Geology of Western Dronning Maud Land, Antarctica – a brief history of Geological Evolution insights

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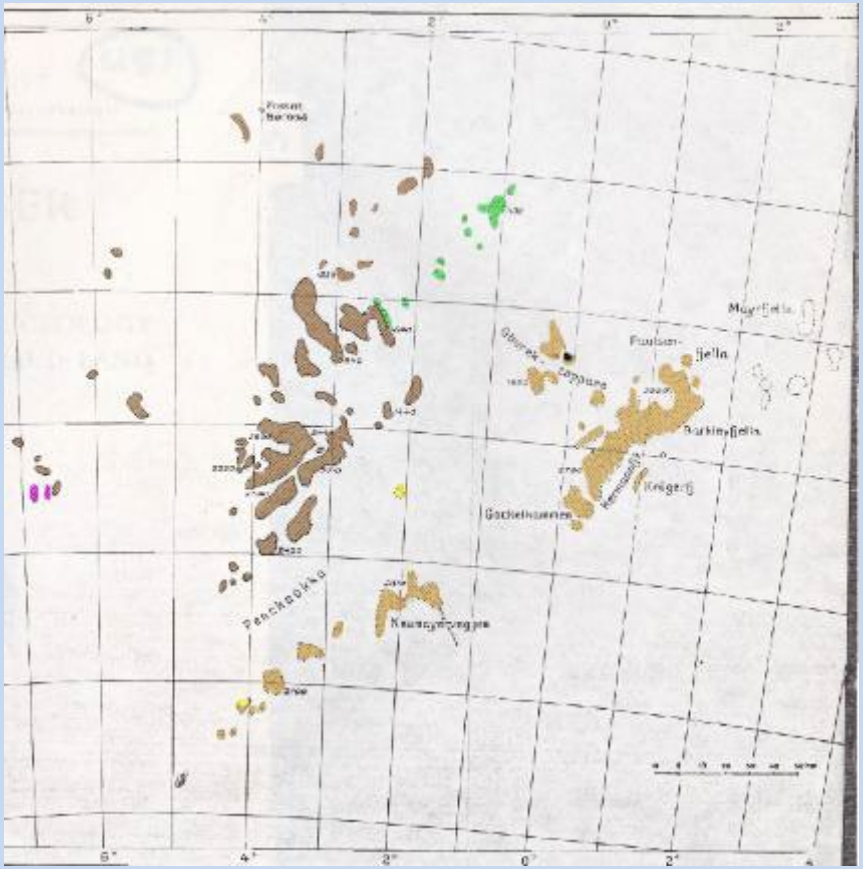
NRF National Research Foundation

Two geological projects funded for 2024-2026 at the University of Johannesburg.

1 – Crustal Evolution of Dronning Maud Land.
Collating, archiving and investigating samples collected from previous studies and selecting samples for chemical and geochronological (age-dating) analysis. Through this exercise, the new Archaean exposure was recognised last year (see later). A number of samples already submitted for radiogenic isotope and trace element analysis with samples for geochronology identified.

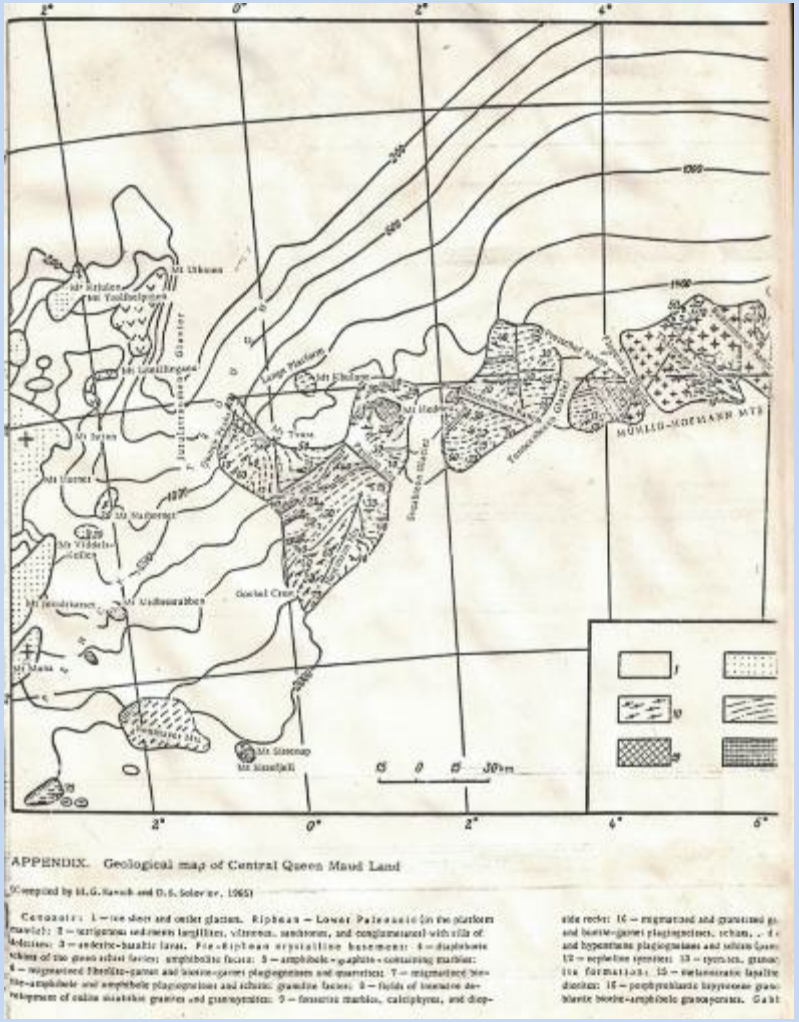
- 2 – Provenance and Paleomagnetics of the rocks of the Grunehogna Craton in Western Dronning Maud Land

Early workers in WDML



Roots, E.F.(1953) Preliminary note on the geology of western Dronning Maud land. Norsk. geologisk Tidsskrift, 32, 17-33.

The first geological reconnaissance in this part of Dronning Maud Land was done by the Norwegian-British-Swedish Antarctic Expedition 1949–52 (ROOTS 1953). In 1960 the Soviet Antarctic Expedition, during its regional investigations of East Antarctica, also covered parts of H. U. Sverdrupfjella (RAVICH and SOLOVEV 1966). In 1968 members of Expédition Antarctique Belge visited outcrops in the eastern part of H. U. Sverdrupfjella for comparative purposes (AUTENBOER 1972). The present work deals with observations made by A. HJELLE



Ravich, M.G. and Solo'vev, D.S. (1966) Geology and petrology of the mountains of central Queen Maud Land (East Antarctica). Transactions of Science Research Inst. of Arct. Geological, Minist. of Geological of U.S.S.R., vol. 141. 348pps. Transactions from Russian Israel Prog. for Science Transactions.1969

1959-1961 fieldwork

Early work and publications

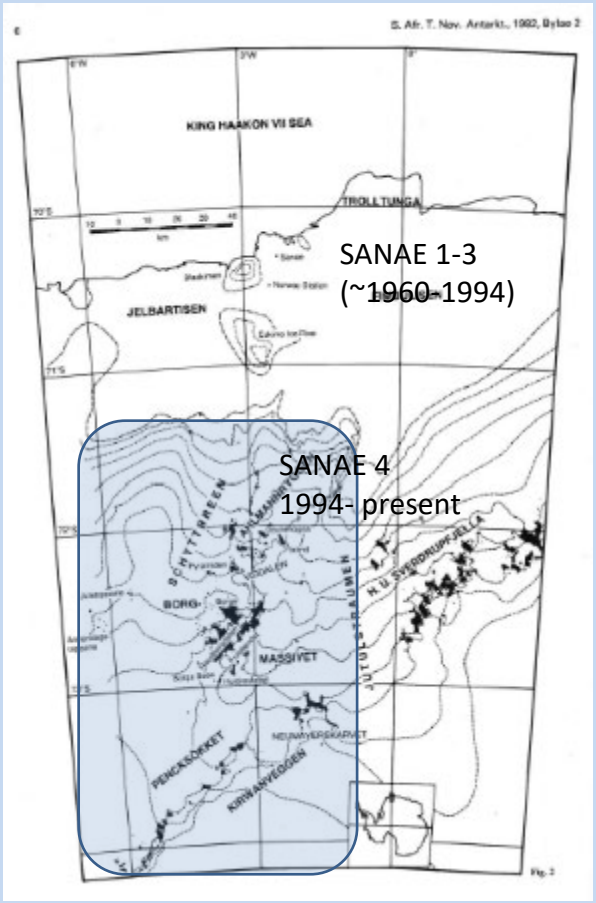
South African Journal of Antarctic Research
Suid-Afrikaanse Tydskrif vir Navorsing in Antarktika
Supplement 2, 1982 Bylae 2, 1982

