Aeromagnetic and gravity anomaly constraints for an early Paleozoic subduction system of Victoria Land, Antarctica

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[1] In Victoria Land three fault-bounded tectonostratigraphic terranes are generally recognized: the Robertson Bay Terrane, the Bowers Terrane and the Wilson Terrane. Accretion and suturing of terranes at the East Antarctic Craton margin is usually related to west-dipping subduction during the early Paleozoic Ross Orogen: however, nature of subduction-related basement under the Bowers and Robertson Bay terranes is still debated and this adds uncertainty to existing tectonic models. This paper interprets aeromagnetic and gravity data against geologic and geochemical evidence to elaborate a new tectonic model for Victoria Land. We propose that the contrasting magnetic and gravity signatures over the northern and southern Bowers Terrane are linked to different basement rocks, specifically, buried oceanic basement beneath the northern Bowers Terrane and continental basement beneath the southern Bowers Terrane. The relevant linear magnetic anomaly in Central Victoria Land might also be a previously unrecognized suture within the Wilson Terrane. *INDEX TERMS:* 1219 Geodesy and Gravity: Local gravity anomalies and crustal structure; 9310 Information Related to Geographic Region: Antarctica; 1517 Geomagnetism and Paleomagnetism: Magnetic anomaly modeling; 8015 Structural Geology: Local crustal structure; 9614 Information Related to Geologic Time: Paleozoic

1. Introduction

[2] Three fault-bounded tectonostratigraphic terranes affected by the early Paleozoic Ross Orogen are generally recognized over northern Victoria Land: the Robertson Bay Terrane, the Bowers Terrane and the Wilson Terrane (Figure 1). Terrane accretion at the Precambrian East Antarctic Craton margin has been related to west-dipping subduction [*Kleinschmidt and Tessensohn*, 1987], to eastward subduction followed by westward subduction [*Findlay et al.*, 1991], to strike-slip faulting [*Weaver et al.*, 1984] and to transpression [*Musumeci*, 1999]. Following terrane docking, renewed subduction led to the emplacement of Devonian-Carboniferous plutons [*Kleinschmidt and Tessensohn*, 1987].

[3] Nature of subduction-related basement under the Bowers and Robertson Bay terranes is not firmly established adding uncertainty to these tectonic models; magnetic and gravity studies may help delineate buried basement. Previous potential field imaging over Victoria Land has however led to controversial interpretations. *Bosum et al.* [1989], noting the lack of magnetic signature for the Ross Orogen at the Ross Sea coast, concluded that subduction models were not tenable. *Finn et al.* [1999] confirmed a subduction scenario at the Pacific Coast from magnetic signatures, but indicated that transpressional/translational terrane accretion models were unlikely. Magnetic crust over part of the Wilson Terrane has also been related to subduction [*Ferraccioli and Bozzo*, 1999]. We interpret aeromagnetic and gravity data over a larger sector of Victoria Land [*Reitmayr*, 1997; *Chiappini et al.*, 2002] to advance a new tectonic model for northern Victoria Land terranes by contrasting potential field signatures against geologic and geochemical evidence.

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2. Geological Outline

[4] Low to high grade metamorphic rocks of the Wilson Terrane are intruded by Cambro-Ordovician Granite Harbour Intrusives [*Roland and Olesch*, 1997]. These intrusive rocks, of calc-alkaline magmatic arc affinity, may relate to southwestward subduction of the paleo-Pacific plate beneath the East Antarctic Craton [*Kleinschmidt and Tessensohn*, 1987]. The Bowers Terrane includes marine sediments interdigitating with Middle Cambrian Glasgow Volcanics, overlain by shallow marine and non-marine rocks [*Weaver et al.*, 1984]. The Robertson Bay Terrane is a thick Cambrian-Early Ordovician flysch sequence. The structural boundary between the Wilson Terrane and the craton is not exposed. Two major thrust faults of Ross-age, the top-to-SW Exiles Thrust and the opposing top-to NE Wilson Thrust occur within the Wilson Terrane [*Flöttmann and Kleinschmidt*, 1991] (Figure 1). The Lanterman Fault, punctuated by mafic-ultramafic rocks, is interpreted as a suture between the Wilson and the Bowers terranes [*Capponi et al.*, 1999a]. The Leap Year Fault forms a boundary between the Bowers and the Robertson Bay terranes and is marked by the Millen Schist belt [*Kleinschmidt and Tessensohn*, 1987]. Following the Ross Orogen the three terranes were intruded by Devonian-Carboniferous Admiralty Intrusives, with calc-alkaline associations [*Fioretti et al.*, 1997].

