AUSTRALIAN ANTARCTIC TERRITORY

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Australian Antarctic Division

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Geoscience Australia

GEOLOGY OF THE STILLWELL HILLS

KEMP LAND
ANTARCTICA

Edition 1

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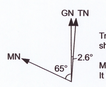
GeoCat - 72717
Map number - 13521

PROJECTION: Universal Transverse Mercator Zone 40
HORIZONTAL DATUM: WGS84
VERTICAL DATUM: Mean Sea Level
NOMENCLATURE: Names have been approved by the Australian Antarctic Names and Medals Committee

SCALE 1:25 000

0 0.5 1 2 3 4 Kilometres



True North, Grid North and Magnetic North are shown diagramatically for the centre of the map.

Magnetic North is correct for September 2008. It moves westerly by approximately 0.15° per year.

Refuge
Coastline
Geological boundary
Approximate form surface
Continental ice or snow
Glacier
Water

NEO-PROTEROZOIC

>ca. 718 Ma — **Cp** — **Cosgrove Pegmatites**
Coarse grained K-feldspar+plagioclase+quartz+biotite (±garnet) pegmatite dykes range in width from 10cm to 10m. May extend laterally for 100's of metres.

>ca. 1100 - 900 Ma — Rayner Orogen

PALEO-MESOPROTEROZOIC

Pspg — **Stefansson Paragneiss**
Pelitic gneiss with garnet+sillimanite+K-feldspar+quartz (±biotite, plagioclase, magnetite). Locally developed layers dominated by silimanite.

Ppng — **Point Noble Gneiss**
Mafic layers occur as 5 - 20m thick layers within the Ives Gneiss, comprised of clinopyroxene+orthopyroxene+garnet+plagioclase+hornblende+ilmenite+quartz.

Pig — **Ives Paragneiss**
Iron-oxide stained, metapelitic gneiss comprised of garnet+sillimanite+alkali feldspar+quartz+biotite+rutile+ilmenite (±plagioclase, magnetite, pyrite, graphite) with minor intercalated felsic gneiss. Variably migmatitic. Referred to as 'Rusty Gneiss' by Halpin et al. (2007).

Pkd — **Kemp Dykes**
Deformed or dismembered mafic dykes containing clinopyroxene+orthopyroxene+plagioclase+garnet (±hornblende, ilmenite). May extend laterally for 100's of metres. Possible metamorphosed / deformed equivalent to the Amundsen dykes (Napier Complex ca. 1190 Ma).

Pkg — **Keel Paragneiss**
Well layered calc-silicate and/or silica-undersaturated metapelitic lenses/pods interbedded with mafic gneiss, minor intermediate gneiss and metaquartzite.

>ca. 1620 Ma — **Psc** — **Scoresby Charnockite**
Felsic orthogneiss containing plagioclase+quartz+K-feldspar+orthopyroxene+ilmenite+magnetite (±clinopyroxene, garnet, hornblende, biotite). May contain megacrystic K-feldspar grains up to 6cm. Xenoliths are common.

Psg — **Sperring Paragneiss**
Weakly foliated felsic gneiss dominated by perthitic alkali feldspar+quartz+plagioclase with minor garnet+biotite. Lenses of garnet+sillimanite+biotite metapelitic migmatite are common.

ARCHEAN

Dovers Paragneiss

Adgf — *Garnet felsic gneiss, quartzite, biotite+sillimanite metapelite, minor hornblende+clinopyroxene+orthopyroxene+plagioclase mafic gneiss.*

Adgg — *Garnet+K-feldspar gneiss.*

Admg — *Hornblende+clinopyroxene+orthopyroxene+plagioclase mafic gneiss.*

Adqf — *Quartzite with garnet felsic gneiss, biotite+sillimanite pelite, minor hornblende+clinopyroxene+orthopyroxene+plagioclase gneiss.*

Adqm — *Magnetite quartzite.*

Adqz — *Quartzite with minor felsic gneiss, hornblende+clinopyroxene+orthopyroxene+plagioclase mafic gneiss.*

>ca. 3460 Ma — **Aso / Asom** — **Stillwell Orthogneiss**
Granoblastic orthogneiss with a pervasive gneissosity (Aso, gneissic; Asom, massive) defined by alternating mafic and felsic-intermediate gneiss. Referred to as the Stillwell Gneiss by Trail (1970). Felsic layers contain K-feldspar+plagioclase+quartz+clinopyroxene+orthopyroxene±ilmenite. Mafic layers contain clinopyroxene+orthopyroxene+plagioclase+magnetite+ilmenite+quartz (±garnet, biotite, hornblende).