Geological investigations in Western Dronning Maud Land, Antarctica — a synthesis

L.G. Wolmarans and L.E. Kent

ISSN 0081-2455

South Africa – SANAE 1 &2
Fieldwork Geological Survey of South Africa1960-1974



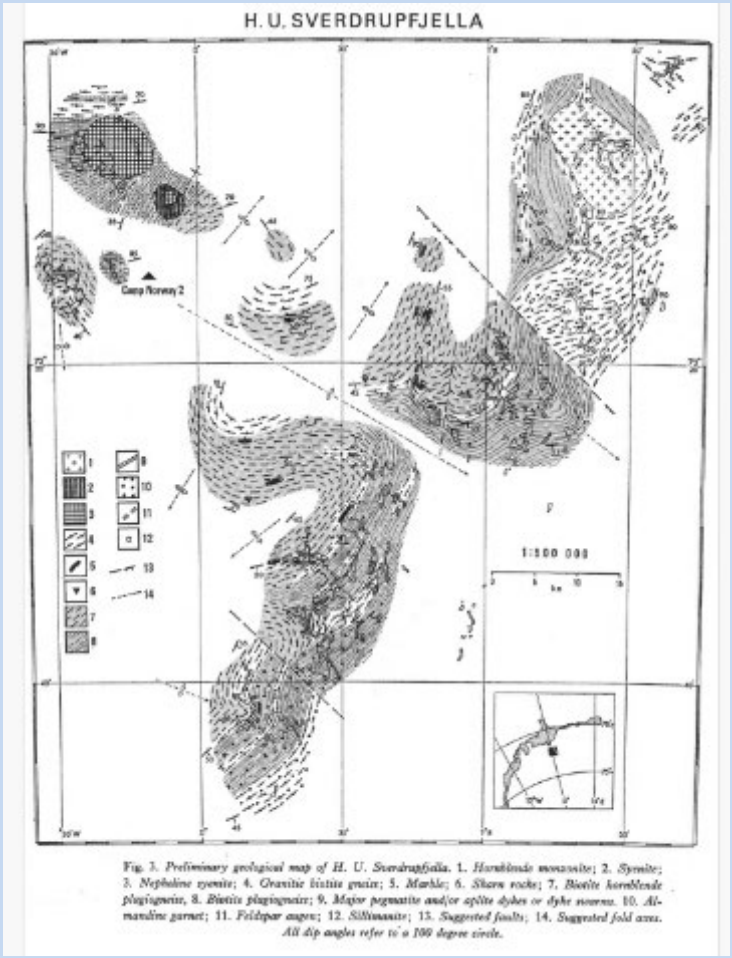
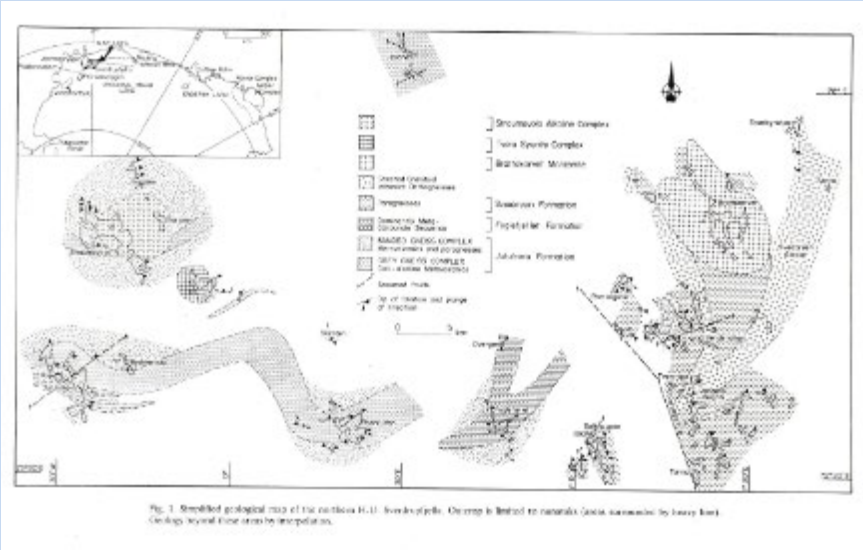


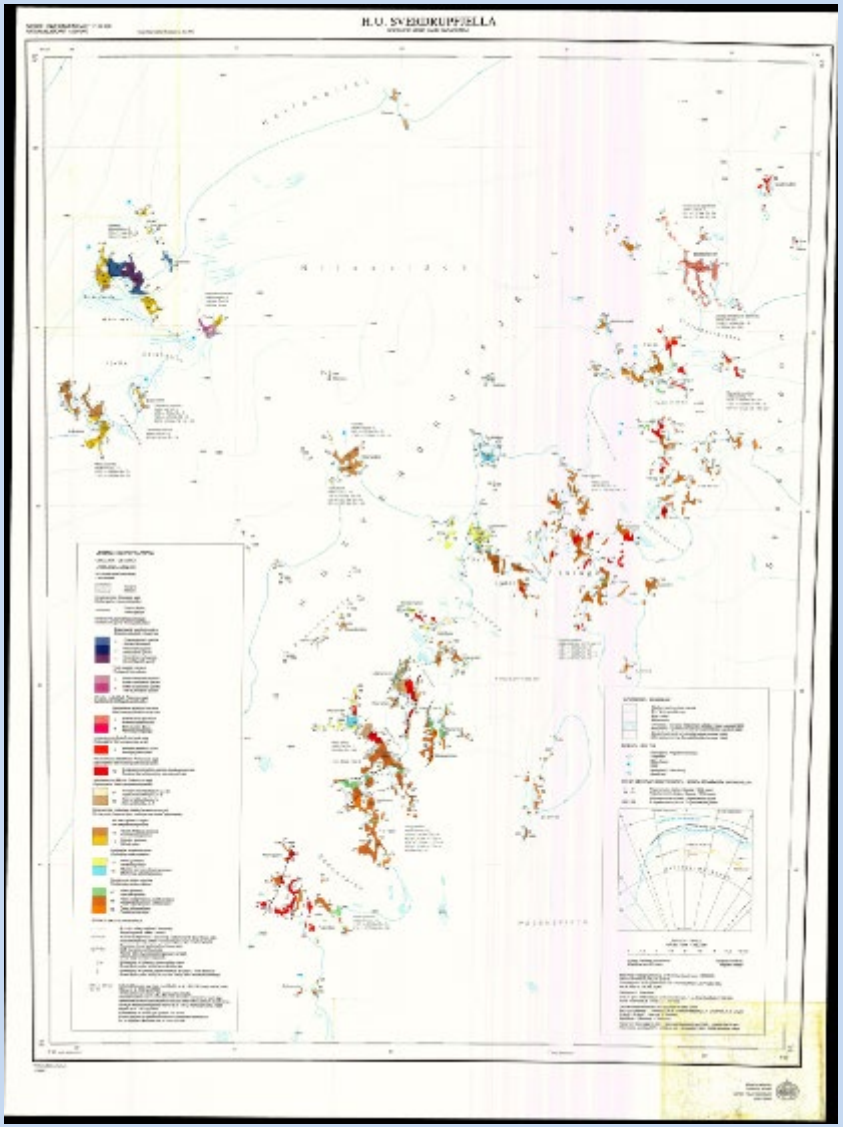
Fig. 3. *Preliminary geological map of H. U. Sverdrupfjella.* 1. *Hornblende monzonite;* 2. *Syenite;* 3. *Nepheline syenite;* 4. *Granitic biotite gneiss;* 5. *Marble;* 6. *Skarn rocks;* 7. *Biotite hornblende plagiogneiss;* 8. *Biotite plagiogneiss;* 9. *Major pegmatite and/or aplite dykes or dyke swarms.* 10. *Almandine garnet;* 11. *Feldspar augen;* 12. *Sillimanite;* 13. *Suggested faults;* 14. *Suggested fold axes. All dip angles refer to a 100 degree circle.*

Hjelle, A. (1972) Some observations on the geology of H.U. Sverdrupfjella, Dronning Maud Land. Norsk Polarinstitutt Arbok, 1972, 7-22.

SANAP mapping – 1980 – 2005 Universities



Grantham, G.H., Groenewald, P.B. and Hunter, D.R. (1988) Geology of the northern H.U. Sverdrupfjella, western Dronning Maud land and implications for Gondwana reconstructions. South African Journal Antarctic Research, 18, 2-10.

