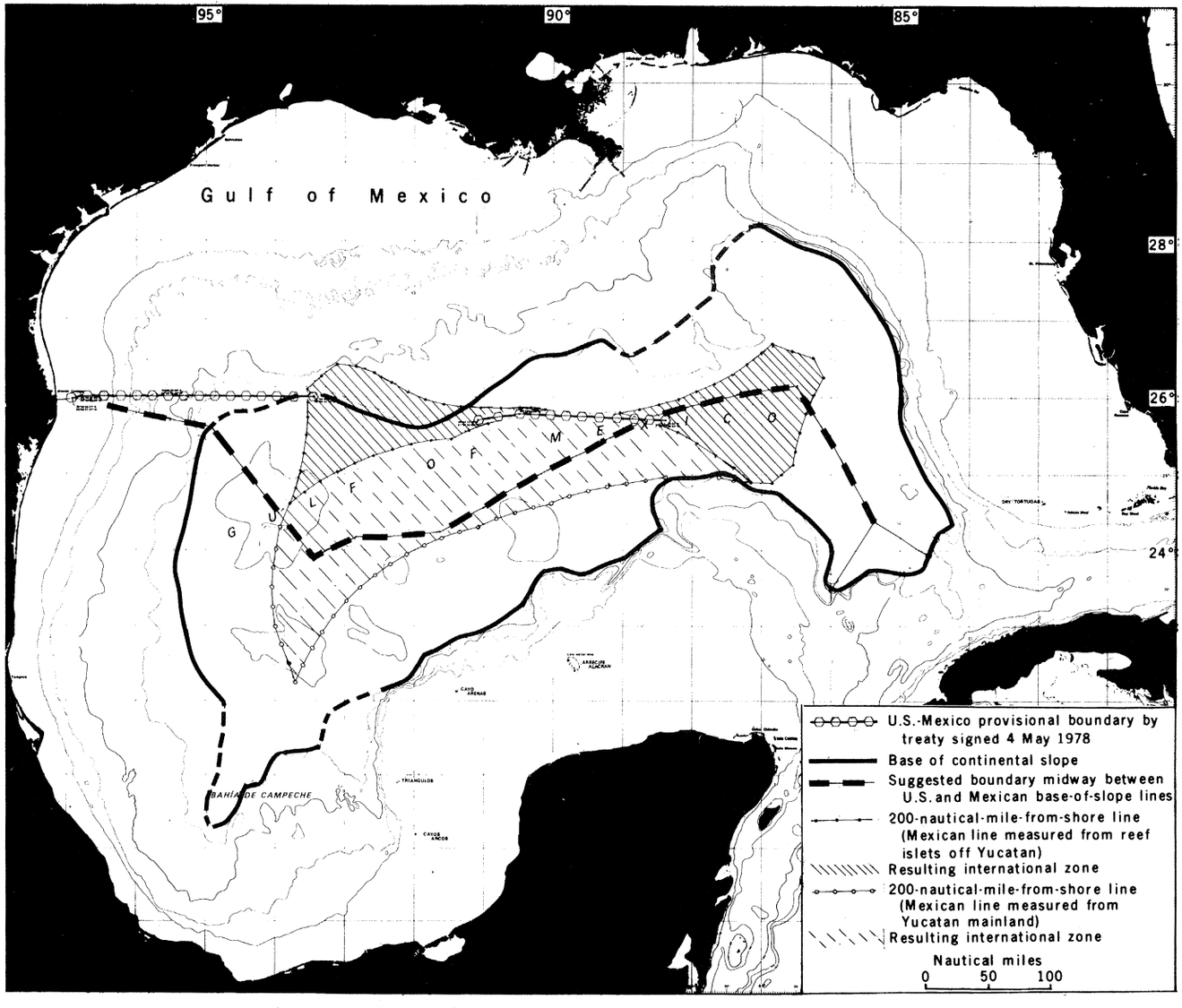

Fig. 5. Some lines pertinent to an international boundary in the Gulf of Mexico.

spect to its less sound provisions, either the political skill with which they have been advanced or the gullibility of some national delegations.