3. Potential Field Signatures

[5] Magnetic and gravity maps portray contrasting signatures over the inferred Early Paleozoic active margin (Figures 1 and 2). Magnetic anomalies with amplitudes of 40–400 nT lie on-strike with the Exiles Thrust and high susceptibility values occur at Exiles Nunataks (0.016 SI) over hornblende-bearing granodiorite belonging to the Granite Harbour Intrusives [*Talarico et al.*, 2001]. To the south a comparable linear anomaly lies along the ice-covered Central Victoria Land Boundary (CVLB). It may relate to Granite Harbour Intrusives along the southern prosecution of the Exiles fault [*Ferraccioli and Bozzo*, 1999].

[6] A 250-nT anomaly chain called the GITARA Anomaly Complex (GAC) occurs along the CVLB. The large susceptibilities (0.03 SI) used to model the buried plutons causing the anomaly [*Ferraccioli and Bozzo*, 1999] are similar to those measured in the Reeves Glacier (RG) over the magnetite-rich quartz-diorite of the Granite Harbour Intrusives [*Lanza and Tonarini*, 1998]. Further northeastward, 500-nT magnetic anomalies also mark mafic Granite Harbour Intrusives complexes at Hornblende Bluff (HB) and Kavrayskiy Hills (K) [*Schüssler et al.*, 1993]. The positive anomaly field continues southwards to about 72°S, and, though relatively subdued, indicates similar buried Granite Harbour Intrusives. Southwards and westwards, a regional negative anomaly dominates over low-susceptibility ilmenite-rich Granite Harbour Intrusives [*Ferraccioli and Bozzo*, 1999]. A 400-nT anomaly marks the Tonalite Belt (TB), parallel to the Lanterman fault zone [*Musumeci*, 1999]. At the Ross Sea Coast [*Bozzo et al.*, 1995] the Wilson–Bowers boundary has limited magnetic expression. This

