

Geology of the Terre Adélie Craton (135 – 146° E)

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Abstract More than 15 years of field and laboratory investigations on samples from Terre Adélie to the western part of George Vth Land (135 to 146°E) during the GEOLETA program allow a reassessment of the Terre Adélie Craton (TAC) geology. The TAC represents the largest exposed fragment of the East Antarctic Shield preserved from both Grenville and Ross tectono-metamorphic events. Therefore it corresponds to a well-preserved continental segment that developed from the Neoproterozoic to the Paleoproterozoic. Together with the Gawler Craton in South Australia, the TAC is considered as part of the Mawson continent, i.e. a striking piece of the Rodinia Supercontinent. However, this craton represents one of the less studied parts of the East Antarctic Shield. The three maps presented here clearly point out the extent of two distinct domains within the Terre Adélie Craton and suggest that the TAC was built up through a polyphased evolution during the Neoproterozoic-Siderian (*c.a.* 2.5Ga) and the Statherian (*c.a.* 1.7Ga) periods. These data support a complete re-assessment of the TAC geology and represent a valuable base for the understanding of global geodynamics changes during Paleoproterozoic times.

Citation: Ménot, R.P., G. Duclaux, J.J. Peucat, Y. Rolland, S. Guillot, M. Fanning, J. Bascou, D. Gapais, and A. Pêcher (2007), Geology of the Terre Adélie Craton (135 – 146° E), in *Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES*, edited by A.K. Cooper and C.R. Raymond et al., USGS Open-File Report 2007-1047, Short Research Paper 048, 5 p.; doi:10.3133/of2007-1047.srp048

Introduction

The Terre Adélie Craton (TAC) is located on the eastern part of the East Antarctic Shield (Fig. 1). Three geological maps are presented here that review some 15 years of field, petrological and geochronological investigations in Terre Adélie and western George Vth Land. A general localization map (Fig. 1) illustrates large-scale features of the TAC geology. It emphasizes the distinction of main lithotectonic domains based on rock types, structure and age of peak metamorphism (Monnier et al., 1995). A second map (Fig. 2) focuses on the easternmost domain of the craton, which corresponds to a Neoproterozoic polycyclic basement and the overlying Paleoproterozoic Cape Hunter basin. Finally the third map (Fig. 3) relates to the highly strained and metamorphosed Paleoproterozoic Dumont D’Urville basin which is juxtaposed to the west of the Archean domain. Furthermore, small outcrops of Rocher Mathieu and Rocher X allow extending the TAC more to the west without precision on its exact western boundary (cf. star and broken line on the inset map of Fig. 1).

Previous work

The first geological investigations were carried out during Sir Douglas Mawson’s expedition in the Cape Denison during the 1911-1914 Australasian Antarctic Expedition (AAE) wintering. Stillwell (1918) and Tilley (1923) described the metamorphic rocks from the basement of Commonwealth Bay and the surrounding

areas (George Vth Land). Later, in the early 1950’s and 1960’s, French Polar Expeditions reported new data from Terre Adélie, further West, including a preliminary geological map of the coast between Pointe Géologie and Cape Denison, and the first absolute dating of the Pointe Géologie migmatitic formations at *ca.* 1.5 Ga (Aubert de la Rüe and Tchernia, 1951; Heurtebize, 1952a, b; Bellair, 1961a, b; Bellair and Delbos, 1962).

More recently, Stüwe and Oliver (1989) attempted to integrate the previous, and scarce, data in a regional framework involving both Terre Adélie and South Australia in Rodinia and Gondwana reconstruction. Subsequently, petrological and geochronological (SHRIMP) results were obtained by Oliver and Fanning (1997, 2002) from samples collected during the 1911-1914 AAE (see below).

Finally, in the early 1990’s, new field investigations were undertaken through the GEOLETA program supported by the French Polar Institute (IPEV). Detailed mapping of the Terre Adélie Craton (TAC) from 135 to 146°E together with petrological and geochronological investigations allow us to propose a complete re-assessment of the TAC basement (this paper and references therein). Moreover these results have also been used to constrain better the mechanical behaviour of the Neoproterozoic continental lithosphere (Duclaux et al., 2007a) and the role and distribution of fluids (Pelletier et al., 2005) during orogenic processes.

