THE ANTARCTIC PALAEO-PACIFIC MARGIN OF EASTERN GONDWANA: CONSTRAINTS FROM NORTHERN VICTORIA LAND

[1,2]RICCI, C.A., [2]PALMERI, R. and [1]TALARICO, F. [1]Dipartimento di Scienze della Terra, Siena, Italy; [2]Museo Nazionale dell'Antartide-Sezione Scienze della Terra, Siena, Italy

Summary

Subduction-accretion processes driven by westward-directed subduction of a proto-Pacific plate beneath the East Antarctic margin of Gondwana led, in late Neoproterozoic-Early Palaeozoic times, to the development of the Ross Orogen.

In northern Victoria Land a major suture bounds the inboard low- to high-Temperature Wilson "Terrane", against two outboard low- to very low-grade Bowers and Robertson Bay terranes. The Wilson "Terrane" can be subdivided into an inner, broad, low-Pressure high-Temperature belt and hosting subduction-related (530-480 Ma) granitoids, and an outer narrow and discontinuous belt, composed by medium- to high-Pressure (up to eclogite facies) rocks. The final amalgamation of the two belts and the tectonic coupling with the outboard Bowers Terrane was locally accompanied by the emplacement of syn- to late-kinematic granitoids of likely continental arc affinity and occurred under low-Pressure amphibolite facies conditions and a prevailing transpressional regime.

Overall the petrological and geological records in the NVL segment of the Ross Orogen may be comprehensively interpreted in terms of a Cordilleran-type magmatic arc + accretionary wedge system recording several stages of the thermo-tectonic reworking of the palaeo-Pacific margin, from the early subduction phase, to a complex collision/accretion phase of strike-slip to contractional tectonics which determined strong telescoping and suturing of the two outboard terranes and differential tectonic denudation of the inboard Wilson "Terrane" metamorphic belts.

Introduction

During late Proterozoic-early Palaezoic, one of the longest orogenic belt in the world developed at the pacific margin of eastern Gondwana. It is known as Ross Orogen in Antarctica, Delamerian Orogen in Australia, Saldanian Orogen in Africa, and Sierra Pampeanas in South America (Fig. 1a).

The geological and petrological records of the Ross Orogen in northern Victoria Land provide significant constraints on the tectonic evolution of Antarctic palaeo-Pacific margin of eastern Gondwana (Kleinschmidt & Tessensohn, 1987; Borg & DePaolo, 1991; Ricci *et al.*, 1997; Ricci &Tessensohn, in press). According to most authors, the most likely geodynamic scenario for this region in early Paleozoic time involves long-lasting subduction-accretion processes, driven by westward-directed subduction of a proto-Pacific plate beneath the East Antarctic continent (Fig. 1b).

Within this framework, the geological record of northern Victoria Land is particularly important, with the internal low- to high-grade Wilson Terrane, corresponding to the activated paleo-margin of the East Antarctic Craton, and the external low- to very low-grade Bowers and Robertson Bay terranes, interpreted as possible allocthonous terranes (Bradshaw *et al.*, 1985) (Fig. 1c).

