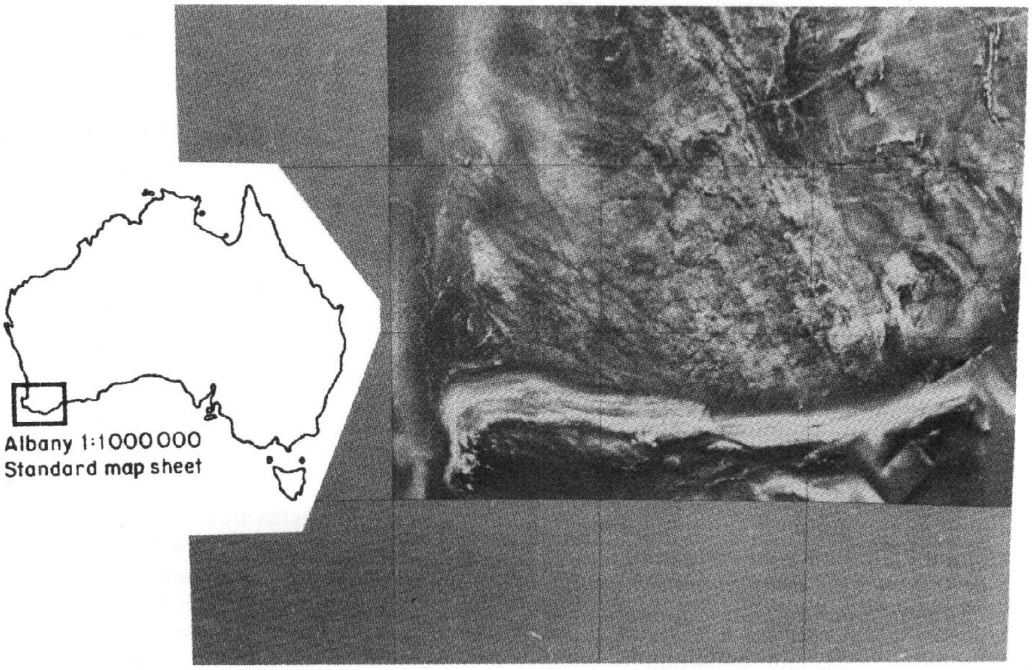

Fig 1 Albany 1 : 1 000 000 sheet area total magnetic intensity greyscale map reduced to 1 : 5 000 000 scale for presentation.

coincides with the magnetic quiet zone, and some scattered granite outcrops on geological maps. What is clear in the new pixel presentations is the prominence of the contact along the northern side and the apparent simplicity of the preserved folds of metasediments. The enveloping of the metasediments indicates that the granite was intruded upwards into a belt of sediments in the Albany Mobile Belt. A few scattered mineral occurrences in this area of extensive cover suggest that it may be of great interest for exploration.

Ground control of satellite observations of the geomagnetic field

J. C. Dooley

Division of Geophysics, Bureau of Mineral Resources, GPO Box 378, Canberra, ACT 2601, Australia.

Measurements of the vector magnetic field were made at about 8000 stations over Australia, mainly during the period 1967–75 (Dooley & McGregor 1982); these measurements comprised the Third-order Regional Magnetic Survey. The distribution of the measurement sites is shown in Fig. 1. One of the objectives of this survey was to improve the representation of the field for the production of magnetic charts; however, it also provides an opportunity to study long wavelength anomalies associated with crustal features.

Another set of vector data over the continent is provided by the MAGSAT project. Anomalies of crustal origin have been extracted from satellite magnetic data and analysed for various parts of the world; for Australia, so far only the scalar field has been used. The limit of resolution of anomalies from satellite data appears to be at a wavelength of about 250 km. It is expected that combined use of the satellite and ground data should improve the resolution, and also enable better treatment of systematic errors present in one or other data set but not in both. The use of vector data should improve the prospects of determining the directions of magnetization of the anomalous bodies.

