ØRSTED AND MAGSAT: A COMPARISON OVER THE KURSK MAGNETIC ANOMALY

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Abstract

We examined the Ørsted magnetic field data over the Kursk Magnetic Anomaly (KMA) region of Russia, one of the world's largest magnetic features, in order to determine if the relatively short wavelength crustal magnetic anomalies were present. Our resulting Ørsted magnetic map was compared with the previously derived Magsat anomaly field. The largest anomalies of both data sets were totally correspondent; anomaly amplitude variance follows a $1/r^3$ dipole curve. Differences in these two anomaly maps were the result of the greater number and homogeneity of orbit profiles from the Ørsted mission. Comparison of these anomalies with known crustal tectonic features was noted.

The Kursk Magnetic Anomaly (KMA) of Russia (51° north, 37° east) has long been recognized as one of the largest magnetic anomalies on Earth. It is associated with the massive iron-ore formations of this region; however, model studies have revealed that the relationship between the two is not obvious. In an early effort to demonstrate the validity of Magsat data for crustal research a detailed study of the KMA, at an average altitude of 350 km, and the surrounding region was made (Taylor and Frawley, 1987). They recorded a 27 nT high and a -9 nT low giving a 37 nT peak-to-trough anomaly over the immediate area (40° to 65° north and 15° to 45°) of the KMA (Figs 1 and 2).

Despite the much higher altitude of Ørsted (645 to 845 km) we revisited the KMA to determine if this mission would also be able to record an associated anomalous crustal signature. We computed an Ørsted magnetic anomaly map (Fig. 3) with profiles selected from April to August 1999. From these data we chose those with an altitude range of 644 to 700 km and they were subsequently gridded, by least-squares collocation, to a mean elevation of 660 km. Both ascending (Fig. 4) and descending (Fig. 5) data were examined and signals common to both were extracted and averaged (Alsdorf *et al*, 1994). A correlation coefficient between the fields derived from these two orbit orientations of 0.82 was computed. The quadrant-swapping method of Kim *et al.* (1998) was applied. Removal of the main geomagnetic field was accomplished with a polynomial fitting procedure (Fig. 6). A positive anomaly of >2.5 nT with an associated negative of <-0.5 nT for a >3 nT peak-to-trough range were computed (Fig 3). These Magsat and Ørsted results are consistent with the decay of a dipole field over the studied altitude range. Significant differences between these two anomaly fields are due to the greater number of orbit profiles and therefore greater number of intersecting orbits (ascending and descending) available in the Ørsted compilation (cf. Fig. 2 with Figs. 4 and 5).

There are three large anomalies in both maps (two positive and one negative). The two positive anomalies are readily correlated with known tectonic features (Voronezh Bulge and Belorussian-Lithuanian uplift, Fig. 7). While the negative anomaly is associated with a region of relative crustal thinning (< 40 km., Meissner et al., 1987). In the southwestern quadrant of this region the southeastern end of the Tornquist-Teisseyre Zone is apparent in both satellite fields. This linear magnetic anomaly gradient defines the terminus of the East European Craton. Linear negative anomalies trending in a generally north-south direction cross the Black Sea; while these anomalies are apparent in both fields the paucity of Magsat orbits along the southern edge of the KMA study region makes a robust comparison less certain. The same idealized three-body model can represent both anomaly maps (Figs. 8 and 9). Our correlation between the two different satellite anomaly fields would suggest that additional crustal geologic information should be gained from Ørsted anomaly data.

