

Scouting craton's edge in paleo-Pacific Gondwana

Carol A. Finn

U.S. Geological Survey, MS 945, Denver Federal Center, Denver, CO 80226, USA

John W. Goodge

Department of Geological Sciences, University of Minnesota, Duluth, MN 55812, USA

Detlef Damaske

Bundesanstalt für Geowissenschaften und Rohstoffe, Stillweg 2, Hannover 30655, GERMANY

C. Mark Fanning

Research School of Earth Sciences, The Australian National University, Mills Road,
Canberra, ACT 0200, AUSTRALIA

Abstract

The geology of the ice-covered interior of the East Antarctic shield is completely unknown; inferences about its composition and history are based on extrapolating scant outcrops from the coast inland. Although the shield is clearly composite in nature, a large part of its interior has been represented by a single Precambrian block—termed the Mawson block—that includes the Archean-Mesoproterozoic Gawler and Curnamona cratons of Australia. In Australia, the Mawson block is bounded on the east by Neoproterozoic sedimentary rocks and the superimposed early Paleozoic Delamerian Orogen, marked by curvilinear belts of arc plutons, and on the west by the unexposed Coompana block and Mesoproterozoic Albany-Fraser mobile belt. In Antarctica, these crustal elements are inferred to extend across Wilkes Land and south to the Miller Range region. Aero- and satellite magnetic data provide a means to see through the ice, helping to elucidate the broad composition of the shield. Rocks of the Mawson block in Australia produce distinctive magnetic anomalies; Paleoproterozoic granites and Meso- to Neoproterozoic mafic igneous rocks are associated with high-amplitude, broad-wavelength positive aero- and satellite-magnetic anomalies. The same types of magnetic anomalies can be traced to ice-covered Wilkes Land, Antarctica, and are interpreted to signify similar rocks. However, the diagnostic satellite magnetic high ends ~800 km south of the Antarctic coast, suggesting that the Mawson block is smaller than first proposed and that the remaining East Antarctic shield is composed of several Precambrian crustal blocks of largely undetermined composition and age. Nonetheless, the coincident eastern borders of these magnetic highs and high seismic-velocity anomalies characteristic of the Precambrian shield, together define the edge of thick cratonic lithosphere. East of this boundary, magnetic lows are explained by magnetite-poor upper Neoproterozoic and lower Paleozoic sedimentary rocks, and their metamorphic equivalents, which crop out discontinuously along the Ross margin of Antarctica and in eastern Australia. These rocks are inferred to overlie a Neoproterozoic rift margin, which transects older basement provinces. The coincidence of this cratonic rift boundary with the western limit of Paleozoic and Jurassic magmatism suggests that, although tectonically modified by younger events, the composite Antarctic-Australian shield comprised thick lithosphere that was not penetrated by Paleozoic and younger convergent-margin magmas.

Introduction

The East Antarctic shield is one of Earth's oldest and largest cratonic assemblies, with a long-lived Archean to early Paleozoic history. Based on age and poorly constrained stratigraphic relations, a

large part of the shield is proposed to represent a single Precambrian block—the Mawson block comprised of the Archean-Mesoproterozoic Gawler (GC, Fig. 1) craton in Australia and George V Land (GVL, Fig. 1), Terra Adelie and the Miller Range (Fig. 1) (Fanning et al., 1995; Fitzsimons, 2000; Fitzsimons, 2003; Goodge and Fanning, 1999). The earliest events in the Mawson block are recorded in ~3100 Ma gneisses in the Miller Range with activity continuing intermittently until the amalgamation of the block with the remainder of Gondwana ~1200-1000 Ma (Fanning et al., 1995). Because of nearly complete coverage by the East Antarctic ice sheet, however, the crustal architecture of the Wilkes Land sector of East Antarctica is largely unknown. In particular, geological connections between exposures along the coast (Fanning et al., 1995; Fitzsimons, 2000; Peucat et al., 2002; Tingey, 1991) with those ~1800 km south in the Miller Range area (MR, Fig. 1) (Goodge et al., 2001) are largely untested. Recent geological studies in exposed basement of the Transantarctic Mountains (TAM) and Wilkes Land margin suggest tentative correlation of Paleoproterozoic events that may help define the character and extent of the Mawson block. For example, Paleoproterozoic orogenic magmatism, high-grade metamorphism and eclogite formation in the Nimrod Group of the Miller Range at ~1.7 Ga (Goodge et al. 2001) may correspond to igneous and metamorphic events of this age in the Commonwealth Bay region in Antarctica (CB, Fig. 1) (Oliver and Fanning, 1997; Peucat et al., 2002) and in the Gawler craton of Australia (GC, Fig. 1) (Daly et al., 1998).

