The Fit of the Continents around the Atlantic

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IV. The fit of the continents around the Atlantic

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The geometrical fit of the continents now separated by oceans has long been discussed in relation to continental drift. This paper describes fits made by numerical methods, with a 'least squares' criterion of fit, for the continents around the Atlantic ocean. The best fit is found to be at the 500 fm. contour which lies on the steep part of the continental edge. The root-mean-square errors for fitting Africa to South America, Greenland to Europe and North America to Greenland and Europe are 30 to 90 km. These fits are thought not to be due to chance, though no reliable statistical criteria are available. The fit of the block assembled from South America and Africa to that formed from Europe, North America and Greenland is much poorer. The root-mean-square misfit is about 130 km. These geometrical fits are regarded as a preliminary to a comparison of the stratigraphy, structures, ages and palaeomagnetic results across the joins.

1. Introduction

The approximate fit of the coastlines of Africa and South America has been noticed by many writers and formed an important part of the evidence used by Wegener (1912, 1924) in support of his hypothesis of continental drift. du Toit (1937), Martin (1961) and others have pointed out resemblances of stratigraphy and structure on the two sides of the South Atlantic Ocean.

In fact the fit of the two coastlines is not close and is in any case not very meaningful, since the position of the coastline would, in many places, be greatly changed by a small rise or fall of sea level. The real 'edge of the continent' is the continental slope where the sea floor runs down steeply from 50 or 100 fm. to over 2000 fm. in a few miles. Wegener pointed out that the fit should be made at the continental edge, but did not pursue the matter in detail. Carey (1958) was the first to show that the fit of Africa and South America is much closer at the continental edges than it is at the coastline. In spite of this, Jeffreys has expressed a total disbelief in the reality of the fit; he says (1964): 'I simply deny there is an agreement.' The reason for this scepticism is not clear; perhaps it is connected with doubts about the accuracy of Carey's fits carried out on a globe provided with moveable transparent caps.

The matter is clearly important and the purpose of this paper is to put the facts beyond doubt by using the best data available and finding the 'best fits' by objective arithmetic methods. The results do not depend on the small scale and generalized topography shown on globes and are unaffected by errors of tracing or uncertainties of judgement as to what is the best fit.There is, of course, some arbitrariness and personal judgement in choosing what is to be fitted. We have fitted continental blocks that seemed by inspection to fit well and which could reasonably be supposed to have once been in contact and to have moved apart. Naturally the whole of a given contour line can only be fitted if it runs all the way along both coasts; we have been forced to omit a few short stretches where shallow submarine ridges, such as the Iceland–Faeroes ridge, cross the ocean and abut on the continental edge. A few other short stretches where the fit was very bad have also been omitted in selecting the best fits, but can be seen in the maps; the most notable is to the southwest of Ireland.

The area studied includes North and South America, Greenland, Europe and Africa. Africa and South America were first fitted, then a second block was assembled from North America, Greenland and Europe; the closeness of these fits exceeded our expectations and fully confirms the work of Carey. An attempt was then made to fit the two blocks together; here the fit was less good.

2. The methods of fitting

A contour line at the edge of a continent can be defined by the latitudes and longitudes of a set of points along it, spaced at small enough intervals for the form of the contour to be interpolated between them. If the two contours on opposite sides of an ocean are

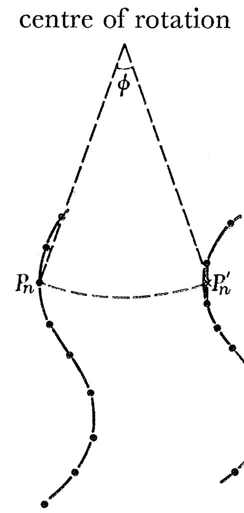


Figure 1. Fitting contours on the opposite sides of an ocean.

defined in this way, one may be considered to be moved over the surface of the Earth until it fits as well as may be to the other. By the fixed point theorem, usually called Euler's theorem in this application, any displacement of a spherical surface over itself leaves one point fixed; that is any displacement of a contour line or of a continent may be considered as a rigid rotation about a vertical axis through some point on the surface of the Earth. We call this point the 'centre of rotation'. The problem is to find its latitude and longitude and the rotation about it that gives as good a fit as possible between the two contour lines. A number of criteria might be suggested for finding the best fit. The one that we have used is illustrated in figure 1. Let P_n be one of the points chosen to define the contour line off the coast of the more westerly continent and P_n' a point on the contour off the coast of the easterly continent that is at the same distance as P_n is from the centre of rotation; this latter point was obtained by linear interpolation between the chosen points on each side of it. Let ϕ_n be the difference in 'longitude' measured relative to the centre of rotation as pole (we use the inverted commas to distinguish 'longitude' relative to the centre of rotation from longitude relative to the Earth's axis). A rotation, ϕ_0, of one continent relative to the other about the centre of rotation will then leave a difference of 'longitude' of $(\phi_n - \phi_0)$. The sum of the squares of this quantity over all chosen points on the easterly continent gives a measure of the misfit. The similar misfit $(\phi_n' - \phi_0)$, starting from a chosen point on the contour off the eastern continent and interpolating on the western one, would give an equally valid measure of the misfit, for symmetry the mean of the two was used, giving a mean square misfit

$$Q^2 = \frac{1}{2N} \sum_{m=1}^{N} [(\phi_n - \phi_0)^2 + (\phi_n' - \phi_0)^2], \tag{1}$$

where the sumation is over the N chosen points on each side. For a given centre of rotation this is a minimum if

$$\phi_0 = \frac{1}{2N} \sum_{n=1}^{N} (\phi_n + \phi_n'). \tag{2}$$

The misfit with this rotation will depend on the position of the centre of rotation. The relation between the position and the misfit is complicated and the most convenient

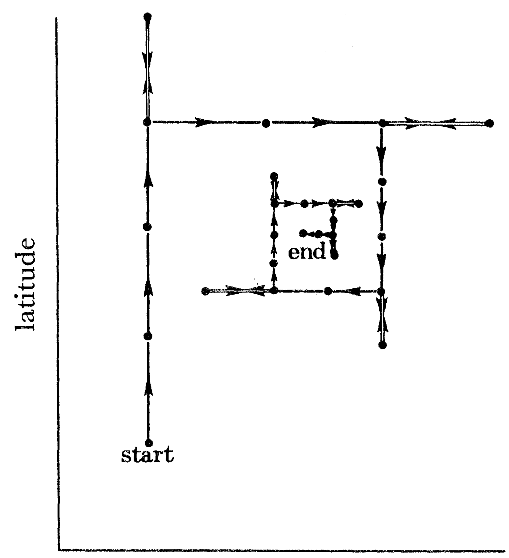


FIGURE 2. Approach to the best fit.

method of finding the minimum is to start from an estimated position and search systematically about it. This was done with the computer EDSAC 2 by the process illustrated in figure 2. The misfit, $Q(\theta, \lambda)$, was calculated from (1) for an assumed centre of rotation with latitude θ and longitude λ using the best angle of rotation given by (2). The latitude of the centre of rotation was then increased by some small angle δ (usually 2°) and $Q(\theta+\delta, \lambda)$ found. If this was smaller than $Q(\theta, \lambda)$, further increases in latitude were made till for some integer, r, $Q(\theta+(r+1)\delta, \lambda)$ was found to be larger than $Q(\theta+r\delta, \lambda)$. The longitude of the centre of rotation was then increased in a similar manner until a position of least misfit was found, giving $Q(\theta+r\delta, \lambda+s\delta)$, where s is an integer. The whole process was then repeated with increments $-\frac{1}{2}\delta$, starting from this point, in order to locate the minimum more accurately. This multiplication of the interval by $-\frac{1}{2}$ was continued until the increment had fallen below some chosen value (usually 0·1°).

The process starts from a point in the neighbourhood of a minimum and 'homes in' on it by changing the latitude and longitude of the centre of rotation alternately, as shown in figure 2. The process always finds a minimum, but does not necessarily find the deepest minimum. This complication, which does not occur in the usual least squares fitting of a linear function, is due to the difference, ϕ, between the 'longitudes' of corresponding points on the two contours not being linearly related to the position of the centre of rotation. To find the deepest minimum the calculation was started again from other trial centres of rotation in the neighbourhood of the one first found. Usually it was sufficient to take the previous minimum as the next trial point and to stop when a minimum was found to which the homing process returned. This process could fail to find a minimum that was narrow compared to the coarsest step used, but sufficient exploration of the $Q(\theta, \lambda)$ surface has been carried out to ensure that this has not happened with the steps actually used.

Other criteria might be suggested for defining the best fit, for example the mean square misfit measured perpendicular to the contours might be minimized. It seems unlikely that such criteria would give appreciably different results, the one used is perhaps the simplest arithmetically and was chosen largely for that reason.

In all these calculations the Earth has been taken to be spherical; on an ellipsoid a movement of a portion of the surface involves distortions, these would be of the order of 0·2 km and are negligible compared with the misfits found.

3. The data

In most parts of the world detailed hydrographic surveys do not reach the continental slope and the delineation of the contours below 100 fm. depends on a relatively few traverses by surveying and oceanographic vessels. It is not practicable to go back to the original data and it is therefore necessary to accept the contours on some chart. We have used the map of the world in 12 sheets on an equatorial scale of 1:12 233 000 published in 1961 by the U.S. Hydrographic office (H.O. Misc. 15254). This map gives 100, 500, 1000 and 2000 fm. contours which appear to have been drawn to give a smooth representation of the observations without reference to any views as to what 'ought' to be the form of submarine features. It is probable that the use of observations made since 1961 would greatly improve the detail of the map, but there does not seem to be any practicable way of collecting them. There is an inevitable lag in the compilation of data from so wide an area and a project of this kind is necessarily based on data which are several years old. We have examined the Admiralty plotting sheets of deep sea soundings for the South Atlantic on a scale of 1:1 000 000; as would be expected they agree closely with the U.S. map, but they do not add much to it for our purposes since they give few crossings of the continental edge.

It is difficult to estimate how accurately the position of the contours is known; as an informed guess we estimate that over most of our area the 100, 500 and 1000 fm. contours are positioned within 0·5° of their true positions but are frequently more than 0·1° in error. In some areas, such as the eastern seaboard of the U.S.A. and the west coast of Europe, there is no uncertainty of any consequence.

4. The fit of South America to Africa

The fit of South America to Africa was studied in more detail than the other areas. The results are summarized in table 1. The root-mean-square misfit is shown as a function of depth in figure 3, the change with depth is not very striking; it hardly could be since the

100, 500 and 1000 fm. contours are usually less than 1° apart, and the fit of the 500 fm. contour on one side to the 1000 fm. contour on the other is as good as that to the opposing 500 fm. contour. On the whole, fitting the 500 fm. contours seems the best; it gives the closest fit and usually lies on the steepest part of the slope and therefore in a relatively well defined position.