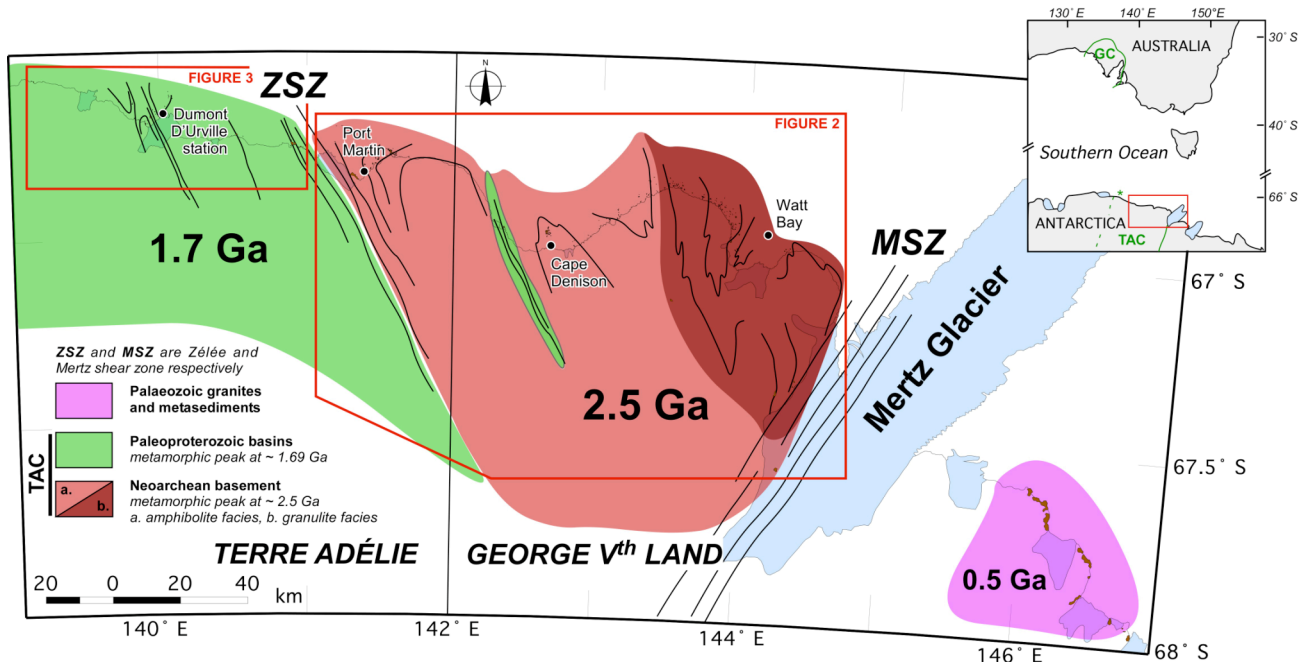


Figure 1. Geological sketch map of the Terre Adélie Craton illustrating the 2.5 and 1.7 Ga domains localization – Projection UTM 53S. Inset : location and limits of the Terre Adélie Craton (TAC) in East Antarctica and of the Gawler Craton (GC) in South Australia; continuous green lines : known boundaries of the Paleoproterozoic cratons; broken green line : supposed western boundary of TAC; star : position of outcrops of the Rocher X and Rocher Matthieu.

The Neoproterozoic basement

The Easternmost domain (Fig. 2) extends from the Zélée SZ (141°E) to the Mertz SZ (145°E) and reveals a composite Neoproterozoic basement, made of mainly felsic to mafic orthogneisses and granodiorites intruding subordinate metasedimentary country rocks including marbles and calc-silicates. This 2.55-2.44 Ga continental crust segment exposes two distinct tectonic units that represent two crustal sections from deep and intermediate levels equilibrated under granulites and amphibolites facies conditions respectively (Ménot et al., 2005). Within the Neoproterozoic gneissic basement, the Cape Hunter phyllites (see below) could be considered as remnants of a Paleoproterozoic, autochthonous, sedimentary basin. A large scale 1.7Ga thermal and tectonic overprinting was assumed by Di Vincenzo et al. (2007) on the base of Ar/Ar dating. But, according to our data (Duclaux et al., 2007b), the 1.7 Ga resetting recorded in the gneissic basement is restricted to only narrow fluid-bearing anastomosed shear zones, concentrated on the edges of the Neoproterozoic domain and along the Cape Hunter basin.

