

The South Georgia Enigma
Using PALEOMAP

By
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THE SOUTH GEORGIA ENIGMA using PALEOMAP

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The South Georgia microcontinent is located approximately 2000 km east of Cape Horn, the southern tip of South America (figure 1), at the eastern end of the North Scotia Ridge. Similarities between the geologic history and structure of the island and of the east-west trending portion of the southernmost Andean cordillera have been recognized for several decades. Increasingly detailed studies over the past fifteen years have made it virtually unquestionable that the microcontinent was originally part of the cordillera (figure 2), and indicate that it was most likely separated from the continental shelf east of Cape Horn during or since the mid-Cretaceous (Dalziel, 1981). Simple reconstructions of the Scotia Arc based on the kinematic history of seafloor spreading between South America and Antarctica during the mid- to late Cenozoic are unable to "restore" the South Georgia microcontinent to its presumed original position. We have investigated two possible reconstructions utilizing the POMP database and the Paleomap program with both interactive computer graphics and simple Calcomp plots.

Since the observed seafloor spreading in the Scotia Sea could not have resulted in the simple movement of South Georgia from near the tip of South America to its present position (see the observed magnetic anomalies in figure 3), we have suggested two *ad hoc* models. The first will be referred to as the "melon pip" tectonics model and the second the "banked billiard shot" tectonics model. The "melon pip" model assumes that South Georgia moved along the North Scotia Ridge (NSR) fault system without leaving telltale seafloor magnetic anomalies behind (figure 4A). The NSR fault is the left-lateral strike slip fault (figure 1) that separates the Scotia plate from the South American plate. It is conceivable that South Georgia moved eastward along this fault but it would have to have been separated from the Scotia Plate by an additional strike-slip fault or the NSR fault would have had to have bifurcated around South Georgia.

While most of the magnetic anomalies in the Scotia Sea were identified by Barker (Barker, 1970, 1972a, 1972b; Barker and Burrell, 1977), the oldest identified magnetic anomaly in the Scotia Sea region is anomaly 10 (30 Ma) identified by LaBrecque and Rabinowitz (1977). Since the NSR fault did not exist prior to opening of the Scotia Sea, either South Georgia was moved eastward prior to the opening of the Scotia Sea or all of its eastward motion occurred in the last 30 million years. Since the present day left lateral

strike slip motion on the NSR is less than 20 mm/yr (based on BAS Misc. Map 3 shown in figure 1, and Barker and Dalziel (1983)) and has been approximately that for the last 30 million years, then the total left lateral strike slip motion did not exceed 600 km along the NSR fault. That amount of motion is clearly insufficient to move South Georgia 2000 km east of where its geology ties it into the southern Andean Cordillera.

The "banked billiard shot" model (figure 4B) utilizes the ocean floor magnetic anomalies shown in figure 3. The east-west magnetic anomalies in the central Scotia Sea (Barker and Burrell, 1977) indicate that South Georgia could have been translated from northeast of the South Orkney Islands between anomaly 6 (20.5 Ma) to its present position at just younger than anomaly 5 (~9 Ma). If opening of the western Scotia occurred between ~8.5 Ma and anomaly 10 (30.2 Ma) time, that motion may have brought South Georgia from near Burwood Bank to just northeast of the South Orkney Islands. The trajectory of South Georgia from South America careening off the South Orkney Block and then travelling northward suggests the motion of a billiard ball.

Using Paleomap

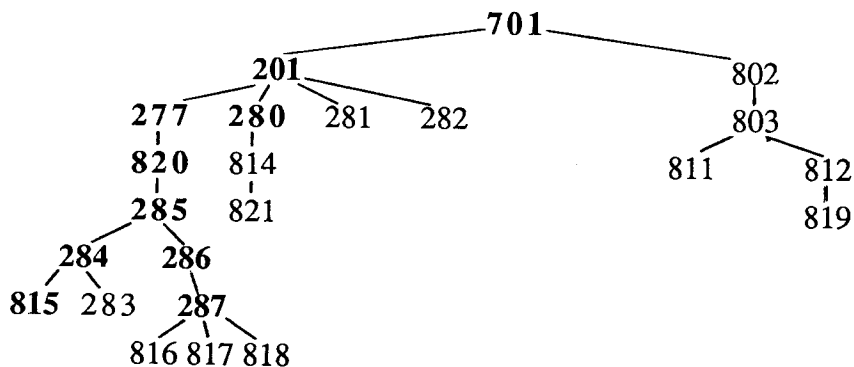
The magnetic lineations and tectonic features (ie. continental margins, fracture zones, and oceanic highs) shown in figure 3 were digitized and assigned plate numbers. The plate identification numbers are shown in figure 5. There are 20 plates shown in figure 5 with South America designated #201, the Antarctic Peninsula #803, and the South Orkney Block being #812. South Georgia has the plate number 285 with Shag Rocks (figure 3) identified as a separate plate number 284. The anomalies south of Shag Rocks were given the same number with corresponding ages based on the identified magnetic anomalies. The anomalies on the south side of the inferred abandoned spreading center in the central Scotia Sea were designated plate #815 which includes an oceanic high known as Bruce Bank.

Given the set-up of Paleomap, all plates when they are used in a reconstruction, are moved with respect to another plate except for the reference plate which is either held fixed or is moved in frame of Ziegler, et al. (1982), which is based on paleomagnetic polar wander curves. For instance, if Africa (#701) is held fixed and motion between South America (#201) with respect to Africa is known then entries in the rotation file would read:

PLATE I.D.#	AGE (Ma)	Lat.	Long.	Angle	FIXED PLATE
201	0.0	0.00	0.00	0.00	701 ! SAM-AFR PRESENT-DAY
201	1.9	68.75	-41.47	0.62	701 ! SAM-AFR AN 2
201	5.9	66.57	-37.30	2.02	701 ! SAM-AFR AN 3A

If a third plate is involved it can either be moved with respect to Africa as South America is or it can be moved with respect to South America. If it is moved with respect to South America then when it is plotted with Paleomap its position is calculated with respect to Africa. All entries in the Paleomap rotation file must be related to another entry in the reference frame except for the one held fixed. Eventually the chain of relative motion must be moved with respect to the one fixed reference plate (usually Africa).

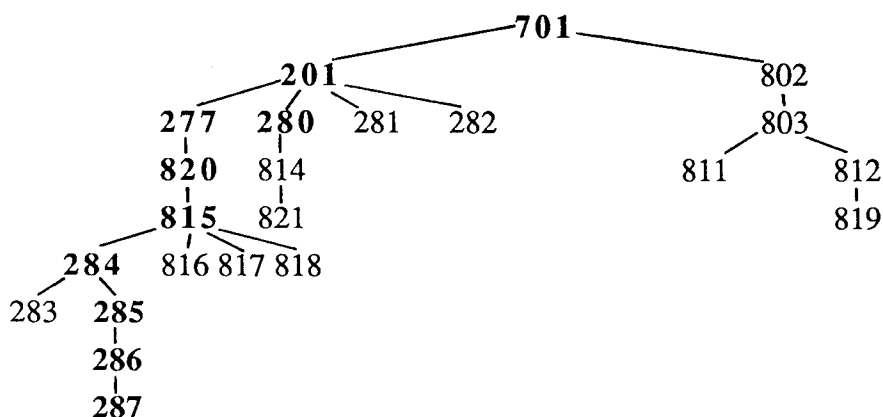
Consequently when figures 6A through 6F for the "melon pip" tectonics model were produced, the South Sandwich Islands (#287) were moved with respect to the Sandwich Plate West (#286) for the period 7 Ma to present [Table 1]. The Sandwich Plate West was assumed fixed to South Georgia (#285) prior to the opening in the eastern Scotia Sea (anomaly 4 [7 Ma] and younger), as were the South Sandwich Islands (#287) also fixed to South Georgia. South Georgia was fixed to the West Scotia Sea Plate (#820) between anomaly 6 (20.5 Ma) and present but was moving with respect to South America (#201) prior to anomaly 6 time. The movement of the Bruce Bank Plate (#815) with respect to Shag Rocks (#284) produced the motion shown in figures 6B and 6C which show that the Bruce Bank outline moved southward with time. The reference frame for these plates is diagramed below and listed in Table 1.



201=South America, 277=northwest Scotia Sea, 280 =northwest Scotia Sea north of Quest Fracture Zone, 284=Shag Rock, 285=South Georgia, 286=Sandwich Plate west, 287=South Sandwich Island Arc, 701=Africa, 815=Bruce Bank Plate, 820=Southwest Scotia Sea (Antarctic side)

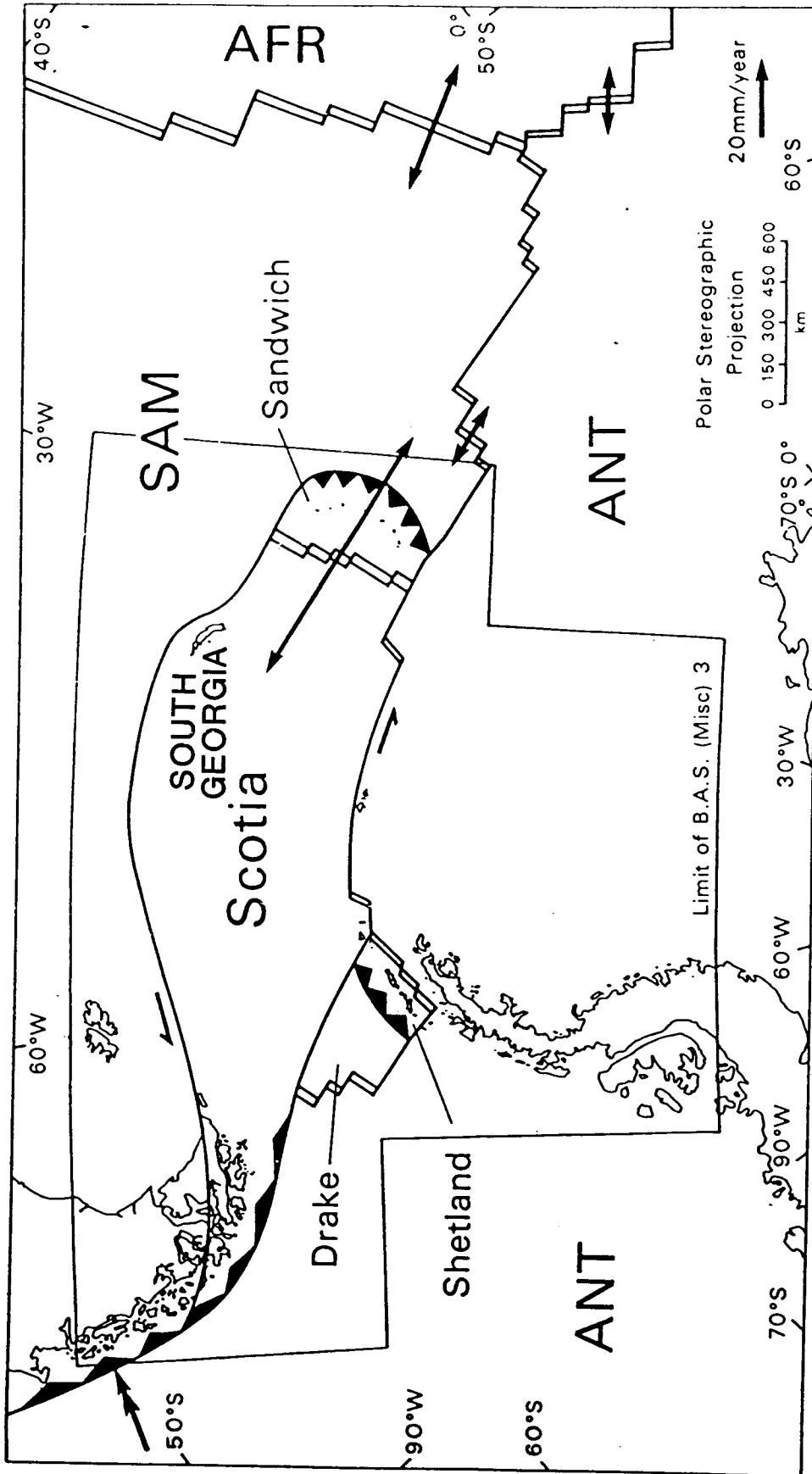
Using the reference frame diagramed above, the Bruce Bank Plate moves southward opening from a stationary South Georgia with time. In order to produce the "banked billiard shot" model that has South Georgia moving northward from a stationary Bruce Bank, a new reference frame must be devised. In the alternative reference frame, South Georgia (#285) must be moved with respect to the Bruce Bank Plate which moves with respect to South America, the reverse of the diagram shown above. Instead of South Georgia being attached to the Southwest Scotia Sea [Antarctic side] (#820), the Bruce Bank

Plate (#815) is attached to the Southwest Scotia Sea [Antarctic side]. Shag Rock (#284) is moved with respect to the Bruce Bank Plate and South Georgia is fixed to Shag Rock [see Table 2].