TABLE 1. SOUTH ATLANTIC FITS

fit	S. America (fm.)	Africa (fm.)	Niger Delta and Walvis Ridge	extent of lines	centre of rotation lat. (° N)	centre of rotation long. (° W)	rotation angle (°)	r.m.s. misfit (°)	misfit (% of rotation)	misfit (km)
1	100	100	included	*A–A*	39·0	29·0	60·0	1·43	2·4	140
2	500	500	included	*A–A*	42·9	30·1	57·1	0·95	1·7	90
3	1000	1000	included	*A–A*	43·8	30·1	55·8	1·03	1·8	85
4	2000	2000	included	*A–A*	45·1	29·1	50·8	2·05	4·0	190
5	500	500	removed	*A–A*	42·5	29·9	57·6	0·84	1·4	80
6	1000	1000	removed	*A–A*	43·9	30·1	56·1	0·79	1·4	75
7	500	1000	removed	*A–A*	43·9	30·3	56·6	0·73	1·3	69
8	1000	500	removed	*A–A*	43·5	30·0	56·7	0·79	1·4	75
9	500	500	removed	*B–B*	44·0	30·6	57·0	0·93	1·6	88
10	1000	1000	removed	*B–B*	44·1	30·3	56·1	1·05	1·9	100
11	500	1000	removed	*B–B*	44·1	30·5	56·5	0·91	1·6	86
12	1000	500	removed	*B–B*	44·4	30·5	56·3	1·08	1·9	102

The latitudes and longitudes of the centres of rotation are relative to the present position of Africa.

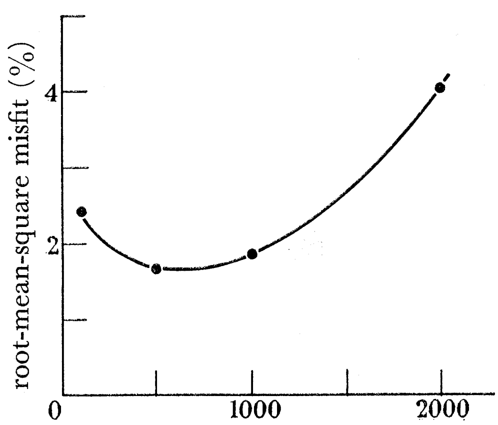


FIGURE 3. Misfit as a function of the depth of the contour used in the fitting.

Two stretches of the continental edge were fitted, one, *BB* (figure 4), rather longer than the other, *AA*. All solutions showed a substantial misfit of up to 270 km at the Niger delta; this is not surprising as this delta has been built out in the Tertiary and is certainly a recent addition to the continental edge. The point of junction of the African coast with the Walvis ridge shows a misfit of up to 130 km; there is no direct evidence as to the age of the Walvis ridge, but it is an off-shoot of the mid-ocean ridge system which is of Tertiary age everywhere it has been investigated. Since the Niger delta and the Walvis ridge (dashed in figure 4) appear to be recent excrescences on the edge of the African continent they are best omitted from the fitting, table 1 shows that, owing to the small lengths of coast involved, their omission reduces the misfit only slightly. The projection in the contour off South America in latitude 20° S, which overlaps the African coast, is connected with a ridge running out to Trinidade island, this is presumably volcanic and Tertiary and should perhaps have been omitted, it was not.

Expressed as a root-mean-square change in the 'longitude' relative to the centre of rotation the misfit for the section BB of the 500 fm. contours is 0·93° (fit 9 of table 1) which is 1·6 % of the whole rotation of 57°. The last column of table 1 gives the angular misfits, $\delta\phi$, converted to distances at the middle of the line, these distances, s (km), have been obtained from

$$s = 111\,\delta\phi \sin\psi,$$

where $\delta\phi$ is in degrees and ψ is the angular distance from the centre of rotation to the middle of the line (70° for the line BB). The misfit for the 500 fm. fit on BB is 88 km.

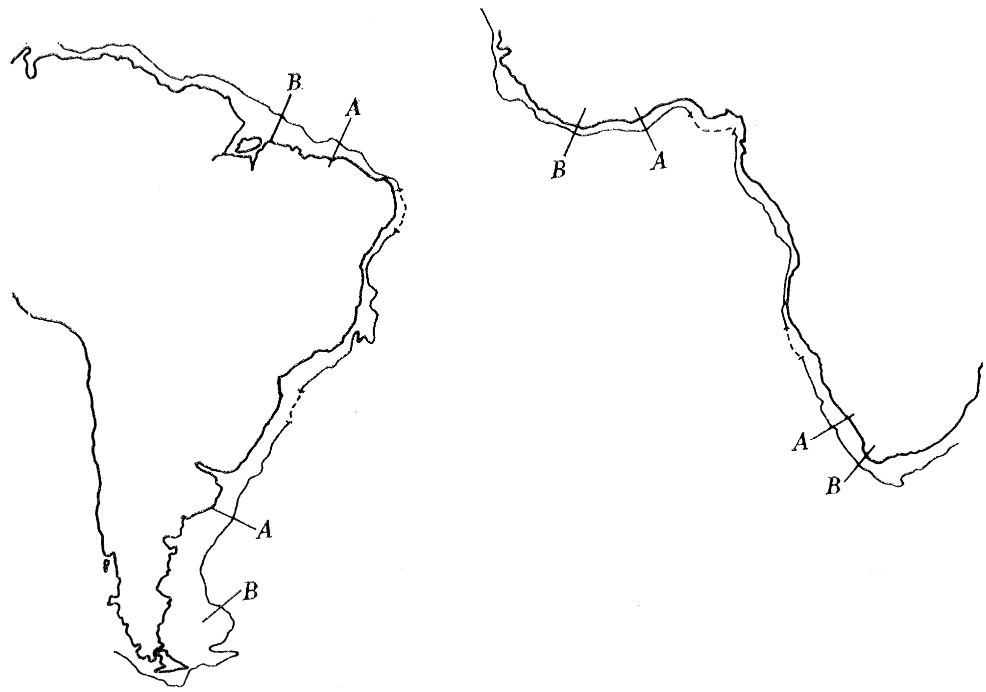


FIGURE 4. Sections of continental edge fitted. The coast line and the 500 fm. contour are shown, 80 points were taken on AA and 100 on BB. The sections omitted are dotted.

The fit of the 500 fm. contours (fit 9 of table 1) is shown in figure 5. The projection is Mercator's, Africa being plotted in its present position. The lines of latitude and longitude over South America give the co-ordinates corresponding to the present position of that continent. The curvature of the lines over South America is a consequence of the projection of a rotated co-ordinate grid and does not represent a distortion of the continent.

5. The fit of the North Atlantic

The fitting of the lands around the North Atlantic requires the bringing together of three major continental masses, North America, Greenland and Europe. A fit of Greenland to northern Europe on the 500 fm. contour was first attempted. In this fit Iceland was ignored altogether, as were also the ridges joining it to Greenland and to the Faeroes (these ridges are shallower than 500 fm.). Iceland is composed of Tertiary and Recent igneous rocks and its omission is clearly justified. There is no direct evidence as to the age of the ridges, but they, like the Walvis ridge, are typical of the 'transverse ridges' associated with the mid-ocean ridges and there is little doubt that they are Tertiary. The Rockall Bank is a more doubtful case, Rockall itself is Tertiary (Miller 1965*a*), but it may well be

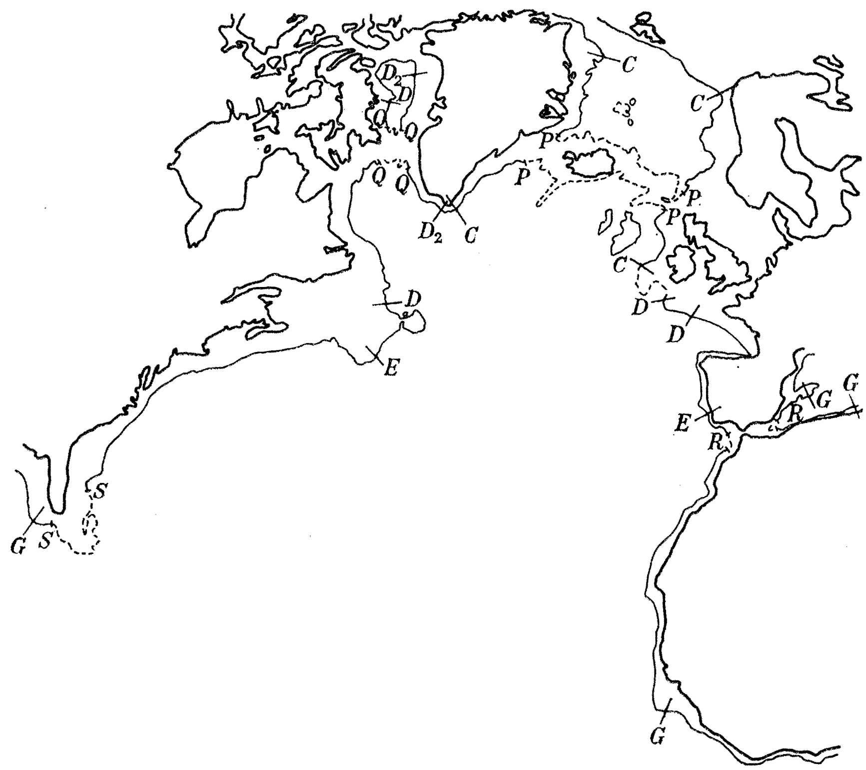


FIGURE 6. Sections of the continental edge used in fitting. The coast line and the 500 fm. contour are shown. The sections *PP*, *QQ*, *DC*, *RR* and *SS* were omitted in making the fits.

TABLE 2. NORTH AND CENTRAL ATLANTIC FITS

fit	continents fitted (500 fm.)	extent of lines	centre of rotation lat. (° N)	centre of rotation long. (° W)	rotation angle	misfit (°)	misfit (% of rotation)	misfit (km)
1	Greenland to Europe	*C–C*	73·0	−96·5	−22·0	0·74	3·4	43
2	Europe and Greenland to North America	D_2–*D*	88·4	−27·7	38·1	0·97	2·5	34
3	Europe and Greenland to North America (Spain rotated)	D_2–*E*	88·5	−27·7	38·0	0·94	2·5	52
4	Africa to North America	*G–G*	80·0	65·0	45·0	—	—	—
			44·5	19·8	34·4	2·15*	6·3*	130*

* Owing to a peculiarity of the computer programme used for fitting, it was necessary to make two successive rotations for this fit. The misfit has been calculated from the second rotation, it is not precisely that which would be obtained from the single rotation equivalent to the two given here. The equivalent single rotation is 74·8° about the point 67·6° N, 14·0° W.

intrusive into older rocks as are many of the Tertiary igneous rocks of western Scotland. We have retained the Rockall Bank in the fit, largely because it fills what would otherwise be a gap; further study of the bank is very desirable to determine whether it does, in fact, contain older rocks.

The section *CC* (figure 6) of the 500 fm. line off the east coast of Greenland was fitted to the section *CC* off the west coast of Europe, omitting the sections *PP* where transverse ridges meet the continents. The fit is shown in figure 7 and table 2 (fit no. 1), it gives a root-mean-square misfit of 0·74°, corresponding to 43 km at the middle of the line, this is a closer fit than the fit of South America to Africa but over a shorter length of contour. The agreement of the two sharp corners in the contours off Greenland with the corresponding bends in those of Europe is striking.