Relation of Boundary Proposals to U.S. Coasts

Since both the base-slope-boundary-zone formula and the Irish formula involve the base-of-slope, it is important for us to see just where this feature falls with relation to various coasts of the United States. Likewise, since it appears to be the meaning of the Informal Composite Negotiating Text that coastal states would be given rights out to the outer edge of the margin only where this was beyond the 200-n.m. limit of the Exclusive Economic Zone, it is important to compare the location of the base-of-slope line with the 200-n.m. line. Finally, we must see how my proposed treatment of "restricted seas" would affect the United States.

Northern Alaska, Bering Sea, Pacific Coast, Hawaii. I have discussed the situation for the Arctic Coast of Alaska recently and have shown on a map (*4*, figure 6) that a vast shallow-water area of the Chukchi Shelf lies beyond the 200-n.m. line but is landward of the base of the continental slope.

I have discussed the Bering Sea (*4*) and have shown that a 200-n.m. boundary would lose to the United States much of the prospective petroleum area of the deepwater part of this sea. However, the Bering Sea would qualify as a "restricted sea" according to the procedure recommended in the base-slope-boundary-zone proposal, and the entire area of this sea beyond the base-of-slope would be divided on an equitable basis between the United States and Soviet Union.

Also, I will not comment further on the U.S. Pacific Coast or Hawaii. Off these narrow-margin coasts all areas of petroleum promise would go to the United States by either the base-slope-boundary-zone proposal or the 200-n.m. rule. There is urgent need, however, to give further attention to the Gulf of Mexico, the U.S. Atlantic Coast, and U.S. island dependencies.

Gulf of Mexico. Geologically, the whole Gulf of Mexico (Fig. 4) may be considered prospective petroleum territory. The base-of-slope is indicated by the heavy black line. It is clearly identifiable around most of the periphery of the Gulf except at the Mississippi Delta cone, across which it must be extrapolated as shown by the dashed lines.

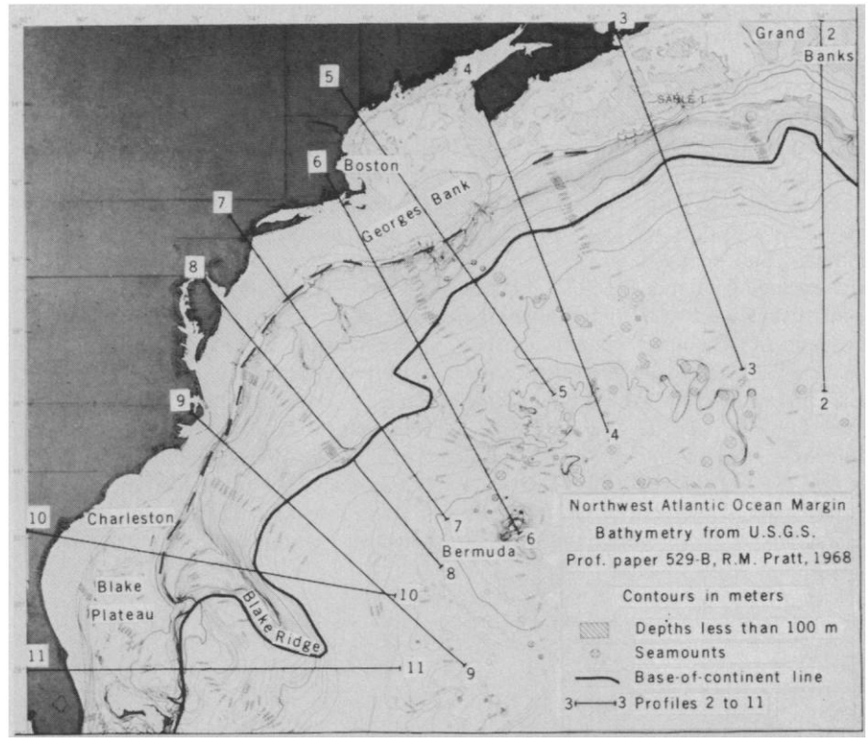

Fig. 6. Bathymetric map of the northwest Atlantic Ocean margin off the eastern United States and Canada showing the locations of profiles 2 to 11.