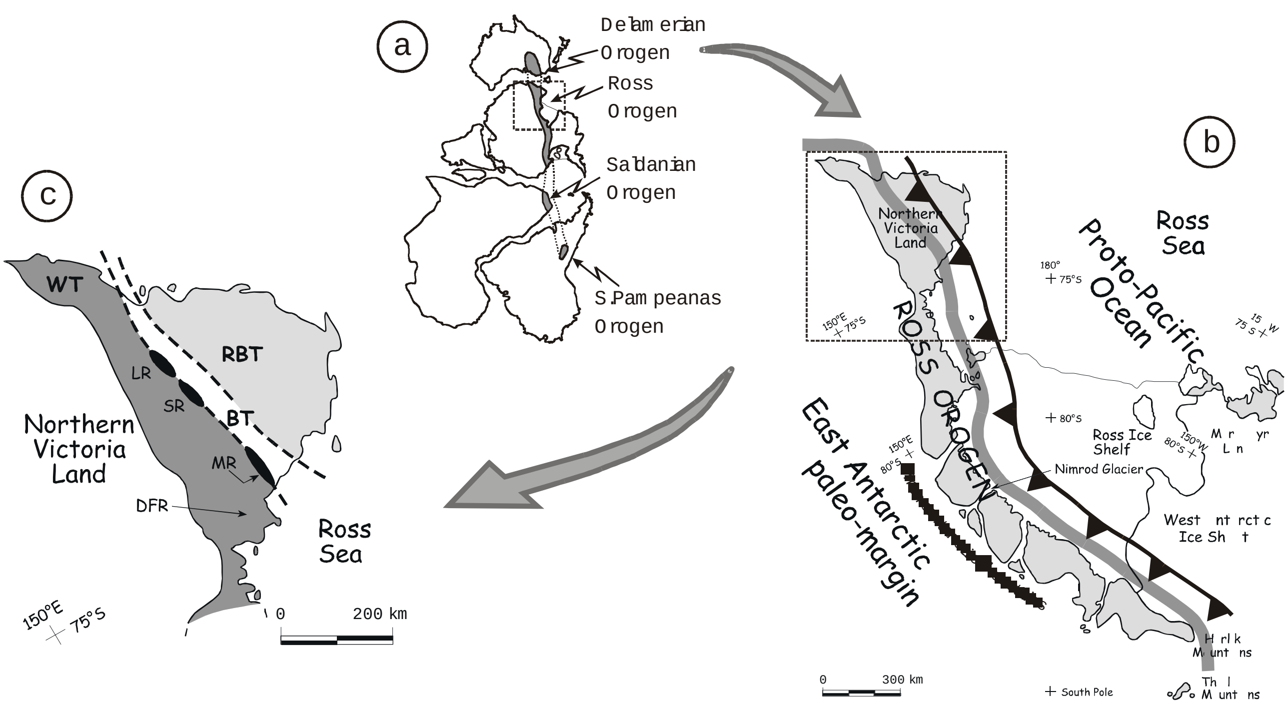

Fig. 1 - a) The early Palaeozoic orogenic belts at the Pacific margin of eastern Gondwana; b) the Ross Orogenic Belt in Antarctica; c) tectonic sketch of northern Victoria Land. WT = Wilson Terrane; BT = Bowers Terrane; RBT = Robertson Bay Terrane; LR = Lanterman Range; SR = Salamander Range; MR = Mountaineer Range; DFR = Deep Freeze Range.

This paper mainly focuses on the metamorphic and structural records of the Wilson Terrane, particularly its easternmost part - close to the tectonic boundary with the Bowers Terrane -. Our primary aim is to review and discuss existing and new geological and petrological data important for determining the early Paleozoic thermo-tectonic evolution and for comparisons with other well studied segments of the palaeo-Pacific margin of Gondwana.

Geology of northern Victoria Land

In northern Victoria Land a major suture bounds the inboard low- to high-grade Wilson "Terrane", corresponding to the activated East Antarctic palaeo-margin, against two outboard low- to very low-grade terranes including renmants of a primitive island arc (Bowers Terrane) and thick turbidite sequences of Cambrian-Ordovician age (Robertson Bay Terrane). The Wilson "Terrane" can be subdivided into an inner, broad, low-Pressure high-Temperature belt with low cooling rates after a stage of moderate crustal thickening and hosting subduction-related (530-480 Ma) granitoids (the Granite Harbour Intrusive Complex, GHI), and an outer narrow and discontinuous belt composed by medium- to high-Pressure (up to eclogite facies) rocks, and characterized by high cooling rates. The final amalgamation of the two belts and the tectonic coupling with the outboard Bowers Terrane was locally accompanied by the emplacement of syn- to late-kinematic granitoids of likely continental arc affinity and occurred under low-Pressure amphibolite facies conditions.

The Wilson Terrane

Existing and new geological and petrological data on the tectono-metamorphic evolution (Palmeri, 1997; Schuessler *et al.*, 1999; Talarico *et al.*, 1998), the structural evolution (Musumeci, 1999) and the Granite Harbour petrology and geochronology (Rocchi *et al.*, 1998) provide significant constraints on the tectono-thermal history of the Wilson Terrane and its margin along the tectonic contact with the Bowers Terrane during the Ross Orogeny. In particular, both petrological and geological data further support the presence of a paired metamorphic belt including an inboard low-P belt and an ouboard medium- to high-P belt.