Data compilation and acknowledgements

Geology:
2002 G.L. Clarke, J.A. Halpin, F.C. Schröter, R.W. White
1999 J. A. Fitzherbert, C.L. Gerakiteys, N.M. Kelly
1997/98 V. Bennett, N.M. Kelly, R.W. White
1984/85 G.L. Clarke
1961 I.R. McLeod, W.R McCarthy, D.S. Trail

Compiled 2009 by J.A. Halpin
GIS consultation U. Harris, D. Smith and H. Brolsma, Australian Antarctic Data Centre
Cartography by M.A. Woods, Geoscience Australia

Coastline, glacier tongue - Refer to metadata record 'Australian Antarctic Territory Coastline 2003' which can be accessed at http://data.aad.gov.au/metadata

Plough Lake digitized from aerial photography (1997)

Place names - Australian Antarctic Gazetteer http://data.aad.gov.au/aadc/gaz/

It is recommended that this map be referred to as : J.A. Halpin, G.L. Clarke, R.W. White, C.L. Gerakiteys, N.M. Kelly, J.A. Fitzherbert, F.C. Schröter, V. Bennett and C.J. Carson, (2012) *Solid geology of the Stillwell Hills Antarctica.* 1st edition (1:25000) Geoscience Australia
Stratigraphic column indicative only and largely based on available published and unpublished geochronology. Indicated conformable contacts and unconformities speculative and inferred only. Primary lithological contacts and relationships obscured by tectonism during the ca. 1100-900 Ma Rayner Orogeny.

For further reference to the geology of the Stillwell Hills see the following publications:

Clarke G.L. (1987) *A comparative study of the structural and metamorphic evolution of the Olary (South Australia) and Stillwell Hills (Antarctica) Precambrian terrains.* Ph.D. thesis. The University of Melbourne, Melbourne, 254 pp

Clarke G.L. (1988) *Structural constraints on the Proterozoic reworking of Archaean crust in the Rayner Complex, MacRobertson and Kemp Land coast, East Antarctica.* Precambrian Research 40-41: 137-156

Crohn P.W. (1959) *A contribution to the geology and glaciology of the western part of Australian Antarctic Territory.* Bureau of Mineral Resources Geology and Geophysics Bulletin 52:1-103

Halpin J.A., Gerakiteys C.L., Clarke G.L., Belousova E.A., Griffin W.L. (2005) *In situ U-Pb geochronology and Hf isotope analyses of the Rayner Complex, east Antarctica.* Contributions to Mineralogy and Petrology 148: 689-706

Halpin J.A., White R.W., Clarke G.L., Kelsey D.E. (2007) *The Proterozoic P-T-t evolution of the Kemp Land coast, east Antarctica; constraints from Si-saturated and Si-undersaturated metapelites.* Journal of Petrology, 48: 1321-1349

Halpin, J.A. (2007) *Metamorphic and geochronological evolution of the Kemp and Mac.Robertson Land coast, east Antarctica.* Ph.D. thesis. School of Geosciences, The University of Sydney, 154 pp

Halpin J.A., Clarke G.L., White R.W., Kelsey D.E. (2007) *Contrasting P-T-t paths for Neoproterozoic metamorphism in MacRobertson and Kemp Lands, east Antarctica.* Journal of Metamorphic Geology, 25: 683-701

Kelly N.M., Clarke G.L., Fanning C.M. (2002) *A two-stage evolution of the Neoproterozoic Rayner Structural Episode; new U-Pb sensitive high resolution ion microprobe constraints from the Oygarden Group, Kemp Land, East Antarctica.* Precambrian Research 116(3-4): 307-330

McCarthy W.R., Trail D.S. (1964) *The high-grade metamorphic rocks of the Mac.Robertson Land and Kemp Land coast.* In: Adie R.J. (ed) *Antarctic Geology.* North-Holland, Amsterdam, p 473-481

Sheraton J.W., Tingey R.J., Black L.P., Offe L.A., Ellis D.J. (1987) *Geology of an unusual Precambrian high-grade metamorphic terrane - Enderby Land and western Kemp Land, Antarctica.* Australian Bureau of Mineral Resources Bulletin 223:51 pp

Trail D.S. (1970) *ANARE 1961 Geological Traverses on the Mac.Robertson Land and Kemp Land Coast.* Bureau of Mineral Resources, Geology and Geophysics Report 135:1-32

Trail D.S., McLeod P.J., Cook G.R., Wallis G.R. (1967) *Geological Investigations by the Australian National Antarctic Research Expeditions, 1965.* Bureau of Mineral Resources, Geology and Geophysics Report 118:1-48

HOW TO QUOTE A GRID REFERENCE FOR A PARTICULAR POINT

1. Quote this map .....GEOLOGY OF THE STILLWELL HILLS 13521
2. Locate the VERTICAL grid line to the left of the point 602
3. Estimate metres from the grid line to the point 900
4. Locate the horizontal GRID LINE BELOW THE POINT 2519
5. Estimate metres from the grid line to the point 130