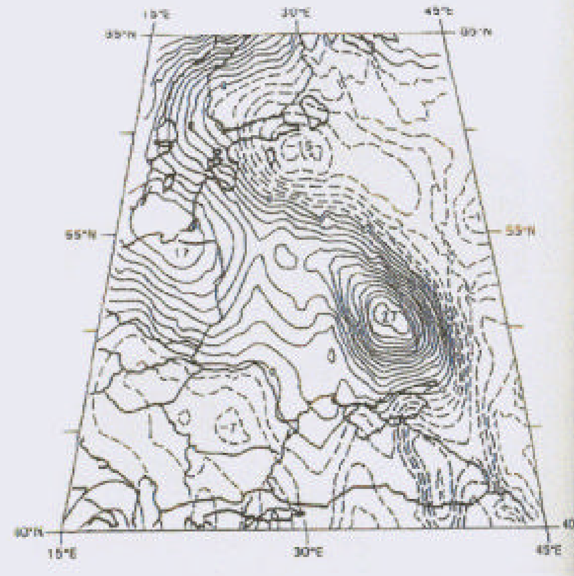

Figure 1. Total intensity-magnetic anomaly map of the KMA area from Magsat data. Contour interval is 2 nT with the zero contour labeled. Solid contours are positive values and dashed negative (Taylor and Frawley, 1987).

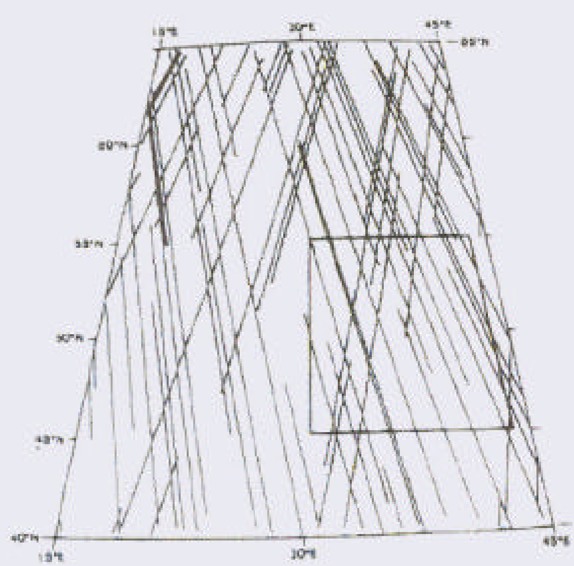

Figure 2. Magsat orbits used to produce anomaly map. Satellite altitude varied between 340 and 360 km.

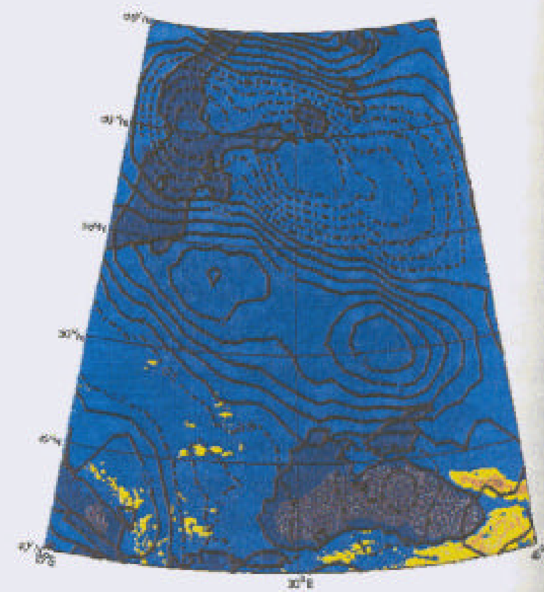

Figure 3. Total intensity-magnetic anomaly map of the KMA area at 660 km altitude from Ørsted data. Contour interval is 0.5 nT. Spectral quadrant swapping (Kim et al., 1998) was applied.