The section *DD* of the 500 fm. contour east of the American coast of the Davis Strait was next fitted to the displaced section D_2D_2 of the 500 fm. contour west of Greenland and to the section *DD* off the coast of Europe. The sections *QQ* where the Davis Strait is shallower than 500 fm. were omitted. The fit obtained is shown in figure 7 and in table 2 (fit 2). Figure 7 is drawn on a conical projection with standard parallels at 45° and 75°; North America is plotted in its present position, the grids for Europe and Greenland give the latitudes and longitudes for their present positions.

In the extreme northwest of Greenland the narrow and shallow strait separating it from Ellesmere Island is shown widened to 400 km, it would have been more realistic to regard Ellesmere Island as part of Greenland, on to which it fits closely, and to have displaced it with Greenland. We did not do this as we were doubtful where to draw the limits of the block and did not wish to become involved in arbitrary assumptions about an area not closely connected with our main theme. A striking aerial photograph of the northern part of the strait, the Robeson channel, has been published by Wilson (1963); it shows both shores as straight cliffs which may mark fault scarps.

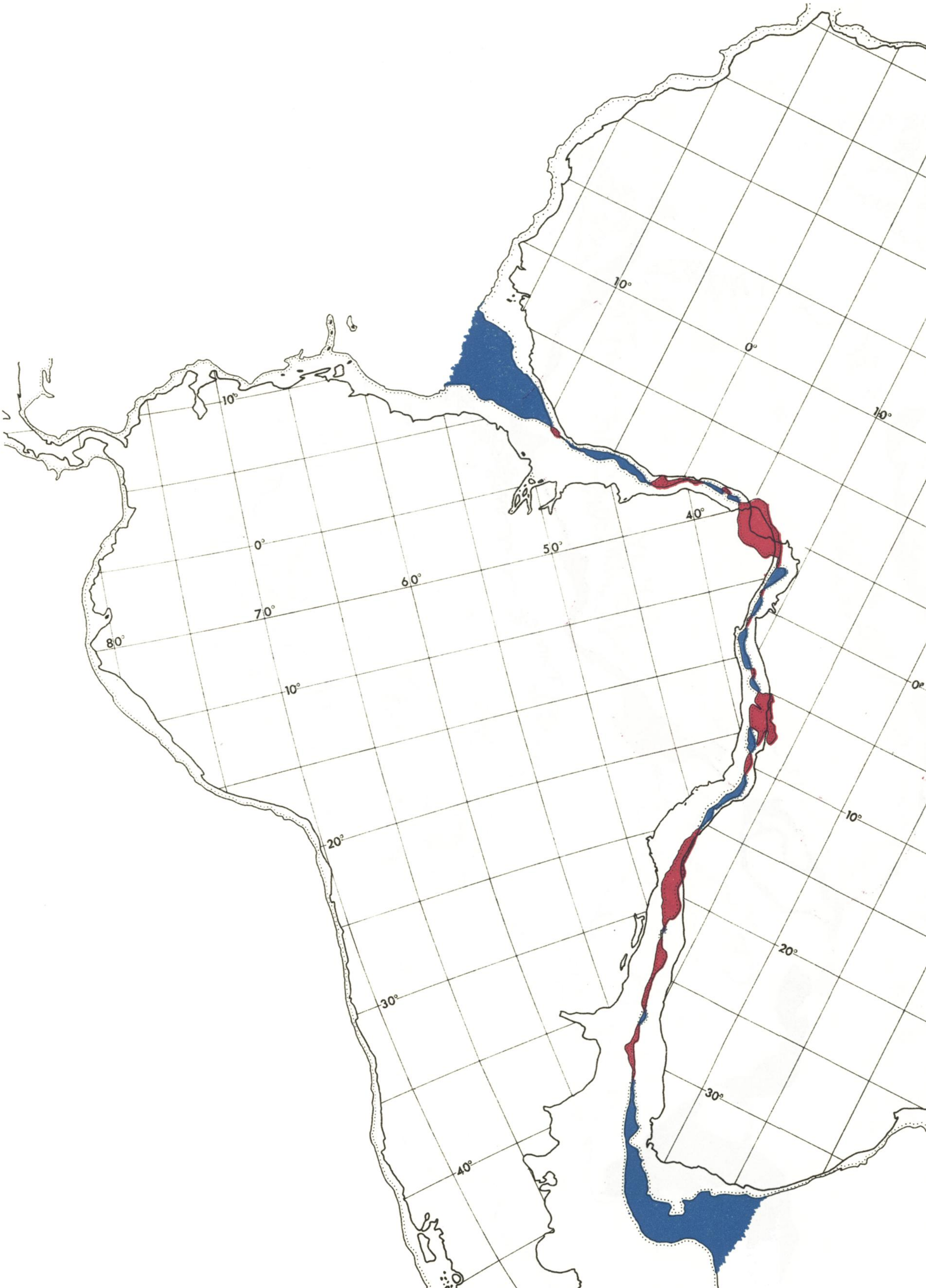
For the rest of the west coast of Greenland the fit is excellent, the misfit being usually only a few tenths of a degree. South of this the 500 fm. contour to the northeast of Newfoundland lies against that off the end of the English Channel, leaving a gap 230 km in width. The Porcupine Bank overlaps the shelf to the north of the Flemish Cap and the Flemish Cap would overlap the shelf off Brittany if the deep water gap between the Flemish Cap and Newfoundland had not been closed. The Porcupine Bank should be further investigated, it slopes down rather gently to the deep ocean and appears to differ from the steeper sections of 'typical' shelf edge to the north and south.

The root-mean-square misfit of Greenland and Europe to America is 0·97°, which is a little greater than for the Africa–South America fit, but it must be remembered that the badly fitting section *CD* has been omitted in finding the misfit.

6. The fit of the whole Atlantic

It is natural to try to fit together the two blocks shown in figures 5 and 7. If northwest Africa is fitted to eastern North America, Africa overlaps the position of southern Spain determined from the north Atlantic fit of figure 7. It is thus impossible to get any reasonable fit without some distortion of the continents.

