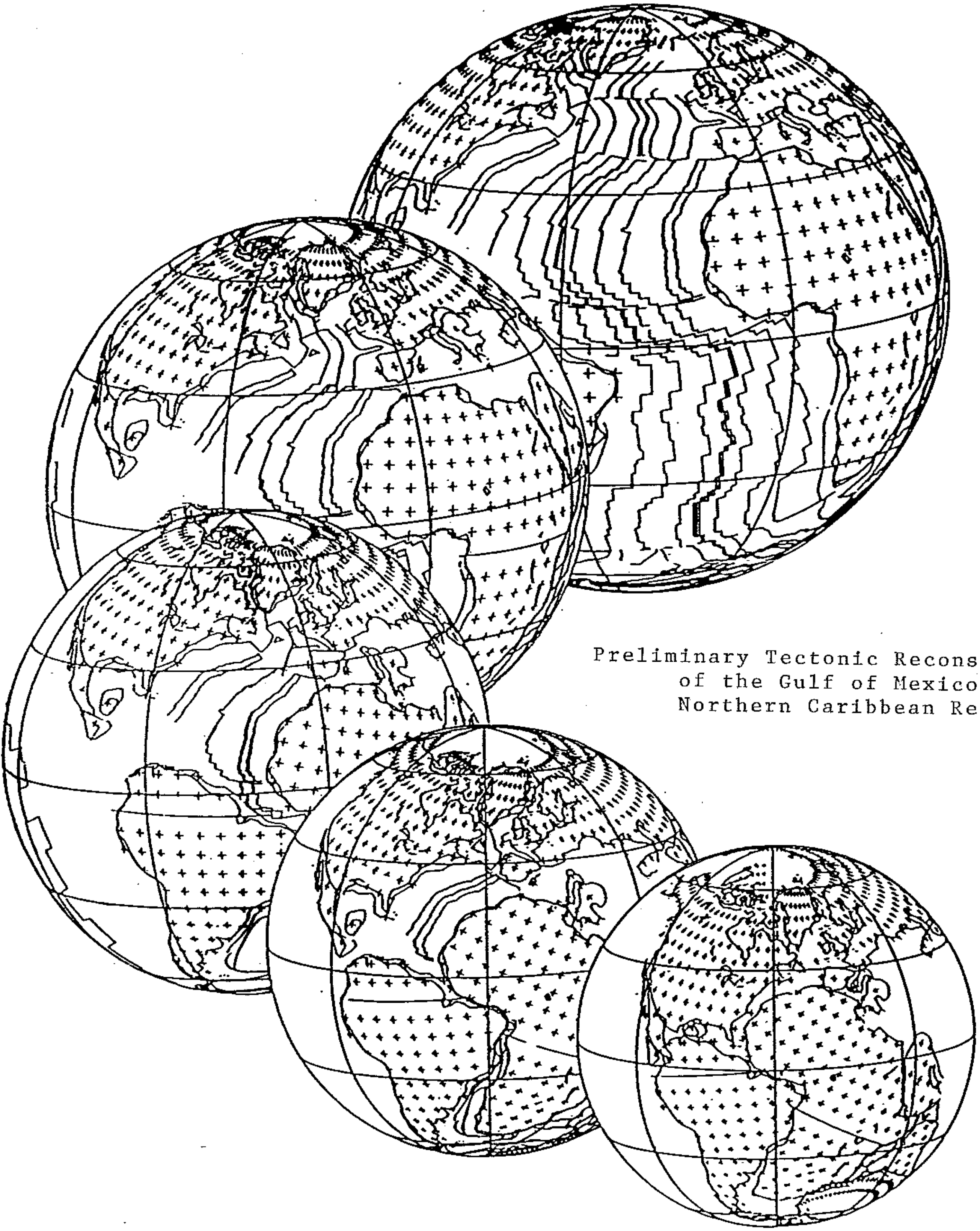
PALEOCEANOGRAPHIC MAPPING PROJECT
PROGRESS REPORT NO. 11-0586



Preliminary Tectonic Reconstructions of the Gulf of Mexico and Northern Caribbean Region

by
M.I. Ross and
C.R. Scotese

University of Texas Institute for Geophysics Technical Report No. 58

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Abstract. The evolution of the Caribbean region has been complex. Due to this complexity, exsisting models are controversial. The most efficient and accurate way to test these models is to break them into their component parts. We have started to do that by looking in detail at the Gulf of Mexico and the northern Caribbean plate boundary (Cayman Trough). Preliminary results indictate that the Gulf of Mexico opened in two phases, east-west strike slip (175 mya to ~168 mya), then north-south extension (168 mya to ~152 mya). A new interpretation of magnetic anomalies in the Cayman Trough indictates that spreading there has been going on since the early Eocene, it has been asymmetric, and has undergone ridge jumps and rates changes due to changes in motions of the surrounding major plates.

Introduction

During the past year, we have made a special attempt to increase the precision and resolution of our plate tectonic models, especially in complex areas such as the Caribbean, western Mediterranean, western Pacific, and Antarctic region. This report describes the new geographic data set that has been compiled for the Gulf of Mexico and Caribbean, and presents preliminary tectonic reconstructions for the Gulf of Mexico and northern Caribbean. The illustrations presented in this report were produced using the new POMP geographic data file, CARB01.DAT (Caribbean version #01), in conjunction with the plate tectonic mapping program, PALEOMAP. This geographic data set was compiled by the authors as part of an ongoing project to produce a new set of plate tectonic reconstructions of the Gulf of Mexico and Caribbean region; the work described here, in large part, comprises the thesis research of Malcolm I. Ross (and John Dunbar, for the Gulf of Mexico).

The work of previous investigators has shown (Pindell and Dewey, 1982; Case and Holcolmbe, 1980; Buffler et al., 1985; Pindell and Barrett, 1986) that the tectonic evolution of the Gulf of Mexico and the northern Caribbean region has been complex, and there are many unresolved questions (e.g. where does Yucatan fit against the Gulf Coast?, what is the nature of the Yucatan basin?, what is the history of the Cayman Trough?). In order to address these questions, and to begin to model the tectonic evolution of this region, we compiled a digital version of the tectonic lineaments and features that define the major tectonic elements of the Gulf of Mexico and Caribbean (Figures 1, 2, and 3).

According to our usage, a tectonic element is any crustal block that has had an independent history of motion. A tectonic element may be as large as a continental craton, or as small as a thrust sheet or horst. The tectonic elements that we have defined are rarely smaller than a few square degrees. In order to model the complex tectonic evolution of this region, we have divided the Gulf and Caribbean into approximately 70 tectonic elements (Figures 2 and 3, and listed in Table 1).

Preliminary Reconstruction of the Gulf of Mexico

Numerous scenarios have been proposed for the evolution of the Gulf of Mexico (Walper and Rowett, 1972; Malfait and Dinkelman, 1972; White, 1980; Buffler et al., 1984; Salvador and Green, 1980, Anderson and Schmidt, 1983; Klitgord and Schouten, 1983; Pindell, 1985). Although these models share many elements (and seem to be converging on the form of Pindel and Dewey, 1982), it is fair to say that no consensus has been reached.

The various models for the development of the Gulf of Mexico can be compared and contrasted in terms of the five major tectonic constraints:

1) the fit of the continents around the Gulf of Mexico.

2) the extent of oceanic crust in the central Gulf of Mexico.

3) the width and degree to which continental crust (transitional crust) along the Gulf Coast and northern Yucatan margins has been stretched.

4) the pre-rift position of Yucatan.

5) the timing and amount of motion along the Mojave-Sonora megashear.

1. The fit of the continents around the Gulf of Mexico.

The fit of the continents around the Gulf of Mexico is probably the single most important tectonic constraint. Numerous fits have been proposed; some very loose (Bullard et al., 1965), others very tight (Van der Voo, 1976). A discussion of the merits of various Gulf of Mexico reconstructions is given in POMP Progress Report #6. In this report we concluded that any reconstruction of the continents bordering the Gulf of Mexico must take into account: 1) the morphological fit of the margins, (preferably palinspastically restored), 2) the match of geologic and tectonic trends across the refitted margins, 3) post-rifting tectonic activity along the margins (e.g. younger volcanic edifices or strike-slip movement along the margin), 4) the match of cratonic apparent polar wander paths. Our preferred fit (Figure 4), based on these criteria, is similar to the North America/Africa reconstructions of LePichon et al. (1977) and Wissmann and Roeser (1982).

2. The extent of oceanic crust in the central Gulf of Mexico.

The extent of oceanic crust in the central Gulf of Mexico (Figure 2) is based on the work of Buffler et al. (1985). The magnetic anomalies identifications suggested for this region (Shepard, Ms. Thesis) are tentative and have not been used in the reconstruction.

3. The width of transitional crust on margins of the Gulf of Mexico.

To accurately reconstruct the Gulf of Mexico, the broad swath of stretched continental crust that extends oceanward from the Gulf Coast and the narrower swath of the northern Yucatan margin must be palinspastically restored (Dunbar and Sawyer, in prep.). As described in Appendix A, the pattern of extension along the Gulf margins was used to estimate the pole of rotation describing the relative motion of Yucatan and North America. The results indicate that the pole most likely lies along a latitudinal swath at approximately 30° N stretching from 25° E to 75° W longitude.

Contoured values indicating the degree of stretching along the margins of the Gulf of Mexico (Dunbar and Sawyer, 1986) are mapped (Figure 2). We have used these contours to prepare a series of reconstructions illustrating the phase of extension in the Gulf of Mexico that preceded the formation of ocean floor (Figures 4, 5, and 6). In these reconstructions we have closed the contours by an amount proportional to the inferred amount of stretching in a attempt to palinspastically restore the southern margin of North America. The "pre-stretching" closure of Yucatan against North America is shown in Figure 6. This result is consistent with the pole of rotation by Dunbar and Sawyer (1986), located at 25° N and 75° W.

4. and 5. The pre-rift position of Yucatan, and the Timing of Motion along the Mojave-Sonora Megashear.

Yucatan originally occupied a position in the northern Gulf of Mexico. In the fit shown, the west coast of Yucatan is adjacent to the east side of the Yaqui block (in figure 8, similar to Klitgord et al., 1980) As the initial breakup of northern Gondwana occurred, the Mojave-Sonora Megashear transformed the opening motion out to the trench on the Pacific side, thereby isolating North America. During the time of motion on the Mojave-Sonora Megashear (175-165 my), Yucatan moved east along with Yaqui block, which in turn was part of Gondwana (figure 7). By 165 mya, motion on the Mojave-Sonora Megashear stopped (figure 7, Total offset: <150 km) and motion between North America and Gondwana took place along a fault now covered by the Trans-Mexican volcanic belt . At this time, Yaqui (Northern Mexico) became part of North America, and Yucatan and the Guerrero block (southern Mexico) continued to move with Gondwana. Extension between Yaqui and Yucatan stranded several structural highs between them (Golden Lane Block). The extension was short-lived, and brought the Yucatan to it's pre-rift position (figure 6, similar to Pindell and Dewey 1984; and Dunbar and Sawyer, 1986). The weakness of the zone of left-lateral offset between Yucatan and cratonic North America was then exploited as the rift zone when the North America - Gondwanaland (of which Yucatan was a part) became dominately extensive, and the Gulf of Mexico opened.

Preliminary Reconstructions of the northern Caribbean plate boundary

The evolution of the northern plate boundary of the Caribbean region has been extensively studied (Bucher, 1948; Skerlac and Hargraves, 1980; Kafka and Wiedner, 1981; Sykes et al, 1983). The area of interest is bounded on the west by the Gulf of Tehuantepec, Mexico and the Pacific Ocean, on the east by Puerto Rico, to the north by the Bahamas Bank, and to the south by the Hess Escarpment and the Muertos Trough. While there is little consensus concerning age and tectonic development of the area, investigators do agree that the most important features in understanding the evolution of this region are the Cayman Trough and Cuba. Cuba is politically inaccessable, so investigations have centered around the Cayman Trough.