Given the extensive ice cover, airborne and satellite geophysical data are a powerful means to characterize broad areas of sub-ice basement and expand our knowledge of the East Antarctic shield interior. Aeromagnetic coverage of the Mawson sector of Antarctica is largely limited to the TAM region, consisting of isolated profiles and transects with widely-spaced flight lines crossing the polar plateau (Fig. 1). In contrast, Australia is well-covered by low-altitude, high-resolution (flight lines spaced less than ~400 m apart) aeromagnetic data that are routinely used to map buried Precambrian basement (Fig. 1) (Daly et al., 1998; Myers et al., 1996; Rajagopalan et al., 1993). Satellite magnetic data (**CH**allenging **M**inisatellite **P**ayload, CHAMP) (Fig. 2), augmenting sparse aeromagnetic data coverage in Antarctica, outline very broad (300-500 km) geologic provinces (Maus et al., 2002). Interpretation of previous satellite data identified a magnetic high over the Gawler craton that extended into Antarctica (Frey et al., 1983; Von Frese et al., 1999; von Frese et al., 1986) but did not determine the geologic sources.

To better delineate the Mawson block in Antarctica, we rotated the available airborne (Fig. 1) and CHAMP satellite (Fig. 2) magnetic data from Australia and the Wilkes Land sector of Antarctica into their relative Gondwana positions (Dalziel, 1991). Comparison of magnetic anomalies from the well-understood Australian portion with those of East Antarctica enables a first attempt to map the extent and composition of the Mawson block, as well as the western limits of the Ross Orogen and Jurassic Ferrar magmatic provinces in Antarctica. Additionally, in conjunction with seismic tomography data (Shapiro and Ritzwoller, 2002), the magnetic data help locate the craton edge more broadly through Antarctica.

Interpretation of Magnetic Anomaly Data

Magnetic data reflect variations in the distribution and type of magnetic minerals—primarily magnetite—in the Earth's crust. Magnetic rocks can be mapped from the surface to great depths, depending on their dimensions, shape, and magnetic properties, and on the character of the local geothermal gradient. At regional scales, magnetic highs are often associated with magnetite-bearing batholiths, large volumes of volcanic rocks, and metamorphic rocks derived from mafic igneous protoliths. Magnetic lows can be caused by sedimentary rocks, reversely magnetized volcanic rocks, magnetite-poor plutons, and metamorphic rocks of sedimentary origin.

The extensive coverage and high resolution of aeromagnetic data for Australia (Milligan and Tarlowski, 1999) contrast sharply with data from Antarctica (Golynsky et al., 2001), such that only gross comparisons can be made. Despite the variance in survey flight characteristics, broadly similar magnetic anomaly patterns can be identified. Satellite magnetic data collected over ~14 months along ~100° paths in Antarctica at an altitude of 438 km image crustal-scale provinces ≥ 500 km wide (Maus et al., 2002) and, aided by aeromagnetic data, allow for broad geologic correlations.

