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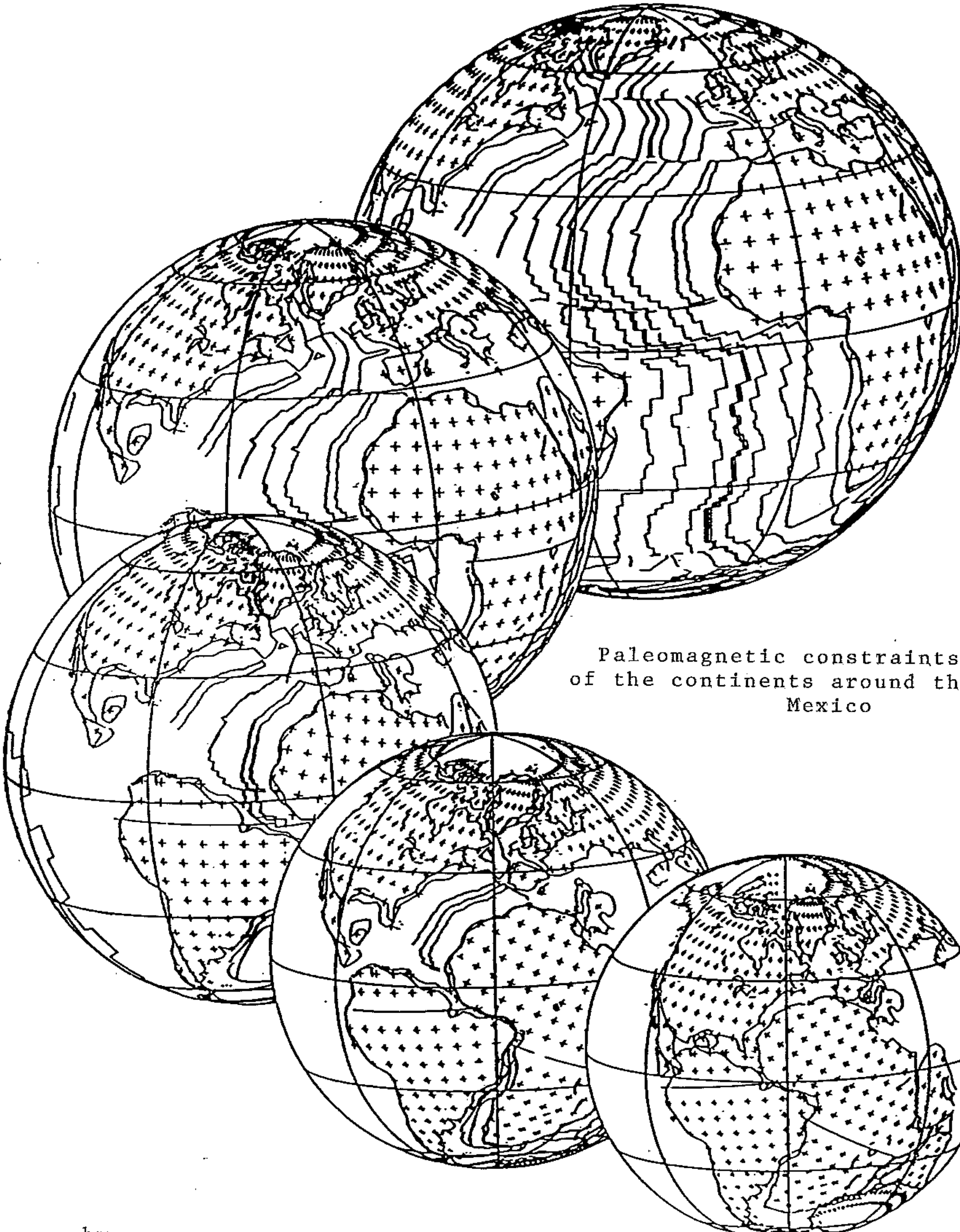

Paleomagnetic constraints on the fit of the continents around the Gulf of Mexico

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University of Texas Institute for Geophysics Technical Report No. 54

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DRAFT

Abstract

Paleomagnetic results from the Helderberg and Trenton carbonates have been shown to be remagnetizations of Late Carboniferous or Early Permian age, and these results differ in a systematic way from other North American poles of the same age. In this paper we argue that these well-determined remagnetized limestone results may be more valid than previously published poles because all of the latter are from red bed studies in which the nature and origin of the magnetization are uncertain. A modified Pangea A2 with North America positioned according to the limestone poles has a looser fit in the critical Gulf of Mexico region, and is therefore more in accord with reconstructions based on geological data only.

