EUG XI

Symposium LS08

Age Growth and Evolution of Antarctica (AGEANT)

Convenors

Chris Wilson
Simon Harley

LS08
Age Growth and Evolution of Antarctica (AGEANT)

Tuesday AM Session

LS08 : TUam01 : G3
Some Major Geophysical Initiatives and their Possible Contribution to AGEANT (Age, Growth and Evolution of Antarctica)

Fausto Ferraccioli (magne@dipteris.unige.it) & **Emanuele Bozzo**
DIPTERIS- Univ. di Genova, Viale Benedetto XV,5, 16132 Genova, Italy

Basement geology of the Antarctic continent is a key to complete Gondwana and possibly also Rodinia reconstructions. Pre-break-up geology and tectonics of the Antarctic are poorly understood due to extensive ice-cover and because of the hostile environment, which severely limits field investigations. Geophysical initiatives are therefore a primary tool, which must be combined with Antarctic geologic studies. In many Cambrian and Precambrian Gondwana terranes of Africa, India and Australia interpretation of magnetic anomalies arising from partially buried igneous and metamorphic rocks provide a unique window on basement geology and structural architecture. In 1995 ADMAP (Antarctic Digital Magnetic Anomaly Project) was launched, supported by IAGA and SCAR, to compile and integrate into a digital database all existing near-surface and satellite magnetic anomaly data south of 60ºS (Johnson et al., 1997). Over Victoria Land (VL) interpretation of the ongoing compilation initiative (Chiappini et al., 1999) has already begun. Mesozoic to Cenozoic tectonics of the West Antarctic Rift-TAM tectonodynamical system has prominent magnetic signature, but fundamental basement geology features have also been highlighted. For example, aeromagnetic signatures over northern VL and south-eastern Australia basement have been interpreted to confirm subduction-related Ross-Delamerian Orogens, but seem to question the validity of existing terrane accretion models (Finn et al., 1999). Ferraccioli and Bozzo (1999) magnetically imaged a major buried boundary in the Wilson Terrane. The northern part of this lineament was previously inferred to mark the unexposed boundary between highly magnetic Precambrian shield crust and the weakly magnetic Cambrian-Ordovician Ross Orogen. The more recent interpretation favours Ross-age magmatic arc rocks along the buried Exiles thrust fault zone as the sources for the observed anomalies which, if true, shifts the location of unreworked Precambrian basement further to the west, possibly beneath the Wilkes Basin (WB). Major geophysical programmes, namely the German-Italian GANOVEX-BACKTAM programs and the US-Italian AEROTAM, have been initiated with the 1999-2000 campaign in the WB region. Gravity and magnetic data have also been acquired along the ITASE transect. These programmes might delineate the eastern boundary of the Wilkes Land shield which is a very prominent satellite magnetic anomaly feature also (von Frese et al., 1999). A new magnetic anomaly map over part of East Antarctica has also been compiled within ADMAP. Four main boundaries of the East Antarctic shield are magnetically imaged within Enderby Land and eastern Dronning Maud Land indicating contrasting Archean stable blocks and Proterozoic mobile belts. The absence over the Lützow-Holm Bay terrane of anomalies on strike with the proposed Pan-African orogeny lends credence to intraplate models rather than to suture-zone models (Golynski et al., in press).

Johnson AC, von Frese RRB & ADMAP Working Group, *EOS*, **78**, 185, (1997).
Chiappini M, Ferraccioli F, Bozzo E, Damaske D & Behrendt JC, *Annali di Geofisica*, **42**, 277-292, (1999).
Finn C, Moore D, Damaske D & Mackey T, *Geology*, **27(12)**, 1087-1090, (1999).
Ferraccioli F & Bozzo E, *Journal of Geophysical Research*, **104(11)**, 25,297-25, 319, (1999).
von Frese RRB, Kim HR, Tan L, Kim JW, Taylor PT, Purucker ME, Alsdorf D, & Raymond CA, *Annali di Geofisica*, **42**, 309-326, (1999).
Golynski AV, Alyavdin SV, Masolov VN, Tscherinov AS, & Volnukhin VS, *Tectonophysics (in press)*

LS08 : TUam02 : G3
Mapping Rodinia and Gondwana Basement in Antarctica and Australia with Aeromagnetic Data

Carol Finn (cfinn@usgs.gov)[1],
Detelf Damaske (d.damaske@bgr.de)[2] &
Tim Mackey (tmackey@agso.gov.au)[3]
[1] U.S. Geological Survey, MS 964, Denver Federal Center, Denver, CO, 80225, USA
[2] BGR, Stillweg 2, Hannover, Germany
[3] AGSO, GPO Box 378, Canberra, Australia

Comparison of the aeromagnetic data from Australia and Antarctica yields new information on the composition of the mostly covered Rodinia and Gondwana basement in these regions. Rocks that compose the Archean Gawlor craton in Australia produce distinctive magnetic anomalies. Similar anomalies can be observed in parts of Wilkes Land, Antarctica. Mafic middle to Late Proterozoic Gawlor igneous rocks buried under Adelaidean sedimentary rocks, Australia are associated with high-amplitude, broad-wavelength positive magnetic anomalies. The same type of anomalies occur over ice-covered central Victoria Land and are interpreted to be due to similar rocks. Exposed and buried gabbros and diorites, the roots of a Paleozoic magmatic arc, in the Delamerian orogen and Glenelg zone east of the Gawlor rocks, produce distinctive magnetic highs over a 200-km wide area that can be traced into the Wilson terrane. East of these regions are prominent 100 to 400 km long and 30-60 km wide linear belts of 400 nT magnetic highs over the Stavely, Australia and Bowers, Antarctica zones, respectively. The exposed volcanics in these zones produce circular, high-frequency anomalies with amplitudes of only about 25 nT. This suggests that the volcanic rocks are not the primary sources of the high-amplitude linear positive anomaly belts in either location. Instead, we interpret that the highs are primarily related to boninites, drilled in the Stavely belt, which may compose ophiolites that may underlie the Bowers and Stavely volcanics. East of these belts are the Stawell, Australia and Robertson Bay zones composed of Cambrian to Ordovician turbidites intruded by Devonian to Carboniferous granites. The Stawell zone constitutes the western portion of the 800-km wide Lachlan Fold Belt. Over these areas are magnetic quiet zones broken by scattered circular highs with amplitudes of approximately 40 nT associated with the intrusions.

The aeromagnetic data can be used to extend the clearly defined basement units from northern Victoria Land south to the Royal Society Range. Similarities of the geology and geophysical signatures of southeastern Australia with comparable data from West Antarctica suggest that the pre-rift basement of at least parts of the Ross Sea and Interior Ross Embayment consists of bits of the Wilson and Bowers terranes and large portions of the Antarctic equivalents to the Lachlan Fold Belt, that is, the Robertson Bay terrane.

Finn, CA, Moore, D, Damaske, D and Mackey, T, *Geology*, **27**, 1087-1090, (1999).

LS08 : TUam04 : G3
Tectonic Evolution of the Mesoproterozoic Albany-Fraser Orogen and Neoproterozoic Leeuwin Gneiss Complex, Southwestern Australia: Australian Portions of Antarctic-Australian Orogens

John Myers (jmyers@sparky2.esd.mun.ca)[1] &
David Nelson (inelson@info.curtin.edu.au)[2]
[1] Department of Earth Sciences, Memorial University, St John's, Newfoundland, A1B 3X5, Canada
[2] Geological Survey of Western Australia, 100 Plain Street, East Perth, WA 6004, Australia

The Albany-Fraser Orogen is exposed for 800 km along the southern coast of Western Australia. The orogen resulted from the collision of a West Australian continent with a South Australian - East Antarctic continent at c.1300 Ma. The orogen was split longitudinally during the rifting of Australia from Antarctica at c. 100 Ma, and the southern part of the orogen is exposed along the adjacent coast of Antarctica in Wilkes Land and the Bunger Hills.

The Albany-Fraser Orogen is truncated to the west by the Darling Fault and juxtaposed against the Neoproterozoic Leeuwin gneiss complex. This complex strikes north-south and is exposed for 100 km along the southwestern coast of Australia. The Leeuwin Complex was truncated to the south by the opening of the Southern Ocean, and the southern continuation of this gneiss complex is exposed in the Prydz Bay - Denman Glacier region of Antarctica.

This presentation will provide an overview of the tectonic and magmatic evolution of both the Albany-Fraser Orogen and Leeuwin Complex, and draw comparisons with their Antarctic equivalents.

The Albany-Fraser Orogen mainly consists of orthogneiss and granite. The orthogneiss was mostly derived from c. 2630 and 1700 - 1600 Ma granitic protoliths that were intensely deformed at c.1300 Ma. These rocks, together with c.1300 Ma gabbro and granite, were stacked in thrust and duplex structures a few kilometres thick and hundreds of kilometres long, at deep crustal levels. Locally derived granitic melts formed in low strain zones during the peak of metamorphism.

Between c.1300 and 1280 Ma, the resulting thrust pile was transported northwards and elevated onto the edge of the West Australian continent. Associated tectonic fabrics formed at decreasing metamorphic grades from amphibolite to greenschist facies, and ductile structures were increasingly superceded by brittle structures.

After a tectonically dormant period of 100 million years, there was renewed intrusion of large volumes of granite in the southern part of the Australian portion of the orogen, accompanied by regional dextral transpression between c. 1180 and 1130 Ma.

Most of the Leeuwin Complex was derived from c. 780 and 695 Ma granites intruded into Mesoproterozoic anorthosite and c. 1090 Ma granite. The rocks were strongly deformed and converted to granulite facies gneisses at c. 615 Ma, an event that may reflect the amalgamation of an Australian - Antarctic continent with India to form an eastern component of Gondwanaland. These gneisses were intruded by granite at c. 535 Ma, and again deformed and recrystallized in granulite facies during an episode of extension.

LS08 : TUam05 : G3
Correlating the Tectonics and Exhumation from the Southern Prince Charles Mountains to Prydz Bay, Antarctica

Christopher J. L. Wilson
(cjlw@unimelb.edu.au)[1],
Steven D. Boger, **Jeffery J. Vassallo** &
Helen J. Gibson (mail@geotrack.com.au)[2]
[1] School of Earth Sciences, The University of Melbourne, Victoria, 3010, Australia
[2] Geotrack International, 37 Melville Rd, Brunswick West, Vic. 3055, Australia

Regions of the Archaean and Proterozoic sequences in the southern Prince Charles Mountains and Prydz Bay are transected by early Palaeozoic tectonism that laterally transects the east Antarctic Craton. This belt juxtaposes Archaean crust to the south and east against Meso-Neoproterozoic metamorphics to the north and west and defines a separate lithospheric block, consisting of a large section of east Antarctica and India, that did not form part of east Gondwana or Rodinia as they are portrayed in some reconstructions. Instead, this Indo-Antarctic continent accreted with west Gondwana along the Mozambique suture shortly before collision and suturing along a slightly younger (~550-490 Ma) and more easterly "Pan African" suture located in the southern Prince Charles Mountains and Prydz Bay.

Younger quartz- and calcite-filled brittle faults, superimposed on this suture are related to a NNE-SSW trending depression known as the Lambert Graben. Kinematic data from these faults suggest that they formed in response to a NW-SE directed extension, oblique to the axis of the Lambert Graben. The bulk of the movement along these faults was dextral strike slip, accommodating both normal and reverse offset. In the northern Prince Charles Mountains these faults, with kilometre scale offsets, juxtapose the Permo-Triassic Amery Group against the Proterozoic basement. Equivalent strike-slip faults in the southern Prince Charles Mountains produce dextral offset of metamorphic isograds across the Lambert glacier.

Apatite fission track thermochronological data suggests that the Proterozoic and Archaean blocks within the Prince Charles Mountains were exhumed episodically and culminated with a brittle-faulting episode. There is evidence to suggest at least four cooling episodes affected the Prince Charles Mountains, with cooling beginning as a Palaeozoic event between 260 and 220 Ma (Permo-Triassic) and sometime between 140 and 90 Ma (Cretaceous), and between 25 and 0 Ma (Late Tertiary). In the Vestfold Hills the apatite fission track data suggests there was a cooling event beginning sometime between 240 and 220 Ma (Triassic).

This suggests that both surface uplift and denudation of the Prince Charles Mountains-Prydz Bay region began at least by the Permo-Triassic and this tectonism was fairly extensive within the central parts of the east Antarctic shield. Since some faulting clearly post-dates Permo-Triassic sedimentation, and the orientation of the palaeostress field suggested from our kinematic data is consistent with that responsible for rifting between India and Antarctica, we therefore propose that the Lambert Graben is of Cretaceous age, not Permo-Triassic. Furthermore, we suggest that the Lambert Graben is a continental transform zone, which developed in response to continental extension and rifting between India and Antarctica. The chronology of denudation documented by the fission track data is closely linked to the tectonic evolution of the east Antarctic shield and subsequent break-up of Gondwana (Early to Mid Cretaceous).

LS08 : TUam06 : G3
EMAGE 96-2000: Timing of Early Gondwana Break-Up

Wilfried Jokat (jokat@awi-bremerhaven.de),
Uwe Meyer (umeyer@awi-bremerhaven.de) &
Tobias Boebel (tboebel@awi-bremerhaven.de)
Alfred Wegener Institute, Columbusstrasse, Bremerhaven, 27568, Germany

Since the past 20 years there is a considerable interest within the geoscientific community to understand the dynamic and the processes during the break-up of the super continent Gondwana in Jurassic times. While the existing geophysical data give good constraints on the processes during break-up of Australia and New Zealand, this is not true for India and especially for Africa and South America. Here, high quality magnetic data are missing to constrain the plate movements. For closing this gap the East Antarctic Margin Aeromagnetic and Gravity Experiment (EMAGE) began in 1996/97 and has been continued during the austral summers in 1998, 1999 and 2000. This survey was supplemented by helicopter-based magnetic measurements in the austral season 1999/2000 to date the southernmost magnetic anomalies. The results of the first four seasons show remarkably continuous sea floor spreading anomalies from 0° to 20°W along the margin. In the investigated area the anomalies are parallel to the continental margin and show amplitudes up to 200 nT. The pattern of the anomalies suggest a surprisingly simple opening history compared to previously published geodynamic models in the area of the Explora Escarpment. New magnetic data show that the earliest opening started in the Riiser-Larsen Sea at Chron M24, while South America was still attached to Antarctica. The final separation of East and West Gondwana was finished around Chron M13, when the rift system propagated approximately from 0° to Astrid Ridge in a relative short period of time. The consequence of this age model is that the seaward dipping reflectors sequences of the Explora Wedge are most likely not 180 Myr old but were created some 140 Ma. This is in excellent agreement with the Albian age of black shales drilled within the ODP programme in that region. However, the time gap between the initial onshore volcanism in South America, Africa and Antarctica (190-180 Ma) is more than 40 Myr till the final separation of West and East Gondwana occurred. The magnetic anomalies are more complex in the Lazarew Sea. Here, the initial rifting between South America and Africa began.

