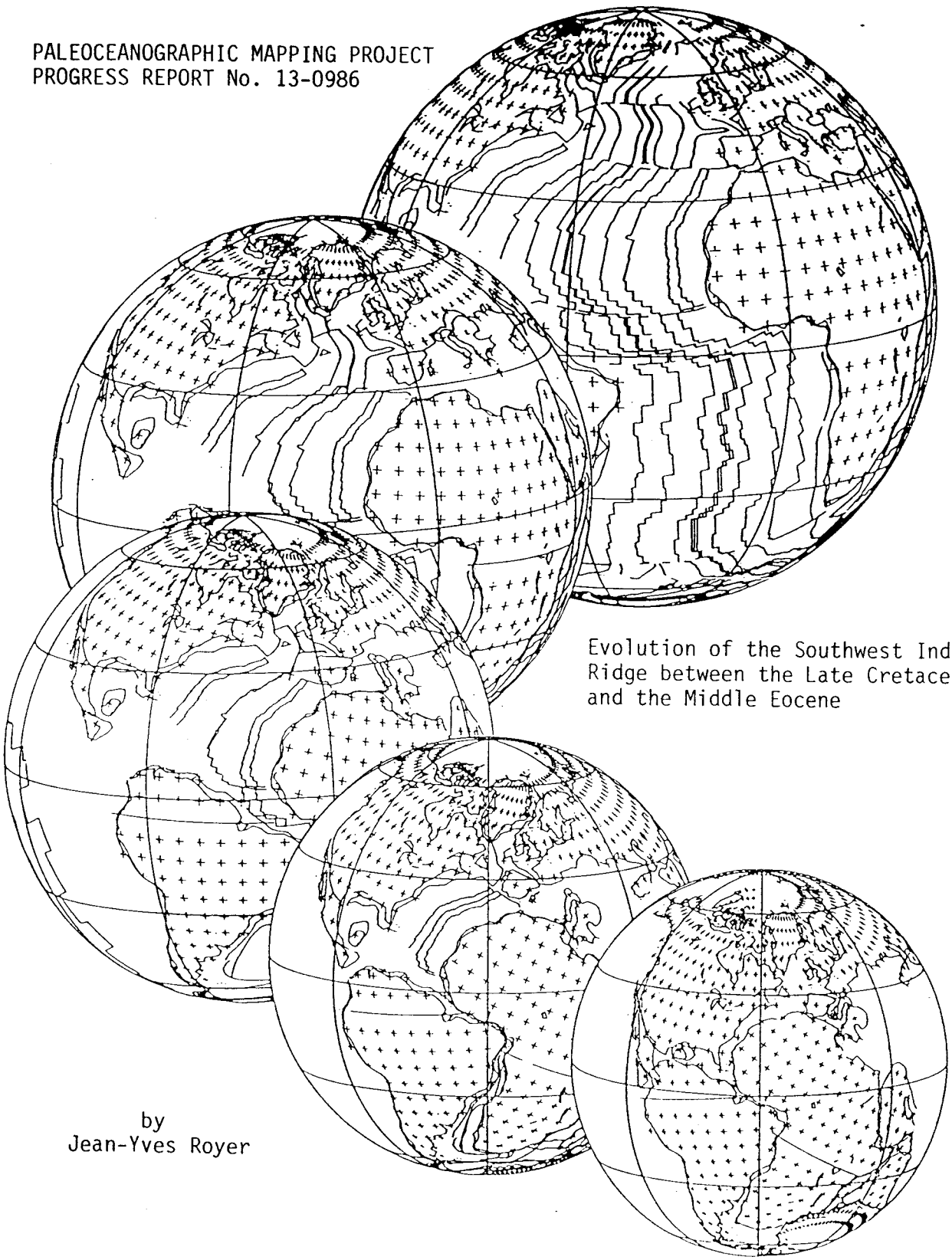
PALEOCEANOGRAPHIC MAPPING PROJECT
PROGRESS REPORT No. 13-0986



Evolution of the Southwest Indian Ridge between the Late Cretaceous and the Middle Eocene

by
Jean-Yves Royer

Evolution of the Southwest Indian Ridge from the Late Cretaceous (anomaly 34) to the Middle Eocene (anomaly 20).

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The history of the relative motions between Antarctica and Africa is of particular importance in understanding the breakup of Gondwana. Two different models have been proposed to explain the pattern of seafloor spreading between Africa and Antarctica during the Late Cretaceous and the Early Tertiary (anomaly 34 to 20). In the first model, the pole of rotation that describes the relative motion of the two continents remains fixed since the time of anomaly 34 (84 Ma; Fisher and Sclater, 1983). In the second model, a major change of the pole of rotation occurred after the time of anomaly 32 (74 Ma) and before anomaly 24 (56 Ma; Patriat et al., 1985).