The Paleoproterozoic metasedimentary basins

The Western domain (Fig. 3), extending westward from the Zélée shear zone (141°E) corresponds to the highly strained and metamorphosed Paleoproterozoic Dumont d'Urville (DDU) basin. It consists in metapelitic migmatitic gneisses with subordinate metagraywackes, silicic metavolcanic rocks and mafic intrusions. Oldest

crustal precursors are 2.2-2.4 Ga old (T_{DM}) with inherited zircons up to 2.8 Ga. A short time span brackets sediment deposition at about 1.72 Ga (age of the youngest inherited volcanic zircons) to HT-LP metamorphism, anatexis and coeval intrusion of mafic magmas dated at 1.69 Ga (Peucat et al., 1999; Pelletier et al., 2002).

More to the East, the Cape Hunter metapelites occur as a small outcrop squeezed within the Neoproterozoic basement. Based on rock types, ages of deposition and of metamorphism, the Cape Hunter basin is quite comparable with the larger Dumont d'Urville basin, but metamorphic conditions were significantly lower. The Cape Hunter metapelites recrystallized under greenschist facies conditions at *ca.* 1.7 Ga (Oliver and Fanning, 1997).

West from Pointe Géologie, rare outcrops allow the recognition of a 1.6 Ga magmatic event recorded by calc-alkaline granites and microgranites from Rocher Janet. Based on petrography, geochemistry and age of crystallization, these granites are very similar to the felsic blocks found in the moraines along the Terre Adélie coast and to the Gawler Range Volcanics of South Australia (Peucat et al., 2002).

More to the West, outcrops of Rocher X and Rocher Matthieu (Inset, Fig.1) are still badly known; they display biotite-hornblende migmatitic gneisses associated with mafic and intermediate intercalations as amphibolites and metatonalites. They are cross cut by numerous pegmatitic dikes. The metamorphic evolution may be compared to that of the migmatitic series of Pointe Géologie, but ages