The difference in outcome is shown in figures 7A and 7B. Figure 7A shows the "banked billiard shot" reconstruction for 20 Ma and figure 7B the reconstruction for 30 Ma. The "banked billiard shot" reconstruction for 10 Ma is virtually identical to the reconstruction of the "melon pip" tectonics reconstruction because the only region changed is that of the central Scotia Sea, shown with the differing positions of South Georgia in figure 8. For 20 million years, it is obvious from a comparison of figures 6C and 7A that South Georgia is in two different positions with respect to South America. The closure of the anomalies in the western Scotia Sea between plates #277 (labelled #201) on figure 4 and #820 is best approximated by a pole at $-67^\circ, -78^\circ$ which is right off the lower lefthand corner of the figures 6 and 7. By 20 Ma South Georgia is attached to the Southwest Scotia Sea plate but further from the pole, so it is rapidly moved northward as shown in figure 7B. What that means is that the simple "banked billiard shot" model does not answer the South Georgia Enigma any better than the *ad hoc* "melon pip" tectonics model does. If South Georgia did not behave as a simple "banked billiard shot", perhaps one can suggest that some *english* was put on the ball. As shown on figure 3, there are some tentatively identified north-south trending magnetic lineations that are evident northwest of the South Orkney block. If these anomalies are older than the central Scotia Sea anomalies, it is conceivable that South Georgia rifted off the tip of South America in a southeast direction, was translated eastward with the anomalies in Protector Basin and then moved northward with the anomalies in the Central Scotia Sea. This "banked billiard shot with *english*" model is shown in figure 9 but mostly to illustrate that by connecting certain plates to certain other plates at the right time one can produce almost any construction one wants. Table 3 has the changes from table 2 boxed to indicate the differences.

- BARKER, P.F., 1970: Plate tectonics of the Scotia Sea region. *Nature*, London, 228, - 1293-1297.
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- BARKER, P.F., 1972b: A spreading center in the east Scotia Sea. *Earth planet. Sci. Lett.*, 15, 123-132.
- BARKER, P.F. and BURRELL, J., 1977: The opening of Drake Passage, *Marine Geology*, 25, 15-34.
- BARKER, P.F. and DALZIEL, I.W.D., 1983: Progress in geodynamics in the Scotia Arc region; in Cabre, R. (ed.), *Geodynamics of the eastern Pacific region, Caribbean and Scotia arcs*. American Geophysical Union, Geodyn. Ser. 9, 137-70.
- BRITISH ANTARCTIC SURVEY, 1985: Tectonic Map of the Scotia Arc. 1:3000000. *BAS (Misc.) 3*. Cambridge, British Antarctic Survey.
- DALZIEL, I.W.D., 1981: Back-arc extension in the Southern Andes: a review and critical reappraisal. *Phil. Trans. Roy. Soc. London, Series A*, 300, 300-335.
- FORSYTH, D.W., 1975: Fault plane solutions and tectonics of the South Atlantic and Scotia Sea, *Journal of Geophysical Research*, 80, 1429-1443.
- HILL, I.A. and BARKER, P.F., 1980: Evidence for Miocene back-arc spreading in the central Scotia Sea. *Geophys. Journal Royal astr. Soc.*, 63, 427-440.
- LaBRECQUE, J.L. and RABINOWITZ, P.D., 1977: Magnetic anomalies bordering the continental margin of Argentina. *Amer. Assoc. Petr. Geol. Map Series AAPG*, Tulsa.
- ZIEGLER, A.M., SCOTESE, C.R., and BARRETT, S.F., 1982: Mesozoic and Cenozoic Paleogeographic Maps, in Brosche, P. and Sünderman, J. (eds.), *Tidal Friction and the Earth's Rotation II*, Springer-Verlag, Berlin, 240-252.



1. Map of the Scotia Sea region showing the major plates: AFR=African, ANT=Antarctic, SAM=South American. Line with black diamonds represents a subduction plate boundary. Double line represents an extensional plate boundary. Single line represents a transform boundary. The Drake plate probably should not be considered a separate plate. This figure is taken from the Tectonic Map of the Scotia Arc, 1:3000000 BAS (Misc.) 3, Cambridge, British Antarctic Survey (1985).

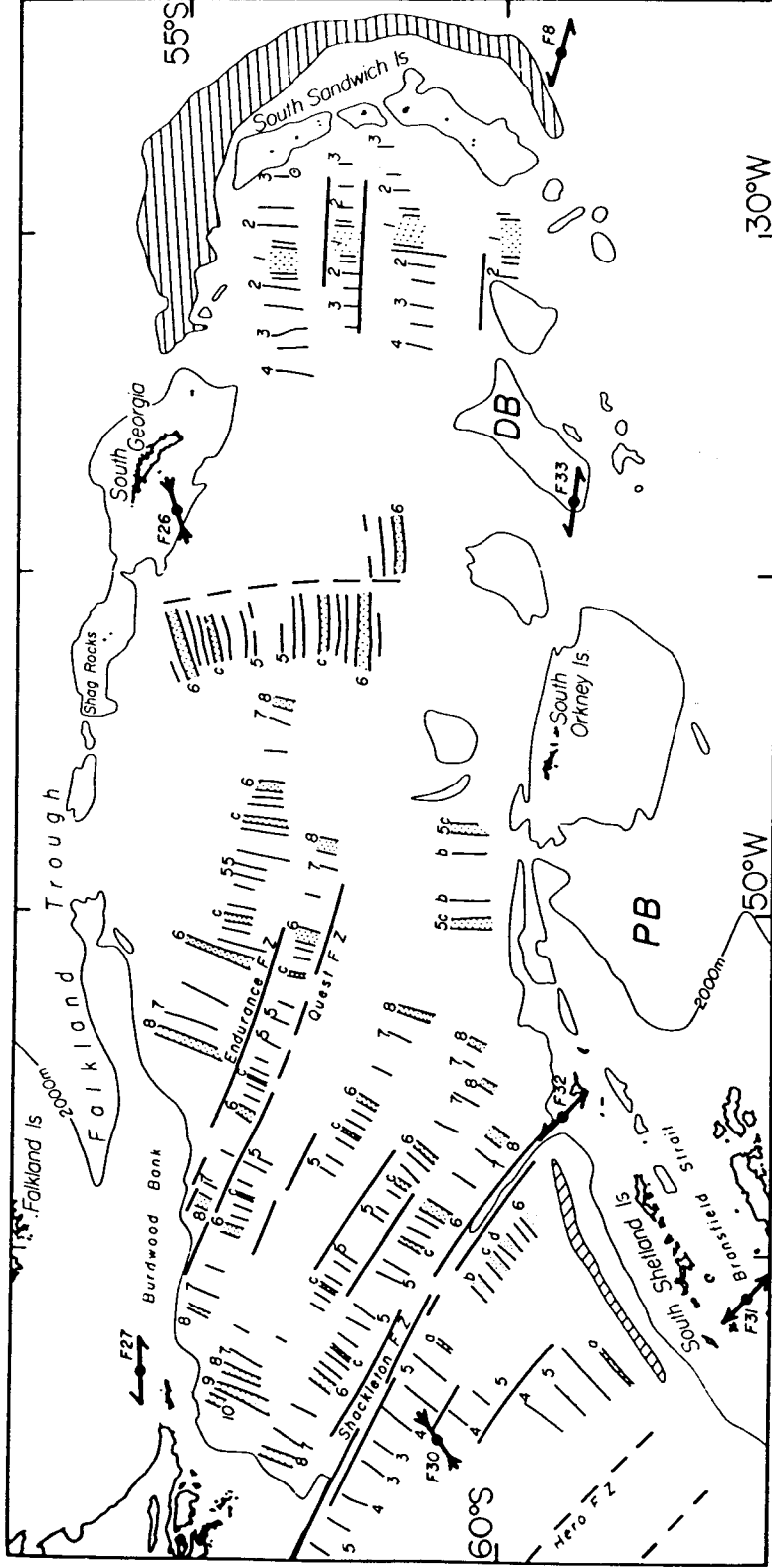
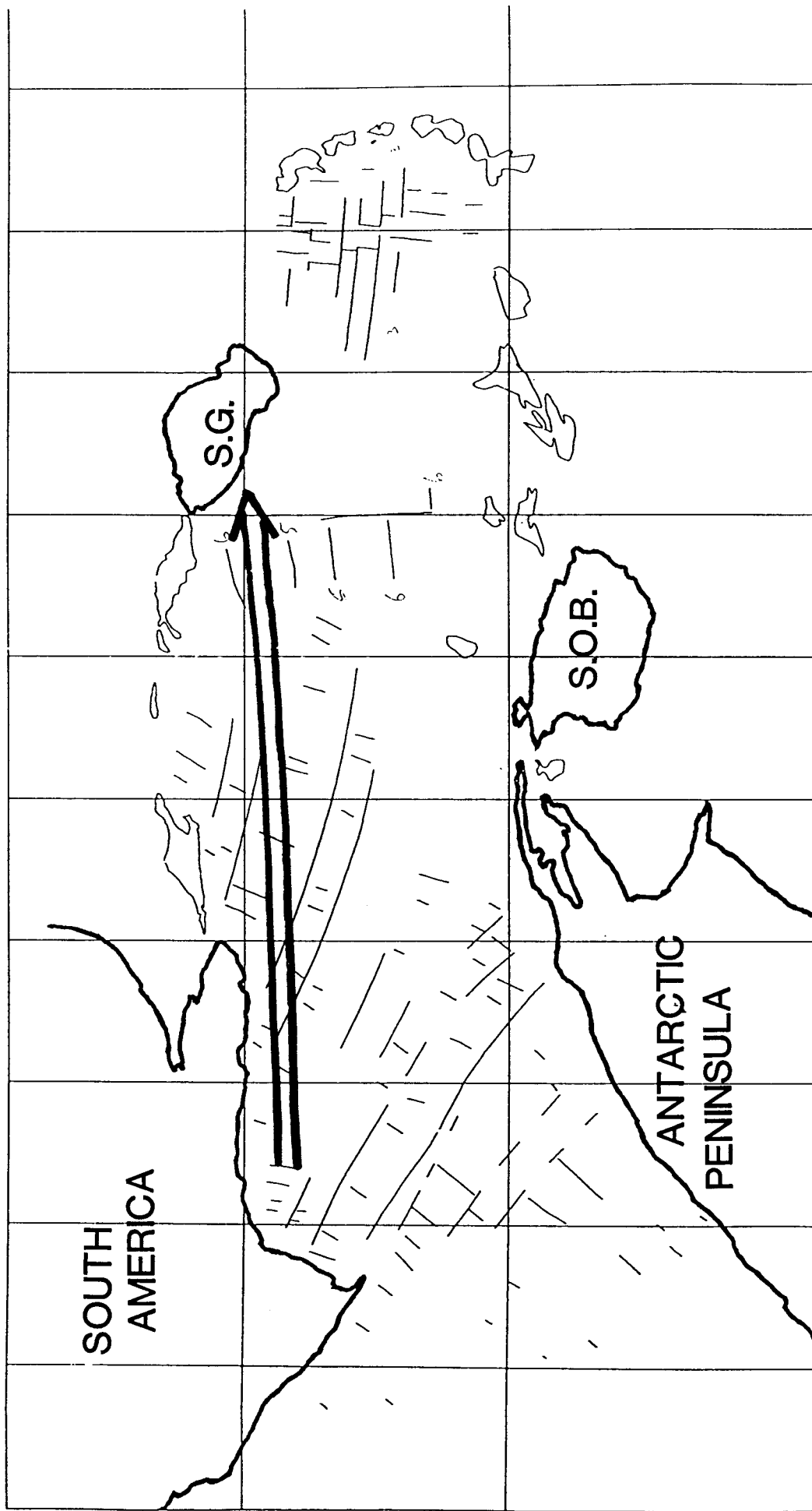
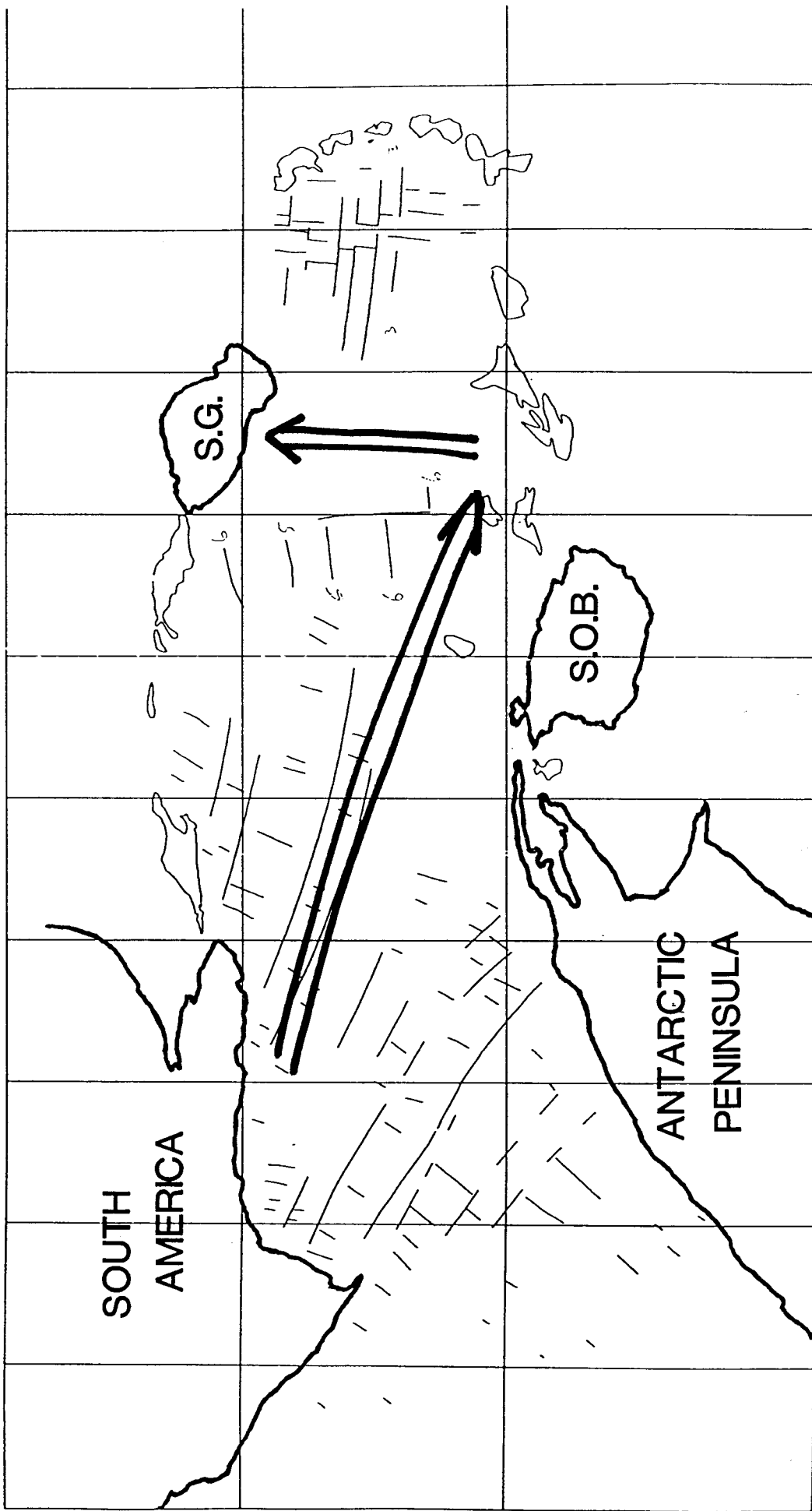