Aeromagnetic signatures of the Mawson block and adjacent regions

Aeromagnetic data help delimit the approximate eastern edge of Precambrian rocks in Australia, called the Tasman line (Hill, 1951), the precise location, age and tectonic significance of which is debated (Direen and Crawford, 2003). Here we use the original definition, the boundary between Precambrian and Phanerozoic rocks (Hill, 1951), with no tectonic or age significance implied. West of the line, Precambrian rocks of various ages produce distinctive magnetic anomalies. The Gawler (GC) craton (Figs. 1 and 2) comprises Archean to Mesoproterozoic rocks that have remained substantially undeformed since ~1450 Ma (Parker et al., 1993). Intrinsic to the Gawler craton are ~1.7 Ga metamorphic and igneous events, including bimodal volcanism, granite intrusion, and granulite-facies metamorphism (Daly et al., 1998). These rocks are exposed in places, but much of the Gawler basement remains hidden by younger materials. By imaging the covered basement with aeromagnetic data and obtaining U-Pb ages from limited outcrops, the Precambrian geology and structure of this province were mapped in detail (Daly et al. 1998; also compare (Drexel et al., 1993). Gneisses, iron formations and granites of the Archean Sleaford and Mulgathing complexes, located in the southeast and northwest parts of the craton, respectively (Fig. 1), can be differentiated with aeromagnetic data. Low-amplitude aeromagnetic lows over Sleaford (SC) and Mulgathing (MC) granites contrast with linear, positive anomalies over iron formations and Paleoproterozoic flows and intrusions (e.g. Lincoln Complex, LC). A satellite magnetic low over the Eyre Peninsula (EP, Fig. 2) most likely reflects the generally magnetite-poor Archean basement. Broad, high-amplitude positive anomalies relate to the Mesoproterozoic Gawler Ranges bi-modal volcanic suite and comagmatic Hiltaba granites (GV and HS, respectively, Fig. 1) and granitoids of the Ifould complex (included in HS, Fig. 1) (Daly et al., 1998; Rajagopalan et al., 1993). The dominant signature in satellite data over this region is a positive anomaly interpreted to be due primarily to magnetite-rich Paleoproterozoic Lincoln Complex intrusions in the southeast, and Mesoproterozoic Gawler volcanics/Hiltaba granites in the west and central regions (Gawler craton, Fig. 2).

West of the Gawler craton lies a buried granitic and gneissic continental fragment, the Coompana block (Shaw et al., 1996) (Figs. 1 and 2), that may have amalgamated with the Gawler craton by at least ~1450 Ma (Fitzsimons, 2003). The sources of the ovoid positive magnetic anomalies are not well determined, but the northeast trends of linear positive anomalies in the east parallel those of the Paleoproterozoic deformation trends in the Gawler craton and might reflect dikes or faults. The western boundary of the Australian Mawson block includes the Albany-Fraser orogenic belt (Figs. 1 and 2), a collision zone between the Yilgarn craton, Coompana block and Gawler craton that formed in two stages at about ~1350-1260 Ma and 1210-1140 Ma (Clark et al., 2000; Fitzsimons, 2003) and produces high-amplitude linear anomalies that truncate magnetic fabrics in the adjacent Yilgarn and Gawler cratons. Magnetic highs relate to syn-tectonic intrusions.

Satellite magnetic highs over the Gawler and Yilgarn cratons reflect thick, magnetic crust, whereas lows characterize the Proterozoic mobile belts consisting of thick sequences of magnetite-poor rocks—most likely to be of sedimentary and metasedimentary origin. Northeast trends in the magnetic data reflect deformation associated with the collisions. Compared to the Gawler Craton, the Coompana block is associated with a narrower, lower amplitude east-trending satellite magnetic high, and a gradient characterizes the Albany-Fraser belt (Fig. 2).

The eastern edge of the Mawson block in Australia is marked in the aeromagnetic data by a broad quiet zone punctuated by magnetic highs related to the early Paleozoic Delamerian Orogen (DO and KI, Fig. 1). The Delamerian belt is expressed by curvilinear highs (100-500 nT) related to exposed and buried gabbroic and dioritic intrusions representing the roots of a magmatic arc along the early Paleozoic convergent margin of Gondwana (Finn et al., 1999; Flottmann et al., 1993). These, and mid-Paleozoic igneous rocks associated with ovoid magnetic highs farther east, intrude magnetite-poor greywackes and metamorphosed siliciclastic rocks ranging in age from Neoproterozoic and early Cambrian in the west, possibly deposited along the rifted craton margin (Mancktelow, 1990), to Cambrian-Ordovician in the east that produce the magnetic quiet zone.