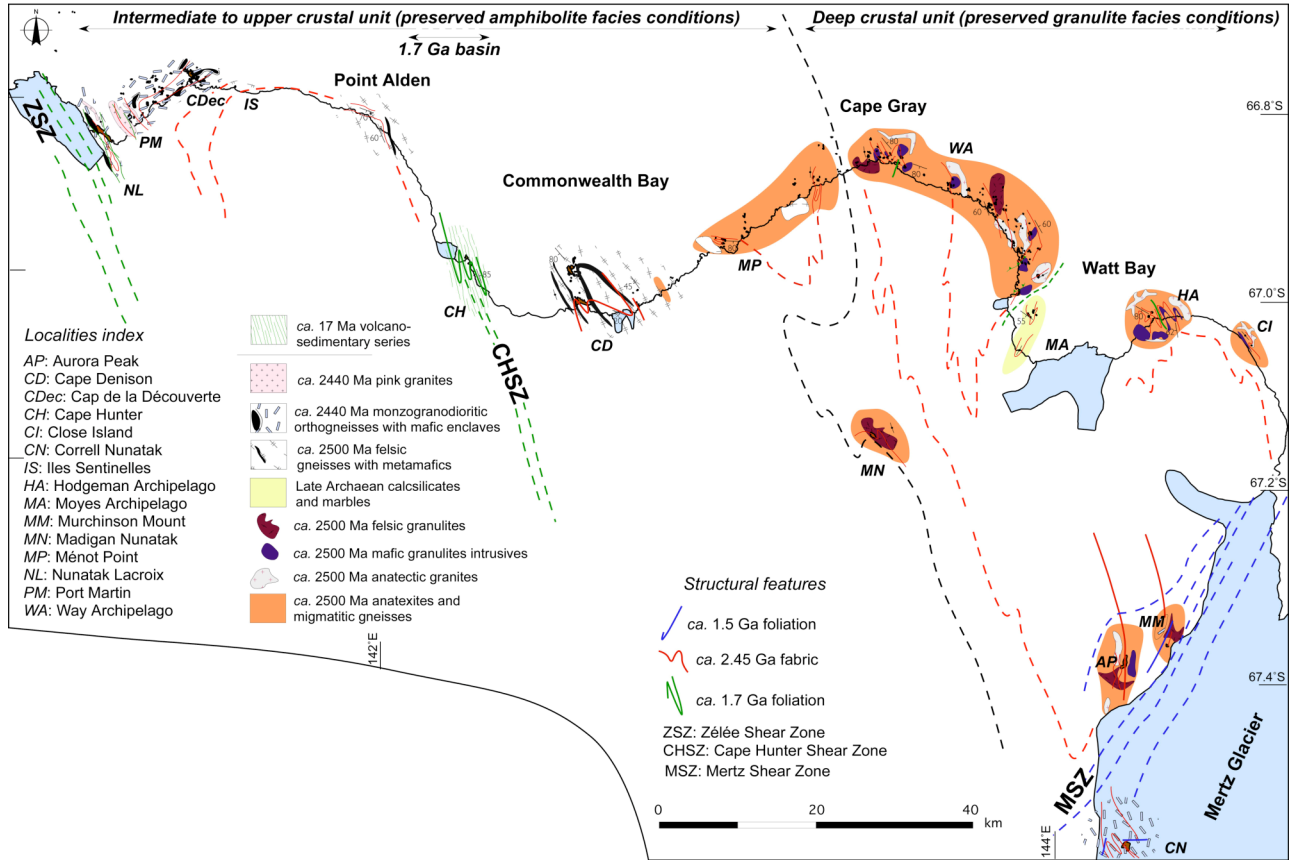


Figure 2. Geological sketch map of the Neoproterozoic domain and the overlying Cape Hunter Paleoproterozoic basin, east of the TAC.

need to be more accurately determined.

Late tectonic activity

The latest tectono-thermal event seems to be of limited spatial extent, concentrated on the Mertz shear zone (MSZ) (Talarico and Kleinschmidt, 2003) where synkinematic recrystallizations have been dated between 1550 and 1500 Ma (Di Vincenzo et al., 2007). The MSZ separates the Neoproterozoic basement from the Early Palaeozoic unit of Cape Webb and Penguin (Fanning et al., 2002; Di Vincenzo et al., 2007) and therefore it represents the eastern boundary of the TAC and of the East Antarctica Shield (Fig.1).

Finally, the opening of the Southern Ocean drove the rifting and the latter separation of the Terre Adélie and the Gawler cratons during Mesozoic times.

Discussion and conclusion

As clearly shown by the different maps presented here, the TAC may be considered as a composite basement built up through two major orogenic events at *c.a.* 2.5 and 1.7 Ga and devoid of any later significant reworking. Then it differs from most of others areas of the East Antarctic shield that display strong tectonic and/or metamorphic reworking related to Mesoproterozoic and

Neoproterozoic-Cambrian orogens. Therefore, the TAC represents a meaningful place to constrain continental crust's genesis and recycling processes and to precisely define the evolution of the geodynamic processes during the Archaean to Paleoproterozoic transition.

In that context, detailed investigations are carried on to better understand the behaviour of the “young”, Neoproterozoic and Paleoproterozoic, continental lithosphere during orogenesis. Through numerical experiments and field constraints, Duclaux et al. (2007a) demonstrated the role of gravity in the structural evolution of a hot Neoproterozoic continental crust. The related 2.45 Ga L>S fabric recognized in the TAC reflects a massive orogen-parallel flow that was acquired during the progressive waning of the tectonic force at the end of convergence. With regard to the 1.7 Ga event, Gapais et al. (2007) and Duclaux et al. (2007b) described the contrasted evolution between the cooled and stabilized Neoproterozoic basement and the warmer, radiogenic-rich, intracontinental Paleoproterozoic basin of Dumont d'Urville.