Introduction

Controversy has surrounded the hypothesis of the supercontinent Pangea since it was first proposed by Wegener (1924). Initially the Pangea hypothesis was firmly rejected by the geophysical community due to the lack of a convincing mechanism for continental drift, even though it provided an explanation for paradoxes such as the disjunct nature of certain faunal realms and tectonic provinces. More recently, the advent of plate tectonics once again brought Wegener's Pangea to the attention of earth scientists, but controversy continues. The Bullard et al. (1965) Pangea reconstruction of the Atlantic-bordering continents illustrated the jigsaw puzzle-like fit of the continents, but it has since been shown that although this reconstruction may be valid for the Late Triassic-Early Jurassic, it is not in accord with Late Paleozoic-Early Triassic paleomagnetic results (e.g.

Van der Voo and French, 1974; Van der Voo et al., 1976; Irving, 1977, Morel and Irving, 1981). The present debate surrounds this earlier history of Pangea. Two models for a Late Paleozoic-Early Triassic supercontinent are currently under serious consideration because they satisfactorily reconcile the paleomagnetic data. Irving (1977) and Morel and Irving (1981) envision an early Pangea (termed Pangea B) with eastern North America juxtaposed against northwestern South America. In this model the transition from Pangea B to a Bullard et al. fit (Pangea A) is accomplished by Triassic megashear between the northern and southern continents. The other model (Van der Voo and French, 1974; Van der Voo et al., 1976) satisfies the paleomagnetic data by rotating Gondwana 20° clockwise from a Pangea A fit while closing the Gulf of Mexico and moving suspect terranes in Middle America elsewhere. Although this fit for the Late Paleozoic-Early Triassic, termed Pangea A2, may be more plausible than Pangea B on purely geological grounds (Hallam, 1983), Van der Voo et al. (1984) have shown that both fits satisfy the available paleomagnetic poles within the error limits of the data.

One possible objection to Pangea A2 is the very tight fit it requires between the Gulf coast of the United States and northern South America. However, such objections may not ultimately condemn the model due to a number of uncertainties inherent in such reconstructions. These uncertainties include: 1) the detailed validity of the geocentric dipole field hypothesis; 2) the extent of crustal extension of rifted margins; 3) the limits of post-rift accreted terranes; and 4) the accuracy of both position and time calibration of currently available paleomagnetic poles. However, the margins for error are strained in light of recent models of Gulf of Mexico-Caribbean evolution that place microplates between North and

South America for early Pangea time (e.g. White, 1980; Pindell and Dewey, 1981; Pindell, 1985). Such models, though appealing on geological grounds, are in violation of the available paleomagnetic data.

This paper addresses one of the issues that bear upon the validity of the Pangea A2 fit, that of the accuracy of location of Late Carboniferous and Early Permian paleomagnetic poles for cratonic North America. A comparison between previously published poles for that interval and recent results from the Helderberg carbonates (Scotese et al., 1982) and the Trenton Limestone (McCabe et al., 1984) appears to shed new light on the configuration of Pangea.

The Paleomagnetic Results

Two recent studies of Paleozoic limestones from the eastern United States have resulted in paleomagnetic poles that were shown to be remagnetizations of Late Carboniferous-Early Permian age. The Devonian Helderberg Group limestones (Scotese et al., 1982, McCabe et al., 1983) yielded a characteristic magnetization acquired during the Alleghenian orogeny, with its paleomagnetic pole near Late Paleozoic ones for North America. The Trenton Limestone (McCabe et al., 1984) yielded a pole that is virtually coincident with the Helderberg pole. All directions from these studies are of reversed polarity, in accord with Kiaman Interval results from other areas. Further, both results are paleomagnetic determinations of high quality because the magnetizations were extremely stable during thermal demagnetization, and because the blocking temperature spectra of the component magnetizations were well separated. The mean paleomagnetic south pole from these two studies is located at 51.6°S, 308.1°E and is constrained to be Late Carboniferous or Early Permian in age.