LS08 : TUam07 : G3
Evidence for a Pan-African Orogenic Belt in Western Dronning Maud Land, Antarctica

Warwick S. Board (foak@geology.uct.ac.za),
Hartwig E. Frimmel & **Richard A. Armstrong**
Department of Geological Sciences, University of Cape Town, Rondebosch, 7701, South africa

The East Antarctic Shield consists of extensive high-grade polydeformed metamorphic provinces surrounding Archaean cratonic nuclei. These metamorphic belts record two significant tectonothermal episodes, at ~1200-1000 Ma and ~550-450 Ma respectively, throughout the shield (e.g. Krynauw, 1996). In Western Dronning Maud Land (WDML) the high-grade Maud Belt is juxtaposed against the Archaean Grunehogna Province and has traditionally been interpreted as a Grenvillian mobile belt that was reworked during the early Palaeozoic (e.g. Grantham et al., 1995; Groenewald et al., 1995). The nature and extent of this reworking in WDML is poorly understood due to the lack of unequivocal evidence for a Pan-African tectonic overprint, and widespread ~500 Ma mineral ages have been interpreted as reflecting isotopic resetting during a regional thermal episode characterised by an absence of penetrative deformation (e.g. Stüwe and Sandiford, 1993).

We studied the H.U. Sverdrupfjella, which form the northern part of the Maud Belt in WDML and record a complex tectonometamorphic history similar to that in adjacent areas. There an early eclogite facies event (M1) was followed by isothermal decompression to upper amphibolite facies conditions (M2). The latter is associated with migmatisation and intense penetrative fabric development. Potassium metasomatism (M3) under a similar regional stress-field followed and outlasted the deformation. M1 and M2 have previously been ascribed to the Mesoproterozoic orogeny and M3 associated with the Pan-African episode (e.g. Grantham et al., 1995). New U-Pb SHRIMP ages on metamorphic monazites hosted in kyanite-garnet-biotite metapelitic gneisses reflect a maximum age of ~530 Ma for the intense fabric and the M2 event. Monazite inclusions of Pan-African age in kyanite indicate that all of the metamorphism recorded in the H.U. Sverdrupfjella is related to the Pan-African episode. This new interpretation of the H.U. Sverdrupfjella representing a Pan-African orogenic belt has significant implications for both crustal evolution models for the Maud Belt and for Rodinia/Gondwana palaeocontinental reconstructions.

Grantham, GH, Jackson, C, Moyes, AB, Groenewald, PB, Harris, PD, Ferrar, Gand Krynauw, JR, *Precambr. Res*, **75**, 209-229, (1995).
Groenewald, PB, Moyes, AB, Grantham, GHand Krynauw, JR, *Precambr. Res*, **75**, 231-250, (1995).
Krynauw, JR, *Terra Antarctica*, **3**, 77-89, (1996).
Stüwe, Kand Sandiford, M, *In: R. H. Findlay, R. Unrug, H. R. Banks and J. J. Veevers (eds.), Gondwana Eight, Balkema, Rotterdam*, 125-130, (1993).

LS08 : TUam10 : G3
Grenville-Age Versus Pan-African Magnetic Anomaly Imprints in Western Dronning Maud Land, East Antarctica

Joachim Jacobs (jojacobs@uni-bremen.de)[1] &
Alexander Golysnky[2]
[1] Universitaet Bremen, FB5-Geowissenschaften, PF 330440, 28334 Bremen, Germany
[2] VNIIOkeangeologia, St. Petersburg, Russia

In this paper we examine aeromagnetic data from a part of the western margin of the Pan-African East Antarctic Orogen. The East Antarctic Orogen represents the southern continuation of the East African orogen that together formed during the collision of E- and W-Gondwana during Late Neoproterozoic/Early Paleozoic times (c. 580-515 Ma). The western margin of the East Antarctic Orogen is exposed in Heimefrontfjella, western Dronning Maud Land, where the western front of this orogen crops out as the Heimefront Shear Zone. Crust west of the Heimefront Shear Zone has typical Mesoproterozoic to Early Neoproterozoic (Grenville-age) K-Ar and Ar-Ar mineral cooling ages and magnetic anomalies are broad, of high-amplitude, elongate, craton-parallel with long wavelengths. East of the Heimefront Shear Zone, K-Ar and Ar-Ar mineral cooling ages range between c. 570-470 Ma and the magnetic anomaly pattern is entirely different. Here, a large magnetic low persists, that is overprinted by small-scale anomalies which are oriented parallel to the regional Pan-African structural trends at a high angle to the Mesoproterozoic anomalies. Thus, the Pan-African tectono-thermal overprint has caused a fundamental redistribution of magnetic minerals. The data show that the combination of aeromagnetic mapping along with detailed field work is a powerful method to delineate the extent of the East Antarctic orogen in poorly exposed Antarctica.

LS08 : TUam11 : G3
Age and Evolution of the Tugela and Mzumbe Terranes, Natal Belt, South Africa

Avinash Bisnath (avinash@pixie.udw.ac.za)[1],
Steve McCourt (smccourt@pixie.udw.ac.za) &
Richard A. Armstrong[2]
[1] University of Durban-Westville, Department of Geology, Private Bag X54001, Durban, South Africa
[2] Research School of Earth Sciences, Australian National University, Canberra ACT 02000, Australia

Two major events, the 1.1 Ga Kibaran and the 0.7 to 0.5 Ga Pan African orogenic episodes shaped Africa prior to its inclusion within the heart of the supercontinent Gondwana. This paper outlines the activities along the Natal Belt between 1.3 and 1.0 Ga. The geochronological history of the Natal Belt can be compared to adjacent sections of Mesoproterozoic crust in Rodinian reconstructions (e.g. Maud Province of East Antarctica). Igneous activities, deformation events and metamorphism can be used to correlate these now widely dispersed areas.

The Kibaran age Natal Belt of South Africa consists of three tectonostratigraphic terranes (Thomas, 1989). These terranes are the Tugela, Mzumbe and Margate terranes. In the Mzumbe terrane the oldest rocks recognised comprise 1235 Ma arc-related, felsic to mafic metavolcanic supracrustal gneisses with subordinate metasediments (Thomas et al, 1994). The Mzumbe orthogneiss a calc-alkine, I-type tonalite-trondjemite unit emplaced at 1207 Ma intrudes these supracrustal rocks. Thomas et al. (1999) also documents syntectonic intrusions of sheet-like leucocratic granites emplaced at 1.1 Ga in both the Mzumbe and Margate terranes and late stage granitoids and charnockite plutons at 1065 +15 Ma with minor intrusive activity continuing until 1025 Ma.

The Tugela terrane remains poorly constrained and is divisible from north to south into the Nkomo, Madidima, Mandleni and Tugela, respectively (Matthews, 1972). The overall mafic nature of the Tugela terrane has led to the suggestion that the terrane represents a part of a mesoproterozioc ophiolite (Matthews, 1972). Recent geochemical and petrological studies of the Tugela terrane point in a different direction.

The Tugela sheet includes the Kotongweni meta-tonalite, a homogeneous body that yields a U-Pb age of 1209±5 Ma making it the oldest component in the Tugela terrane. Geochemical studies of the Kotongweni meta-tonalite indicate that it formed in an oceanic-arc setting and the mafic wall rocks are interpreted as metamorphosed oceanic-arc basalts (McCourt et al, 2000). The Tugela and Mandleni sheets host large mafic/ultramafic layered intrusions. Zircons from these complexes indicate a magmatic event at 1180 Ma. Significant amounts of granitic sheets and dykes intrude into all four sheets and are discordant to the regional fabric. Zircons form sheets in the Madidima sheet yield a U-Pb age of 1155±6 Ma. A link between the Tugela and Mzumbe terranes is demonstrated by arc related magmatism at 1.2 Ga, and the emplacement of post fabric mafic complexes and younger granitic sheets between 1200 and 1100 Ma. The 1050 Ma granite has not been recognised in the Tugela terrane. With regard to the Maud Province of east Antarctica Jackson (1999) obtained a U-Pb age of 1134±11 Ma for a granitic orthogneiss with a single fabric that can be correlated to the granitic sheets present in the Tugela terrane.

Jackson C, *Unpublished (Final Report to SACAR)*, 1-79, (1999).
Matthews PE, *Nature*, **240**, 37-39, (1972).
McCourt, S, Bisnath A, Pather S, Mitchell AA, Johnston ST, Arima M, Tani K, Kawate S & Armstrong RA, *J Afr Earth Sciences (Special Abstract Issue GSSA 27)*, **31**, 48-49, (2000).
Thomas RJ, *S Afr J Geol*, **93**, 761-765, (1989).
Thomas RJ, Cornell DH, Moore JM & Jacobs J, *S Afr J Geol*, **97**, 8-14, (1994).
Thomas RJ, Cornell DH & Armstrong RA, *S Afr J Geol*, **102**, 83-88, (1999).

LS08 : TUam12 : G3
Two Contrasting Charnockite Types, and their Implication for Early Palaeozoic Tectonic Evolution of East Antarctica

Evgueni Mikhalsky (emikhalsky@hotmail.com)[1], **John W. Sheraton**[2] & **Boris Beliatsky**[3]
[1] VNIIOkeangeologia, 1 Angliisky Ave., St. Petersburg 190121, Russia
[2] Department of Geology, Australian National University, Canberra, ACT 0200, Australia, : Stoneacre, Bream Road, St Briavels, Glos. GL15 6TL, UK
[3] Institute of Precambrian Geology and Geochronology, Makarova emb., 2, St Petersburg 199034, Russia

Charnockite (orthopyroxene granite, s.l.) is a prominent rock type throughout much of East Antarctica. It forms large plutons which dominate the geological structure of central Dronning Maud Land (DML) and are widespread in northern MacRobertson Land (MRL) and elsewhere. Those in DML (dated at c. 510 Ma by Mikhalsky et al. 1997) are essentially post-tectonic, whereas those in MRL (dated at c. 980 Ma by Kinny et al. 1997) are syn- to late-tectonic. Although both suites comprise various lithologies (opx-bearing monzodiorite, monzonite, syenite, and granite), there are systematic compositional differences for a given SiO_2 content. Early Palaeozoic charnockites from DML are generally enriched in K_2O, Zr, Ba, and Th, have much higher Fe/Mg, and do not have the prominent Nb anomalies shown by Neoproterozoic MRL charnockites, at least some of which may have a major mantle component. There are also differences in many incompatible element ratios, so that DML and MRL rocks plot in distinct fields on most discrimination diagrams. DML charnockites commonly correspond to intraplate post-orogenic A-type rocks, whereas MRL charnockites have compositional features of orogenic granitoids.

Three magmatic zircon size fractions from a charnockite pluton in the isolated Grove Mountains (Princess Elizabeth Land, PEL) have indistinguishable nearly concordant ages of about 504±2 Ma. However, in spite of being much younger, this charnockite has a very similar chemical composition to some of the abundant early Neoproterozoic charnockite plutons in MRL, and thus appears to have originated in a late-orogenic, rather than anorogenic, tectonic environment. Preliminary ages from the Grove Mountains (unpublished data of the authors) provide evidence for, as yet, geologically poorly defined Palaeoproterozoic (c. 2000-1700 Ma) and younger (Meso- Neoproterozoic to Pan-African) events; the youngest event was dated at c. 510-508 Ma and probably reflects waning stages of high-grade metamorphism in this area only shortly before charnockite emplacement. Such major Pan-African tectonic activity suggests closer affinities with the Prydz Bay coast area of PEL than MRL.

Assuming that the contrasting geochemical features reflect different source composition and/or tectonic environments, we suggest that Pan-African processes in DML and the Prydz Bay-Grove Mountains area may have been of somewhat different natures. The former was affected by essentially within-plate deformation and anorogenic magmatism, whereas the latter represents a Pan-African mobile (orogenic) belt, with charnockites more comparable with those of MRL in having larger mantle-derived components.

Kinny, P.D., Black, L.P. & Sheraton, J.W., *AGSO Journal of Australian Geology and Geophysics*, **16**, 637-654, (1997).
Mikhalsky, E.V., Beliatsky B.V., Savva, E.V., Wetzel, H-U., Fedorov, L.V., Weiser, T. & Hahne, K., *In: Ricci, C.A. (ed), The Antarctic region: geological evolution and processes. Terra Antartica Publication*, 45-53, (1997).

LS08 : TUam13 : G3
Grove Mountains: A Segment in the Collage during East Antarctic Shield Forming?

Xiaohan Liu[1], **Yue Zhao**[2], **Xiaochun Liu** & **Liangjun Yu**[1]
[1] LTE Lab. Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, 100029, P.R.China
[2] Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing, 100081, P.R.China

Recent thermo-tectonic and geochronological data from the Grove Mountains, expanding between both the Southern and Northern Prince Charles Mountains, Larsemann Hills and Vestfold Hills, indicates that the Pan-African aged mobile belt in Prydz Bay region outspreads southward into inland of Antarctic Ice Sheet 400 km at least. Certain of different characterastics in metamorphic rock types, representational mineral assemblages, structural aspects and the process of metamorphic evolution are occuring between different outcrop localities in that belt. Some idiocratic of tectonic and metamorphic evolution in the Early Paleozoic mobile belts (Chinese Pan-African aged orogenic belt?) outspreads between the South-east China block and the Yantzi Craton, with that of North-Eastern India and the coast region of West Australia, suggests a complicate archipelago style during accretion history of East Gondwana Supercontinent. Both the local case and large scale tectonic background are apt to that the East Antarctic Shield has been formed by collage of small continental blocks after the Rodinia Supercontinent broken out.