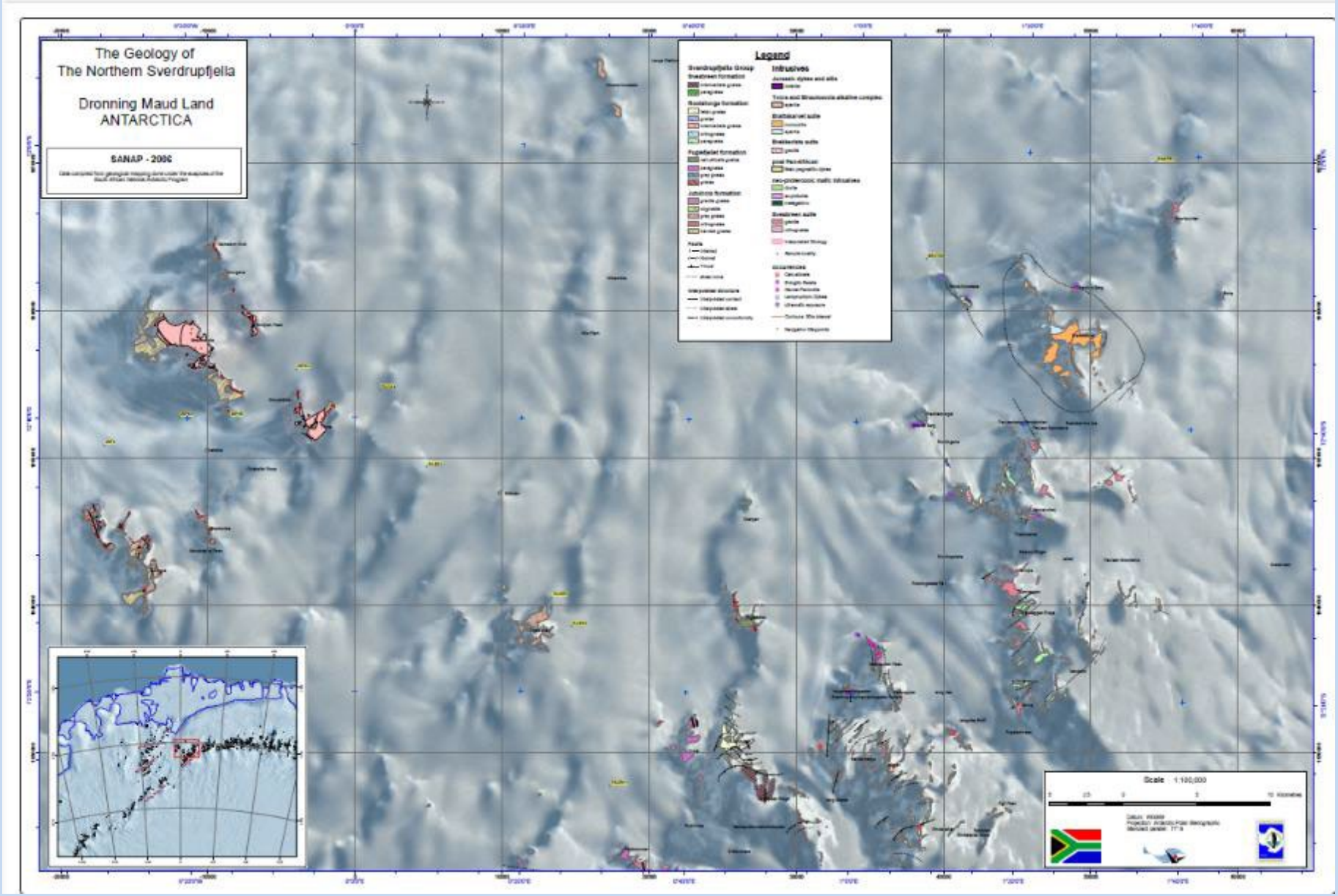


Norsk Polarinstitut Map of Sverdrupfjella (1996) compiled from PhD theses of G.H. Grantham (1993), P.B. Groenewald (1995) and subsequent field seasons by UKZN personnel.

Geological Post graduate degrees – 24 completed to date

Author	Year	title	degree	institution
Victor von Brunn	1963	Scientific Studies in western Dronning Maud Land, Antarctica, 1960	MSc	University of Cape Town.
Neethling D.C.	1971	South African Earth Science exploration of western Queen Maud Land, Antarctica	PhD	University of Natal
Bredel J.	1976	The Ahlmannryggen group, the Viddalen Formation and the associated igneous rocks in theViddalen area, Western Droning Maud Land, Antarctica	MSc	University of Pretoria
Johan Rynhardt Krynauw	1986	The petrology and geochemistry of intrusions at selected nunataks in the Ahlmannryggen and Gaeverryggen, western Dronning Maud Land, Antarctica	PhD	University of Natal, Pietermaritzburg.
E.P. Ferreira	1986	n Sedimentologies-stratigrafiese ondersoek van die sedimentere gesteentes in die Ahlmannryggen, Antarktika	MSc	Stellenbosch University
J.J.P Swanepoel	1988	Die stratigrafie en sedimentologie van die Ahlmannryggengroep in die Borgmassivet, Wes Koningin Maudland, Antarktika	MSc	Stellenbosch University
Geoffrey Hugo Grantham	1993	Geological evolution of western H.U. Sverdrupfjella, Dronning Maud Land, Antarctica	PhD	University of Natal, Pietermaritzburg.
Gavin Ferrar	1994	The metamorphic geology of the Armalsryggen, western dronning Maud Land, Antarctica	MSc	University of Natal
Peter Bruce Groenewald	1995	The geology of northern H.U. Sverdrupfjella and its bearing on crustal evolution in Dronning Maud Land, Antarctica.	PhD	University of Natal, Pietermaritzburg.
Mawson R.D. Croaker	1999	Geological Constraints on the Evolution of the Urfjell Group, southern Kirwanveggan. We4stern Dronning Maud Land, Antarctica.	MSc	University of Natal, Durban
Phillip David Harris	1999	Geological evolution of Neuemeyerskarvet in the northern Kirwanveggan, western Dronning Maud Land, Antarctica.	PhD	RAU/University of Johannesburg.
Samantha Perritt	2001	The Ahlmannryggen Group, western Dronning Maud Land, Antarctica.	PhD	University of Natal, Durban
Warwick Stuart Board	2001	Tectonothermal evolution of the southern H.U. Sverdrupfjella, western Dronning Maud Land, Antarctica.	PhD	University of Cape Town
Warren Peter Johnstone	2001	A stable isotope investigation into fluid-rock interaction during regional metamorphism in western Dronning Maud Land, East Antarctica	MSc	University of Cape Town
Avinash Bisnath	2005	Tectono-thermal evolution of Gjelsvikfjella, Western Dronning Maud land, Antarctica.	PhD	University of Cape Town
Eugene Grosch	2005	A metamorphic and geochemical study of mafic rocks across the Pencksökket-Jutulstraumen Discontinuity, western Dronning Maud Land, East Antarctica.	MSc	University of Cape Town
Sukey Anna Jay Thomas	2014	Metamorphic and melt-migration history of midcrustal migmatitic gneisses from Nupskapa, The Maud Belt, Antarctica	MSc	University of Cape Town
Dave McGibbon	2014	Shear Zones of the Maud Belt, Antarctica: Kinematics and Deformation	MSc	University of Cape Town
Gregory Byrnes	2015	Tectono-metamorphic history of the reworked, high-grade Maud Belt at central-Eastern H.U. Sverdrupfjella, Antarctica	MSc	University of Cape Town
Dreyer T S	2015	Petrogenesis of the peralkaline granite (and associated syenite) dykes of the Straumsvola Complex, Western Dronning Maud Land, Antarctica	MSc	University of Cape Town
Neo Geogracious Moabi	2015	A Geological comparison of the Espungabera Formation of central Mozambique and the Straumsnutane Formation of western Dronning Maud Land Antarctica	MSc	University of Pretoria
Mabuela Andries Morake	2019	Petrography and Geochemistry of Early-Middle Jurassic Mafic Dykes from the H.U. Sverdrupfjella, Antarctica	MSc	University of Johanneburg.
Johan Francis O'Kennedy	2020	Paleomagnetism of Jurassic dykes from Dronning Maud Land, Antarctica	MSc	University of Johannesburg
Erasmus Petrus Burger	2023	Tectonic constraints from thin Granitoid Sheets in H.U. Sverdrupfjella, western Dronning Maud Land, Antarctica	PhD	University of Pretoria

Consolidation of mapping dominated studies – Maps produced in a GIS based database
eg. Geological Map northern Sverdrupfjella 2006