The exposure of Paleoproterozoic basins developed upon a Neoproterozoic basement gives a good opportunity to investigate crustal recycling and juvenile, mantle derived, accretion processes and their relative contribution during the 2.8 – 1.6 time span. Preliminary results based on Sm-

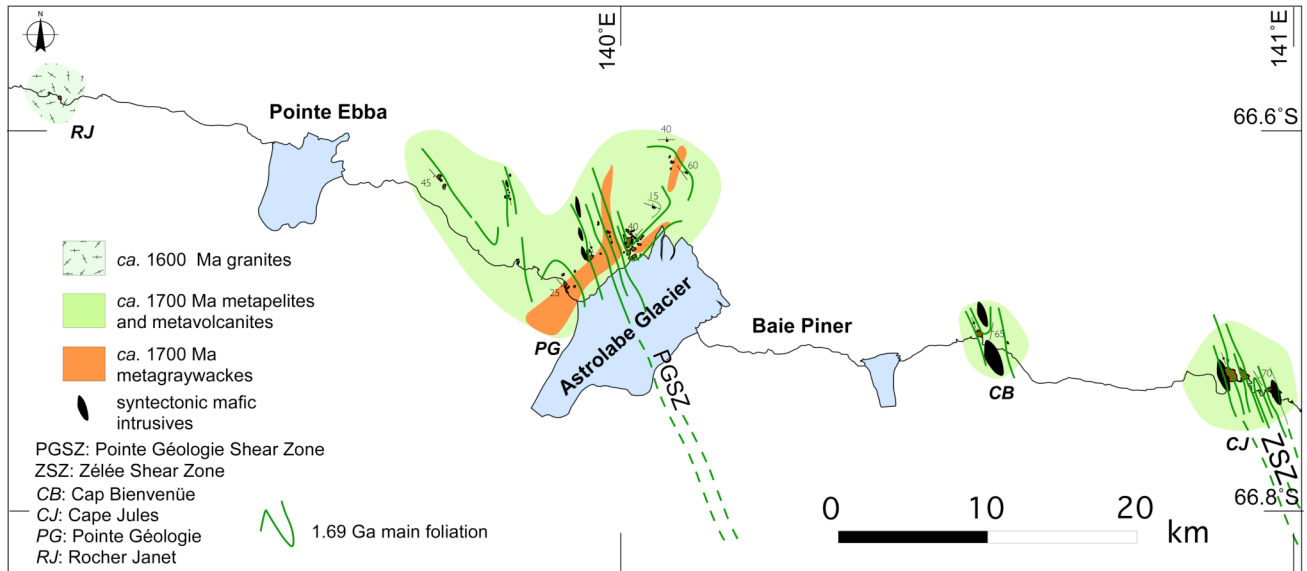


Figure 3. Geological sketch map of the Paleoproterozoic Dumont D'Urville basin.

Nd and trace element geochemistry have been proposed (Peucat et al., 1999b) and further elucidation will be forthcoming (Duclaux, PhD in progress).

The high quality of outcrops and rocks permits a detailed study of relationships between metamorphic reactions and partial melting. Migmatitic gneisses from DDU area display very different degrees of melting at peak metamorphism and varied retrograde mineral assemblages. Such features are assumed to be associated with space and time heterogeneities in the distribution of fluids within the Paleoproterozoic ductile crust (Pelletier et al., 2005).

Furthermore, according to Fanning et al. (2002,2003), the TAC represents also a key region linking the East Antarctic Shield and the Gawler Craton in Southern Australia. This link was examined in details and is supported by lithological, structural and age similarities. It supports the Mawson continent hypothesis (Fanning et al., 2003), i.e. a remnant of the Rodinia Supercontinent that was later amalgamated to the East Antarctic continent (Fitzsimons, 2003 and ref. therein). A better understanding of the geological evolution of the TAC and of adjacent areas (Eastern George V Land) would improve models for Rodinia and East Gondwana reconstructions.

Acknowledgements. This research has been funded by the French Polar Institute (IPEV) during the GEOLETA program and by INSU-CNRS (Dyeti project). We also warmly thank Prof. Chris Harris (Cape Town) and our ISAES editor, Wes LeMasurier, for their highly constructive reviews.

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