AGSO Journal of Australian Geology & Geophysics, 17(2), 11–21

Australian national airborne geophysical databases

I.G. Hone[1], P.R. Milligan[1], J.N. Mitchell[1], K.R.Horsfall[1]

The Australian Geological Survey Organisation maintains national databases of aeromagnetic, radiometric and digital elevation data, which have been progressively collected since the 1950s and are still being added to. The quality of the information collected in recent years is such that a case can be made for re-flying large parts of Australia, over which only old, poor-quality data are available.

Introduction

The major, publicly available, Australia-wide databases of airborne geophysical data are those operated by the Australian Geological Survey Organisation (AGSO). State government departments hold sets of data relating to their particular State and some private companies maintain proprietary databases.

The national airborne geophysical databases held in AGSO contain data covering 99 per cent of onshore Australia, and substantial areas offshore, encompassing over 9 000 000 km^2 in total. The data have been collected continually since 1951 and have a wide range of specifications, resulting from changes in technology, procedures, and specific requirements over this period. Data types have expanded from just magnetic, to include gamma-ray spectrometry data and, since 1992, digital elevation data. The databases, which are being continually upgraded, are a valuable resource for Australia.

At the end of 1996, the databases held 11 000 000 km of magnetic data, 8 000 000 km of gamma-ray data, and 1600 000 km of digital elevation data. The areal percentage coverage of onshore Australia is:

Type	*Total coverage*	*Acceptable broad reconnaissance (3200 m line spacing)*	*Acceptable regional (500 m line spacing)*
Magnetic	99%	85%	23%
Gamma-ray	50%	50%	23%
Elevation	6%	6%	6%

The data in AGSO's national airborne geophysical databases provide a strategic framework necessary for both Government, industry and other researchers to assess resource potential, determine land use and environmental management policies, and plan detailed exploration activities. They form an integral basis for establishing the geological framework of Australia and maintaining Australia's international exploration competitiveness.

AGSO (formerly the Bureau of Mineral Resources, Geology & Geophysics—BMR) commenced airborne geophysical surveying in Australia with a survey in the Gippsland area of Victoria in 1951. Since then, AGSO has been acquiring data from surveys it has flown itself, and from surveys flown for it under contract. The data have been catalogued and stored and form the basis of the national airborne geophysical databases. These data have been added to by data from State surveys and companies, and by data which came available through the Petroleum Search Subsidy Acts (PSSA).

The State government databases of airborne geophysical data can be divided into two types, based on how they were acquired. The first contains data acquired by private companies as part of their exploration programs and provided to the State government as part of the legal requirements for the issuing of exploration tenements. Most of the data sets in these databases arise from surveys over small areas, and thus are not regional. Data sets over large areas will be incorporated into regional databases. Some of the company data are held confidentially. The second type contains data which have usually been acquired under contract for the State government. Most data in the latter databases have been incorporated into AGSO's national airborne geophysical databases.

Databases held by private companies contain data the companies have acquired from government or other agencies and data they have had flown for themselves. The companies do not usually make data available from their databases. However, some geophysical contractors hold data which they will sell on a multi-client basis, and brokerage services exist which have the rights to sell some private company data.

This paper describes AGSO's databases, which hold the widest coverage of publicly available regional data. An earlier review of the airborne magnetic surveys in these databases was given by Tucker et al. (1988).

Rate of accumulation of data

AGSO acquires, on average, approximately 250 000 line km of geophysical data annually with its own aircraft and up to 300 000 line km by contract (Figs 1, 2). The AGSO program is long-term and ensures a steady stream of data to the latest quality standards.

In recent times, increased airborne geophysical activity by State governments has markedly increased the growth rate of the databases. Recent data acquisition is summarised in Table 1. Of the formal State exploration initiatives, the South Australian

Table 1. Summary of recent airborne geophysical data acquisition by State government.

State	*Period*	*Amount (km)*	*Comments*
New South Wales	1994 – 1996	800 000	Discovery 2000. Additional 180 000 km in joint projects with AGSO.
Northern Territory	–1996	930 000	Long-term program.
Queensland	1994 – 1996	290 000	Mainly Airdata—part of Geomap 2005.
South Australia	1993 – 1995	930 000	South Australian Exploration Initiative. Additional 70 000 km in joint projects with AGSO.
Tasmania		70 000	
Victoria	1994 – 1997	360 000	Victorian Initiative for Minerals and Petroleum. Additional 200 00 km in joint projects with AGSO.
Western Australia	1994, 1995	120 000	Additional 170 000 km in joint projects with AGSO.