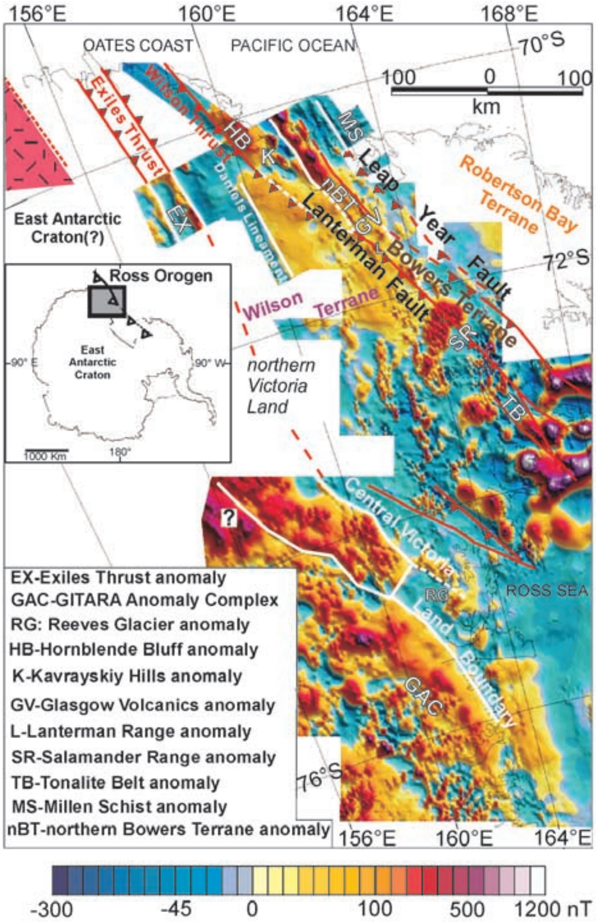

Figure 1. Magnetic anomalies over early Paleozoic Victoria Land terranes. Inset shows location in Antarctica. Ross-age structures are displayed in red and aeromagnetic lineaments in white. Magnetic anomalies described in the text are labeled in white. Other anomalies relate to later Jurassic and Cenozoic rocks [*Ferraccioli and Bozzo*, 1999].

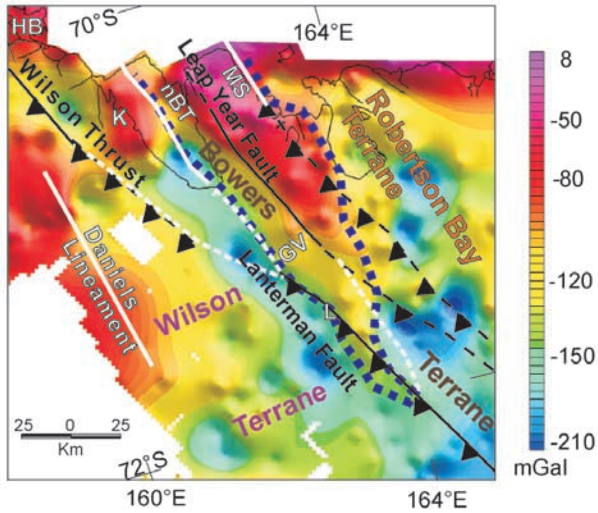

Figure 2. Bouguer gravity map modified from *Reitmayr* [1997]. Dotted blue line outlines edges of a high-density oceanic(?) body beneath the northern Bowers Terrane and western RBT. Aeromagnetic lineaments, anomalies and faults are also reported for comparison.

is surprising because the Bowers Terrane is interpreted to be underlain by oceanic crust [*Weaver et al.*, 1984]. However, there are no anomalies over the southern Bowers Terrane, in contrast to the northern Bowers Terrane (nBT) where a broad, 400-nT anomaly occurs. The nBT may reveal buried oceanic crust beneath the exposed Glasgow Volcanics, that produces the higher-frequency, lower-amplitude anomalies [*Finn et al.*, 1999]. A 100-mGal Bouguer gravity high over the northern Bowers Terrane extends beneath the northwestern Robertson Bay Terrane that is also consistent with the presence of high-density, likely oceanic crustal rocks (Figure 2).

[7] A 250-nT anomaly (SR) cross-cuts the Lanterman Fault in the Salamander Range. It overlies exposed and buried Early Carboniferous Admiralty Intrusives and associated Gallipoli Volcanics [*Fioretti et al.*, 1997], with high susceptibilities (>0.01 SI), confirmed by measurements [*Bozzo et al.*, 1995]. High-frequency (5–10 nT) magnetic anomalies mark the Bowers-Robertson Bay boundary over the Leap Year Fault and associated Millen Schist (MS) belt, that may involve slivers of oceanic crust [*Finn et al.*, 1999].

4. Geologic Modeling

[8] Figure 3 gives a generalized compositional model of the crust that can account for the potential field anomalies. These terranes may have been accreted and sutured by westwards subduction as shown in Figure 4.

