GEOPHYSICAL INTERPRETATION OF THE MAGNETIC ANOMALIES OF THE EARTH DERIVED FROM MAGSAT DATA

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A global scalar magnetic anomaly map does not show a direct correlation between magnetic anomalies and their causative sources. A positive scalar magnetic anomaly near a geomagnetic pole can be associated with a positively induced magnetic body, whereas such a body creates a negative anomaly near the geomagnetic equator. A magnetic anomaly of an induced magnetic body appears approximately over the body at high and at low geomagnetic latitudes, while it is displaced toward the equator at mid-latitudes, creating a lobe toward the respective pole with opposite sign. Furthermore, a magnetic body with a given magnetic susceptibility produces a stronger anomaly at higher latitudes than at lower latitudes, since the main geomagnetic field is weaker and almost horizontal at lower latitudes. These ambiguities pose questions about geophysical implications based on the correlation of scalar magnetic anomalies and geological features. They also hamper the comparative interpretation of widely separated anomalies. A method is developed in order to convert scalar magnetic anomalies into a map of the lateral variations of magnetic susceptibility of the lithosphere (susceptibility anomalies). This map can be directly correlated with the causative sources. The method is based on spherical harmonic analysis of lateral variations seen on the scalar magnetic anomaly map and those of the lithospheric magnetic susceptibility. Their harmonic coefficients are related through the fundamental causality relationship governing a magnetized body and its associated scalar magnetic anomaly. The main features of the resulting magnetic susceptibility anomalies are as follows.

Young oceans have relatively low magnetic susceptibility anomalies, implying that the oceanic lithosphere is relatively more uniform than the lithosphere beneath the continents. Oceanic regions younger than about 80 Ma (except the South Indian Ocean) have almost no magnetic signature, suggesting that under the young lithosphere, there is only a very small volume of material below the Curie point. Many Circum-Pacific subduction zones have positive susceptibility anomalies. This can be related to the downward displacement of the Curie isotherm by the cold subducting plates.

Continental and old oceanic lithosphere has relatively more significant susceptibility anomalies than the young oceanic lithosphere. Anomalies in different continents are quite similar. There is no obvious correlation between susceptibility anomalies and major shields. However, small scale cratons have positive susceptibilty anomalies. Most of the aulacogens associated with the rupture of the Atlantic Ocean, some modern uplifts and recently reactivated old rifts seem to correlate with negative susceptibility anomalies. All these anomalies can be explained by a common model. Major shields are locally demagnetized by hot spots or by intrusion of hot material into rifts so that they are effectively fragmented into several small blocks. The demagnetization effects of a hot asthenospheric intrusion into the lithosphere are studied on the basis of the thermal evolution of different intrusion models. It is concluded that the initial temperature perturbations of the lithosphere caused by a hot asthenospheric intrusion require about 200 Ma to decay to a negligible magnitude, in accordance with the demagnetization model proposed.