The Cayman Trough is a narrow linear basin that stretches from the Yucatan Peninsula to the southeast tip of Cuba (1100 km.) and reaches depths greater than 6000 meters. Focal plane solutions (Molnar and Sykes, 1969) derived from earthquakes in the area indictate that the Trough is a left-lateral left-stepping pull apart basin controlled by the left-lateral motion between the North America and Caribbean Plates (Holcombe et al., 1973). The pull apart graben developed into a spreading center early in its history, and the basalt generated at that spreading center has recorded the interactions of the major plates in the region (North America and the Caribbean) and the microplates trapped in between.

Holcombe and Sharman (1984) recognized the importance of the magnetic anomalies created by the Cayman spreading center and in 1973 collected a series of 5 magnetic profiles perpendicular to the spreading axis. They examined the observed magnetic field above the youngest 200 km. of crust created and interpreted the anomalies to indicate that the ridge has been spreading at 20 mm/yr full rate for the last 8.5 my (See appendix B, figure 1). If these rates are projected to the time of opening, they suggest that the rifting began in the late Eocene. This age contrasts with an early Eocene opening age suggested by Erikson (1972) based on preliminary heat flow measurents, Rosencrantz (in press) based on depth-to-basement estimates, and based on late Paleocene/early Eocene sediments found in the Wagwater graben of Jamaica (Mann (1981)).

The descrepancy between ages based on magnetic anomaly identifications and ages based on other methods suggests that alternative identifications can be made. We have re-identified the anomalies based on a method that takes into account the affect of basement features on the observed magnetic field (figure 9 and appendix B). In areas of rough basement topography, more than 30% of the observed field can be due to topograpy alone. Original identifications did not take this into account. Results of the study of the magnetics are:

1.) The Cayman Trough began to rift during the early Eocene. This age indictates that rifting began just prior to the thrusting in the Greater Antilles arc (middle to late Eocene (Mann, 1984)), and agrees with the age indictated by preliminary heat flow measurements (Erickson et al. 1972).

2.) Initial opening rates of the Cayman Trough are somewhat faster than previously estimated (20 mm/yr versus 15 mm/yr).

3.) The spreading has been asymmetric and slowed markedly (to <14 mm/yr for the last 20 my) after the collision of the Greater Antilles arc with the Bahamas Platform or when the restraining bend formed in Hispaniola.

4.) Anomaly patterns and basement topography suggest that during the Oligocene, the ridge jumped to the east (Rosencrantz et al. (in press)).

A set of preliminary maps has been produced that illustrate the tectonic evolution of the northern plate boundary of the Caribbean region from the Early Eocene (AN 25) to the Present based on our new identifications. The reconstructions include the following tectonic elements: Chortis, Guayape, Nicaraguan Rise, Cayman Ridge, Jamaica, Cuba, Hispaniola (4 sections), and Puerto Rico. Although these maps illustrate the major tectonic features and events, they do not capture the dynamic aspects of the plate tectonic process. To capture the dynamic aspects, we have prepared a color animation of the plate tectonic development of the northern Caribbean that is available as a movie or a videotape on request.

To quanitify the complex deformation of the area south of the Cayman Trough, we simplified it into three tectonic elements: the Chortis Block, the Guayape Block, and the Nicaraguan Rise. Future reconstructions will break the Chortis block into seven elements and the Nicaraguan Rise into five elements.

Table 1 - Tectonic Elements and their rotation ID #'s

101	North American Craton
104	Mexico (Yaqui)
105	Baja Mexico
201	South American Craton
204	Hondouras (Chortis)
205	Stable Yucatan
206	Central Cuba
208	Chiapas
209	Cuchumantanes
210	Polochic-Motagua
211	Santa Cruz
212	Guayape
213	Motagua-Jocotan
214	Golden Lane
215	Guerrero
216	Cayman Ridge
217	West Cayman Trough
218	East Cayman Trough
219	Thunder Knoll
220	Rosalind Bank
221	Pedro Bank
222	Jamaica
223	Quinto Sueno
224	Caribbean Ocean Floor
225	Maricaibo
226	Romeral
227	Santa Marta
228	Perija
229	Eastern Panama
230	Central Panama
231	Western Panama
232	Hess Block
233	Florida Straits Block
234	Lesser Antilles Arc
235	Aves Ridge
236	Saint Christopher Block
237	Puerto Rico
238	Eastern Puerto Rican Trough
239	Western Puerto Rican Trough
240	Muertos Trough
241	Gulf of Tehuantepec
242	Gulf of Gonave
243	Accreted Chortis
244	Accreted Chiapas
245	Accreted Guayape
246	Accreted Lesser Antilles-Barbados
247	Transitional Guerrero
248	Transitional Lesser Antilles
249	Transitional North America
250	Transitional Mexico (Yaqui)
251	Transitional Yucatan
252	Southern Hispaniola
253	San Juan/Hispaniola
254	Hispaniola Cordillera
255	Northern Hispaniola
256	Pinar Del Rio
257	Yucatan Basin
258	Southern Cuba
259	Sierra Maestra of Cuba
260	Transitional Cuba
261	Transitional Southern Cuba
262	Transitional Sierra Maestra
263	Empty Slot
264	Beta=2, Northern Gulf of Mexico
265	Beta=2, Southern Gulf of Mexico
266	Beta=3, Northern Gulf of Mexico
267	Beta=3, Central Gulf of Mexico
268	Beta=3, Southern Gulf of Mexico
269	Beta=4, Northern Gulf of Mexico
270	Beta=4, Northern Gulf of Mexico
271	Sigsbee Block
272	Beta=4, Central Gulf of Mexico
273	Puerto Rico Trench

Table II : Rotations in the Gulf of Mexico
Relative to a fixed North America

Time: 155 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-40.4	-98.7	24.4
Yucatan	-29.5	-99.8	4.5
Florida Straits	-68.8	162.7	0.3
Sigsbee	-34.4	99.7	2.3

Time: 160 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-45.3	-107.0	25.9
Yucatan	-29.5	-99.8	15.8
Florida Straits	-66.9	162.5	1.1
Sigsbee	-34.4	99.7	7.9

Time: 165 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-48.9	-115.3	27.8
Yucatan	-30.6	98.0	28.7
Guerrero	-79.5	136.9	0.8
Florida Straits	-66.8	162.5	2.4
Sigsbee	-34.4	99.7	11.3

Time: 170 mya	Lat.	Lon.	Angle
Baja	36.1	-92.2	6.5
Mexico (Yaqui)	-52.3	96.5	0.9
S. America Craton	-51.6	-123.5	30.0
Yucatan	-31.4	94.9	36.7
Guerrero	-74.1	117.0	3.6
Florida Straits	-66.8	162.5	4.3
Sigsbee	-34.4	99.7	11.3

Time: 175 mya	Lat.	Lon.	Angle
Baja	30.5	-94.7	4.9
Mexico (Yaqui)	-52.2	96.4	2.6
S. America Craton	-52.4	-126.6	31.0
Yucatan	-33.0	94.4	36.9
Guerrero	-70.4	111.1	6.8
Florida Straits	-66.8	162.5	5.0
Sigsbee	-34.4	99.7	11.3

Table III : Rotations along the Northern Plate Boundary of Caribbean Relative to a fixed North America

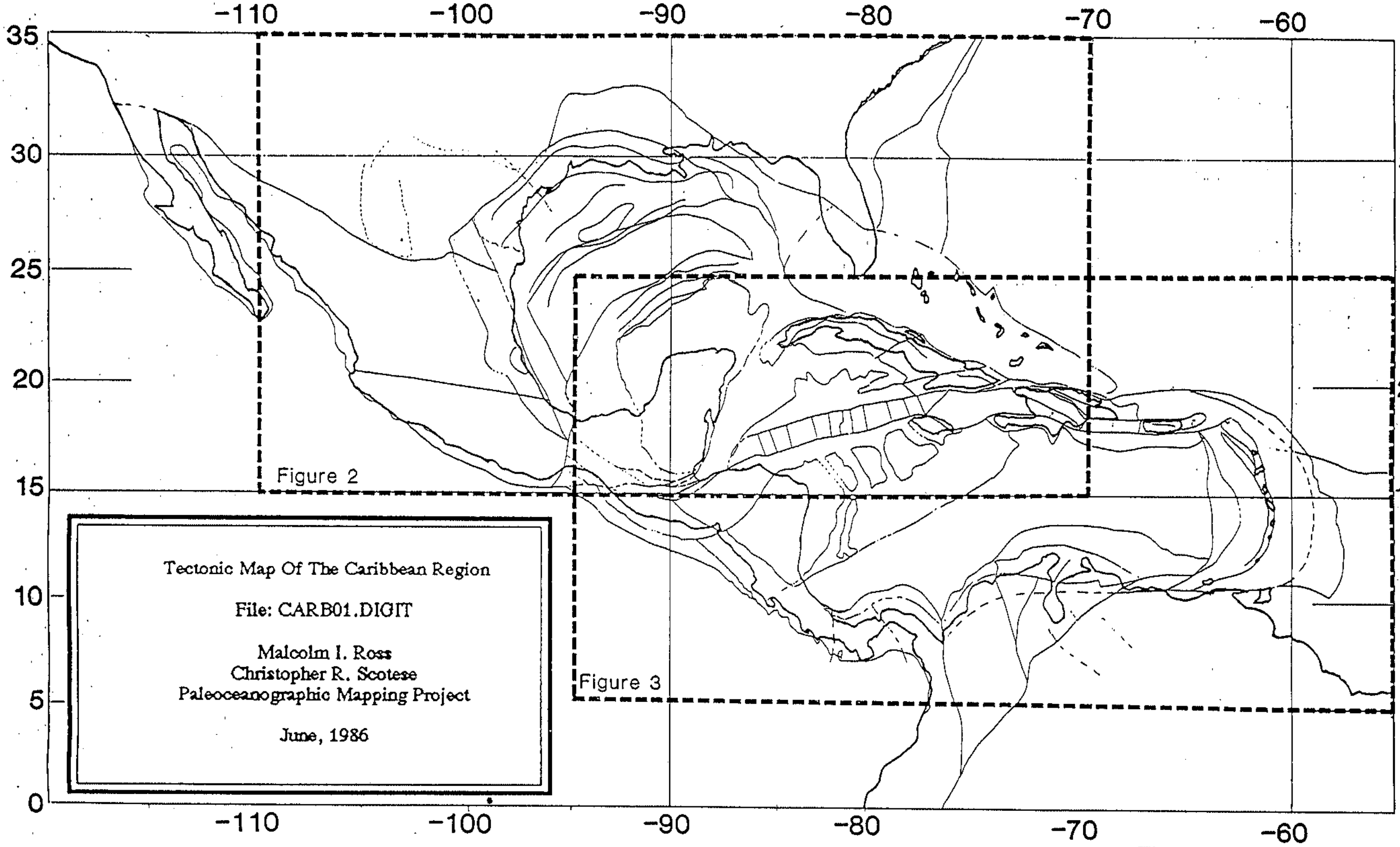
Time: 10 mya	Lat.	Lon.	Angle
Chortis	-56.4	-62.8	1.0
Guayape	-56.4	-62.8	1.0
E Cayman Trough	-56.4	-62.8	1.0
Nicaraguan Rise	-56.4	-62.8	1.0
Jamaica	-56.4	-62.8	1.0
Southern Hispaniola	-56.4	-62.8	1.0
San Juan/Hispaniola	-56.4	-62.8	1.0
Hispaniola Cordillera	-32.5	-92.8	4.7
Northern Hispaniola	-56.4	-62.8	1.0

Time: 20 mya	Lat.	Lon.	Angle
Chortis	-58.2	-59.0	2.4
Guayape	-58.2	-59.0	2.4
E Cayman Trough	-58.2	-59.0	2.4
Nicaraguan Rise	-58.2	-59.0	2.4
Jamaica	-58.2	-59.0	2.4
Southern Hispaniola	-58.2	-59.0	2.4
San Juan/Hispaniola	-58.2	-59.0	2.4
Hispaniola Cordillera	-36.3	-87.4	8.7
Northern Hispaniola	-58.2	-59.0	2.4

Time: 35 mya	Lat.	Lon.	Angle
Chortis	-58.1	-55.0	4.7
Guayape	-58.1	-55.0	4.7
E Cayman Trough	-58.1	-55.0	4.7
Nicaraguan Rise	-58.1	-55.0	4.7
Jamaica	-58.1	-55.0	4.7
Southern Hispaniola	-39.8	-76.6	5.0
San Juan/Hispaniola	-39.8	-76.6	5.0
Hispaniola Cordillera	-43.6	-86.7	13.7
Northern Hispaniola	-58.0	-55.0	2.8