Fig. 6. Ocean floor magnetic anomalies in the Scotia Sea province compiled from Barker (1972b), Barker and Burrell (1977) and LaBrecque and Rabinowitz (1977). Anomalies northwest of the South Orkney Islands are only tentatively dated (Hill and Barker, 1980). Preferred interpretations of earthquake focal mechanisms from Forsyth (1975). PB is the Powell basin and DB Discovery bank.

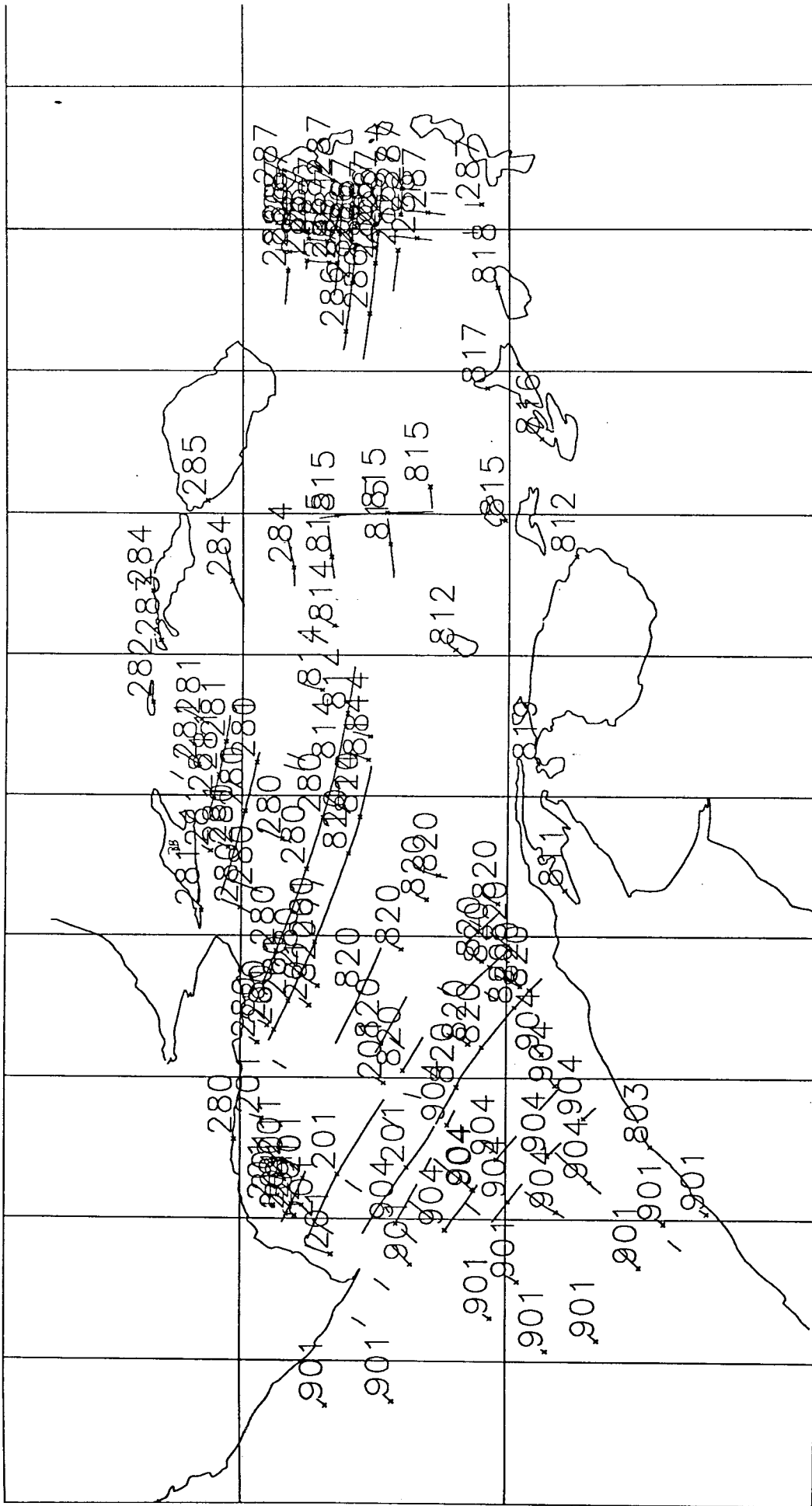
3. Ocean floor magnetic anomalies in the Scotia Sea province compiled from Barker (1972b), Barker and Burrell (1977) and LaBrecque and Rabinowitz (1977). Anomalies northwest of the South Orkney Islands are only tentatively dated (Hill and Barker, 1980). Preferred interpretations of earthquake focal mechanisms from Forsyth (1975). PB=Powell Basin, DB=Discovery Bank. Figure taken from Barker and Dalziel (1983).



4A. Cartoon illustrating the "melon pip" tectonics model. This *ad hoc* model assumes the South Georgia microcontinent moved along the North Scotia Ridge.

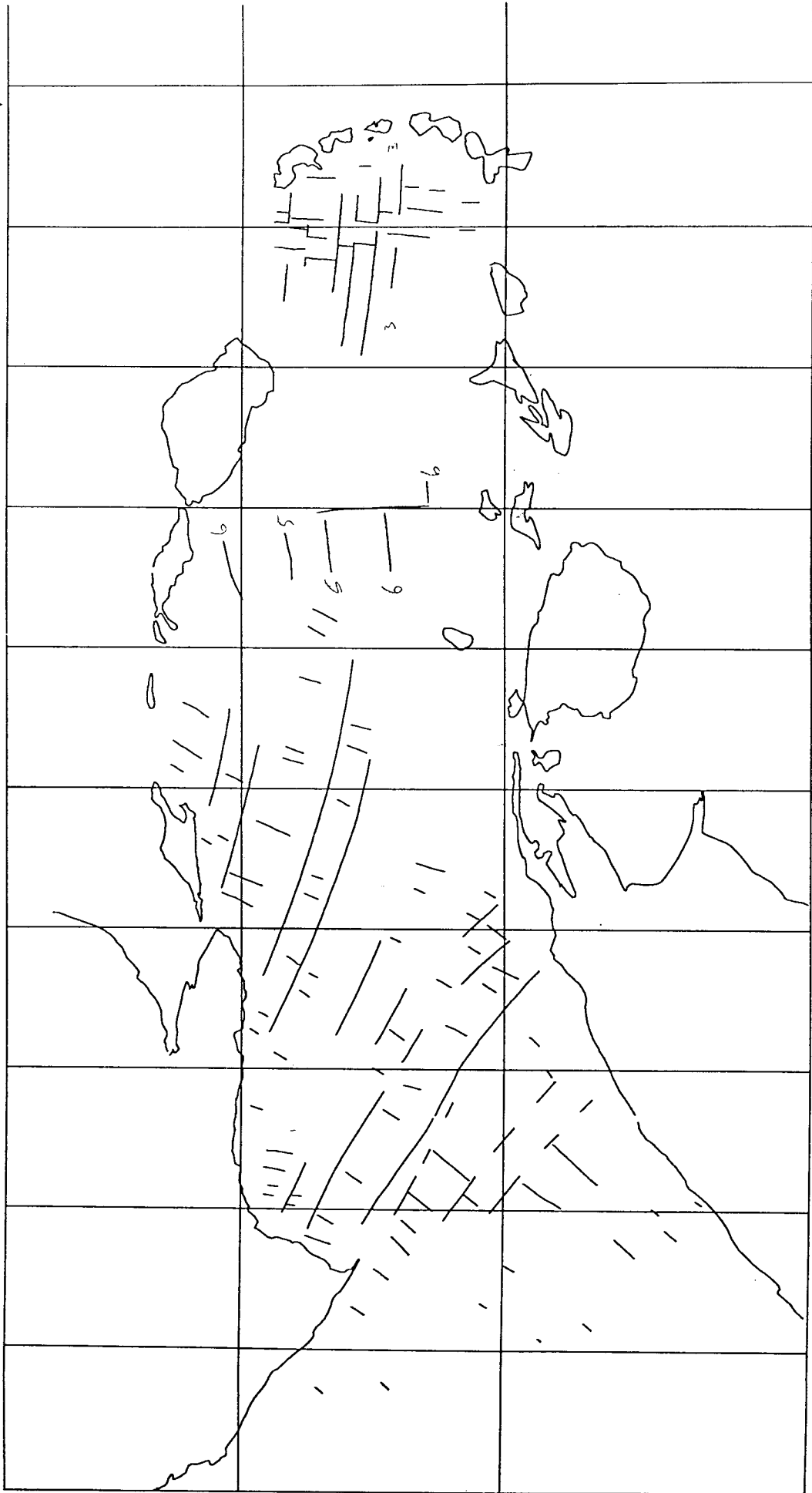


4B. Cartoon illustrating the "banked billiard shot" tectonics model. This model suggests that South Georgia moved southeastward from South America as evidenced by the magnetic anomalies in the western Scotia Sea. It then moved northward as evidenced by the magnetic anomalies in the central Scotia Sea.