Zhao Y, Liu X, et al, *Precambrian Research*, **75**, 175-188, (1995).
Dirks PHGM & Wilson CJL, *Precambrian Research*, **75**, 189-207, (1995).
Henson BJ & Zhou B, *Australia Journal of Earth Science*, **42**, 249-258, (1995).
Boger SD, Carson CJ, Wilson CJL & Fanning CM, *Precambrian Research*, **104**, 1-24, (2000).
Manton WIet al, *Recent progress in Antarctic Earth Sciencd, Terra Scientific Pub. Com*, 179-189, (1992).
Zhao Y, Liu XC & Liu XH, *proceeding of 31th IGC*, (2000).

Tuesday PM Session

LS08 : TUpm25 : G3
The Dufek Intrusion: A Centre for Ferrar Large Igneous Province Dyke Emplacement?

Julie Ferris (jkf@bas.ac.uk)[1], **Bryan Storey** (b.storey@anta.canterbury.ac.nz)[2], **Alan Vaughan** (apmv@bas.ac.uk)[1], **Phil Jones** (pcj@bas.ac.uk)[1] & **Philip Kyle** (kyle@mailhost.nmt.edu)[3]
[1] British Antarctic Survey, High Cross, Madingley Road, Cambridge, CB3 OET, UK
[2] University of Canterbury, Private Bag 4800, Christchurch, New Zealand
[3] New Mexico Tech, Socorro, NM 87801, US

The gabbroic Dufek intrusion of the Ferrar Large Igneous Province (FLIP), Antarctica covers 6,600 km^2. It may represent the location of a mantle superplume responsible for Gondwana breakup. The intrusion has been proposed as a feeder for FLIP sills and lavas that extend 3,500 km along the Transantarctic Mountains into Tasmania and New Zealand. However, no feeder dykes or connecting sills have been found. Newly acquired aeromagnetic data in the vicinity of the Dufek Intrusion indicate the presence of three sets of dykes. One set is spatially related to Cambrian volcanic and intrusive rocks and could be Cambrian in age. The other two sets may be Jurassic; one parallels the East Antarctic margin (Ross Sea trend), and the other has a more localized trend. We suggest that the dykes emplaced parallel to the Ross Sea trend were feeders for the FLIP. Similarities with the Mackenzie dykes and intrusions of Northwest Canada imply that the Jurassic dykes may have been emplaced into the existing Ross Sea extensional regime during doming above a mantle plume. However, the survey area is too small to show the dykes radiating from a focal point that would indicate the plume position.

LS08 : TUpm26 : G3
A Combined Gravity and Magnetic Survey of the Ferrar Large Igneous Province in the Northern Pensacola Mountains, Antarctica

Philip C. Jones (pcj@bas.ac.uk) & **Julie K. Ferris** (jfk@bas.ac.uk)
British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK

The existence in the study area of the Dufek intrusion, part of the Ferrar Large Igneous Province (FLIP), has led to the speculation that the northern Pensacola Mountains was the impact site of a mantle superplume, which led to Gondwana break-up. The FLIP gabbro bodies along with the surrounding Palaeozoic sedimentary rocks are flanked on all sides by sub-glacial basins (average bedrock height 750 m below sea level) forming a distinctive topographical feature; an island of relatively high bedrock with an average height of 500 m above sea level. An even sampling of the gravity field over the majority of the Pensacola Mountains has now been obtained from an airborne gravity survey, in which 4,500 line km of data was acquired. The free air anomaly field was recovered with an accuracy of 5 mGals for wavelengths greater than 10 km. Simultaneous measurements of the magnetic field were recorded and ice thickness and topographical data were obtained from radio echo soundings. Faults and structural trends interpreted from the Bouguer and magnetic anomaly maps show significant correlation in location. By combining magnetic and gravity models, it is possible for the first time to place boundaries on the volume of gabbro in a major part of the FLIP. Such volume estimates are a vital indicator in deciding whether the Dufek intrusion was the immediate centre for the evolution of all Ferrar magmas.

LS08 : TUpm28 : G3
From Breakup of Rodinia to Breakup of Gondwana: Evidence for Episodic Mantle Magmatism from Basic Dikes of the Schirmacher Oase, Central Dronning Maud Land (Antarctica)

Friedhelm Henjes-Kunst (henjes-kunst@bgr.de)
Bundesanstalt f. Geowissenschaften u. Rohstoffe, Stilleweg 2, D30655-Hannover, Germany

Basement rocks of the Schirmacher Oase in central Dronning Maud Land (East Antarctica) are intersected by different generations of basaltic to granitic dikes. Field relations and petrographical, geochronological (Henjes-Kunst, in press; Rolf & Henjes-Kunst, in press), geochemical and isotopic data allow to distinguish between 4 groups of basic dikes. All these dikes show high Mg/(Mg+Fe) (> 0.59) and elevated Cr concentrations (130 - 1280 ppm) but lack significant Eu anomalies thus indicating near-primitive mantle-derived melt compositions without evidence of significant crustal contaminations or AFC processes. For the early- to synkinematic granulite-facies *group 1 dikes*, the emplacement age is constrained by Sm-Nd model ages (c. 1.0 Ga) and the age of Pan-African high-grade metamorphism (c. 625 Ma). In multi-element chemical variation diagrams, these dikes exhibit smooth convex-upwards patterns with moderately enriched incompatible-element concentrations and maximum values for the HFS elements Nb and Ta. The age constraints, geochemical characteristics and ε_{Nd} values (calculated at 0.8 Ga) of c. +5 suggest that group 1 dikes represent plume-related continental-flood basalts linked to the breakup of Rodinia in the early to middle Neoproterozoic.

Syn- to latekinematic granulite-facies *group 2 dikes*, which crosscut group 1 dikes, and undeformed and unmetamorphosed *group 3 dikes* (lamprophyres s.l.) were emplaced in latest Neoproterozoic and Cambrian times, respectively and are therefore closely related in time and space to the early and late pulses of anorogenic AMCG-type magmatism in central Dronning Maud Land (c.f. Jacobs et al. 1998). These dikes show moderately (group 2) to strongly (group 3) incompatible-element enriched compositions typical for lamprophyric rocks. Dikes of both groups are characterized by negative Nb and Ta anomalies documenting a lithospheric mantle source modified by subduction processes. Constant initial ε_{Nd} values of +2 for group 2 dikes contrast with variable values of +2 to -15 for group 3 rocks. This indicates addition of a low ε_{Nd} "Archaean" component to the subcontinental lithosphere between formation of group 2 and group 3 dikes in the latest Neoproterozoic. Group 2 and group 3 (meta-) lamprophyres are interpreted to result from anorogenic magmatism postdating collisional events during late Pan-African amalgamation of Gondwana.

Group 4 dikes are undeformed and unmetamorphosed dolerites of Jurassic age. Two investigated dikes have compatible and rare-earth element concentrations similar to group 1 metabasalts but are moderately enriched in the strongly incompatible LIL elements K, Ba, and Rb, show negative Nb-Ta anomalies and have initial ε_{Nd} values in the range of group 3 lamprophyres. Therefore, an origin from a lithospheric mantle source similar to that envisaged for group 3 dikes is likely for the dolerites. Group 4 dikes are related to the large Karoo continental-flood basalt province and thus are witness of breakup of Gondwana in central Dronning Maud Land.

Henjes-Kunst F, *Geol. Jb. (accepted for publication)*
Jacob J, Fanning M, Henjes-Kunst F, Olesch M & Paech H, *J. Geol*, **106**, 385-406, (1998).
Rolf C & Henjes-Kunst F, *Geol. Jb. (accepted for publication)*

LS08 : TUpm30 : G3
Zircon Chemistry and the Definition of High-Grade Events in East Antarctica

Simon Harley (sharley@glg.ed.ac.uk)
Dept of Geology & Geophysics, University of Edinburgh, Kings Buildings, West Mains Road, Edinburgh, Scotland, UK

Application of zircon U-Pb mineral geochronology to unravelling the complex geological histories of ancient (3000-1000 Ma) crustal domains influenced by later Pan-African events in East Antarctica is problematic because of the highly variable chemical and physical response of zircon to the younger events. Textural and trace element analysis of suites of dated zircons from the Napier Complex and Rauer Islands have been applied to establish the control exerted by metamorphic garnet on zircon REE chemistry and define the event significance of zircon U-Pb age data in each case, with implications for the interpetation of Pan-African overprints in the Rauer Islands. Observations from the Napier Complex demonstrate that metamorphic zircon HREE chemistry is strongly controlled by the presence of garnet and hence allows such zircons to be tied to reactions operating at high-T conditions. Zircons show 2900-2500 Ma structured cores, often transected by sealed fractures, inside relatively homogeneous overgrowths which give 'ages' of 2400-2600 Ma. Whereas zircon cores preserve highly HREE enriched chemistry with high Yb/Gd, zircon rims in garnet-bearing samples have flat HREE patterns (low Yb/Gd) that are comparable to garnet HREE ($D^{(zircon/garnet)}$ = 0.4-0.7 at Holmium) and to aluminous orthopyroxene formed with garnet or on its breakdown at high temperature. Texturally-modified zircons in garnet-deficient paragneiss, on the other hand, preserve steep HREE patterns with high Yb/Gd in lobate-cuspate rim zones , consistent with the absence of garnet and with partial equilibration with orthopyroxene that also has steep HREE. Application of this approach to zircons from a garnet-bearing metamorphosed ferrodiorite from the Rauer Islands (Harley et al., 1998) indicates that the inference of a high-grade (granulite facies) Pan-African overprint in this terrain must be viewed with caution. 2840 Ma igneous zircons show partial and localised U-Pb resetting at ca. 510 Ma, texturally associated with lobate and cuspate BSE zones, that could be inferred to reflect a high-grade metamorphic event at that time. However, these zircon zones show steep HREE patterns with high Yb/Gd that are inconsistent with equilibration with the abundant garnet in the rock. Hence, garnet formation and high-grade metamorphism in this example preceeded and was not related to the Pan-African event that caused resetting of these zircons. It is crucial that zircons are characterised for both their textures (in-situ) and trace element chemistry before their preserved U-Pb ages are attributed to specific metamorphic events, particularly in demonstrably poly-metamorphic high-grade terrains, particularly in cases where the grade of the final event(s) is similar to or lower than the earlier events that it variably overprints.

Harley SL, Snape I & Black LP, *Precamb.Res.*, **89**, 175-205, (1998).

LS08 : TUpm31 : G3
500 Ma Migmatisation Event in Gjelsvikfjella, Dronning Maud Land – Implications for Continent-Continent Collision

Oskar Paulsson (oskar.paulsson@geol.lu.se)[1] & **Hakon Austrheim** (hakon.austrheim@toyen.uio.no)[2]
[1] Dept. of Geology, Solveg. 13, S-223 62 LUND, Sweden
[2] Mineralogical-Geological Museum, Sars gate 1, N-0562 Oslo, Norway

Zircons from a heterogeneous granitic migmatite from Jutulsessen nunataks, Gjelsvikfjella, Dronning Maud land has been dated by ionprobe. The migmatisation is extensive in the Jutulsessen area and zircons from paleosome and neosome where analysed separatedly. The zircons are compositionally complex with oscillatory zoned cores and more homogeneous rims. Zircons from paleosome and zircon cores from neosome yielded an age of 1156 ±10 Ma. The Th/U ratio indicates a magmatic origin and the age is interpreted as the crystallisation age of the protolith granite. Sm-Nd depleted mantle model ages of the Jutulsessen granitic migmatite are c. 1400 Ma indicating the presence of older material in the source of the protolith granite.

The U-Pb age of the zircon rims from neosome is 504 ±7 Ma and the Th/U ratio typical of metamorphic zircon. The same age was obtained from sector-zoned zircons in pegmatite dykes. The migmatite formation is thus the result of Cambrian metamorphism and suggested to been caused by the collision between the Kalahari craton and east Antarctica during the Kuunga orogenesis (Meert, 2000).

The migmatite veins are cross cut by the Stabben syenite intrusion and later by aplitic dykes. They yielded an U-Pb age of 500 ±19 Ma and 495 ±15 Ma respectively. The Sm-Nd model age for the Stabben syenite is 1365 Ma and for the aplitic dykes 1825 Ma. This implies that the Stabben intrusion and the aplitic dyke were derived from a heterogeneous Mezoproterozoic crustal source.

The late Mezoproterozoic Dronning Maud Land is correlated with the Namaqua-Natal Belt in S. Africa which is interpreted to be formed as an volcanic arc, later accreted onto the Kalahari craton at 1090-1000 Ma (Fitzsimons, 2000, Cornell et al., 1996, Jacobs et al., 1999). The Jutulsessen heterogeneous granitic migmatite compares well with early orthogneisses from the Natal province.

The Neoproterozoic setting of Dronning Maud Land is uncertain but a continent-continent collision between the Kalahari craton and east Antarctica with a suture from near Lützow-Holmbukta to Shackleton range have been suggested (Fitzsimons, 2000).

Geochemically the Stabben intrusion is a within plate intrusion (WPG). Continent-continent collision settings tends to produce late or post-collisional granites with a WPG affinity (Forster et al., 1997). The established tectonic model for a continent-continent collision with thickening of the crust and detachment of the lithosperic root (Andersen et al., 1991) may be applied for the Cambrian collision between Kalahari and east Antarctica, Kuunga orogen. Detachment of the lithosperic root leads to a large heat input from the mantle, late or post-collisional plutonism and high temperature low pressure metamorphism of the crust with formation of migmatites as seen in this study.

Andersen, T.B., Jamtveit, B., Dewey, J.F., and Swensson, E., *Terra Research*, **3**, 303-310, (1991).
Cornell, DH, Thomas, RJ, Bowring, SA, Amstrong, RA, and Grantham, GH, *Precambrian Research*, **77**, 243-271, (1996).
Fitzsimons, ICW, *Geology*, **28**, 879-882, (2000).
Forster, HJ, Tischendorf, G, and Trumbull, RB, *Lithos*, **40**, 261-293, (1997).
Jacobs, J, Hansen, F, Henjes-Kunst, F, Thomas, RJ, Weber, K, Bauer, W, Armstrong, RA, and Cornell, DH, *Terra Antarctica*, **6**, 377-389, (1999).
Meert, J, *Tectonophysics*, (in press).