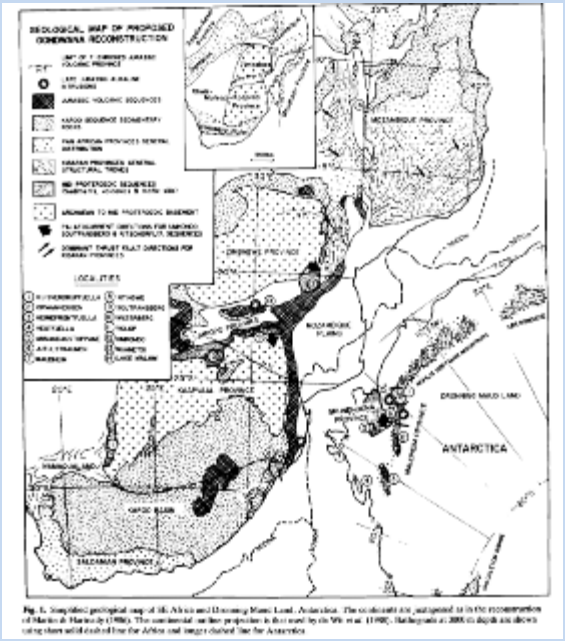
Research publication focus 1980-2005

Ahlmannryggen – Borg Massivet

- Petrology of Sill intrusions
- Sedimentology and Stratigraphy of the sedimentary succession

Sverdrupfjella and Kirwanveggan

- Documenting rock types, ages, geochemistry and structural histories of basement rocks
- Documenting types, ages and geochemistry of younger granitic and basaltic intrusions.
- Correlating the basement and intrusion histories with Mozambique recognising its proximity in Gondwana reconstructions.
- The early focus was largely related to understanding the correct configuration of Antarctica within Gondwana and the timing of the Break-up of Gondwana within a plate tectonic context.



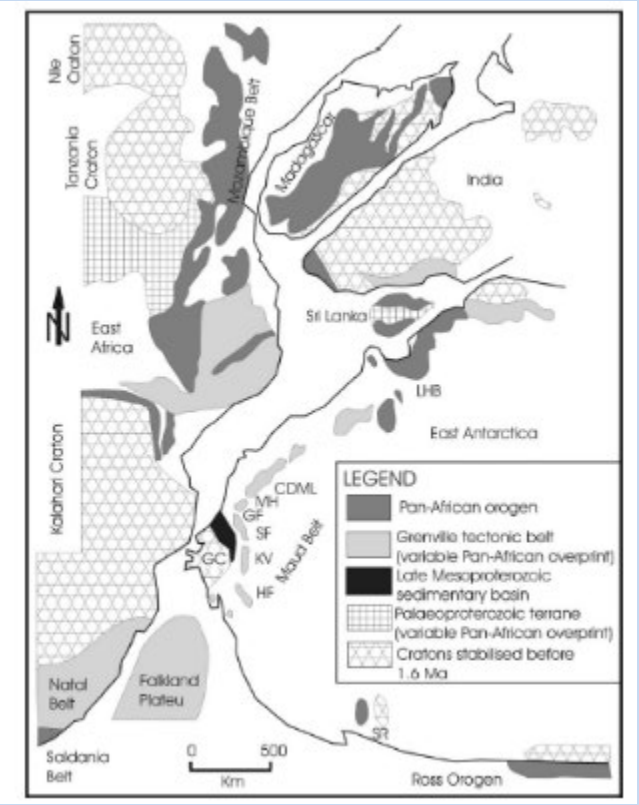
Correlation was made between WDML and N. Mozambique with continuation into the Natal Belt. Orogenesis (Mountain Building) deformation and metamorphism was inferred to be 1000-1200 Ma from the limited age data available.

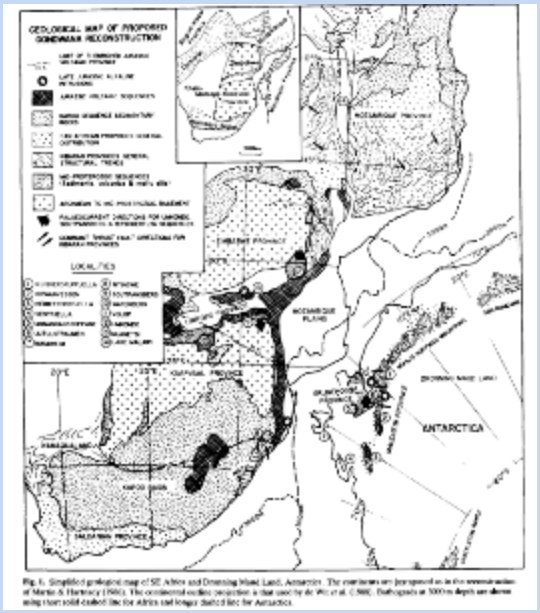
Grantham, G.H., Groenewald, P.B. and Hunter, D.R. (1988) Geology of the northern H.U. Sverdrupfjella, western Dronning Maud land and implications for Gondwana reconstructions. South African Journal Antarctic Research, 18, 2-10.

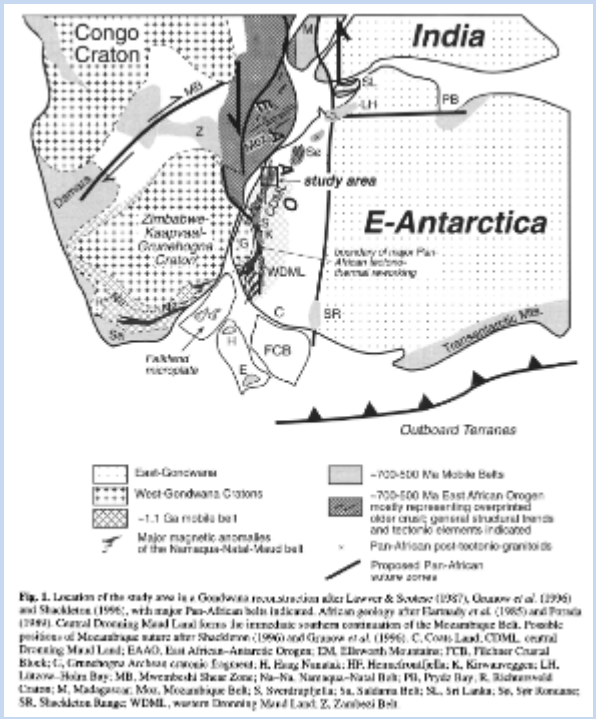
P. B. GROENEWALD, G. H. GRANTHAM and M. K. WATKEYS Geological evidence for a Proterozoic to Mesozoic link between southeastern Africa and Dronning Maud Land, Antarctica. *Journal of the Geological Society 1991; v. 148; p. 1115-1123.*

Beginning focus on Gondwana Amalgamation – 2003-2008

Research interest moved from Gondwana configuration and breakup at ~180-200 my to when and how was the Gondwana supercontinent amalgamated at ~ 600 – 480 my







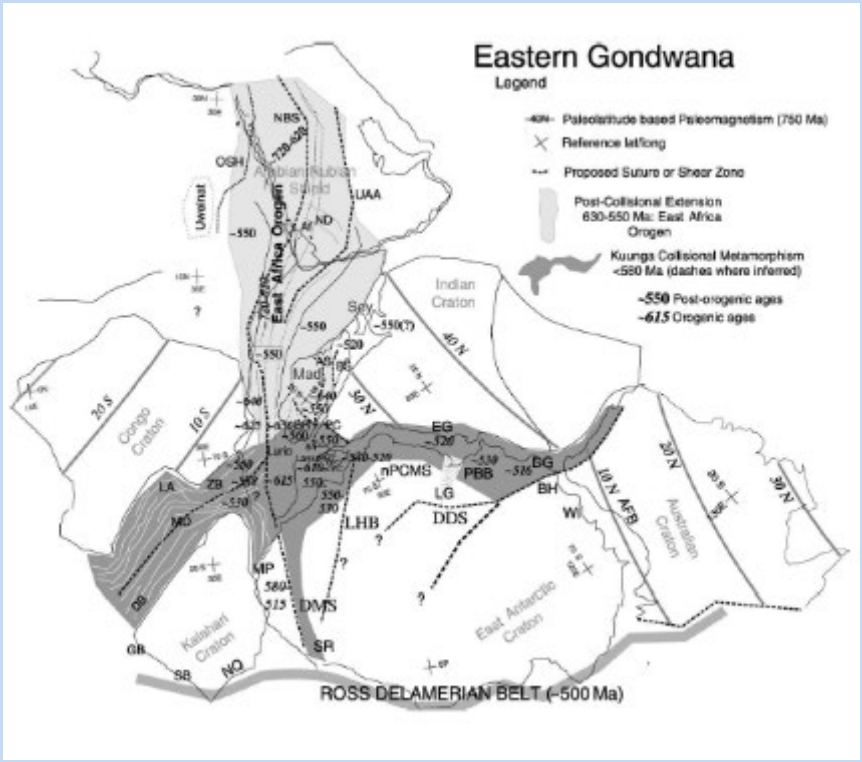
A. Bisnath, H.E. Frimmel, *R.A. Armstrong, W.S. Board.* Tectono-thermal evolution of the Maud Belt: New SHRIMP U–Pb zircon data from Gjelsvikfjella, Dronning Maud Land, East Antarctica. Precambrian Research 150 (2006) 95–121

As more data, particularly age data, became available two different interpretations arose – namely Mesoproterozoic/Grenvillian (1000-1200Ma) vs Neoproterozoic East African Orogeny or Pan African (600-500Ma)

J. JACOBS R. KLEMD, C. M. FANNING, W. BAUER & E COLOMBO
Extensional collapse of the late Neoproterozoic-early Palaeozoic East African-Antarctic Orogen in central Dronning Maud Land, East Antarctica.
From YOSHIDA, M., WINDLEY, B. E & DASGUPTA, S. (eds) 2003. Proterozoic East Gondwana: Supercontinent Assembly and Breakup. Geological Society, London, Special Publications, 206, 271-287. 0305-8719/03/$15 9
The Geological Society of London.