Aeromagnetic data (flight line spacing ~4500-10,000 m) from northern Victoria Land, Antarctica (Chiappini et al., 2002; Golynsky et al., 2001; Studinger et al., 2004), display prominent magnetic highs (P's, Fig. 1) averaging 200-500 nT over the Ross Orogen/TAM region, primarily related to exposed and buried gabbroic and dioritic intrusions that form the southern continuation of the Gondwana-margin magmatic arc in Australia (Ferraccioli et al., 2002; Ferraccioli et al., 2003; Finn et al., 1999). Recently collected data over the Oates and George V Coasts of Antarctica (Damaske et al., 2002; Ferraccioli et al., 2003) show similar wavelength (~100-300 km) magnetic highs near scant outcrop of early Paleozoic plutons (Mark Fanning, unpublished data) (anomalies P1-2, GVL, Fig. 1). Although these anomalies have been interpreted as magnetic Precambrian or Jurassic rocks (Damaske et al., 2003; Talarico et al., 2001), their amplitudes, wavelengths and trends are more similar to those associated with Paleozoic plutons in Australia (DO and SB, Fig. 1) and Antarctica (e.g. anomalies P3-P5) (Ferraccioli et al., 2002; Ferraccioli et al., 2003; Finn et al., 1999) than to Jurassic and Precambrian rocks, suggesting similar Paleozoic sources. If so, these postulated plutons may mark the western edge of the Paleozoic Gondwana margin identified previously by Damaske et al. (2003). Similar wavelength and amplitude highs were interpreted to represent early Paleozoic plutons over the TAM in southern

Victoria Land (eg. P5-6, Fig. 1) (Bozzo et al., 1997; Ferraccioli and Bozzo, 1999; Ferraccioli et al., 2003). However, the Paleozoic plutons do not have a consistent magnetic signature over the entire TAM. Many of the granites are non-magnetic and produce no magnetic anomalies (Damaske and Bosum, 1993; Ferraccioli et al., 2002), or magnetic lows as in the Central TAM region (Goodge et al., 2004).

Although arc rocks can produce significant positive anomalies in aeromagnetic data, their thickness is insufficient to produce regional anomalies in satellite data (Fig. 2). Instead, the satellite data show a broad regional low that reflects the magnetite-poor Neoproterozoic and Cambrian sedimentary basement underlying the early Paleozoic arc, as well as non-magnetic early Paleozoic plutons and metamorphic rocks. The coincidence of the satellite low and local aeromagnetic highs (P1-3) provide further support for the argument that these highs primarily relate to Paleozoic plutons and not magnetic Precambrian crust as suggested previously (Damaske et al., 2003; Talarico et al., 2001). East of the satellite magnetic low are magnetic highs over southeastern Australia (including Tasmania) and Antarctica (Fig. 2), the origins of which are not clear but may reflect oceanic crust (Finn et al., 1999), abundant magnetite-rich mid-Paleozoic plutons and/or buried Jurassic intrusions.

Superimposed on the Ross Orogen/TAM anomaly pattern are short wavelength (2-10 km), linear 50-300 nT positive anomalies (Fig. 1) associated with Jurassic dolerites that continue north to Tasmania (Elliot and Gray, 1992). The western-most extent of the dolerites is unknown, but along the George V Coast they extend nearly to the western edge of the Paleozoic plutonic belt (Damaske et al., 2003). Farther south, along the Aerotam (Studinger et al., 2004) and ITASE (Ferraccioli et al., 2001) transects (Fig. 1), models of local high-frequency magnetic highs are consistent with Jurassic dolerite and basalt sources that extend ~400-500 km west of the Transantarctic Mountains.

Based on unique patterns of metamorphism and detrital zircon ages in metapelites from the southern Eyre Peninsula and Commonwealth Bay in Terre Adélie (CB, Fig. 1), the ~1.7 Ga Gawler signature appears to extend from southern Australia into the Wilkes Land region of East Antarctica (Oliver and Fanning, 1997). It is unknown, however, where this basement province extends beyond the narrow coastal exposures of the Commonwealth Bay region (Peucat et al., 2002), due to a lack of aeromagnetic data. Southeast (in rotated coordinates), over the western edge of Victoria Land, long-wavelength (~100-300 km) 200-500 nT highs are linked to Precambrian shield rocks (e.g. S, Fig. 1) (Bosum et al., 1989; Ferraccioli and Bozzo, 1999) or Paleozoic plutons (e.g. P's, Fig. 1) (Bozzo et al., 1997). Scattered magnetic profiles (Golynsky et al., 2001) and the Aerotam (Studinger et al., 2004) and ITASE transects (Ferraccioli et al., 2001) (Fig. 1) show high-amplitude (700-3000 nT) anomalies over the polar plateau adjacent to the Transantarctic Mountains. Interpretation of the sub-ice geology in this region is problematic due to the great distance between the data sets, but is aided by satellite observations indicating a continuation of the magnetic high (Frey et al., 1983; von Frese et al., 1986) associated with Paleoproterozoic and Mesoproterozoic igneous provinces of Australia into Wilkes Land (Fig. 2). The southern terminus of the positive anomaly lies just north of the Aerotam transect (Fig 2).

