Project error of the total intensity magnetic anomaly and importancce of three component magnetic anomalies

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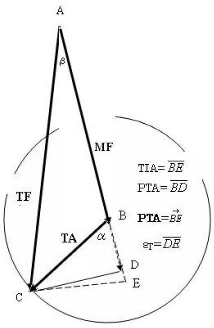
Many previous studies about underground magnetization structure have been conducted. In every case, the data used for analyses were TIA defined as the difference between TF (the intensity of observed geomagnetic total field) and MF (the intensity of geomagnetic main field).
TIA=TF - MF (1).
Because TIA is a scalar without information on its direction, TIA is not a harmonic potential field and does not hold Laplace's equation. Usually MF is defined from the international geomagnetic main field model.
TA (geomagnetic anomaly vector) is defined as
TA=**TF** - **MF** (2)
where **TF**is a vector of TF, and **MF** is a vector of MF.It is clear that TIA is not equal to TA except in the case that **TF** is parallel to **MF**.
PTA is defiend as the partial differencial of scalar potential v. Both v and PTA hold Laplace's equation, however, TIA does not.
If angle beta in the figure is so small, namely TF is regarded to be parallel to MF, TIA is almost the same as PTA. Therefore, TIA has been regarded as the one component of magnetic anomaly field in the direction of MF. Although TIA is essentially not harmonic, as Parker and Klitgord (1972, GEOPHYSICS) told, TIA has been used instead of PTA, which has been treated so far in almost all analyses (upward continuation, reduction to the pole, etc) as harmonic without any attention.
e_T=TIA - PTA (5)
is the project error of TIA.
As seen in the figure, the angle beta and e_T reach the maximum when TA is almost perpendicular to MF, where TIA is almost 0 because TF is almost equal to MF. In the practical case, there is no information for TA in the TF survey, so TA must be assumed for estimation of e_T.
If TIA is positive, we get
TF=MF$*$cos(beta) + root(TA^2-MF^{2}sin^2(beta))
PTA=root(TA^2-TF^{2}sin^2(beta))
e_T=2$*$TF$*$sin^2(beta/2) (6)
if TIA is negative, we get
TF=MF$*$cos(beta) - root(TA^2-MF^{2}sin^2(beta))
PTA=root(TA^2-MF^{2}sin^2(beta))
e_T=2$*$MF$*$sin^2(beta/2) (7)
When MF and TA are assumed as MF=50,000 nT and TA=1,000 nT, e_T is obtained from equation (6),(7) at any angle beta. The relative project error defined by e_T/TIA can be obtained for the angle alfa changing from 0 to 180 degrees. At the maximum angle beta, e_T reaches 10nT, 1% of TA. However e_T/TIA becomes very large because e_T is the maximum and TIA is nearly 0 nT which reflects on the effective digit of the analysis result.
In this lecture,the analysis results of inversion for magnetization analysis using block model showing the large e_T and e_T/TIA corresponding conbination of MF,TF,beta and the magnetization sourse shape.
TIA must not be used for magnetic analysis because TIA is not a physical magnetic field, and the vector magnetic fields must be used instead of TIA for analysis of magnetic anomalies.


A
β
MF
TF
TIA= $\overline{BE}$
PTA= $\overline{BD}$
B
PTA= $\vec{BE}$
TA
α
ε_T= $\overline{DE}$
D
E
C