From a compilation of magnetic and bathymetric informations, along with a new interpretation of fracture zone positions based on satellite altimetry data (Seasat), we have derived 10 new reconstructions that illustrate the evolution of the Southwest Indian Ridge between 84 and 46 Ma (anomaly 34 to 20). These data confirm an important shift in the direction of spreading beginning at the time of anomaly 32 (74 Ma). From anomaly 31 to 28 (71 to 66 Ma), spreading was very slow and the directions of spreading gradually shifted 45° from their initial orientation. The directions of motion then shifted back toward the earlier NE-SW directions with a reorganization of the Southwest Indian Ridge configuration between the times of anomalies 26 and 24 (61 to 56 Ma).

These results, added to the previous determinations of the relative motions between India and Antarctica, and Africa and South America, provide important new constraints concerning the dispersal of the Gondwana fragments. First, it provides a starting point (anomaly34) from which we can revise the Mesozoic reconstructions and the early spreading history of the Indian Ocean. Second, it constrains the motion of India relative to Africa before the Paleocene, specifically the fit of India with Seychelles and the closure of the Mascarene Basin. Third, it provides information about the motion of South America relative to Antarctica before the Eocene, that could help to interpret the magnetic pattern in the Weddel Sea and understand the evolution of the American-Antarctic Ridge.

Special consideration has been given to the development of the large linear fracture zones that characterize the Southwest Indian Ridge in the vicinity of Prince Edward Island. The present-day fracture zones in this area appear to be younger features (Eocene) than their lengths might imply, and do not record the change of motion described above. This example shows that the trend of fracture zones should be carefully used to determine relative plate motions. Since the last direction of motion always overprints and erases the previous fracture zone trend, complex changes in past motions may be easily overlooked. This effect is all the more important when the offsets are large and the fracture zones closely spaced.

References:

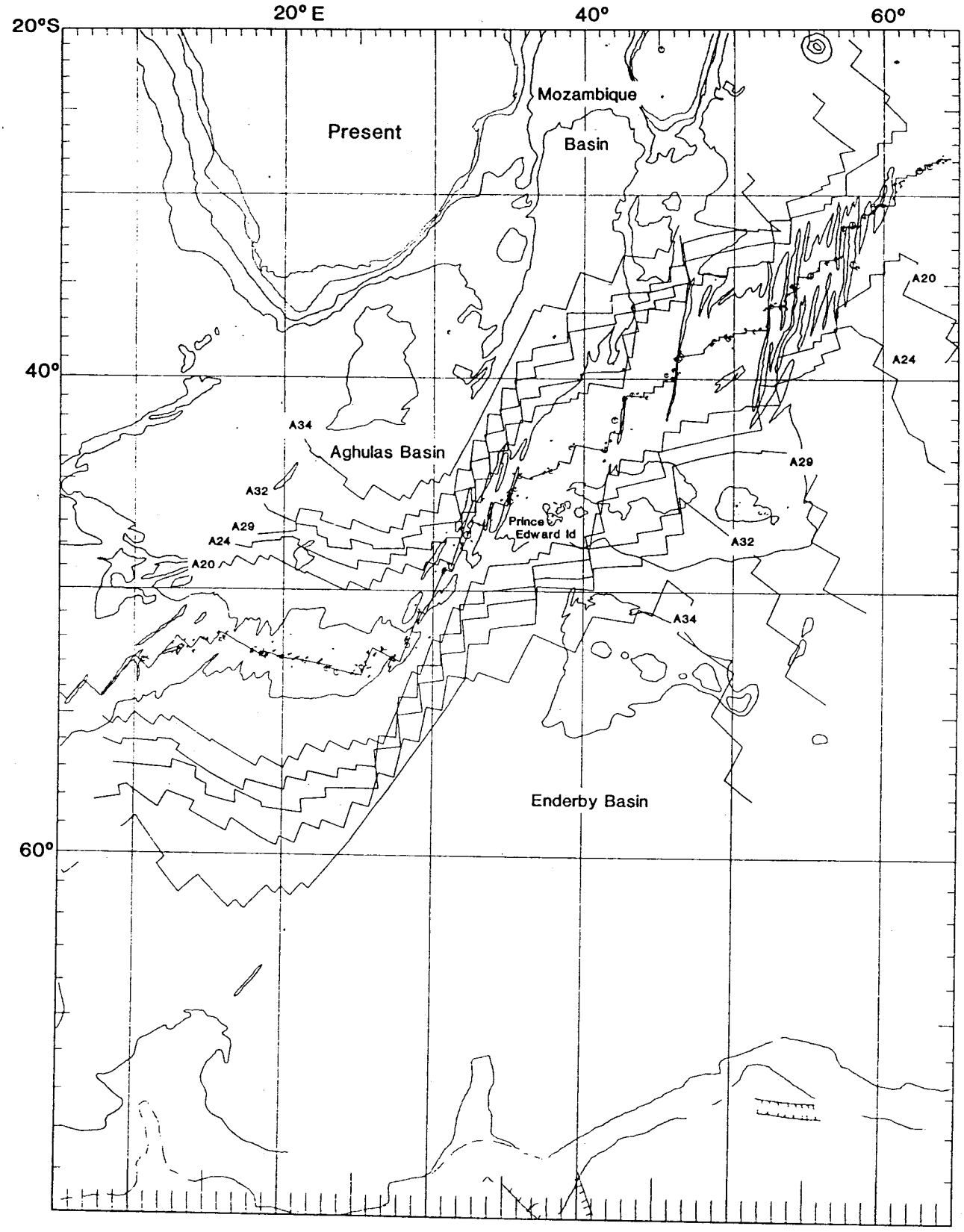
Fisher R.L. and Sclater J. G., 1983: Tectonic evolution of the Southwest Indian Ridge since the Mid-Cretaceous: plate motions and stability of the pole Antarctica/Africa for at least 80 Ma. Geophys. J. Roy. astr. Soc., 73: 553-576.