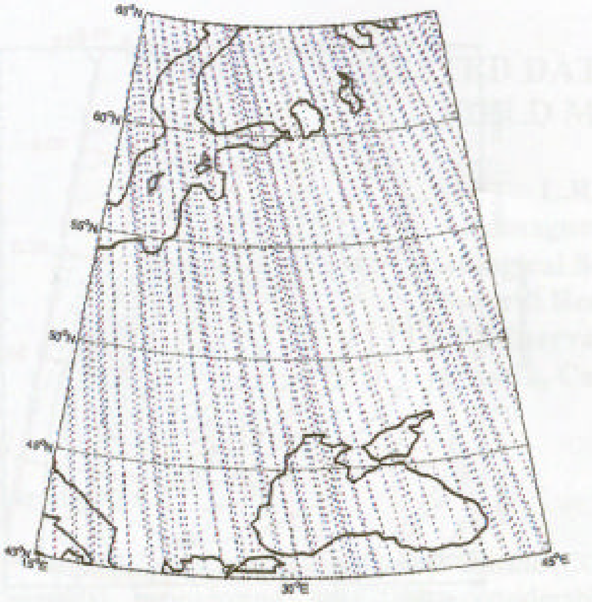

Figure 4. Ørsted ascending orbits over KMA region.

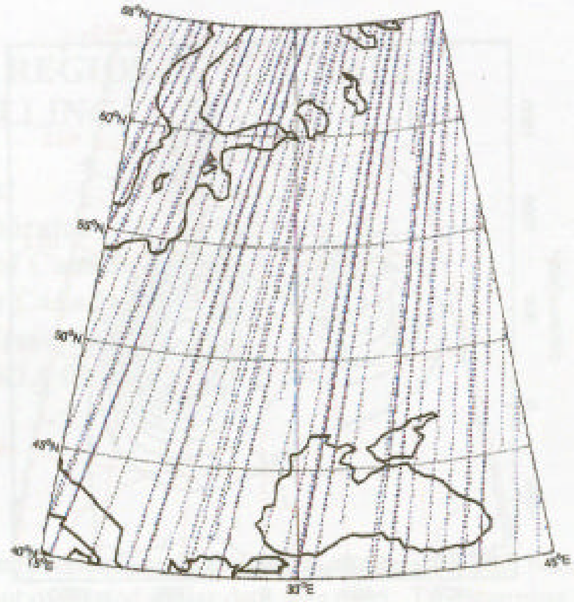

Figure 5. Ørsted descending orbits over the KMA region.

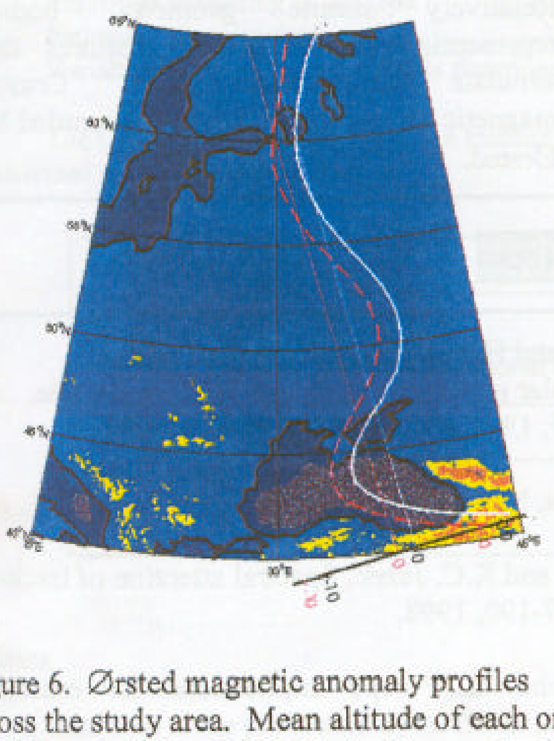

Figure 6. Ørsted magnetic anomaly profiles across the study area. Mean altitude of each orbit is 677 km (solid) and 652 (dashed) respectively.

Figure 7. Basement relief map of Eastern Europe (from Beloussov, 1981).