According to the base-slope-boundary-zone procedure, the Gulf of Mexico would be considered to be a "restricted sea" so that the central portion beyond the base of the slope would be divided in its entirety between Mexico, the United States, and Cuba. However, in contrast, the use of the 200-n.m.-from-shore boundary, currently favored by the Law of the Sea Conference, would bring in the complication of leaving a small isolated portion of the central Gulf in an international zone. Furthermore, if, as seems probable from the Informal Composite Negotiating Text, the 200-n.m. zone were measured from some small, nearly barren reef islets belonging to Mexico at the Yucatán shelf edge about 100 miles off the Yucatán shore rather than from the Yucatán mainland, the greater part of the central Gulf would go to Mexico.

An interesting recent development is that in May 1978, without waiting for any Law of the Sea decision, the United States and Mexico signed a treaty essentially dividing up the Gulf, or at least setting a southern limit to U.S. claims and a northern limit to Mexican claims. However, instead of using the base of the slope as a guide to an equitable division of the central area of the Gulf, as would have been called for under the base-slope-boundary-zone formula, the dividing line was drawn on the basis of distance from shore, and the nearly barren reef islets at the outer edge of the broad Yucatán Shelf were used as the Mexican shore. As a consequence, the points specified as marking the dividing line lie at or north of latitude 25° 41′, thus presuming a relinquishment of any U.S. claim to more than a very meager part of the northern central Gulf.

Figure 5 of the Gulf of Mexico shows: (i) a heavy black base-of-slope line surrounding the deep central area of the Gulf; (ii) a heavy dashed line that would have marked the Mexico-U.S. boundary under the base-slope-boundary-zone formula which would consider the Gulf of Mexico as a "restricted sea" whose central area beyond the base of the slope should be divided equally and completely between its bordering countries; (iii) a central international area (dense cross-hatching) that would be left under the 200-n.m.-from-shore formula if distance from shore were measured from the Mexican shelf-edge islets; (iv) an additional central international area (light cross-hatching) that would be left under the 200-n.m.-from shore formula if distance from shore were measured from the Mexican mainland; and (v) the Mexican-U.S. limits (beaded lines) as called for by the May 1978 draft treaty.

This is a good example of the disproportionate influence of even tiny shelf islets under the 200-n.m. boundary con-

cept. It is also a specific demonstration of how the United States is on the way to losing some of the best potential deepwater oil territory about its borders through failure to support the base-slope-boundary-zone formula.

The prolific petroleum production in the Gulf region of both the United States and Mexico to date has come from the landward limb of the huge semicircular geosyncline of sediments whose axis lies some distance offshore paralleling the periphery of the Gulf. The undrilled seaward limb of this geosyncline rises basinward under the deep waters beyond the slope and may also be abundantly petroliferous. A research hole of the DSDP on the Sigsbee Knolls (Fig. 4) in the deepest part of the central Gulf already has established the presence there of salt plugs and oil. The northern part of the central Gulf, which we appear to be preparing to relinquish, could be by far the most promising deepwater petroleum territory anywhere to which the United States might rightfully have claim. Fortunately, the treaty with Mexico has not yet been ratified by the U.S. Senate so the issue might still be salvaged.

Atlantic Coast. The location of the base of the continental slope along its Atlantic coast should be a matter of serious concern to the United States. There is a discrepancy between the base-of-slope as clearly manifested at a depth of about 5000 meters both to the north off the Grand Banks of Canada and to the south off Georgia and Florida, and the base-of-slope conventionally shown on most maps at a water depth of only 2000 to 2500 meters off the Northeastern and Middle Atlantic states.

The heavy black line on Fig. 6 shows where I would put the base of the slope off the Atlantic seaboard on a purely geomorphic basis, marking "the foot of the oceanwardmost major course of downward inclination" in the generally descending profile from the land to the abyssal plain. However, commonly on U.S. maps, the base of the slope is placed at the foot of a relatively precipitous descent much nearer land, shown by the lighter dashed line just off the crosshatched area on Fig. 6 where the words Georges Bank are written; and what I would consider to be the lower part of the slope off the eastern United States has been traditionally called "upper rise" by most American oceanographers.

The matter, though dismissed as only semantic by some and completely ignored by others, may be of very great importance with respect to U.S. offshore resources. It would make a difference of some 150,000 square miles in what is assigned to the U.S. continental slope, and could make a difference of some 50,000 square miles or more of prospective petroleum territory in the assignment of area to U.S. jurisdiction in any formula using the base of the slope as a guide to the national-international boundary.