Time: 49 mya	Lat.	Lon.	Angle
Chortis	-58.0	-54.9	6.4
Guayape	-58.0	-54.9	6.4
E Cayman Trough	-58.0	-54.9	6.4
Nicaraguan Rise	-58.0	-54.9	6.4
Jamaica	-58.0	-54.9	6.4
Southern Hispaniola	-39.5	-67.7	7.1
San Juan/Hispaniola	-56.9	-56.8	2.9
Hispaniola Cordillera	-50.5	-84.4	17.4
Northern Hispaniola	-57.9	-54.9	2.8

Time: 59 mya	Lat.	Lon.	Angle
Chortis	-54.8	-57.9	7.7
Cuba	1.5	-65.6	3.3
Guayape	-54.8	-57.9	7.7
Cayman Ridge	-32.7	-76.2	1.7
E Cayman Trough	-54.8	-57.9	7.7
Nicaraguan Rise	-54.8	-57.9	7.7
Jamaica	-54.8	-57.9	7.7
Southern Hispaniola	-39.4	-67.5	9.4
San Juan/Hispaniola	-58.0	-62.7	5.6
Hispaniola Cordillera	-59.7	-81.7	18.9
Northern Hispaniola	-57.9	-43.7	4.3



Tectonic Map Of The Caribbean Region

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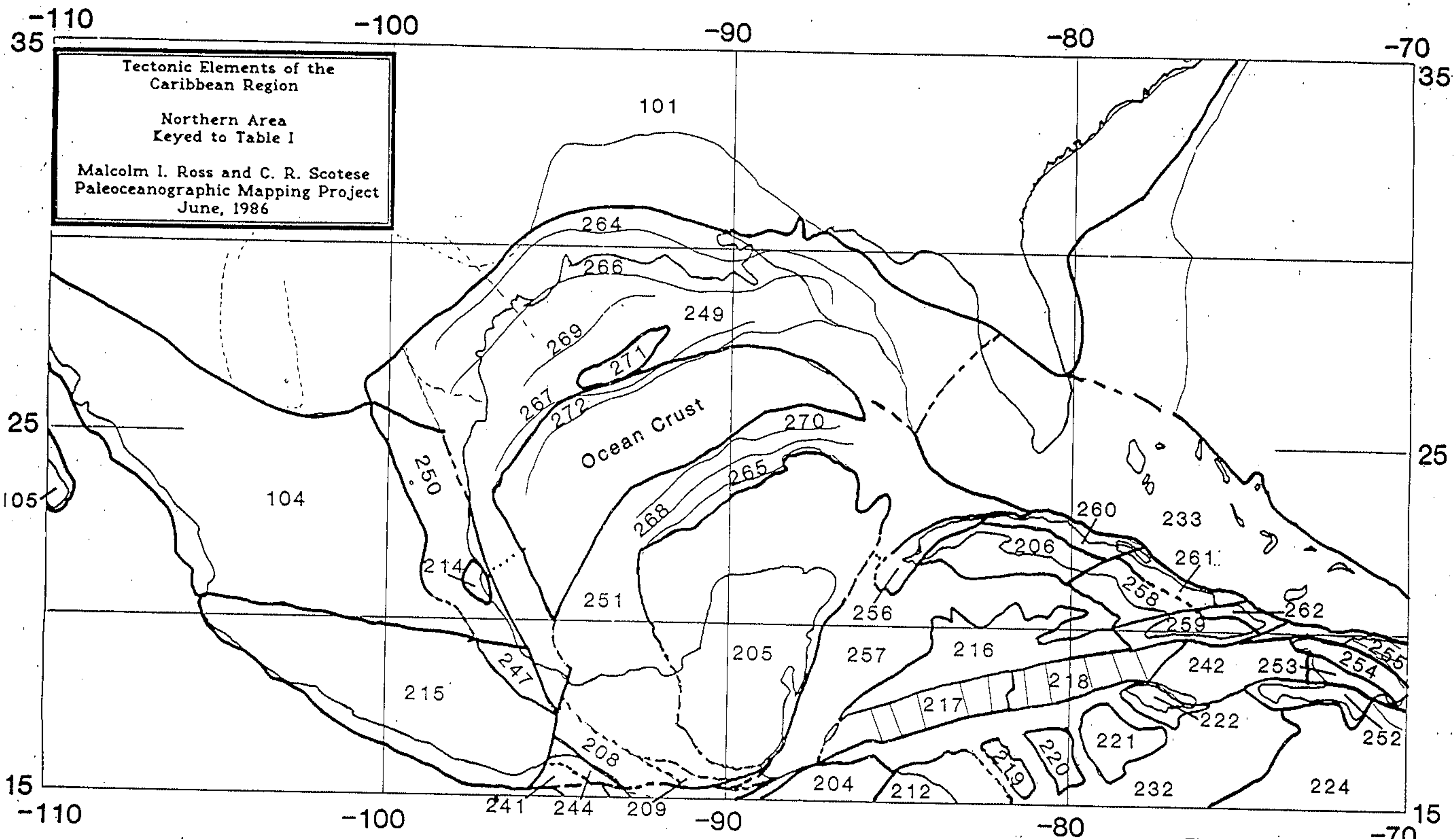
Malcolm I. Ross
Christopher R. Scotese
Paleoceanographic Mapping Project

June, 1986

Figure 1


Tectonic Elements of the
Caribbean Region
Northern Area
Keyed to Table I
Malcolm I. Ross and C. R. Scotese
Paleoceanographic Mapping Project
June, 1986
-110
-100
-90
-80
-70
35
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101
104
105
264
266
249
269
271
267
272
Ocean Crust
270
265
268
250
214
251
256
260
233
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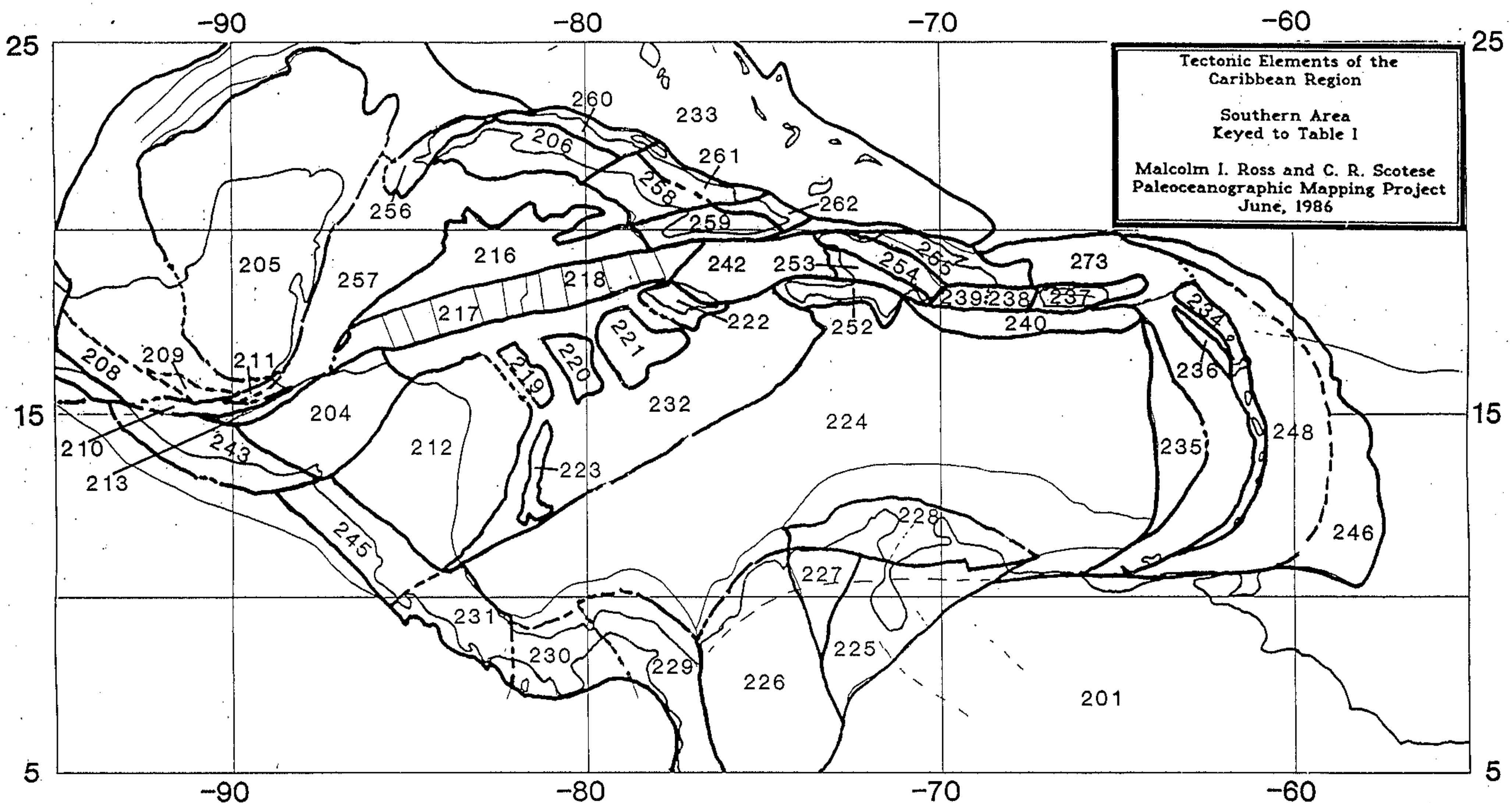
Figure 2


Tectonic Elements of the Caribbean Region
Southern Area
Keyed to Table 1
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Paleoceanographic Mapping Project
June, 1986
-90
-80
-70
-60
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201
204
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Figure 3