[1] Australian Geological Survey Organisation, GPO Box 378, Canberra, ACT 2601

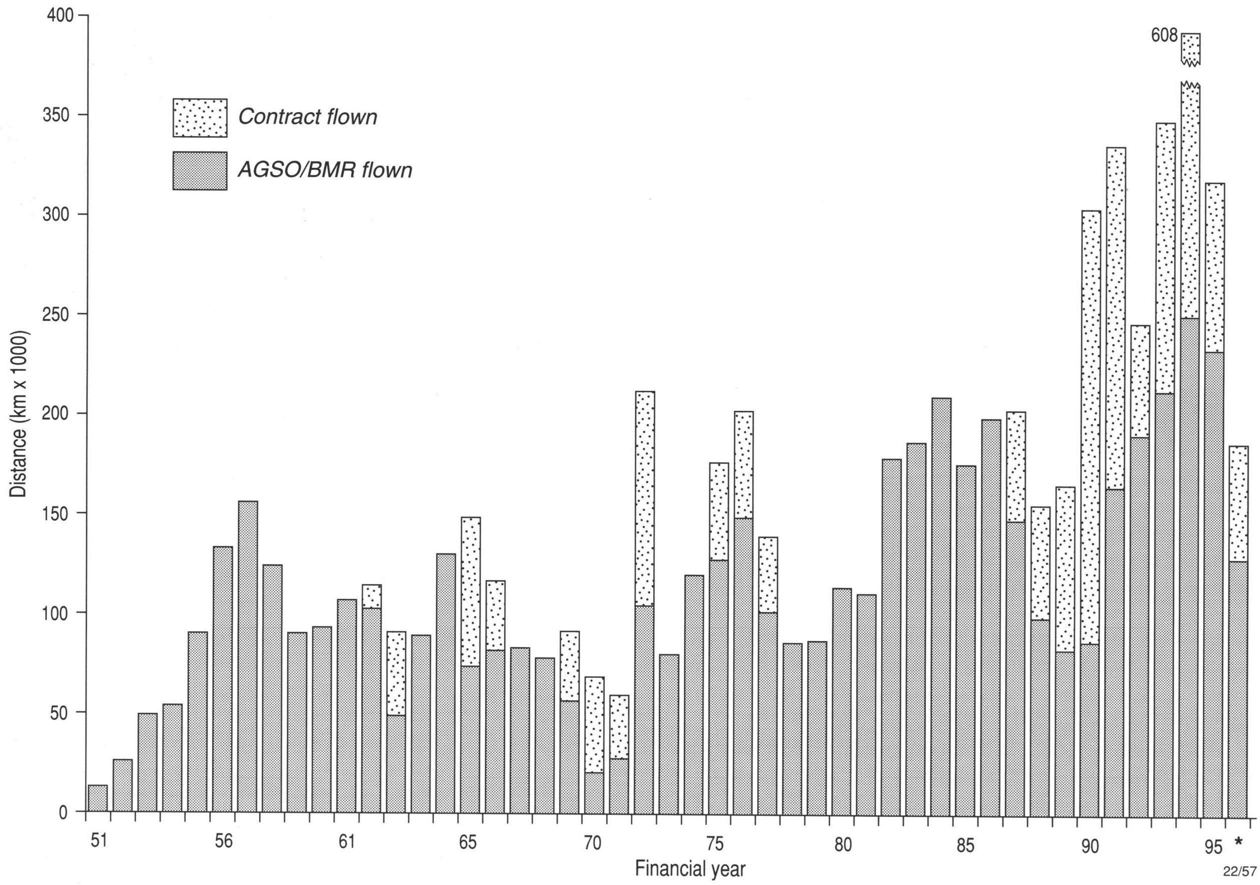

Figure 1. Accumulation of AGSO data into national airborne geophysical databases—frequency distribution up to December 1996.

Exploration Initiative has just been completed, and data acquisition in the Victorian, New South Wales, and Queensland initiatives is programmed to finish in 1997, 2000, and 2000, respectively.

Survey cover

Airborne magnetic surveying and, more recently, gamma-ray spectrometric surveying, in Australia have been conducted in a systematic manner for the past 40 years. The Australian continent is topographically mapped into regular mapping areas, the standard mapping unit for Australia-wide reconnaissance airborne surveys being the 1:250 000 map sheet. Each sheet is 1.5° longitude by 1.0° latitude, equating to approximately 150 km by 100 km (depending on latitude).

Approximately 99 per cent of onshore Australia has coverage of magnetic data (Fig. 3). The only areas with no coverage are Rawlinson, Wilson, and Webb 1:250 000 Sheet areas in central Australia. Although completion of first pass coverage was aimed for by 1989, it is now unlikely that complete coverage will be obtained until 1997 or later.

Gamma-ray data which can be presented as maps cover about 50 per cent of onshore Australia (Fig. 4). Many of the early gamma-ray data were acquired and processed in such a way that the best form of presentation was as locations of the most significant anomalies; these data are not considered as part of the coverage in the maps in this paper, although the results are still available from the database.

Digital elevation data cover about 6 per cent of onshore Australia (Fig. 5).

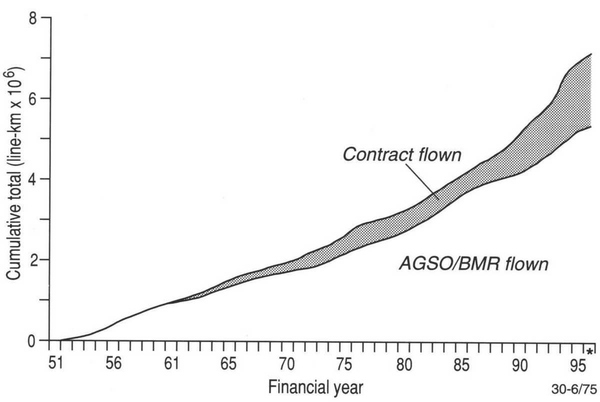

Figure 2. Accumulation of AGSO data into national airborne geophysical databases—cumulative distribution.

Line spacing

Figures 3, 4 & 5 show line spacing of data coverage over Australia for magnetic, gamma-ray and digital elevation data. For areas surveyed more than once, the line spacing of the latest survey has been used.

The line spacing of aeromagnetic data in the coverage of Australia has a wide range and is an important consideration when discussing coverage. Until the 1980s, 1500–1600 m was considered satisfactory as a first pass reconnaissance standard for hardrock areas, and 3200 m for sedimentary basins. AGSO surveys, which were the major contributors to the databases, reflected this. Data acquired at wider line spacings were considered substandard, but adequate for first pass reconnaissance coverage. A few areas where 1600 m spaced lines were parallel to strike, or where there were large noise envelopes on data, were also considered substandard.

The early acceptance of 1500–3200 m line spacing was strongly motivated by a desire to achieve airborne magnetic coverage over all of onshore Australia as soon as possible.

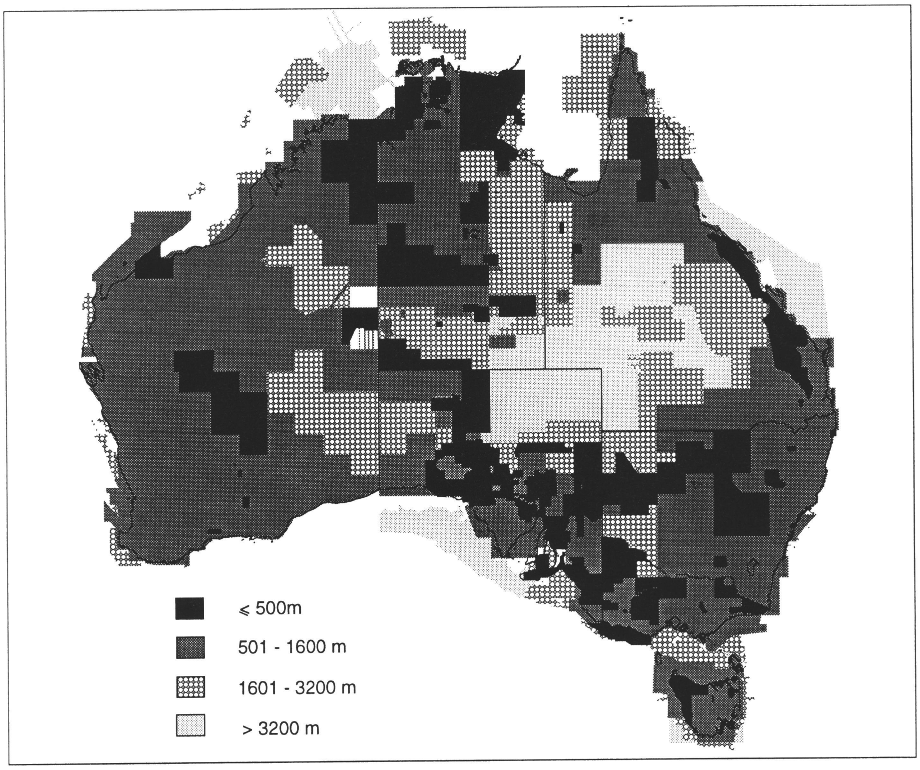

Figure 3. Airborne magnetic coverage of Australia—line spacing.