LS08 : TUpm34 : G3
Granitic Magmatism in the Kerala Khondalite Belt, Southern India: Results of EPMA and U-Pb Dating of Monazite

Ingo Braun (ingo.braun@uni-bonn.de)[1] & **Michael Bröcker** (brocker@nwz.uni-muenster.de)[2]
[1] Dept. of Mineralogy, University of Bonn, Poppelsdorfer Schloß, 53115 Bonn, Germany
[2] Dept. of Mineralogy, University of Münster, Corrensstr. 24, 48149 Münster, Germany

The Kerala Khondalite Belt (KKB) in southern India formed part of an internal mobile belt within East Gondwana and was subjected to granulite-facies metamorphism during Pan-African Orogeny c. 550 Ma ago. In addition to supracrustal lithologies of pelitic and psammitic composition, rocks of magmatic origin are widespread in the northern and central part of the KKB and comprise granitic garnet-biotite gneisses and garnet- and/or biotite-bearing leucogranites. Granitic gneisses are medium- to coarse-grained rocks and often characterized by a conspicuous augen texture which is defined by cm-sized feldspar porphyroblasts. Field relations, microtextures and the results of EPMA monazite dating suggest a derivation from porphyritic granites which were emplaced into the KKB metasediments prior to Pan-African deformation and high-grade metamorphism. Biotite dehydration-melting during the peak-metamorphic stage of the Pan-African orogeny led to intense migmatization of the gneisses and to the generation of peraluminous leucogranites. U-Pb monazite dating of selected leucogranite and gneiss samples yielded mostly concordant ages between 590 - 520 Ma. The data do not support previous interpretations according to which the emplacement of leucogranitic melts significantly postdated the peak stage of Pan-African metamorphism in the KKB (Braun et al. 1998). Furthermore, the results obtained for the granitic gneisses rather reflect cooling from UHT temperatures (≥900°C; Braun et al. 1996, Chacko et al. 1996, Nandakumar & Harley 2000) and the time of closure of the U-Pb system in monazite than providing further constraints on the timing of intrusion of the porphyritic granites. The large scatter of concordant ages finally indicates that during Pan-African orogeny the lower crustal basement of the KKB was exposed to high- to ultra-high temperatures over a fairly long time period and that subsequent exhumation and cooling was rather slow. These findings are in agreement with the results of geochronological studies carried out on granulite-facies rocks from southern Madagascar (Ashwal et al. 1999) and provide further insights into the tectono-thermal evolution of East Gondwana at the end of the Proterozoic.

Braun I, Montel JM & Nicollet, C, *Chem. Geol.*, **146**, 65-85, (1998).
Braun I, Raith M & Ravindra Kumar, *J. Petrol.*, **37**, 1285-1305, (1996).
Chacko T, Lamb M & Farquahar J, *Gondwana Res.Group Mem.*, **3**, 157-165, (1996).
Nandakumar v & Harley SL, *J Geol*, **108**, 687-703, (2000).
Ashwal LD, Tucker RD, Zinner EK, *Geochim. Cosmochim. Acta*, **63**, 2839-2851, (1999).

LS08
Age Growth and Evolution of Antarctica (AGEANT)

LS08 : TUpm35 : G3

The Achankovil Cordierite Gneisses, South India: Melt-Producing and Melt-Consuming Reactions, P-T Path and Position in Gondwana

Bénédicte Cenki (cenki@mail.min.uni-bonn.de)[1],
Ingo Braun (ingo.braun@uni-bonn.de) &
Leo M. Kriegsman (leo.kriegsman@utu.fi)[2]
[1] Mineralogisch-Petrologisches Institut, Universität Bonn, 53115 Bonn, Germany
[2] Department of Geology, University of Turku, FIN-20014 Turku, Finland

The NW-SE trending Achankovil Shear Zone (ASZ) separates the Kerala Khondalite Belt (KKB), located at the southernmost tip of the Indian Precambrian shield, from the Madurai Block further north. Ultra-high grade metamorphism of Pan-African age has affected both supracrustal series and early intrusives of the KKB and the ASZ (Braun et al. 1996, Miller et al. 1997, Bartlett et al. 1998, Nandakumar & Harley 2000), now mainly consisting of Grt-Bt-Sil gneisses (khondalites), Grt-Bt leptynitic gneisses, augen gneisses and Crd gneisses. Metapelitic cordierite gneisses exclusively occur within the ASZ and were first investigated by Sinha-Roy et al. (1984) and Santosh (1987). Recently published results of Grt-Opx thermobarometry carried out on these rocks yielded P-T values of 6.5-7.5 kbar and 860-920°C (Nandakumar & Harley 2000).

The present study investigates the development of reaction textures and phase assemblages in the Achankovil cordierite gneisses during the pro- and retrograde stages of Pan-African high-grade metamorphism and puts special emphasis on the interaction between the in-situ melt and coexisting mineral phases. The earliest recorded mineral assemblage in most samples is Bt-Sil-Qtz, which breaks down via successive dehydration melting reactions producing a series of high-T assemblages (e.g., Grt-Crd-Liq, Opx-Liq, Spl-Crd-Liq). Retrograde reactions between the incongruent phases and the in situ crystallizing melt resulted in thin Crd coronas separating Grt from leucosome, and partial resorption of Grt to Opx-Crd or Crd-Bt-Qtz symplectites.

Since classical thermobarometers (e.g., Grt-Opx-Pl-Qtz) do not take into account the melt phase, their use in deducing the P-T evolution of anatectic migmatites is problematic. We therefore present a KFMASH partial petrogenetic grid that includes the melt phase in both prograde and retrograde reactions. Two qualitative pseudosections for microdomains of high and low Al/Si ratios are used to interpret the observed assemblages and reaction textures. This yields a clockwise P-T path culminating at about 6-7 kbar and 900-950°C. Similarities and differences with published P-T paths from adjacent East Gondwana fragments are discussed, with emphasis on similar cordierite gneisses.

Bartlett JM, Dougherty-Page JS, Harris NBW, Hawkesworth CJ & Santosh M, *Contrib. Mineral. Petrol.*, **131**, 181-195, (1998).
Braun I, Raith M & Ravindra Kumar GR, *J. Petrol.*, **37**, 1285-1305, (1996).
Miller JS, Santosh M, Pressley RA, Clements AS & Rogers JJW, *J. Southeast Asian Earth Sci.*, **14**, 127-136, (1997).
Nandakumar V & Harley SL, *J. Geology*, **108**, 687-703, (2000).
Santosh M, *Contrib. Mineral. Petrol.*, **97**, 343-356, (1987).
Sinha-Roy S, Mathai J & Narayanaswamy, *J. Geol. Soc. India*, **25**, 231-244, (1984).

LS08 : TUpm36 : G3

Is the Petrographical P-T-t Path Consistent with the Real Thermal Path? The Example of the Polymetamorphic Ultra-High Temperature Granulites of Andriamena (Madagascar)

Philippe Goncalves
(p.goncalves@opgc.univ-bpclermont.fr)[1],
Christian Nicollet
(nicollet@opgc.univ-bpclermont.fr)[1],
Jean-Marc Montel (montel@cict.fr)[2],
Brieuc Lefevre
(lefevre@opgc.univ-bpclermont.fr)[1],
Jean-Louis Paquette
(paquette@opgc.univ-bpclermont.fr)[1],
Jean-Marc Lardeaux (lardeaux@univ-lyon1.fr)[3] &
Christian Pin (pin@opgc.univ-bpclermont.fr)[1]
[1] Laboratoire Magmas et Volcans, 5, rue Kessler, Clermont-Ferrand, 63 000, France
[2] LMTG, 39, allées J. Guesde, 31 000 Toulouse, France
[3] Laboratoire de dynamique de la lithosphère, 43, bd du 11 Novembre, 69 622 Villeurbanne, France

Due to their refractory behaviour, Mg-Al granulites preserve numerous coronitic textures providing plenty information to reconstruct continuous petrographical paths. In most cases, these granulites have suffered a polymetamorphic history. Without geochronological data, it is thus difficult to interpret them and infer tectonic interpretations. Our study area is located in the Andriamena mafic gneiss belt (North-Central Madagascar). It is characterized by a polymetamorphic and magmatic history since 2,5 Ga to 530 Ma and by the occurrence of sapphirine-bearing granulite relics and metapelitic migmatites. Petrographical investigations of both samples clearly show two different PT evolutions : - Mg-granulites preserve UHT assemblages (grt0-spr0-qz / opx1-sil1-qz) suggesting minimal PT conditions of 1050°C, 11 kbar. Subsequently, a sequence of complex coronitic textures (spr2-crd2 / opx2-spr2-crd2 / opx2-crd2) suggest an isothermal decompression (ITD) from 11 to 7 kbar at T>900°C. Finally, the crd2 are overprinted by an opx3-sil3-qz symplectite implying a return into the opx-sil-qz stability field probably through an isobaric cooling (IBC) at about 7 kbar. - Migmatites record a heating-cooling path at about 7 kbar, without any significant change in pressure. Partial melting was achieved by biotite dehydration reactions at T<850°C, followed by back melting reactions with the residual silica-undersatured melt. PT conditions of the retrograde path are similar to the IBC of the Mg-granulites. Multi-method geochronology (microprobe U-Th-Pb, U-Pb, Lu-Hf, Sm-Nd) are used to constrain these PT evolutions. In-situ electron microprobe dating has the advantage to combine textural features, chemical compositions and ages to distinguish several episodes of monazite growth. The Mg-granulite monazites included in garnets yield the oldest age of about 2,5 Ga. We suggest that this age reflect the age of the UHT metamorphism. Matrix monazites in close association with the opx3-sil3-qz symplectites yield an age of 771±18 Ma. Chemical and textural features suggest a new episode of monazite crystallisation contemporeanously with the IBC. Migmatite monazites yield an U-Th-Pb age poorly constrained of about 770 Ma. U-Pb and Lu-Hf/Sm-Nd garnet geochronology better constrain them. Geochronological data imply that the petrographical path recorded in the Mg-granulites cannot obviously be interpreted as a continuous PT path in a single metamorphic event. Two thermal events occurred : firstly, late Archean UHT metamorphism was followed by a cooling to the steady state geotherm in a single tectonothermal event. At 770 Ma, the second thermal event occured at lower pressure. Therefore, it suggests that the ITD is a fictive path joining these two events : the 2,5 Ga high pressure event and the 770 Ma low pressure one. The Neoproterozoic event could be the consequence of a thermal perturbation caused by the emplacement of mafic intrusions at 787±16 Ma (Guérrot et al., 1993) in a continental arc setting in relation with the subduction of the Mozambique ocean (Handke et al., 1999).

Guerrot C, Cocherie A & Ohnenstetter N, *Terra Abstracts*, **5**, 387, (1993).
Handke MJ, Tucker RD & Ashwal LD, *Geology*, **27**, 351-354, (1999).

LS08 : TUpm37 : G3

Revised Precambrian Crustal History of the Nimrod Group, Central Transantarctic Mountains, Antarctica

John W. Goodge (jgoodge@mail.smu.edu)[1] &
C. Mark Fanning (prise.fanning@anu.edu.au)[2]
[1] Department of Geological Sciences, Southern Methodist University, Dallas, Texas, 75275, USA
[2] Research School of Earth Sciences, The Australan National University, Canberra, ACT, 0200, Australia

High-grade metamorphic and igneous rocks of the Nimrod Group represent some of the only known crystalline basement of the East Antarctic shield exposed in the Transantarctic Mountains (TM). SHRIMP U-Pb zircon age data show that this assemblage preserves multiple geologic events spanning 2.5 b.y. of Archean to early Paleozoic history, culminating in thermomechanical reworking and active-margin magmatism during the Ross orogeny.

The oldest layered gneisses have ages that document magmatic Archean crust between 3150-3000 Ma. Correspondence of U-Pb zircon crystallization ages with whole-rock Sm-Nd model ages indicates formation from a juvenile mantle melt. This Archean magmatic crust extends beneath the polar ice cap to the central TM where it experienced subsequent Paleoproterozoic and late Neoproterozoic dynamothermal effects.

Magmatism at c.3000 Ma was followed closely by high-temperature metamorphism, recorded by zircon crystallisation at 2955-2900 Ma. This metamorphism may be a consequence of high advective heat transfer associated with magmatism. One leucocratic gneiss unit also shows evidence of anatexis at c.2500 Ma, and a quartzofeldspathic gneiss records similar aged magmatism. There is no other independent petrologic evidence to reveal the nature of this event, but it is interpreted to reflect magmatism and ultra-metamorphism related to late Archean orogenic activity.

Some gneissic and metaigneous rocks record a major period of deep-crustal metamorphism and magmatism between c.1730-1720 Ma. Zircons from Archean layered gneiss protoliths show metamorphic overgrowths of c.1730-1720 Ma, and a preserved eclogitic block has a metamorphic zircon crystallization age of c.1720 Ma. An intrusive and deformed granodiorite yielded a concordant c.1730 Ma age. Despite scant petrologic evidence for these metamorphic and igneous events, the data from these diverse rock types indicate major crustal thickening, possibly due to collision, in the late Paleoproterozoic. We therefore recommend revival of the term Nimrod Orogeny to describe Paleoproterozoic events in East Antarctica that may have played an early role in supercontinent assembly.

The Nimrod Group basement is intruded by several syntectonic intrusions at 540-520 Ma. These record Ross deformation in the deep-level orogenic basement. U-Pb ages on late- to post-tectonic granitoid plutons that cross-cut all other deformed units reveal that kinematically late magmatism was also diachronous. A small gabbroic body containing discrete thin shear zones yielded an age of c.540 Ma with no inheritance. A gneissic leucogranite yielded a similar age, and may represent local melting. Two other units - a hornblende-biotite granodiorite and a muscovite-biotite-tourmaline granite - yielded ages of c.500 Ma with abundant older cores. These are the first reliable zircon U-Pb age results for late-stage Granite Harbour intrusions in high-grade basement. Inherited zircon components are compatible with melting of lower crust like that presently exposed in the TM, but the small proportion of older cores suggests that melt production involved relatively large degrees of fractional melting.