The proposed southern extension of the Mawson block to the area of the Miller Range is based on similar age and thermal histories in rocks with clear evidence of an Archean and Proterozoic

ancestry, including: (a) juvenile Archean magmatism between 3150-3000 Ma; (b) crustal stabilization and metamorphism between 2955-2900 Ma; (c) ultra-metamorphism and magmatism at ~2500 Ma; (d) metamorphism and magmatism between 1730-1720 Ma; and (e) post-1700 Ma sedimentation (Fanning et al., 1995; Goodge and Fanning, 1999; Goodge et al., 2001). Comparison of satellite magnetic data from the Wilkes Land portion of the Mawson block and Miller Range region show significant differences, however. A magnetic low characterizes the Miller Range region, in contrast to a broad high as observed over Wilkes Land to the north. A magnetic low over the Eyre Peninsula, although similar to that in the Miller Range region is attributed to different geologic sources that is Archean basement in contrast to Proterozoic reworked margin rocks. The lack of evidence for a ~1600 Ma volcanic event in the Miller Range region that is equivalent to the Gawler and Hiltaba suites in South Australia partially explains the lack of correlated positive magnetic anomalies with the Mawson block. Furthermore, there are no observed anomalies we can attribute to igneous rocks equivalent to the Paleoproterozoic Lincoln complex.

Discussion

Distinct high-amplitude positive anomalies in both airborne and satellite magnetic data from Australia image mafic volcanic rocks and intrusions of the Paleoproterozoic Lincoln complex, and Mesoproterozoic Gawler rhyolitic volcanic rocks and Hiltaba granitic intrusions. The extension of the satellite magnetic high south to Wilkes Land, Antarctica, as well as the presence of 1590 Ma volcanic clasts in glacial moraines on the coast (Peucat et al., 2002), suggest that much of Wilkes Land is underlain by the same Paleo- and Mesoproterozoic igneous rocks. The southern boundary of the satellite magnetic anomaly may indicate their southern limit, but it does not indicate whether older (Archean) Mawson block rocks continue south.

The nature and age of rock units associated with high-amplitude positive aeromagnetic anomalies over the western sector of the Aerotam transect (Fig. 1) cannot be determined, although the anomalies are characteristic of thick magnetic crust associated with Precambrian cratons. A remaining question is whether this crust belongs to the Mawson block or to some other distinguishable crustal province. Comparison of magnetic anomalies associated with this deeply buried (~3500 m ice thickness (Studinger et al., 2004)) terrane with the Gawler craton magnetic anomalies shows significant differences (Fig. 1). Despite the significantly greater depth of burial, the amplitudes of the positive magnetic anomalies (2000-3000 peak-to-trough amplitude) are generally higher than in Gawler craton magnetic data (800-1900 nT) that have been adjusted (by 3500 m) to match the distance-to-source of the Antarctic data. The northwesterly trends (our rotated coordinate system) of the Aerotam anomalies differ from the east and north trends of positive anomalies over the Paleo- and Mesoproterozoic Gawler rocks (Aerotoam and GC, Fig. 1). In addition, coincident with the magnetic highs over the Paleo- and Mesoproterozoic rocks in Australia are regional Bouguer gravity highs modeled as mid-crustal high-density mafic rocks (Daly et al., 1998; Rajagopalan et al., 1993; Shi, 1993). In contrast, the regional magnetic highs over the western portion of the Aerotam and ITASE transects are mostly associated with Bouguer gravity lows inferred to relate to a rift basin (Ferraccioli et al., 2001) or compressional feature (Studinger et al., 2004) not observed in Australia. All of these data sets suggest that the

Mawson block does not continue south to the location of the Aerotam transect, indicating a possible terminus to the Mawson block along the southern edge of the satellite magnetic high (pink dashed line, Fig. 2).

