out by subtracting a base station record made simultaneously with that of the moving survey instrument, but only if fluctuations at the base station and at the survey instrument are expected to be the same. Such information is precisely that supplied by observations such as those in Fig. 2. In places, in Australia, base station and survey instrument may correctly be separated by distances of approximately 100 km. In other places, and notably near coastlines, significant errors may be introduced by 'base station to survey instrument' distances of as little as 10 km. Knowledge of the geomagnetic induction patterns of a continent and of its coastal seas allow such errors to be minimized.

The spatial pattern of the daily magnetic variation over Australia, with application to the correction of magnetic survey data

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Time variations of the earth's geomagnetic field, with periods of a few seconds to the daily variation, can introduce errors of up to tens of nanoteslas into magnetic survey data (Lilley 1982; Riddihough 1971). These errors may be removed either by rapid looping methods similar to those used in gravity surveys, or, as is more usually the case, by subtracting from the survey data the record of a continuously monitored ground station. This latter method usually works well if the survey is undertaken relatively close to the base monitor, but when the distances involved become of the order of several hundred kilometres, as they may in aeromagnetic surveying in Australia, the assumption of uniform variations on this scale may not be valid. Since magnetic surveys are not usually undertaken on days of strong disturbance of the geomagnetic field, the main errors will arise from pulsation events (I. Hone & D. Pridmore, pers. comm.), and from the daily variation, which is further considered here.

Spatial non-uniformities in the daily variation can arise either from irregularities in the ionospheric current systems producing the primary external field, or from secondary fields produced by currents induced in the ground by the primary field. In general, the normal daily variation differs between observation sites with a simple local-time phase dependence, as the earth rotates beneath the source currents, which remain stationary with respect to the sun, and with a smooth latitude dependence observed in the amplitude (Lilley 1982).

Several anomalous zones have been defined in Australia by Lilley (1982, 1984), using arrays of magnetometers. The effects are most noticeable for short period events of up to a few hours duration, but significant lateral variations in the diurnal field are visible in the records from near Cobar, where current-channelling is postulated within the near-surface formations. The coast effect across south-east Australia is also prominent in the daily variation (Bennett & Lilley 1973). Anomalous zones in northern South Australia and south-west Queensland are most obvious for short-period events, and this is true again for the more southerly regions of South Australia, which have now been mapped in some detail (White & Polatajko 1978, 1985; White & Milligan 1985; Chamalaun 1985). It is interesting that a very strong anomaly at short periods on the southern Eyre Peninsula, South Australia (White & Milligan 1984), appears to have negligible effect on the daily variation. There are, however, still large areas of Australia, particularly in Western Australia, the Northern Territory, and eastern Queensland, where geomagnetic variation studies using arrays of magnetometers have not been undertaken; hence geological effects on the magnetic variations are unknown for these regions.

Some information regarding the spatial distribution of the daily variation across Australia is available from recordings made by the Bureau of Mineral Resources (BMR) as part of their first-order magnetic surveys for the production of epoch maps of the seven geomagnetic elements. Records of H, D, Z and F are available for at least 2 days in succession from a network of more than 60 repeat sites across Australia (Fig. 1). Although these data have not been simultaneously recorded, variations at each site may be compared with observatory data from Gnangara, Port Moresby, Toolangi and Canberra to give an estimate of the spatial distribution across Australia. As Lilley and Parker (1976) point out, the analysis of 1 day may be used to compare variations between two different sites, even though it may not give a reasonable estimate of the average daily variation at a single location.

Riddihough (1971) compared the records of seven sites across Ireland with the corresponding total field records derived from Valentia Observatory. He found that the errors involved in assuming uniformity in the daily variation lie between ± 2 and ± 6 nT, with a maximum station separation of approximately 300 km. Daily variations at each site were found to be highly correlated with those at the observatory, and it was concluded that while both time and amplitude differences affect the errors in reduction of magnetic survey data, the time variations have much less effect than the amplitude variations. A consistent geographical pattern of amplitude differences was contoured for Ireland, and subsequently used as a basis for estimating errors involved in reducing magnetic survey data. Srivastava (1971) described a similar analysis for the east coast of Canada, using