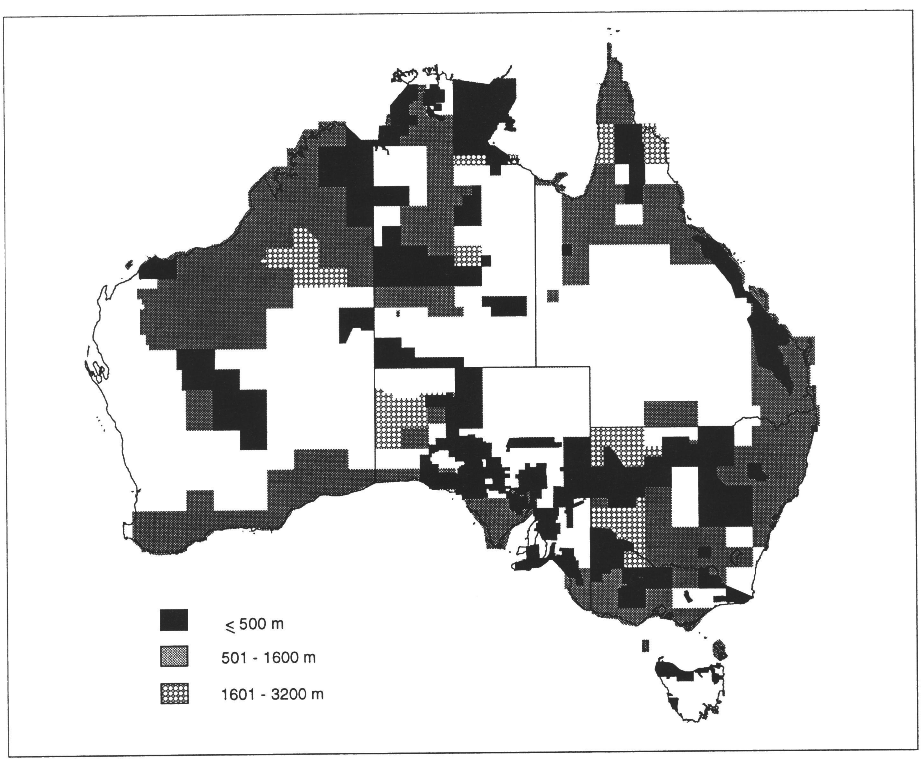

Figure 4. Airborne gamma-ray coverage of Australia—line spacing.

As closer line spacing slows down the rate of coverage, a trade-off was made for a moderate amount of information over large areas in preference to a large amount of information over small areas.

Despite the tendency to survey with 1500–3200 m line spacing, and closer in recent years, there is still almost 15 per cent of onshore Australia where line spacing is more than 3200 m. For most of this area digital line data are not available. Digital gridded data with a basic cell size of 2 km, which were generated for the 1976 Magnetic Map of Australia (BMR 1976), are the only digital data available.

Less than 25 per cent of onshore Australia is covered with aeromagnetic data acquired along flight lines spaced at 500 m or less. Spacing of 400–500 m is now considered the standard for onshore regional surveys with appropriate line direction, and for most future regional surveys it will be no more than 400 m.

Figure 6 illustrates the effects of line spacing on the resolution of magnetic pixel image maps and the usefulness of data, particularly for geological mapping. The data are from a small portion of the Broken Hill 1:100 000 Sheet area and were acquired with a line spacing of 100 m and a flying height of 60 m above ground surface. They form part of the data set acquired by AGSO for the Broken Hill Exploration Initiative, a collaborative program between the governments of New South Wales, South Australia and the Australian Federal Government.

The four colour images (Fig. 6 a–d), display histogram-equalised TMI data at 1:100 000 scale for line spacing of 100, 200, 400 and 800 m, with grid intervals of one-fifth of the line spacing—20, 40, 80 and 160 m, respectively. Note that the calculated grid cells have not been interpolated to a smaller grid cell size, which would give smoother looking images, but would not increase the amount of information. Whereas the 100 m and 200 m line-spaced data show good resolution, there is some degradation when the line spacing increases to 400 m. Resolution of anomalies is poor for the data at 800 m spacing.

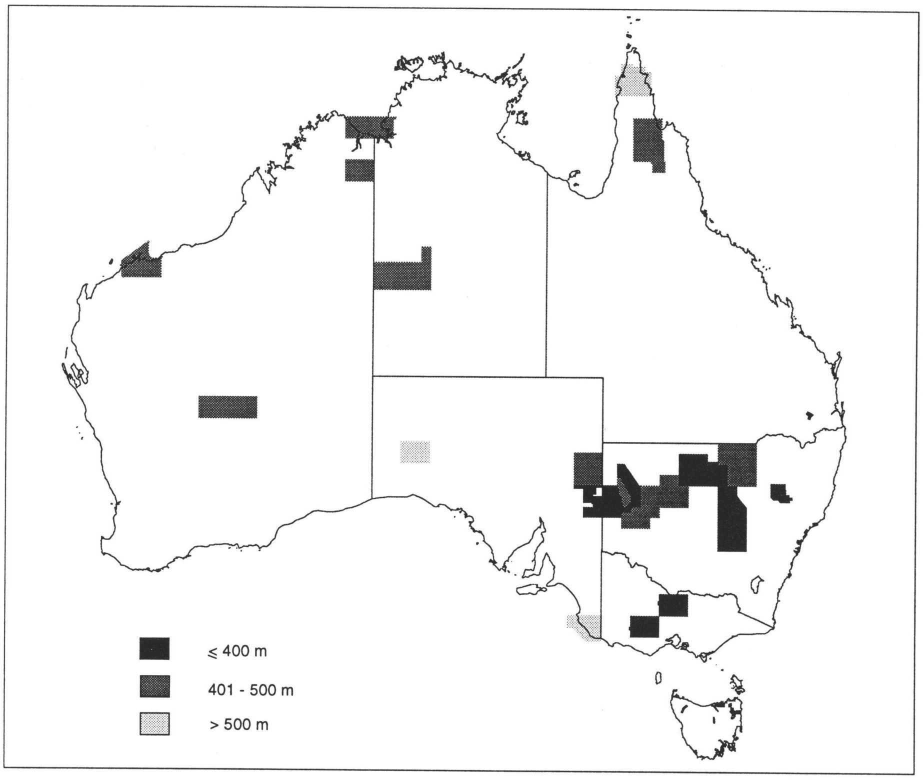

Figure 5. Coverage of Australia by digital elevation models derived from airborne geophysical surveys—line spacing.

