GRM AS A FOLLOW-ON TO MAGSAT

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Magsat was the first near-earth spacecraft dedicated to measurement of the vector geomagnetic field. Its objectives were to use the vector measurements to measure and model both the main field and the crustal field of the earth. The main field measurements were to be used for the 1980 world charts and to study the earth's core. The crustal fields were to be utilized to aid in modeling large-scale variations in the geologic and geophysical characteristics of the crust.

Main field modeling efforts have been spectacularly successful, even beyond expectation. The near-earth field at 1980 is now extremely well-defined, including the long-wavelength external field contribution. Further, studies relating to the fluid core have been undertaken with some success, as will be reported in other papers.

A large amount of the effort expended on the crustal field measurements has been focused on an understanding of the data, rather than its interpretation. Questions addressed have been:

1. How much of the so-called crustal field is really crustal?
2. How much of the total crustal field is included and how much is masked by the main and external fields?
3. What is the true zero level of the crustal field, or, what is the effect of not knowing this zero level?
4. Why do the crustal fields seem to have an east-west elongation?
5. Do the vector measurements provide additional information beyond what is contained in the scalar anomalies?

Many of us are now convinced that our maps do indeed represent crustal fields, at least to within ±2 nT, and that the north-south anomaly gradients can be discussed with reasonable accuracy. It now seems clear that the very longest wavelength crustal fields are masked by the core field. Much of the ocean-continent difference is contained in these wavelengths. At the short wavelength end, the limitation is imposed by the fact that our average altitude is about 400 km and the measurements have a finite noise level. This limitation constitutes the resolution limit of the measurements and has been variously estimated to lie between 250 and 600 km. The east-west elongation is partly due to the field geometry but is also contributed to by the fact that the satellite path is nearly north-south and along-track filtering is required to eliminate external fields. The question of the value of vector data in anomaly studies has been answered in the negative by Mayhew but I believe the question is still open.

The full answer to the usefulness of the vector data requires theoretical study, not more data. A lower inclination orbit, preferably about 50^{o}, is required to finally resolve the questions about the east-west trends. An undeterminant zero-level remains a consequence of the presence of the main field. GRM will not address any of these problems.

Some actual crustal modeling has been accomplished. This includes models of Broken Ridge, the Lord Howe Rise, and the Churchill-Superior boundary zone. It has now been shown that sea floor spreading anomalies have a signature in the satellite data and that, in some regions, it is possible to utilize the satellite data to aid in mapping the depth to the Curie isotherm.

In addition to the problems already mentioned, the major limitation for crustal studies lies in the lack of resolution. This would be addressed directly by GRM. Resolution is a very strong function of altitude, but is also strongly dependent upon the distance between the bodies when separation is less than the observational altitude. The increase in resolution due to decrease in altitude from Magsat (~350 km) to GRM (~150 km), for bodies separated by distances approximately equal to or greater than Magsat altitude (350 to 550 km) is about an order of magnitude. As the separation decreases below the altitude of Magsat, the increase in resolution dramatically increases (to a factor of ~30 for body separation of 250 km and to a factor of ~300 at 150 km body separation). At approximately GRM and lower altitudes, widely separated bodies (>250 km) are distinct--that is, bodies of different separation have approximately the same resolution at any given altitude. This situation simplifies interpretation, as differences in resolution can be attributed to differences in susceptibility or volume. At Magsat altitudes the same bodies separated by 250 to 550 km will have resolutions which vary by about an order of magnitude, complicating interpretation.

Although not explicitly designed to study the main field, nevertheless the GRM data should yield a main field model at its epoch of comparable quality to those derived from Magsat data. The combination of GRM, Magsat, and magnetic observatory data should yield an improved definition of secular variation and, therefore, enable more detailed study of processes in the core which generate the main field.