5. Plate I.D. numbers assigned when the magnetic anomalies and tectonic features from figure 3 were digitized. NSR=North Scotia Ridge, SSP=South Sandwich Plate, DB=Discovery Bank, SOB=South Orkney block.

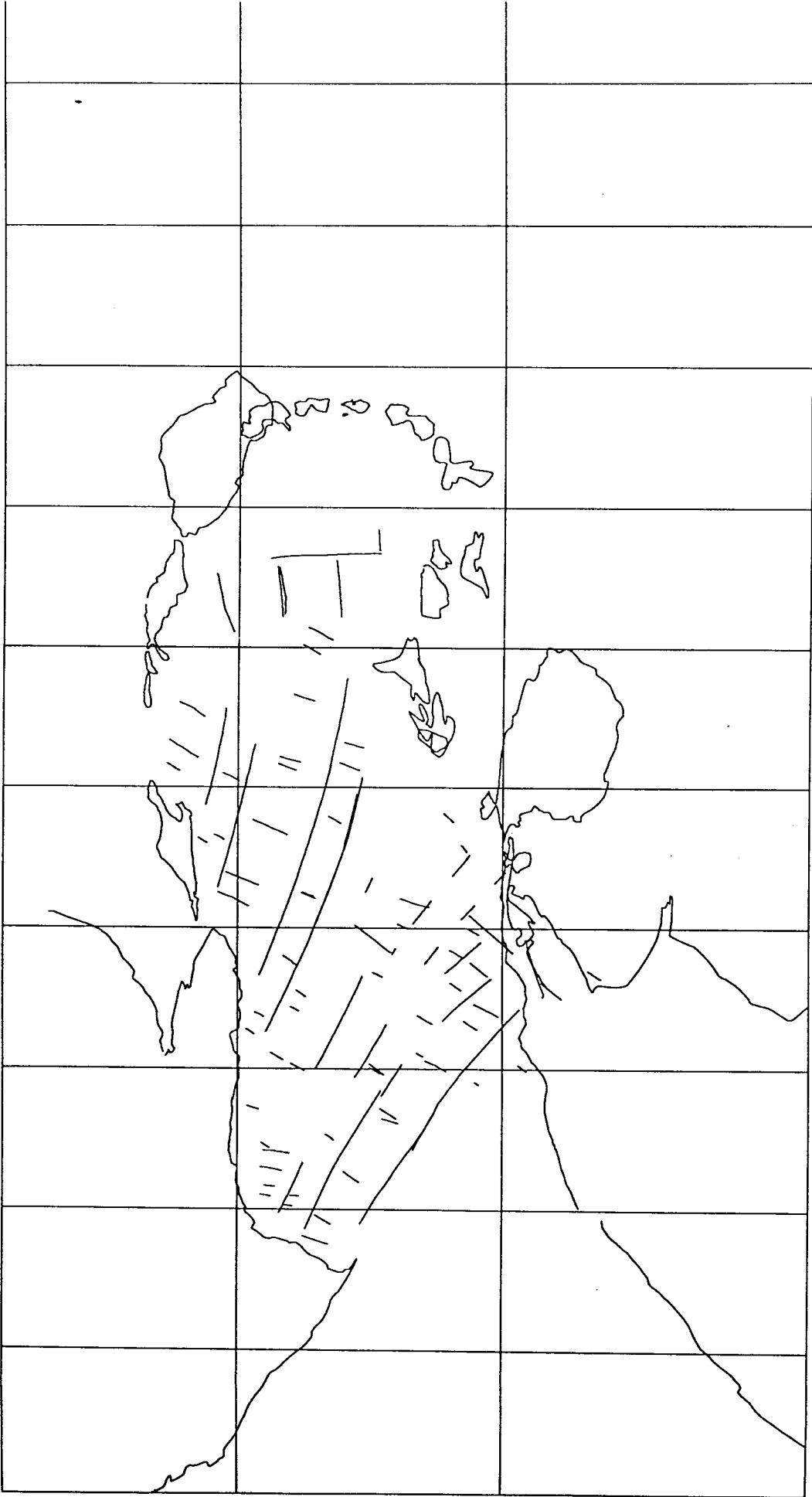
- | | | | | | |
|-----|---------------------|-----|------------------|-----|--------------------------|
| 277 | Western Scotia Sea | 286 | SSP west | 817 | DB east |
| 280 | Burdwood Bank Plate | 287 | SSP east | 818 | Herdman Bank |
| 281 | NSR west Plate | 811 | South Shetland | 819 | SOB west |
| 282 | NSR east Plate | 812 | SOB | 820 | Western Scotia southeast |
| 283 | Shag Rock west | 814 | West Scotia east | | |
| 284 | Shag Rock | 815 | Bruce Bank | | |
| 285 | South Georgia | 816 | DB west | | |



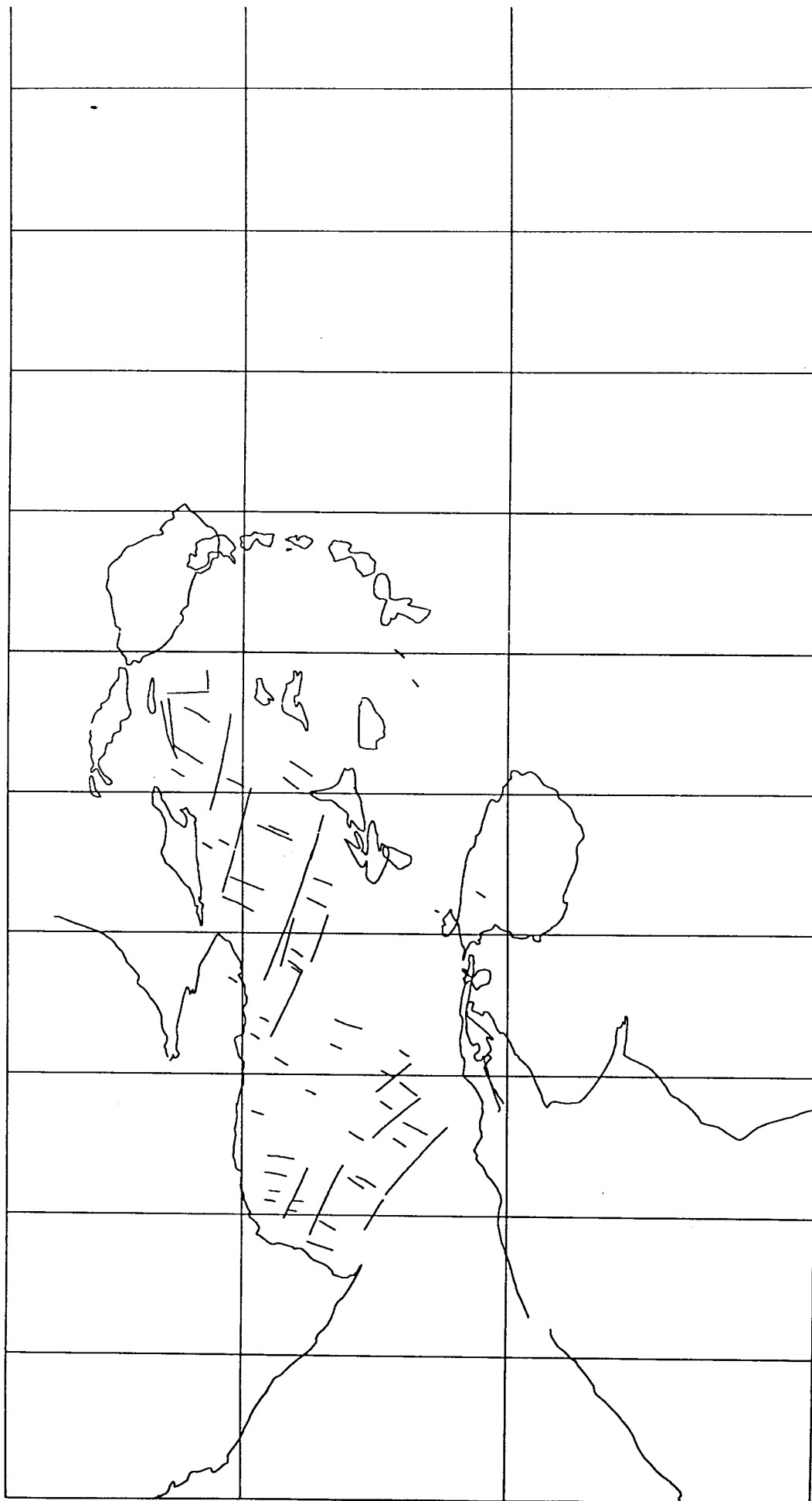
6A. Present day digitized magnetic anomalies and tectonic features.

277	-100.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	0.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	245.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
280	-100	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	0.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	245.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
281	-100	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	0.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	245.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
282	-100	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	0.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	245.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
283	-100	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	0.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	245.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
284	-100	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
284	0.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
284	245.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
285	-100	0.0	0.00	0.00	820	!SGR-WSS (South Georgia Plate)
285	0.0	0.0	0.00	0.00	820	!SGR-WSS (South Georgia Plate)
285	20.5	0.0	0.00	0.00	820	!SGR-WSS (South Georgia Plate) CHANGE FROME
285	20.5	-59.7	176.8	4.16	201	!SGR-SAM (South Georgia Plate)
285	35.0	-78.49	-35.74	30.26	201	!SGR-SAM (NO FURTHER THAN BURWOOD BANK)
285	100.0	78.49	144.26	-37.82	201	!SGR-SAM-TRY TO DO GEOLOGIC CONTINUITY
285	100.0	78.49	144.26	-37.82	201	!SGR-SAM (South Georgia Plate)
286	-100	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	0.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	245.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
287	-100	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	0.0	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	1.9	-24.17	-27.66	-0.78	286	
287	4.8	-24.17	-27.66	-6.00	286	!GUESS BECAUSE MISSING WEST ANOM.
287	7.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
287	245.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
811	-100	0.00	0.00	0.00	803	!SSHT-WAP, 100 MY FUTURE
811	000.0	0.00	0.00	0.00	803	!SSHT-WAP
811	3.8	-62.51	-55.66	-7.19	803	!SSHT-WAP (MALCON POLE)
811	245.0	-62.51	-55.66	-7.19	803	!S SHETLAND KEPT FIXED TO W ANT. PENNINSULA
812	-100	0.00	0.00	0.00	803	!SORK-WAP, 100 MY FUTURE
812	000.0	0.00	0.00	0.00	803	!SORK-WAP
812	25.0	0.00	0.00	0.00	803	!SORK-WAP
812	35.0	-64.81	-45.14	47.99	803	!SORK-WAP
812	245.0	-64.81	-45.14	47.99	803	!S ORKNEY IS. KEPT FIXED TO W ANT. PENNIN.
813	-100	0.00	0.00	0.00	807	!CHT-SNZ, 100 MY FUTURE
813	000.0	0.00	0.00	0.00	807	!CHT-SNZ
813	065.0	0.00	0.00	0.00	807	!CHT-SNZ
813	084.0	41.00	-15.90	7.47	807	!CHT-SNZ FIT
813	245.0	41.00	-15.90	7.47	807	!SCOTESE & LAWVER (1986)
814	-100	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	0.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	9.8	-5.36	-38.14	-0.41	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	20.5	-4.24	-38.75	-3.91	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	26.0	-4.24	-38.75	-6.88	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	27.7	-4.24	-38.75	-7.90	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	245.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
815	-100	0.0	0.00	0.00	284	!BBK-SAM (Bruce Bank Plate)
815	0.0	0.0	0.00	0.00	284	!BBK-SAM (Bruce Bank Plate)
815	9.8	-45.99	-108.65	1.21	284	!FIT USING ANOM. CENTRAL SCOTIA SEA
815	20.5	-43.21	-103.74	4.83	284	!FIT USING ONE ANOM. FIT CENTRAL SS
815	245.0	-43.21	-103.74	4.83	284	!TEMP FIT MIR 6/17/87
816	-100	0.0	0.00	0.00	287	!DBW-SAM (Discovery Bank W Plate)
816	0.0	0.0	0.00	0.00	287	!DBW-SAM (Discovery Bank W Plate)