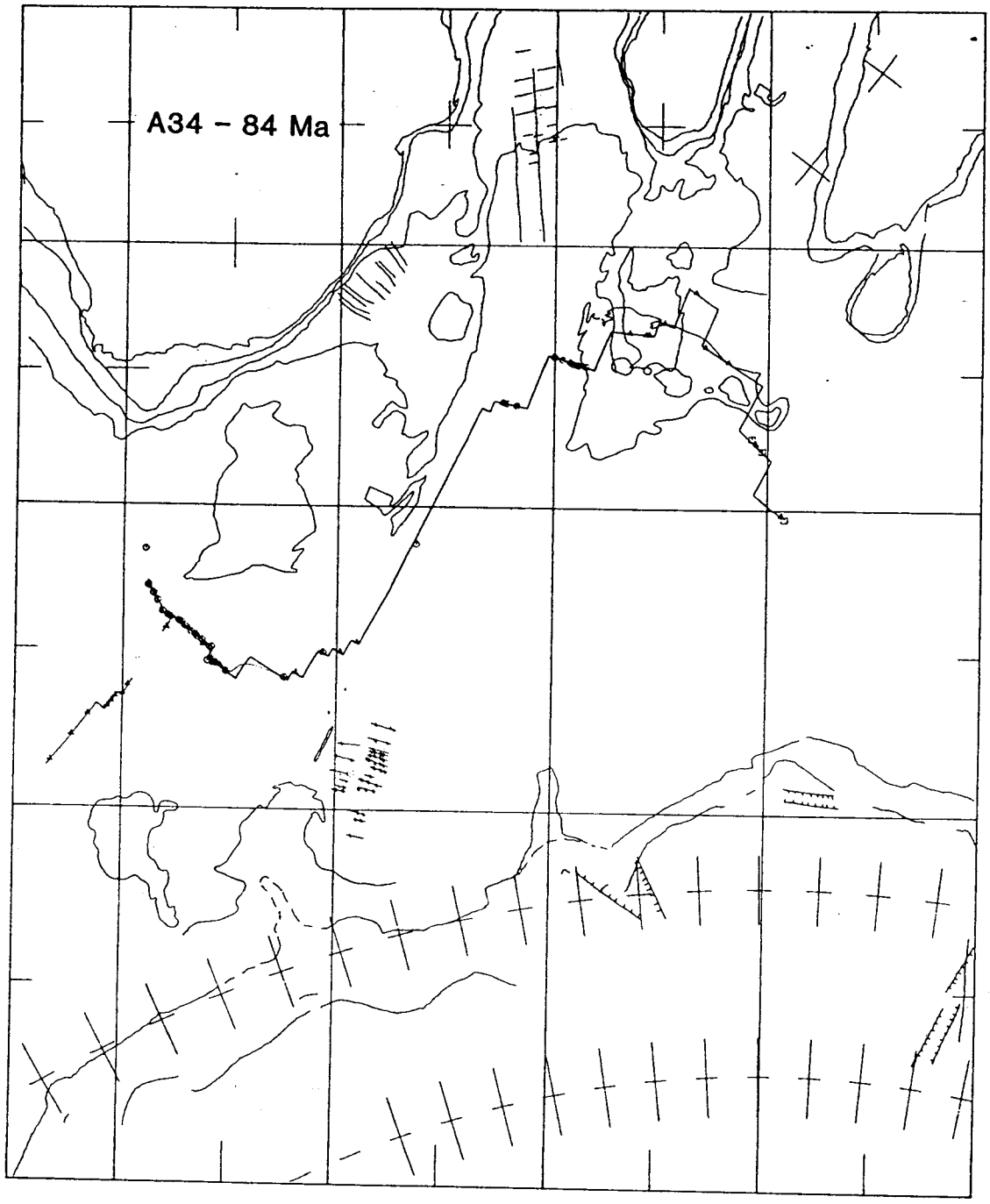
Patriat P., Segoufin J., Goslin J. and Beuzart P., 1985: Relative positions of Africa and Antarctica in the Upper Cretaceous: evidence for a non-stationary behaviour of fracture zones. Earth Planet. Sci. Lett., 75: 204-214.