The low-P metamorphic belt forms a *c.* 200 km large belt exposed in the region to the west of Rennick and Aviator Glaciers. Here the low-P character of the regional metamorphism is well documented by the regional occurrence in metapelites of cordierite and of the andalusite-sillimanite transition (Grew *et al.*, 1984; Talarico *et al.*, 1992). Mapping of critical mineral assemblages in metapelite and calc-silicate rocks outlined a complex metamorphic zonation ranging from lower greenschist facies to upper amphibolite facies and anatexis (Talarico *et al.*, 1992). On a regional scale the distribution of metamorphic zones indicates that the metamorphic grade increases either along strike or sub-orthogonal with respect to the regional structural trend.

Cambro-Ordovician Granite Harbour granitoids ranging in composition from gabbro to sieno-granite are very abundant (up to 80% area cover). They are mainly unfoliated discordant bodies which cross-cut the isograds; however, abundant syn-metamorphic intrusions are particularly widespread throughout the medium- and high-grade zones where they occur as foliated and, sometimes, folded dykes or sheet-like plutons.

Phase relations and thermobarometric estimates (Palmeri *et al.*, 1991, 1994) indicate a P-T metamorphic gradient that ranges from about 2 kbar at 350-400 °C in the lowest grade zone to 4.5 kbar at 700-750°C in the highest grade zone. Metapelites from the Sil-Kfs zone record an early prograde evolution - testified by the progression from andalusite- to sillimanite-bearing assemblages -, reached maximum P-T conditions in the Grt-Kfs-Crd facies and subsequently followed a near-isobaric cooling path (Giorgetti *et al.*, 1996; Palmeri, 1997). A counterclockwise P-T-t path has been reconstructed by Palmeri *et al.* (1994) for medium- to high-grade metapelites outcropping in the Mt. Levick/Wishbone ridge area (Deep Freeze Range). A similar path has been proposed by Borghi & Lombardo (1994) for higher-grade, migmatitic gneiss which are exposed along the coast in the Gerlach Inlet (Terra Nova Bay).

The shape of these P-T-t trajectories in conjuction with the abundance of syn-metamorphic intrusions in the medium- to high-grade zones were used as key-arguments to infer a moderate thickening - magmatic accretion tectonic model (Palmeri *et al.*, 1994) as the most likely geotectonic setting for the onset of the low-P high-T metamorphism in the Terra Nova Bay- Deep Freeze Range. This model may be possibly extended to the whole Wilson Terrane west of the Rennick and Aviator Glaciers, as far as both lithological features and low-P metamorphic zones recognized in the SW Wilson Terrane appear to be potentially extended to the North, from the Helliwell Hills, through the Daniel Range, to the Wilson Hills (Schuessler *et al.*, 1999).