Tuesday PO Session

LS08 : TUpo01 : PO

Antarctic Crustal History in Context of Evolution of the Supercontinents

Garrik Grikurov, **Evgueni Mikhalsky** & **German Leitchenkov**
VNIIOkeangeologia, Angliisky ave., 1, St. Petersburg 190121, Russia

Extensive isotope geochemistry data suggest that most varieties of the exposed Antarctic igneous and metamorphic assemblages, except the oldest (> 3.5 Ga) Napier Complex highest-grade rocks, were mainly formed at the expense of crustal material whose emplacement age considerably exceeds the time of formation of the analyzed specimens, sometimes by more than 1.5 Ga.

The mode and the geodynamic environment of emergence of the Archean and Paleoproterozoic crustal protoliths are largely unknown although their sporadic presence throughout the greatest part of the continent is now well established. Regionally traceable Precambrian events broadly correspond to the Mesoproterozoic cycle (1.6 - 1.1 Ga) and its terminating Grenvillean orogeny. The nature of this orogeny remains contradictory, since the assemblages of this age exhibit features suggestive of variable geodynamic environments. No appreciable crustal growth can be attributed to the Grenvillean event which was, perhaps, essentially a transtensional healing of weakened zones in the older continental lithosphere, with local manifestations of subduction-related magmatic activity and limited evidence of formation of new crust.

The early Paleozoic (Pan-African) tectonic processes in East Antarctica were entirely of within-plate origin and did not involve formation of mantle-derived rocks (with a possible exception of poorly dated ophiolite assemblage in the Shackleton Range), though were obviously responsible for generation of large amounts of anatectic melts resulting in emplacement of predominantly mid-crustal anorogenic intrusions accompanied by transtentional and thrust tectonics in the upper crust. In the Transantarctic Mountains the synchronous Ross events apparently included extensive subduction-related magmatic processes, although the existence of a Late Precambrian Paleo-Pacific ocean in place of West Antarctica is not conclusively confirmed.

On the basis of the above observations it is concluded that throughout its geological history Antarctica (or at least the eastern part of the continent) behaved as a continental unity whose integral parts never experienced complete separation by major, long-lived oceanic openings. Such view can also be supported by the presence of high-Mg mafic dykes in Enderby Land, Vestfold Hills and the southern Prince Charles Mountains. These dykes in all three areas display undistinguishable geochemical compositions and identical isotopic ages of c. 2.4 Ga thus suggesting that their host assemblages had been in a compact conjugate position even since before the dykes were intruded in the earliest Paleoproterozoic time.

The lack of unambiguous evidence of Antarctica's amalgamation from isolated blocks of continental lithosphere, and/or of participation of the entire Antarctic continental mass in amalgamation of the supercontinents may have impact on the current concepts of Rodinia and Gondwana as different historical entities separated by the prolonged period of large-scale continental drift.

LS08 : TUpo02 : PO

Proterozoic Sm-Nd Internal Isochron Ages of the Sapphirine- and Orthopyroxene-Bearing Metamorphic Rocks from Tonagh Island, Napier Complex, East Antarctica, Possible Relation to the Rayner Complex

Masaaki Owada (owada@sci.yamaguchi-u.ac.jp)[1], **Yasuhito Osanai** (osana@cc.okayama-u.ac.jp)[2], **Tsuyoshi Toyoshima** (ttoyo@sc.niigata-u.ac.jp)[3], **Toshiaki Tsunogae** (tunogae@edu.shimane-u.ac.jp)[3], **Tomokazu Hokada** (hokada@nipr.ac.jp)[5] & **Hiroo Kagami** (kagami@gs.niigata-u.ac.jp)[3]
[1] Dept. Earth Sciences, Yamaguchi Univ., 1677-1 Yoshida, Yamaguchi, Japan
[2] Dept. Earth Sciences, Okayama Univ., 3-1-1 Tsushima-naka, Okayama, Japan
[3] Grad. School Sci. & Tecnol., Niigata Univ., 2 Ikarashi, Niigata, Japan
[4] Dept. Earth Sciences, Shimane Univ., Nishi Kawazu, Japan
[5] National Inst. Polar Res., 1 Kaga, Itabashi-Ku, Japan

The Napier Complex, East Antarctica is one of the oldest Archaean complexes in the world. It is also recognized as metamorphic terrane having undergone ultrahigh-temperature (UHT) metamorphism, characterized by spinel-quartz, sapphirine-quartz and orthopyroxene-sillimanite-quartz associations (e.g. Sheraton et al., 1987). Metamorphic P-T conditions are up to 1.1 GPa and 1100ºC (e.g. Harley and Hensen, 1990). The dominant rock type is pyroxene- and garnet-bearing quartzo-feldspathic gneiss of igneous origin (orthogneiss), with subordinate mafic, ultramafic and sedimentary rocks (Sheraton et al., 1987). The tonalitic precursor of the orthogneiss intruded into the crust - 3800 Ma, as revealed by ion microprobe U-Pb analysis of zircon (Harley and Black, 1997). Owada et al. (1995) reported the Sm-Nd whole rock isochron of the mafic gneisses with an age of 3807 ±376 Ma. Granitic intrusive rocks and mafic dykes are also present.

Geochemical studies for the mafic gneisses and meta-ultramafic rocks from the Napier Complex have been conducted by previous workers (e.g. Sheraton et al., 1987; Owada et al., 2000). Owada et al. (2000) described geochemical characteristics of mafic gneisses and meta-ultramafic rocks on Tonagh Island. Most of the mafic gneisses and the meta-ultramafic rocks occur as intercalated layers or lenses within the quartzo-feldspathic gneisses. These rocks are high-Mg composition and have undergone ultrahigh-temperature metamorphism. Some of the mafic gneisses and the meta-ultramafic rocks locally cut the layers or foliations of neighboring quartzo-feldspathic gneisses, suggesting that these mafic gneisses and meta-ultramafic rocks were originally intrusive rocks. Major and trace element compositions of the mafic gneisses and the meta-ultramafic rocks resemble those of komatiitic basalt to komatiite from Archaean greenstone belts.

We measured Sm-Nd dating of the meta-ultramafic rock and the sapphirine-bearing felsic gneiss. In addition to the whole rock, garnet and pyroxene separated from the meta-ultramafic rock give a Sm-Nd internal isochron age of 1537 ±11 Ma. Similar ages (c. 1500 Ma) are reported from the Rayner Complex (Black et al., 1986). After 1500 Ma, the tectonothermal events of the Napier Complex resemble those of the Rayner Complex, suggesting that the timing of amalgamation between the Napier Complex and the Rayner Complex could be regarded as prior to 1500 Ma. An inclination line connecting with garnet, whole rock, sapphirine and felsic fraction gives an age of 1876 ±61 Ma. The age may reflect a tectonothermal event followed by ultrahigh-temperature metamorphism (c. 2500 Ma) of the Napier Complex.

Black LP, Sheraton JW & James PR, *Precambrian Res*, **32**, 343-368, (1986).
Harley SL & Black LP, *Antarct. Sci*, **9**, 74-91, (1997).
Harley SL & Hensen BJ, *High-temperature metamorphism and crustal anatexis, London, Uniwin Hyman*, 320-370, (1990).
Owada M, Osanai Y, Kagami H & Shiraishi K, *Abst. VII Inter. Symp. Antarct. Ear. Sci. , Siena*, 292, (1995).
Owada M, Osanai Y, Tsunogae T, Toyoshima T, Hokada T & Crowe WA, *Polar Geosci*, **13**, 86-102, (2000).
Sheraton JW, Tingey RJ, Black LP, Offe LA & Eliss DJ, *BMR Bull*, **223**, 51 p, (1987).

LS08 : TUpo03 : PO

Age and Tectonic Setting of a Neoproterozoic Mafic Intrusion from Sri Lanka and Implications for its Position in Rodinia

Matthias Willbold[1], **Ernst Hegner**, **Reiner Kleinschrodt**[2], **Alfred Kröner**[3] & **Heinz Günter Stosch**[4]
[1] Ludwig Maximilians-Universität München, Theresienstr. 41/III, 80333 München
[2] Universität Köln, Zülpicherstr. 49b, 50674 Köln
[3] Johannes Gutenberg-Universität Mainz, Becherweg 21, 55099 Mainz
[4] Universität Karlsruhe, 76128 Karlsruhe

The lithotectonic terranes of Sri Lanka offer an opportunity to study the Neoproterozoic development of Rodinia and Gondwana in East Antarctica. Here we investigate the nature of a postulated terrane boundary (extensional versus compressional setting) between the Wanni Complex (WC), situated in the NW of Sri Lanka, and the Highland Complex (HC) to the SE. The boundary was inferred from Nd model ages showing a range of 1 to 2 Ga in the WC, and >2.2 Ga in the HC (Milisenda et al., 1994). We suggest that the age and chemical composition of a mafic layered intrusion (Kandy Intrusion (KI); Kleinschrodt et al., 1991), situated in the vicinity of the postulated plate boundary in the central part of the island, shed light on this issue.

For zircons from a metagabbro we have obtained an U-Pb age of ca. 790 Ma that is interpreted as the time of crystallization of the KI. The age agrees with the chronological evolution of the WC showing a range of magmatic zircon ages up to 1.1 Ga (Hölzl et al., 1994; Kröner et al., 1994; Kröner, pers. com.). The initial εNd values of the samples are highly heterogeneous (+2 to -11) and we interpret them as evidence of contamination of heterogeneous, mantle-derived melt batches with older crust. The initial εNd values are positively correlated with subduction-related trace element characteristics such as the magnitude of negative Nb-(e.g. La/Nb) and Ti-anomalies. These features are best preserved in samples with highest εNd values and we interpret this relationship as unequivocal evidence for an origin of the KI in a subduction environment associated with an active continental margin. In a Sm-Nd isochron diagram, most of the samples plot on a mixing line with the WC as a crustal endmember, and a mantle component with positive εNd values. This observation strongly supports an origin of the KI on the margin of the WC. Our conclusion implies that WC and HC are distinct lithotectonic units separated by a cryptic suture and that they were juxtaposed sometime after 790 Ma.

The data for the KI corroborate the evidence for a long-lasting igneous activity in the WC probably due to a long-lived magmatic arc facilitating the assembly of microcontinents from ca. 1000 to 800 Ma. The data provide further evidence for a close relationship between Sri Lanka and Madagascar during the final development of Rodinia (Handke et al., 1999; Kröner et al., 2000).

Handke MJ, Tucker RD & Ashwal LD, *Geology*, **27 (4)**, 351-354, (1999).
Kleinschrodt R, Voll G & Kehelpannala W, *Geologische Rundschau*, **80 (3)**, 779-800, (1991).
Kröner A, Jaeckel P, Williams IS, *Precambrian Research*, **66 (1-4)**, 151-181, (1994).
Kröner A, Hegner E, Collins AS, Windley BF, Brewer TS, Razakamanana T & Pidgeon RT, *American Journal of Science*, **300**, 251-288, (2000).
Milisenda CC, Liew TC, Hofmann AW & Köhler H, *Precambrian Research*, **66 (1-4)**, 95-110, (1994).

LS08 : TUpo04 : PO

Preliminary Report on Metamorphic and Geochemical Study of Rocks from the Grove Mountains, East Antarctica

Liangjun Yu[1], **Xiaohan Liu**[1], **Xiaochun Liu**[2] & **Yue Zhao**[2]
[1] Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[2] Institute of Geomechanics, Chinese Academy of Geological Sciences, Beijing 100081, China

The geological expeditions of the Grove Mountains (GMs), East Antarctica, were carried out in 1998-1999 and 1999-2000, in order to know the lithosperic structure and tectonic evolution of the GMs among the Larsemann Hills, the south Prince Charles Mountains and the north Prince Charles Mountains, which belong to Pan-Africa orogenic belt, Neoproterozoic mobile belt and Archaean cratonic block, respectively. The GMs is located to the 400 km south of the Prydz Bay, East Antarctica. The primary rock types are charnockite, mafic granulite, metabasite, garnet and hornblende-bearing biotite plagioclase gneiss, K-feldspar granite and granodiorite, with minor quartzite. Granulite outcropping are centralized in the Mt. Harding, with minor in the Davey Nunataks, Zakhroff Ridge and Gale escarpment, charnockite as well. All rocks underwent granulite facies metamorphism. Spinel + quartz = cordierite was recognized from metapelite (sample S1167) in Wilson Ridge, spinel as residual. Garnet + quartz + H_2O = hornblende + plagioclase + epidote was also recognised from metabasite (sample S116) in the same ridge, plagioclase and epidote as symplectites. Based on garnet-bearing cordierite biotite gneiss outcropping, together with the above two reaction textures, we suggest that two periods of granulite facies metamorphism (medium - pressure M1 and low - pressure M2) were also developed in various metamorphic rocks from the GMs, concurrently with in other areas of East Antarctica. Charnockites intrude high-grade metamorphic zone, e.g. East Antarctica, Africa, central Australia, southern India, Sri Lanka. Detailed geochemical and isotopic studies on these plutons enables important constraints to the regional tectonic setting as well as the origin. These charnockite magmas were mainly derived from mantle are proposed, which consists with the model of crustal accretion processing, which suggests the accretion of the East Antarctic Craton. Based on the field and geochemical study, the mafic granulite magmas were derived from the upper mantle. They were tectonic emplacement dykes, not allochthonous block.

Carson CJ, Dirks PHGM, Hand M et al., *Geological Magazine*, **132**, 151-170, (1995).
Dirks PHGM, Carson CJ, Wilson CJL, *Antarctic Science*, **5**, 179-192, (1993).
Boger SD, Carson CJ,Wilson CLJ et al., *Precambrian Research*, **104**, 1-24, (2000).
Tingey RJ, *Oxford University Press*, 1-73, (1991).
Zhao y, Liu XC,Fanning CM et al., *Abstract Volume of 31th International Geological Congress*, (2000).
Zhao Y, Liu XH, Song Bet al, *Precambrian Research*, **75**, 175-188, (1995).