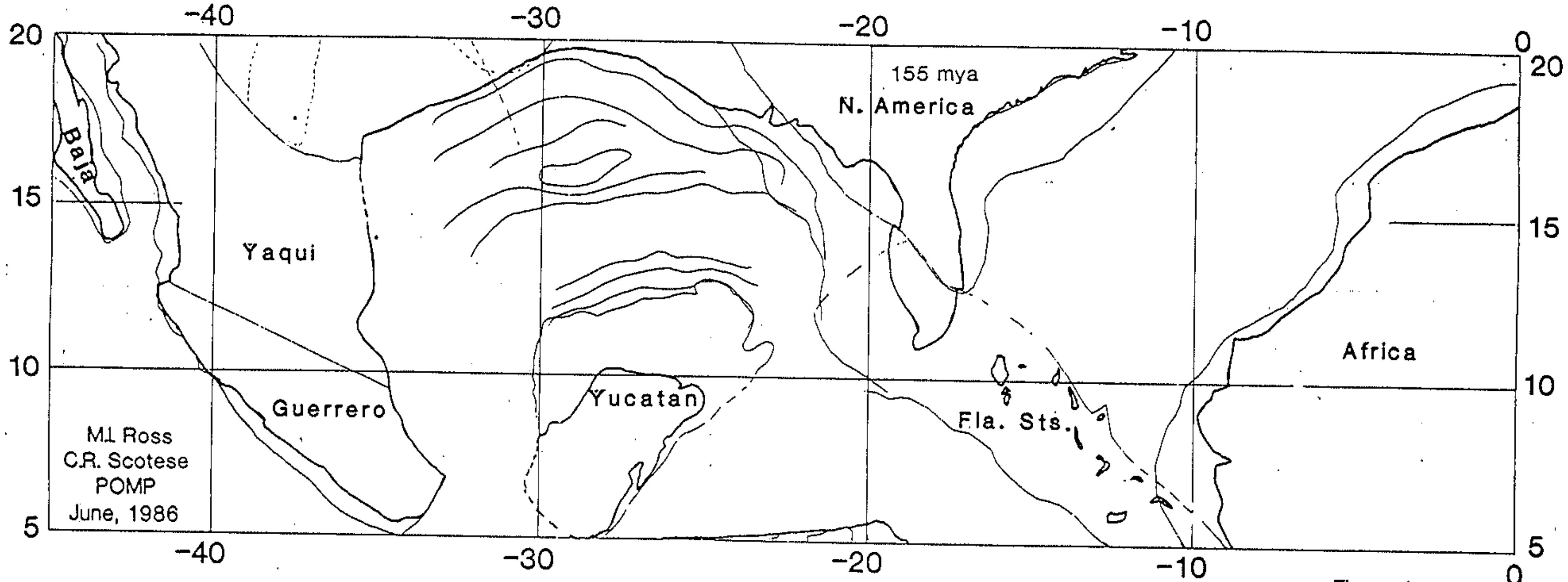


Figure 4

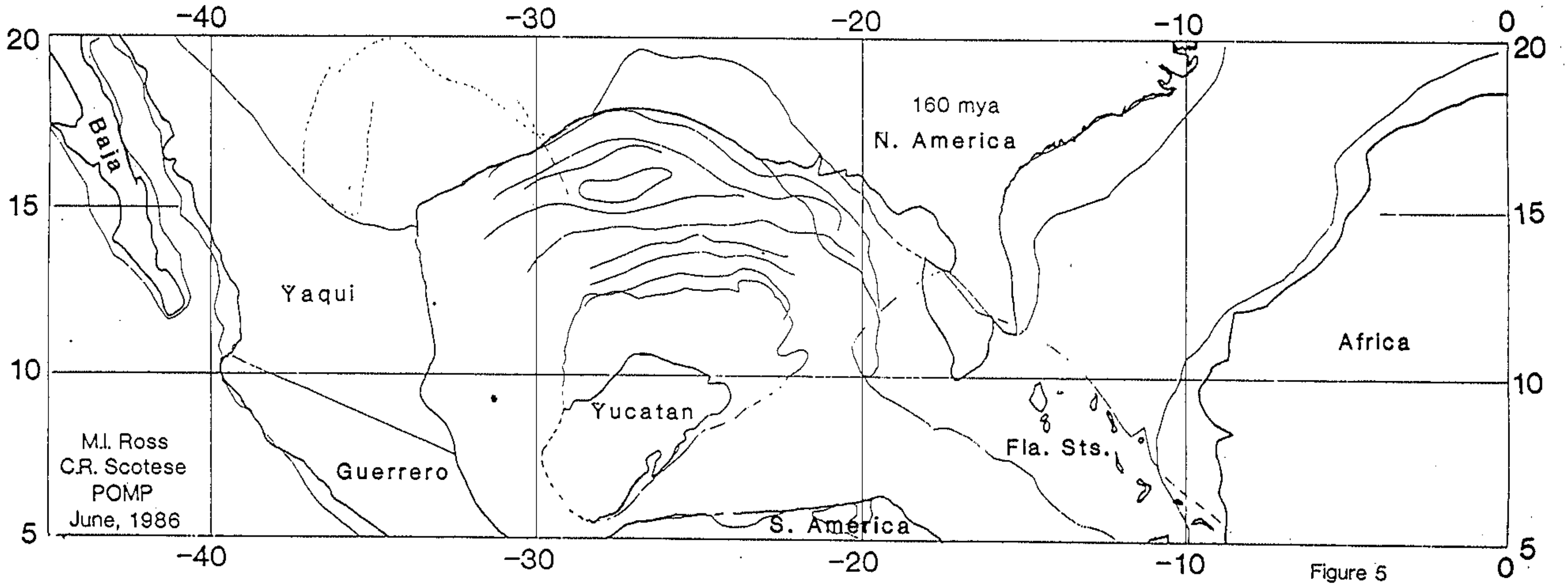


Figure 5

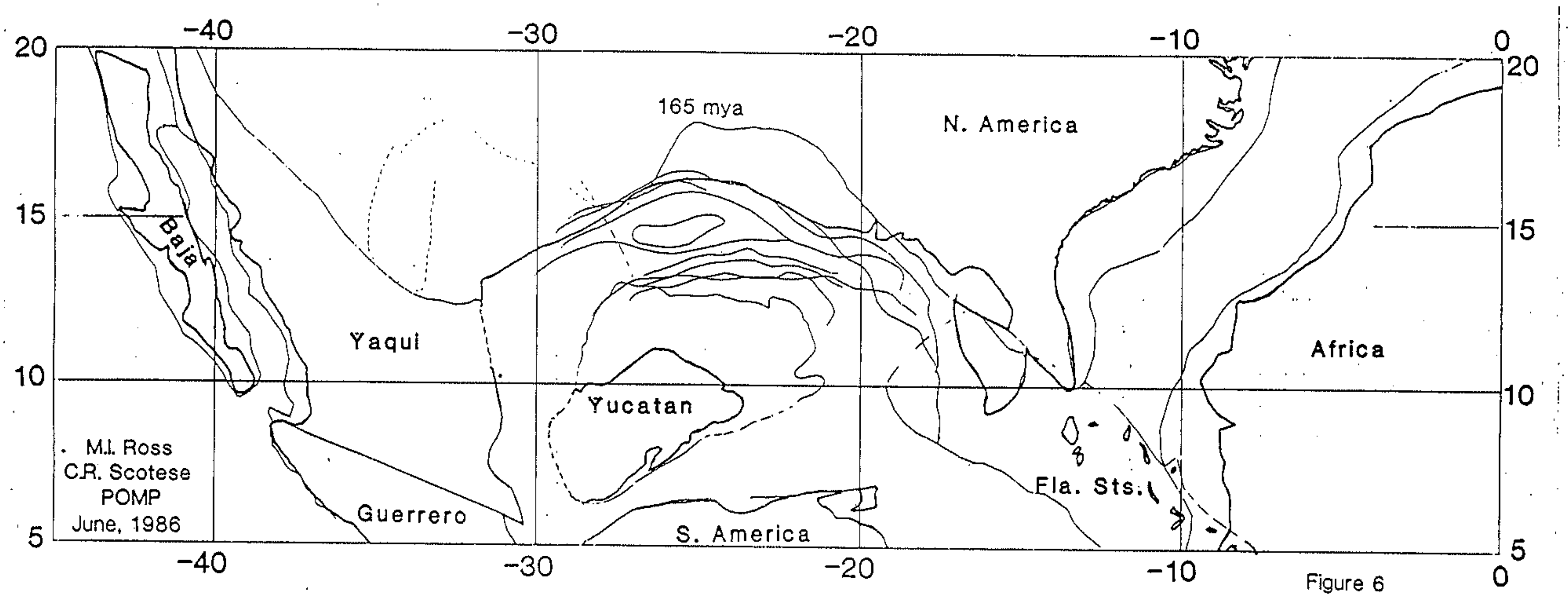


Figure 6

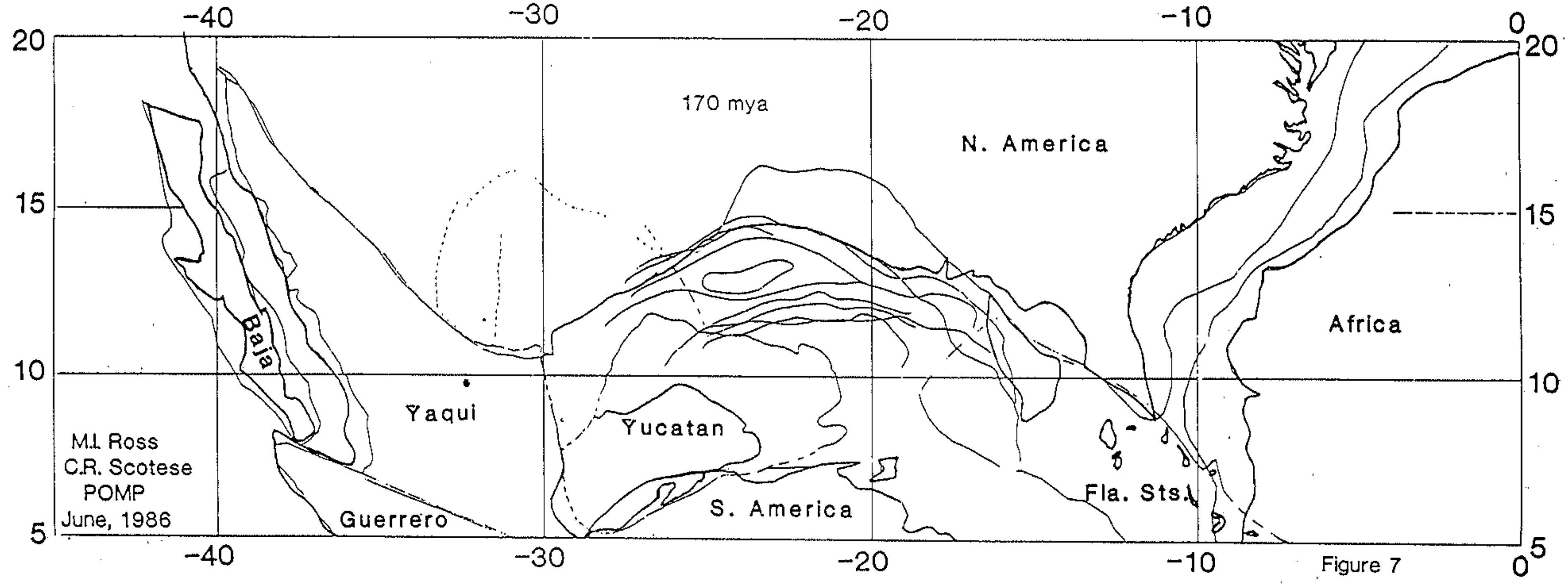
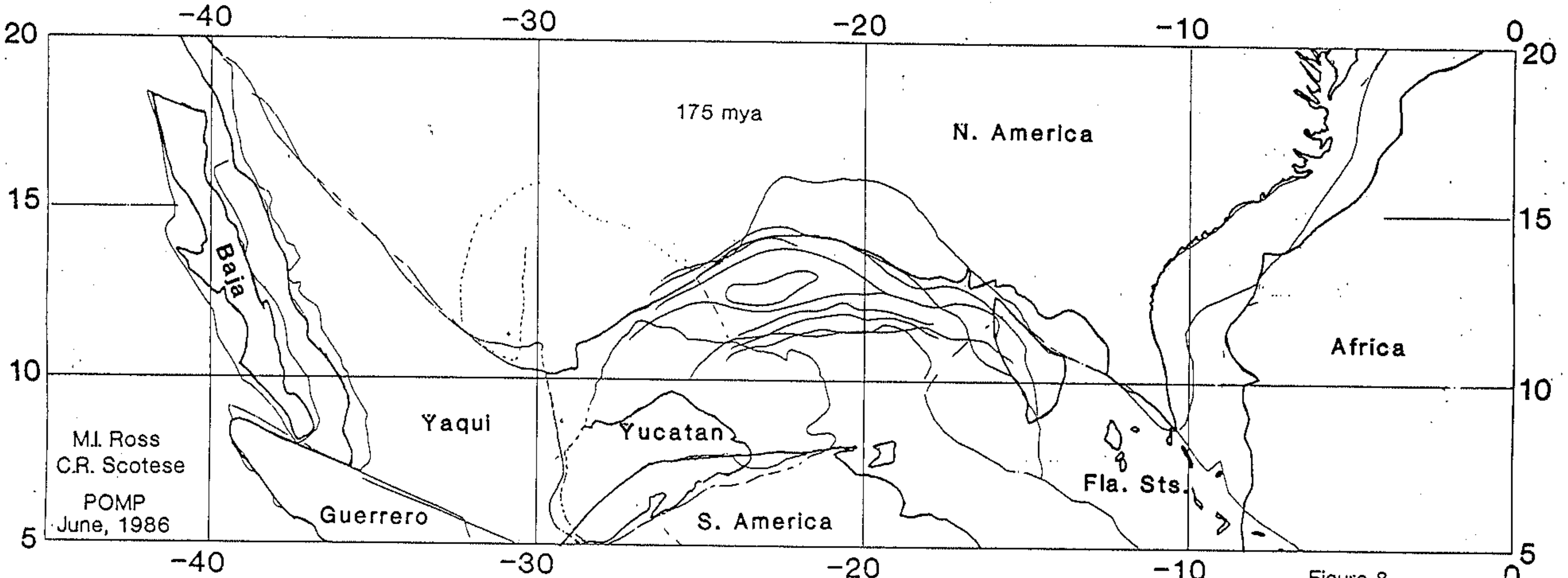