The four grey-scale images (Fig. 6 e–h) further illustrate the concept and show how manipulations of data require close line spacing. Grid data used to generate these images have been reduced to the geomagnetic pole and the first vertical derivative calculated. This is a technique which emphasises high frequencies, and with the addition of a sun angle (from the west for these images) is capable of revealing very subtle information in the data. This technique is frequently used in exploration and geological mapping. For detailed mapping, these images illustrate that data from the 400 m line spacing break down under the first vertical derivative, and that even the 200 m line-spaced data do not give full resolution. 100 m line-spaced data are required for the first vertical derivative transformation in this instance.

Recent experience in using airborne magnetic data in regional geological mapping, such as described above, and analysis of large areas of airborne magnetic data acquired at 400/500 m flight-line spacing vis à vis 800 m and 1500/1600 m spacing, indicate that 400 m is the acceptable standard for regional airborne surveys (see Fig. 4 and later).

As with magnetic data, reassessment of data coverage has redefined what is an acceptable standard for coverage of gamma-ray data. At present, to be acceptable, gamma-ray data from areas of hard-rock outcrop should be acquired with 400/500 m flight-line spacing. In other areas, spacing of 1600 m may be acceptable, but closer is desirable, and mandatory in many instances.

Flying height

Figures 7 and 8 show the flying height of data coverage over Australia for magnetic and gamma-ray surveys. Most regional airborne geophysical data over Australia have been acquired on surveys flown at a nominal constant terrain clearance. Some early surveys in hydrocarbon-related projects and surveys in very mountainous areas maintained a constant height above sea-level. These surveys could have a large range of terrain clearance.

Most coverage of magnetic and gamma-ray data is at 150 m flying height, and is generally from surveys conducted before 1989. Specifications set at the start of the National Geoscience Mapping Accord (NGMA) require a flying height of 100 m. In some areas of Australia this has been lowered in practice to enable a better match with surveys organised by States or to enable the data to better solve specific geological problems. In general, exploration surveys have been flown at a lower height than surveys for regional geological mapping.

Accuracy of data

The data in the national geophysical databases show there has been a large range of instrumentation and survey specifications used over the years of acquisition. Changes have resulted from the quest for improvement in data quality and efficiency of acquisition and processing. Some of the major changes that have occurred and their effect on data quality are given in Table 2.

Data in the databases have been generated by a large range of instrumentation, as illustrated in the Appendix, which provides details of the acquisition systems employed by AGSO since 1951.

Magnetic data acquired by AGSO since 1975 have had the International Geomagnetic Reference Field (IGRF) for the appropriate year removed. Data from some earlier AGSO surveys also had the IGRF removed, but, for many surveys, an arbitrary regional was removed, which was not always documented.

Table 2. AGSO airborne survey instrumentation and specifications, 1951–1996.

Years	Navigation and flight path recovery	*Effect on data quality*
1951–1980	Photographs alone	Overall improvement in accuracy of locations—accuracies range from 200 m to better than 5 m.
1971–1991	Photographs and Doppler	
1955–1965	Early radio-navigation (e.g. requiring flying in arcs)	Departures from the desired track range from over 2 km to less than 20 m.
1980–1992	Later radio-navigation	
1988–	GPS, differential GPS (and real-time differential GPS navigation)	
	Magnetometry	
1951–1983	Fluxgate magnetometers	Reduction in rates of drift: up to 50 nT/hr for fluxgates (particularly in early stages of a flight); almost zero for proton precession and alkali vapour.
1963–1989	Proton precession magnetometers	More accurate digital recording—proton precession and alkali vapour.
1985–	Alkali-vapour magnetometers	Changes in noise level of magnetometers: fluxgate, 0.1–0.5 nT; proton precession, 5 nT (very early magnetometers)–0.1 nT; alkali vapour, 0.1 nT–better than 0.01 nT. Changes in sample interval: fluxgate, continuous analogue recording, records digitised usually at 1 s intervals; proton precession, 0.2–1 s (60–70 m at normal survey speeds)—note that noise level increased as the sample interval decreased for any instrument; alkali vapour, 0.1–0.3 s (6–7 m to 18–21 m at normal survey speeds).
	Gamma-ray spectrometry	
1952–1968	Scintillometers	Increase of channels from 1 (i.e. total count) to 256—note that some spectrometers have 1024 channels.
1969–	Spectrometers	
	Size of crystals	
1952–1981	0.4–< 17 L	Decrease in noise of acquired data.
1979–1991	17 L	Approximate decrease in relative noise by 1.4 when crystal size is doubled.
1985–	33 L	
1984–	Removal of effects of atmospheric radon by use of upward-looking crystals	
1989–	by analysis of the spectrum	Improvement in quality and integrity of processed gamma-ray data.
	Data acquisition systems	
1951–1974	Analogue recording and processing systems	
1968–	Digital recording and processing systems	Enables better processing of digital data.

Datums

Following recommendations by the Intergovernmental Committee on Surveying and Mapping (ICSM) in 1994 that the Australian geodetic reference system should be based on a geocentric datum, airborne geophysical data since October 1994 have been located using the WGS84 datum. At present, these data sets are the only ones in the national airborne geophysical databases using this datum.

Most location data older than 1966 are referenced to the Clarke 1858 ellipsoid. The Australian Geodetic Datum was adopted in 1965 as the official datum for Australia. However, for some surveys conducted after 1965, the maps used for flight-path recovery were still in the previous datum and, thus, the geophysical data were still referenced to the earlier datum.

Fluxgate magnetometers provide field values to an arbitrary datum. Proton precession and alkali-vapour magnetometers give absolute readings of the magnetic field. AGSO data recorded with these instruments have had 5000 nT added following removal of the IGRF. This is not usually the case for data acquired from other sources.

The height datum used in the digital elevation models is the Australian Height Datum (AHD).

Contents of database

The data holdings in the national airborne geophysical databases consist of analogue and digital data and include original material gathered in the field as well as processed data.

Digital data

The digital data are stored in survey units. For ease of access and indexing, most AGSO surveys correspond to regular areas, such as one or more full 1:250 000 Sheet areas or 1:100 000 Sheet areas. Three sets of digital data are normally archived:

- raw field data,
- checked and edited (but otherwise unprocessed) data, and
- final, processed data—both point-located and gridded data.

Three copies of each set are archived: one copy is kept at AGSO, two are stored off-site.