The least distortion that will avoid the large overlap is a rotation of Spain to close up the Bay of Biscay and bring its north coast against the 500 fm. contour of western France. Such a rotation has been suggested previously (du Toit 1937; Carey 1958), and is supported by some palaeomagnetic evidence which suggests a post-Triassic rotation (Irving 1964, pp. 254–6). Since the Mesozoic and Tertiary fold belt of the Pyrenees lies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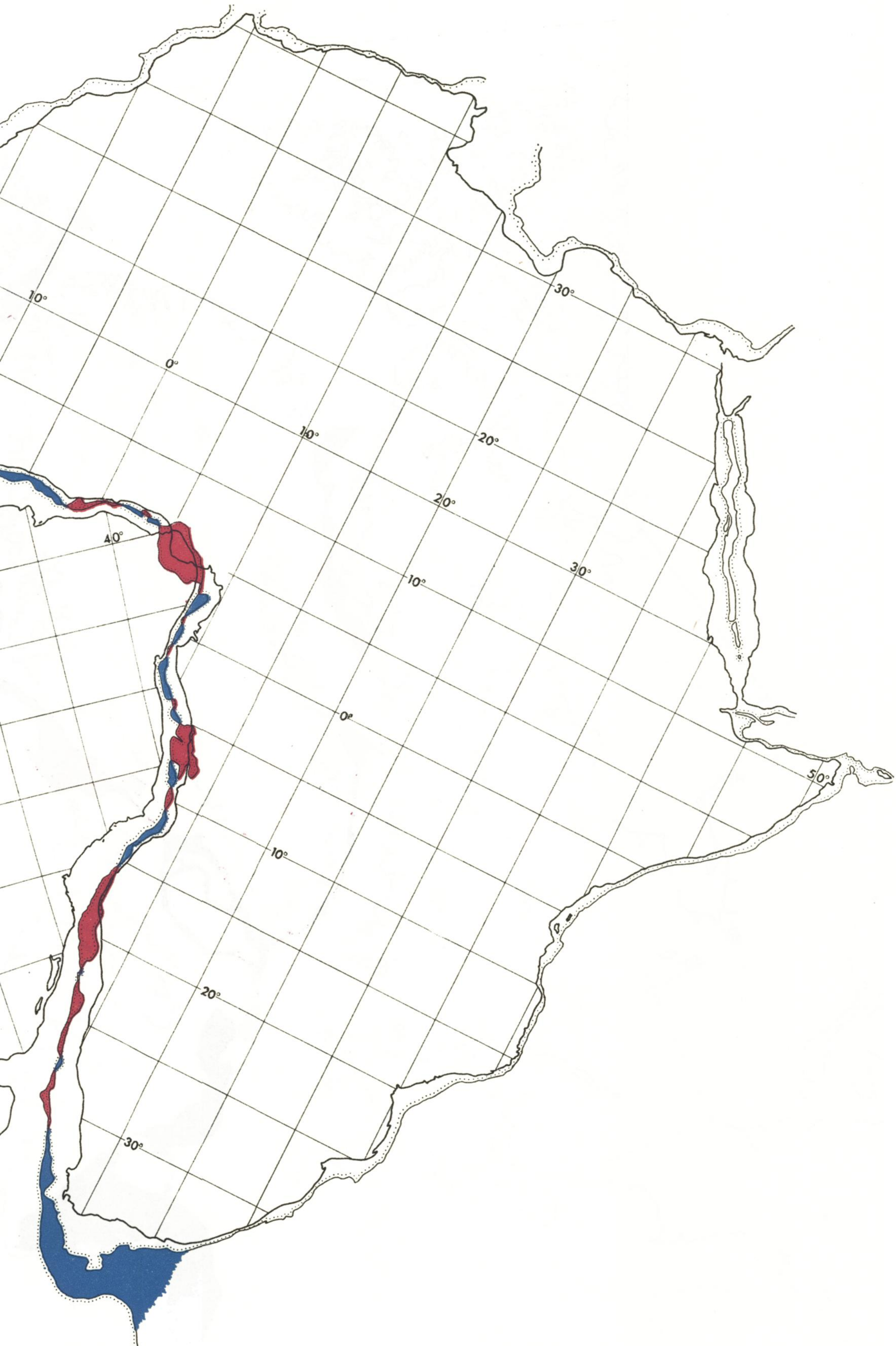
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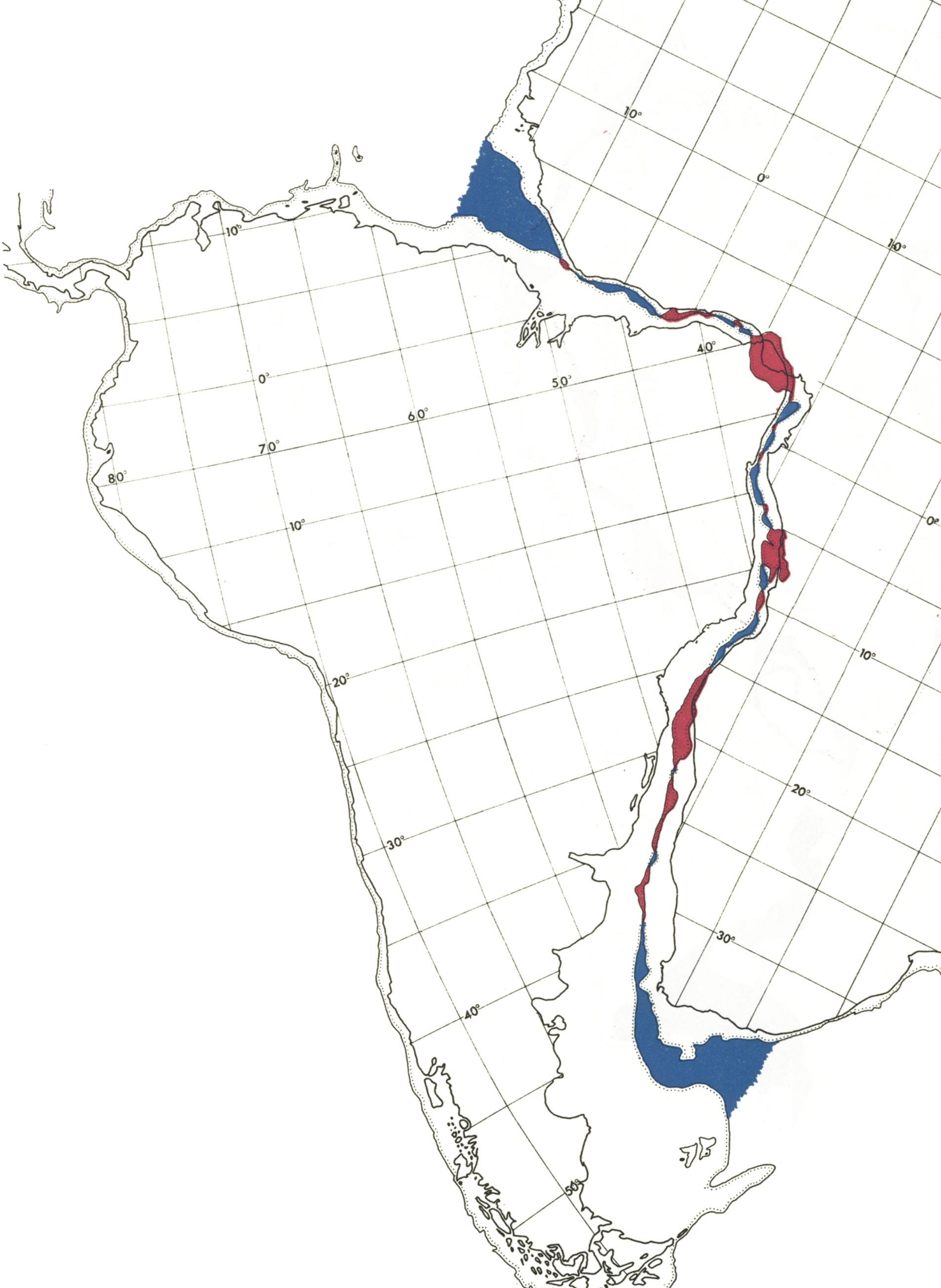
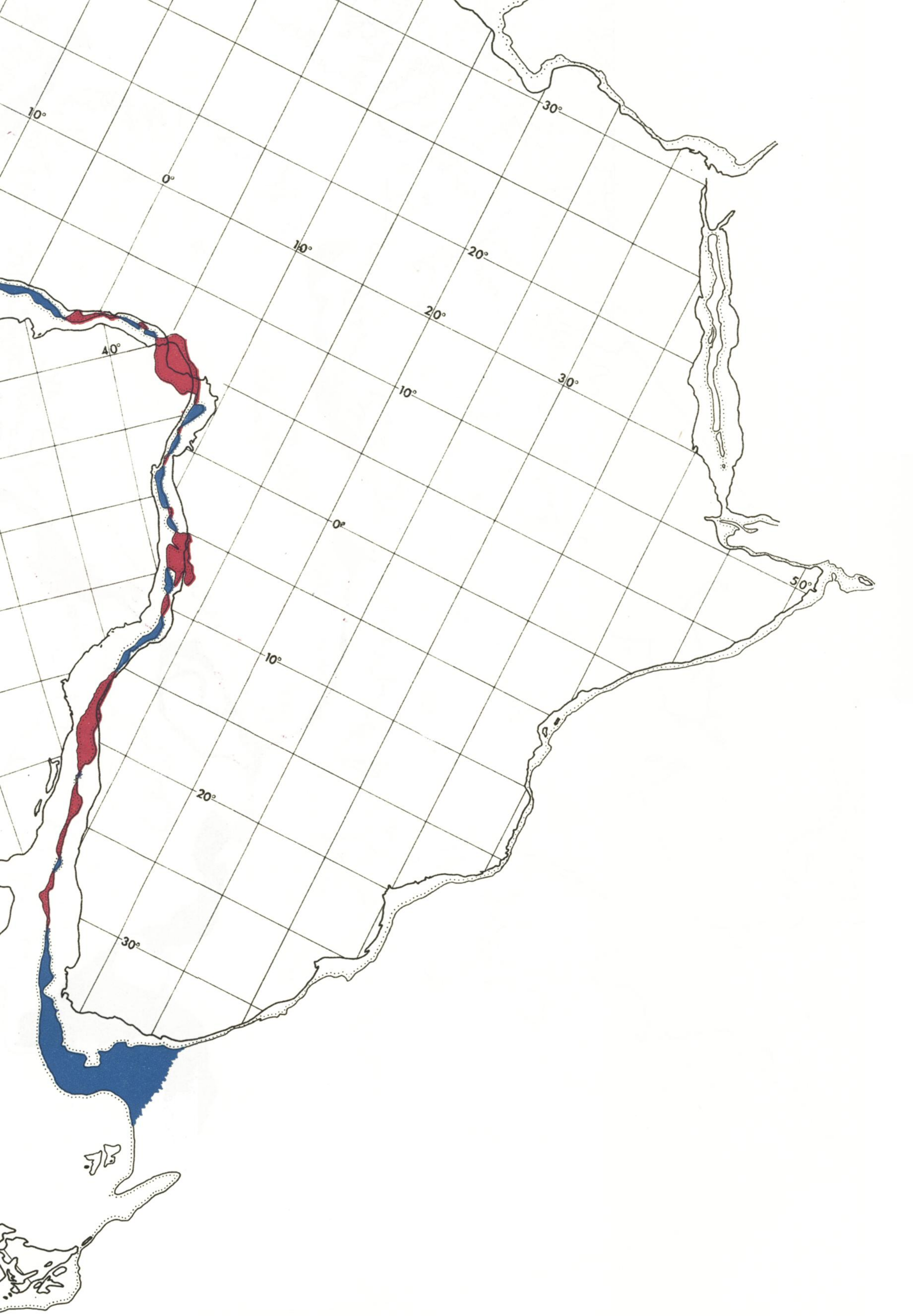


FIGURE 5. The fit of Africa and South America at the 500 fm. con
Mercator's projection. Overlaps in red, gaps in b



nd South America at the 500 fm. contour (fit 9 of table 1), projection. Overlaps in red, gaps in blue.

