PALEOCEANOGRAPHIC MAPPING PROJECT
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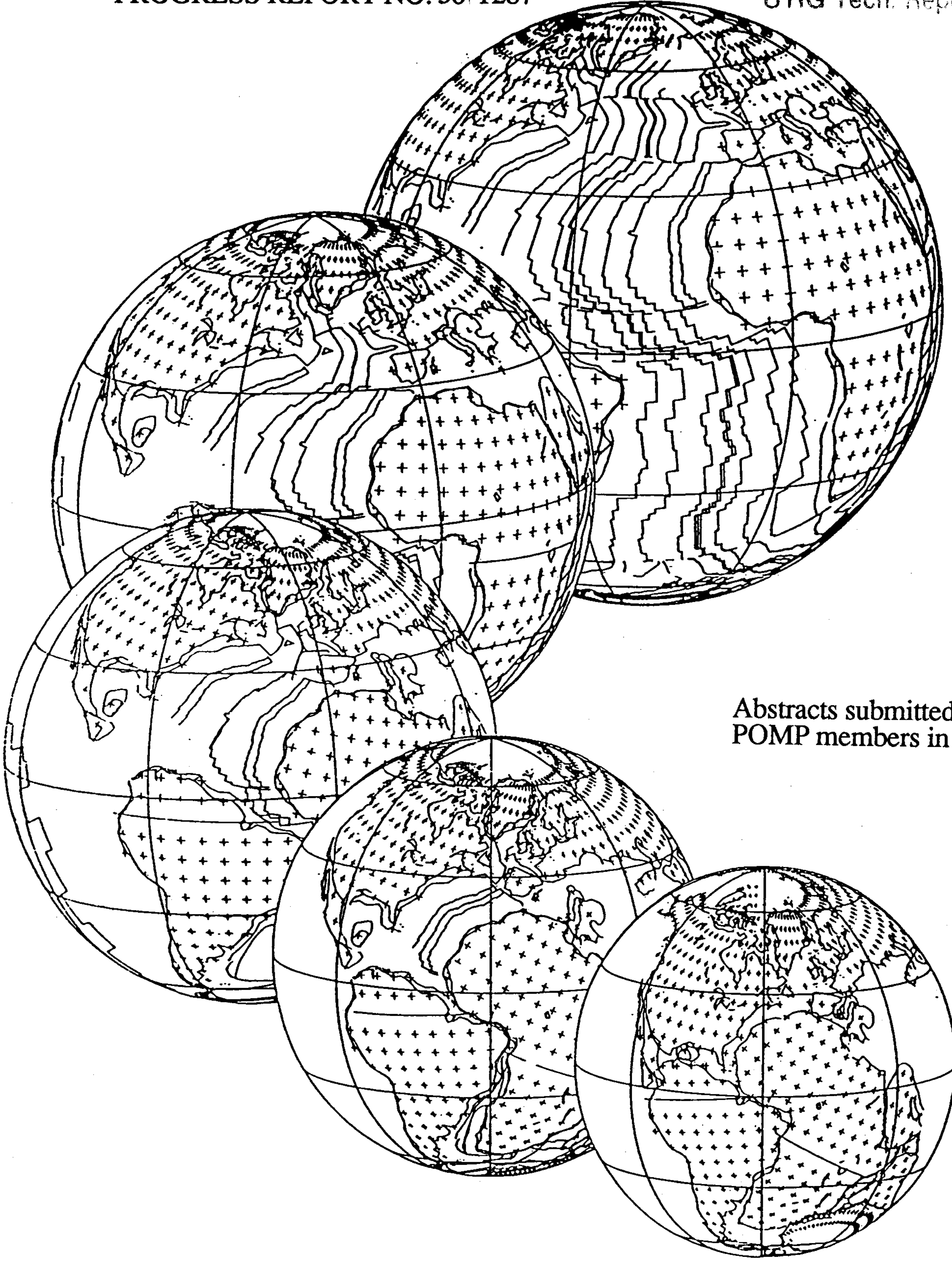

Abstracts submitted by
POMP members in 1987

A GLOBAL MODEL OF MESOZOIC AND CENOZOIC PLATE MOTIONS

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During the past 3 years the Paleoceanographic Mapping Project (POMP) has compiled a global marine tectonic data base that illustrates the position of modern plate boundaries, marine magnetic anomaly lineations, magnetic anomaly picks, fracture zone lineations, oceanic volcanic edifices, and the boundaries between continental and oceanic crust. These data are being used to construct an isochron map at a scale of 1:10,000,000 and to produce a hierarchical tectonic model (HTM) that describes the plate tectonic evolution of the ocean basins and continents since the early Mesozoic.