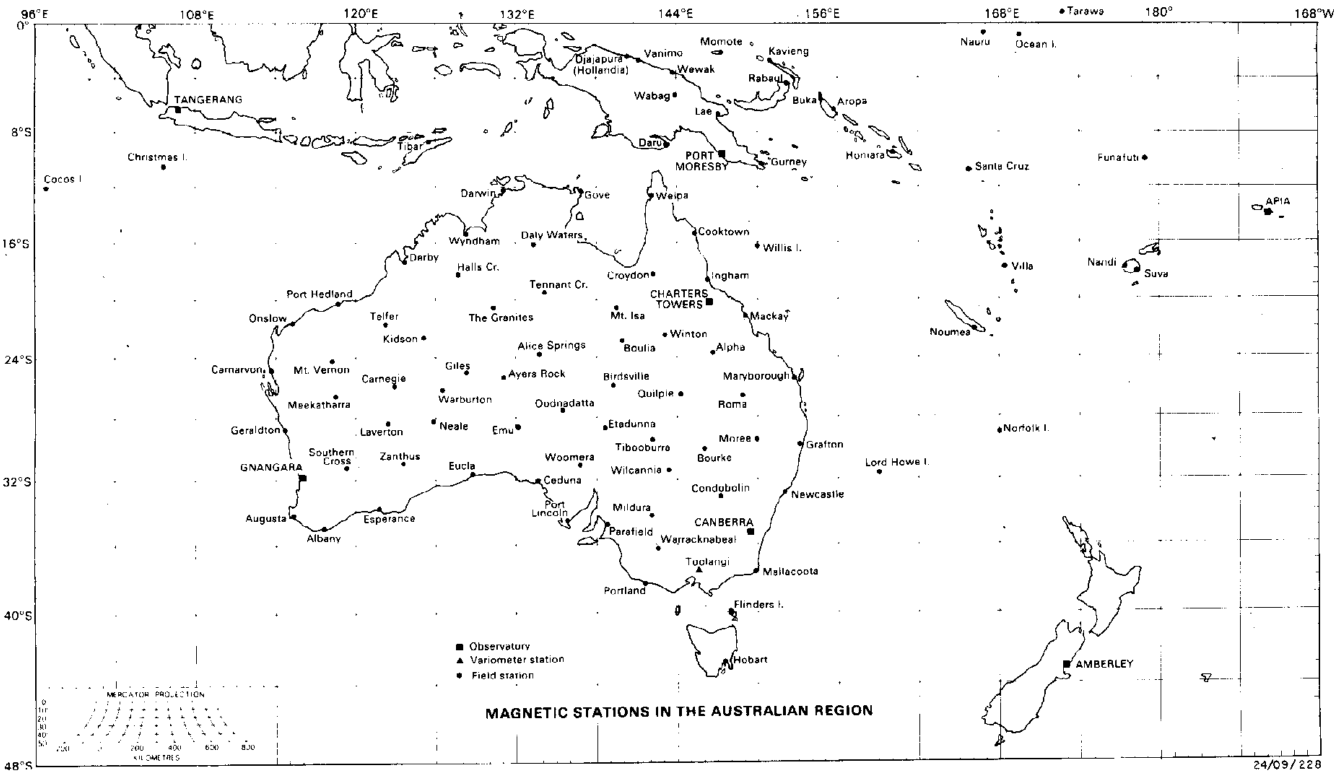

Fig 1 Current first-order magnetic sites, variometer stations, and magnetic observatories for the Australian region.