The lack of aeromagnetic data (Fig. 1) makes delineation of the western edge of the Mawson block difficult. Small outcrops of granodiorite gneiss of unknown age on Lewis and Anton islands (LI, Fig. 2), >1090 Ma granitic gneiss at Al'bov Rocks (AR, Fig. 2), and >750 Ma charnockite and granite gneiss on Chick and Henry islands (HI, Fig. 2) are comparable to rocks in the Mawson block, Albany-Fraser Orogen, and poorly known Coompana Block to the north (Figs. 1 and 2) (Fitzsimons, written comm., 2003). The Lewis and Anton islands rocks occur within the region of Mawson block identified by an ovoid satellite magnetic high (Fig. 2), whereas the exposures to the west are associated with an east-trending (rotated coordinates) magnetic high similar to that over the Coompana block. Therefore, we define the western edge of the Mawson block by the gradient between the prominent ovoid magnetic high corresponding to both the Paleoproterozoic Lincoln complex and Gawler Range Volcanics/Hiltaba Suite granites and the lower amplitude, east-trending high similar to that over the similar-aged Coompana block. Farther west, outcrops in Windmill Islands (WI, Fig. 2) and Bunger Hills (BH, Fig. 2) have been equated with the Albany-Fraser Orogen (Fitzsimons, 2003; Harris, 1995). However, the satellite magnetic signature differs. The inferred southern continuation of the Albany-Fraser Orogen into Antarctica (brown dashed lines, Fig. 2) is characterized by an east-trending magnetic high, rather than a northwest-trending gradient as seen in Australia, so it is difficult to define the orogen in Antarctica. Outcrops between Mirny Station and Cape Charcot (MS-CC, Fig. 2) correlate with the Pinjarra Orogen in Australia (Fitzsimons, 2003), both of which are associated with low-amplitude satellite magnetic highs (Fig. 2). The low-amplitude magnetic high over these rocks in Antarctica is truncated on the south by a satellite magnetic low over a province of unknown affinity. A northwest-trending gradient (rotated coordinates) interpreted from aeromagnetic data to relate to a major tectonic boundary at Lake Vostok (Studinger et al., 2003) bounds this low to the southwest (Vostok, Fig. 2).

In Australia, the eastern edge of the Mawson block is marked by Neoproterozoic-early Cambrian magnetite-poor sedimentary rocks related to rifting along the craton (Mancktelow, 1990). These rocks produce lows in both aero- and satellite magnetic data (magnetic quiet zone near DO, Fig. 1 and east of Tasman line, Fig. 2). Similarly, the western (rotated coordinate system) end of the George V Land aeromagnetic data (GVL, Fig. 1), central portions of the Aerotam and ITASE magnetic transects (near orange dashed line, Fig. 1) and satellite magnetic data (WSB, Fig. 2) are marked by magnetic lows. These lows are interpreted as magnetite-poor Neoproterozoic and lower Paleozoic sedimentary rocks within the Wilkes Subglacial Basin related to a rift (Ferraccioli et al., 2001) or compressional feature (Studinger et al., 2004). The similarity in satellite magnetic signature for Proterozoic and Paleozoic rocks precludes clear definition of the reworked craton margin, but isotopic data suggest that Proterozoic lower crust does underlie much of the TAM (Borg and DePaolo, 1994). Additional evidence for the location of the boundary between the thick, relatively undeformed craton and reworked Neoproterozoic margin comes from seismic tomography data. The eastern edge of high-velocity perturbations interpreted to relate to the Precambrian shield of East Antarctica (Ritzwoller et

al., 2001) is approximately coincident with the eastern edge of the satellite magnetic high (Fig. 2). Given the >500 km resolution of both the satellite magnetic and seismic tomography data sets, this coincidence is strong support for locating the eastern boundary of thick Mawson block lithosphere significantly inboard of the present-day TAM.

South of the proposed Mawson block boundary, the sources of satellite magnetic highs are of unknown nature. The lower amplitude magnetic high northeast of the satellite magnetic high extending from the Miller Range to the Aerotam transect (Fig. 2) may indicate Precambrian crust. Farther north, the observed satellite magnetic high most likely reflects magnetic oceanic crust inferred to underlie northern Victoria Land (Armadillo et al., 2004; Ferraccioli et al., 2002; Finn et al., 1999). Alternatively, the damped high could relate to large proportions of middle Paleozoic plutons. While the composition of crustal blocks in much of the central East Antarctic shield cannot be determined with the satellite data, the magnetic highs most likely point to the existence of a thick Archean-Mesoproterozoic igneous craton, whereas observed lows probably reflect large regions underlain by Proterozoic and younger sedimentary and volcanic successions, or by Grenville-age or younger mobile belts.