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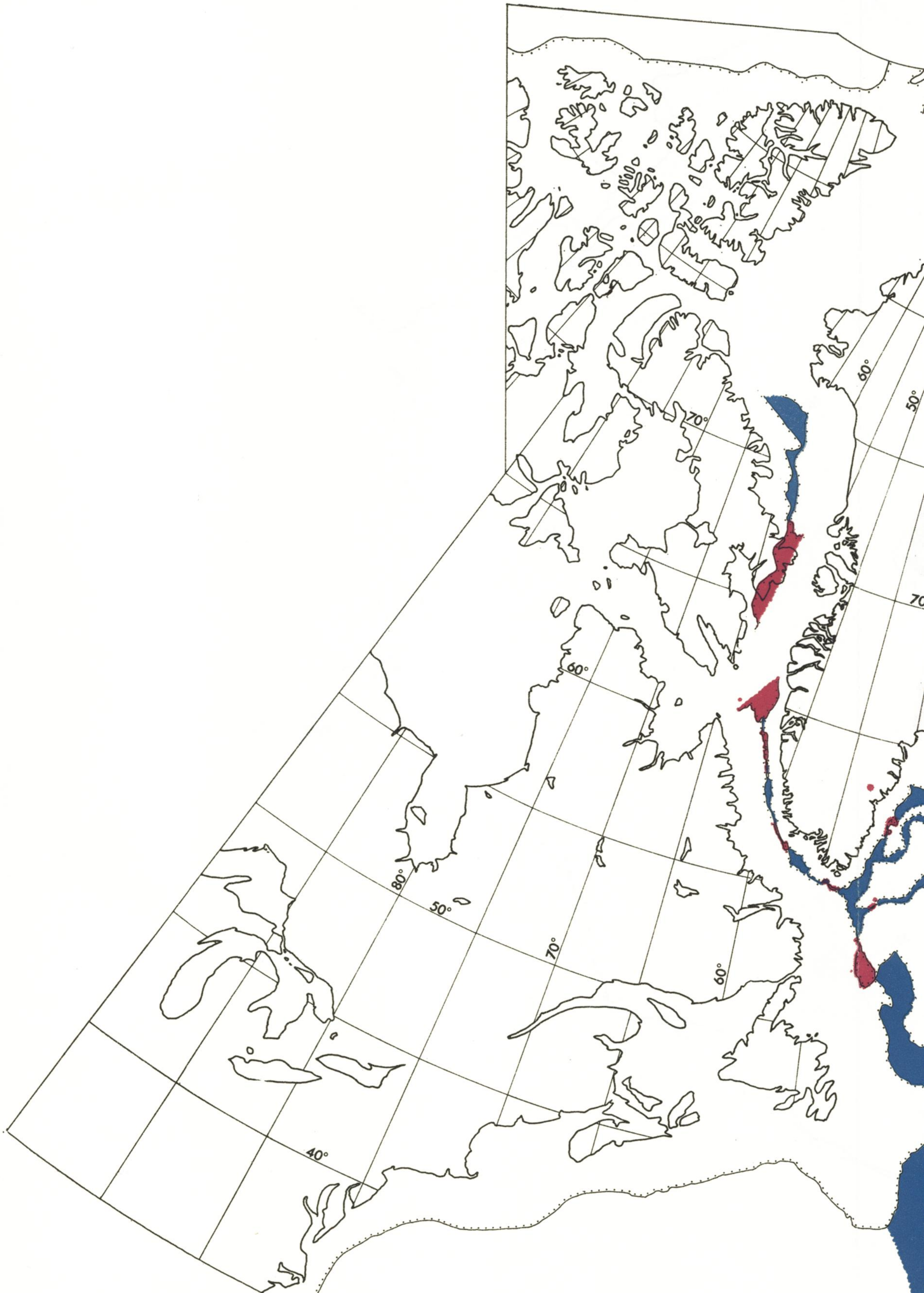
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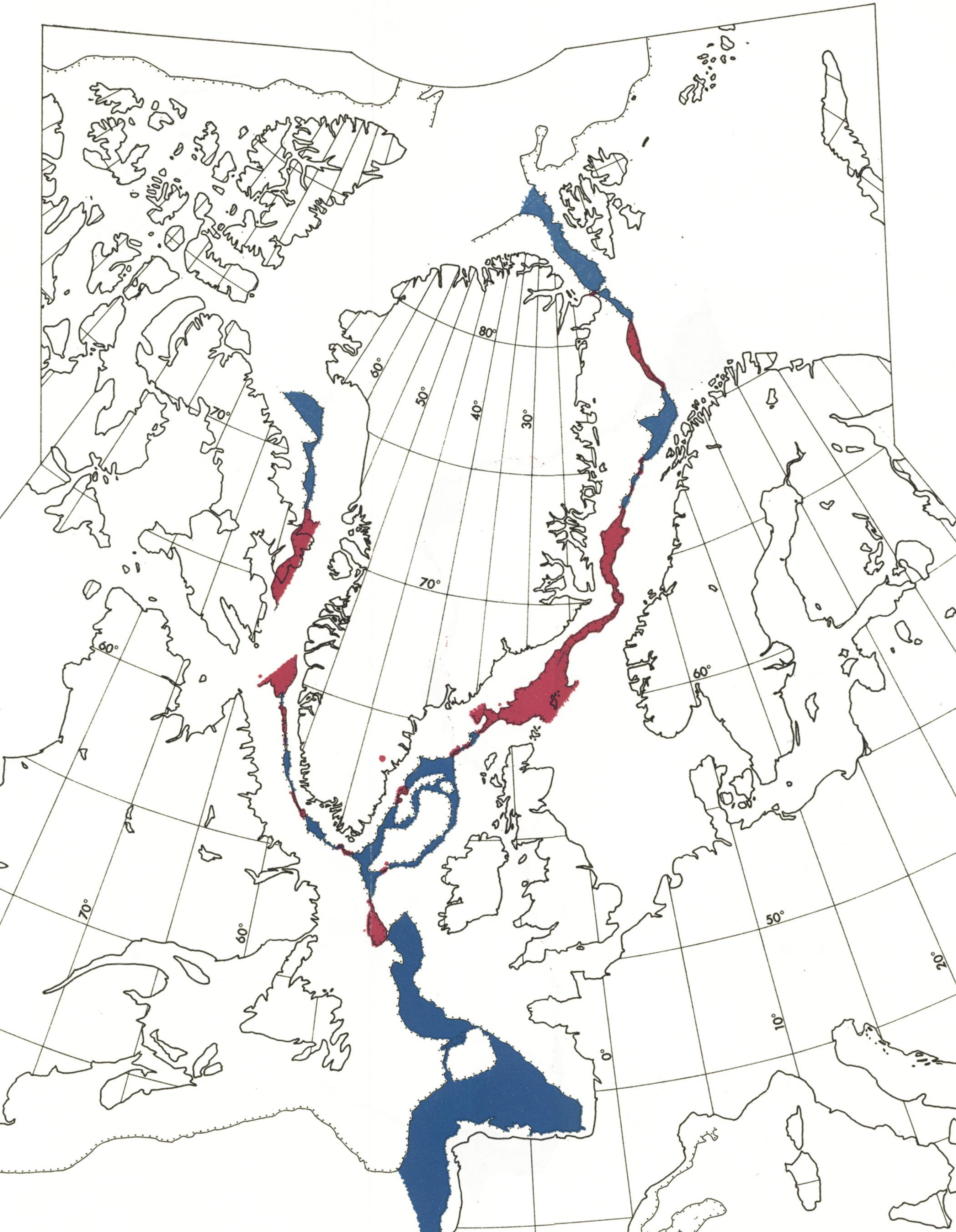
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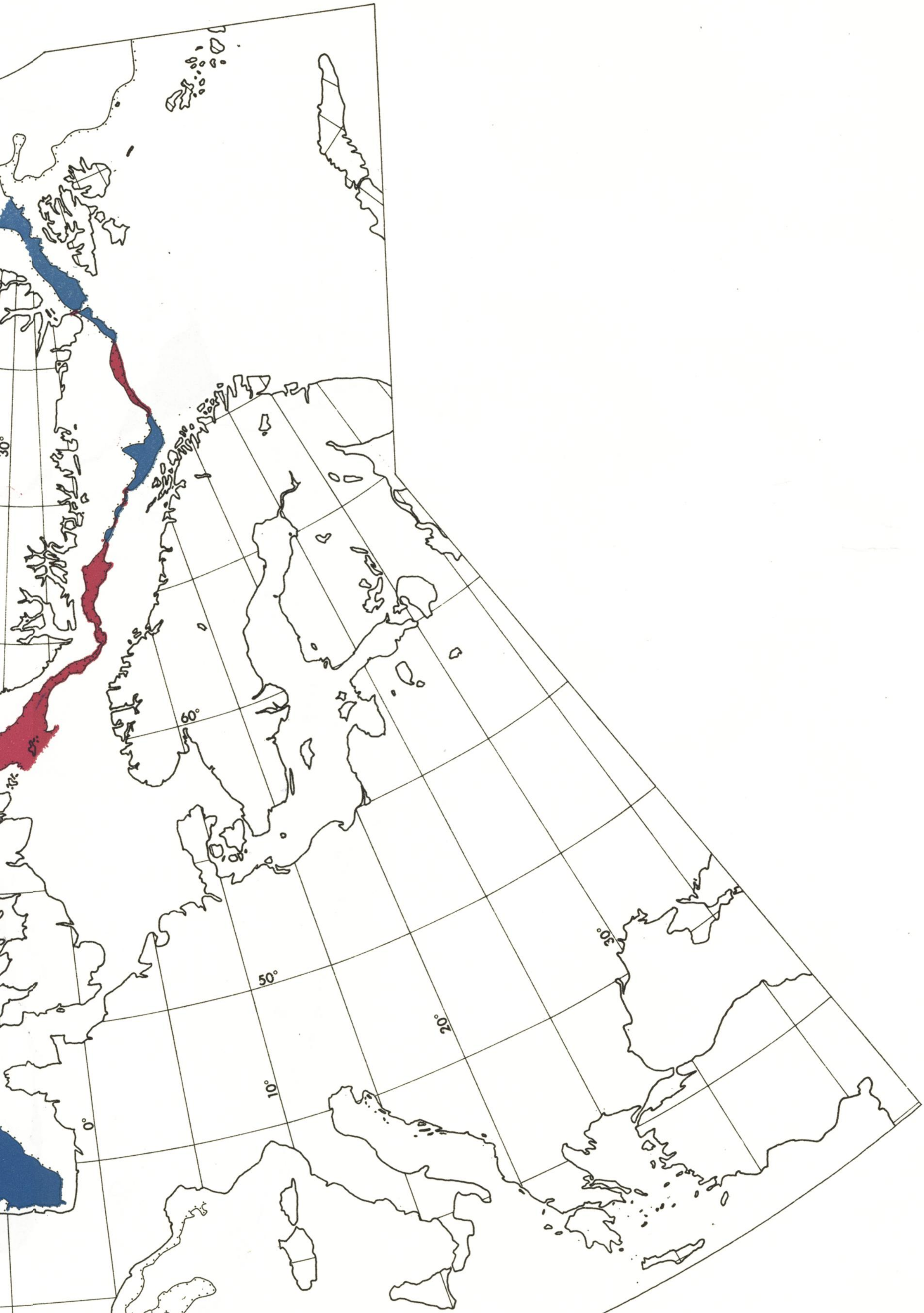
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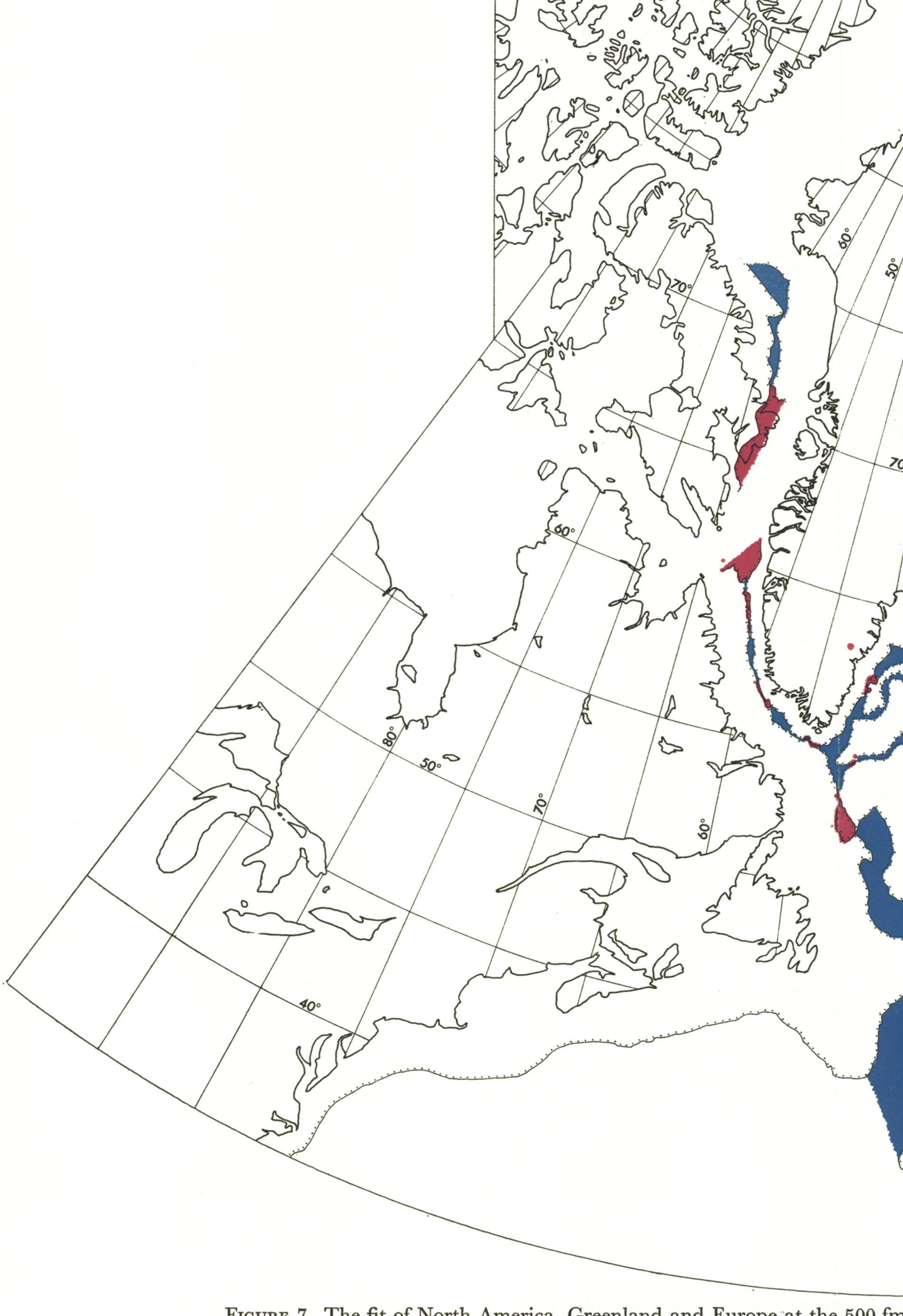
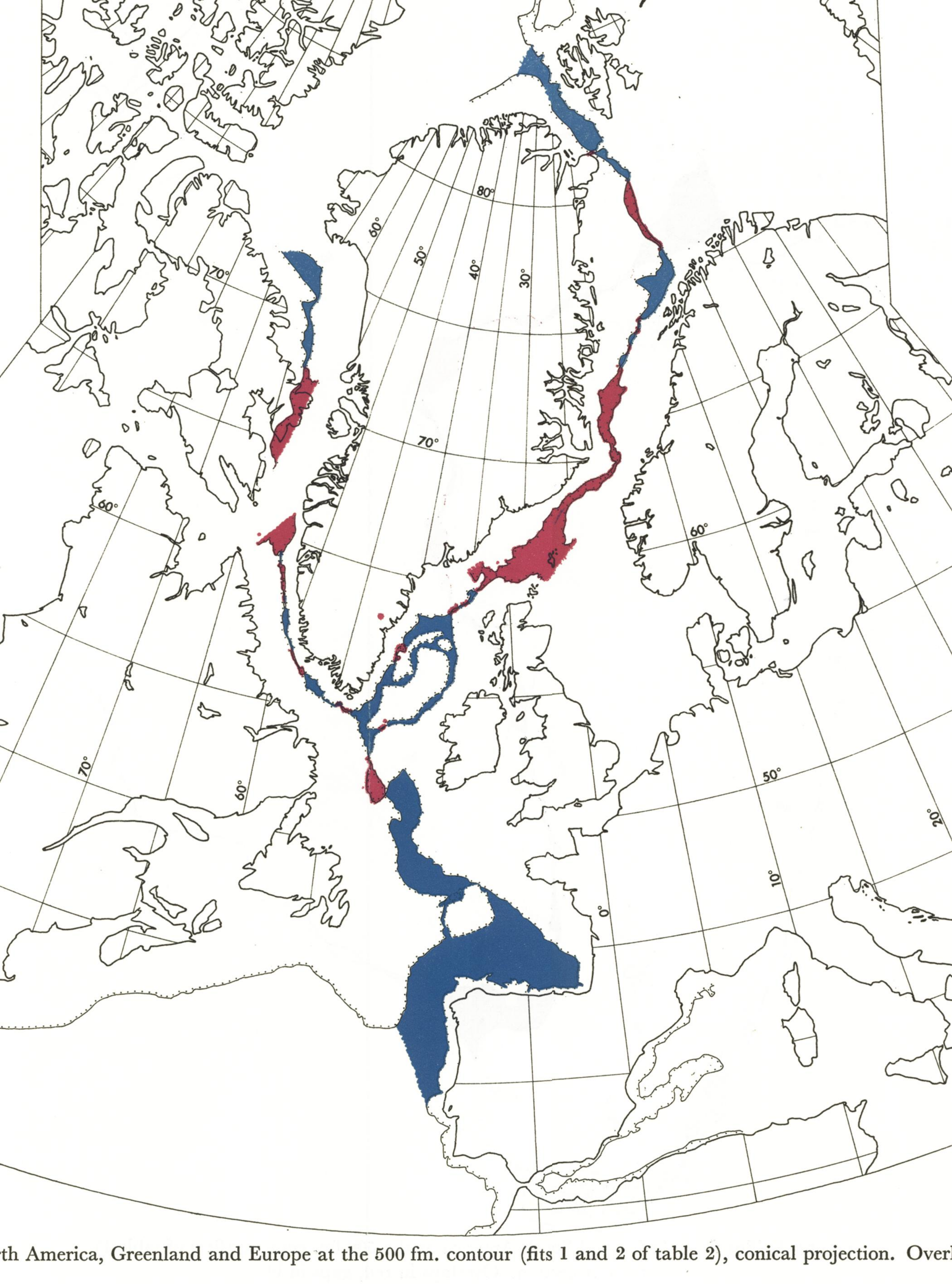
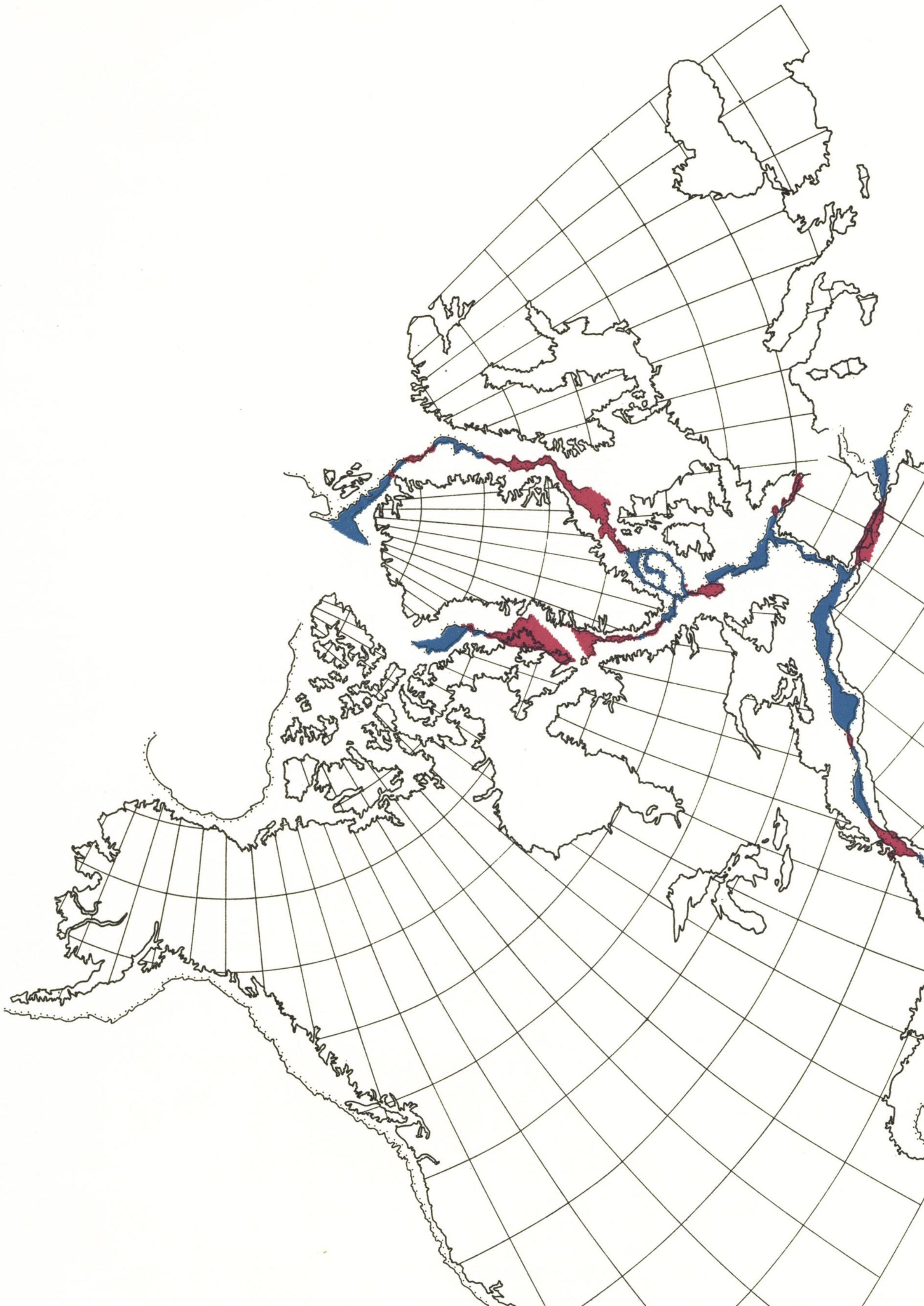


