PALEOMAGNETISM, MANTLE PLUMES
AND ABSOLUTE PLATE MOTIONS (GP)

North Cotillion *Tuesday 1330h*

Chairman: DAVID HARGRABES (Princeton University)

Numerical Modelling of Instantaneous Plate Tectonics. A self-consistent plate tectonic model is constructed from the observations of relative velocities between plates at plate margins through a systematic inversion procedure.

The data inverted are measurements of the magnitudes (spreading rates), and directions (transform fault orientations and slip vectors of earthquakes) of relative velocity vectors between plates. The overdetermined linearized system of equations relating changes in the pole positions and rates of rotation to first order changes in the relative velocity vectors is inverted by the maximum likelihood procedure. The use of Gaussian statistics is justified. Because we use a linear theory we can determine the uncertainties in the model induced by small errors in the data, and also study the relative importances of the data. We have also inverted the azimuths of 25 volcanic chains, distributed over nine plates, under the assumption that they were caused by hot spots fixed in the mantle. With the exception of Iceland, very good fits were obtained, yielding a model for plate motions over the mantle. The velocity of the Pacific plate over the Hawaiian hot spot for this model is 8.9 cm/y.

GP17 (Invited Paper; 15 min)
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Hot Spots and Pacific Plate Motion. Nearly all linear island and seamount chains on the Pacific plate lie along small circles generated about either a Hawaiian pole at 69°N, 68°W or an Emperor pole at 17°N, 107°W. The average rates of rotation of the Pacific plate relative to the Hawaiian hot spot can be calculated from the age progression along the Hawaiian-Emperor chain: 1.2°/m.y. about the Hawaiian pole (0 to 20-25 m.y.), <0.5%/m.y. about a pole near the Hawaiian pole (20-25 to 42-44 m.y.), and about 0.8%/m.y. about the Emperor pole (42-44 to 67-70 m.y.). If the various hot spots are fixed with respect to one another, then this proposed rotational model can be used to predict the ages of seamounts and islands in other Pacific plate chains formed by hot spots. The agreement of predicted and measured ages is good with the exception of two K-Ar ages from the Austral chain. The hypothesis that hot spots are fixed relative to the earth's spin axis can be tested by comparing the polar path reconstructed from the rotational model with paleomagnetic data, and by comparing predicted Tertiary sedimentation patterns with those observed. Equatorial Pacific Deep Sea Drilling sites generally have their highest sedimentation rates at times consistent with the proposed motion model. A predicted isopach map of post-middle Eocene equatorial sediments, based on the motion model and an equatorial sedimentation model, is remarkably similar to the isopach map of Ewing and others determined by seismic profiling. The sensitivity of this predicted isopach map to uncertainties in input parameters is investigated.

GP18 (Invited Paper; 15 min)
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Observable Motions, Unobservable Causes. The relative motions which are currently observable on the 10^6 to 10^8 year time scale are: plate-plate, plate-asthenosphere, plate-rotation axis, plate-mantle (as expressed by the imbedded plumes, and rotation axis-mantle. An independent set of observations on the 1-100 year time scale is possible for plate-plate, plate-asthenosphere, and plate-rotation axis motions. New criteria for data acceptability are emerging from the initial exploration of earth kinematics. Extending the observations to time scales between 10^2 and 10^6 years and beyond 10^8 years is a difficult task for the future. Dynamic interpretations of the motions are still controversial. The plate-asthenosphere-mantle system may be one tightly coupled dynamic unit, with the choice of the rotation axis, the equatorial bulge, and the core convection constituting a second system. Interactions between the two systems occur through the gravity anomalies and through thermal coupling at the core-mantle boundary.

GP19 (Invited Paper; 15 min)
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The Present Plume Population. About sixty plumes can be identified from Recent alkaline vulcanism on uplifts. These vary in horizontal dimensions, amount of uplift and volcanic intensity. The global distribution of such plumes is asymmetric: more than one quarter occur under the African plate. Plume traces show that some plumes have appeared and others have disappeared within the last 100 m.y. We infer the existence of many more active plumes from the behaviour of southern Africa where Neogene basins, and swells without vulcanism, suggest that some plumes may make no volcanic mark even when under a stationary plate. We suggest that three factors inhibit plume-generated vulcanism: plumes may exist which are too weak to produce vulcanism for part or all of their lives; it may be more difficult for any given plume to cause vulcanism through continental as opposed to oceanic lithosphere, and it is probable that a plume is less likely to cause vulcanism and uplift the faster the lithosphere is moving over it. Because abundant plume vulcanism started when the African plate came to rest relative to plumes, we suggest that lithosphere motion is dominant in obscuring the existence of many plumes under other plates. If plumes are fairly evenly distributed, a total population of about 150 plumes can be inferred from the sample shown by the African plate.

GP20
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Plate Tectonics and Plume Mechanics. A likely mechanism for driving lithospheric plates appears to be that they slide off the tops (often triple points) of plumes which rise from fixed locations in the deep mantle. Ocean basins open where rifts connect lines of plumes. In one type, mid-ocean ridges remain over plumes to spread steadily for perhaps 100 million years. In a second type the interference of spreading plates pushes mid-ocean ridges off their plumes. The old ridges become inactive and after a few tens of millions of years the plumes generate new ridges. Possible examples are the Arctic and Tasman Seas and Indian Ocean. Some plates, particularly the African, seem to be stationary relative to plumes and

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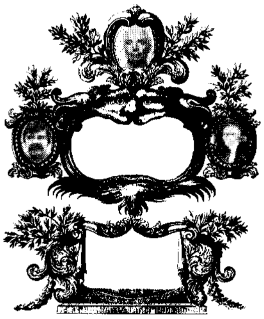

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