Figure 7



175 mya
N. America
Africa
Baja
Yaqui
Yucatan
Fla. Sts.
Guerrero
S. America
M.I. Ross
C.R. Scotese
POMP
June, 1986
-40
-30
-20
-10
0
20
15
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5

Figure 8

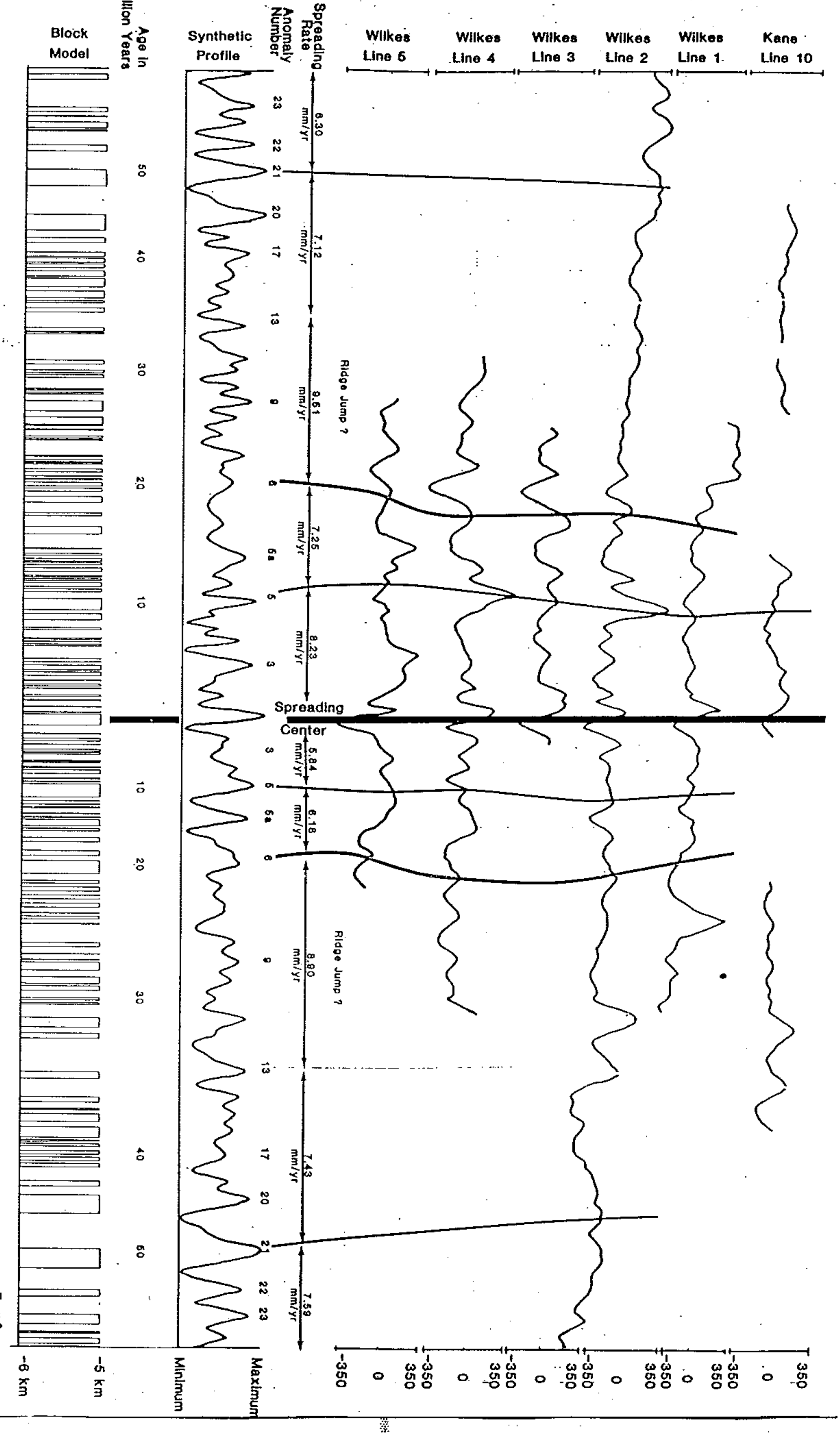
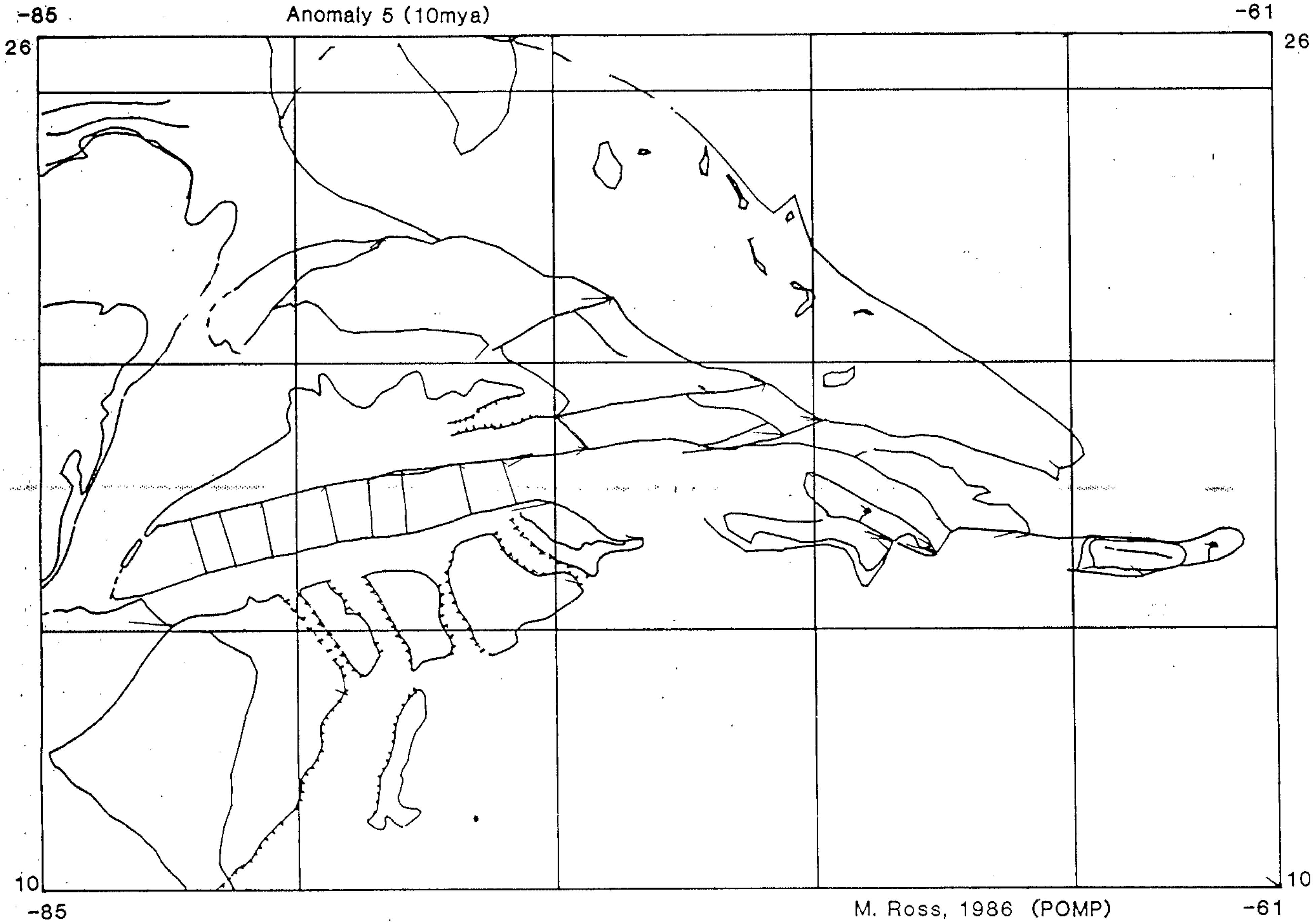

Block Model
Age in Million Years
Synthetic Profile
Anomaly Number
Spreading Rate
Wilkes Line 5
Wilkes Line 4
Wilkes Line 3
Wilkes Line 2
Wilkes Line 1
Kane Line 10
6.30 mm/yr
7.12 mm/yr
9.61 mm/yr
7.25 mm/yr
8.23 mm/yr
5.84 mm/yr
6.18 mm/yr
8.80 mm/yr
7.43 mm/yr
7.59 mm/yr
23 22 21 20 17 13 9 6 6a 5 3
3 5 6a 6 9 13 17 20 21 22 23
50 40 30 20 10
10 20 30 40 50
Ridge Jump ?
Ridge Jump ?
Spreading Center
-6 km
-5 km
Minimum
Maximum
-350 0 350

Figure 9

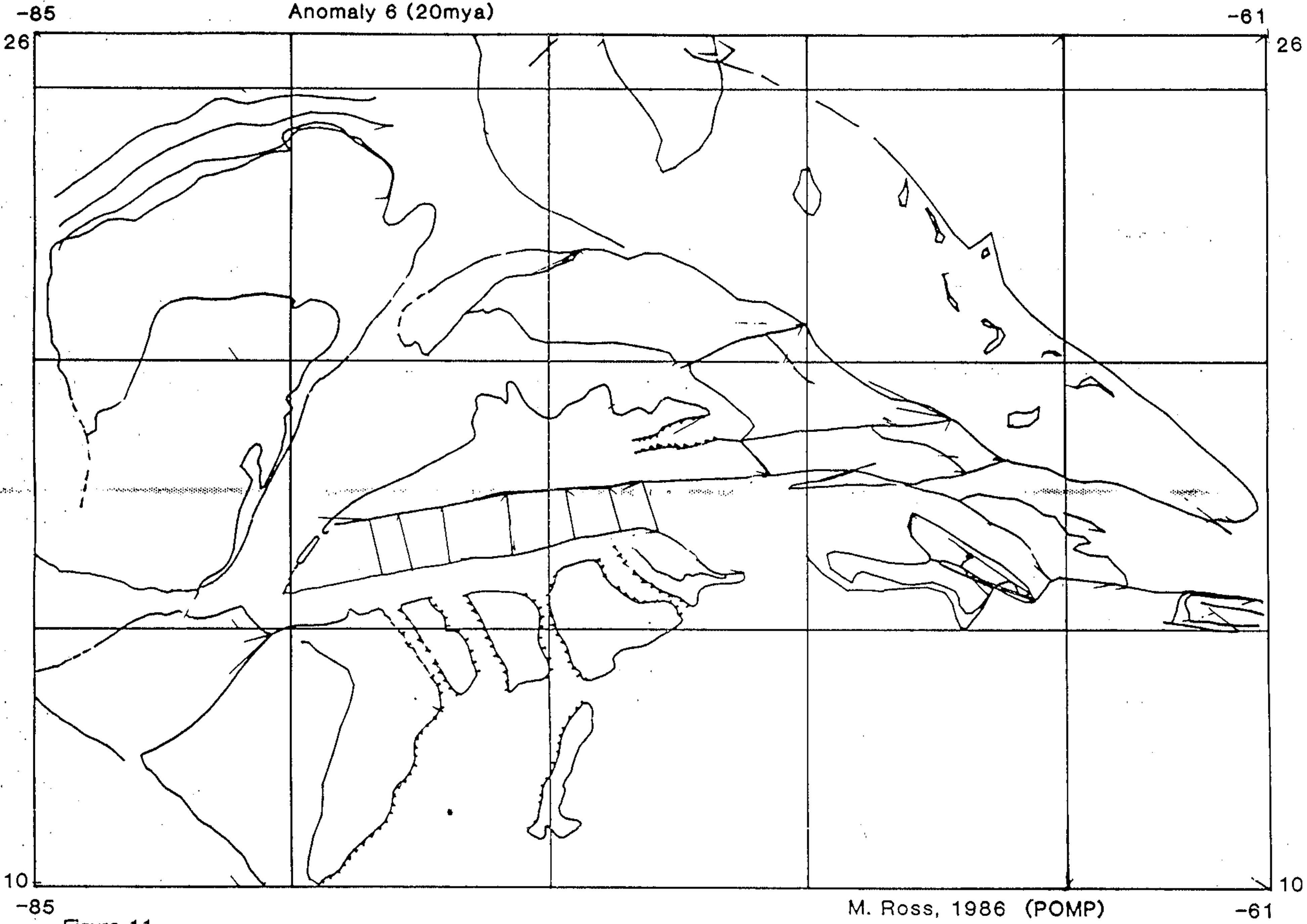
Anomaly 5 (10mya)