Conclusions

The combination of airborne and satellite magnetic data show that the Mawson block may only extend across part of Wilkes Land, Antarctica (Fig. 2). The composition of the craton south of the Mawson block is largely unknown. However, the variability of the satellite magnetic anomalies, and proposed tectonic boundary at Vostok based on aeromagnetic data (Studinger et al., 2003), suggest the existence of a heterogeneous, composite province. The coincidence of the eastern limit of high-magnetization and high-velocity crust delimits the edge of thick, relatively undeformed Precambrian (Archean-Paleoproterozoic?) craton. We define the craton edge as the gradient separating magnetic highs related to Precambrian shield basement and lows over magnetite-poor reworked Neoproterozoic-lower Paleozoic craton-margin rocks (Fig. 2).

The coincidence of the inferred cratonic edge and western limit of Paleozoic and Jurassic magmatism suggests either that the craton margin exerted fundamental control on younger tectonic events or it was significantly modified by these events, in particular the Paleozoic Ross Orogeny. For example, magnetic anomalies associated with Jurassic Ferrar dolerites trend generally northeasterly (rotated coordinates) from the Miller Range (unpublished data) to northern Victoria Land and Tasmania (Fig. 2), parallel to the craton boundary. The trends of these anomalies change to northwesterly (projected coordinates) along George V Land, corresponding to a similar change in trend of anomalies associated with Paleozoic plutons (GVL, Fig. 1). These plutons correlate with those on Kangaroo Island, Australia (KI, Fig. 1), where trends of magnetic highs diverge in an easterly direction from the curvilinear NNE-NNW Delamerian trends and the tomography data show a westward jog in the craton boundary (Fig. 1). All these observations suggest that the edge of cratonic lithosphere (formed during Rodinia breakup?) could have exerted mechanical control on subsequent volcanism and tectonic events. We further suggest here that the intact craton margin, developed in the Neoproterozoic, lies significantly west of the present Transantarctic Mountains uplift. The Transantarctic Mountains are

often considered to mark the eastern edge of the East Antarctic craton, but the edge delineated by magnetic and tomographic data is everywhere to the west and far west along Geroge V Land (Figs. 1 and 2). Isotopic data indicate the presence of Paleoproterozoic and younger lower crust beneath much of the presently-exposed Ross Orogen, but there it may be significantly thinned and distended, representing transitional-type basement to the overlying sedimentary cover and granitic intrusions. An example of this type of crust may be found in the Miller Range where non-magnetic lower crust is exposed (Goodge et al., 2004). The combination of extended non-magnetic lower crust with weakly magnetic sedimentary and igneous units could yield the observed satellite magnetic lows marking the proposed craton edge. The locus of Paleozoic and Jurassic Ferrar magmatism consistently extends westward to this craton edge, probably following Paleozoic strata, and may represent a better geologic marker than present-day orographic features.

Success in interpretation of magnetic patterns in the covered Gawler craton gives optimism for identifying similar patterns in the ice-covered East Antarctic shield. Acquisition of new aeromagnetic data over exposures along the margin of the shield and penetrating farther inland will help constrain the age, composition and structure of the shield.

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Figure 1: Australian (Milligan and Tarlowski, 1999) (Magnetic map of Australia is copyrighted; Australian Geological Survey Organisation, 1999.) and rotated Antarctic aeromagnetic data (Chiappini et al., 2002; Golynsky et al., 2001; Studinger et al., 2004) with Australia fixed in a Gondwana reconstruction (Lawver et al., 2003). Grid lines represent map position in meters in the rotated coordinate system. Solid black lines indicate boundaries of major crustal elements in Australia (Shaw et al., 1996), dashed where inferred from outcrop (Fitzsimons, 2000) and airborne and satellite magnetic data in Antarctica, as follows: Mawson block—pink dashed line and the edges of the Albany-Fraser belt in brown. The thick dashed lines represent the eastern limit of cratonic blocks in Antarctica inferred from the magnetic (orange) and seismic tomography data (blue) (Shapiro and Ritzwoller, 2002). Australia: BH=Broken Hill; CC=Curnamona Craton; DO=Delamerian Orogen; GC=Gawler Craton; GVL=George V Land; HI= Henry and Chick Islands; HS=Hiltaba Suite; KI=Kangaroo Island; LC=Lincoln Complex; MC= Mulgathing Complex; SB=Stavelly Belt; SC=Sleaford Complex. Antarctica: AR=Al'bov Rocks; BH=Bunger Hills; CB=Commonwealth Bay; LI=Lewis Island; MR=Miller Range; MS-CC=Mirny Station to Cape Charcot; OC=Oates Coast; VL=Victoria Land; WI=Windmill Islands. WSB=Wilkes Subglacial Basin. Other letters refer to anomalies discussed in the text.