W. S. BOARD, H. E. FRIMMEL & R. A. ARMSTRONG
Pan-African Tectonism in the Western Maud Belt: P–T–t Path for High-grade Gneisses in the H.U. Sverdrupfjella, East Antarctica.
JOURNAL OF PETROLOGY VOLUME 46 NUMBER 4 PAGES 671–699
2005 doi:10.1093/petrology/egh093

Gondwana amalgamtion debate between EAO and Kuunga Orogeny – continues to this day



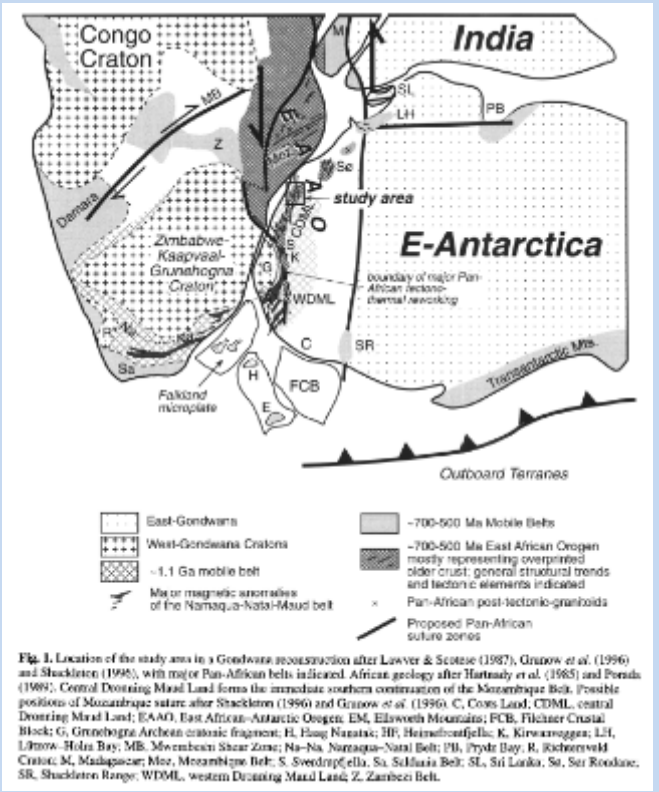
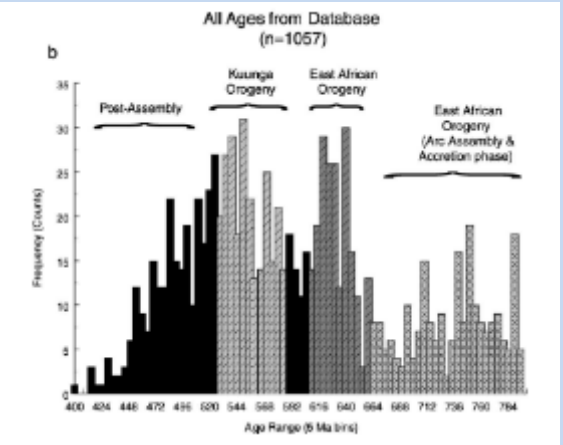


Fig. 1. Location of the study area in a Gondwana reconstruction after Lawver & Scotese (1987), Grunow et al. (1996) and Shackleton (1996), with major Pan-African belts indicated. African geology after Hartnady et al. (1985) and Porada (1989). Central Dronning Maud Land forms the immediate southern continuation of the Mozambique Belt. Possible positions of Mozambique suture after Shackleton (1996) and Grunow et al. (1996). C, Coats Land; CDML, central Dronning Maud Land; EAAO, East African–Antarctic Orogen; EM, Ellsworth Mountains; FCB, Filchner Crystal Block; G, Grunehogna Archean cratonic fragment; H, Haag Nunatak; HF, Heimefrontfjella; K, Kirwanveggen; LH, Lützow–Holm Bay; MB, Mwembeshi Shear Zone; Na–Na, Namaqua–Natal Belt; PB, Pryde Bay; R, Richtersveld Craton; M, Madagascar; Moz, Mozambique Belt; S, Sverdrupfjella; Sa, Salsburia Belt; SL, Sri Lanka; Sr, Ser Rondane; SR, Shackleton Range; WDML, western Dronning Maud Land; Z, Zambezi Belt.