M. Ross, 1986 (POMP)

Figure 10

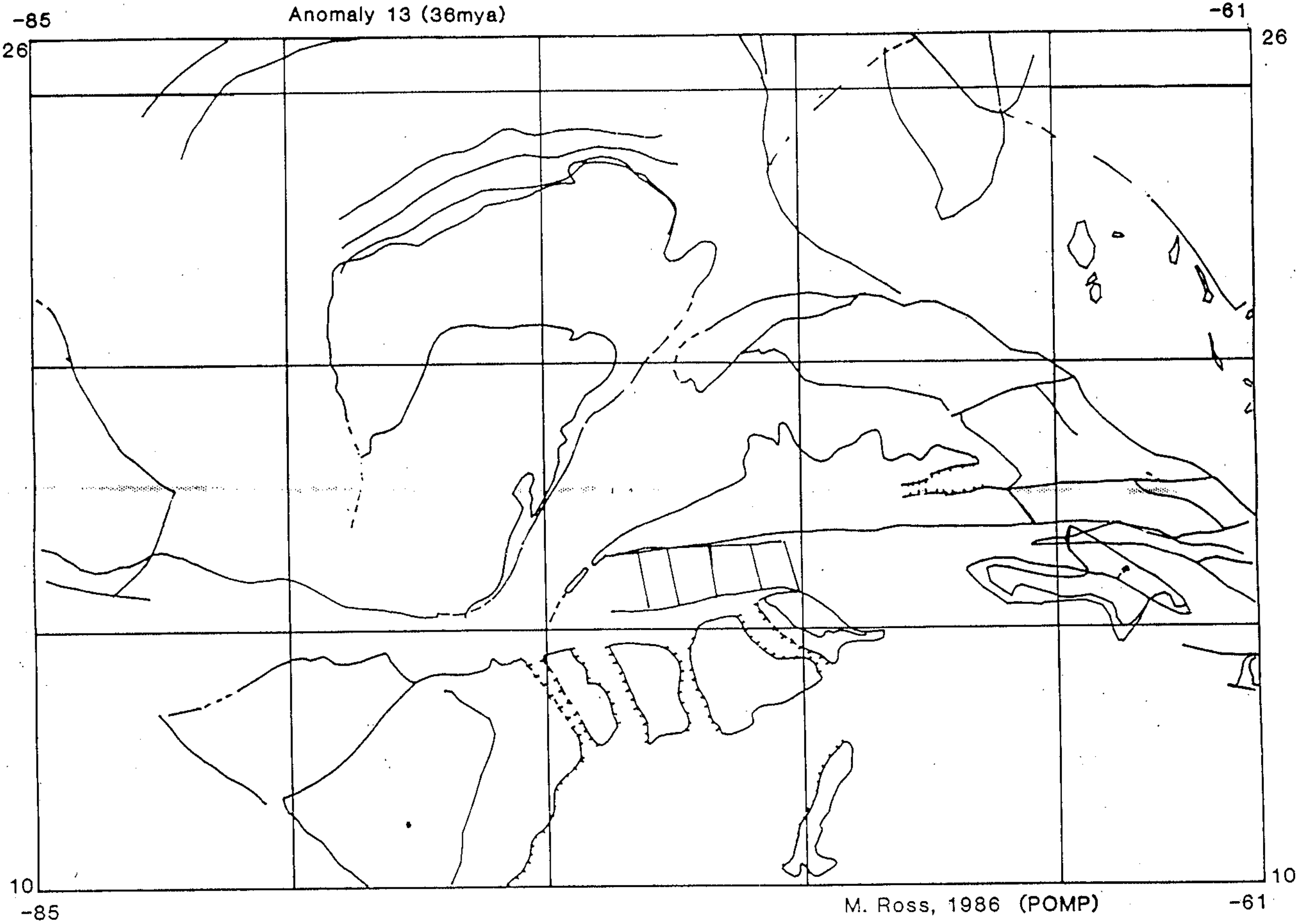
Anomaly 6 (20mya)



M. Ross, 1986 (POMP)

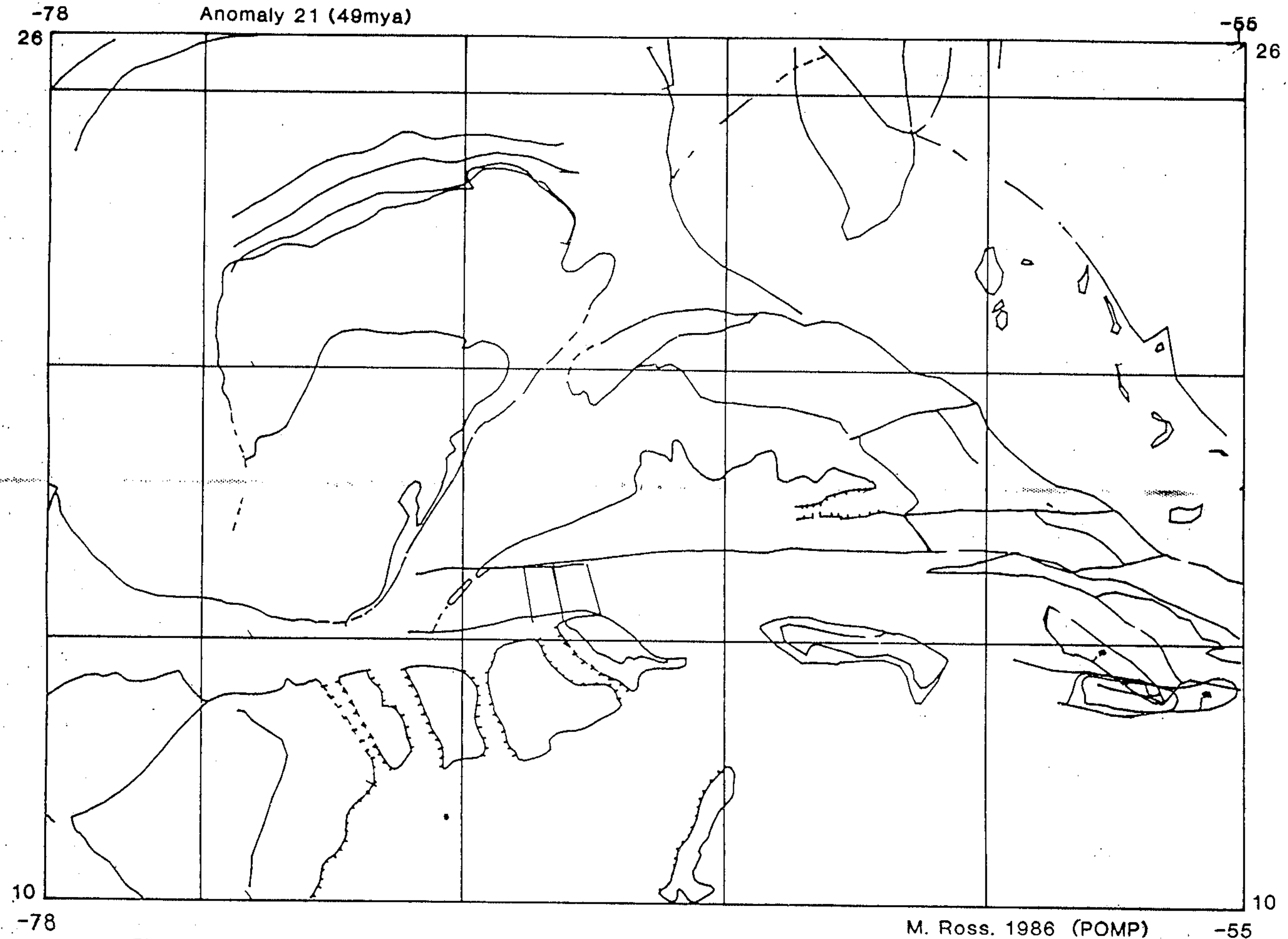
Figure 11

Anomaly 13 (36mya)



M. Ross, 1986 (POMP)

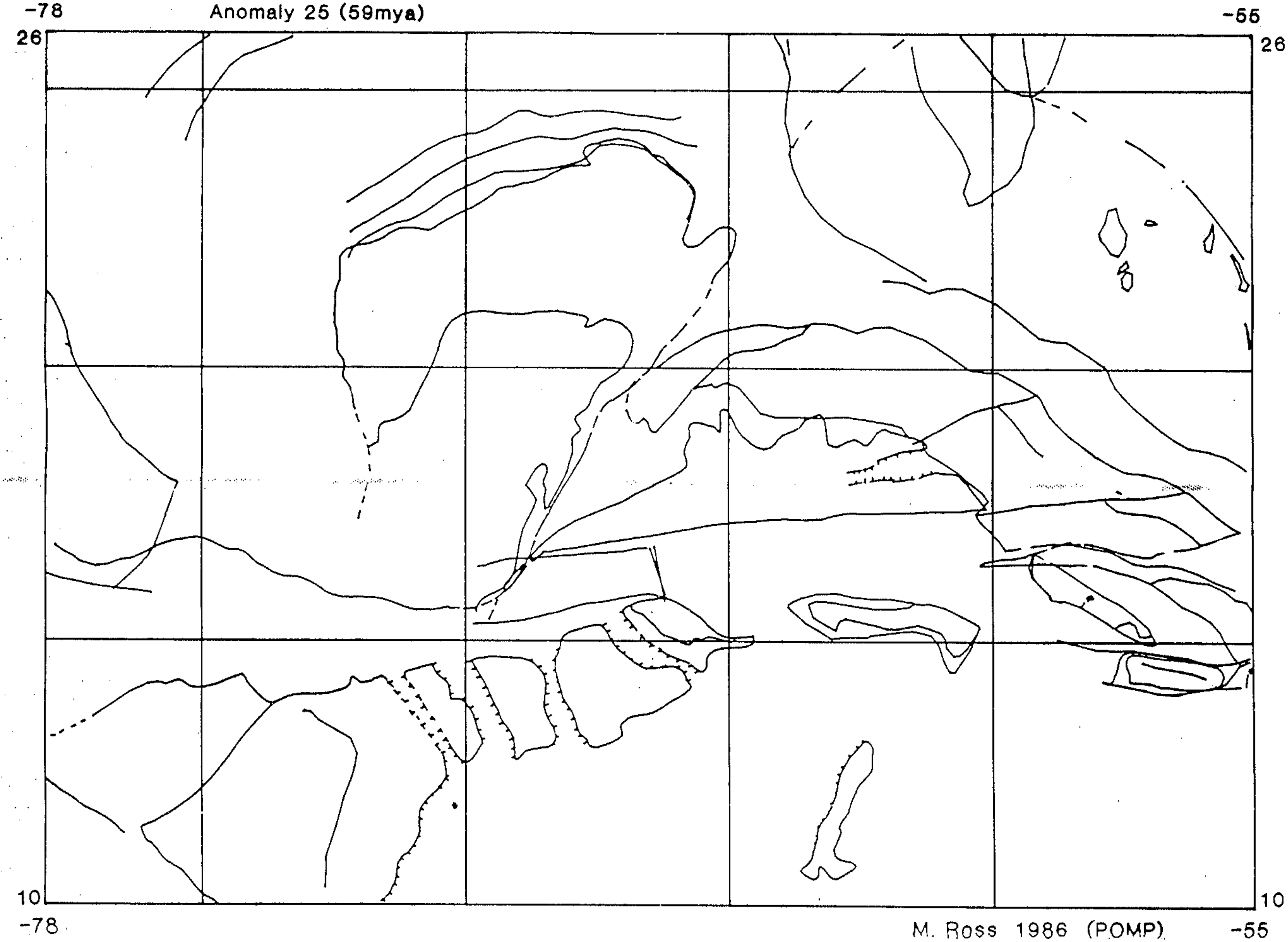
Figure 12



Anomaly 21 (49mya)

M. Ross. 1986 (POMP)

Figure 13



Anomaly 25 (59mya)