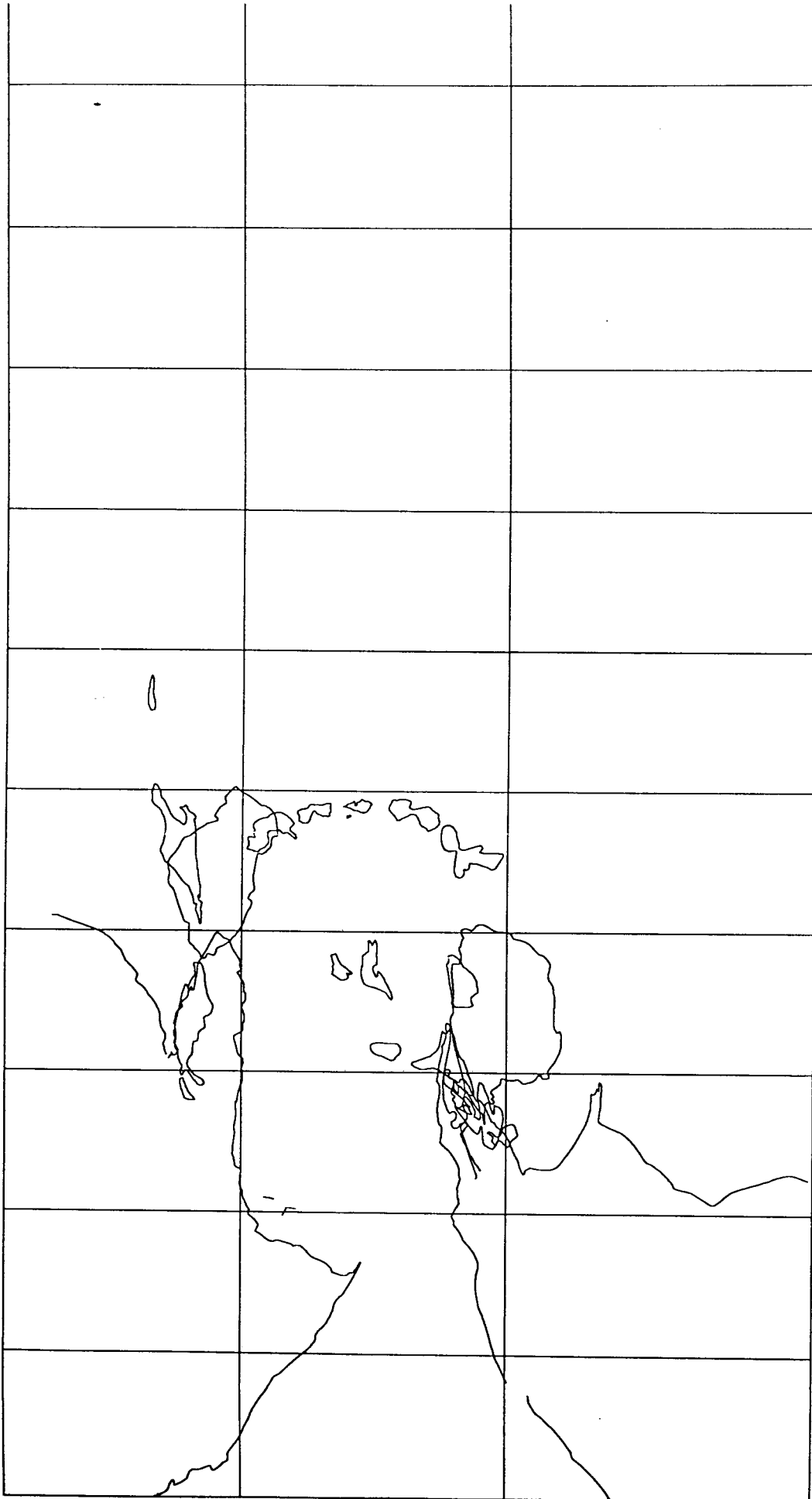
816	245.0	0.0	0.00	0.00	287	!DBW-SAM (Discovery Bank W Plate)
817	-100	0.0	0.00	0.00	287	!DBE-SAM (Discovery Bank E Plate)
817	0.0	0.0	0.00	0.00	287	!DBE-SAM (Discovery Bank E Plate)
817	245.0	0.0	0.00	0.00	287	!DBE-SAM (Discovery Bank E Plate)
818	-100	0.0	0.00	0.00	287	!HDB-SAM (Herdman Bank Plate)
818	0.0	0.0	0.00	0.00	287	!HDB-SAM (Herdman Bank Plate)
818	245.0	0.0	0.00	0.00	287	!HDB-SAM (Herdman Bank Plate)
819	-100	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	0.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	245.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
820	-100	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	0.0	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	9.8	-5.36	-38.14	-0.84	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	20.5	59.67	-3.23	-4.16	277	!S.ONA-S.YAGHAN-CHANGE IN POLE
820	26.0	-67.24	-78.16	25.34	277	!S.ONA-S.YAGHAN-COMPROMISE MATCH
820	27.7	-67.24	-78.16	28.88	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	30.2	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	245.0	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-NOT CLOSURE
821	-100	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	0.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	245.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)



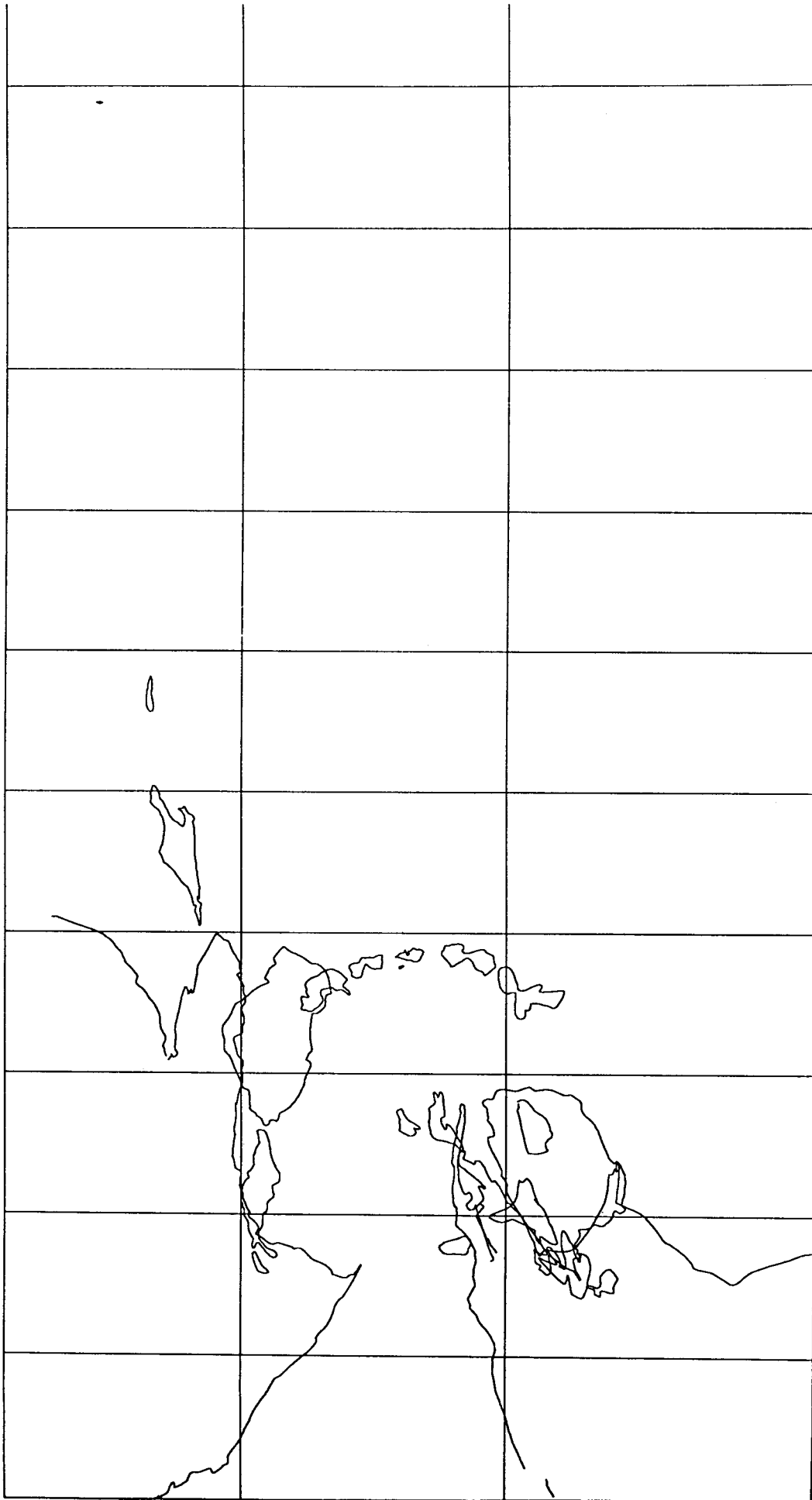
6B. 10 Ma reconstruction of "Melon Pip" model



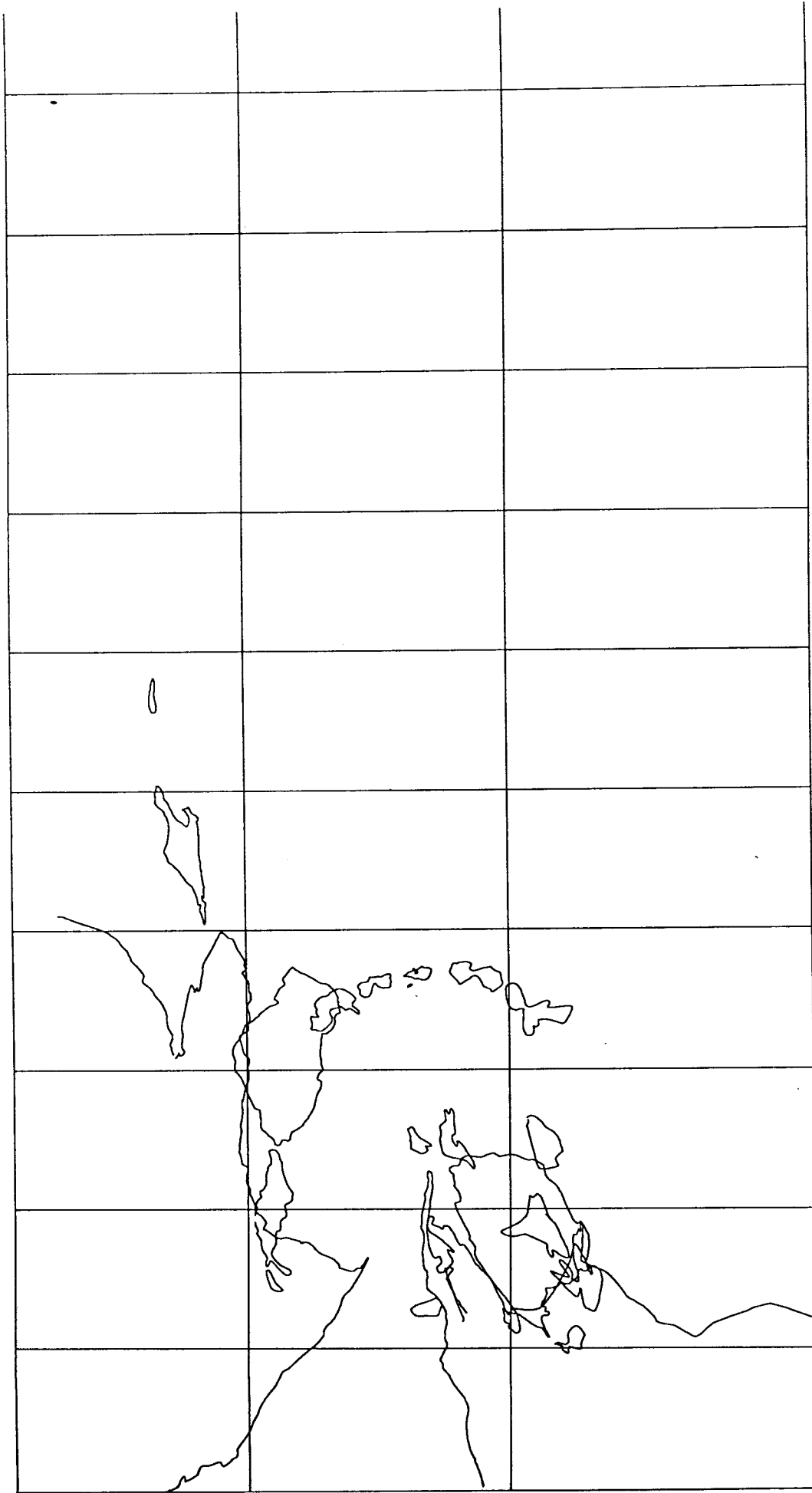
6C. 20 Ma reconstruction of "Melon Pip" model