In order to demonstrate that, regardless of where others are placing their base-of-slope, I am using a true and consistent base-of-continent line, I have drawn a series of 11 bathymetric profiles across the continental margin from the Grand Banks to Florida (Fig. 7). These show the changes in profile proceeding from north to south and may help to explain how the discrepancy has come about.

Profiles 1, 2, and 3 are in the Grand Banks–Nova Scotia area of Canada and show a clear base-of-continent line at about 4000 to 5000 m. Profiles 4, 5, and 6 from Nova Scotia to Martha's Vineyard accord very well with profiles 1, 2, and 3 as regards a base-of-continent at 4000 to 5000 m, but begin to show a "notch" separating the very steep upper part of the slope from the lower part. It is the base of this "notch" which in the United States has become known as the "base of the continental slope"; and in order to explain the continuing rather steep gradient beyond the "notch," the term "upper continental rise" has been coined to distinguish it from the true rise much farther oceanward which is commonly called the "lower continental rise."

Profiles 7, 8, and 9 from New Jersey to North Carolina accord with the previous

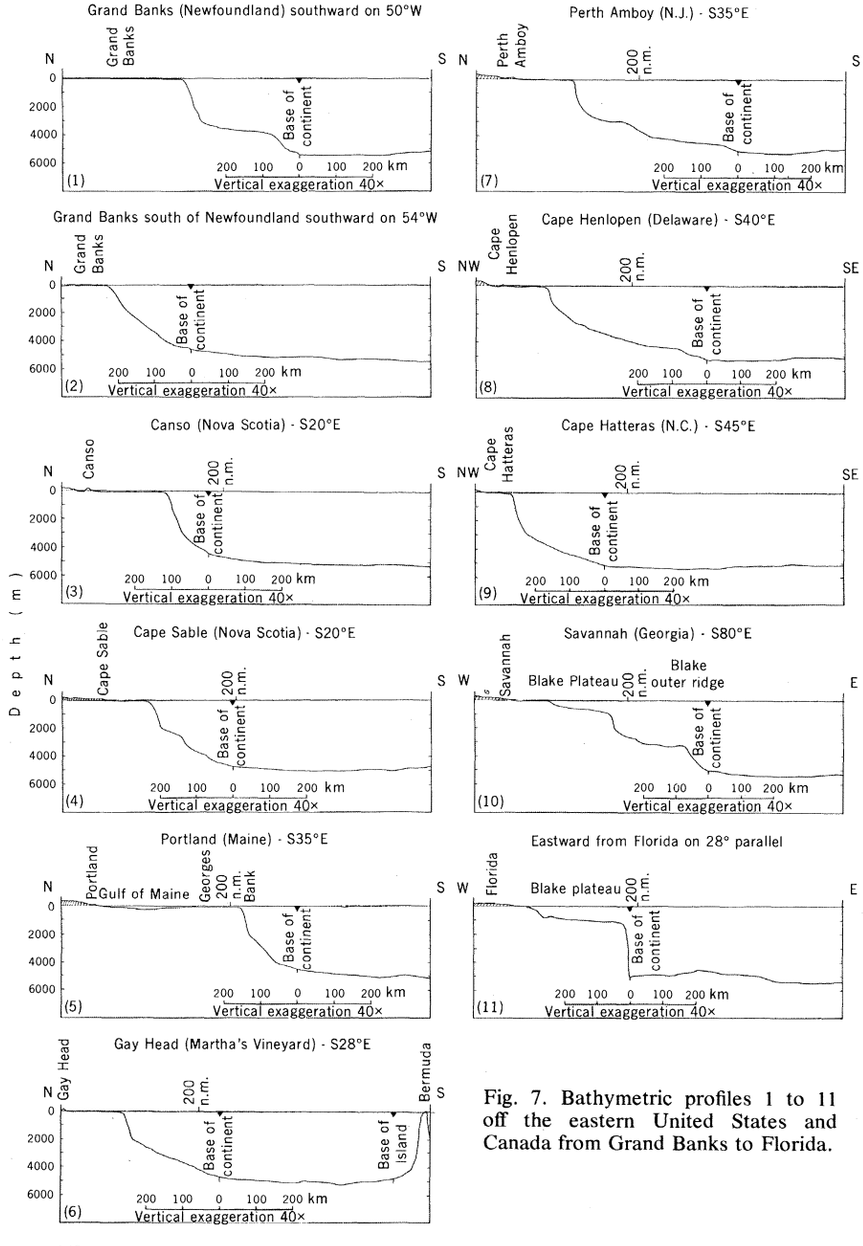

Fig. 7. Bathymetric profiles 1 to 11 off the eastern United States and Canada from Grand Banks to Florida.