Until 1994, all digital data were archived on archive-quality 9-track magnetic tapes. Because of the large volumes of data being generated from recent surveys (0.1 s sampling intervals for magnetic data, 256 channels of gamma-ray data recorded each second), compared to the capacity of a 9-track tape, since 1994 data have been archived on 5 Gb Exabyte tapes, using two different brands per set. A fourth copy of the processed digital data is now also archived on magneto-optical

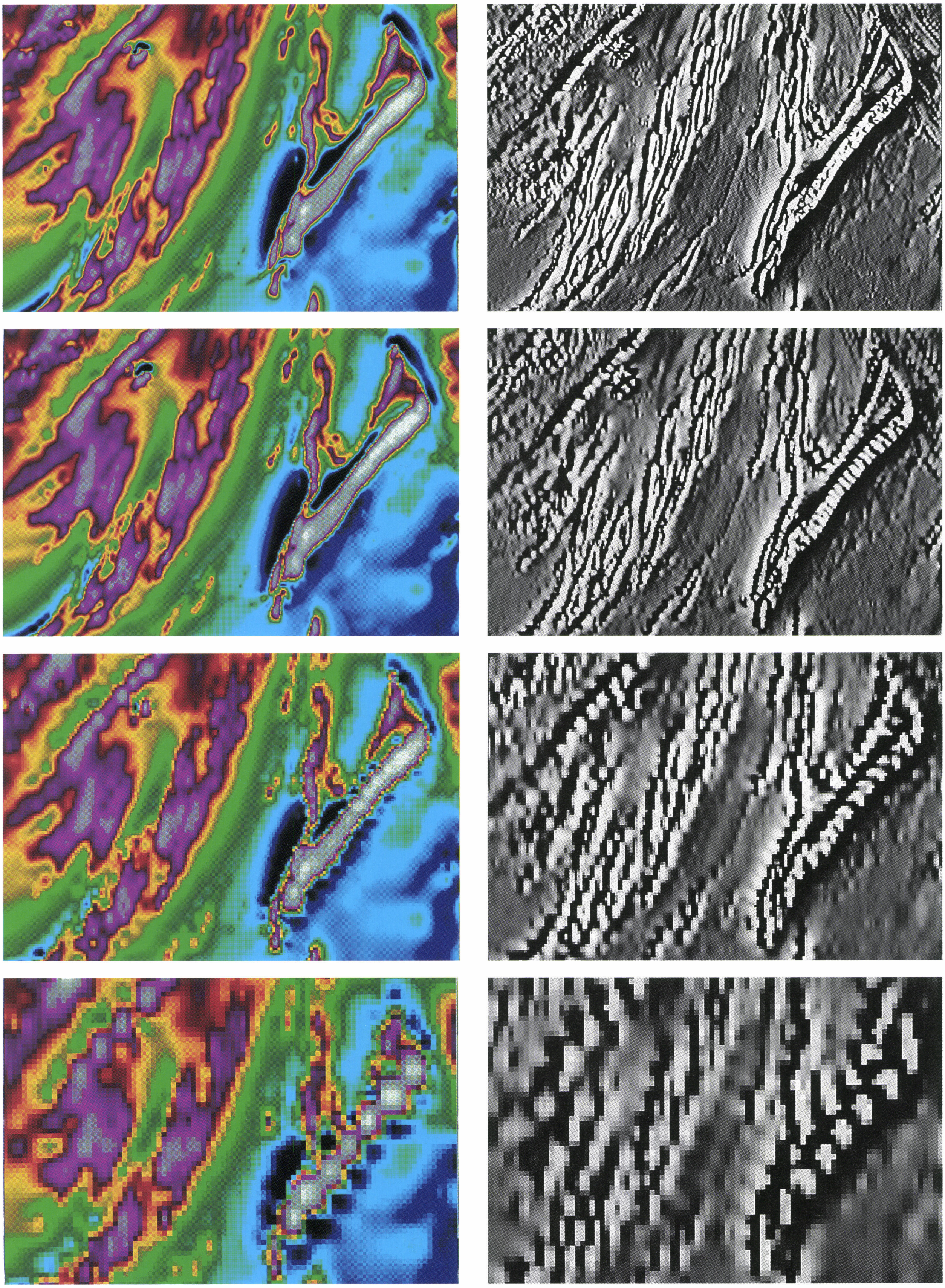

Figure 6. Effect of line spacing on resolution of airborne magnetic surveys. From top to bottom, left-hand column—total magnetic intensity: (a) 100 m, (b) 200 m, (c) 400 m, (d) 800 m; right-hand column—first vertical derivative: (e) 100 m, (f) 200 m, (g) 400 m, (n) 800 m. Survey flown 60 m above ground level.

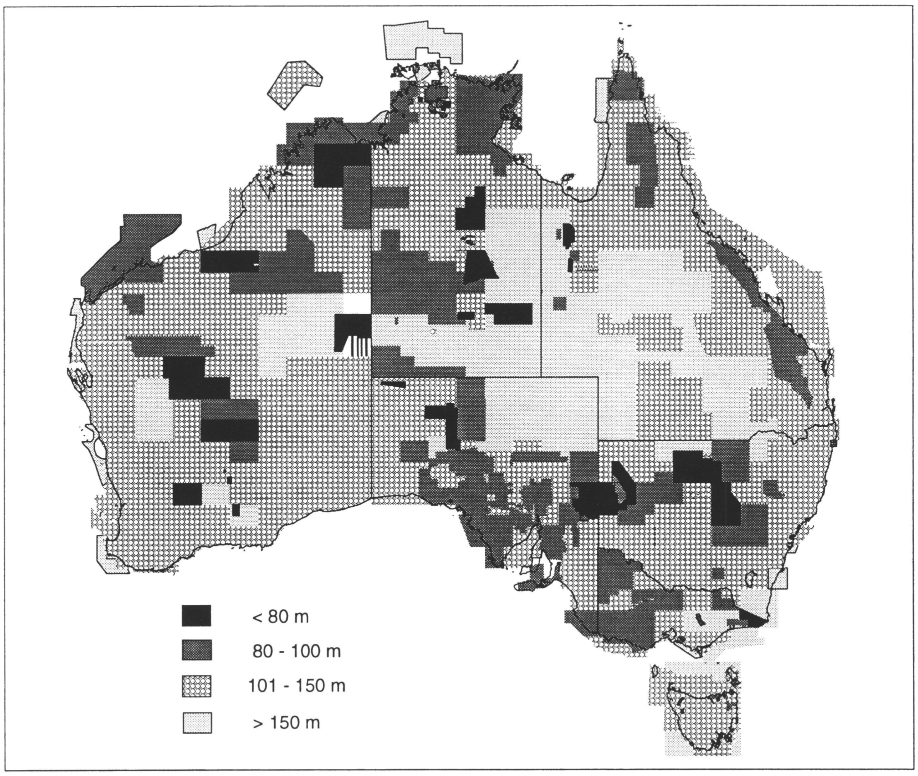

Figure 7. Flying height—magnetic data.