6D. 30 Ma reconstruction of "Melon Pip" model



6E. 40 Ma reconstruction of "Melon Pip" model



6F. 50 Ma reconstruction of "Melon Pip" model

New Scotia ROT

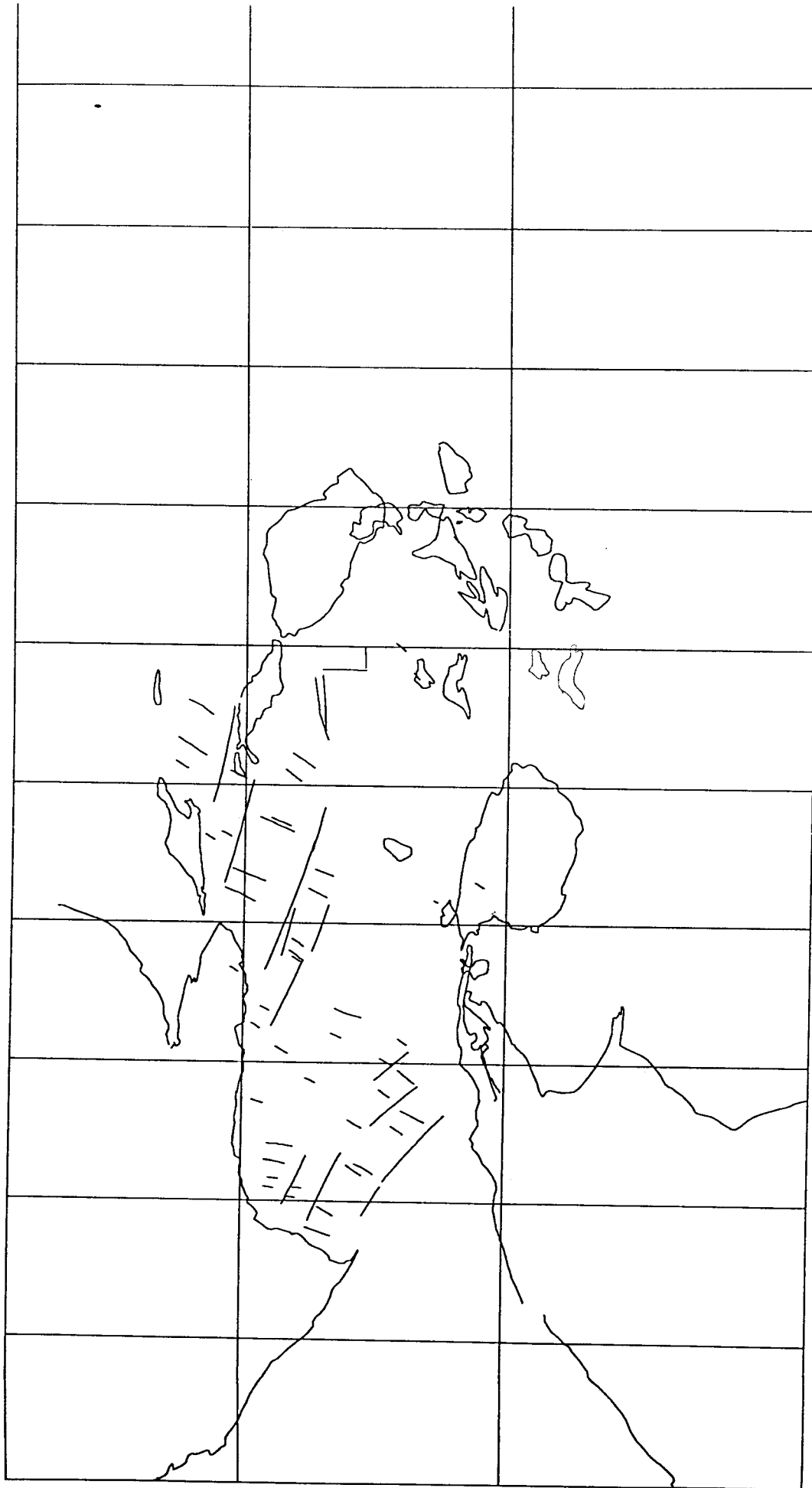
TABLE 2

277	-100.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	0.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	245.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
280	-100	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	0.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	245.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
281	-100	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	0.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	245.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
282	-100	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	0.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	245.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
283	-100	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	0.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	245.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
284	-100	0.0	0.00	0.00	815	!BBK-SAM (Bruce Bank Plate)
284	0.0	0.0	0.00	0.00	815	!BBK-SAM (Bruce Bank Plate)
284	9.8	-45.99	-108.65	-1.21	815	!FIT USING ANOM. CENTRAL SCOTIA SEA
284	20.5	-43.21	-103.74	-4.83	815	!FIT USING ONE ANOM. FIT CENTRAL SS
284	245.0	-43.21	-103.74	-4.83	815	!TEMP FIT MIR 6/17/87
999	-100	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
999	0.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
999	245.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
285	-100	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate)
285	0.0	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate)
285	20.5	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate) CHANGE FROME
285	20.5	-59.7	176.8	4.16	201	!SGR-SAM (South Georgia Plate)
285	35.0	-78.49	-35.74	30.26	201	!SGR-SAM (NO FURTHER THAN BURWOOD BANK)
285	100.0	78.49	144.26	-37.82	201	!SGR-SAM-TRY TO DO GEOLOGIC CONTINUITY
285	245.0	78.49	144.26	-37.82	201	!SGR-SAM (South Georgia Plate)
286	-100	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	0.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	245.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
287	-100	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	0.0	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	1.9	-24.17	-27.66	-0.78	286	
287	4.8	-24.17	-27.66	-6.00	286	!GUESS BECAUSE MISSING WEST ANOM.
287	7.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
287	245.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
811	-100	0.00	0.00	0.00	803	!SSHT-WAP, 100 MY FUTURE
811	000.0	0.00	0.00	0.00	803	!SSHT-WAP
811	3.8	-62.51	-55.66	-7.19	803	!SSHT-WAP (MALCON POLE)
811	245.0	-62.51	-55.66	-7.19	803	!S SHETLAND KEPT FIXED TO W ANT. PENNINSULA
812	-100	0.00	0.00	0.00	803	!SORK-WAP, 100 MY FUTURE
812	000.0	0.00	0.00	0.00	803	!SORK-WAP
812	25.0	0.00	0.00	0.00	803	!SORK-WAP
812	35.0	-64.81	-45.14	47.99	803	!SORK-WAP
812	245.0	-64.81	-45.14	47.99	803	!S ORKNEY IS. KEPT FIXED TO W ANT. PENNIN.
813	-100	0.00	0.00	0.00	807	!CHT-SNZ, 100 MY FUTURE
813	000.0	0.00	0.00	0.00	807	!CHT-SNZ
813	065.0	0.00	0.00	0.00	807	!CHT-SNZ
813	084.0	41.00	-15.90	7.47	807	!CHT-SNZ FIT
813	245.0	41.00	-15.90	7.47	807	!SCOTESE & LAWVER (1986)
814	-100	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	0.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	9.8	-5.36	-38.14	-0.41	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	20.5	-4.24	-38.75	-3.91	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	26.0	-4.24	-38.75	-6.88	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	27.7	-4.24	-38.75	-7.90	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	245.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
815	-100	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)
815	0.0	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)