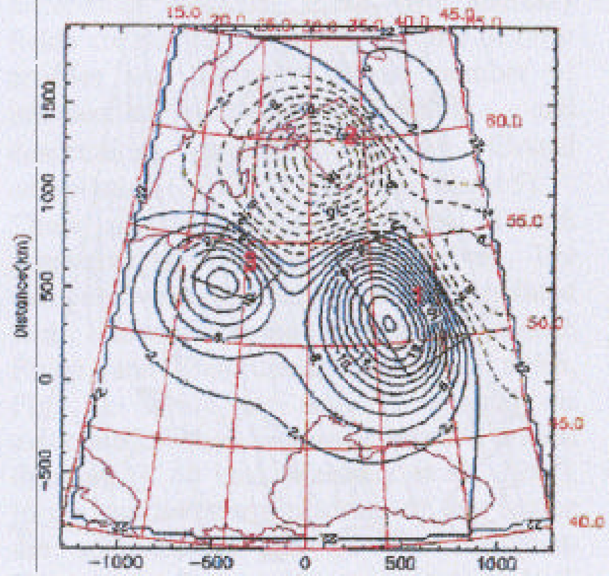

Figure 8. Model magnetic anomaly field produced by three idealized bodies at an altitude of 375 km. Contour interval is 2 nT.

Body 1: represents the Voronezh Bulge
Body 2: region of relatively thin crust (Meissner et al., 1987)
Body 3: represents the Belorussian-Lithuanian Uplift

All bodies have same magnetization, 3 A/m. Bodies 1 and 3 normally magnetized (dip 47° down and declination 67° east, Taylor and Frawley, 1987) while Body 2 is reversely magnetized.

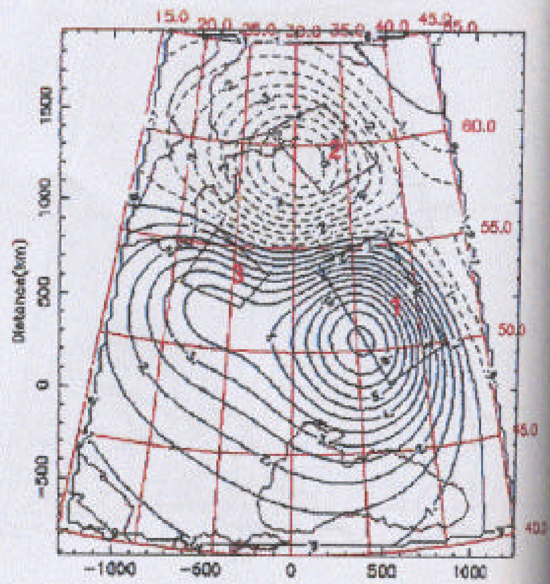

Figure 9. Same model as Figure 8 computed at the Ørsted altitude of 660 km. Contour interval is 0.5 nT.

Conclusion

Magsat and Ørsted anomaly data are in agreement over the region of the KMA. Relatively simple geometric bodies representing major tectonic features can simulate both anomaly fields. Crustal magnetic anomaly signatures are recorded by Ørsted.

References

Alsdorf, D. E., R.R.B. von Frese, J. Arkani-Hamed, and H. Noltimier, Separation of lithospheric, external, and core components of the polar geomagnetic field at satellite altitude, Journal of Geophysical Research, vol. 99, 4655-4667, 1994.

Belloussov, V.V., Continental Endogeneous Regimes, Mir Publishers, Moscow, 295pp., 1981.

Kim, J.W., J-H Kim, R.R.B. von Frese, D.R. Roman and K.C. Jezek, Spectral attention of track-line noise, Geophysical Research Letters, vol. 25, 187-190, 1998.

Meissner, R., Th. Wever, E.R. Flüh, The Moho in Europe--Implications for crustal development, Annales Geophysicae, vol. 5B, 357-364, 1987.

Taylor, P.T. and J.J. Frawley, Magsat anomaly data over the Kursk region, U.S.S.R., Physics of the Earth and Planetary Interiors, vol. 45, 255-265, 1987.