The intermediate- to high-P belt is much more narrow (less than 30 km), discontinuous and characterized by a significant paucity of granitoids of the Granite Harbour Igneous Complex. A salient geological feature of this belt is the occurrence of mafic/ultramafic lenses and pods which form a narrow zone elongated along the faulted zone which mark the contact with the Bowers Terrane. In the Lanterman Range, geochemical and petrological data on ultramafic rocks (Kleinschmidt *et al.*, 1987; Talarico *et al.*, 1999) indicate that the different ultramafic bodies retain different geochemical signatures and record contrasting metamorphic P-T trajectories. Most of the mafic rocks consist of amphibolites including fine-grained biotite-bearing, garnet-bearing varieties. Very well preserved eclogites, discovered about 6 km SW of Husky Pass (Ricci *et al.*,1996), formed under high temperature conditions (up to ≈ 850°C) at a minimum pressure of 15 kbar (Di Vincenzo *et al.*, 1997), possibly as high as 25 kbar (Talarico *et al.*, 1999). Geochemical investigations on amphibolites and some retrogressed eclogites point to a tholeiitic, N- to E-MORB affinity with Nd isotopic data indicative of differentiation from a depleted mantle source and to a mantle-enriched signature for the well preserved eclogites (Di Vincenzo *et al.*, 1997). A rather wide range of estimated peak metamorphic conditions were calculated for the different metamorphic complexes distinguished and mapped in the Lanterman and Mountaineer ranges (Bernstein Metamorphic Complex, Gateway Hills Metamorphic Complex, and Dessent Metamorphic Complex) (Castelli *et al.*, 1994; Talarico *et al.*, 1998). The belt shows both along-strike and orogen-normal lithological and petrological variations. These potentially reflect either differences in initial burial or exhumation history, or tectonic reworking during late suturing with the Bowers Terrane. Available geochronological evidence indicate cooling rate as high as 30 °C/my (Goodge & Dallmeyer, 1996) and even more, as testified by the overlapping of ages obtained by the application of different mineral systematics (Di Vincenzo *et al.* 1997). In all P-T paths reconstructed, the retrograde metamorphic gradient spans conditions from an initial slightly T-decreasing decompression (*i.e.* Gateway Hills Metamorphic Complex) to cooling-unloading, a type of retrograde evolution compatible with relatively fast exhumation rates, possibly reflecting the post-thickening evolution of an orogenic belt of small initial width (< 200 km) and with a high angle of obliquity - *i.e.* the angle between the displacement vector and the convergent margin (Thompson *et al.*, 1997).

The Bowers Terrane and Robertson Bay Terrane

The Bowers Terrane is 40-60 km wide, 400 km long, and includes renmants of a primitive island arc metavolcanites interbedded with shallow marine and continental metasedimentary rocks and overlain by fluvio-marine metasedimentary rocks. The Robertson Bay Terrane is mainly contituted by a thick turbidite sequence of Cambrian-Ordovician age. The two terranes are intruded by the Devonian-Carboniferous Admiralty Igneous Complex, some plutons of which also intrude the eastern portion of the Wilson Terrane.

They have been considered either as two exotic terranes accreted to the margin (Bradshaw *et al.*, 1985; Borg & Stump, 1987) or as a volcano-sedimentary forearc basin sequence and an accretionary wedge, respectively (Finn *et al.*, 1999).

Discussion and conclusions

The major petrological and geological datasets, as summarized and interpreted by Ricci *et al.* (1997), clearly document an initial Ross orogenic phase including the onset of the Granite Harbour calc-alkaline magmatism (Borg & De Paolo, 1986; Vetter & Tessensohn, 1987; Ghezzo *et al.*, 1989; Armienti *et al.*, 1990), possibly as early as 530-540 Ma (Stump, 1995, and references therein; Rocchi *et al.*, 1998), accompanied by high-T low-P metamorphism (Grew *et al.*, 1984; Talarico *et al.*, 1992) inboard of the margin, and the development of an accretionary wedge and medium- to high-P metamorphism, up to eclogite facies along the outer margin (Ricci *et al.*, 1996; Di Vincenzo *et al.*, 1997).

During continued convergence and at around 500 Ma, the next phase is represented by a structural reworking of the margin which produced an early phase of exhumation of high pressure rocks and their juxtaposition with medium pressure rocks. The subsequent stage, possibly no later than 470 Ma based on the upper limit of cooling ages of most metamorphic and igneous minerals (Stump, 1995, and reference therein; Di Vincenzo *et al.* 1997, 1999), likely included several processes such as i) further exhumation of high-P rocks and tectonic stitching under amphibolite facies conditions with low-P metamorphic rocks, ii) the truncation of the portion of the palaeo-margin corresponding to the forearc, and iii) the beginning of collision of the low-grade Bowers Terrane with the Wilson Terrane and interruption of the subduction process.

A final stage of continental margin development then involved strong telescoping of the Wilson Terrane margin and the Bowers Terrane, during their final suturing under prevailing low-grade conditions. The locus of subduction eventually jumped outboard of the Robertson Bay Terrane and a new magmatic arc, the Admiralty Intrusive Complex, developed in the time range between 400 and 350 Ma.

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