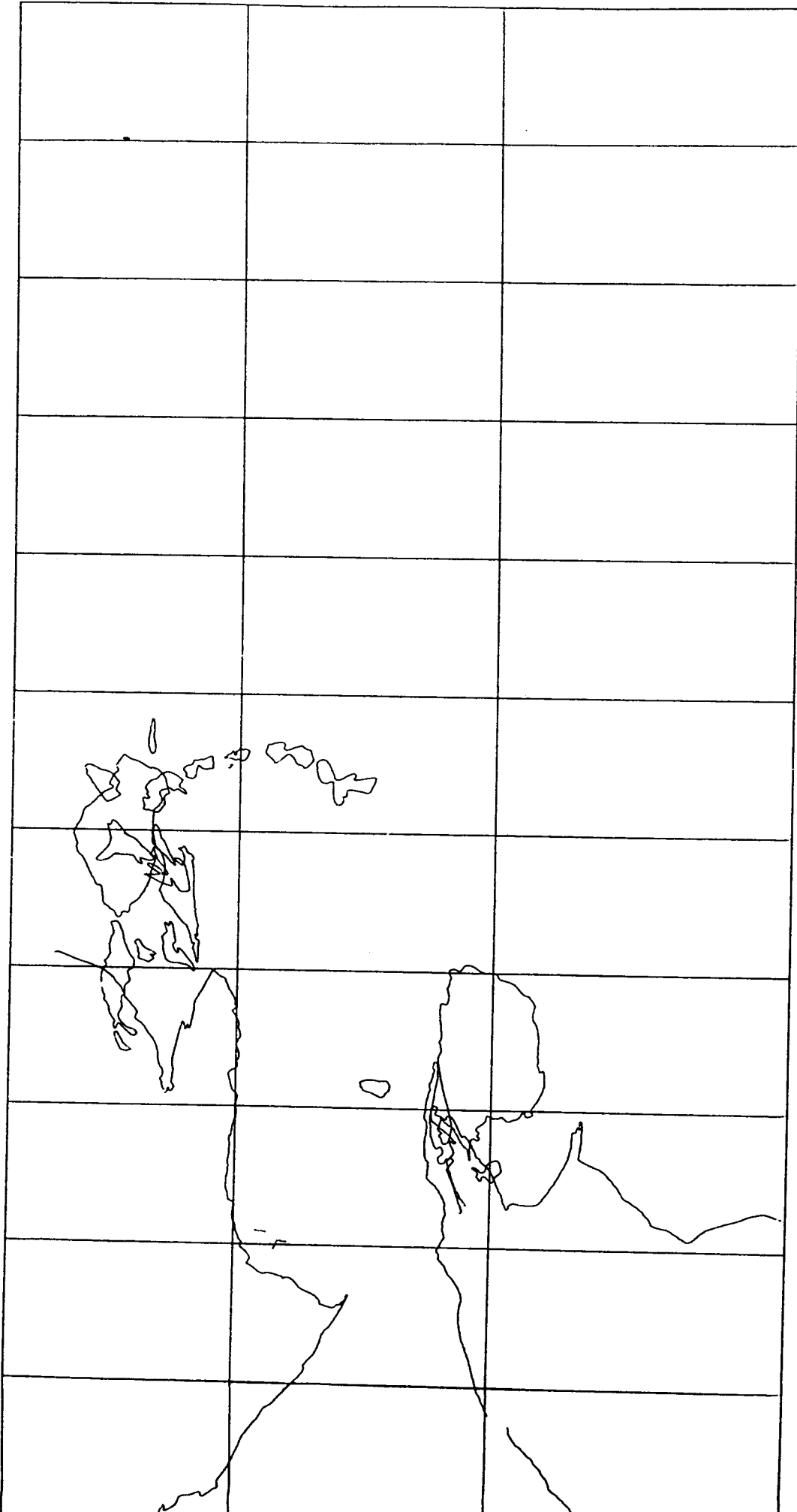
New Sechin Rot

TABLE 2

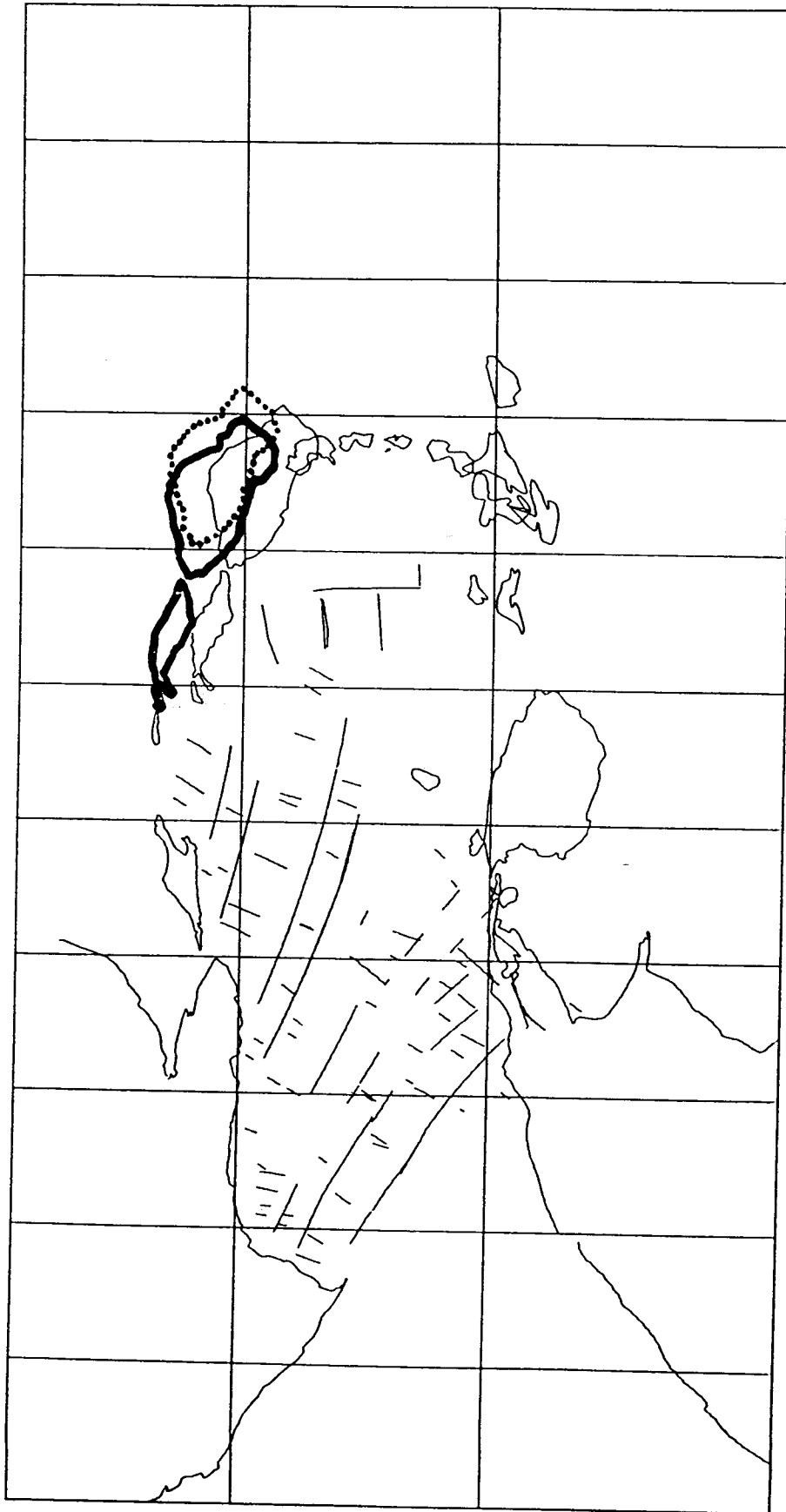
999	9.8	-45.99	-108.65	1.21	284	!FIT USING ANOM. CENTRAL SCOTIA SEA
999	20.5	-43.21	-103.74	4.83	284	!FIT USING ONE ANOM. FIT CENTRAL SS
999	245.0	-43.21	-103.74	4.83	820	!TEMP FIT MIR 6/17/87
815	245.0	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)
816	-100	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
816	0.0	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
816	245.0	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
817	-100	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
817	0.0	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
817	245.0	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
818	-100	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
818	0.0	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
818	245.0	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
819	-100	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	0.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	245.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
820	-100	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	0.0	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	9.8	-5.36	-38.14	-0.84	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	20.5	59.67	-3.23	-4.16	277	!S.ONA-S.YAGHAN-CHANGE IN POLE
820	26.0	-67.24	-78.16	25.34	277	!S.ONA-S.YAGHAN-COMPROMISE MATCH
820	27.7	-67.24	-78.16	28.88	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	30.2	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	245.0	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-NOT CLOSURE
821	-100	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	0.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	245.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)



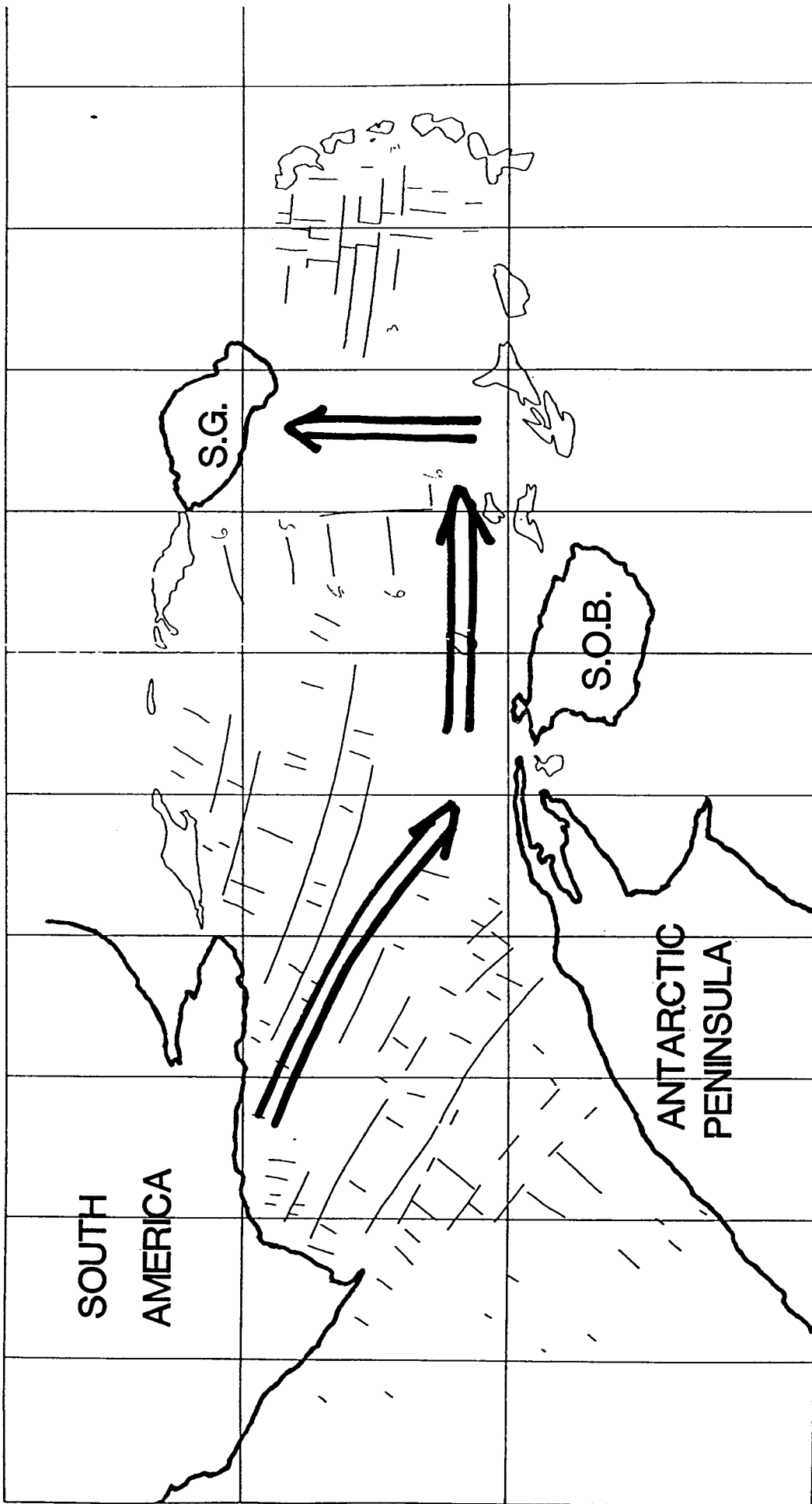
7A. 20 Ma reconstruction of "banked billiard shot" tectonic model.



7B. 30 Ma reconstruction of "banked billiard shot" tectonic model.



8. Superposition of original position of South Georgia (dotted) on 10 Ma "banked billiard shot" reconstruction of the Scotia Sea. The 10 Ma position of South Georgia using the "melon pip" model is shown as a heavy line. Note that the "banked billiard shot" South Georgia is located south of the "melon pip" South Georgia.



9A. Cartoon illustrating the "banked billiard shot with *english*" tectonic model for the movement of South Georgia.