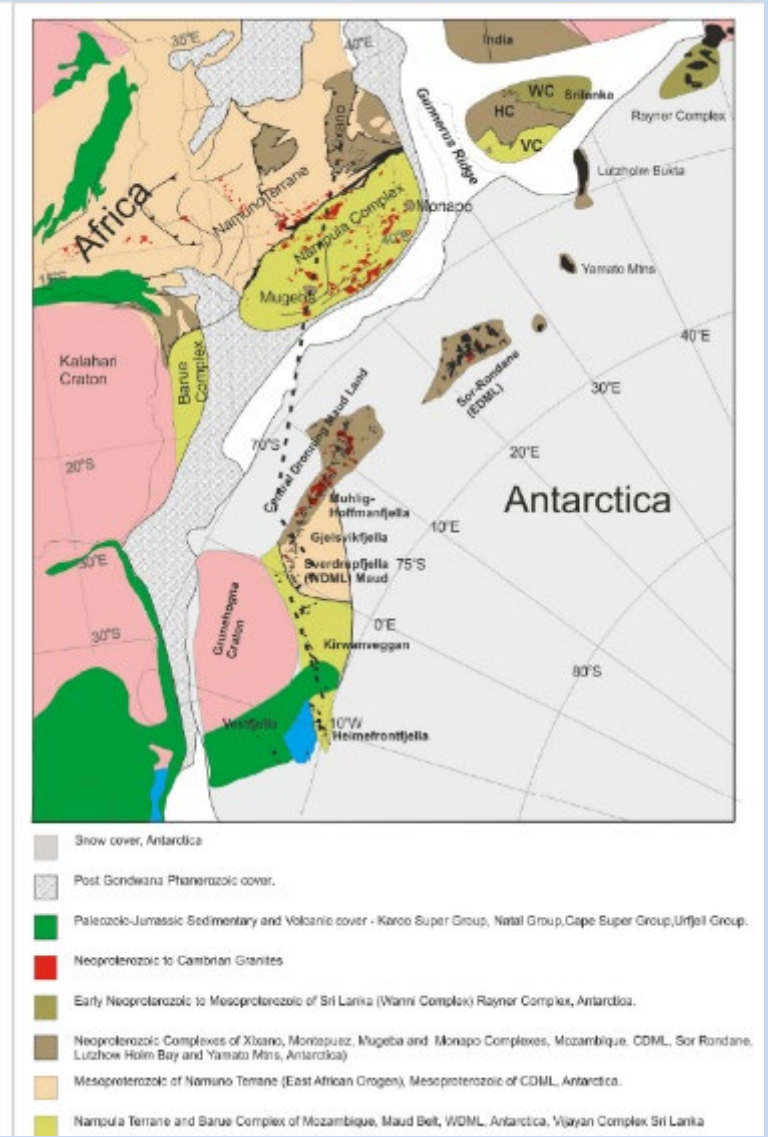
Geochronology
Age study

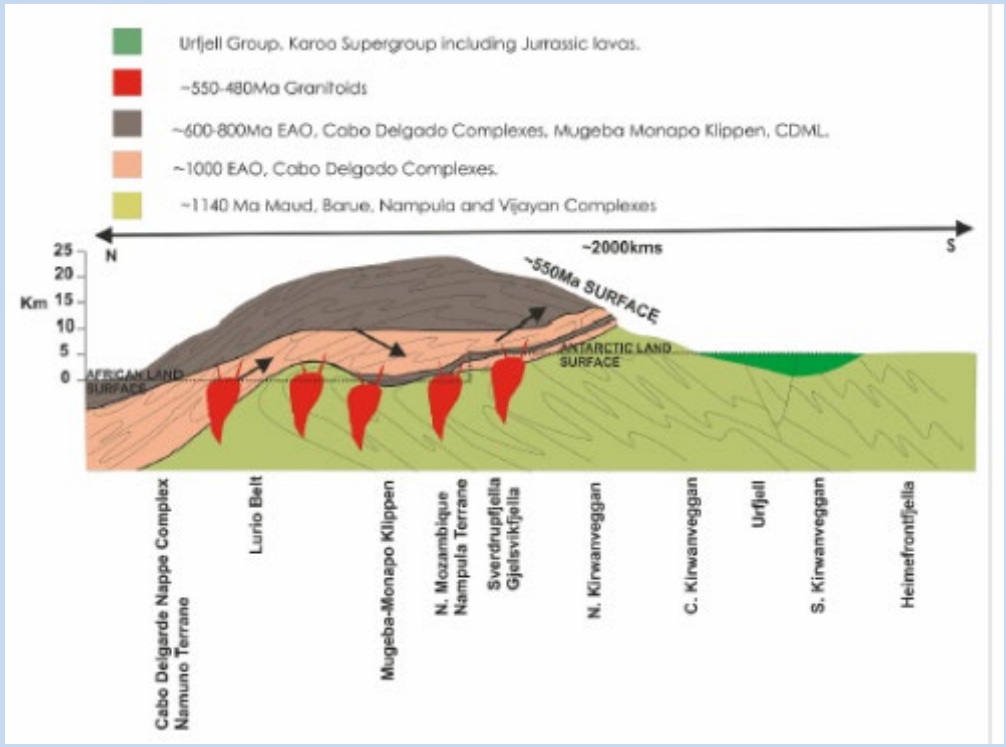
J. JACOBS R. KLEMD, C. M. FANNING, W. BAUER & E COLOMBO
Extensional collapse of the late Neoproterozoic-early Palaeozoic East African-Antarctic Orogen in central Dronning Maud Land, East Antarctica.
From YOSHIDA, M., WINDLEY, B. E & DASGUPTA, S. (eds) 2003. Proterozoic East Gondwana: Supercontinent Assembly and Breakup. Geological Society, London, Special Publications, 206, 271-287. 0305-8719/03/$15 9
The Geological Society of London.

Joseph G. Meert (2003) A synopsis of events related to the assembly of eastern Gondwana. Tectonophysics 362 (2003) 1 –40.

2008 -2012 Gondwana Amalgamation contd.

- No geological field program in Antarctica between ~2006 -2012 but extensive work by South Africa, Norway, Finland, BGS and Mozambicans in Mozambique for a World bank Funded project provided new.
- The publication below supports Kuunga Orogeny interpretation based on integrated ages, rock types, structure data and metamorphic P-T estimate data.

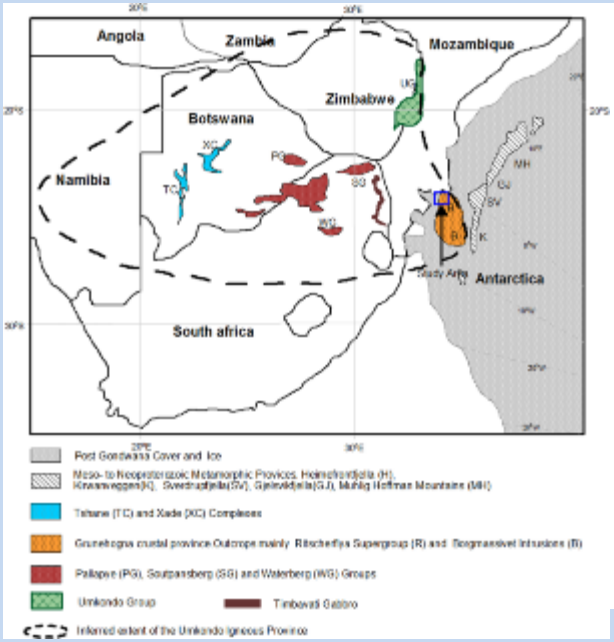




G. H. Grantham, P. H. Macey, B. A. Ingram, M. P. Roberts, R. A. Armstrong, T. Hokada, K. Shiraishi, C. Jackson, A. Bisnath and V. Manhica (2008) **Terrane correlation between Antarctica, Mozambique and Sri Lanka; comparisons of geochronology, lithology, structure and metamorphism and possible implications for the geology of southern Africa and Antarctica.**
Geological Society, London, Special Publications v. 308; p. 91-119.

2013-2018 Geological fieldwork contd.

Craton Correlation – Straumsnutane (WDML) Espungaberra (Mozambique) using paleomagnetism and whole rock chemistry including isotopes



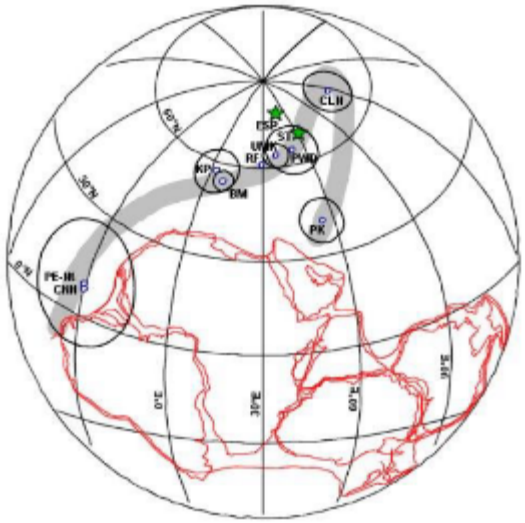
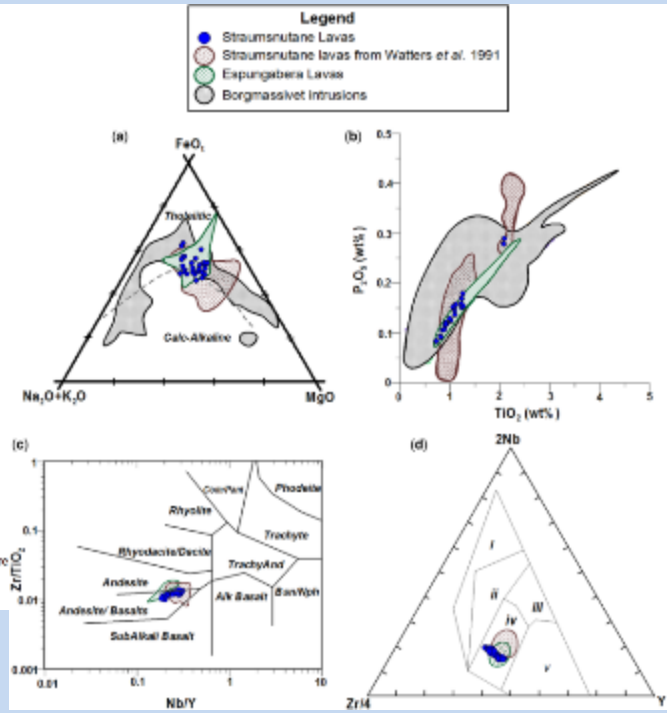


Figure 8: Proposed APWP for the Kalahari craton based on the poles listed in Table 7. Individual poles are keyed to their code entry in the list. Pole from the current study indicated as green stars (modified after Meert and Torsvik, 2003).



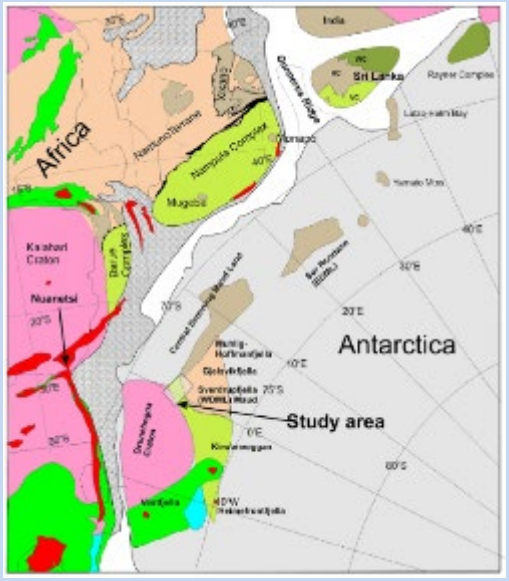
Study was based on layered volcanic rocks – lavas – the value of paleomagnetic data is that, collected from lavas which have layering which is typically horizontal – intrusions have uncertainty as to the original orientation.