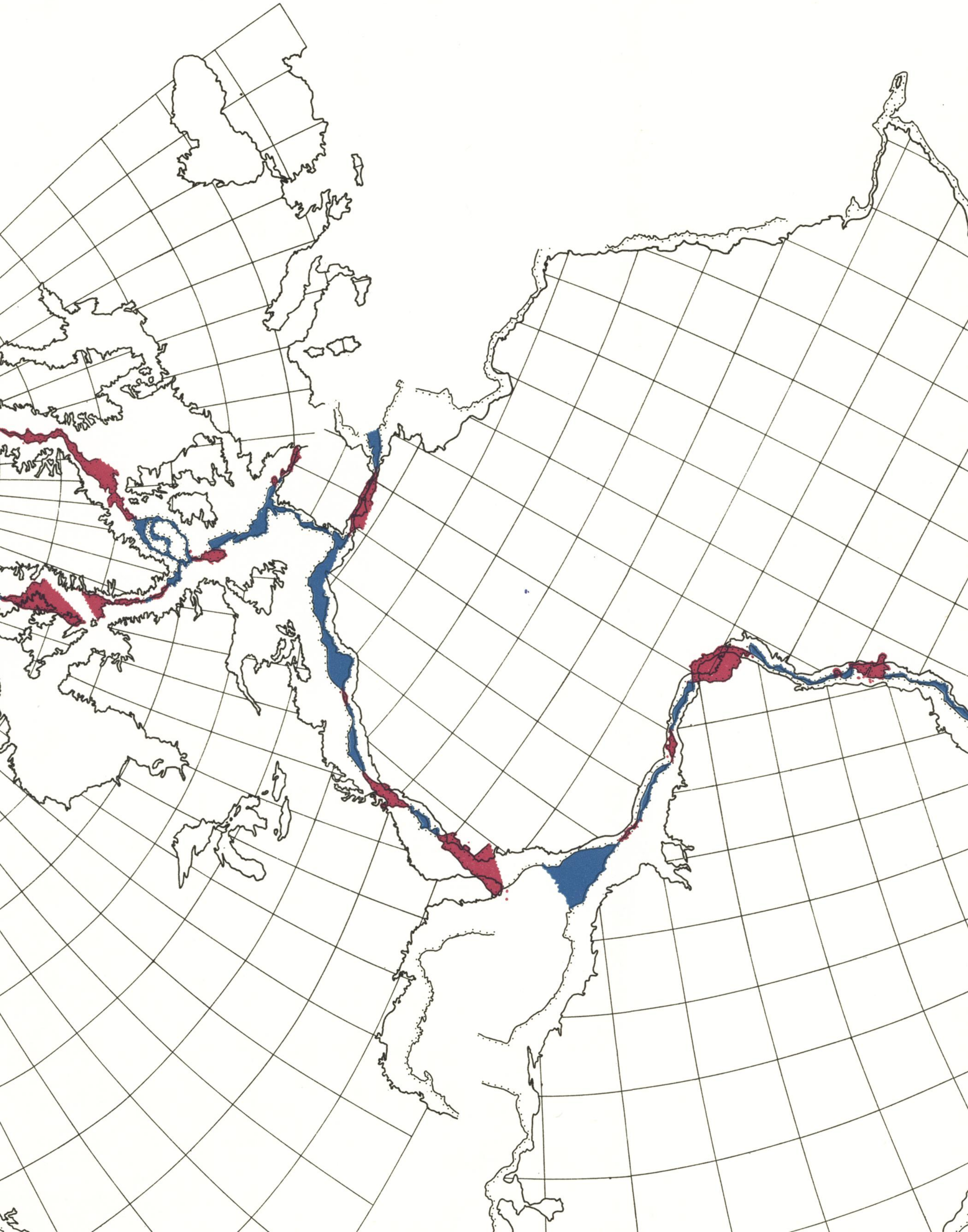
FIGURE 7. The fit of North America, Greenland and Europe at the 500 fm