Sources of information for this compilation include public domain data banks, the published literature, and collaborative projects with visiting scientists. One of the single, most useful sources of information, however, has been the measurement of sea-surface heights from satellite altimetry (SEASAT). Using the SEASAT data we have constructed a tectonic fabric map of the world (Figure 1). This map has been instrumental in producing better constrained plate tectonic reconstructions and we believe that the subtle changes in the tectonic fabric reflect global plate reorganizations.

It is the plan of Working Group 2B of the International Commission on the Lithosphere to combine results of the Paleoceanographic Mapping Project with the work of other research groups (Alan Smith/Cambridge, Zonenshain and Khain/Moscow, Dercourt and Beuzart/France, Ziegler and Rowley/Chicago, Powell/Australia) to produce an Atlas of Mesozoic and Cenozoic plate reconstructions. The results of this synthesis will be presented at the International Geological Congress in Washington, D. C., in 1989. The preliminary results of this synthesis are presented here.

The Paleoceanographic Mapping Project has been made possible through the cooperation of numerous visiting scientists. We would especially like to thank, Philippe Patriat (Paris), Hugh Bergh (B.P.I), Peter Barker (Birmingham), Chris Powell (Macquarie), Mike Coffin (Canberra), Martin DeWitt (B.P.I.), Steve Barrett (AMOCO), and Ann Grunow (Lamont), as well as our colleagues at the Institute for Geophysics, in particular Dave Sandwell, Ian Dalziel, Dale Sawyer, John Dunbar, and Paul Mann.

Presented at the **1987 Geodynamics Symposium:**
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Plate Tectonic Evolution of the Circum-Antarctic Passive Margins

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Abstract

Passive margins that formed during the Late Jurassic and Cretaceous account for approximately 80% of the 15,000 km circumference of Antarctica. There are no passive margins younger than Late Cretaceous. Approximately 28% of these margins are Late Jurassic in age, 24% are Early Cretaceous in age, and the remaining 48% formed during the Late Cretaceous. The tectonic style of the rifting events that formed these margins varies considerably along the perimeter of Antarctica. In several areas the initiation of seafloor spreading was preceeded by a long period of extension and pre-drift stretching (Wilkes Land). Along other portions of the margin, rifting proceeded rapidly with little evidence for a lengthy phase of pre-drift extension (Queen Maud Land). Though extension is the dominant tectonic style,there is evidence for large-scale strike-slip movement associated with the early phases of continental breakup along the coasts of Crown Princess Martha Land and Victoria Land. Except for a short segment of the margin between the West Antarctic peninsula and Marie Byrdland, the Antarctic passive margins have not been affected by subsequent subduction-related compressive deformation.

This presentation will review the plate tectonic evolution of the Circum-Antarctic passive margins during 5 time intervals: Early Jurassic, Late Jurassic, Early Cretaceous, mid Cretaceous and latest Cretaceous. A map illustrating the relative amounts of extension along the margin of Antarctica will be presented, and a computer animation illustrating the breakup of Gondwana from an Antarctic perspective will be shown.

Presented at the **A.A.P.G. Annual Convention**,
Los Angeles, California, june 1987.
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PLATE TECTONIC EVOLUTION OF THE SOUTHERN OCEANS: AN ANTARCTIC PERSPECTIVE

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The breakup of Gondwana and the subsequent evolution of the Southern Oceans is best reviewed from an Antarctic perspective. The break-up of Gondwana began in Early Jurassic (170 Ma) with the widespread Ferrar and Karoo flood basalts of Antarctica and Africa. Those together with the Jurassic mainly silicic volcanism in southern South America record the initial break-up event. The first phase in the breakup of Gondwana was dominated by strike-slip movements as the eastern half of Gondwana (Madagascar, India, Australia, East Antarctic craton) separated from the western half (Africa, South America) along a series of transform faults that ran parallel to the Davie Ridge, Mozambique escarpment, Explora Wedge, and Astrid Ridge. Seafloor spreading in the Mozambique and Somali Basins can be dated from earliest Late Jurassic and produced a passive margin along East Antarctica between 10°W and 35°E. A new phase of rifting began in the earliest Cretaceous as Greater India/Sri Lanka separated from Antarctica/Australia forming a new passive margin between 35°E and 120°E. The Straits of Mannar, which now separate Sri Lanka from India, may represent a failed rift produced during the early phase of continental separation.