M. Ross 1986 (POMP)

Figure 14

Table 1 - Tectonic Elements and their rotation ID #'s

101	North American Craton
104	Mexico (Yaqui)
105	Baja Mexico
201	South American Craton
204	Hondouras (Chortis)
205	Stable Yucatan
206	Central Cuba
208	Chiapas
209	Cuchumantanes
210	Polochic-Motagua
211	Santa Cruz
212	Guayape
213	Motagua-Jocotan
214	Golden Lane
215	Guerrero
216	Cayman Ridge
217	West Cayman Trough
218	East Cayman Trough
219	Thunder Knoll
220	Rosalind Bank
221	Pedro Bank
222	Jamaica
223	Quinto Sueno
224	Caribbean Ocean Floor
225	Maricaibo
226	Romeral
227	Santa Marta
228	Perija
229	Eastern Panama
230	Central Panama
231	Western Panama
232	Hess Block
233	Florida Straits Block
234	Lesser Antilles Arc
235	Aves Ridge
236	Saint Christopher Block
237	Puerto Rico
238	Eastern Puerto Rican Trough
239	Western Puerto Rican Trough
240	Muertos Trough
241	Gulf of Tehuantepec
242	Gulf of Gonave
243	Accreted Chortis
244	Accreted Chiapas
245	Accreted Guayape
246	Accreted Lesser Antilles-Barbados
247	Transitional Guerrero
248	Transitional Lesser Antilles
249	Transitional North America
250	Transitional Mexico (Yaqui)
251	Transitional Yucatan
252	Southern Hispaniola
253	San Juan/Hispaniola
254	Hispaniola Cordillera
255	Northern Hispaniola
256	Pinar Del Rio
257	Yucatan Basin
258	Southern Cuba
259	Sierra Maestra of Cuba
260	Transitional Cuba
261	Transitional Southern Cuba
262	Transitional Sierra Maestra
263	Empty Slot
264	Beta=2, Northern Gulf of Mexico
265	Beta=2, Southern Gulf of Mexico
266	Beta=3, Northern Gulf of Mexico
267	Beta=3, Central Gulf of Mexico
268	Beta=3, Southern Gulf of Mexico
269	Beta=4, Northern Gulf of Mexico
270	Beta=4, Northern Gulf of Mexico
271	Sigsbee Block
272	Beta=4, Central Gulf of Mexico
273	Puerto Rico Trench

Table II : Rotations in the Gulf of Mexico
Relative to a fixed North America

Time: 155 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-40.4	-98.7	24.4
Yucatan	-29.5	-99.8	4.5
Florida Straits	-68.8	162.7	0.3
Sigsbee	-34.4	99.7	2.3

Time: 160 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-45.3	-107.0	25.9
Yucatan	-29.5	-99.8	15.8
Florida Straits	-66.9	162.5	1.1
Sigsbee	-34.4	99.7	7.9

Time: 165 mya	Lat.	Lon.	Angle
Baja	37.9	-91.3	7.4
S. America Craton	-48.9	-115.3	27.8
Yucatan	-30.6	98.0	28.7
Guerrero	-79.5	136.9	0.8
Florida Straits	-66.8	162.5	2.4
Sigsbee	-34.4	99.7	11.3

Time: 170 mya	Lat.	Lon.	Angle
Baja	36.1	-92.2	6.5
Mexico (Yaqui)	-52.3	96.5	0.9
S. America Craton	-51.6	-123.5	30.0
Yucatan	-31.4	94.9	36.7
Guerrero	-74.1	117.0	3.6
Florida Straits	-66.8	162.5	4.3
Sigsbee	-34.4	99.7	11.3

Time: 175 mya	Lat.	Lon.	Angle
Baja	30.5	-94.7	4.9
Mexico (Yaqui)	-52.2	96.4	2.6
S. America Craton	-52.4	-126.6	31.0
Yucatan	-33.0	94.4	36.9
Guerrero	-70.4	111.1	6.8
Florida Straits	-66.8	162.5	5.0
Sigsbee	-34.4	99.7	11.3

Table III : Rotations along the Northern Plate Boundary of Caribbean Relative to a fixed North America

Time: 10 mya	Lat.	Lon.	Angle
Chortis	-56.4	-62.8	1.0
Guayape	-56.4	-62.8	1.0
E Cayman Trough	-56.4	-62.8	1.0
Nicaraguan Rise	-56.4	-62.8	1.0
Jamaica	-56.4	-62.8	1.0
Southern Hispaniola	-56.4	-62.8	1.0
San Juan/Hispaniola	-56.4	-62.8	1.0
Hispaniola Cordillera	-32.5	-92.8	4.7
Northern Hispaniola	-56.4	-62.8	1.0

Time: 20 mya	Lat.	Lon.	Angle
Chortis	-58.2	-59.0	2.4
Guayape	-58.2	-59.0	2.4
E Cayman Trough	-58.2	-59.0	2.4
Nicaraguan Rise	-58.2	-59.0	2.4
Jamaica	-58.2	-59.0	2.4
Southern Hispaniola	-58.2	-59.0	2.4
San Juan/Hispaniola	-58.2	-59.0	2.4
Hispaniola Cordillera	-36.3	-87.4	8.7
Northern Hispaniola	-58.2	-59.0	2.4

Time: 35 mya	Lat.	Lon.	Angle
Chortis	-58.1	-55.0	4.7
Guayape	-58.1	-55.0	4.7
E Cayman Trough	-58.1	-55.0	4.7
Nicaraguan Rise	-58.1	-55.0	4.7
Jamaica	-58.1	-55.0	4.7
Southern Hispaniola	-39.8	-76.6	5.0
San Juan/Hispaniola	-39.8	-76.6	5.0
Hispaniola Cordillera	-43.6	-86.7	13.7
Northern Hispaniola	-58.0	-55.0	2.8

Time: 49 mya	Lat.	Lon.	Angle
Chortis	-58.0	-54.9	6.4
Guayape	-58.0	-54.9	6.4
E Cayman Trough	-58.0	-54.9	6.4
Nicaraguan Rise	-58.0	-54.9	6.4
Jamaica	-58.0	-54.9	6.4
Southern Hispaniola	-39.5	-67.7	7.1
San Juan/Hispaniola	-56.9	-56.8	2.9
Hispaniola Cordillera	-50.5	-84.4	17.4
Northern Hispaniola	-57.9	-54.9	2.8

Time: 59 mya	Lat.	Lon.	Angle
Chortis	-54.8	-57.9	7.7
Cuba	1.5	-65.6	3.3
Guayape	-54.8	-57.9	7.7
Cayman Ridge	-32.7	-76.2	1.7
E Cayman Trough	-54.8	-57.9	7.7
Nicaraguan Rise	-54.8	-57.9	7.7
Jamaica	-54.8	-57.9	7.7
Southern Hispaniola	-39.4	-67.5	9.4
San Juan/Hispaniola	-58.0	-62.7	5.6
Hispaniola Cordillera	-59.7	-81.7	18.9
Northern Hispaniola	-57.9	-43.7	4.3

Appendix A

CRUST EXTENSION WITHIN THE GULF OF MEXICO: IMPLICATIONS FOR THE BREAKUP OF WESTERN PANGEA

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Many different reconstructions have been proposed for the Gulf of Mexico region and western Pangea. Neither paleomagnetic nor conventional plate kinematic constraints are sufficient to discriminate between them. We investigate the potential of using the pattern of extension along rifted continental margins to provide further constraint to the reconstruction problem. The pattern of crust extension within the Gulf of Mexico Basin is used to constrain the location of the pole and angle of rotation of the Yucatan block with respect to North America. In this approach, extension is estimated on a point-by-point basis using the sediment unloaded depth to the pre-rift basement. For each rotation pole to be tested, the extended crust within the basin is restored to its pre-rift thickness along small circle flow lines about that pole. We compute the misfit between restored plate edges and generate a contour map of its variation versus pole location. An elongate belt of potentially valid poles extends from east of the Bahama Islands, across the Central Atlantic, and through North Africa (Figure 1). Reconstructions for poles on this trend place the Yucatan block in contact with North America along the Texas and Louisiana coast (Figure 2A). Figure 2B indicates the range of pre-rift positions for the Yucatan block for which the RMS misfit between the restored plate edges is less than 75 km. We conclude that the complete closure of the Gulf of Mexico requires that the Yucatan block moved independent of both North America and Gondwanaland in a direction south relative to North America, about a pole somewhere along the Central Atlantic to North Africa trend.

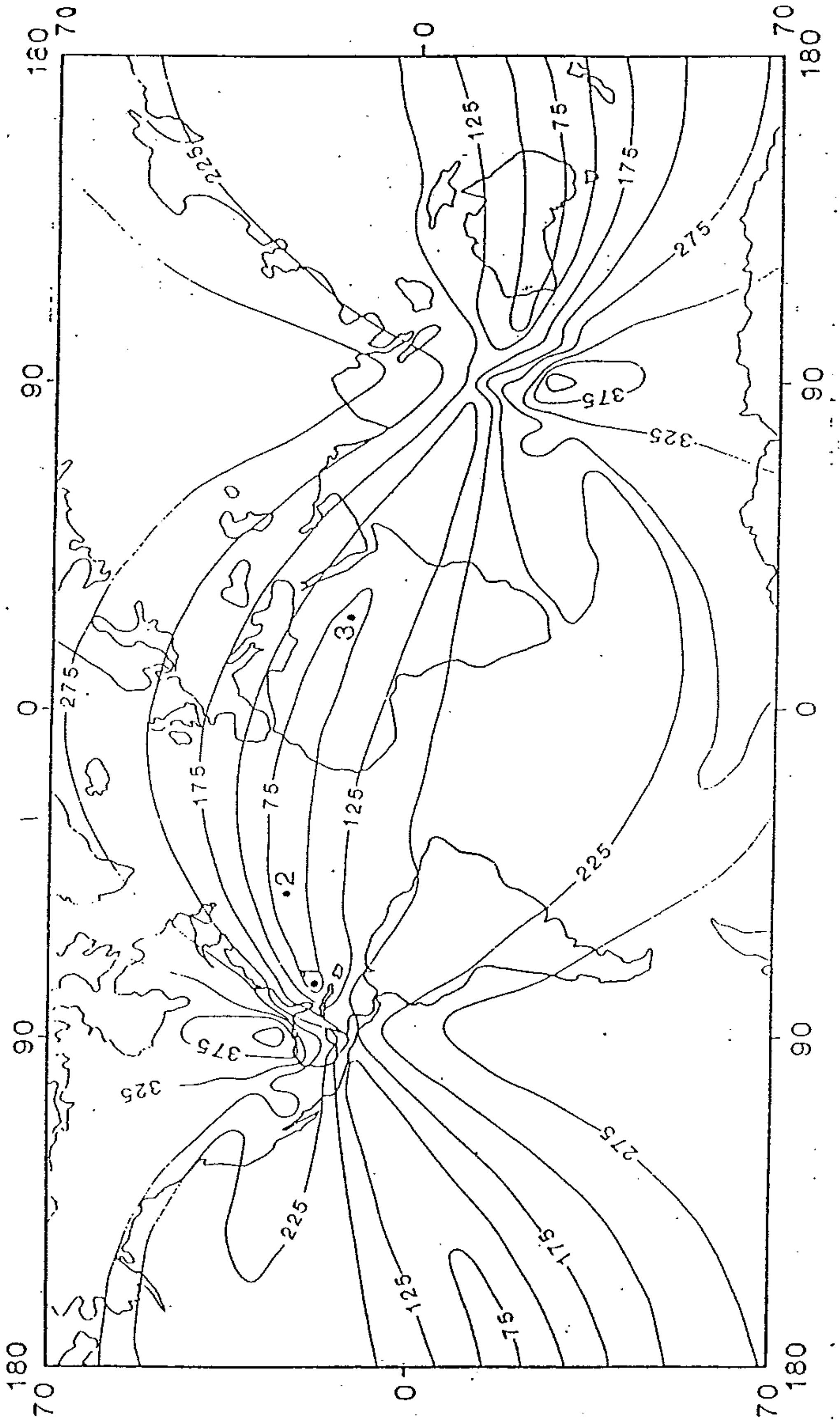

Figure 1. RMS misfit for the reconstruction of the Gulf of Mexico versus pole location. The contour interval is 25 km. Poles 1, 2, and 3 characterize the range of reconstructions for which the RMS misfit is less than 75 km (Figure 2).