Two-dimensional Fourier analysis appears to be the most appropriate method for analysis of the data sets over the continental region. It has been shown that distortion due to assumption of a flat earth over a region of the sphere of radius up to about 30° is only about 2%. More serious errors are likely to arise from truncation of the third-order data at the continental boundary. Such errors may be reduced by using vector data from the US Project Magnet, along profiles flown over the oceans adjacent to Australia during the period 1957–63. About 5700 observations have been selected in the region bounded by latitudes 10°N and 90°S, and longitudes 80°E and 180°E.

In order to study crustal anomalies, it is necessary to remove a main field component from the observations. Because of the number of years over which the observations were made, it is also necessary to apply appropriate secular variation corrections to the third-order and Project Magnet data. As the variations amount to several hundred gammas, it becomes important to select an appropriate model, preferably a mathematical model suitable for computer use because of the larger number of observations.

Main field and secular variation models for the region are based on magnetic observatory recordings, and on observations at field stations throughout Australia and on nearby islands, these being repeated at intervals of 5–10 years. There are about 60 such stations in Australia, known as first-order stations.

Global models of the magnetic field, in the form of spherical harmonic series, are produced every 5 years by the International Association of Geomagnetism and Aeronomy (IAGA). The first of these, the International Geomagnetic Reference Field for 1965, gave a reasonable representation of the field over Australia at that epoch, but the predicted secular variation proved to be inaccurate. The model for 1980 incorporated satellite observations, and is more accurate than the previous models. In addition, IAGA in 1981 adopted definitive models (DGRF) for 1965, 1970, and 1975.

Although IGRF and/or DGRF models provide magnetic charts for the Australian region, they are weighted heavily in favour of the northern hemisphere (at least before 1980) because of the larger number of observatories and field observations there. Therefore it has been found advisable to produce charts specifically for the Australian region using local and regional data. Charts for all vector components

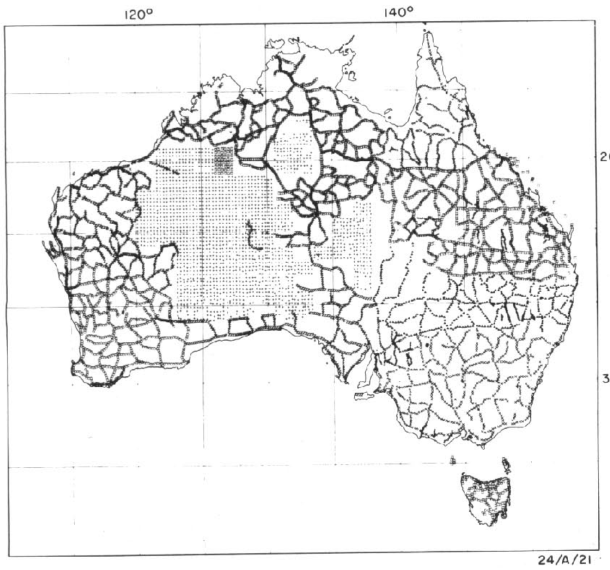

Fig 1 Distribution over Australia of third-order regional magnetic stations.

have been produced by the Bureau of Mineral Resources (BMR) for 1957.5, 1970, and 1980, and for declination only for 1942.5, 1955.5, 1960.5, and 1965.0. Each of these charts included a predicted secular variation model.

The 1980 BMR charts were based on fourth-order polynomials in latitude and longitude, fitted to the observed values for D, H, and F corrected to 1980.0 by a graphically derived secular variation; the secular variation was also fitted with a polynomial. A comparison of this model with global spherical models was made by McGregor *et al.* (1982). Previous charts were derived and contoured manually. Recently these contour maps have been digitized and polynomials have been fitted to the digital values.

Another model was derived by the Marine Geophysical Survey Group when it was found that the IGRF 1965 model was inappropriate for applying secular variations in this area; this was called the Australian Geomagnetic Reference Field (AGRF). It is a spherical harmonic series, and is based on global data, but paying particular attention to fitting the available data in the Australian region. It includes quadratic time coefficients for secular variation.