ones in showing my base-of-continent at nearly 5000 m. The "notch" is becoming less sharp, particularly on profile 8 off Delaware. Profile 10 off Georgia shows the slope broken into two segments by the Blake Ridge; and profile 11, off Florida, shows a continuous and abrupt descent down to an obvious base-of-slope at about 5000 m, which I believe can be considered to correspond with the base-of-continent line, incidentally at about this same depth, extending all the way to Canada where it coincides with a base-of-slope at about 5000 m off the Grand Banks.

It is thus my opinion that the true base-of-slope along the Atlantic seaboard should be recognized as coinciding with my base-of-continent as shown by the solid black line on Fig. 6. At the moment, this is only my own personal opinion and I believe that the matter should be submitted to a group of competent oceanographic scientists for thorough review and for a recommendation one way or another regarding the location of the base of the continental slope off the U.S. Atlantic coast. What we call the base-of-slope may seem to many to be only a matter of words, but words become quite important when they become a part of the law.

Figure 8 is a larger-scale bathymetric contour map of the United States and Canada Atlantic Coast extending out as far as Bermuda. The stippled area is that with enough thickness of sediments to be of some interest with respect to petroleum prospects. Again, the heavy black line is my base-of-continent line. And it is evident that for any boundary related to the base of the slope, it would not only be more correct but also far more advantageous to the United States to consider this the base of the continental slope, rather than the break that has conventionally been called the base of the slope (indicated by dash-and-x line just off the crosshatched area in Fig. 8).

The heavy dashed line is the outer limit of a 100-km boundary zone, between which and the heavy black base-of-continent line the United States should draw its outer boundary for mineral resources jurisdiction if the base-slope-boundary-zone formula were adopted.

The heavy dotted line is the 200-n.m.-from-shore line; and it is evident that if the conventional base-of-slope (dash-and-x line near edge of crosshatched pattern) were accepted as *the* base-of-slope, then it is the dotted 200-n.m. line that would probably become our boundary, since the outer edge of our continental margin would in that case not lie beyond 200 n.m. from shore.

The small numbers at grid intersections on Fig. 8 represent only very approximate thickness of sediments in kilometers (*14*). The stippled area is that probably possessing at least 1 km thickness of sediments and hence is of some interest for petroleum prospecting. The heavy dashed line boundary, marking the outer limit of a 100-km boundary zone, is obviously far more favorable to the United States than the dotted 200-n.m. limit, which would cut the United States out of a broad band of some 50 to 100,000 square miles of prospective petroleum territory with a probable thickness of up to 2.5 km of sediments, and particularly two large areas: (i) at the Blake Ridge and (ii) midway between New York and Bermuda in both of which, as it happens, the presence of methane hydrate has been suggested during DSDP operations.

It is apparent that either the dashed or the dotted boundary would leave some of the prospective petroleum territory (stippled) on both sides, and even some of the prospective manganese nodule acreage on both sides.

What the Irish formula would do here would of course depend very much also on which base-of-slope line was used. Where exactly the Irish formula boundary would lie I would not attempt to estimate on the basis of present information on sediment thickness, but I doubt that it would give the United States any more acreage of great potential significance for petroleum than the base-slope-boundary-zone line (heavy dashed line).