Royer J.-Y., Patriat P., Bergh H. W. and Scotese C. R., (submitted): Evolution of the Southwest Indian Ridge between the Late Cretaceous (anomaly 34) and the Middle Eocene (anomaly 20). Tectonophysics.

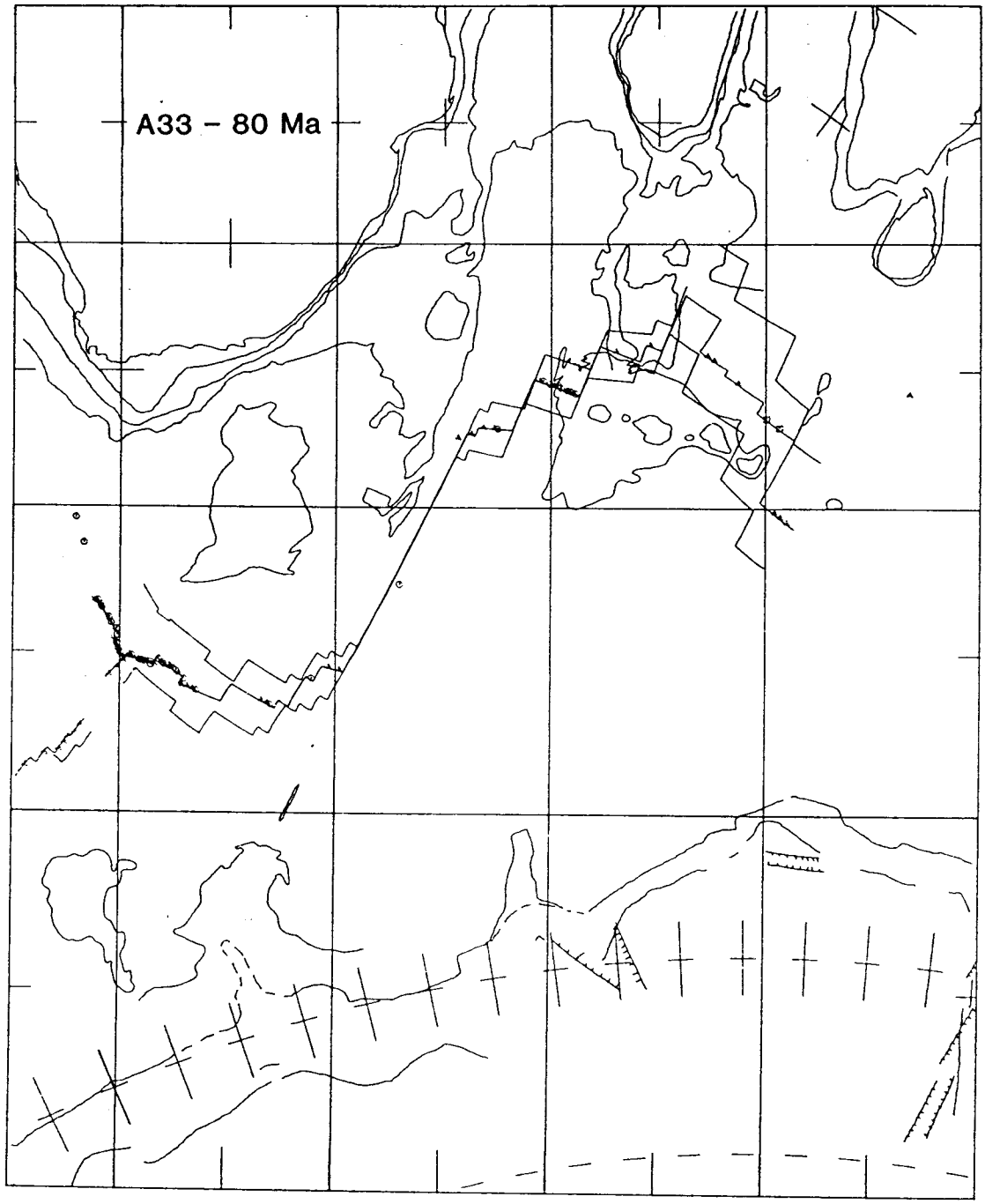
Figure captions:

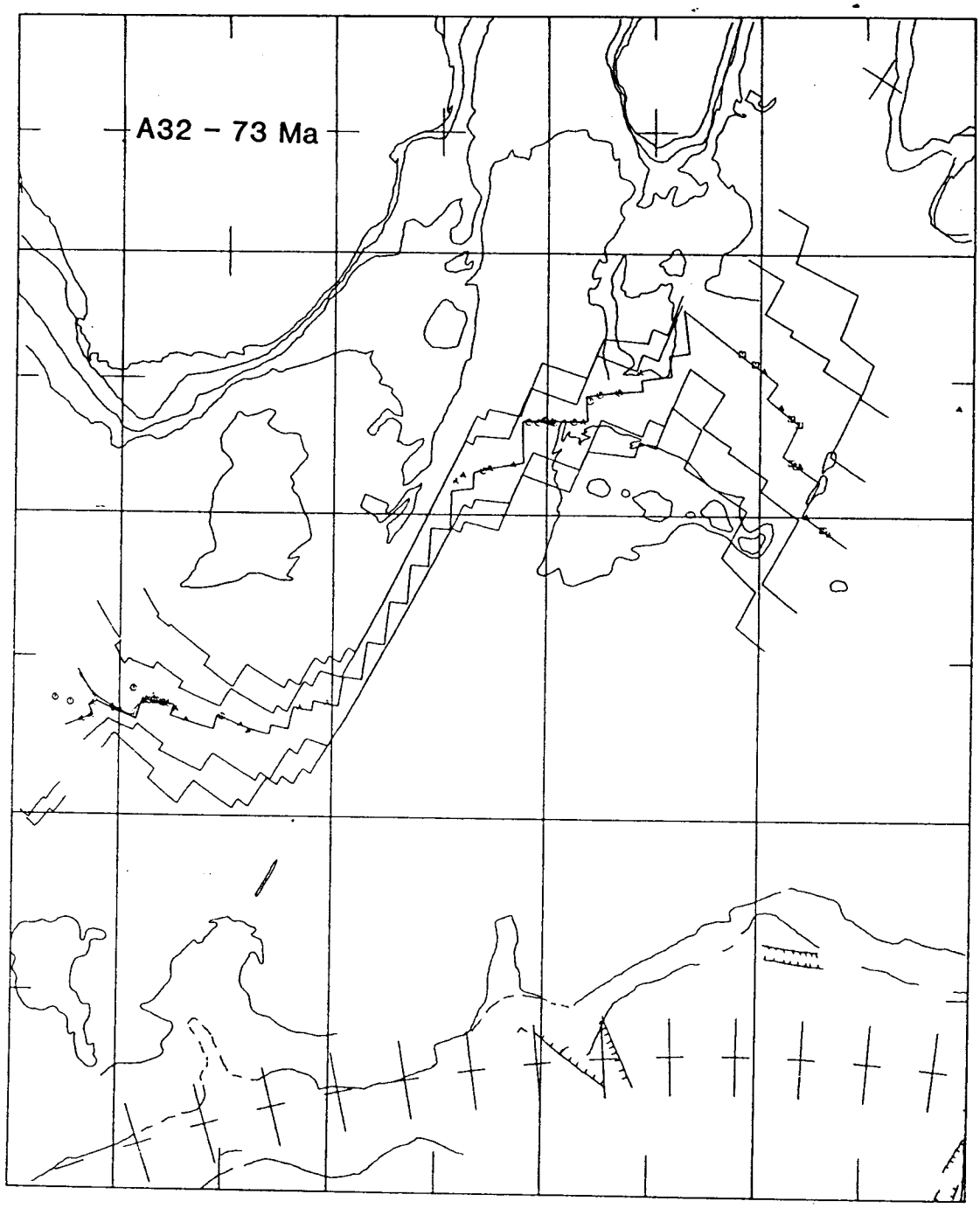
The following figures illustrate the present configuration of the Southwest Indian Ridge and six stages of its evolution. Contours are coastlines (Africa, Madagascar & India), limits of the continental shelf, and 2000 and 4000 meters isobaths. Circles, triangles and squares are magnetic anomaly picks from the African, Antarctic and Indian plates, respectively. Data along the present ridge axis are earthquake epicenters. Isochrons are A34(84 Ma), A33(80 Ma), A32(73 Ma), A31(68 Ma), A29 (66 Ma), A28(64 Ma), A26(61 Ma), A24(56 Ma), A21(50 Ma) and A20(46 Ma). On all reconstructions, Africa has been held fixed.