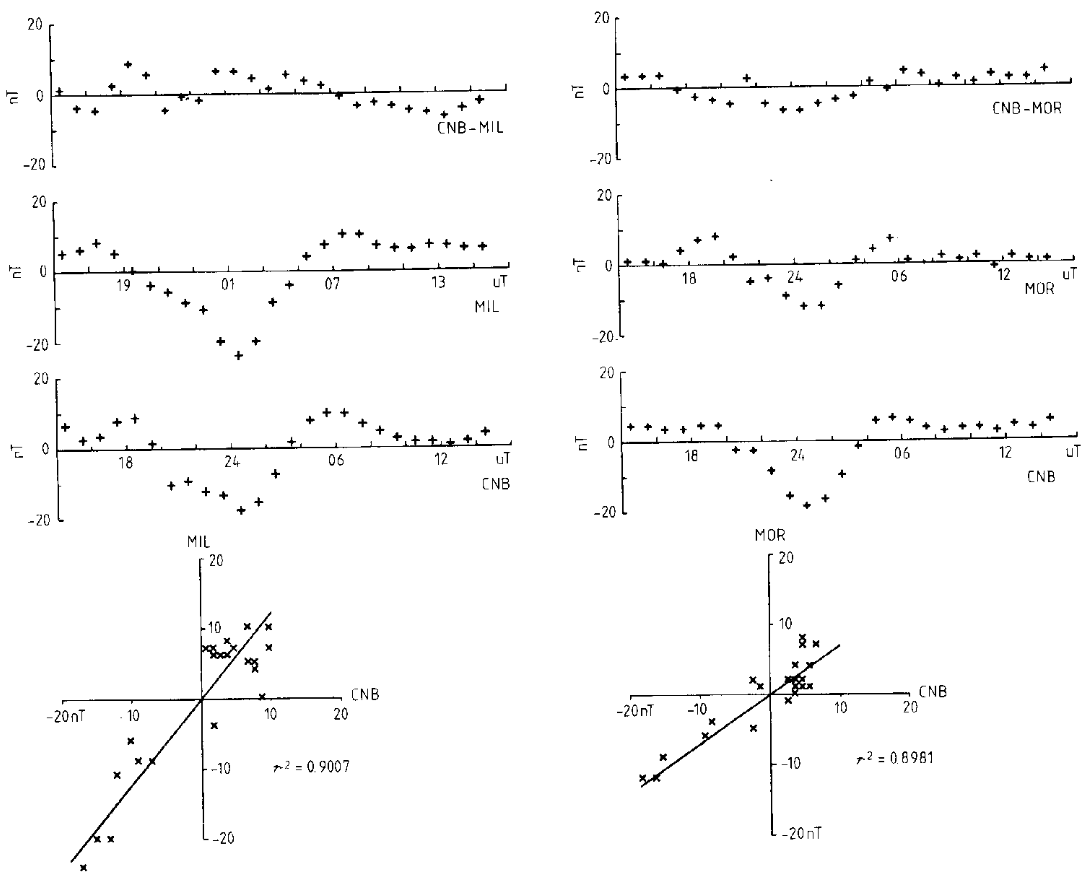

Fig 2 Examples of total field daily records of hourly means from Mildura (MIL) and Moree (MOR) compared with the corresponding records from the Canberra Observatory (CNB). The high degree of linear correlation is indicated.

both correlation analysis in the time domain, and comparison of Fourier amplitude and phase values, from several days of continuous data.

It is proposed that similar analyses be undertaken in Australia using the first-order data available, and supplemented, where possible, by selected data available from the base monitors of aeromagnetic surveys. These analyses should complement the information already available from previously mentioned array studies, the usefulness of which for magnetic survey reduction has already been suggested by Lilley (1982, 1984). First-order stations are re-occupied, on average, once every 5 years, with variometer recording having commenced about 1965. Thus the variability of station differences can be tested over several epochs. It may be that Australia can be divided into northern and southern zones on either side of the 40°S dip latitude, which is the approximate focus of the Sq current system. Sq variations in F and H are reversed in northern and southern Australia about this line, the position of which is variable from day to day (McGregor 1979). If an average latitudinal effect can be removed from the correlated data, it may be possible to produce a map which reflects mainly changes in the expected pattern of the daily variation across Australia due to geology. Figure 2 illustrates the high degree of correlation obtainable for selected days of total field measurements between Canberra Observatory and Mildura (similar latitude) and Moree (similar longitude). The spatial resolution is limited by the large average spacing between the first-order sites (approximately 500 km). Future large-scale array experiments across Australia will help define better the influence of geology and tectonics on the geographical pattern of the daily variation, and also short-period variations.

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Estimating the three-dimensional structure of the electrical conductivity of the earth

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One way to assess the three-dimensional structure of the electrical conductivity of the earth is to piece together as a mosaic the results from local studies. In part, the construction of such mosaics is the motivation for local studies. On the one hand they supplement the information available from an averaged global model; on the other, they define limits on the range of applicability of global models.

Another way is to use available world-wide geomagnetic data to identify global features in the earth's transient magnetic field, and to then derive, using these features, averaged three-dimensional electrical conductivity models. Numerous approaches have been suggested to overcome the following difficulties: the complexity of the earth's geomagnetic field, which consists of the external and internally-induced transient field, coupled with the internally-generated permanent and transient fields; the erratic sparse nature of the available geomagnetic data; and the need to stabilize, in some appropriate way, the inherent improperly-posedness of the underlying mathematical model of electromagnetic induction, which relates the observational data to the electrical conductivity. The obvious manifestations of these difficulties is the failure of the various methods to yield reasonably consistent models for the electrical conductivity. In fact, about their only common feature is the conclusion that electrical conductivity increases abruptly at a depth somewhere between 400 and 750 km. There is no agreement