Leonie Maré, Neo Moabi and Geoff Grantham (2015) PALEOMAGNETIC RESULTS FROM THE ESPUNGABERA FORMATION OF CENTRAL MOZAMBIQUE AND THE STRAUMSNUTANE FORMATION OF WESTERN DRONNING MAUD LAND, ANTARCTICA. Council for Geoscience Report number 2015-0124.

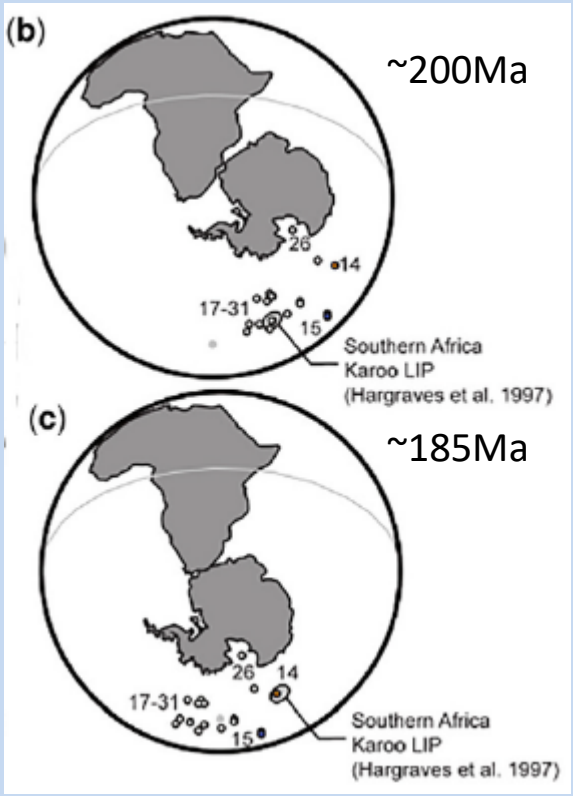
NEO G. MOABI, GEOFFREY H. GRANTHAM, JAMES ROBERTS & PETRUS LE ROUX (2017) The geology and geochemistry of the Straumsnutane Formation, Straumsnutane, western Dronning Maud Land, Antarctica and its tectonic setting on the western margin of the Kalahari Craton: additional evidence linking it to the Umkondo Large Igneous Province. Pant, N. C. & Dasgupta, S. (eds) Crustal Evolution of India and Antarctica: The Supercontinent Connection. Geological Society, London, Special Publications, 457, https://doi.org/10.1144/SP457.4.

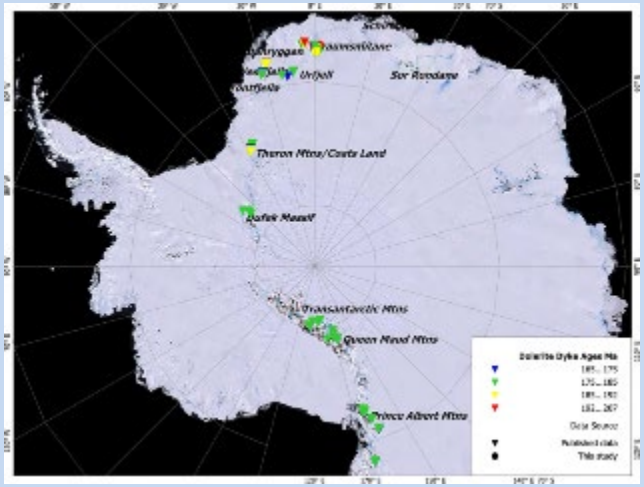
2013-2021
Paleomagnetic and age of dolerite dykes compared to SA in Gondwana

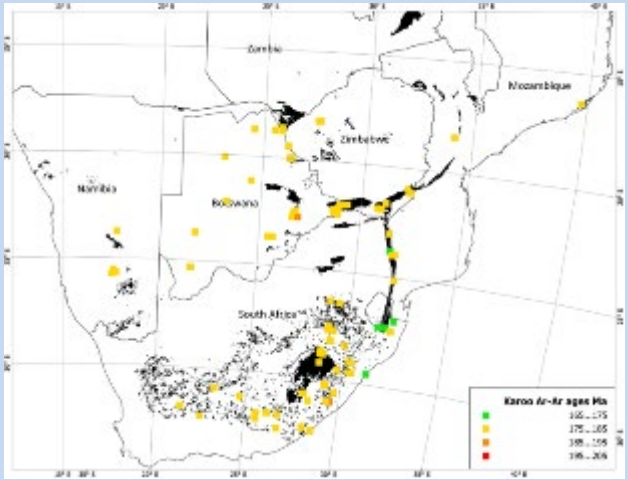
M. A. Morake, J. N. F. O'Kennedy, M. W. Knoper, M. de Kock, J. D. Kramers, G. H. Grantham, G. Belyanin and M. A. Elburg. (2021) The age and palaeomagnetism of Jurassic dykes, western Dronning Maud Land: implications for Gondwana Breakup. From: Srivastava, R. K., Ernst, R. E., Buchan, K. L. and de Kock, M. (eds) Large Igneous Provinces and their Plumbing Systems. Geological Society, London, Special Publications, 518



- Gondwana Breakup began ~200 Ma and not ~180 Ma as previously thought.
- By ~185 Ma Antarctica already drifted significantly away from southern Africa

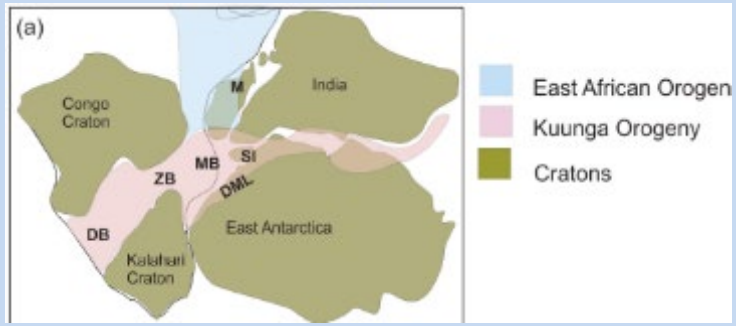


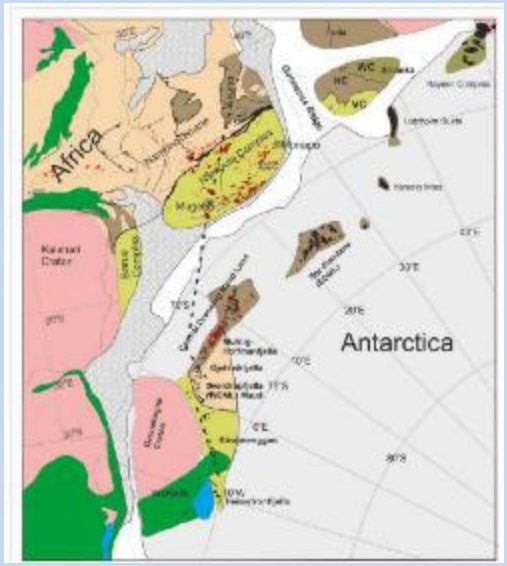




2013-2023
Kuunga Orogeny – 550Ma

Geoffrey H. GRANTHAM, M. SATISH–KUMAR, Kenji HORIE and Henriette UECKERMANN (2023). The Kuunga Accretionary Complex of Sverdrupfjella and Gjelsvikfjella, western Dronning Maud Land, Antarctica. Journal of Mineralogical and Petrological Sciences (2023) 118:S007