United States island dependencies. How many persons realize the tremendous and undue importance given to island dependencies by the 200-n.m.-from-shore boundary formula which currently seems likely to become part of the Law of the Sea? Even an uninhabited island

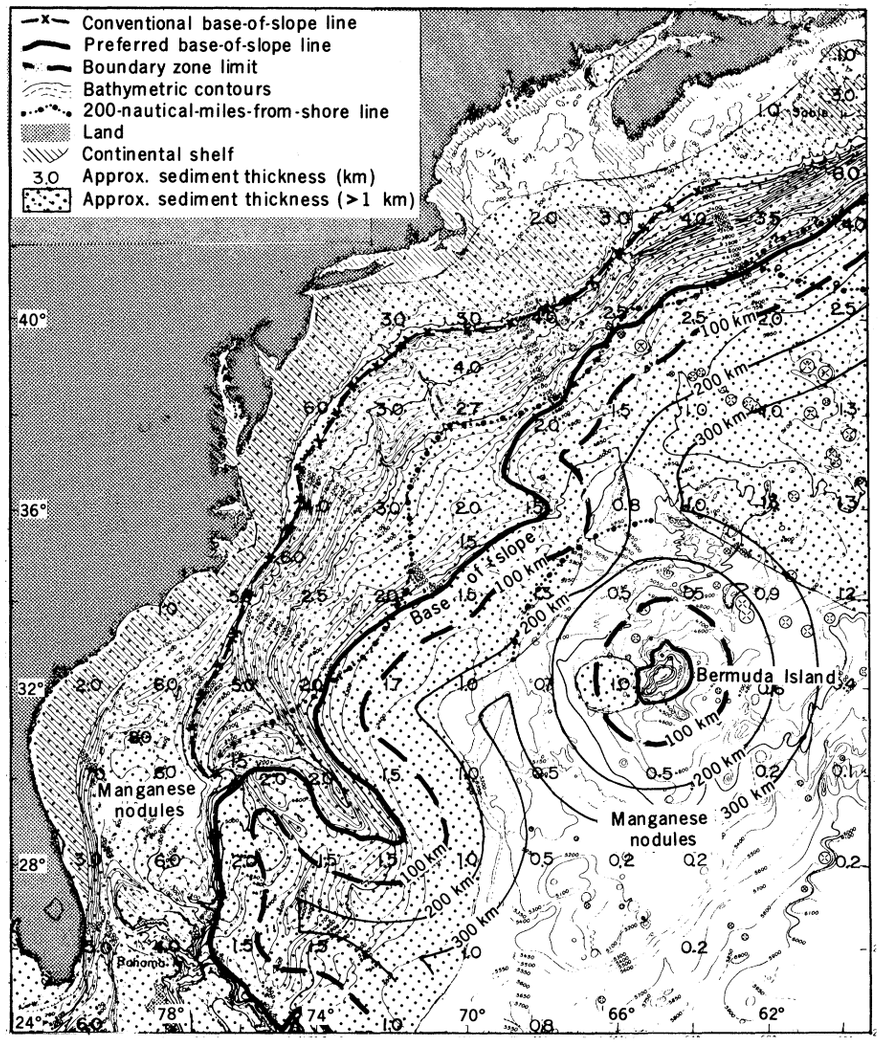

Fig. 8. Bathymetric map of the Atlantic Ocean off the eastern United States and Canada showing the base-of-slope; the 100-, 200-, and 300-km boundary zone limits; and the 200-n.m.-from-shore line. Bathymetry, as in Fig. 6, is from Pratt (*15*). The stippled area has probably more than 1 km of sediment [slightly modified from (*4*)].