LS08 : TUpo05 : PO
Southern Australia 1.6 Ga Felsic Volcanic-Type Recognized in the Moraines of the Terre Adélie Craton (TAC) in Antarctica

Jean-Jacques Peucat (peucat@univ-rennes.fr)[1], **Raymond Capdevila** (capdevil@mailhost.univ-rennes1.fr)[1], **C. Mark Fanning** (prise.fanning@anu.edu.au)[2], **Laurence Pécora** (peucat@univ-rennes.fr)[1] & **René-Pierre Ménot** (menot@univ-st-etienne.fr)[3]
[1] Géosciences Rennes, UMR CNRS 6118, 35042 - Rennes cedex, France
[2] Research School of Earth Sciences, ANU, Mills Road, ACT0200, Australia
[3] Université J. Monnet, UMR CNRS 6524, 42023 - Saint Etienne cedex2, France

Terre Adélie (TA) and George V Land (GVL) constitute the Terre Adélie Craton (TAC) in East Antarctica. Outcrops are scarce and restricted to sporadic coastal exposures with some small nunataks on the continent. An alternative mechanism of gathering information about the sub-glacial geology of Antarctica is provided by the more extensive moraines that also occur along the coastal ice edge. A broad range of rock types can be observed, some are totally exotic compared to the local geological setting yet can be used to expand our knowledge of the TAC. This is particularly the case of prominent brick-red, undeformed felsic volcanic erratics which can be found along ca 100 km of coastal line of TA and GVL. All of these felsic volcanic erratics exhibit porphyritic texture with various amount of phenocrysts, ranging from 1 mm to more than 1 cm in size, surrounded by an aphanitic groundmass. Plagioclase, K-feldspar, quartz, biotite and small magnetite phenocrysts are observed in all samples. Some have small phenocrysts of clinopyroxene, clino-amphibole and ilmenite. Hydrothermal alteration which provides brick-red colour occurs in all samples. These volcanics range in composition from rhyodacites to alkali-feldspar rhyolites. It is an hypovolcanic, pyroclastic l.s. and ignimbritic magmatism which is chemically compatible with anorogenic and post-orogenic settings. It corresponds to an high temperature ferro-potassic calcalkaline magmatism emplaced at ca 1.6 Ga (SHRIMP and Pb evaporation zircon ages). The initial εNd values close to 0 at 1.6 Ga are interpreted to result from mixing of 1.6 Ga mantle-derived magmatism with crustal sources, or alternatively derived from an old mafic depleted lower crust mixing with old felsic component to produce a source of intermediate εNd composition . It is similar in age, in petrographical and chemical compositions to the Gawler Range Volcanics (GRV) described in the Gawler craton (GC) of South Australia, and more specifically similar to the Lower Gawler Range Volcanics. Such similarities strengthen correlations previously established between the GC and TAC that together formed a Rodinia nucleus, the so-called Mawson Continent (MC). Moreover, the present petrological, geochemical and radiometric data give new insights on the major latest thermal event that the MC underwent before cratonization. The presence in TAC of 1.6 Ga felsic volcanics in all respects eqivalent to the GRV of the GC signifies that either there is a similar large volcanic province sub-glacial in the east Antarctic craton, or that the Lake Acraman bolide impact spread ejecta as far as Antarctica during the late Neoproterozoic.

LS08 : TUpo06 : PO
U-Pb Zircon Ages of a Synkinematic Intrusion in the Crustal-Scale Moyar Shear Zone of South India

Birgit Meißner (meissner@petro1.min.uni-muenchen.de), **J. Immo Wendt** (jimmo@iaag.geo.uni-muenchen.de) & **Hermann Köhler** (koehler@petro1.min.uni-muenchen.de)
Institut für Mineralogie, Petrologie und Geochemie, Universität München, Theresienstr.41, D-80333 München, Germany

In the high-grade basement of South India, the amphibolite facies Moyar shear zone (MSZ) constitutes a crustal-scale tectonic boundary separating the Archaean Dharwar Craton in the north from the Late-Archaean Nilgiri Block in the south. Forming part of a prominent system of shear zones (Cauvery shear system) at the southern boundary of the Dharwar Craton, the MSZ plays an important role in reconstructing the position of India within the East Gondwana terrane assembly. In the MSZ, subvertical stretching lineations on EW-trending, steeply S-dipping foliation planes of mylonites indicate predominantly reverse faulting of the Nilgiri Block.

In order to put age constraints on the timing of shear deformation in the central MSZ, we carried out U-Pb zircon dating on plutonic rocks that intruded synkinematically into high-grade metamorphic gneisses and amphibolites near Moyar village. The samples include a metatonalite with protomylonitic textures and a metagranite with quartz ribbons and shearclasts (hornblende, plagioclase, allanite) exhibiting more pronounced mylonitic fabrics. Both the metatonalite and the metagranite record I-type metaaluminious signatures with low $^{87}Sr/^{86}Sr_i$ values. Compared to ~2.7 Ga-Nd model ages of the adjacent high-grade gneisses the intrusive rocks gave unusually young Nd model ages of 1.8-1.9 Ma suggesting derivation from a Proterozoic upper mantle source, presumably with minor contribution of an older crust.

U-Pb zircon ages were obtained from single euhedral prismatic grain fractions and from abraded cores of originally prismatic zircons separated from either lithology. The majority of fractions yielded statistically equivalent concordant U-Pb ages that are interpreted to record crystallisation ages of 616±19 Ma for the metagranite and 633±23 Ma for the metatonalite, respectively (2σ including decay-constant errors). Thus, there is no indication for secondary disturbance of the U-Pb system in zircons due to shear deformation. However, CL-images show incipient corrosion and displacement of magmatically grown zircon phase with internal zoning by a secondary homogenous zircon phase. This feature may be related to the deformation event immediately following magmatic zircon crystallisation but precise age determination of this process is beyond resolution using the techniques applied.

The syntectonic nature of the cogenetic granite-tonalite suite implies that the weighted mean of the intrusion ages (623 ±15 Ma) also records a good estimate for the time Pan-African shearing occurred in the MSZ. This interpretation receives support from a corresponding Sm-Nd garnet-whole rock age of 624 ±9 Ma reflecting coeval metamorphic garnet growth in adjacent anatectic gneisses. Rb-Sr data obtained from muscovites grown postkinematically in nearby exposed reworked gneisses yielded a mineral-whole rock isochron with a slope equivalent to an age of 594 ±25 Ma that provides a lower limit for the age of ductile shearing processes in the MSZ.

LS08 : TUpo07 : PO
The 500 Ma Event in East and West Antarctica: Granitoid Intrusions and Plate Tectonic Setting

Norbert W. Roland (nw.roland@bgr.de)
BGR, Stilleweg 2, 30655 Hannover, Germany

At about 500 Ma, granitoids intruded the East Antarctic Craton in central Dronning Maud Land (cDML) as well as the Ross Orogenic belt which formed an active continental margin bordering the Paleo-Pacific, and which is exposed in the todays Transantarctic Mountains (TAM). Both granitoid provinces are different in geochemistry and in their plate tectonic setting. But which process started the granite formation especially in the within-plate position, and is there a link between the active margin and the within-plate granitoid generating processes?

The granitoids in cDML (monzonites, syenites, granodiorites, closely related to charnockites) are unfractionated, undeformed, coarse crystalline, peraluminous to metaluminous, or subalkaline with a slight trend to alkaline. They are A2-type granitoids, representing lower continental or underplated crust generated in a within-plate position of the Gondwana continent.

The granitoids in the TAM form an active continental margin magmatic arc more than 2000 km in length stretching from the Oates Coast to the Thiel Mts. They are an orogenic calc-alkaline suite of syn- to post-tectonic granitoids, mainly porphyritic biotite or two-mica granites, granodiorites and tonalites showing I-type and peraluminous S-type character. Westward directed subduction and terrane accretion is accepted for northern Victoria Land. In southern Victoria Land, transpressional tectonics in an oblique subduction setting and/or collision are indicated.

Two contrasting plate tectonic settings are obvious. S-type and I-type granitoids occur at the plate margin in a compressional environment related to subduction. A2-type granitoids occur in an unorogenic within-plate position associated with a tensional regime rather than compression. We envisage the problem that the classical plate tectonics can not sufficiently explain intra-plate features. Other models must assist. Some features can best be explained by delamination of the lower lithosphere which allowed the asthenosphere to be juxtaposed to the thickened crust and to heat it up on a regional - or even continental scale. The process of decratonization may be caused after Black & Liegeois (1993) either by an active margin with subduction processes destabilizing the crust and upper mantle, or the craton underwent an intense and frontal hypercollision. For the latter, we did not find sufficient arguments in cDML. It is therefore the coupling of subduction and delamination which is favored to explain the varying magmatic activities at about 500 Ma. Subduction may trigger delamination (Black & Liegeois, 1993), but can also delamination start first and allow subduction to begin or to accelerate as slap-pull is active?

Black R & Liegeois J-P, *Journal of the Geological Society, London*, **150**, 89-98, (1993).

LS08 : TUpo08 : PO
The Structure of Central Dronning Maud Land, Antarctica

Detlef Damaske (d.damaske@bgr.de), **Norbert W. Roland**, **Gernot Reitmayr** & **Hans-J. Paech**
BGR, Stilleweg 2, 30655 Hannover, Germany

During the Geomaud expedition (1995/96) of the Federal Institute for Geosciences and Natural Resources, Hannover, the central Dronning Maud Land (cDMG) was investigated by various geoscientific methods. Results of geological, aeromagnetic and gravity surveys are presented here.

Upper Mesoproterozoic rocks (~ 1.1 Ga) of bimodal volcanic, sedimentary and plutonic origin have undergone high-grade metamorphism and polyphase deformation primarily in Grenvillian time (1.0 Ga) with a subsequent pervasive overprinting associated with coeval igneous activity (now orthogneiss) during the Pan-African (600 - 500 Ma). Most of the voluminous granitoid rocks (mainly granite, monzonite, syenite, granodiorite, charnockite) post-date the Pan-African event (510 Ma). Prominent Pan-African structures in the metamorphic rocks trend E-W to NE-SW in the Orvinfjella. In the Wohlthatmassiv the trend varies considerably due to the interaction with the rigid body of the Gruber anorthosite (600 Ma, predating the Pan-African event). The Pan-African structural pattern evolved within an overall sinistral transpressive regime. The aeromagnetic anomaly pattern distinguishes between a unit over the ice-shelf, an inland unit and a transition unit inbetween. This transition unit is characterized by a magnetic low with narrow, up to 120 km long anomalies, striking E-W to ENE-WSW. The amplitudes are small, compared to the large positive anomalies of areal extent in the ice shelf unit. The linear anomalies could represent dike swarms. This assumption is supported by geological findings as the main trend in the rose diagram of the mafic dike directions in the Schirmacher Oase show the same WSW-ENE trends. All trends are roughly parallel to the coast. The possible dike swarms could have been formed during the break-up of Gondwana, when India and Antarctica separated.

A strong isostatic anomaly derived from gravity shows a minimum partly overlapping with the aeromagnetic transition zone. This minimum could be explained by a deficit of mass within the crust, e.g. a sedimentary basin infill up to a few km thick. This model, however, is not supported by the geological results: Sedimentary rocks do not occur in any outcrops within this area. Additionally, the isostatic anomaly minimum overlaps with the southern part of the ice shelf unit of the aeromagnetic map which indicates shallow magnetic basement rather than sedimentary rocks. The lack of isostatic compensation after a receding of the ice sheet north of the mountain chains of the Orvinfjella and the Wolthatmassiv is the best explanation for the isostatic low. An ablation of up to 2000 m has to be postulated, which is substantially more than assumed so far.

LS08 : TUpo09 : PO
Timing of Pan-African Events in the Eastern Dronning Maud Land, East Antarctica

Kazuyuki Shiraishi (shiraishi@nipr.ac.jp)[1] &
C. Mark Fanning[2]
[1] National Institute ofPolar Research, 1-9-10 Kaga, Itabashi-ku, Tokyo 173-8515, Japan
[2] Research School of Earth Sciences, Australian National University, ACT 0200, Australia

In recent times, the Indian Ocean sector (Dronning Maud Land - DML) of East Antarctica has been considered to be the southern continuation of the Mozambique belt in continental plate reconstructions. In the eastern DML, there are several discrete, isolated tectonic terranes; from west (~20°E) to east (~50°E) these are the Sor Rondane Mountains (SRM), Yamato-Belgica Complex (YBC), Lutzow-Holm Complex (LHC), Rayner Complex (RC), and Napier Complex (NC). High precision zircon and titanite SHRIMP U-Pb age determinations, in conjunction with the P-T history of these plutono-metamorphic terranes are essential in the understanding of the formation of Gondwana during the Pan-African events. Specifically the identification of the Pan African Mozambique Suture in the SRM is one of the major discussion points in the amalgamation of East and West Gondwana. Whether there was a single Circum-East Antarctic Grenville-aged mobile belt reactivated in Pan African times, or Pan African juxtaposition and assembly of three discrete Grenville-aged belts into East Gondwana (Fitzsimons, 2000) is a burning question. The SRM are underlain by a medium- to high-grade metamorphic rocks together with various plutonic rocks and minor mafic dykes. No ophiolite sequences have been recognised thus far. Taking into account the previous Sm-Nd and Rb-Sr data, together with our SHRIMP U-Pb data, the basement of the SRM consists of Grenvillian juvenile crust (ca.1100-1300 Ma) with minor amounts of an Archean component from the hinterland of the Sor Rondane regions. The granulite facies regional metamorphism (M1) occurred between 900-1000 Ma, and subsequently the terrane was metamorphosed at ~630-590 Ma under the granulite to amphibolite metamorphic conditions (M2). An M3 event is characterized by extensive A-type granitoid activity from 560 Ma and the youngest granite intrusions occurred at ~515 Ma. Whether the M3 is associated with a regional metamorphism or local thermal effects related to the granitic mass is not clear. This history is similar to that reported for central DML to the west (Jacobs et al., 1998) where initial magmatism occurred at ~1130 Ma with distinct metamorphic events at 1080 Ma, 575 Ma and 520 Ma respectively. On the other hand, in the LHC to the east, the peak metamorphic age is 530-550 Ma with no indication of older metamorphic events, except for the inherited (?detrital) ages from the metasedimentary rocks (Shiraishi et al., 1994). There is little evidence for a Grenvillean basement in this area. The younger Pan-African peak metamorphic events of the LHC compared to those of the SRM implies that it is more probable for the LHC to record the last stage of amalgamation of East and West Gondwana.