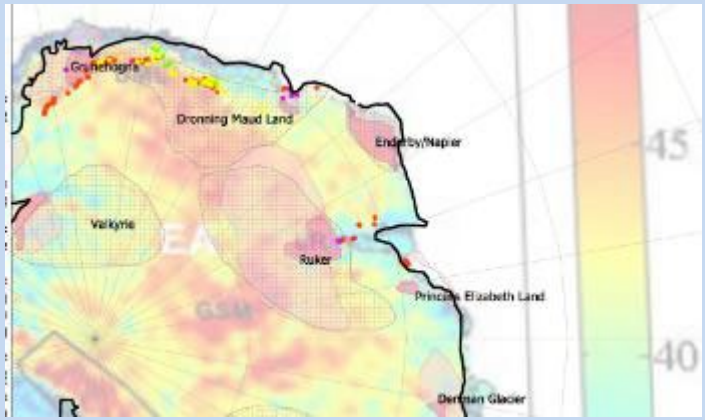


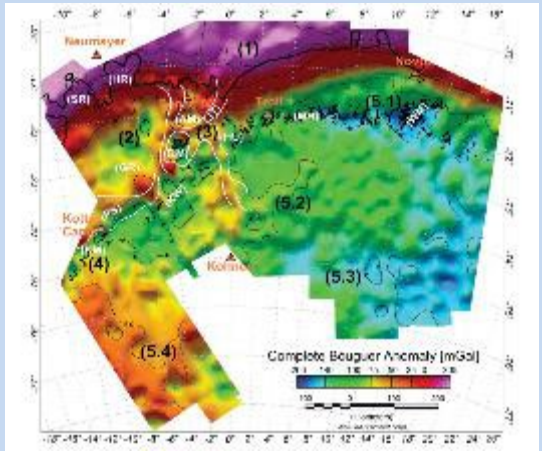


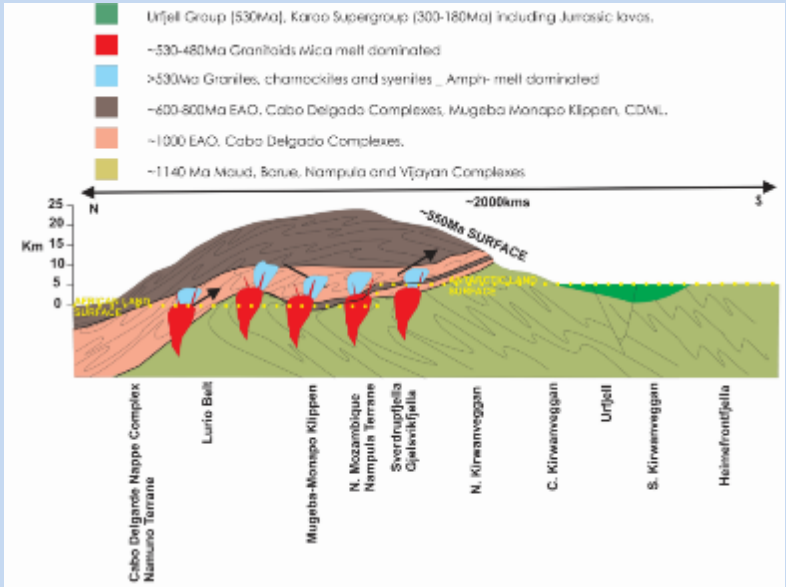
Collision between two continents at 550 Ma with N Gondwana thrust over S Gondwana for at least 600 km forming a mega-nappe complex. The collision between S and N Gondwana is along Kuunga Orogeny interface

Metamorphic studies expose granulites formed at >40kms depth now at surface. Gravity shows DML still underlain by ~50km of crust.

Thick crust extends to Gamburtsev Mtns suggesting the mega-nappe complex probably had an even wider extent than thought.



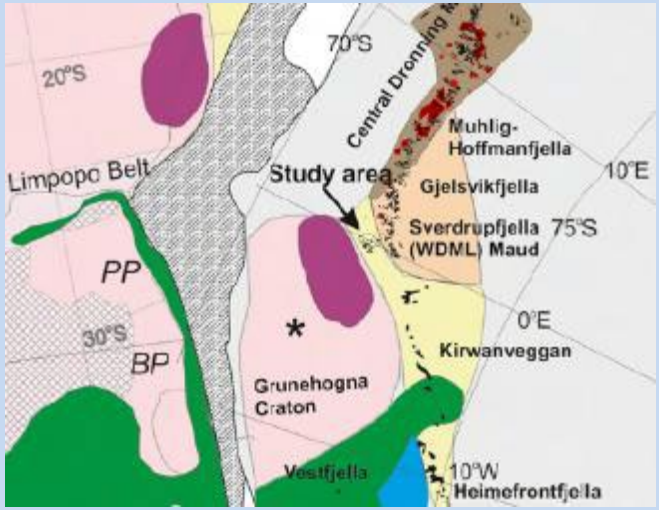


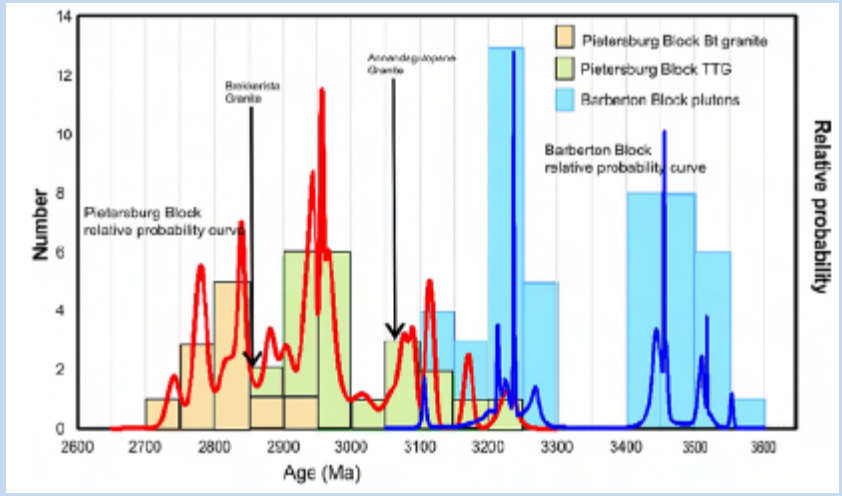


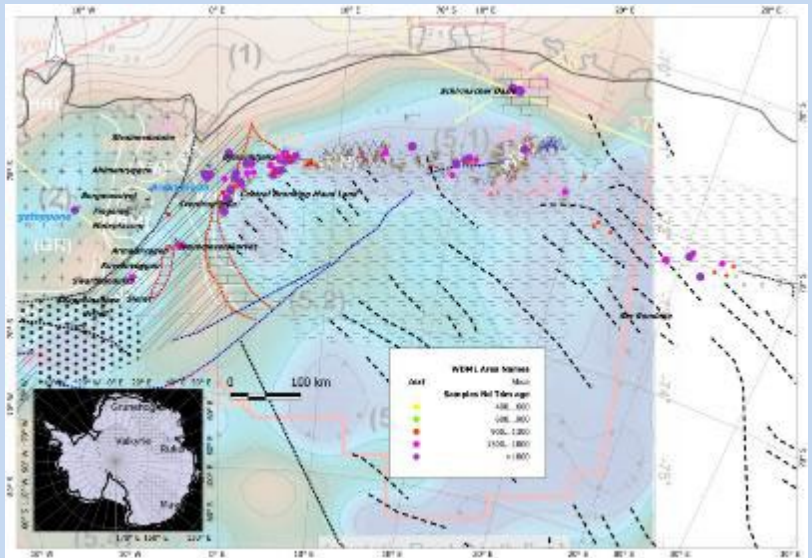
2013-2023
New Archean (>2500 Ma) discovery in DML published 2023

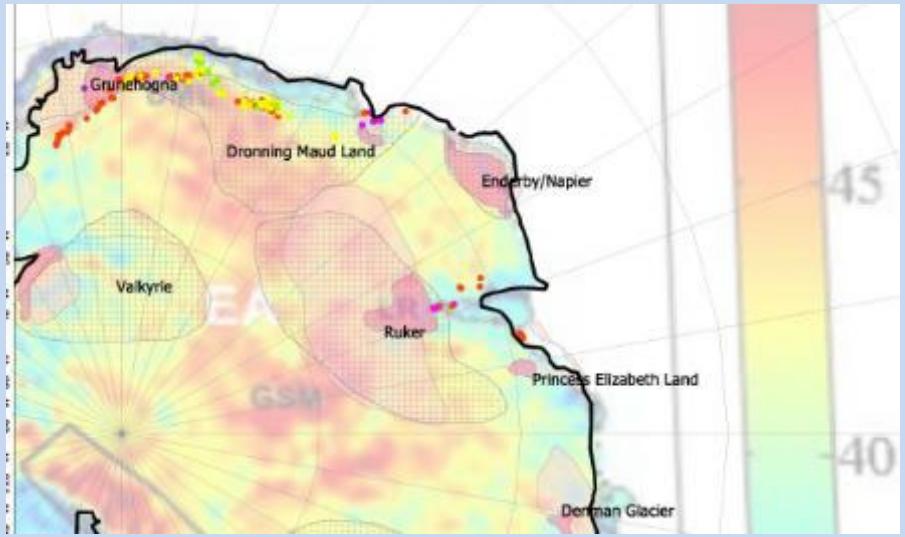
G.H. Grantham, M.A. Elburg, H. Ueckermann, L. Iaccheri, R. Ngobeli, N.G. Moabi (2023)The age and chemistry of granitic gneisses from the western H.U. Sverdrupfjella, Maud Terrane, western Dronning Maud Land, Antarctica. LITHOS 444-445 (2023) 107128

The discovery of a granite with age of 2850 Ma underlying the Maud Belt combined with Depleted Mantle model Nd radiogenic isotope ages of >1800Ma suggests that much of East Antarctica is underlain by Archaean crust.









Conclusions

- Since 1950 from the first fieldwork in WDML, significant progress has been made in understanding the geological evolution of WDML.
- The importance of getting new geochronological age dating in support of fieldwork is essential.