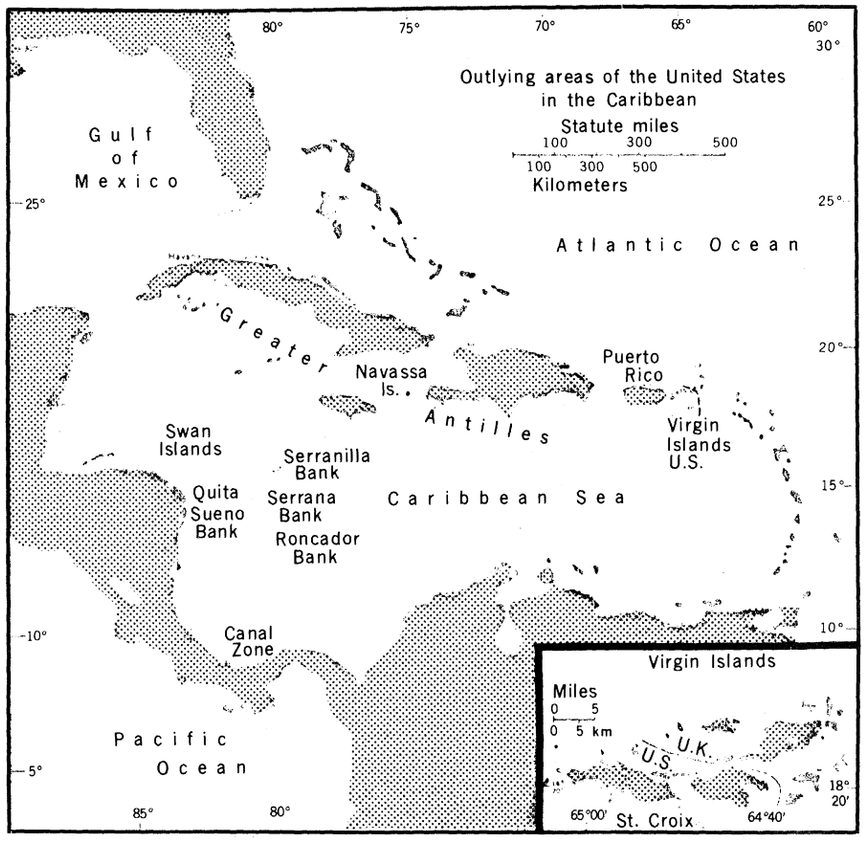

Fig. 9. United States island dependencies in the Caribbean region.

only 1 square mile in area could have a surrounding subsea jurisdictional area of πr^2—a total jurisdictional area not of 1 square mile but of 166,000 square miles plus one!

Figure 9 is a sketch map of U.S. wholly owned and jointly owned island dependencies in the Caribbean Sea. How many know, for example, that Navassa Island and parts of Roncador and Serrana Banks belong to the United States? These previously insignificant pinpoints on the map may now assume greatly increased significance through the claim that they may give to submarine resources out to 200 n.m. from their shores (article 121 of Informal Composite Negotiating Text).

There are two interesting updatings necessary to the map of Fig. 9. We have recently agreed to give away the Panama Canal Zone; and in 1972 we gave Swan Islands, with a land area of 3 square miles, to Honduras, in spite of the fact that in 1863 the United States established, and has ever since maintained, the only habitation on these islands—a radio and weather station. I wonder how many were aware that in giving away Swan Islands we were also giving away many thousands of square miles of seafloor of uninvestigated, but potentially great, resource value. Perhaps we should think well before giving away too many more islands, either in the Caribbean or the Pacific.

Conclusion

In conclusion, I have long urged the necessity for a technical international marine boundary commission to advise the political boundary-makers of the Law of the Sea Conference on boundary proposals and eventually aid in their practical application. I have also strongly urged the need for similar *national* technical marine boundary commissions, and particularly for a U.S. technical marine boundary commission, with members chosen by their peers.

Faced with the need for decisions on such proposals as sediment-thickness boundaries, oceanic- versus continental-crust boundaries, geomorphic boundaries, and the like, and with the need for establishing definitely the location of the U.S. base-of-slope—matters of critical scientific and technical importance to this country's resources for the future—it would seem that the U.S. negotiators would welcome the benefit of the consensus-thinking of a group of independent informed American scientists and technologists in a matter so important, regardless to what extent their opinions might or might not eventually be followed.

The base-slope-boundary-zone solution for a national-international boundary on the ocean floor seems to me to be the most natural, logical, and feasible proposal to date. It gives to each coastal state what seems most naturally to belong to it, and gives to an international regime what seems most appropriately international. Moreover, it is simple and uniform in application and offers the best chance of a lasting broad success because it is based on an appropriate prominent natural feature—rather than on more intricate and possibly prejudiced contrivances.

It has been my hope, if the base-slope-boundary-zone proposal stands up before the critical examination of scientists and technical people with an intimate knowledge of the physical framework of the oceans, that statesmen in the U.S. delegation to the Law of the Sea and in the delegations of other countries might eventually come to recognize its long-term advantages and give it effective support before it is too late.

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12. W. Christopher, Statement of Deputy Secretary of State, Warren Christopher, presented on his behalf by George Taft, Department of State, at 12th Annual Conference of the Law of the Sea Institute, 23 to 26 October 1978, Netherlands.
13. JOIDES is the acronym for Joint Oceanographic Institutions for Deep Earth Sampling.
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