20°S
20° E
40°
60°
40°
60°
Present
Mozambique
Basin
Aghulas Basin
Prince
Edward Id
Enderby Basin
A34
A32
A29
A24
A20
A20
A24
A29
A32
A34

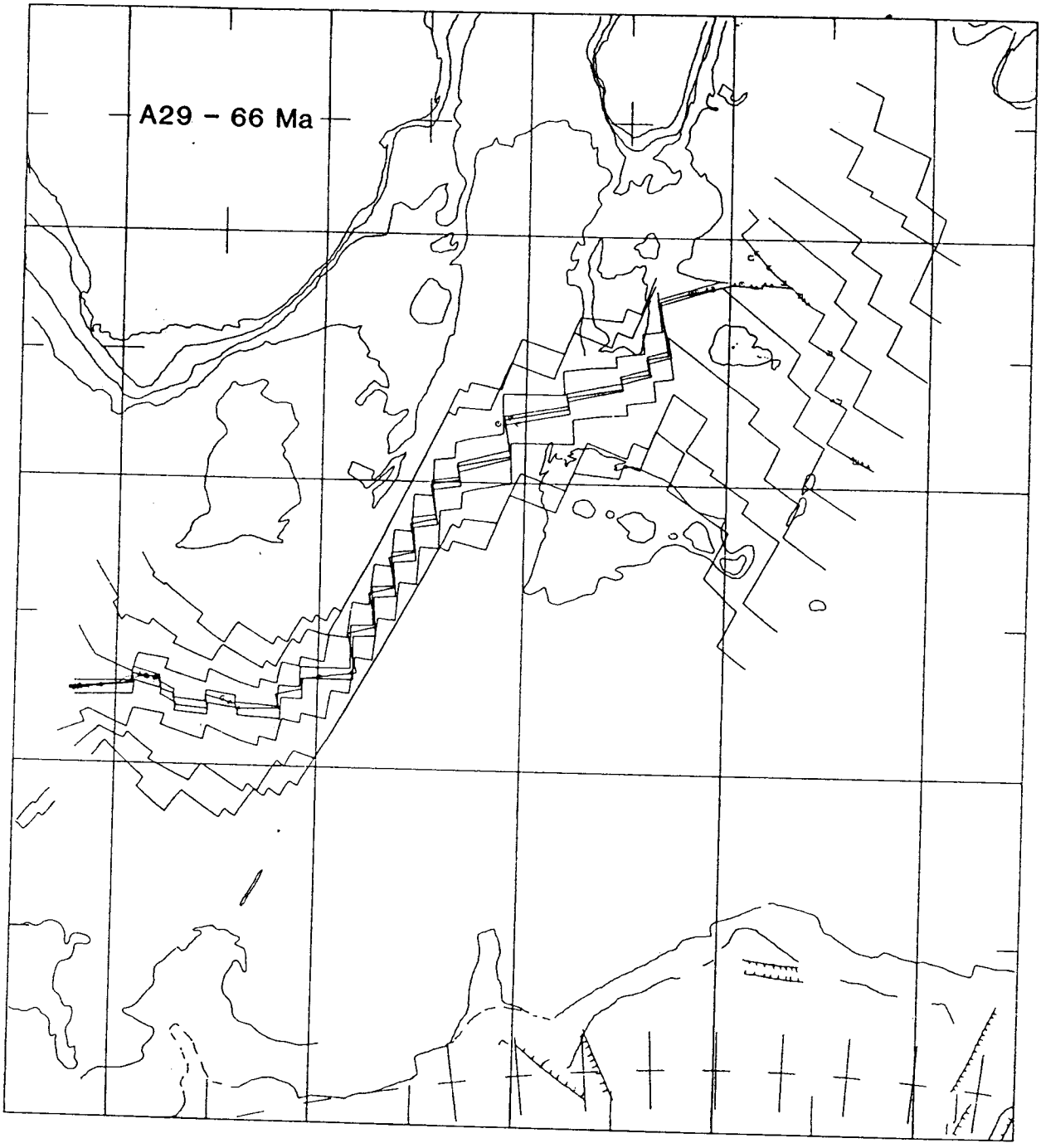


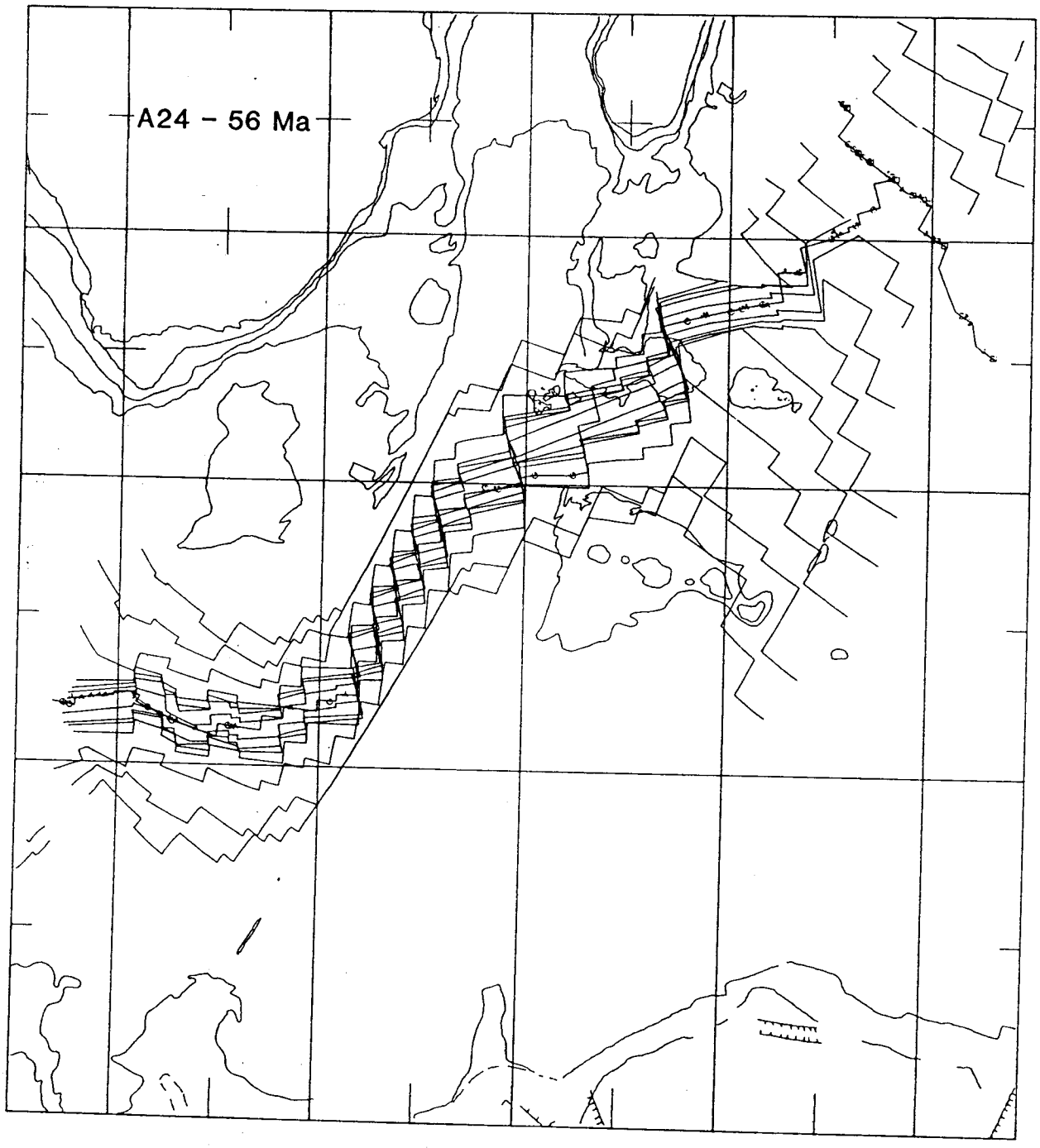
Times A34 to A33 At the time of magnetic anomalies A34/A33 (Late Cretaceous), the ridge axis is offset by a long fracture zone resulting from the different times of the initiation of spreading in the Aghulas Basin (Early Cretaceous) and in the Mozambique and Enderby Basins (Late Jurassic).