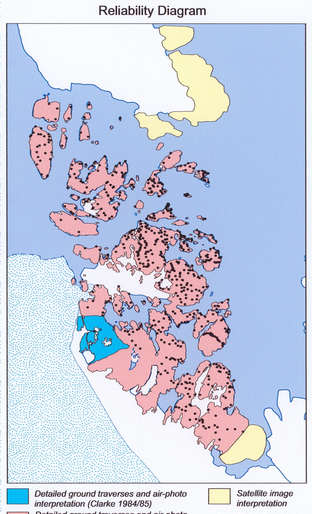
Thus, the reference for KEMP PEAK is: ...GEOLOGY OF THE STILLWELL HILLS 13521 602900, 2519130

The grid interval on this map is 1000 metres

59°20'E 59°25'E 59°30'E 59°35'E
67°18'S 67°20'S 67°22'S 67°24'S 67°26'S 67°28'S

Fold Island
Transverse Island
Keel Island
Mount Whiteside
Green Point
Point Noble
Ives Tongue
Ledingham's Depot
Stefansson Bay
2003
DOVERS GLACIER
Stillwell Lake
Kemp Lake
Kemp Peak
Plough Lake
Cascade Lake
Sperring Point
William Scoresby Bay
STILLWELL HILLS

Reliability Diagram



Detailed ground traverses and air-photo interpretation (Clarke 1984/85)
Detailed ground traverses and air-photo interpretation (1997/98, 1999, 2002)
Satellite image interpretation
Field sites (Halpin et al 2002)

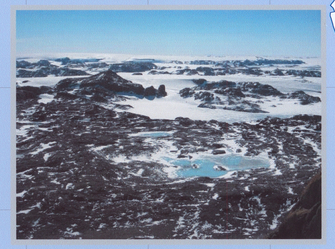
View facing southwest towards Kemp Peak in distance. Rusty orange unit in foreground is the Ives Paragneiss (Pig); the dark lithology in the middle distance is Stefansson Paragneiss (Psm) (by I.R. McLeod, BMR geologist).

Folded and transposed Kemp Dykes (Pkd) hosted by Stillwell Orthogneiss (Aso), southeast Stillwell Hills (figure for scale, photo by I.R. McLeod, BMR geologist).

Pyroxene granulite lens (Kemp Dykes, Pkd) in Stillwell Orthogneiss (Aso), southeast Stillwell Hills (figure for scale, photo by I.R. McLeod, BMR geologist).

View of Stillwell Orthogneiss (Aso) at the north end of Keel Island, displaying macroscopic F3 fold defined by multiple transposed Kemp Dykes (Pkd), northwest Stillwell Hills (facing south, figure at base of cliff for scale, photo by J.A. Halpin).

Aerial view, facing northwest, of Ledingham's Depot and polar pyramids during 2002 mapping season. Outcrops in the background are Ives Paragneiss (Pig) and Point Noble Gneiss (darker unit along ridges, Ppng) (photo by J.A. Halpin).



View facing north from Kemp Peak towards the northern Stillwell Hills and Fold Island (on horizon). Stillwell Lake located in middle of photo. Outcrops in the foreground are part of the Dovers Paragneiss sequence (photo by G.L. Clarke).

The Stillwell Hills – Geological Summary

The Stillwell Hills region comprises granulite-facies gneisses which record evidence for multiple episodes of deformation and metamorphism spanning more than 2500 million years. The predominant orthogneiss package (Stillwell Orthogneiss) is thought to represent the margin of an Archaean craton exposed in Enderby Land, some 150 km to the west that was reworked during the late Proterozoic. Younger additions to the crust include Paleoproterozoic charnockitic gneiss (Scoresby Charnockite) and Meso-Neoproterozoic mafic sills and dykes (Point Noble Gneiss, Kemp Dykes) and felsic pegmatites (Cosgrove Pegmatites). Subordinate supracrustal rocks, including metaquartzite, metapelitic, metapsammitic and calc-silicate gneiss (Dovers Paragneiss, Sperring Paragneiss, Stefansson Paragneiss, Keel Paragneiss, Ives Paragneiss) are intercalated and infolded with the Archaean-Paleoproterozoic orthogneisses.
Together with adjacent high-grade rocks in Kemp and Mac.Robertson Lands, these rocks preserve relics of an extensive Meso-Neoproterozoic mobile belt, which developed during continental collision. At least two high-grade tectonothermal events occurred during the Archaean – Paleoproterozoic in this terrane (local D_1 and D_2), whereas three events are attributed to collisional tectonics during Neoproterozoic orogenesis (D_3 – D_5), referred to as the Rayner Structural episode in the regional literature. Penetrative deformation at mid- to lower-crustal levels at *ca.* 940 million years ago produced a pervasive sub-horizontal S_3 gneissosity (the dominant form surface) and reclined to recumbent F_3 folds which are invariably overprinted by dome and basin-type folding developed during D_4 and D_5. Metamorphic conditions reached 870-930 °C at 7.5-9 kbar during early Neoproterozoic collisional orogenesis, and mineral reaction microstructures suggest the terrane followed a clockwise pressure-temperature-time evolution. Mylonitic shear zones (D_6) cut all ductile structures and reflect amphibolite-facies conditions during later north-directed intraplate deformation.

Map 13521