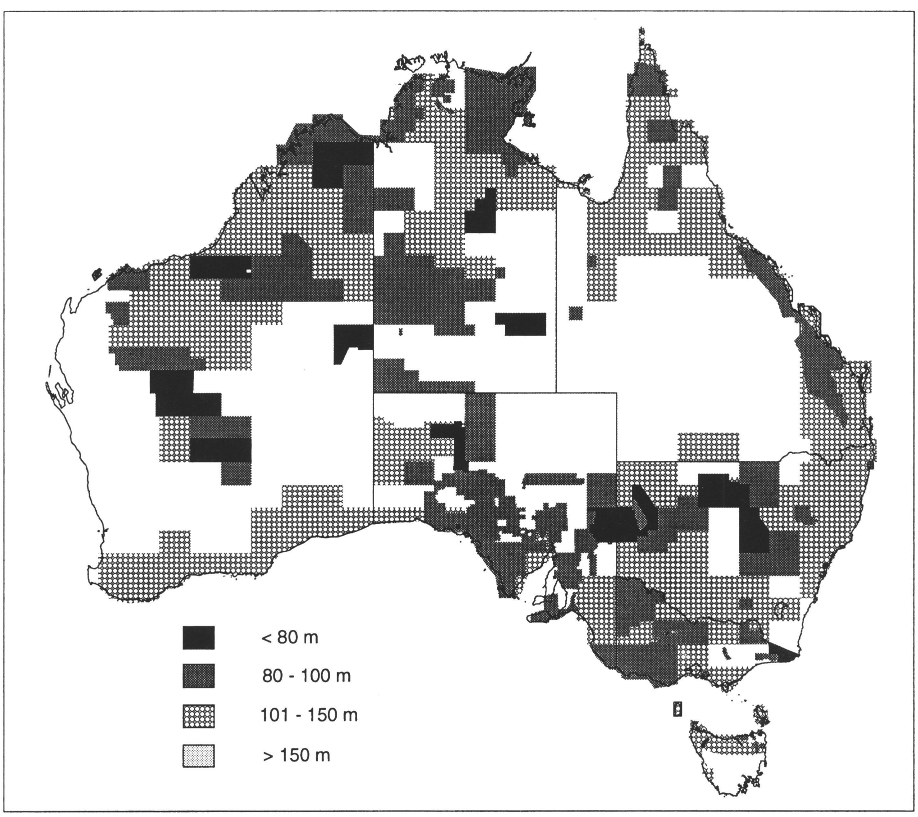

Figure 8. Flying height—gamma-ray data.

disk to facilitate copying for distribution. In 1996, archiving commenced on CD-ROM.

Analogue data

For surveys using analogue data acquisition, the original data and their presentation are archived. For surveys using digital data acquisition, any analogue charts and material which duplicate digital information are temporarily archived for a minimum of two years after processing and public release of the final data.

Original survey data which are archived include:

- analogue charts of magnetic data,
- four-channel gamma-ray data,
- radio-altimeter observations,
- survey documentation, such as information on calibrations, test flights and flight logs.

For surveys carried out before digital recording of magnetic base-station data, the base-station charts are archived. For surveys in which flight-path recovery was calculated using photographs, the final material in the flight-path recovery process, such as base maps and compilation maps, has been archived. Video film is temporarily archived for at least two years after release of the final processed geophysical data.

All presentations of publicly released data are archived. These include contour, profile, and flight-path maps, and pixel image maps.

Product availability

A wide range of products is made available to the public from the national airborne geophysical databases. Most data are available at a low cost from AGSO. Data owned solely by State governments are obtainable from the particular State department. A small number of data are available from airborne survey operators for a fixed period before being available from AGSO. A very small number of data in the databases have been supplied to AGSO on condition that they are not released to the public or that public release only occurs after a specified date.

Digital data

Point-located (profile) digital data and gridded digital data are available.

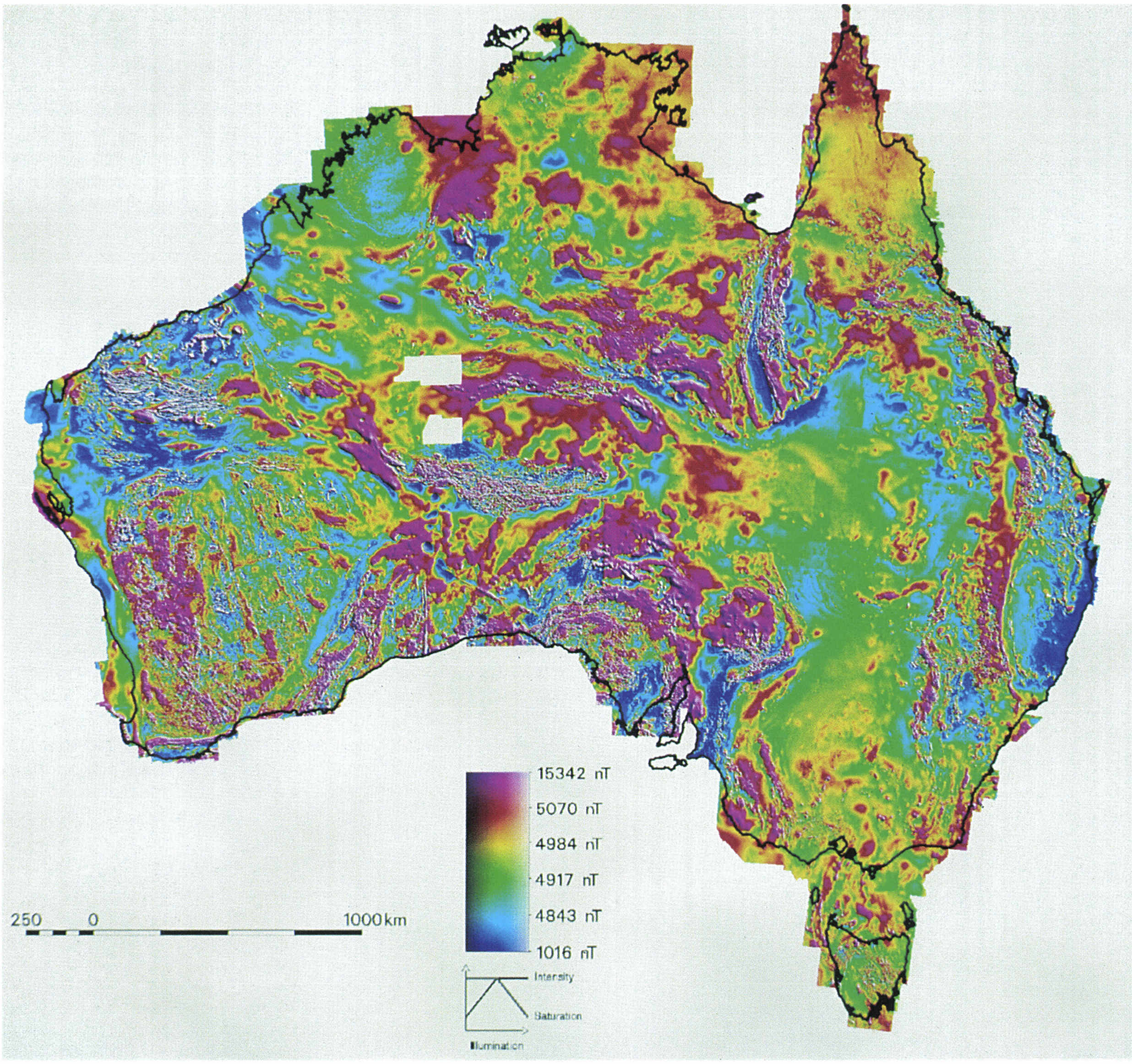

Figure 9. Magnetic anomaly map of Australia.

