

LAB 4

CONTINENTAL RECONSTRUCTIONS USING PALEOMAGNETIC DATA

OBJECTIVES:

1. *Understand how paleomagnetic poles from continental rocks are analyzed and interpreted.*
2. *Test proposed reconstructions of the location of Madagascar in Gondwanaland using paleomagnetic data*

BACKGROUND: Please review how rock magnetic measurements are interpreted to give a paleomagnetic pole. You should be able to transform measurements of inclination and declination into paleo-poles. You need to understand potential sources of uncertainty and how these are incorporated into the analysis.

Plate reconstructions for the time period upper Jurassic to the present utilize the pattern of magnetic anomalies on the floors of the world's oceans. For earlier periods, or for plate reconstructions where oceanic anomalies are not available, we rely heavily on paleomagnetic results from continental blocks.

One such reconstruction for which paleomagnetic data exist and can be used is the paleo-position of Madagascar adjacent to the African continental margin. Three possibilities have been proposed:

- (1) A position adjacent to East Africa off the coast of modern Somalia, Kenya, and Tanzania (rotation of Madagascar relative to Africa about an Euler pole at 9° S, 47° W, by an angle of 15°)
- (2) A position adjacent to Mozambique off the coast of southern Africa (rotation of Madagascar about an Euler pole at 48° S, 70° E, by an angle of 14°)
- (3) Same position as present

Although recently, seafloor magnetic anomalies have been identified for parts of the ocean between Madagascar and Africa, these are very poorly correlated and may be misidentified.

Paleomagnetic results are available for Madagascar sedimentary rocks of the Karoo Supergroup which ranges in age from Late Carboniferous to Middle Jurassic. Paleomagnetic data from comparable age rocks in Africa are heavily biased in the age range Middle Triassic to Middle Jurassic. Fortunately this problem of incomplete data sets for comparison is solvable because data from South America fall primarily in the time span Late Carboniferous to Early Triassic. Thus, if the African and South American data are combined (after first closing the Atlantic) there is a relatively continuous distribution in time of paleomagnetic poles for comparison with Madagascar data.

EXERCISE:

Paleomagnetic data obtained from the literature for South America, Africa, and Madagascar are given in Tables 1 – 3 (you can cite the lab handout for the data source).

1. Determine an average combined Africa - South America paleomagnetic pole position for three time periods: (a) Carboniferous - lower Permian [C-P]; (b) upper Permian - lower Triassic [P-Tr]; and (c) Middle Triassic - Middle Jurassic [Tr-J]. To do this use the MATLAB function **Euler_Rotation** to close the Atlantic - transforming the South American paleomagnetic data into an African frame of reference. [use the Rotation pole: 44° N, 31° W, $\Omega = 57^{\circ}$]
2. Use **Euler_Rotation** to move Madagascar (and its paleomagnetic poles) into the African frame of reference in the three proposed Gondwana reconstructions described above. Compare the fit of paleomagnetic poles in two ways:
 - (i) Use reconstruction figures to plot the appropriate paleomagnetic poles for combined Africa - South America and for Madagascar for each of the three proposed reconstructions. On each figure plot poles for the three time periods (using different symbols/colors) for the C-P, P-Tr, and Tr-J poles. Draw the α_{95} circles of confidence around each pole.
 - (ii) Compile in a single table the separation distances (great circle arc lengths) for corresponding paleomagnetic poles under the three reconstruction hypotheses.

Paleomagnetic Data For Continental Reconstruction Lab

Table 1 - Summary of Paleomagnetic Data from Karoo Supergroup of Madagascar

Age	Group	Pole Latitude	Pole Longitude	k	α_{95}
Trm - Jm	Isalo	74.2° S	97.1° E	78	6.3°
Pu - Trl	Sakamena	65.8° S	111.6° E	96	6.1°
Carb. - Pl	Sakoa	52.8° S	80.7° E	94	7.9°

Table 2 - Summary of Paleomagnetic Data [Carboniferous through Jurassic] for Africa

Age	# of Sites	Locations	Pole Latitude	Pole Long.	k*	α_{95}^*
Trm - Jm	20	Morocco, Kenya, Sierra Leone, Zambia, Zimbabwe, South Africa, Tanzania	68.2° S	67° E	72	4°
Pu - Trl	2	Kenya, South Africa	67° S	88° E	78	5.4°
Carb. - Pm	4	Morocco, Tanzania	37.4° S	60° E	108	5°

Table 2 - Summary of Paleomagnetic Data [Carboniferous through Jurassic] for South America

Age	# of Sites	Locations	Pole Latitude	Pole Long.	k*	α_{95}^*
Trm - Jm	4	Venezuela, Argentina	74.2° S	107.5° W	72	4°
Pu - Trl	9	Argentina, Suriname	83.6° S	127.2° W	78	5.4°
Carb. - Pm	4	Argentina	81° S	33° W	108	5°

* Statistics are given for combined Africa - South America data set