[9] In Figure 3, we propose that the contrasting magnetic and gravity signature over the northern and southern Bowers Terrane

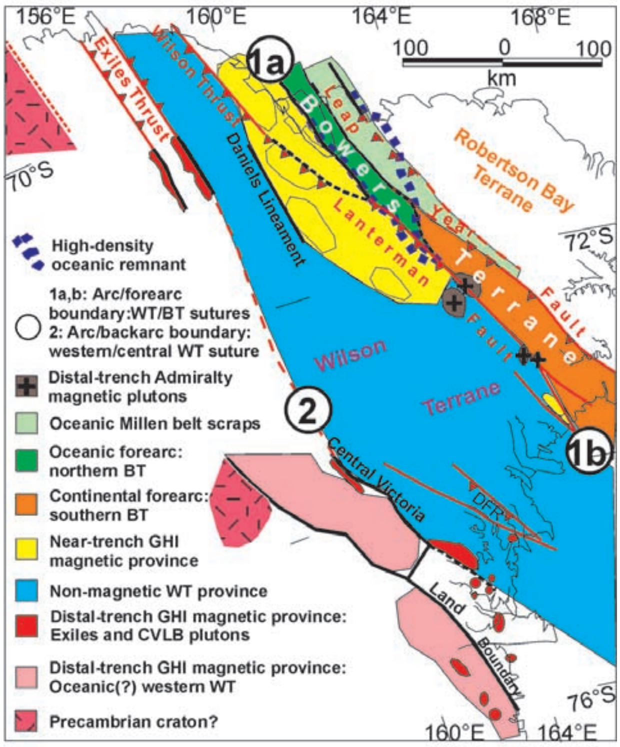

Figure 3. Crustal interpretation from potential field anomalies that may be explained by a tectonic model involving accretion and suturing by Paleozoic subduction. Faults are marked in red, and major magnetic lineaments in black. Abbreviations: Deep Freeze Range (DFR), Robertson Bay Terrane (RBT), Bowers Terrane (BT), Wilson Terrane (WT), Granite Harbour Intrusives (GHI).

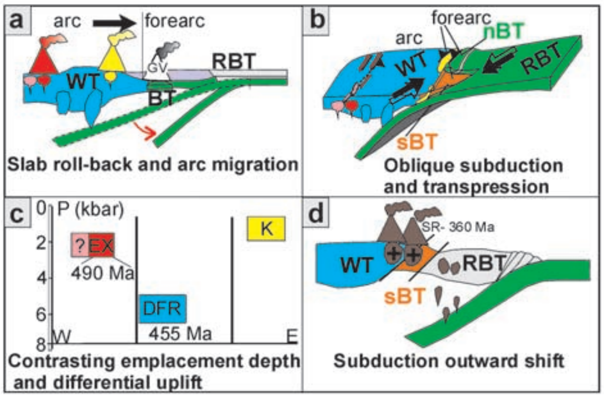

Figure 4. Possible Paleozoic subduction at the paleo-Pacific active margin that yields potential field anomalies described in the text. Abbreviations: Exiles plutons (EX), Deep Freeze Range (DFR), Kavrayskiy Hills (K), Salamander Range (SR). Color coding as in Figure 3.

stems from the different buried basement rocks. Specifically, we suggest buried oceanic basement beneath the northern Bowers Terrane to account for: 1) the observed potential field signatures; 2) the geochemical data on mafic Glasgow Volcanics [*Weaver et al.*, 1984], and 3) the presence of mafic and ultramafic clasts of intrusive rocks and boninite within the Husky Conglomerate of the Lanterman Range [*Weaver et al.*, 1984; *Capponi et al.*, 1999b]. This proposal is also consistent with aeromagnetic data over the formerly adjacent western Tasmania where similar anomalies occur over exposed and likely coeval ultramafic rocks and boninite sequences of oceanic affinity [*Findlay et al.*, 1991].