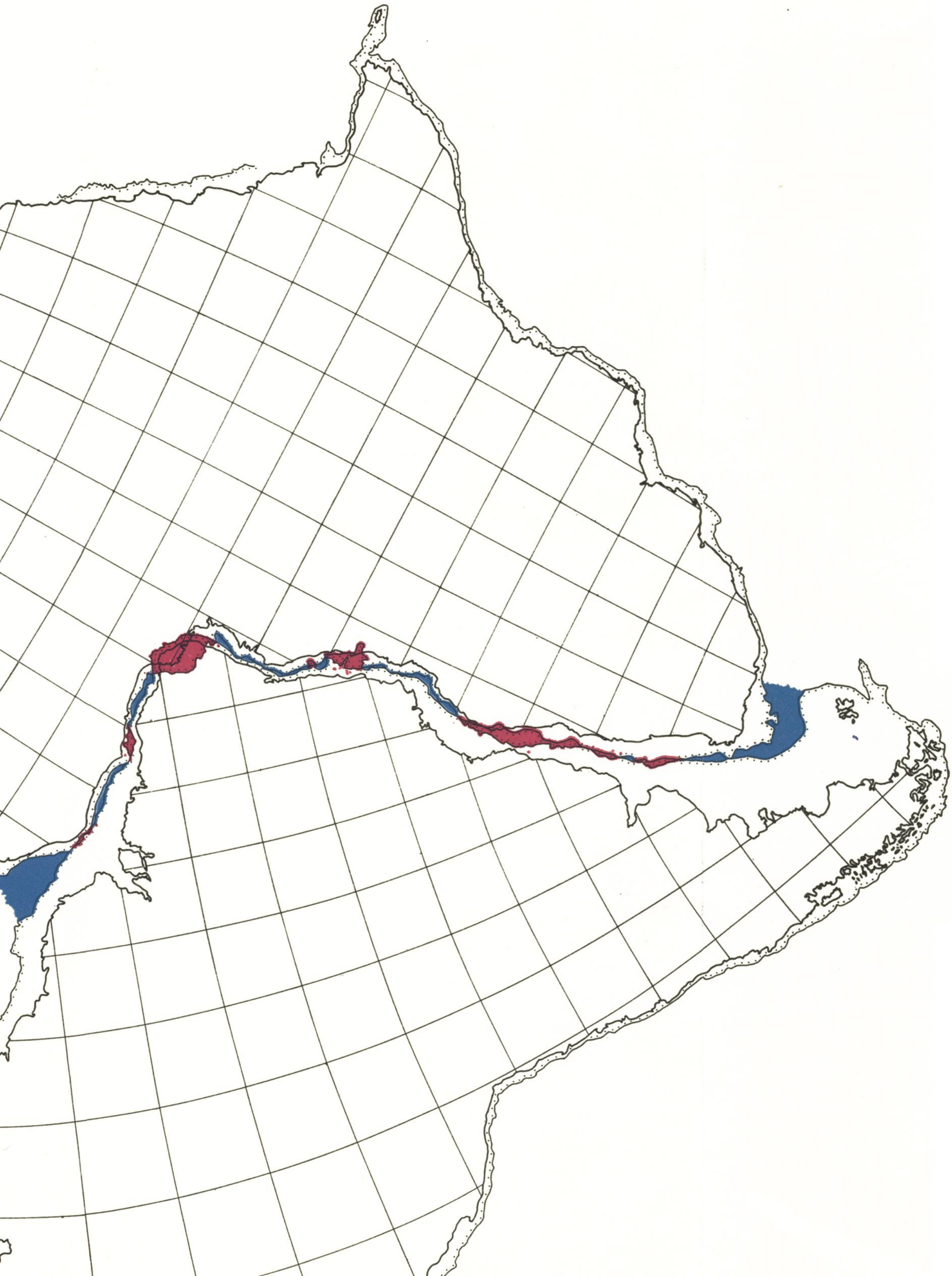


...th America, Greenland and Europe at the 500 fm. contour (fits 1 and 2 of table 2), conical projection. Overl

(fits 1 and 2 of table 2), conical projection. Overlaps in red, gaps in blue.