Figure 2: Satellite magnetic data (Maus et al., 2002) of Australia and Antarctica rotated in a Gondwana reconstruction (Lawver et al., 2003). Grid coordinate system, legend, lines and place names same as for Figure 1.

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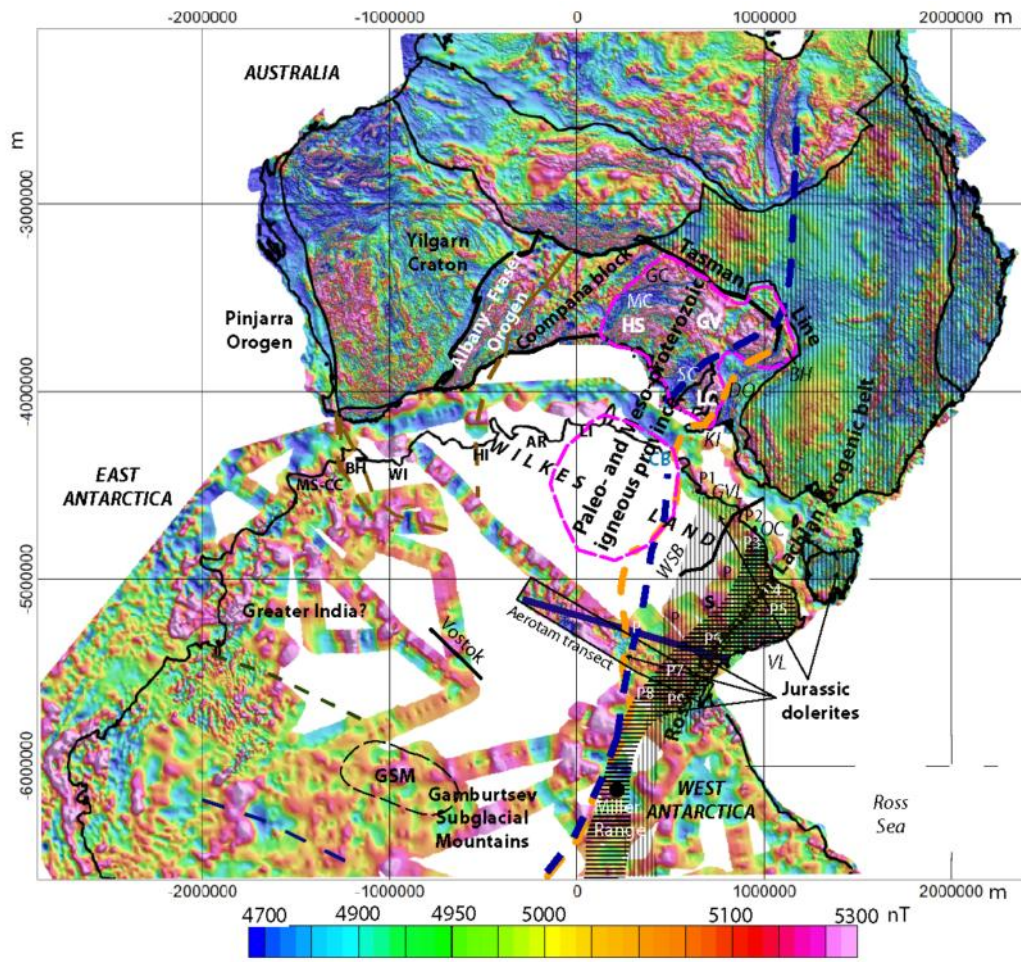
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- eastward limit of high-velocity craton
- eastward limit of craton estimated from magnetic and geologic data
- proposed limit of Paleoproterozoic igneous province
- Ross-Delamerian-Lachlan foldbelts
- Present-day Transantarctic Mountains
- ITASE ground traverse