A33 – 80 Ma

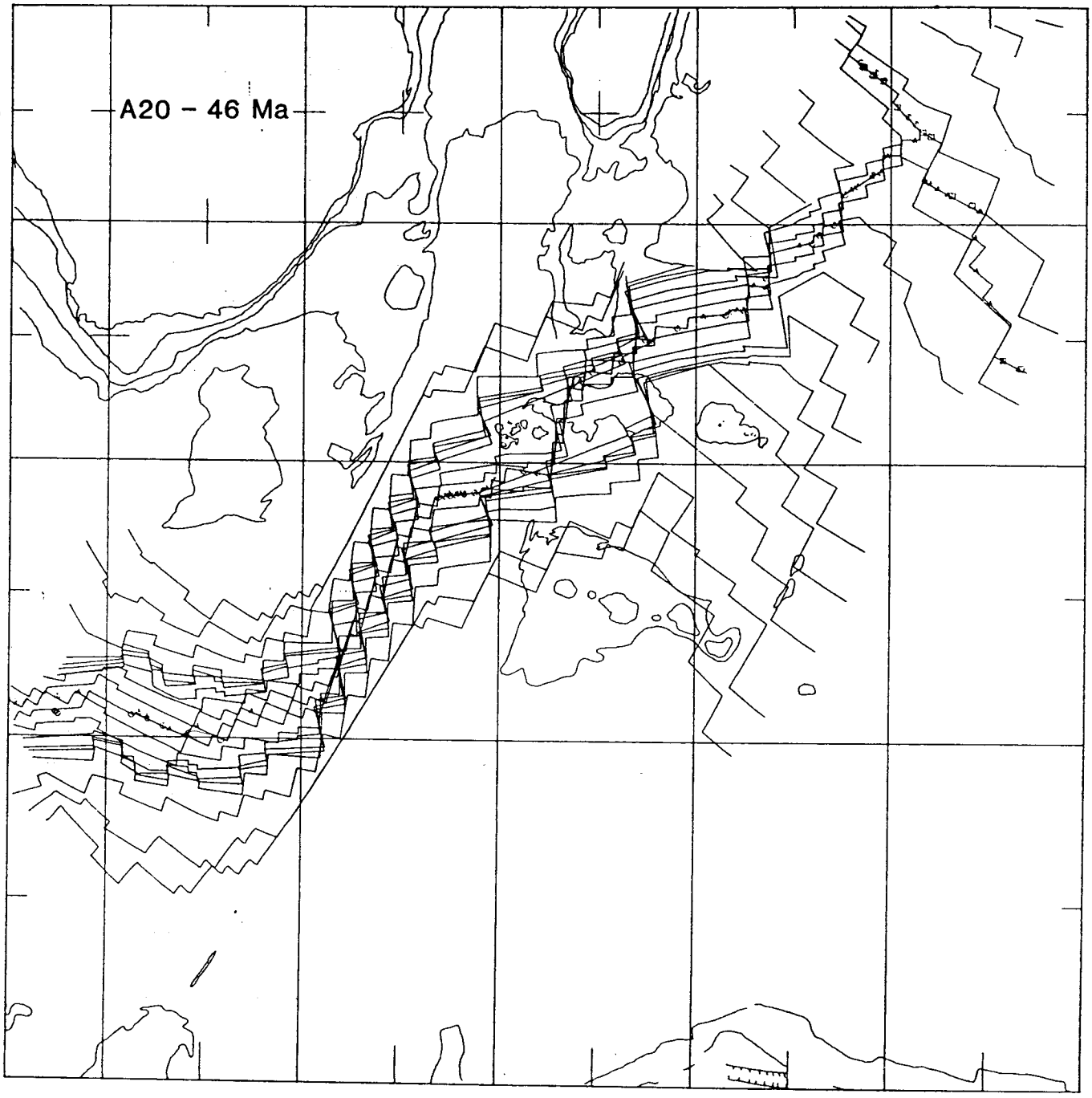


Times A32 to A29 At anomaly time A32 (73 Ma), spreading slows down and the direction of motion changes. The long offset fracture zone breaks into a series of ridge and transform fault segments. At anomaly time A29 (66 Ma), spreading is very slow and oblique.


A29 – 66 Ma



Time A24 Between anomaly time A29 and A24 (56 Ma), the spreading directions shift back to the earlier orientation. This episode ends with an important reorganization of the ridge axis resulting in local ridge jumps and the initiation of new fracture zones.



Time A20 After anomaly time A24, the Southwest Indian Ridge gradually adopts its present configuration, and since the Middle Eocene (anomaly 20, 46 Ma), the direction of motion has remained almost constant.