Though this remagnetized limestone mean pole falls near other North American poles of the same age, there is a systematic difference worthy of note. Figure 1 shows the mean Late Carboniferous and Early Permian Poles for North America (from the pole compilation of Van der Voo et al., 1984) surrounded by their A-95's in comparison with the remagnetized limestone mean pole. The figure indicates that the limestone mean is significantly higher in latitude than both the Late Carboniferous and Early Permian means from previous studies.

We can offer only scant evidence for our preferred explanation for this deviation and acknowledge at this time that our reasoning cannot be seen as conclusive. Possible reasons for the deviation include non-dipole field behavior, previously unrecognized apparent polar wander during the interval in question, or some problem with the paleomagnetic determinations themselves. It is the latter possibility that we want to examine in this paper.

The previous results included in the Van der Voo et al. (1984) compilation are all from red bed studies. Although red beds frequently possess stable magnetizations that appear to be easy to isolate in demagnetization experiments, a number of serious problems are still not resolved with regard to the origin and reliability of such magnetizations. For example, Walker et al. (1981) and Larson et al. (1982) have argued in favor of a long and complex remanence acquisition model for the Moenkopi red beds, and suggest that this rock type may not be a reliable recorder of paleomagnetic fields. In addition, detrital remanent magnetizations may be present, and although these date to the depositional event, a number of processes may result in a deviation of the recorded paleomagnetic direction from that of the ambient field (see review of Verosub, 1977). A commonly observed type of error, inclination error, results in paleomagnetic directions that are shallower than the field present during deposition (Tauxe and Kent, 1984 and references therein).

These potential problems with red bed magnetizations may explain the difference between the remagnetized limestone results and those from red bed studies. For example, a small unresolved chemical or viscous magnetization of recent (and normal polarity) origin will add to a North American Kiaman direction to produce a pole of lower latitude than the Kiaman direction alone. Alternatively, an inclination error will also result in a lower latitude pole. In contrast, these effects should not be present in results from the remagnetized limestones, which are due to chemical remanent magnetizations residing in magnetite. These magnetites are therefore likely to be faithful recorders of the paleomagnetic field, and should not contain components of magnetization of recent, oxidative origin, nor are they subject to inclination errors.

Discussion

In this paper we have made the suggestion that perhaps the Late Paleozoic paleomagnetic data base for North America is not as valid in detail as was previously believed. We recognize, however, that final resolution of this problem will have to await future paleomagnetic studies of rock types other than red beds. Additionally, we have confined our discussion to North American results only. Obviously, doubts concerning the validity of paleomagnetic results from red beds are applicable elsewhere.

this admittedly conjectural thread, we would like to examine ...tonic implications of the remagnetized limestone ... the moment that they have greater validity for the Late Carboniferous and Early Permian of North America than previous results. The limestone mean south pole is farther away from North America than any of the red bed poles, and would therefore indicate a somewhat more northerly paleoposition for North America. With respect to the Pangea A2 reconstruction of Van der Voo et al. (1984) the effect of this would be to create a looser fit between the Gulf coast of the United States and northern South America, thus making this fit more plausible while at the same time allowing room in the Gulf of Mexico area for microplates such as the Yucatan and Florida Straits Blocks (e.g. Pindell, 1985). This is illustrated in Figure 2, which is the Early Permian Pangea A2 fit of Van der Voo et al. (1984) but with the position of North America adjusted according to the remagnetized limestone mean pole only.

Conclusion

We have presented a slightly modified Pangea A2 reconstruction based on North American paleomagnetic results from chemically remagnetized limestones, and have argued that these limestone poles may be more valid indicators of the Late Carboniferous and Early Permian paleomagnetic field for North America than previously available red bed results. However, further study is needed to resolve the question satisfactorily. The main feature of the modified Pangea A2 is a looser fit between North and South America. We feel that this looser fit diminishes objections to the Pangea A2 model by bringing it more in accord with Gulf/Caribbean models that are based on geological data only.

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Figure Captions

Fig. 1. Mean paleomagnetic south poles for North America for the Late Carboniferous (LC) and Early Permian (EP) from data given in Van der Voo et al. (1984), surrounded by their A-95's. Pole marked LS is the mean of the remagnetized Trenton and Helderberg poles (see text). South polar projection.

Fig. 2. (a) Pangea A2 reconstruction for the Early Permian after Van der Voo et al. (1984) compared with modified Pangea, (b), with North America positioned using the remagnetized limestone mean pole (see text).