Fitzsimons, *Geology*, **28**, 879-882, (2000).
Jacobs Jet al, *J. Geology*, **106**, 385-406, (1998).
Shiraishi et al, *J. Geology*, **102**, 47-65, (1994).

LS08 : TUpo10 : PO
The Pan-African Granulite Facies Metamorphism and Syn-Tectonic Magmatism in the Grove Mountains, East Antarctica

Xiaochun Liu (liuxch@263.net)[1],
Yue Zhao (yuezhao@public3.bta.net.cn)[1] &
Xiaohan Liu (xhliu@public3.bta.net.cn)[2]
[1] Institute of Geomechanics, CAGS, Beijing 100081, China
[2] Institute of Geology and Geophysics, CAS, Beijing 100029, China

The Grove Mountains, 400 km south of Prydz Bay, is one of the most poorly surveyed areas of Antarctica. It was regarded as a segment of the Proterozoic mobile belt based upon very limited data (Tingey, 1991). In order to know how is Pan-African belt continues inland, we carried out a geological reconnaissance of the Grove Mountains in 1998-1999 field season. The principal lithologies are high-grade metamorphic rocks intruded by two-feldspar granites. The metamorphic rocks are dominated by pale and dark, orthopyroxene-bearing felsic gneiss, with minor mafic granulite and occasionally scapolite-bearing garnet clinopyroxenite. A floater of charnockite and two floaters of sillimanite-bearing gneiss were collected in Mount Harding and Wilson Ridges, respectively. But no outcrops of these rocks have been identified in the investigated area. Although reaction textures occasionally occur in mafic granulite, paragenesis suggests that the high-grade metamorphic rocks formed during a single granulite facies event. P-T calculations suggest metamorphic conditions of approximately 780¡ãC at 5.5-6.8 kbar (Liu et al., in press), in accordance with medium-pressure granulite facies metamorphism. The granites are intrusive as bands or layers a few centimeters to more than 100 m thick, and usually parallel to the gneissosity of the host metamorphic rocks, but a minority is slightly oblique. The most important feature of the granites is a gneissic structure defined by the orientation of K-feldspar phenocryst, parallel to the gneissosity of the host rocks. This suggests a syn-tectonic origin for the granites. SHRIMP (II) zircon U-Pb dating of a pale felsic gneiss gives a scattered core age of 870, 906 and 953 Ma and a clustered rim age of 529 Ma (Zhao et al. 2000). The older ages are interpreted as the inherited crystallization ages, and the youngest as an age of granulite facies metamorphism. A granite yields an U-Pb age of 534 Ma (Zhao et al. 2000), in accord with the age of granulite facies metamorphism. In fact, the occurrence of syntectonic granite well constrains on the age of granulite facies metamorphism in the Grove Mountains. Contrasting these data with other studies (e.g. Zhao et al., 1995; Dirks and Wilson, 1995; Hensen and Zhou, 1995), it is considered that the Pan-African granulite facies metamorphism is present over the entire Proterozoic mobile belt of East Antarctic Shield.

Dirks PHGM & Wilson CJL, *Precam. Res.*, **75**, 189-207, (1995).
Hensen BJ & Zhou B, *Aust. J. Earth Sci.*, **42**, 249-258, (1995).
Liu XC, Zhao Y & Liu XH, *Inter. Sym. Ant. Earth Sci.*, (in press).
Tingey RJ, *The Geology of Antarctica,Oxford University Press*, 1-73, (1991).
Zhao Y, Liu XC, Fanning CM et al, *Abstract Vol. of 31Th IGC*, **9-7** Section, (2000).
Zhao Y, Liu XH, Song Bet al, *Precam. Res*, **75**, 175-188, (1995).

LS08 : TUpo11 : PO
Early Ordovician Terrane Accretion along the Lanterman Fault Zone (North Victoria Land, Antarctica): New Data on Correlation between Ross and Delamerian Orogens in the Paleo-Pacific Margin of Gondwana

Giovanni Musumeci (gm@dst.unipi.it) &
Pier Carlo Pertusati (pertusati@dst.unipi.it)
Dipartimento Scienze della Terra, Via S. Maria 53, Pisa, Italy

The Wilson Terrane in North Victoria Land (Antarctica) and Delamerian fold belt in southeastern Australia represent some remnants of the paleo-Pacific margin of Gondwana, which were deformed, metamorphosed and intruded by granites during the Cambro-Ordovician Ross/Delamerian Orogeny. Both Wilson Terrane and Delamerian fold-belt underwent to a similar deformation history, which developed as a consequence of plate convergence and terrane accretion along the paleo-Pacific margin (Flöttmann et al., 1993). The allocthonous Bowers Terrane and Stawell Terrane were accreted to eastern margin of Wilson Terrane and Delamerian fold belt respectively, along main tectonic boundaries as the Lanterman Fault Zone in North Victoria Land and Glenelg-Yarramyljup Shear Zone in southeastern Australia. In the eastern margin of Delamerian fold-belt (Glenelg River Complex), left-lateral traspressional deformation related to Stawell Terrane accretion have been dated at 480 Ma along the Glenelg-Yarramyljup Shear Zone (Turner et al., 1993). In North Victoria Land, the Tonalite Belt is a complex of NW-SE trending synkinematic tonalite-granodiorite intrusions, which were emplaced within the Lanterman Fault Zone at the boundary between Wilson and Bowers terranes. Within these intrusions, steeply dipping magmatic to solid state foliations, parallel to the schistosity in host Wilson Terrane metamorphic rocks, show kinematic features that point out a dextral transpression with a top-to-the northeast sense of shear. This shear is consistent with the accretion-related NE-verging thrusting of Wilson Terrane onto Bowers Terrane. The Pb/Pb and U/Pb titanite age of 490-480 Ma, recently obtained for these synkinematic intrusions (Musumeci et al., 2000), allow us to date at the Early Ordovician the Lanterman Fault Zone deformation related to the accretion of allochtonous Bowers Terrane. Moreover this age is comparatively younger than the age of deformation in the inner (cratonward) portion of Wilson Terrane, which is dated at 508 Ma on synkinematic intrusions. This feature likely indicate a diachronous development of deformation from cratonward to oceanward portion of Wilson Terrane. The striking similarity of deformation ages along eastern margins of both Wilson Terrane and Delamerian fold belt, allow us to reinforce the concept of structural continuity between these two orogens. Particularly, we suggest that the paleo-Pacific margin of Gondwana, exposed in North Victoria Land and southeastern Australia, represents a continuous convergent margin along which Early Ordovician terrane accretion occurred. Furthermore, transpessional tectonics recognised along both the Lanterman Fault Zone and Glenelg-Yarramyljup Shear Zone testifies an oblique convergence between plates along this portion of the paleo-Pacific margin of Gondwana.

Flöttmann T, Gibson GM, & Kleinschmidt G, *Geology*, **21**, 319-322, (1993).
Musumeci G, Kramers J & Pertusati PC, *Terra Nova*, **12**, 35-41, (2000).
Turner SP, Adams CJ, Flöttmann T & Foden JD, *Austr. J. Earth Sci.*, **40**, 275-292, (1993).

LS08 : TUpo12 : PO
W- and E-Directed Ross-Orogenetic Thrust Systems in the Wilson Terrane, Northern Victoria Land, Antarctica

Andreas L. Läufer (laeufer@em.uni-frankfurt.de)[1],
Federico Rossetti (rossetti@uniroma3.it)[2] &
Georg Kleinschmidt (kleinschmidt@em.uni-frankfurt.de)[1]
[1] Univ. Frankfurt/M. (Fach 224), Geologisch-Paläontologisches Institut, Senckenberganlage 32-34, 60054 Frankfurt/M., Germany
[2] Dipartimento di Scienze Geologiche, Università Roma Tre, Largo S.L. Murialdo 1, 00146 Roma, Italy

The northern Victoria Land (NVL) segment of Antarctica is part of the Pacific end of the Transantarctic Mountains. Its Early Paleozoic evolution is best described in terms of three tectonometamorphic terranes (from W to E: Wilson, Bowers, and Robertson Bay Terranes). The Wilson Terrane represented the Paleo-Pacific active continental margin of the East Antarctic Craton (EAC). Successive accretion of the island arc of the Bowers Terrane and the turbiditic Robertson Bay Terrane occurred during the Cambro-Ordovician Ross orogeny. In order to find hints on location and character of the boundary between Ross orogen and EAC in NVL, we have carried out structural surveys in the lower Rennick Glacier area during the BGR-PNRA joint expedition GANOVEX VIII (1999/2000). Earlier expeditions proved the existence of a conjugate thrust system in eastern Oates Land with the E-directed (i.e. towards the Paleo-Pacific) Wilson thrust and the W-directed (i.e. towards the EAC) Exiles thrust (Flöttmann and Kleinschmidt 1993). Our aim was to prove the existence of a comparable thrust system in the expedition area and to find arguments concerning the western termination of the Ross orogen indicated by craton-ward (i.e. W-directed) kinematics. We have therefore collected structural data on ductile deformation in the Wilson Terrane, particularly in the westerly located southern Daniels Range, Welcome Mountain, and Outback Nunataks and in the easterly located Morozumi and Lanterman Ranges. In the westerly located areas, high-grade metamorphic units are thrust over low-grade metamorphic schists and shallow granitic intrusions. Shear sense indicators prove W-directed ductile shear accounting for a close relation to the Exiles thrust in Oates Land. Two generations of dykes of the Granite Harbour intrusives (one affected and the other practically non-affected by the deformation) indicate a Ross-age of these structures. Our data suggest the Ross orogen-EAC boundary to be located not much further to the W. Kinematic data collected in the easterly located areas of the Morozumi and Lanterman Ranges indicate opposite (i.e. E- to NE-ward) directed sense of shear which fits to the overall E- to NE-directed tectonic transport towards the Paleo-Pacific margin of Antarctica during the Early Paleozoic. Particularly, E-directed ductile sense of shear in the northern Morozumi Range accounts for a close relation to the Wilson thrust which was found at Renirie Rocks located little further N (Kleinschmidt 1992).

Flöttmann T & Kleinschmidt G, *Geol. Jb.*, **E47**, 419-436
Kleinschmidt G., *Polarforsch.*, **60**, 124-127

LS08 : TUpo13 : PO
Late Archean to Paleoproterozoic Structural and Metamorphic Evolution in the Terre Adélie Craton- East Antarctica Shield

Anne Pelletier (pelletia@univ-st-etienne.fr)[1], **René-Pierre Ménot** (menot@univ-st-etienne.fr)[1], **Denis Gapais** (gapais@univ-rennes1.fr)[2] & **Jean-Jacques Peucat** (peucat@univ-rennes1.fr)[2]
[1] Université Jean Monnet - Laboratoire de Géologie - 23 rue du Docteur Paul Michelon - 42023 Saint Etienne, France
[2] Geosciences Rennes, Universite de Rennes 1, 35042 Rennes cedex, France

The Terre Adélie Craton (TAC), involving the Terre Adélie and George V Land areas (140°E-145°E) is built up by three units which display rather different lithological tectonic and metamorphic features. The TAC includes from East to West : a composite meta-sedimentary and meta-igneous basement (U1) with a prominent Archean tectonic and metamorphic imprint, a mainly granodioritic-orthogneissic unit (U2) of late Archean age (2.4 Ga) locally reworked during a Paleoproterozoic event (1.7 Ga) ; a migmatitic unit (U3) of mainly pelitic origin, deposited and metamorphosed between 1.76 - 1.5 Ga. From structural and metamorphic points of view:

U1 is characterised by early granulitic parageneses with sill-gt in metapelitic gneisses and striking garnet coronas around orthopyroxenes in felsic gneisses. The latter testifies for an early increase of pressure, along a prograde counter-clockwise PTt path under HT-LP conditions (750 ±50°C; P<9 kb). The metamorphic peak was followed by retrogression to amphibolite facies conditions, as suggested by replacement of Sil-Gr assemblage into Spl-Qtz and then into Crd-Qtz assemblages. Such a retrograde path is related to decompression at high temperature and was associated to anatexis and intrusion of granodiorites respectively in the northern and south-eastern parts of U1. As no reliable geochronological data are available, the amphibolite and greenschists facies recrystallisations may be interpreted either as resulting from a single post-granulite retrograde continuous evolution or from a distinct later event. Deformation-recrystallisation relationships in granulite to greenschist facies suggest a polyphased tectonic evolution associated with a transpressive regime. U2 is characterised by large vertical shear zones affecting the Late Archean basement under amphibolite facies conditions (800°C - 8 kb) before 1670 Ma (Rb/Sr biotite cooling ages). U3 displays typical Paleoproterozoic tectonics characterised by superimposed early horizontal, flattened structures and vertical transpressive shear zones. Paragenesis of Sil±Crd±Kfs±Pl±Bi±Qtz±Grt characterised HT-LP (750 ±50°C - 5 ±1 kb) conditions. Considering PT conditions, with a lack of counter-clockwise evolutions and of thrusting structures, we propose a geodynamic model with two successive stages of extension and of later fast uplift suitable by vertical transpressive shear zones.

In summary, U1 and U2 consist of closely similar lithologies which recorded a fini-archean (2.4 Ga) metamorphic evolution comparable to that observed in many areas of the East Antarctica and South Australia shield. Later U2 suffered a tectonic and metamorphic 1.7 Ga old imprint restricted to sub-vertical shear zones. In that scope U3 appears as a very specific bloc where the only observed evolution is 1.7 Ga old and related to major lithospheric extension and transpression.