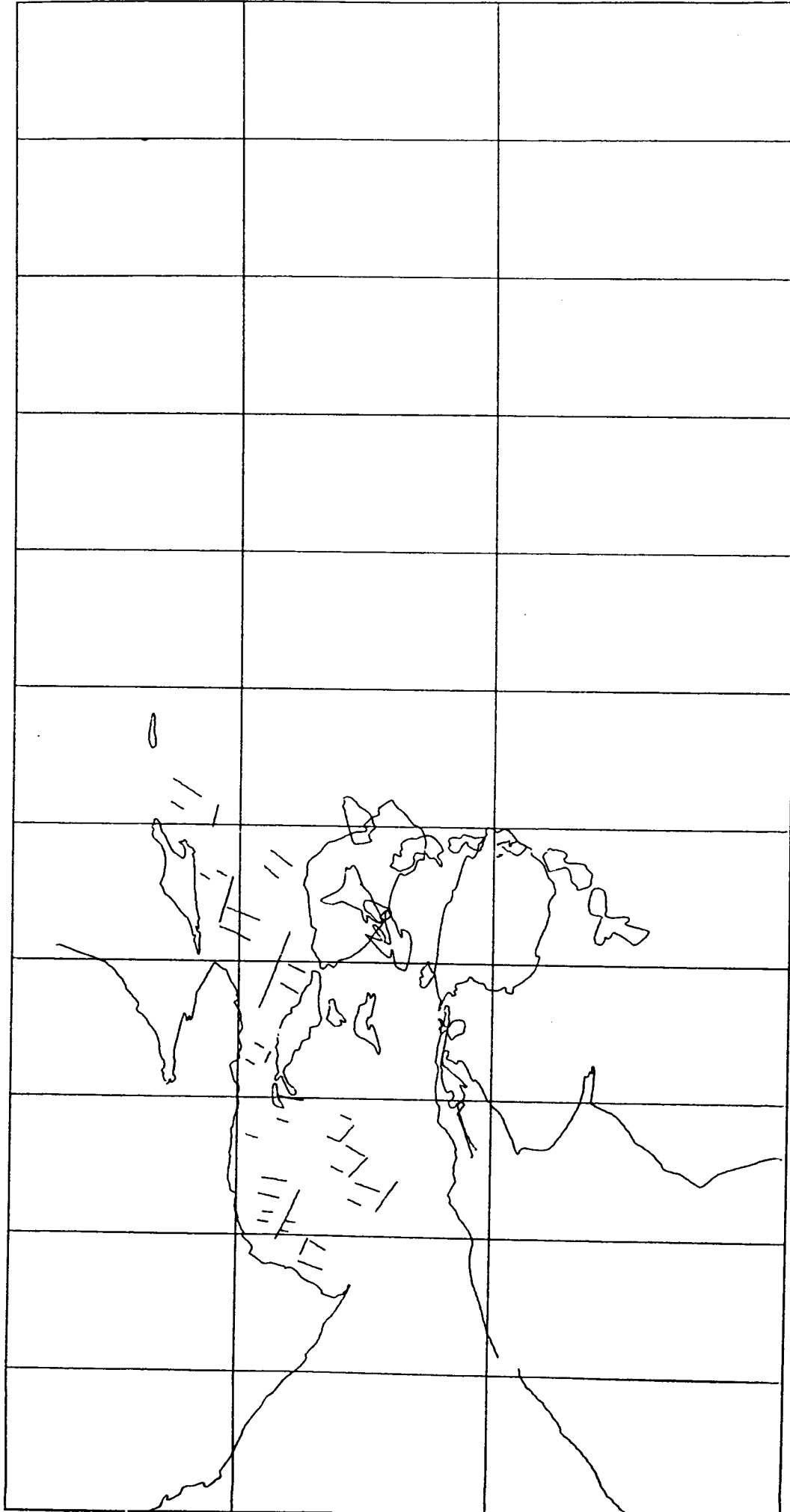
TABLE 3

277	-100.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	0.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
277	245.	0.0	0.00	0.00	201	!S.YAGHAN-SAM (WESTERN SCOTIA SEA)
280	-100	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	0.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
280	245.0	0.0	0.00	0.00	201	!BDW-SAM (Burdwood Plate)
281	-100	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	0.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
281	245.0	0.0	0.00	0.00	201	!NSRW-SAM (N Scotia Ridge W Plate)
282	-100	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	0.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
282	245.0	0.0	0.00	0.00	201	!NSRE-SAM (N Scotia Ridge E Plate)
283	-100	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	0.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
283	245.0	0.0	0.00	0.00	284	!SRW-SAM (Shag Rock W Plate)
284	-100	0.0	0.00	0.00	815	!BBK-SAM (Bruce Bank Plate)
284	0.0	0.0	0.00	0.00	815	!BBK-SAM (Bruce Bank Plate)
284	9.8	-45.99	-108.65	-1.21	815	!FIT USING ANOM. CENTRAL SCOTIA SEA
284	20.5	-43.21	-103.74	-4.83	815	!FIT USING ONE ANOM. FIT CENTRAL SS
284	22.0	-43.21	-103.74	-8.4	815	!BS MOVING SG AS FAR SOUTH AS POSSIBLE
284	245.0	-43.21	-103.74	-8.4	815	!TEMP FIT MIR 6/17/87
999	-100	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
999	0.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
999	245.0	0.0	0.00	0.00	285	!SRE-SAM (Shag Rock E Plate)
285	-100	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate)
285	0.0	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate)
285	245.0	0.0	0.00	0.00	284	!SGR-WSS (South Georgia Plate)
999	30.0	-80.8	-42.5	20.94	201	!SGR-SAM (S.G. Plate) CHANGE FRAME
999	35.0	-78.49	-35.74	30.26	201	!SGR-SAM (NO FURTHER THAN BURWOOD BANK)
999	100.0	78.49	144.26	-37.82	201	!SGR-SAM-TRY TO DO GEOLOGIC CONTINUITY
999	245.0	78.49	144.26	-37.82	201	!SGR-SAM (South Georgia Plate)
286	-100	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	0.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
286	245.0	0.0	0.00	0.00	285	!PSK-SAM (Plsek or S Sandwich Plate W)
287	-100	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	0.0	0.0	0.00	0.00	286	!SSI-SAM (S. Sandwich Island Plate)
287	1.9	-24.17	-27.66	-0.78	286	!SSI-SAM (S. SANDWICH ISLAND PLATE)
287	4.8	-24.17	-27.66	-6.00	286	!GUESS BECAUSE MISSING WEST ANOM.
287	7.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
287	245.0	-24.17	-27.66	-8.40	286	!GUESSIMATE FROM ANOM. 3
811	-100	0.00	0.00	0.00	803	!SSHT-WAP, 100 MY FUTURE
811	000.0	0.00	0.00	0.00	803	!SSHT-WAP
811	3.8	-62.51	-55.66	-7.19	803	!SSHT-WAP (MALCON POLE)
811	245.0	-62.51	-55.66	-7.19	803	!S SHETLAND KEPT FIXED TO W ANT. PENIN.
812	-100	0.00	0.00	0.00	803	!SORK-WAP, 100 MY FUTURE
812	000.0	0.00	0.00	0.00	803	!SORK-WAP
812	25.0	0.00	0.00	0.00	803	!SORK-WAP
812	35.0	-64.81	-45.14	47.99	803	!SORK-WAP
812	245.0	-64.81	-45.14	47.99	803	!S ORKNEY IS. KEPT FIXED TO W ANT. PENNIN.
813	-100	0.00	0.00	0.00	807	!CHT-SNZ, 100 MY FUTURE
813	000.0	0.00	0.00	0.00	807	!CHT-SNZ
813	065.0	0.00	0.00	0.00	807	!CHT-SNZ
813	084.0	41.00	-15.90	7.47	807	!CHT-SNZ FIT
813	245.0	41.00	-15.90	7.47	807	!SCOTESE & LAWVER (1986)
814	-100	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	0.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	9.8	-5.36	-38.14	-0.41	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	20.5	-4.24	-38.75	-3.91	280	!ONA-YAGHAN (WEST SCOTIA REGION)

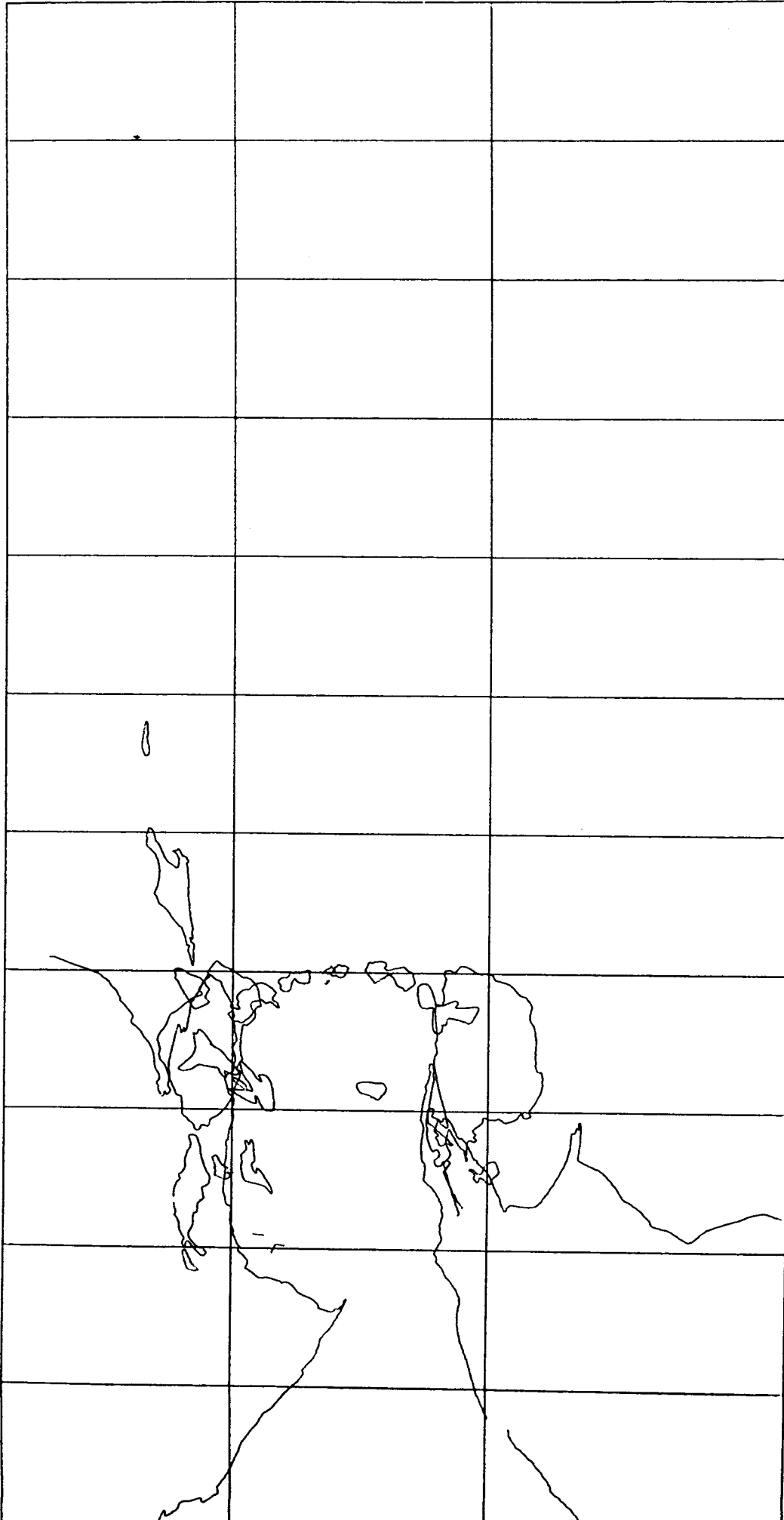
TABLE 3

NNabr_ Scotia. Rot

814	26.0	-4.24	-38.75	-6.88	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	27.7	-4.24	-38.75	-7.90	280	!ONA-YAGHAN (WEST SCOTIA REGION)
814	245.0	0.00	0.00	0.00	280	!ONA-YAGHAN (WEST SCOTIA REGION)
815	-100	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)
815	0.0	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)
815	20.5	0.0	0.00	0.00	820	!changing by closing Protector Basin
815	23.0	42.0	-45.0	-5.00	820	!Protector Basin closed
999	9.8	-45.99	-108.65	1.21	284	!FIT USING ANOM. CENTRAL SCOTIA SEA
999	20.5	-43.21	-103.74	4.83	284	!FIT USING ONE ANOM. FIT CENTRAL SS
999	245.0	-43.21	-103.74	4.83	820	!TEMP FIT MIR 6/17/87
815	245.0	42.0	-45.0	-5.00	820	!Protector Basin closed
999	245.0	0.0	0.00	0.00	820	!BBK-SAM (Bruce Bank Plate)
816	-100	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
816	0.0	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
816	245.0	0.0	0.00	0.00	815	!DBW-SAM (Discovery Bank W Plate)
817	-100	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
817	0.0	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
817	245.0	0.0	0.00	0.00	815	!DBE-SAM (Discovery Bank E Plate)
818	-100	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
818	0.0	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
818	245.0	0.0	0.00	0.00	815	!HDB-SAM (Herdman Bank Plate)
819	-100	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	0.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
819	245.0	0.0	0.00	0.00	812	!OBW-SAM (Orkney Bank W Plate)
820	-100	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	0.0	0.0	0.00	0.00	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	9.8	-5.36	-38.14	-0.84	277	!S.ONA-S.YAGHAN (WESTERN SCOTIA SEA)
820	20.5	59.67	-3.23	-4.16	277	!S.ONA-S.YAGHAN-CHANGE IN POLE
820	26.0	-67.24	-78.16	25.34	277	!S.ONA-S.YAGHAN-COMPROMISE MATCH
820	27.7	-67.24	-78.16	28.88	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	30.2	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-FAIRLY GOOD MATCH
820	245.0	-67.24	-78.16	34.09	277	!S.ONA-S.YAGHAN-NOT CLOSURE
821	-100	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	0.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)
821	245.0	0.0	0.00	0.00	814	!KOV-SAM (Koval Plate)



9B. Reconstruction of the Scotia Sea region at 23 Ma using the "banked billiard shot with *english*" model for the reconstruction.



9C. Reconstruction of the Scotia Sea region at 30 Ma using the "banked billiard shot with english" model for the reconstruction.