Table 1. Pole of Rotation for Gulf of Mexico Fit

Model	NA/AFR Fitting Pole Latitude	Longitude	Angle	North American Early Permian Pole in African Coordinates	
A.	67.04	-12.04	75.5	45.7 S	50.6 E
B.	63.00	-17.50	80.3	39.3 S	55.8 E
C.	58.60	-23.4	85.6	31.0 S	59.0 E
D.	57.00	-20.80	88.9	29.4 S	63.5 E

For comparison, the Gondwana Early Permian Pole is 30.9 S 59.2 E.

References:

Model A. Klitgord and Schouten, 1986 (DNAG vol., in press)

Model B. This paper

Model C. This paper

Model D. Van der Voo et al. (1976)

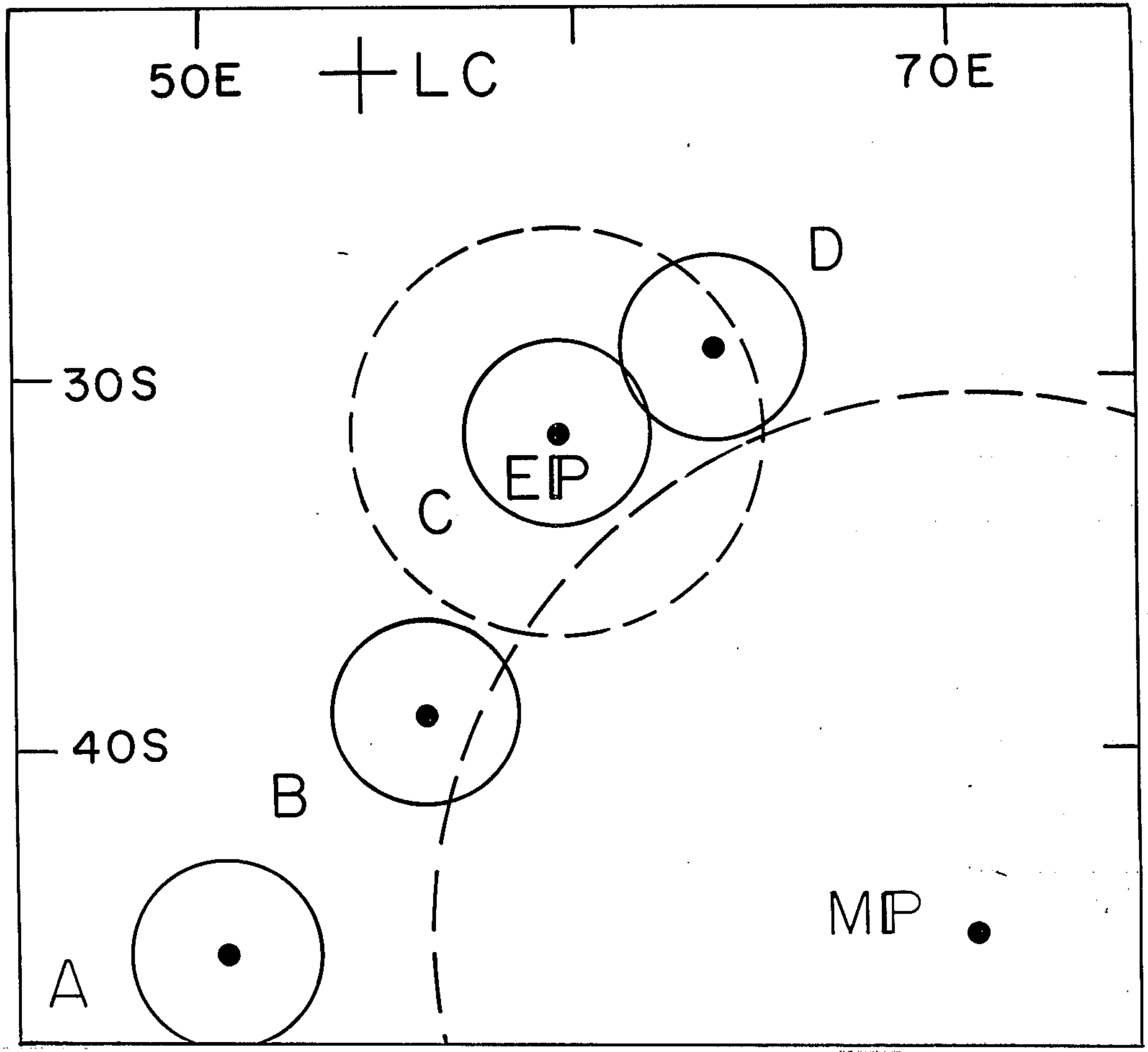
Figure Captions

Figure A. North America/ Africa fit of Klitgord and Schouten (1976). This reconstruction is based solely on the morphological fit of North America and Africa and does not superimpose the Early Permian paleomagnetic data. In this fit the proto-Gulf of Mexico is very loose, and there is a lot of "extra room".