LS08 : TUpo14 : PO
Relationships between Surgeon Island and Robertson Bay Terrane; New U-Pb Zircon and Structural Data

Anna M. Fioretti (anna@dmp.unipd.it)[1], **Giovanni Capponi** (capponi@dipteris.unige.it)[2], **Lance P. Black** (lance.black@anu.edu.au)[3], **Richard Varne** (rick.varne@utas.edu.au)[4] & **Dario Visona'** (dario@dmp.unipd.it)[5]
[1] CNR-Centro Studi geodinamica Alpina, c.so Garibaldi, 37, Padova, Italy
[2] Dip.to per lo Studio del Territorio e delle sue Risorse - Universita', Corso Europa, 26, GENOVA, Italy
[3] Australian Geological Survey Organization, GPO Box 378, Canberra, Australia
[4] Geology Department, University of Tasmania, Hobart, Australia
[5] Dip.to Mineralogia e Petrologia - Universita', c.so Garibaldi, 37, Padova, Italy

Surgeon Island (SI) is one of the furthest fragments of northern Victoria Land (Antarctica), cropping out east of the Robertson Bay Terrane (RBT) in the Yule Bay. Its separation from the Pacific coast by about 5 km makes it impossible to determine structural relationships with its country rocks. SI consists of a foliated biotite-muscovite granitoid with S-type affinity (Vetter et. al., 1983). Only along its northern coast is it intruded by an unfoliated leucogranite tentatively attributed to the Devono-Carboniferous Admiralty Intrusives (Kleinschmidt, et al., 1992). No foliated granitoid older than the Admiralty Intrusives is known either within the Cambrian - Early Ordovician sedimentary sequence of the RBT or within the adjacent Bowers Terrane. Therefore, the geological significance of the SI granitoids is still controversial. Borg & De Paolo (1991) interpreted it as the remnant of a Proterozoic continental block, originally lying east of the RBT. In contrast, Kleinschmidt (1992) proposed the granitoid to be a klippen of original tectonic cover, sunk from the roof of the Yule Bay batholith. SI has also been interpreted as a "huge raft of an older basement carried up by the Yule Bay Intrusion" (GANOVEX team, 1987). Isotopic age determinations (Vetter et al., 1983; 1984) are also controversial and fail to establish a correlation with other sectors of Gondwana.

New studies have been carried out to constraint both the structural setting and to obtain a precise U-Pb chronology for the events that affected SI, in an attempt to better define its geological history. Zircons from one of the less foliated samples in the eastern end of Surgeon island yield an U-Pb ion-microprobe (SHRIMP) age of 508±4 Ma. Based on petrographic evidence this date is interpreted as the emplacement age of the granitoid. This age is significantly younger that the Rb-Sr WR age of 599 ±21 Ma (Vetter et al. 1984), ruling out both the correlation with the Beardmore orogeny proposed by Vetter et al. (1984) and the hypothesis of a Proterozoic continental block (Borg & DePaolo, 1991).

The foliation on Surgeon island strikes about 120° - 140°, with medium to steep dip to the southwest, and is roughly parallel to the cleavage in the adjoining Robertson Bay turbidites, about 30 km to the southeast; these observations match those by Vetter et al. (1983) and Kleinschmidt et al. (1992). Although the deformation in the Robertson Bay sandstone and in the SI granitoid occurred at very different structural levels, it is very unlikely that this similarity is simply coincidence, and a structural legacy is suggested. In this framework, the SI granitoid could represent the crystalline basement on which the Robertson Bay sandstone was deposited. Further investigation on the zircon inheritance pattern will help better contrain this hypothesis.

Borg SG & DePaolo DJ, *Tectonophysics*, **196**, 339-358, (1991).
GANOVEX Team, *Geol. Jb*, **B66**, 7-79, (1987).
Kleinschmidt G, *Polarforschung*, **60 (2)**, 128-132, (1992).
Kleinschmidt G, Matzer S, Henjes-Kunst F & Fenn G, *Polarforshung*, **60 (2)**, 133-134, (1992).
Vetter U, Roland NW, Kreuzer H, Höhndorf A, Lenz H & Besang C, *in Oliver RL James PR & Jago Eds - Antarctic Earth Science, Australian Acad. Sci. , Canberra*, 140-143, (1983).
Vetter U, Lenz H, Kreuzer H, Höhndorf Aand Besang C, *Geol. Jb*, **B60**, 363-369, (1984).

LS08 : TUpo15 : PO
U-Pb Zircon SHRIMP Dating of the Gallipoli Volcanics, Northern Victoria Land (Antarctica)

Anna M. Fioretti (anna@dmp.unipd.it)[1], **Lance P. Black** (lance.black@anu.edu.au)[2] & **Richard Varne** (rick.varne@utas.edu.au)[3]
[1] CNR-Centro Studi geodinamica Alpina, c.so Garibaldi, 37, Padova, Italy
[2] Australian Geological Survey Organization, GPO Box 378, Canberra, Australia
[3] Geology Department, University of Tasmania, Hobart, Australia

During the late Devonian - early Carboniferous, the crystalline basement of northern Victoria Land (Antarctica) was affected by the magmatism that produced the Admiralty Intrusives and the Gallipoli Volcanics. Both intrusive and extrusive rocks are found in all three Terranes (i.e. the Wilson, Bowers and Robertson Bay) that form northern Victoria Land. Plutonic rocks are widespread in the Robertson Bay terrane, common in the Bowers and rare within the Wilson terrane, where they crop out only close to the boundary with the Bowers terrane. Volcanic rocks are much less abundant and crop out in three distinct areas quite far from one another.

At Gallipoli Heights (Wilson Terrane), the volcanic rocks constitute a thick sequence of rhyolitic ignimbrite with subordinate dacite, dacitic andesite, and andesite which unconformably overlie the Cambro-Ordovician granitoids known as the Granite Harbour Intrusives. In the area of the Mariner Plateau, the volcanic rocks crop out astride the thrust separating the Wilson and Bowers terranes. At Mt Anakiwa the lavas are intruded and thermo-metamorphosed by the Mt Supernal pluton, indicating they are older than the pluton. Similar field relationships are observed at Lawrence Peaks (Ganovex-ItaliAntartide, 1995). At Mt. Black Prince the volcanic rocks unconformably overlie the granitoid rocks of Mt. Adams pluton (Findlay & Field, 1982; Findlay & Jordan, 1984), suggesting they post-date the intrusive rocks.

Fioretti et al. (1997) observed that field relationships and currently published isotopic age determinations were consistent with the hypothesis that the Gallipoli Volcanics represent one single volcanic episode, coeval with the emplacement of a younger group of the Admiralty Intrusives. They also noted that because published isotopic ages on the Admiralty Intrusives and Gallipoli Volcanics were obtained from different isotopic systems, (including whole rocks and minerals), these ages should be considered with caution.

U-Pb SHRIMP analyses on zircons was performed on three samples, (each representing a different area of extrusion) with the aim of establishing a precise chronology for the extrusive event(s) that produced the Gallipoli Volcanics and to constraint their relationships with the Admiralty Intrusives. Rhyolitic ignimbrite from the Gallipoli Heights gives a U-Pb zircon age of 355.8 ±2.9 Ma. Zircons from a dacitic andesite collected at Mt Brandal, in the area of Mariner Plateau, gives an age of 369.7 ±3.9 Ma, significantly older than that of the Gallipoli Heights ignimbrite. The sample from Mt Black Prince is chemically similar to that at Mt Brandal, and has identical age of 369.7 ±3.1 Ma. These data indicate that volcanism in northern Victoria Land occurred during at least two distinct episodes. The distribution of their age, younger in the western area and older in the eastern one, is consistent with the age distribution of the Admiralty Intrusives (Fioretti et al. 1997).

Fioretti AM, Visonà D, Cavazzini G & Lombardo B, *Ricci, C.A. (ed.), The Antarctic region: geological evolution and processes, Terra Antartica Publ., Siena, Italy*, 293-296, (1997).
Findlay RH, & Field BD, *N.Z. Antarct. Rec.*, **4(2)**, 11-14, (1982).
Findlay RH, & Jordan H, *Geol. Jb.*, **B60**, 143-145, (1984).
Ganovex-ItaliAntartide, . *Geological and Structural Map of the area between the Aviator Glacier and Victory Mountains- Northern Victoria. Land Selca., Firenze*, (1995).

LS08 : TUpo16 : PO

Constraining the Timing of the Structural Evolution along Terrane Boundaries: The Case of the Lanterman Fault Zone, Northern Victoria Land, Antarctica

Giovanni Capponi (capponi@dipteris.unige.it)[1], **Laura Crispini** (crispini@dipteris.unige.it) & **Gianfranco Di VIncenzo** (g.divincenzo@iggi.pi.cnr.it)[2]
[1] Dip.Te.Ris.- Universita' di Genova, Corso Europa 26, 16132 Genova, Italy
[2] IGGI - CNR, Via Alfieri 1, 56010 Ghezzano (Pisa), Italy

The Lanterman Fault Zone is a major terrane boundary in northern Victoria Land (Antarctica), displaying a poliphase structural evolution. After a west over east thrusting under amphibolite facies metamorphism, the Lanterman Fault Zone experienced a greenschist facies strike-slip shearing. Retrogression under greenschist shear deformation produced variable recrystallisation of the hornblende-type amphibole, intergrowth of micas along amphibole cleavage planes, and irregular overgrowths of actinolite on hornblende-type amphibole. Incremental laser heating ^{40}Ar-^{39}Ar analyses were carried out on amphiboles from selected samples displaying different degree of retrogression. Amphiboles display irregularly discordant age profiles with variations which correlate with irregularities in the elemental ratios indicating that the mineral fraction consist of mixtures of different mineral phases and heterochemical amphiboles. The low-temperature region of the age spectra, dominated by mica intergrowths, places a minimum estimation for the age of the greenschist facies deformation at 445 - 450 Ma. The age of the hornblende-type amphiboles are variable and range from 492 Ma to 460 Ma thus attesting variably re-equilibration of amphibole during shear deformation. Results assign the greenschist facies reworking of the Lanterman Fault Zone to the late stages of the Cambrian - Ordovician Ross Orogeny and precludes a significant influence of the Devonian - Carboniferous Borchgrevink Orogeny.

LS08 : TUpo17 : PO

Absolute Gravity and GPS Measurements in Antarctica (French Station Dumont d'Urville)

Martine Amalvict (mamalvict@eost.u-strabg.fr) & **Jacques Hinderer** (jhinderer@eost.u-strabg.fr)
Institut de Physique du Globe / EOST, 5 rue René Descartes, Strasbourg, 67000, France

It is essential to better know the tectonic behaviour of Antarctica region; in particular, in the case of a vertical displacement, we have to distinguish in the long term any motion of tectonic origin from other contributions like present-day deglaciation for instance. One possible way is to compare GPS records to absolute gravity measurements. In this framework, we plan to study the case of Dumont d'Urville station (latitude: 66.67° S, longitude: 140.17°E , height: 35 m) which is in the "French" Antarctic sector; Terre Adélie. A permanent GPS receiver is operating there since December 1997 indicating a strong uplift (also available is a DORIS station). Absolute gravity observations have been performed for the first time with the gravimeter FG5#206 during one week in February-March 2000 in a thermally regulated shelter. After processing the data, the value of gravity determined at the top of the benchmark is: g = 982 387 174.5 ±24.1 µGal corresponding to 10650 drops (426 sets) and a total duration of 106 hours; the drop to drop scatter is 57.5 µGal. We comment on the quality of the results; with a special attention paid to the influence of tidal ocean loading according to existing models. By comparison with the results from other geodetic series, we will comment on what can be expected from the repetition of absolute gravity campaigns (the measurements will be repeated in 2004). New results from a similar experiment done in the Arctic region (Spitsberg) will be shown.

LS08 : TUpo18 : PO

Ultrahigh-Temperature (UHT) Metamorphism and Melting in the South-Western Part of the Arequipa Massif (Peru): Implication for the Reconstruction of the Grenvillian Belt

Jean-Emmanuel Martelat (martelaj@magellan.umontreal.ca) & **Jacques Martignole** (martigno@ere.umomtreal.ca)
Département de Géologie, Université de Montréal, CP 6128 Montréal QC, H3C 3J7, Canada

The Arequipa massif is the largest exposed fragment of mid-Proterozoic crust (1.2 Ga-1.0 Ga) among a series of outlayers, within the Andean Belt. Between Camana and Mollendo (southwestern part of Arequipa massif) UHT rocks outcrop within a block of 200x50 km that may well be the largest exposed UHT terrane of Grenvillian age. The UHT rocks consist of migmatitic quartzo-feldspathic gneisses with sparce occurrence of mafic rocks. These gneisses are well layered, with aluminous, anhydrous mesosomes and at least 30% of hololeucocratic quartzofeldspathic leucosomes. Foliations and migmatitic banding are generally SSW-dipping with a sub-horizontal stretching or mineral lineation parallel to the axes of mesoscopic SSW-verging folds. The ubiquituous assemblage is: Opx Sil Grt Qtz Kfs. A few sapphirine-quartz assemblages are noted. On the other hand retrograde sapphirine is found in symplectites with cordierite in Sill Crd Spr assemblages suggesting that the reaction Grt + Sil = Spr + Crd proceeded until the disappearance of garnet. Similarly orthopyroxene-cordierite pseudomorphs after garnet are consistent with decompression at relatively high temperature. High-Mg cordierite around 0.9 XMg is also ubiquitous and results from the destabilization of Opx Sill Qtz assemblages. Interstitial magnetite-ilmenite within sillimanite-rich mesosomes probably result from the segregation of an immiscible Fe-Ti-rich liquid issued from the melting of Ti-rich biotites. Rare biotite-quartz symplectites are interpreted as due to melt precipitation. Physical conditions for the peak of metamorphism constrained in part by the absence of kyanite and osumilite, are up to 1050°C between 1-1.3 Gpa based on petrogenetic grids and thermobarometric calculations. Mineral parageneses and reactions are compatible with an apparent isothermal cooling from temperatures in excess of 1000°C at high pressure, followed by a decompression path in the cordierite-garnet field. The dry migmatites of the Arequipa block are thus an example of anhydrous melting of a biotite-poor protolith. In the Neoproterozoic reconstructions of Rodinia, the Arequipa massif stands between Laurentia and Amazonia. This, given the width of the Grenville Province in Canada, and the presence of Grenvillian basement rocks in the Appalachians, implies a minimum width of 1200 km for the Grenville belt. Although genuine UHT assemblages have not yet been reported from Grenville Province, high temperature metamorphism is well documented in its northeastern part. This must taken into account in the reconstitution of Rodinia during the Neoproterozoic, not withstanding the possibility of long-term subduction-erosion along the west coast of south-America.