The point-located magnetic and gamma-ray data for surveys with flight-line spacing of 1500 m or more are available in units of 1:250 000 Sheet areas. For surveys with flight lines of 500 m or less, they are available in units of 7.5′ x 7.5′ for 1:25 000 Sheet areas.

The gridded magnetic data for surveys with flight-line spacing of 1500 m or more are included in compilations of 1:1 000 000 Sheet areas, which are released as part of the Magnetic Map of Australia grid. For surveys with flight lines of 500 m or less, magnetic and gamma-ray data are available in units of 1:100 000 Sheet areas. For some surveys with flight-line spacing of 200 m, grids are also available in units of 1:50 000 Sheet areas. Grids of magnetic and gamma-ray data are available for parts of the Broken Hill area in 15′ x 7.5′ units.

Digital elevation data are available in units of 1:250 000 Sheet areas. For data acquired on flight lines with 100 m spacing, they are available in units of 1:100 000 Sheet areas.

Analogue data

For surveys with flight-line spacings of 1500 m or more, the following basic maps at 1:250 000 are available:

- magnetic data—contours and profiles of residual total magnetic intensity;
- gamma-ray data—contours of total-count channel; profiles of potassium, uranium, thorium, and total-count channels;
- radio-altimeter—profiles;
- flight line map.

For semi-detailed surveys acquired after 1989, the following basic magnetic and gamma-ray maps are available:

1:250 000	*1:100 000*
contours of total magnetic intensity	contours of total magnetic intensity
contours of total-count channel	contours of total-count channel
	profiles of total magnetic intensity
	flight-line map.

For data at 200 m flight-line spacing, the abovementioned maps at 1:100 000 are also available at 1:50 000. For data at 100 m flight-line spacing, the maps are also available at 1:25 000.

Contour maps of digital elevation models are available at

1:250 000 and 1:100 000, depending on the flight-line spacing.

Pixel image maps are available for most data sets acquired after 1989 at flight-line spacings of 500 m or less. They are:

- colour and greyscale magnetic,
- colour gamma-ray composite, and
- colour or greyscale digital elevation model.

These are at 1:250 000 except when the data have been acquired on 100 m flight-line spacing, when they are at 1:100 000.

Compilations at various scales are also available.

Magnetic map of Australia

Several magnetic maps of Australia have been issued by AGSO. The first, which included offshore as well as onshore areas, was released in 1976 as a 1:2 500 000 scale map and a 2 km grid (BMR 1976). A compilation of photo-reduced contour maps from onshore Australia was released in 1984 (Tucker & Hone 1984). Tarlowski et al. (1993) made a major advance in presentation and resolution when they released colour pixel image maps at 1:5 000 000, 1:10 000 000, and 1:25 000 000, which accompanied a grid with 400 m cell size. The second edition map (Fig. 9) and associated grid,which was released in 1996, has additional data and additional processing (Tarlowski et al., 1996).

The magnetic maps of Australia provide a good summary of the status of acquisition of magnetic data over Australia. Because the largest scale of the latest map is 1:5 000 000, the benefits of the 400/500 m flight-line surveys are not shown as well as they would be in larger scale presentations. However, the lack of detail in areas of substandard data at first pass reconnaissance standard is indicated even at the 1:5 000 000 scale.

Conclusions

The national airborne geophysical databases provide data over most of onshore Australia and parts of offshore Australia. Although 99 per cent of onshore Australia is covered by aeromagnetic data, there are substantial areas where the data quality needs upgrading. Offshore, large areas are deficient of data.

The early definitions of standard and substandard data were strongly controlled by a desire to achieve airborne magnetic coverage over all of onshore Australia as soon as possible. Later thinking on what should be considered as the standard for continent-wide coverage has changed for the following reasons:

- first pass coverage is almost complete,
- increasing importance of airborne geophysics in mapping and exploration, and
- increasing demands on quality of data by post-processing, analysis and interpretation.

Over the last ten years, enormous advances have been made in the quality of data, and improvements will continue. Accordingly, as the data age, they become further removed from the latest quality standards. Also, the older data are, the more they are used and more of the information they contain is extracted, until no significantly new information remains to be extracted. However, new data acquired later and of a better quality will reveal new information useful for mapping, exploration, and other purposes. Data more than twenty years old can usually be significantly upgraded, and can be thought of as previous generation. Constant replenishment of the databases is required so that geological mapping and knowledge are upgraded, new mineral discoveries made, and other applications to which the data can be put are more effective.

To ensure that onshore Australia, which occupies the equivalent of about 470 standard 1:250 000 map sheet areas, is covered by data less than twenty years old ('present generation'), new data will have to be acquired at the rate of more than twenty sheet areas a year. The present state of technology demands that flight-line spacing must be 400–500 m for data coverage to be considered satisfactory. This and the other criteria for acceptable standards will become tighter with time. Recent initiatives by State governments have provided an increase in data acquisition in the short term. However long-term programs of data acquisition must be continued to enable a supply of new data to the latest standards.

References

BMR, 1976. Magnetic map of Australia. Residuals of total intensity 1:2 500 000 scale. Bureau of Mineral Resources, Canberra.

Tarlowski, C., Milligan, P. & Simonis, F., 1993. Magnetic anomaly map of Australia, scale 1:5 000 000. Australian Geological Survey Organisation, Canberra.

Tarlowski, C., Milligan, P. & Simonis, F., 1993. Magnetic anomaly map of Australia, scale 1:10 000 000. Australian Geological Survey Organisation, Canberra.

Tarlowski, C., Milligan, P. & Simonis, F., 1993. Magnetic anomaly map of Australia, scale 1:25 000 000. Australian Geological Survey Organisation, Canberra.

Tarlowski, C.Z., McEwin, A., Reeves, C.R. & Barton, C.E, 1996. De-warping the composite aeromagnetic anomaly map of Australia using control traverses and base stations. Geophysics, 61, 696–705.