The remaining passive margins of Antarctica between 120°E and 100°W were formed during a complex series of rifting events during the Late Cretaceous. Initially slow rifting between Australia and East Antarctica coincided with the opening of the Tasman Sea, stretching in the Ross Sea, and the propogation of the SW Pacific ridge system between the Campbell Plateau and Marie Byrd Land. In the Paleocene, spreading in the Tasman Sea and extension in the Ross Sea ceased and the SW Pacific spreading center linked up with sea-floor spreading between Antarctica and Australia, forming the modern plate boundary.

The break-up of Gondwana, and the subsequent evolution of the Southern Oceans will be illustrated in a color, computer animation produced on the Evans and Sutherland System 300.

Presented at the **5th International Antarctic Earth Sciences Symposium,** Cambridge, U.K, August 23-29, 1987.

TECTONIC FABRIC MAP OF THE OCEAN BASINS FROM SATELLITE ALTIMETRY DATA

by L.M. Gahagan, J.Y. Royer, C.R. Scotese, D.T. Sandwell, J.K. Winn, R.L. Tomlins, M.I. Ross, J.S. Newman, R.D. Müller, C.L. Mayes, L.A. Lawver, and C.E. Heubeck

Identifying and locating bathymetric features, such as fracture zones in the ocean basins, are important steps in the process of developing accurate plate reconstruction models. After the tidal and wave effects are removed, the sea surface is a good approximation of the geoid and, as such, reflects the changes in bathymetry beneath it. In 1978, NASA launched the SEASAT satellite, which spent three months acquiring information on certain oceanic parameters. The satellite collected more than four million data points along tracks with equatorial spacings of 165 km. The satellite used radar to measure the distance between itself and the sea surface. Ground-tracking lasers located the position of the satellite in its orbit, permitting the calculation of the distance between the satellite and a reference ellipsoid around the earth. The distance between the satellite and the sea surface was subtracted from the distance between the satellite and reference ellipsoid, with the remainder being the variation in height of the sea surface. The footprint of the satellite was 6.6 km in area which negated the effects of waves. Repeat orbits of the satellite averaged out the tidal effects. By using the digital SEASAT altimetry data, it is possible to identify bathymetric features and tectonic flow lines on the ocean floor.

This study used the deflection of the vertical data (which can be considered the first derivative of the sea surface) obtained from SEASAT data. The sea surface reflects both long-wavelength features (>1000 km), probably due to convection, and short-wavelength features (>30 km), corresponding in part to bathymetric features. To emphasize the bathymetric features, the long-wavelength component and the very short-wavelength noise (<19.8 km) were filtered out of the data, leaving signals for features having wavelengths between 19.8 and 200 km. The locations of the peaks, troughs, and inflection points of the deflections of the vertical were symbolically represented by circles, triangles, and crosses, respectively. Lineations and flow lines were established between plates by connecting like symbols. These SEASAT-derived features may serve as constraints on plate reconstruction models as well as provide information on plate reorganizations and other tectonic events.

Presented at the **G.S.A. Annual Meeting,**
Phoenix, Arizona, October 26-29, 1987.

THE OPENING OF THE ATLANTIC OCEAN - A NEW VIEW BASED ON INTERPRETATION OF SEASAT DATA

by R. Dietmar Müller, Christoph Heubeck, and Dirk Nürnberg

Various models of the opening of the North, Central and South Atlantic have been proposed in recent years. Refinements of their detail mainly reflect the use of new magnetic data and improved modelling techniques. Here, we present new reconstructions of the North, Central and South Atlantic opening history which was derived by combining recent magnetic anomaly data and Seasat altimetry data.

