Mantle Dynamics Beneath the Continental Break-up Region

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As a typical example of slow and stable spreading ridges, we will show results of a case study in the Gulf of Aden. We will present what our seafloor magnetotelluric array study in the Gulf of Aden tells us concerning the following two working hypothesis:

1. Mantle dynamics beneath slow spreading ridges is dominated by buoyant upwelling.
2. Structures beneath stable spreading ridges are symmetric.

This also constitutes a comparative study of the Mantle Elctromagnetic and Tomography experiment, which was done around the fast and moving East Pacific Rise at 17S. Finally, the interaction between the mantle plume that caused the latest continental break-up and the active upwelling beneath the Gulf of Aden will be further discussed.

This study treats the Gulf of Aden located in a region of continental break-up as a typical example of slow and stable, namely, non-moving, spreading centre. We will do this because the Mantle ELectromagnetic and Tomography (MELT) experiment, which was conducted around the fast and moving East Pacific Rise (EPR) at around 17S, has provided us the following new findings.

In the MELT experiment, which was a joint international experiment involving seismology as well as seafloor magnetotellurics, outstanding shear wave splitting and strong anisotropy in electrical conductivity were found and interpreted as being originated from the lattice preferred direction of the olivine mineral in the upper mantle. The experiment showed that the mantle dynamics beneath the super-fast spreading ridge segment is dominated by 'passive upwelling' of mantle materials forced by the fast spreading oceanic plates as well. This was confirmed by both seismic and electromagnetic (EM) imaging of the melt body beneath EPR that revealed a very broad view of the partially molten region. Moreover, the seismic and EM structures showed intense asymmetry of across ridge section, which may be due to the movement of the ridge crest toward the west at a rate of approximately 3 cm/y.

In contrast to EPR, there exists a very slow and stable ridge segment in the Gulf of Aden. The intent of this paper is to verify the following two working hypothesis;

1. Mantle dynamics beneath slow spreading ridges is dominated by buoyant upwelling and hence leaves a very narrow region of partial melt.

2. Structures beneath stable spreading ridges are symmetric.

by a seafloor magnetotelluric (MT) array study.

The seafloor MT array was deployed along a 120 nm long profile perpendicular to the East Sheba ridge in the Gulf of Aden using five ocean bottom electromagnetometers. The duration of the array study extended from early December of 2000 to the beginning of January, 2001 summing up to three-week duration in total. This EM experiment was really a successful one leaving us nearly 100 % data recovery from all the five seafloor instruments. The experiment was characterized by a relatively high sampling rate (max 0.1 Hz) and one order of magnitude improvement in magnetic resolution (10 pT). These two and a combined effect of nearly maximum solar activity have enabled us to delineate deep mantle structures even by this relatively short observation.

It is true that the East Sheba ridge segment is a very slow spreading ridge segment. However, it is unclear whether it is really a stable ridge segment. The KH00-5 cruise, in which the seafloor MT array study was conducted, also provided bathymetry, gravity and magnetic anomaly data. They showed contradictory results, i.e., symmetric mantle bouguer and magnetic anomaly vs asymmetric topography. It is one of our tasks to clarify whether we can obtain an electrical conductivity section beneath the East Sheba ridge that satisfies the symmetric gravity/magnetic anomalies and the asymmetric bathymetry. Three-dimensionality must be examined before verifying any 'symmetry' in two-dimensional interpretation. Finally, the interaction between the mantle plume that caused the latest continental break-up and the active upwelling beneath the Gulf of Aden should be revealed as well.