Tucker, D.H. & Hone, I.G, 1984. Magnetic map of onshore Australia. Contours of residuals of total intensity, BMR airborne database 1984. 1:2 500 000 scale. Bureau of Mineral Resources, Canberra.

Tucker, D.H., Hone, I.G., Downie, D.N., Luyendyk, A.P.J., Horsfall, K.R. & Anfiloff, V., 1988. Aeromagnetic regional survey of onshore Australia. Geophysics, 53(2), 254–265.

Appendix: Summary of AGSO airborne systems used for airborne geophysical surveys

(Modified from Tucker et al 1988)

Year	*Aircraft*	*Magnetometer*	*Gamma-ray instrumentation*		*Recording*	*Aircraft*	*Magnetometer*	*Gamma*		*Recording*
		(B) Bird (S) Stinger	Crystal volume (litres)	Channels	(A) Analogue (D) Digital		(B) Bird (S) Stinger	Crystal volume (litres)	Channels	
1951	DC3 VH-BUR	Flux AN-ASQ-1 (S)	–	–	A					
1952	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A					
1953	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A					
1954	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A	DC3 VH-MIN		0.4	1	A
1955	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A	DC3 VH-MIN		0.4	1	A
1956	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A	DC3 VH-MIN	Flux AN-ASQ-1 (S)	0.4	1	A
1957	DC3 VH-BUR	Flux AN-ASQ-1 (S)	0.4	1	A	DC3 VH-MIN	Flux AN-ASQ-1 (S)	0.4	1	A
1958	DC3 VH-BUR	Flux AN-ASQ-8 (S)	0.4 (I); 1.2 (O)	1	A	DC3 VH-MIN	Flux AN-ASQ-1 (S)	0.4	1	A
1959	Aircraft sold					DC3 VH-MIN	Flux AN-ASQ-8 (S)	0.4 (I); 1.2 (O)	1	A
1960	Cessna 180 VH-GEO	–	0.5	1	A	DC3 VH-MIN	Flux AN-ASQ-8 (S)	0.4 (I); 1.2 (O)	1	A/PT
1961	Cessna 180 VH-GEO	–	0.5	1	A	DC3 VH-MIN	Fluxgate MFS4 (S)	0.4 (I); 1.2 (O)	1	A/PT
1962	Cessna 180 VH-GEO	–	0.5	1	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1963	Cessna 180 VH-GEO	Proton MNS1 (B)	–	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1964	Cessna 180 VH-GEO	Proton MNS1 (B)	–	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1965	Cessna 180 VH-GEO	Proton MNS1 (B)	–	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1966	Cessna 180 VH-GEO	Proton MNS1 (B)	–	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1967	Cessna 180 VH-GEO	Proton MNS1 (B)	0.5	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1968	Aircraft sold	Proton MNS1 (B)	–	–	A	DC3 VH-MIN	Fluxgate MFS5 (S)	0.4 (I); 1.2 (O)	1	A/PT
1969	Aero Commander VH-BMR	Proton MNS1 (B)	3.7	4**	A	DC3 VH-MIN	Fluxgate MFS5 (S)	3.7	2*	A/PT
1970	Aero Commander VH-BMR	Proton MNS1 (B)	3.7	4**	A	DC3 VH-MIN	Fluxgate MFS5 (S)	3.7	2*	A/PT
1971	Aero Commander VH-BMR	Proton MNS1 (B)	3.7	4**	A	Twin Otter VH-BMG	Fluxgate MFS7 (S)	3.7	4**	D
1972	Aero Commander VH-BMR	Proton MNS2 (B)	3.7	4**	A	Twin Otter VH-BMG	Fluxgate MFS7 (S)	3.7	4**	D
1973	Aero Commander VH-BMR	Proton MNS2 (B)	3.7	4**	A	Twin Otter VH-BMG	Fluxgate MFS7 (S)	3.7	4**	D
1974	Aero Commander VH-BMR	Proton MNS2 (B)	3.7	4**	A	Twin Otter VH-BMG	Fluxgate MFS7 (S)	3.7	4**	D
1975	Aero Commander VH-BMR	Fluxgate MFS7 (S)	7.4	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	3.7	4**	D
1976	Aero Commander VH-BMR	Fluxgate MFS7 (S)	5.5	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	5.5	4**	D
1977	Aero Commander VH-BMR	Fluxgate MFS7 (S)	5.5	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	5.5	4**	D
1978	Aero Commander VH-BMR	Proton G803 (S)	5.5	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	5.5	4**	D

Year	*Aircraft*	*Magnetometer*	*Gamma*		*Recording*	*Aircraft*	*Magnetometer*	*Gamma*		*Recording*
1979	Aero Commander VH-BMR	Proton G803 (S)	5.5	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	16.8	4**	D
1980	Aero Commander VH-BMR	Proton G803 (S)	5.5	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	16.8	4**	D
1981	Aero Commander VH-BMR	Proton G803 (S)	7.4	4**	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	16.8	4**	D
1982	Aero Commander VH-BMR	Proton G803 (S)	16.8	4***	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	16.8	4***	D
1983	Aero Commander VH-BMR	Proton G803 (S)	16.8	4***	D	Twin Otter VH-BMG	Fluxgate MFS7 (S)	16.8	4***	D
1984	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D	Twin Otter VH-BMG	Proton G803	16.8 (D) 4.2 (U)	4***	D
1985	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D	Twin Otter VH-BMG	Proton G803	16.8 (D) 4.2 (U)	4***	D
1986	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D	Twin Otter VH-BMG	Proton G803	16.8 (D) 4.2 (U)	4***	D
1987	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D					
1988	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D					
1989	Aero Commander VH-BMR	Proton G813 (S)	16.8 (D) 4.2 (U)	4***	D					
1990	Aero Commander VH-BGE	Helium G833 (S)	33.6 (D) 8.4 (U)	4***	D					
1991	Aero Commander VH-BGE	Helium G833 (S)	33.6	4***	D					
1992	Aero Commander VH-BGE	Helium G833 (S)	33.6	4***	D					
1993	Aero Commander VH-BGE	Helium G833 (S)	33.6	256	D					
1994	Aero Commander VH-BGE	Helium G833 (S)	33.6	256	D					
1995	Aero Commander VH-BGE	Helium G833 (S)	33.6	256	D					
1996	Aero Commander VH-BGE	Helium G833 (S)	33.6	256	D					

* 0.2–3.0 MeV and 1.6–3.0 MeV

** 0.84–3.0, 1.3–1.6, 1.6–1.9, 2.4–2.8 MeV

*** 0.4–3.0, 1.35–1.57, 1.63–1.89, 2.42–2.82 MeV