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# AIRBORNE MAGNETIC METHOD: SPECIAL FEATURES AND REVIEW ON APPLICATIONS

by
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This article describes the main characteristics of the aeromagnetic component of the low altitude survey system of the GTK and discusses future strategies in magnetic data reduction. A second part outlines opportunities for the use of the magnetic survey data. The system was initiated in 1972 and has been used basically the same way until today. Special aeromagnetic features of this second National aerogeophysical programme are as follows: 1) The system was aimed at refining earlier nation-wide measurements at 150 altitude. Hence, it became a low altitude survey (30m) that was equipped with a transverse horizontal gradiometer for improved resolution between survey lines (the first operational system globally). 2) No tie lines were used, because the magnetic sources were too close. 3) Transient and secular corrections were planned to reduce the data to a single event of time (1965.0), hence allowing a free choice of anomaly definition (DGRF 1965.0 was used) and offering an easy opportunity for a global contribution. The following features were developed to facilitate the use of the data since 1980: 4) Grey-tone anomaly display was designed for visual interpretation of the maps. 5) Supplementary nation-wide petrophysical mapping provided a link between magnetic anomalies and geological characteristics of the sources. 6) Supplementary international data reduction and exchange between nearby areas supported regional and crustal scale understanding of the sources. Strategically, high-quality results and easy access to data caused user demand and funding to extend the programme to the whole country, although a minor part only was originally planned for refinement.

Key words (GeoRef Thesaurus, AGI): geophysical surveys, geophysical methods, airborne methods, magnetic methods, magnetic anomalies, magnetic field, magnetic survey maps, petrophysics, Finland

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## BACKGROUND

Between 1951 and 1972, the Geological Survey of Finland (then GTL, now GTK) carried out the first national aerogeophysical mapping programme at a nominal altitude of 150 m above terrain (high altitude survey). The spatial variation of total magnetic field was measured by a flux-gate magnetometer along traverses of separation 400 m on land and 500 m in the coastal waters and the Finnish economic zone. The flight-time variation of the Earth's magnetic field was recorded at a local base station. Data was processed by analogue methods to hand-drawn anomaly contours of floating base level. In 1968–69

# APPENDIX

## Time dependent reductions for aeromagnetic measurements

M. Puranen and J.Korhonen
18.1.1973 (in Finnish)
Geological Survey of Finland
English translation with *explanations*
by Juha V. Korhonen

Reductions are calculated to tie airborne measurement of magnetic total intensity ($F_{rec}$) made at time moment $t_2$ to a fixed time epoch, denoted by $t_0$. The reduced value is called the **absolute value** of the magnetic field at that epoch ($F_{abs}(t_0)$). The reductions include both correction for the annual change in the Earths main field (**secular variation**) within the survey area and correction for the variation in the magnetic field during the measurements (**transient variation**). The change in the intensity of induced magnetic anomalies due to change of inducing magnetic field is neglected.

Secular variation is calculated as a difference between observatory magnetic field values ($F_{obs}$) at time epochs of $t_1$ and $t_0$. The difference between the secular variations in the observatory and in the survey area ($dF_{sec}$) is added to the value of observatory secular variation to obtain the secular variation to be used in reductions for the survey area.

The transient variation is corrected by using magnetic field values ($F_{stat}$), recorded by a fixed magnetic ground station near the survey area. The drift of the magnetic field in the aeroplane during the flight is assumed to be the same as the drift in the magnetic ground station between a fixed time epoch $t_1$ and time moment of measurement $t_2$.

In addition a correction will be applied to remove the effect of magnetic field caused by the aeroplane ($dF_{dir}$). This varies in flight direction.

The correction formula (1) is the following:

$$F_{abs}(t_0) = F_{rec}(t_2) - (F_{obs}(t_1)-F_{obs}(t_0)+dF_{sec}(t_1,t_0)) - (F_{stat}(t_2)-F_{stat}(t_1)) + dF_{dir} \quad (1)$$

$F_{abs}(t_0)$ absolute magnetic total field intensity reduced from the moment of recording to epoch $t_0$.

Values for the quantities are calculated as follows:

$F_{rec}(t_2)$ magnetic field value recorded in the aeroplane (original survey data)

$F_{obs}(t_0)$ magnetic field average of undisturbed days for the epoch of absolute reduction, obtained from the annual reports of the observatory (e.g. 1970.5). *(1965.0 was used for the Finnish low altitude survey)*

$F_{obs}(t_1)$ average total field for an epoch of one hour (e.g. 9.00–10.00 UT), calculated from H and Z component observatory magnetograms. *(Averages for several hours were used. Later on the observatories started to deliver digital F-data, that was used instead of magnetograms.)*

$dF_{sec}(t_1,t_0)$ difference of secular variation between observatory and survey area, calculated from secular variation tables or interpolated from maps. *(This was calculated from secular variation polynomials provided by the Geomagnetic Department of the Finnish Meteorological Institute*)

$F_{stat}(t_1)$ magnetic field average calculated from total field values in the ground station *(The same time epoch, one hour or several hours, was used for all $t_1$ calculations in the same ground station and survey area)*

$F_{stat}(t_2)$ magnetic total field value at the time moment $t_2$, interpolated from ground station measurements *(the airborne measurements were made at 0.5–0.25 sec intervals and the ground station recordings at 10–sec intervals depending on the instrumentation and survey specifications)*

$dF_{dir}$ correction for magnetic field caused by aeroplane in the flight direction of the profile (see M.Puranen and L.Kivekäs, 13.12.1972) *(fully automatic magnetic corrections for aeroplane direction, pitch, roll and yaw was applied since 1994)*

$t_0$ time interval (epoch) of a year, e.g. some internationally agreed reference year, denoted by its average time expressed in year and one or more decimals

$t_1$ time interval (epoch) of magnetically silent hour, or several hours, during the survey, used to tie together secular and transient variations, and denoted by its average time in hour and decimals

$t_2$ time moment of measurement of magnetic field value in aeroplane, considered as a sharp point of time unlike the $t_0$ and $t_1$ that are time periods

In practice the reductions are made as a computer run for each of the survey flights. The corrections are grouped to consist of two terms: the first one is a constant for each profile ($F_{corr}+F_{dir}$) and the second one depends on time ($F_{stat}(t_2)$).

The constant reduction term is calculated as follows:

(2) $$F_{corr} = +(F_{obs}(t_1)-F_{obs}(t_0)+dF_{sec}(t_1,t_0)) - (F_{stat}(t_1) - F_{base})$$

$F_{base}$ selected technical level of magnetic field presentation *(a value of 50000 nT was used for 16-bit computers)*

In each measurement point the correction is calculated as follows:

(3) $$F_{abs}(t_0) - F_{base} = F_{rec}(t_2) - (F_{corr}-dF_{dir}) - F_{stat}(t_2)$$

$F_{stat}(t_2)$ is interpolated from ground station values nearest to time $t_2$.

The input of the data can be done as follows:

Data 1. Magnetic tape of pre-checked airborne magnetic field values and time for each

Data 2. Correction file, consisting of constant correction and directional corrections for each profile in Data 1.

Data 3. Magnetic file of pre-checked ground station records or alternatively a total field file digitized from observatory magnetograms and made absolute.

Result Magnetic tape containing absolute magnetic field intensities *(together with all other information).*

*These formulas have been used since 1973 to present (2005). The level differences indicate an accuracy normally better than $\pm$ 5 nT*