Figure B. Compromise fit proposed in this paper. This fit overlaps the confidence limits of the North American pole with the Middle Permian mean pole for Gondwana. It does a good job fitting the margins North American and Africa. The gap in the north makes better sense than a tighter fit because there is evidence of post-rifting right-lateral movement along the Atlas Fault. There is just enough room in the proto-Gulf of Mexico to accommodate Yucatan and the Bahamas block. Yucatan may have been oriented as show here (Pindell and Dewey, 1976), or may be reconstructed without this severe clock-wise rotation.

Figure C. In this reconstruction, the paleomagnetic mean poles for Africa and North America are overlapped. The fit between Africa and North America is poor; the proto-Gulf of Mexico is very tight.

Figure D. This overly-tight reconstruction of the Gulf of Mexico, first proposed by Van der Voo et al. (1976) is presented for comparison with the other maps. The paleomagnetic basis of this fit is no longer valid.


50E
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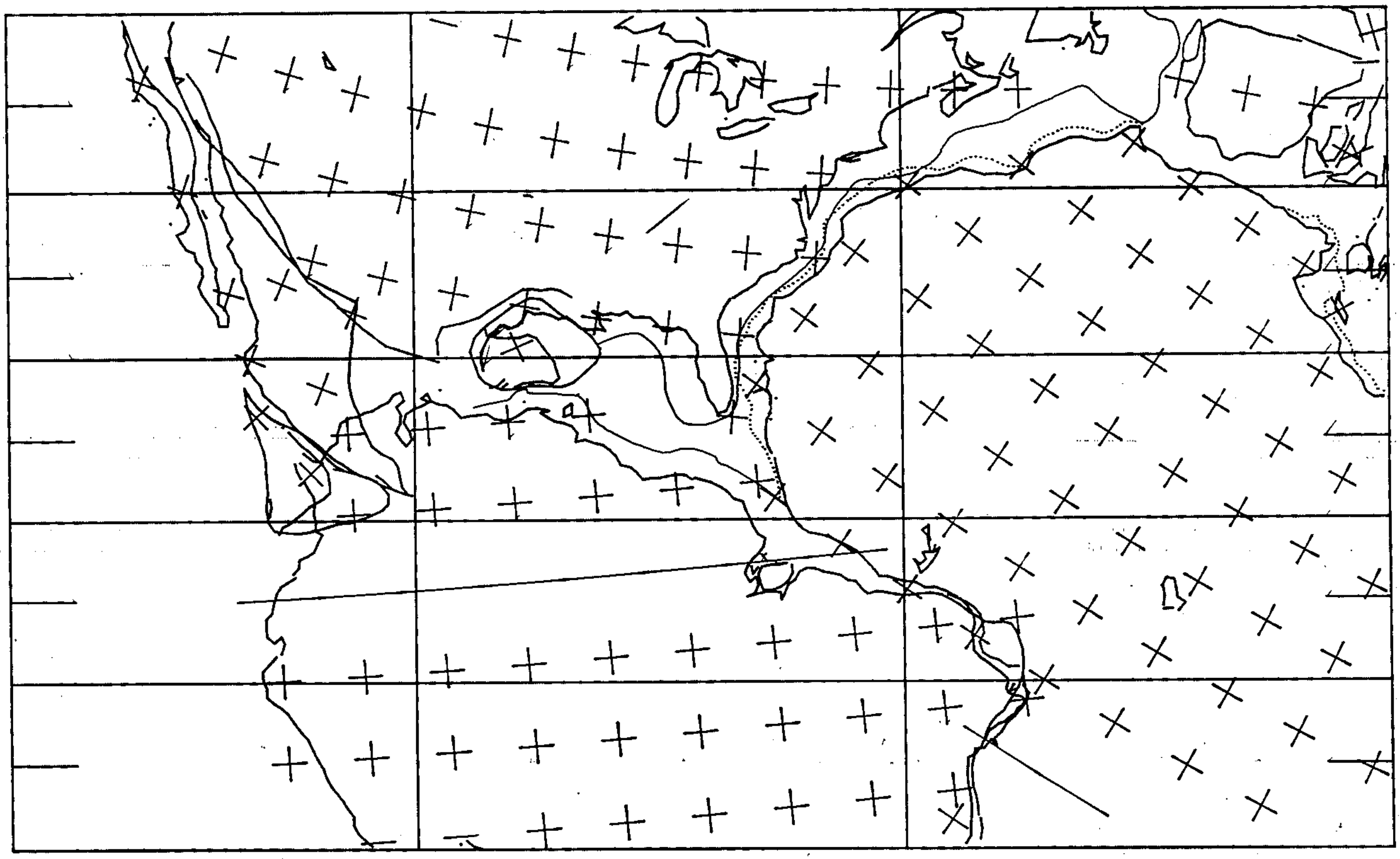
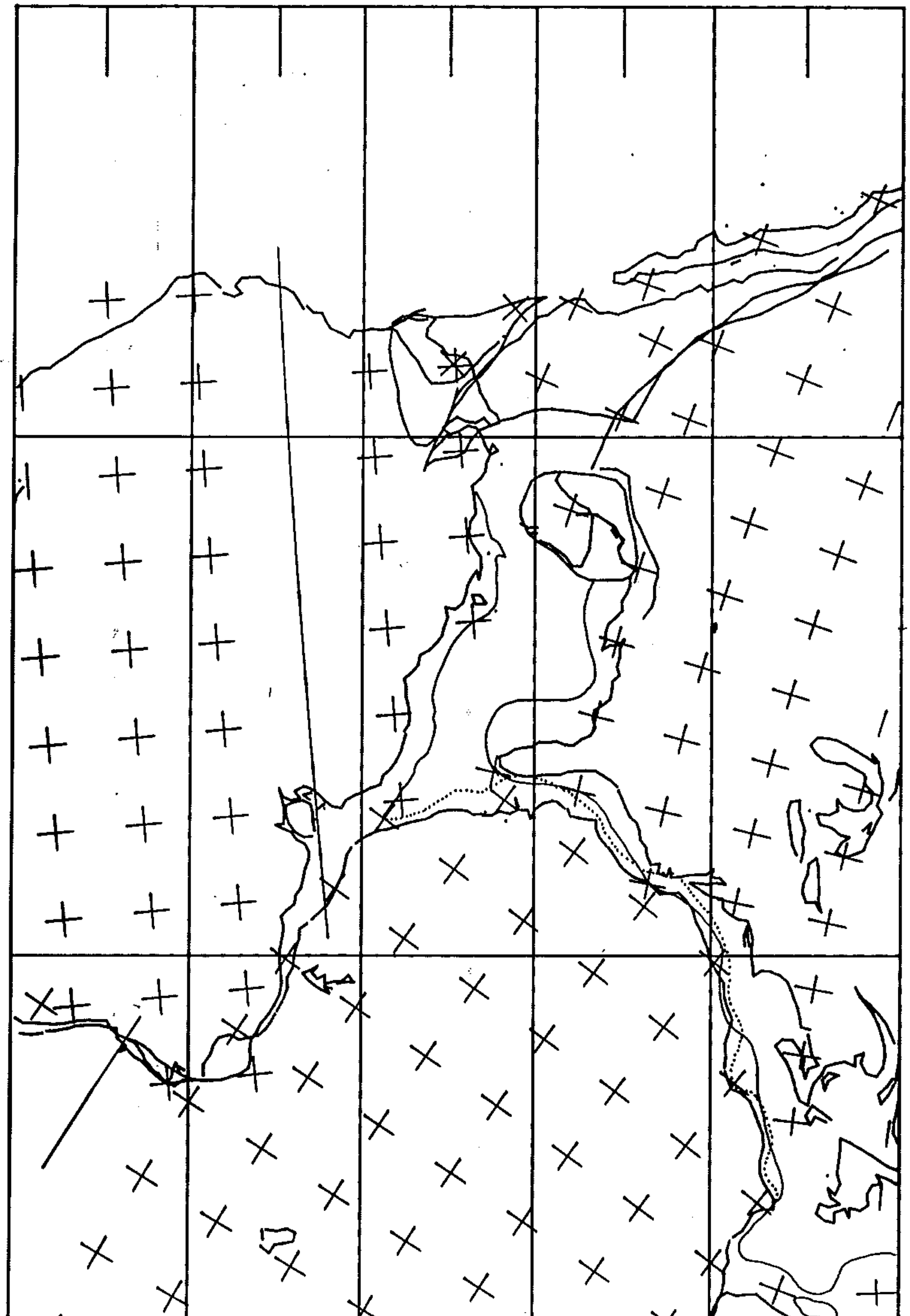