For the proposed Fourier analysis of vector data over the Australian region, the data required are the orthogonal field components X, Y, and Z (in the north, east, and vertical directions) over a 'square' area on the sphere; an origin at 25°S, 135°E seems appropriate, and the area should extend to 3.2 Mm in each direction from the origin. To examine the problem of appropriate models to produce such a data set, plots were made of observed field values, together with those derived from the above models, for X, Y, and Z, for all observatories and first-order stations in the region. For various reasons none of the models is entirely satisfactory for deriving the secular variation corrections.

The DGRF models are a substantial improvement on the earlier IGRF models, but are not altogether appropriate for the region; moreover they are available only from 1965 onwards, and thus do not cover the period of the Project Magnet surveys. An attempt was made to overcome this difficulty by using a quadratic secular variation model, for the field from 1900 to 1965, derived *ad hoc* by Fougere (1969), to project backwards from the 1965 DGRF values. This model appears to be reasonably consistent with observed values earlier in the century; however, nearly all plots show a distinct break in gradient at 1965.

The BMR polynomial models in general do not represent the field well in the outer parts of the region. An area of applicability is defined, mainly for the 1980 models, outside which the polynomials should be used with caution, if at all; however for some of the earlier models, even this area is too large. There are large time gaps in the series of three-component charts. Polynomials for D, H, and F are not easily converted to X, Y, and Z, and the scale of the east co-ordinate, being degrees of longitude, varies with latitude.

The AGRF was plotted from 1955 onwards, and gives a reasonable fit to the observed values for the earlier part of the period; but it starts to diverge from observed values and the more recent models about 1975. The selected approach is to use the AGRF model as a first approximation, and to plot the differences between this and observed values for observatories, and for selected field stations where good continuity of three-component data is available. These plots should indicate the nature of any correction required to the AGRF secular variation, possibly a spline function with coefficients varying smoothly spatially. For the main field, a merge between the 1980 BMR model over most of the area, with the 1980 IGRF to extend this outside its area of applicability, is proposed. There may be some advantages in using a co-ordinate system with one axis aligned along average magnetic north for the region, particularly if total intensity data are to be incorporated at a later stage.

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Processing of satellite magnetometer data

B. D. Johnson

Centre for Geophysical Exploration Research, Macquarie University, North Ryde, NSW 2113, Australia.

The magnetic field observed at distances ranging from 350 to 500 km above the earth is a combination of fields due to several different sources. Electrical currents flowing in the outer core of the earth cause the main magnetic field of the earth, which varies in amplitude from 30 000 to 50 000 nT. The main field has time variations of the order of hundreds to thousands of years and spatial variations of the order of hundreds to thousands of km.

Electrical currents in the ionosphere cause magnetic field disturbances ranging from ten to thousands of nT in amplitude. These ionospheric disturbances have time variations ranging from ms to days and spatial variations varying from metres to hundreds of km. The ionospheric disturbances are particularly large in the auroral zones near to the north and south magnetic poles.

Electrical currents in the magnetosphere form a ring current system around the earth, at a distance equivalent to several earth radii, which gives rise to magnetic field disturbances typically up to 50 nT in amplitude. These magnetospheric disturbances have time variations of the order of a day and spatial variations of several thousands of km.

After removal of the main magnetic field and the ionospheric and magnetospheric disturbances, the residual magnetic field is due to variations in the magnetization of rocks within the crust of the earth. This crustal component of the magnetic field is a few tens of nT in amplitude at satellite altitudes, and has spatial variations of hundreds to thousands of km. The crustal component has essentially no time variations and therefore is separable, in theory, from the other components in spite of its relatively low amplitude. In practice, the data distribution in space and time does not permit complete modelling of the time varying disturbances. In addition, there is an overlap between the spatial frequencies of the core and crustal field components.

A map of the crustal-source magnetic field for Australia, obtained from satellite data (Johnson & Mayhew 1985), is given in Fig. 1.

Reference

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