Regional mapping of the Martian magnetic anomalies on the surface with the SVM method

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The Mars shows strong magnetic anomalies of more than 100 nT at 400 km altitude by the Mars Global Surveyor (MGS) observation during 1997-2006 (e.g. Acuña et al., 1998). The magnetic anomalies indicate existence of the ancient Martian dynamo at about 4Ga, although the present Mars has no global magnetic field. Several previous studies have mapped the magnetic anomalies using the MGS observations at about 400 km altitudes of the mapping phase and at about 120-400 km altitudes of the aerobraking phase. The mapping results show characteristic features: the E-W elongated magnetic anomalies of about 15 degree width, and magnetic reduction/demagnetization at some large craters (e.g. Acuña et al., 1998; Purucker et al., 2000; Connerney et al., 2005; Lillis et al., 2008). However, it is difficult to detect fine structures of the crustal magnetic fields on the maps normalized at high altitudes, since short wavelength components are attenuated. In the present study, we have applied the Surface Vector Mapping (SVM) method (Tsunakawa et al., 2014, 2015) to the Terra Cimmeria region and several craters on the Mars.
Terra Cimmeria is a part of the high land region on the southern hemisphere and one of the strongest magnetic anomaly regions on the Mars. Applying the regional SVM method to the MGS observations in 2005 (30-60 S, 150-180 E; -0.4 ~ 3 km in topographic elevation), the surface magnetic field is estimated to be more than 10000 nT at some areas of the Terra Cimmeria region. The SVM maps show elongated magnetic anomalies with about 5 degree width on the surface, which is much shorter in wavelength than those on the previous maps. These short wavelength components are recognized with relatively smaller amplitudes in the observed magnetic fields. We also have analyzed the magnetic fields observed in 2001. Comparison of the SVM maps between 2005 and 2001 datasets indicates good internal consistency. Based on the SVM results, we have calculated the magnetic field along the pass of about 125-375 km altitudes during the aerobraking phase in 1998, resulting in good agreement of the calculated fields with the observed fields. Thus the Martian magnetic anomalies in the Terra Cimmeria region are successfully mapped on the surface in the present study.
One of the remarkable features on the SVM maps of the Terra Cimmeria region is that total intensities of more than 14000 nT on the surface are restricted at areas with about 2-3 km topographic elevations. The diagram of surface total intensity vs. topographic elevation shows that maximum intensity increases with the elevation in range of -0.4 ~ 2 km. These features suggest that magnetic anomaly sources in this region may be distributed in relatively thin layer near the surface. We also have applied the SVM method to several craters and their surrounding regions. Most of these crater regions show correlations between the the surface total intensity and the topographic elevation, similar to the Terra Cimmeria region. The results from the Terra Cimmeria and crater regions imply that the Martian magnetic anomalies seem to be carried mainly by crustal magnetization of a layer with several kilometer depth.

Keywords: Mars, magnetic anomaly, mapping, crust