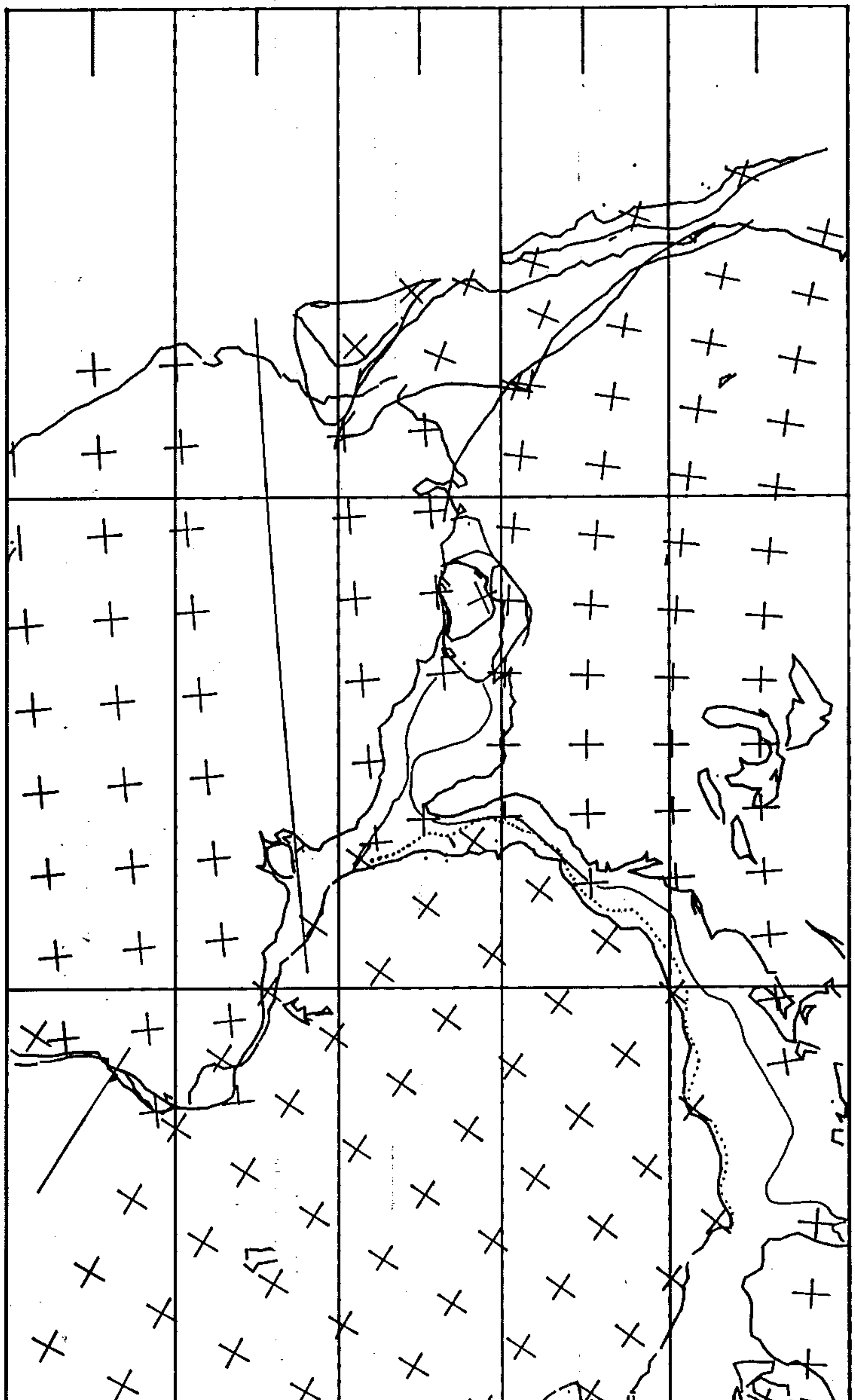
B

A.



A

C



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