[10] The southern Bowers Terrane lacks these anomalies and hence may be underlain by continental basement, of either a separate terrane or the Wilson Terrane. The hypothesis of continental components within the Bowers Terrane agrees with the calc-alkaline affinity of the upper part of the Glasgow volcanic sequence [*Findlay et al.*, 1991] and the presence of felsic components in the Husky Conglomerates from the Bowers Terrane [*Capponi et al.*, 1999b].

[11] The CVLB might also be a previously unrecognized suture within the Wilson Terrane, because of the similarity in the long-wavelength magnetic signature over the western Wilson Terrane and the northern oceanic Bowers Terrane. The prominent magnetic break along the CVLB in Victoria Land resembles the magnetic break over the Trans-European suture zone in northern Europe over the Tornquist Ocean and the terrane accretion zone at the margin of the East European Craton [*Pharaoh*, 1999]. Independent evidence for such a fundamental suture in the Wilson Terrane is presently lacking, but may be contained in the highly-magnetic ultramafic rocks found in Oates Land *Talarico et al.*, 2001].

[12] The tectonic assembly of the terranes in Figure 3 by simple accretion and suturing is problematic because of the apparent lack of the typical paired gravity signature observed over collisional sutures [*Thomas*, 1983]. Hence, we propose that the contrasting potential field signatures may reflect different stages of paleo-subduction that are illustrated in Figure 4.

[13] By the proposed subduction model, the CVLB and the Exiles anomalies to the north may represent distal-trench, magnetite-rich, arc plutons emplaced along the Exiles Thrust. Also, in the northeastern Wilson Terrane, anomalies image near-trench magnetic plutons emplaced in the Wilson Thrust region. These two magnetic domains may then be separated by a weakly-magnetic ilmenite-rich arc province corresponding to the central Wilson Terrane. This magnetic configuration is consistent with the tectonic location of the magnetite/ilmenite boundary in California [*Gastil et al.*, 1990] and possibly opposite thrust systems in northern Victoria Land [*Flöttmann and Kleinschmidt*, 1991]

[14] Initially (Figure 4a) magmatism from a distal-trench was shifted eastwards to a near trench position possibly by slab roll-back [*Finn et al.*, 1999]. This would eliminate the need for a suture between the Wilson and the Bowers terranes since Middle Cambrian Glasgow Volcanics of the northern Bowers Terrane may have erupted over oceanic crust originally adjacent to the Wilson Terrane arc. Hence the mafic-ultramafic rocks along the Lanterman Fault may represent remnants of the adjacent forearc basement. Renewed but oblique subduction under an irregular margin (Figure 4b), produced the contrasting anomaly patterns over the Bowers Terrane. This may have caused uplift of oceanic basement beneath the northern Bowers Terrane, where convergence was more orthogonal [*Goodge and Dallmeyer*, 1996], that was removed by strike-slip movement in the south, where convergence was more oblique. The eastern Wilson Terrane magnetic domain, that is lacking in the south may also have been removed by strike-slip faulting while thrusting was occurring in the north [*Flöttmann and Kleinschmidt*, 1991]. In general the proposed oblique subduction scenario agrees with geochemical evidence over the Wilson Terrane [*Rocchi et al.*, 1998], the transpressional deformation features of the Tonalite Belt [*Musumeci*, 1999] and the derivation of Lanterman Conglomerate from the Wilson Terrane [*Capponi et al.*, 1999a].

[15] Later Ordovician differential uplift [*Vita et al.*, 1991; *Roland and Olesch*, 1997] may also explain the distribution of magnetic Wilson Terrane plutons. The more highly uplifted, deeper arc segments of the Wilson Terrane contain ilmenite-rich plutons, while the shallower level segments include magnetite-rich intrusions (Figure 4c), such as have been typically observed in California, Chile and Japan [*Gastil et al.*, 1990]. Finally the subduction plane may have shifted outboard of the Robertson Bay Terrane in Late Devonian-Early Carboniferous [*Kleinschmidt and Tessensohn*, 1987] generating the distal-trench Admiralty magnetic plutons (Figure 4d).

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