The Seasat altimetry data, which are used in the form of "along-track deflection of the vertical," provide a much-improved picture of the tectonic fabric of the Atlantic basins. Fracture zone lineaments interpreted from Seasat altimetry data, when compared with synthetic flowlines, provide a rough estimate of the quality of such flowlines. Moreover, the interpreted fracture zone lineaments provide additional constraints for the fit of corresponding magnetic anomalies. Using this new technique of combining magnetic anomaly data and Seasat altimetry data, we have assembled a significantly improved database and, with the advanced 3-D graphics capability of an interactive Evans & Sutherland PS 300 computer system, have derived a refined plate tectonic model for the Atlantic Ocean.

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Phoenix, Arizona, October 26-29, 1987.

THE EVOLUTION OF THE INDIAN OCEAN: A NEW SYNTHESIS.

Nº 136993

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A consistent set of reconstructions of the Indian Ocean at twenty different times from the Late Jurassic (Gondwana fit) to present was produced using magnetic and bathymetric data, along with the SEASAT and the new GEOSAT altimetry data. In particular, this work provides a model for the early evolution of the Indian Ocean that accounts for the most recent tectonic evidence shown by the the GEOSAT data in the remote southern latitudes.

Previous reconstructions of the Indian Ocean served as the starting point of this new synthesis. Our main concern was to reconciliate previously published reconstructions in a global frame and to revise the rotations which were not satisfactory with regard to the tectonic lineations deduced from the satellite altimetry data. The consistency of computed and observed rates and directions of spreading was used as a supplementary constraint for the new set of rotations. This work was done using a 3-D interactive reconstruction program on an Evans & Sutherland work-station.

From these results, a new isochron map has been constructed for the Indian Ocean and will be used as a time base for paleodepth studies of this ocean.

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PARAMETRIC CLIMATE MODELLING
AND COASTAL UPWELLING PREDICTIONS

by Christopher R. Scotese and Malcolm I. Ross

A computer program has been developed that models paleoclimate using a parametric approach. The program generates atmospheric pressure values and contours them to produce maps of atmospheric pressure for past times of known land and sea distributions. Wind directions inferred from the pressure distributions can be added to the maps to show where coastal upwelling may have taken place. Organic-rich muds form in such places today, thus upwelling predictions from paleoclimate models may provide clues about the distribution of potential petroleum source rocks. These predictions proved satisfactory for the Cenomanian, a time for which maps of organic-rich rocks are readily available.

The paleoclimate maps derived by the computer modelling approach used here are preliminary. Nevertheless, they offer a reasonable best-guess as to the earth's climate in the past. Eventually, more sophisticated computer modelling techniques may provide better results.

Presented at the **G.S.A. Annual Meeting,**
Phoenix, Arizona, October 26-29, 1987.

GEOSAT RESULTS FROM THE FAR SOUTH ATLANTIC

by L.A. Lawver and D.T. Sandwell

Abstract

Previous Seasat data from the South Atlantic covered to the ice edge at about 58°S with a few very major features such as Astrid Ridge (70°S, 10°E) being apparent through the ice cover. With the Geosat data, the curvature of the Late Cretaceous to Cenozoic fracture zones from the Antarctica-South America plate boundary are very distinct. The Early Miocene change in spreading direction on the American-Antarctic Ridge which was noted by Barker and Lawver (in press) is seen by both the cross fabric cutting of the Bullard Fracture Zone (58°S) and by the South Sandwich Fracture Zone (61°S) as well.

A distinct broad negative Geosat slope anomaly is seen covering most of the region southwest of a line from 64°S, 48°W to 68°S, 43°W and south of 68°S east to 25°W. This negative slope anomaly may be related to either a change in age between the adjacent seafloor or a dramatic slowing in spreading rate. This age contrast may be consistent with a model where Gondwanaland initially separated as a simple two-plate problem with Africa/South America separating from East Antarctica/Madagascar/India. This region of older crust would be related to the earliest spreading in the Somali and Mozambique basins prior to the opening of the South Atlantic that resulted in the separation of South America and Africa, and resulted in the dramatic change in spreading direction in the Weddell Sea region. The general negative anomaly is interrupted by a large lobe of nearly flat, zero-slope anomaly between 30°W and 38°W. This lobe may be related glacially derived, turbiditic sedimentation.