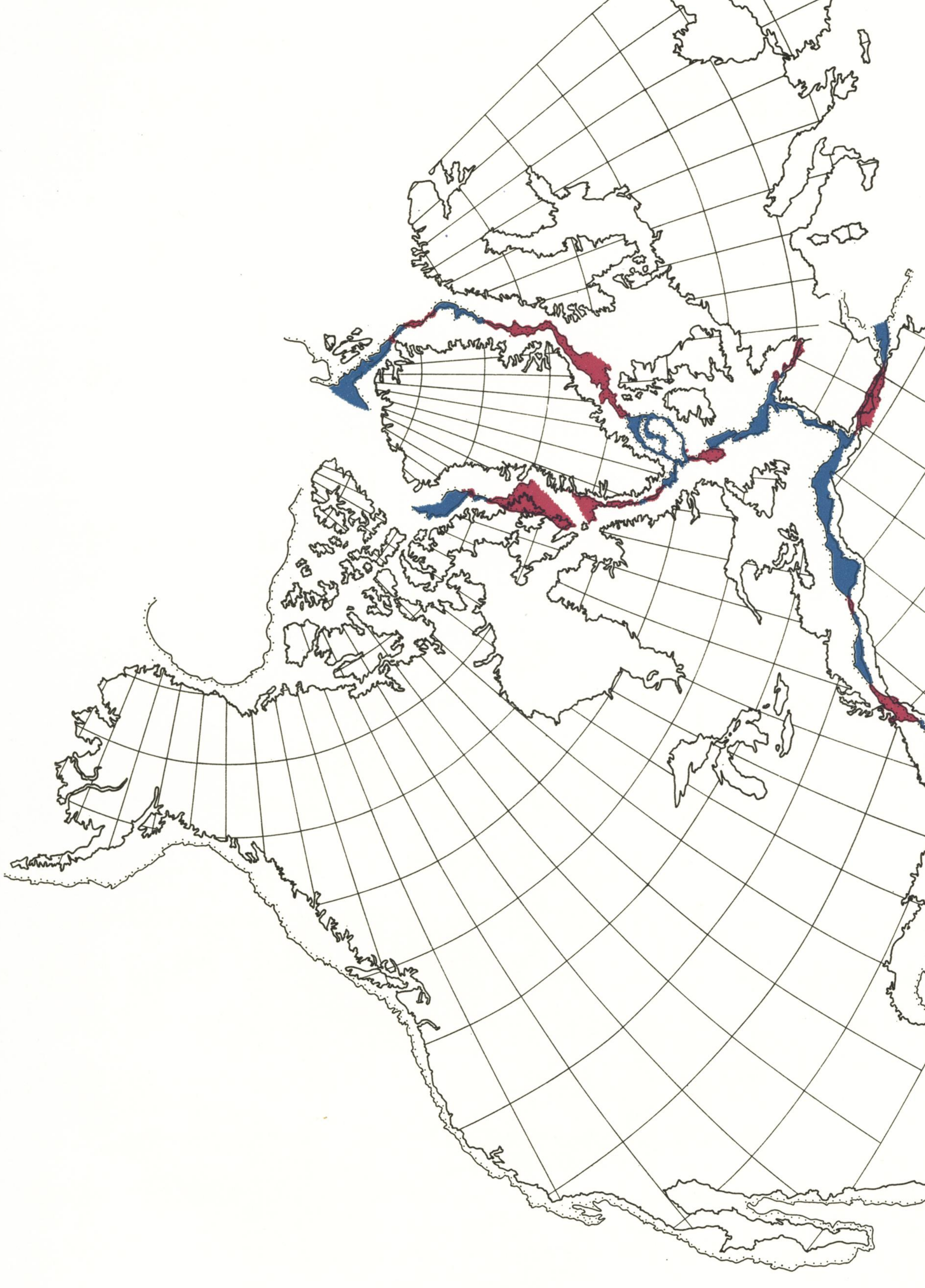


FIGURE 8. Fit of all the continents around the A

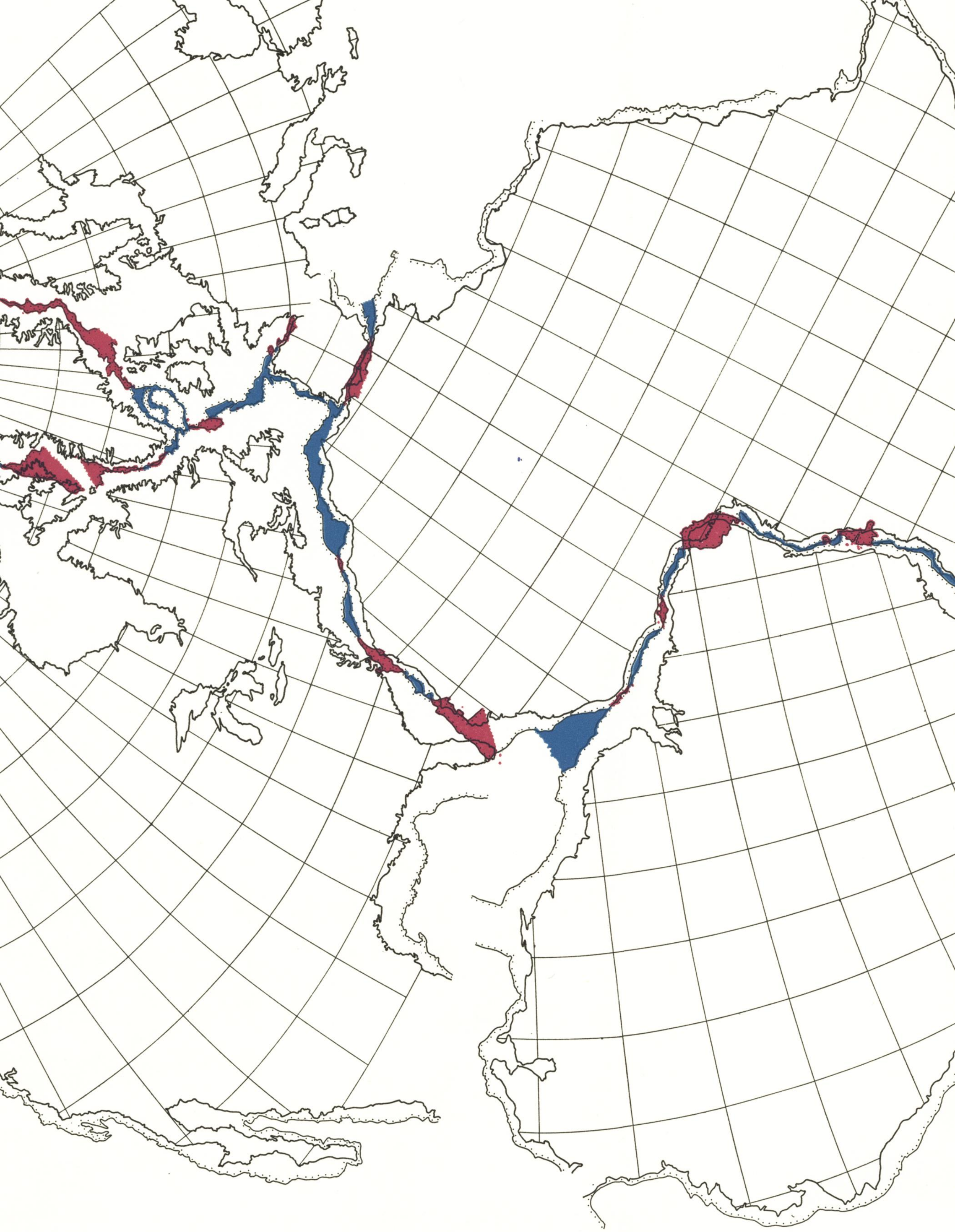
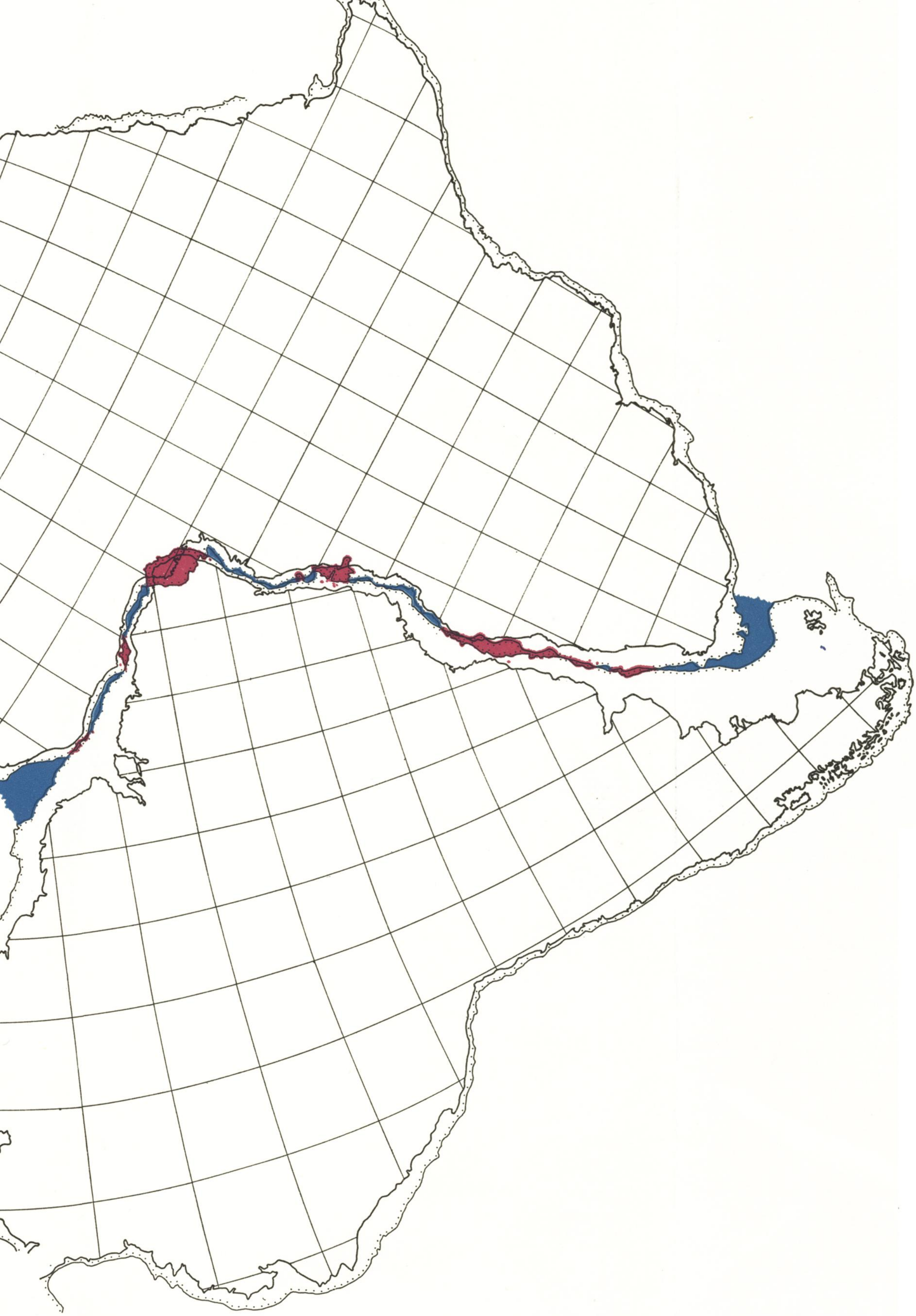


FIGURE 8. Fit of all the continents around the Atlantic at the 500 fm. contour, transverse Mercator projection



500 fm. contour, transverse Mercator projection.

between Spain and Europe some relative movement is not improbable. That there may be something anomalous about the position of Spain was noticed by W. H. Auden (1950) who wrote in 1937 of:

'...that arid square, that fragment nipped off from hot Africa, soldered so crudely to inventive Europe.'

After Spain had been rotated to close up the Bay of Biscay (this was done by inspection and not with the computer), the fit of Europe and Greenland to North America was redetermined using the additional length *DE* of the 500 fm. contour (fit 3 of table 2). The centre, angle of rotation and misfit were nearly the same as in fit 2.

Fit 3 leaves a gap of about 100 km between the west coast of Spain and the east coast of Newfoundland. Since Spain had already been rotated, there seemed no reason not to reduce this gap by moving Spain; this could be done without making the fit with the French coast appreciably worse.

After these adjustments, northwest Africa was fitted to the 500 fm. contour of eastern North America and to the new position of the south of Spain. The stretches of the continental edge as far south as *GG* (figure 6) were used, except for the part *RR* near Gibraltar (which is shallower than 500 fm.) and the Bahama Banks, *SS*. The result is shown in figure 8, and in fit 4 of table 2. The Flemish Cap partially overlaps Spain; for clarity it has been omitted in figure 8. The mean square misfit is 2·15°, which is two or three times as great as for other fits; expressed as distance it is 130 km at the middle of the line. Figure 8 is drawn on a transverse Mercator projection with its 'equator' along the meridian of 60° W. North America is plotted in its present position, the grids of Europe, Greenland, South America and Africa give the latitudes and longitudes for their present positions.

7. Discussion

Only two explanations have been proposed for the approximate fit of the continental blocks; either the fit is due to chance similarities, and is on a par with the similarity of the coast of Italy to a boot, or the continents were once united and have separated with the formation of the Atlantic Ocean. Other explanations are hard to find, they would involve similar processes carving similar shapes on the two sides of the ocean. It is difficult to decide by statistical theory alone whether two continental edges fit more closely than would be expected by chance. There are two main sources of uncertainty, first the sections of contours that are investigated have been selected and paired because they appeared likely to fit and the likelihood of a chance fit depends on the size of the population of curves from which the selection has been made. Secondly, the co-ordinates of neighbouring points selected on the curves are highly correlated and estimates of uncertainty which assume them to be independent will be greatly in error. Perhaps the contours should be treated as random functions and their properties expressed in terms of power series as has been done by Longuet-Higgins (1957) in his study of ocean waves. We hope to return to this question in a future paper, and here merely remark that the fits of figures 5 and 7 do appear striking, while the attempt to join the two blocks in figure 8 is somewhat less convincing. This is perhaps because there has been distortion represented by the Tertiary folding of southern Spain and North Africa. It is noteworthy that the reconstruction shows large gaps in the Caribbean and the Mediterranean which is just where they would be expected in view of the considerable Mesozoic and Tertiary deformation in these regions.

It is perhaps more profitable to approach the problem of significance by considering other aspects of the fits. If the continents were once joined, then not only the shapes but the ages, structures and petrology of the rocks must match across the joins; if they do, the probability that the fits are due to chance is negligible. The importance of the geometrical fits is that they position the continental blocks with an accuracy of the order of a degree and leave little room for adjustment to fit other evidence. Only a brief indication of some of these other lines of evidence will be given here.

The remarkable stratigraphic and structural similarities between the rocks of eastern Brazil and Argentina and those of southwest Africa are well known (du Toit 1937), and become clearer with the growth in our knowledge (Martin 1961). The fit of figure 5 alines the Triassic Cape fold belt of South Africa with that south of Buenos Aires in the manner suggested by du Toit. The match of the ages around the north Atlantic in relation to the fit of figure 7 is considered by Miller (1965 *b*, this Symposium).

It is also remarkable that throughout the entire Atlantic none of the pre-Jurassic orogenic belts (Caledonides, Appalachians, Variscides, etc.) forms a feature at the continental edge or cuts across it to continue as a topographic ridge on the floor of the deep ocean. All such structures appear to be truncated near the continental edge. By contrast some Tertiary features seem to have extensions on the deep sea floor. For example, the folding in southern Spain appears to continue as a not very well marked ridge to the Azores, and the volcanoes of the Cameroons form part of a chain crossing the continental edge and extending to St Helena.

None of this evidence is inconsistent with the hypothesis that figure 8 represents the approximate relative positions of the continents in pre-Jurassic times, and that they were later fragmented with the formation of the Atlantic Ocean. This would imply that the Palaeozoic and earliest Mesozoic mountain belts now bordering the Atlantic were at one time parts of larger systems, which, like the Urals, were intracontinental and quite unlike the present-day circum-Pacific chains. Furthermore, if there was no Atlantic Ocean until the Jurassic, then their position was not related to the present continental edge, which did not then exist.

If the present shapes of the continents do really give an indication of how they once fitted together, then those shapes cannot have been greatly affected by erosion or sedimentation since the separation took place. That, in most places, the continental shelves are not being built outwards is well known (Heezen, Thorp & Ewing 1959) as a result of dredging and of the study of their stratigraphy by sparkers and similar devices; that erosion is also very slow is not so obvious from direct observation.

Clearly, a great deal of work needs to be done before we can fully accept the hypothesis that the Atlantic Ocean was formed by continental fragmentation. And we have merely sketched a few geological implications of this theory. Some of the most important data bearing on it will probably come from detailed comparative geological studies of geometrically matching areas that have structures truncated at the continental margin, particularly where this is narrow. For such studies the authors can supply dyeline prints of figures 5, 7 and 8 on a larger scale.

We hope to see if the continents around the Indian Ocean can be assembled with fits as good as those around the Atlantic. A good fit of Australia and Antarctica has already been obtained, but since the fitted parts are approximately arcs of circles the solution is somewhat ill defined in one direction. Similar difficulties are to be expected from the straight coasts of eastern Madagascar and western India.

All the calculations of the fits, the map projections and the co-ordinate grids were made on EDSAC 2, we are indebted to the Director of the Cambridge University Mathematical Laboratory for the use of this machine, and to Mr J. A. Jackson for much advice on map projections.

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