Appendix A- Figure 1

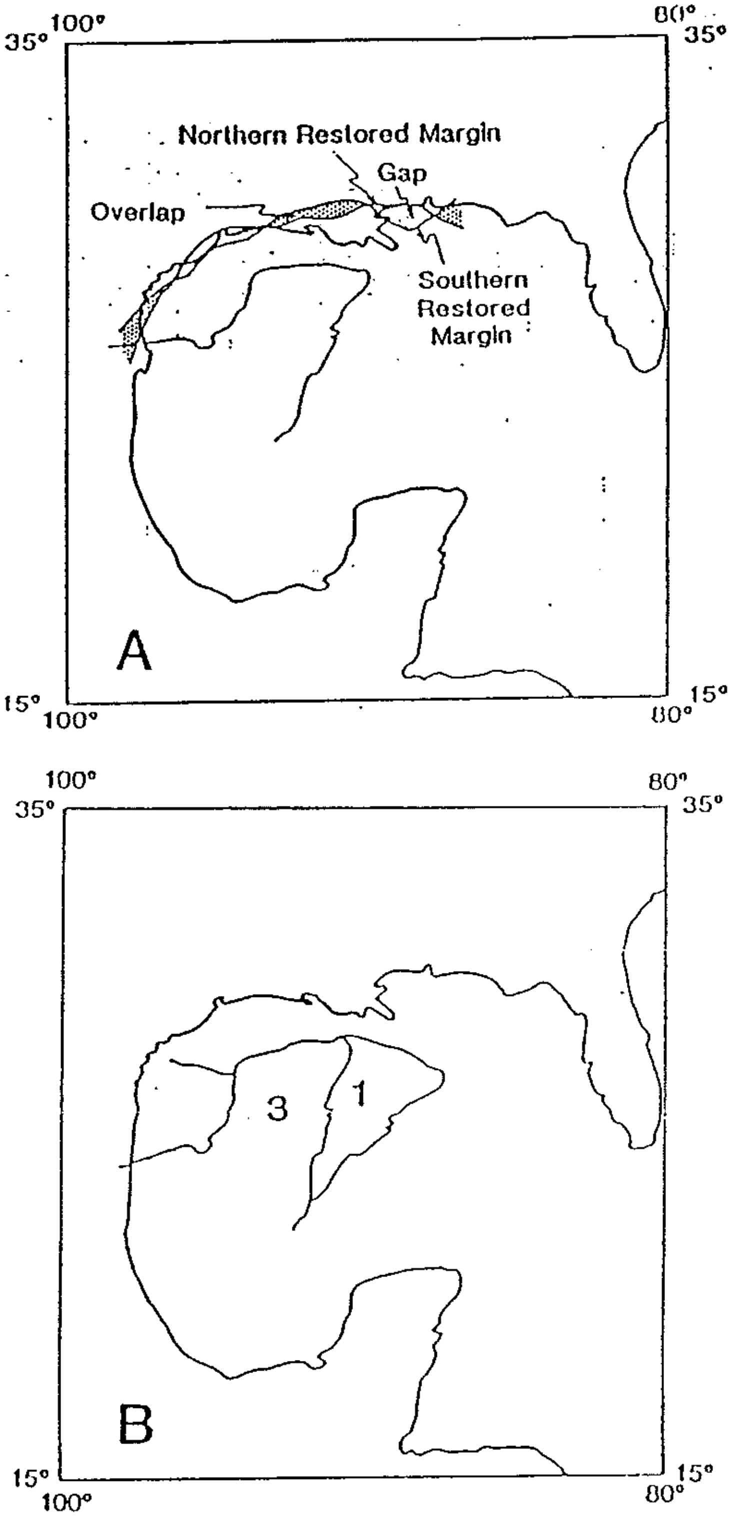

Figure 2. (A) Reconstruction about pole 2 (12.5° counterclockwise angle of opening about 33°N, 50°W), which results in an RMS misfit of 53 km. (B) The range of pre-rift positions of the Yucatan block for which the RMS misfit is less than 75 km. Reconstruction 1 corresponds to a 30° counterclockwise angle of opening about 25°N, 75°W, and results in an RMS misfit of 48 km. Reconstruction 3 corresponds to an 8° clockwise angle of opening about 17°N, 25°E, and results in an RMS misfit of 69 km.

Appendix A- Figure 2

Appendix B - Abstract from 1986 Geodynamics Symposium

CARIBBEAN PLATE RECONSTRUCTIONS: A NEW INTERPRETATIONS OF DATA IN THE CAYMAN TROUGH

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Eric Rosencrantz
Chris Scotese (all at University of Texas Institute for Geophysics, Austin Texas)
Stephen F. Barrett (AMOCO Int. Oil Company, Houston, Texas)

The Cayman Trough is the present active plate boundary between North America and the Caribbean. In the center of the Cayman Trough lies the Cayman Ridge; magnetic anomalies on either side of the Cayman ridge provide important constraints on the tectonic development of the Caribbean Plate. Previous workers (Holcombe et al. 1973, MacDonald et al. 1978, Sykes et al. 1983) correlated linear magnetic anomalies and estimated spreading rates to be 20-40 mm/yr for the last 8.5 my. If these rates are projected back through time, they suggest that the Cayman Trough began spreading in the Late Eocene.

We present an alternative interpretation of the magnetic anomalies of the Cayman Trough using a new method that takes into account bathymetric relief. Our conclusions are based on only those profiles that pass through the middle of the basin in order to avoid basin edge effects. Preliminary results of the study are:

1.) Initial spreading rates across the Cayman Ridge were somewhat faster than previous estimates, however, the rates slow down markedly (to 15 mm/yr for the last 20 my.) after the collision of the Greater Antilles Arc with the Bahamas Platform. This account for the rough near ridge axis-parallel topography and lends credance to the observation that the Cayman Trough is a long lived "pull-apart" basin and thus should show offset rates similar to intercontinental transforms (Burke et al. 1984).
2.) The Cayman Trough began to rift in the Early to Middle Eocene. This age agrees with land observations that place the timing of the thrusting in the Greater Antilles Arc in the Middle to Late Eocene (Mann, 1984), and preliminary heat flow measurements (Erickson et al. 1972).
3.) During the Oligocene, there was a ridge jump. This was first suggested by Rosencrantz et al. (in press) and is based on basement topography.

We have attempted to try to constrain the amount of strike-slip movement that has segmented the Greater Antilles during the offset of the Cayman Trough by modeling the deformation along the palet boundary

zone using paleomagnetic data as estimators of rigid body rotations. It is likely that previous estimates of offset along these faults may have underestimated the total displacement by as much as a factor of two.

We will also present preliminary versions of a new set of Caribbean reconsructions that are based on our interpretations of marine magnetic data from the Cayman Trough as well as a synthesis of previous models. Numerous plate tectonic models for the evolution of the Caribbean have been proposed (Pindell and Dewey, 1980; Burke et al., 1984; Duncan and Hargraves, 1984; Pindell and Barrett, in press). These models are reviewed, rigourously tested using 3-D interactive computer graphics (Evans and Sutherland Professional System 300) and then incorperated into the proposed reconstructions. Preliminary reconstructions have been prepared illustrating the tectonic evolution of the Caribbean region from the Middle Jurassic to the Present. Although these maps illustrate the major tectonic features and events, they do not capture the dynamic aspects of the plate tectonic process. In order to capture the dynamic aspects, we have prepared, and will present a color animation of the plate tectonic development of the Caribbean.

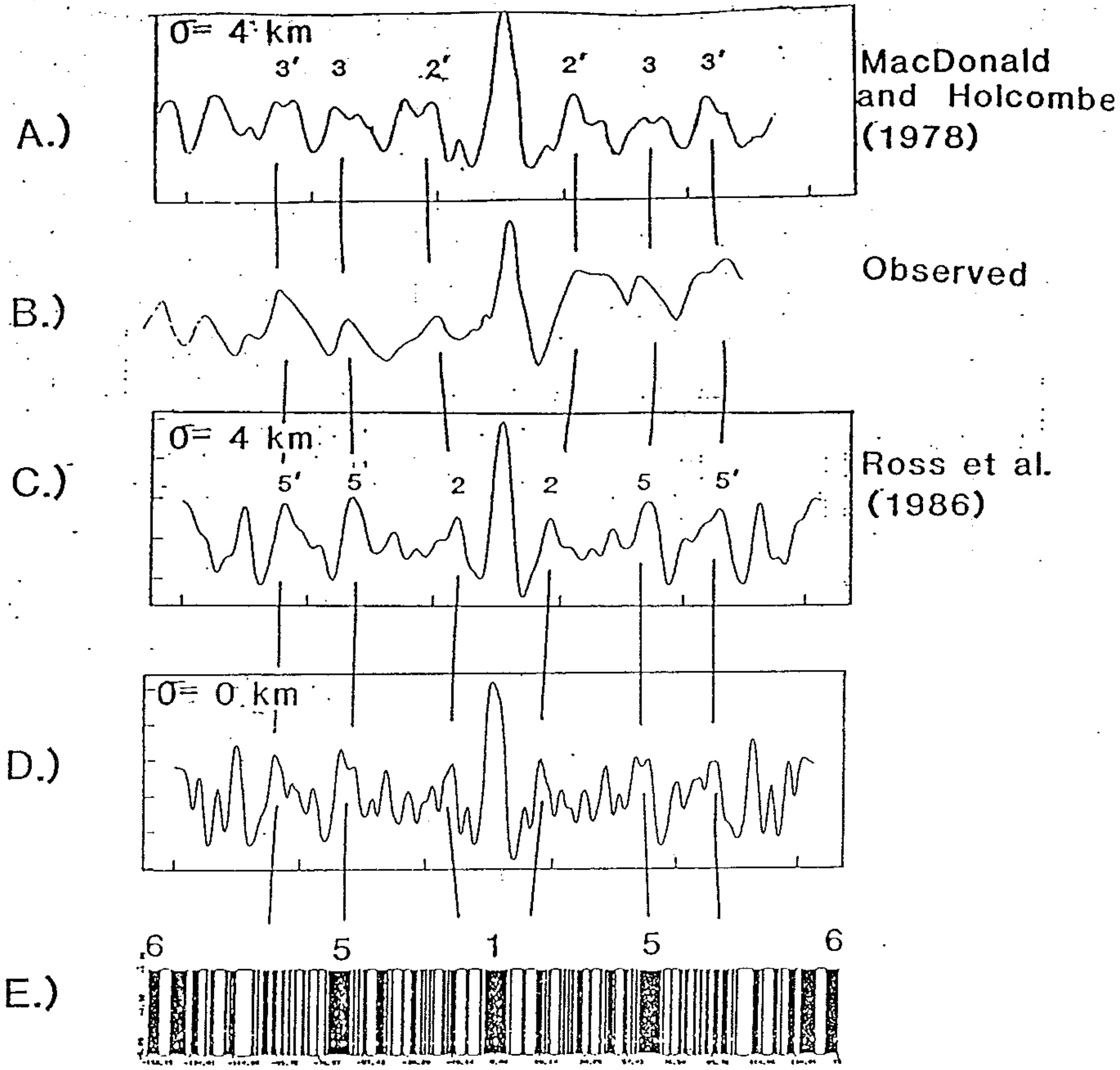

Figure 1

Magnetic anomaly identifications in the Cayman Trough

A- Synthetic anomaly for block model, spreading direction is 80 E, phase shift is 6.0 degrees. Gaussian filter with half width of 4 km to approximate dike injection. Also shown are the anomaly picks made by MacDonald and Holcombe (1978).

B- Observed magnetic anomaly field from line 2 of Wilkes, 1973 cruise. Peak to trough amplitude is 600 gammas.

C- Synthetic anomaly for block model, spreading direction is 80 E, phase shift is 6.0 degrees. Gaussian filter with half width of 4 km to approximate dike injection. Also shown are the anomaly picks illustrating our new interpretation.

D- Synthetic anomaly for block model with phase shift of 6.0 degrees, no gaussian filter.

E- Block model that represents symmetric spreading at a rate of 7 mm/yr since Anomaly 6 time.

Appendix B- Figure 1