A large positive Geosat anomaly at 70°S, 5°W is similar to Astrid Ridge anomaly at 10°E. This anomaly may mark the western boundary of the separation between Africa and East Antarctica.

Presented at the **A.G.U. Fall**
San Francisco, California, December 6-11, 1987.
<u>EOS Trans. AM. Geoph. Un.</u>, v. 68: p. 1485.

NEW RECONSTRUCTIONS OF THE SOUTH PACIFIC USING GEOSAT DATA

by Catherine L. Mayes and David T. Sandwell

Abstract

Using Geosat altimeter data along with published magnetic anomaly identifications, we have developed a new Cenozoic reconstruction model of 5 plates in the South Pacific (Pacific, Cocos, Nazca, Antarctic and Drake). Small offset fracture zones, apparent in GEOSAT altimeter profiles, are used to constrain the geometry of the plate motions while the magnetic anomalies constrain the spreading rates. Our study focuses on two major tectonic reorganizations.

Between chrons 7 and 5 (26-10 Ma), the Farallon plate split to become the Cocos and Nazca plates, with spreading initiating along the Galapagos rift system. As a result, the East Pacific Rise changed its orientation from NNW to NNE. Along the Pacific-Antarctic Rise, between chrons 5 and 3 the GEOSAT data show a change in character from smooth to rough that reflects an increase in spreading rate, perhaps associated with the reorganization of the EPR.

We have also incorporated the Bellingshausen plate into our reconstructions. Between chrons 25 and 18 GEOSAT-derived fracture zone trends are oblique to the magnetic lineations suggesting that spreading between Antarctic and Bellingshausen plates ceased at chron 25 rather than chron 18.

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San Francisco, California, December 6-11, 1987.
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THE EARLY OPENING OF THE ATLANTIC OCEAN: A PROPAGATING RIFT MODEL

by R.Dietmar Müller and Dirk Nürnberg

The breakup of the continents around the Atlantic was characterized by two northward-propagating rift systems, one beginning in the Central Atlantic and another beginning in the southern South Atlantic. Pre-drift reconstructions for the South Atlantic that require rigid South American and African plates result in substantial misfits either in the southernmost South Atlantic or in the equatorial Atlantic. In the North Atlantic, a large overlap between the margins of Greenland and Svalbard is observed when applying a rigid plate model for the fit reconstruction. The application of a propagating rift model improves the predrift fit and accounts for successive unzipping of rift zones.

The pre-drift reconstruction proposed here is constrained by the oceanic/continental crust boundary, geological data from the continental margins, and Seasat altimetry data. Intersections of prominent fracture zones with continental margins were interpreted from Seasat altimetry data and used as tie points for the fit reconstruction.

To achieve a better fit of the continental margins for the South Atlantic, we assume a combination of complex rift and strike slip movements within the African and South American plates. These faults are presumed to have been active before or during the breakup of the continents.

The overlap of the margins of Greenland and Svalbard in the North Atlantic pre-drift reconstruction can be reduced by taking into account strike slip movement in Northeast Greenland as a continuation of the Senja margin.

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<u>EOS Trans. AM. Geoph. Un.</u>, v. 68: p. 1473.

Early evolution of the Indian Ocean: new constraints from GEOSAT altimetry data

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GEOSAT altimetry data provides a unique and new set of data on the tectonic fabric of the seafloor south of 60°S, created during the early opening of the Indian Ocean. In the southwestern Indian Ocean, the GEOSAT data confirm the location of the Astrid FZ and its northward continuation, west of the Prince Edward FZ. They also reveal several subparallel fracture zones that record the spreading direction of Africa relative to Antarctica during the Early and Middle Cretaceous. Further east, the major fracture zone running SW-NE, southwest of the Kerguelen Plateau, fades south of 62°S and curves into the Antarctic margin, just east of the Gunnerus Ridge. In the southeastern Indian Ocean, it is now possible to recognize the counterpart of the Diamantina FZ as well as the conjugate rifted margins of Australia. Finally, the prominent fracture zones south of Tasmania can be precisely traced into George V Basin, off Antarctica. Using available magnetic anomalies along with these new constraints, we derive a model for the early evolution of the Indian Ocean.

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EOS Trans. Am. Geoph. Un., v. 68: p. 1485.