Ministero dell'Istruzione, dell'Università e della Ricerca
Programma Nazionale di Ricerche in Antartide

ANTARCTIC GEOLOGICAL 1:250,000 MAP SERIES

MOUNT MELBOURNE QUADRANGLE (VICTORIA LAND)

2012

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EXPLANATION

m Scree, glacial drift and moraine (m). Quaternary.

md Marine deposits: pebble gravel and sand (md); dashed blue line: Holocene raised beach ridges. Quaternary.

CENOZOIC MAGMATISM AT THE ROSS SEA MARGIN

McMURDO IGNEOUS COMPLEX

Mev MELBOURNE ALKALI-BASALT-BASANITE TO TRACHYTE-RHYOLITE (Mev)
Variably differentiated alkali-volcanic suite forming scattered volcanic centres and a major composite strato-volcano (Mt. Melbourne). The radiometric age of the rocks at the base of Cape Washington is 2.7 Ma; in the surrounding area it ranges from < 2 Ma up to Present.

Mg MEANDER ALKALI-GRANITE AND SYENITE (Mg)
Monzonite-syenite with minor alkali-feldspar granite and gabbro. Several mafic dykes occur in the Random Hills area. An age around 38 Ma is attributed to intrusive facies; the dykes provided 32-38 Ma ages.

POST-ROSS MAGMATISM AND SEDIMENTATION

FERRAR VOLCANIC SUITE

Kb KIRKPATRICK BASALT (Kb)
Subaerial lavas, a few meters up to several tens of meters thick, randomly separated by thinner sedimentary volcanogenic interlayers and pillow lavas. Blue lines (omitted in the cross sections) indicate local beds and lenses of whitish marly siltstones, fine grained sandstones and minor black shales with flora relics mostly in the lower portion of the volcanic sequences. The Mesa Range basalts (Mt. Murchison quadrangle) provided 178 Ma K/Ar ages.

Fd FERRAR DOLERITE (Fd)
Tholeiitic dolerite sills and minor dykes, usually intruded in the sedimentary sequence of the Beacon Supergroup, immediately above the pre-Beacon peneplain. Black lines (omitted in the cross sections) indicate major lenses and seams (meanly some ten meters thick) of Section Peak Formation sandstones, forming sandwich type interlayers within the Ferrar Dolerite sills. A K/Ar age of 174±10 Ma has been reported from Archambault Ridge (Mt. Murchison quadrangle).

BEACON SUPERGROUP

Sf SECTION PEAK FORMATION (Sf)
Mainly fluviatile cross-bedded, coarse-to medium-grained sandstone with feldspathic to quartzose composition. Minor intercalations of conglomerate, black shale, in places carbonaceous silty mudstone and minor coal occur as well. A Middle to Late Triassic age is indicated by the presence of flora and microflora at Timber Peak and of *Dicroidium odontopteroides* at Vulcan Hills (Mt Murchison quadrangle).

Nt NEALL MASSIF TILLITE (Nt)
Massive or faintly bedded green sandy mudstone matrix- supported diamictite. An Upper Carboniferous-Permian age is tentatively inferred.

TERRANES AND UNITS OF THE ROSS OROGEN
WILSON TERRANE

GRANITE HARBOUR IGNEOUS COMPLEX

GHl GRANITE HARBOUR LEUCOGRANITE (GHl)
Medium-to fine-grained late-to post-kynematic leucogranite, occurring as elongated small intrusions or as sills and dykes. An age of 475±5 (Rb-Sr on Ms) Ma has been obtained. A mylonite fabric is locally present (Black Ridge).

GHm GRANITE HARBOUR MONZODIORITE (GHm)
Fine grained monzodiorite and melamonzogranite occurs as small sills and dykes mostly in the Northern Foothills. An age of 493±7 (U-Pb on Zrc) Ma has been obtained.

GHgr **a** GRANITE HARBOUR GRANODIORITE AND GRANITE (GHgr)
Syn-to post-kynematic granite, granodiorite and syenite intruded in the Wilson Metamorphic Complex as large plutonic bodies. In the Mount Abbott area an age of 495±4 (U-Pb on Zrc) Ma has been obtained. A coeval mafic (gabbro-diorite) (a) and hybrid (melamonzogranite) facies crop out in the Mount Abbott area.

GHt GRANITE HARBOUR TONALITE, DIORITE, GABBRO (GHt)
Tonalite and gabbrotonalite, with poorly to highly foliated fabric: Cape Confusion Northern Foothills, 513-526 (U-Pb on Zrc) Ma; tonalite, quartz diorite, diorite and gabbro: North of Mt. Gerlache, Mt. Larsen, Teall Nunatak 'O Kane Glacier, Corner Glacier, Mt. New Zealand.

GHgn GRANITE HARBOUR GNEISS (GHgn)
Intensely deformed granite, tonalite, quartzdiorite with gneissic fabric conformably intruded in Wilson Metamorphic Complex (Inexpressible Orthogneiss, Skinner,1989). An age of 517-531(U-Pb on Zrc) Ma has been obtained.

WILSON METAMORPHIC COMPLEX

Wg **l** GREENSCHIST FACIES METASEDIMENTS (Wg)
Metasandstone, slate, phyllite and metalimestone, often contact metamorphosed. Major metalimestone lenses (l) occur North of Mt. Baxter. The age is unknown, but a Precambrian to Cambrian age on literature data is inferred. Local name: Priestley Formation.

Wa **mb** AMPHIBOLITE FACIES METASEDIMENTS (Wa)
Fine-to medium-grained biotite schist and quartz-biotite paragneiss. Major marble and calc-silicate lenses (mb) occur in the E side of O'Kane Glacier and in the NW corner of Gerlache Inlet. Biotite cooling ages indicate that metamorphism is older than 480 Ma. Local name: Priestley Schist.

Wmg MIGMATITE GNEISS (Wmg)
Stromatic migmatite with minor agmatitic varieties, hornblende gneiss including some small and irregular amphibolite layers, and calc-silicate horizons alternating with fine-grained biotite gneiss. Biotite cooling ages around 475-480 Ma. Local name: Murchison Formation.

WILSON POLYMETAMORPHIC COMPLEX

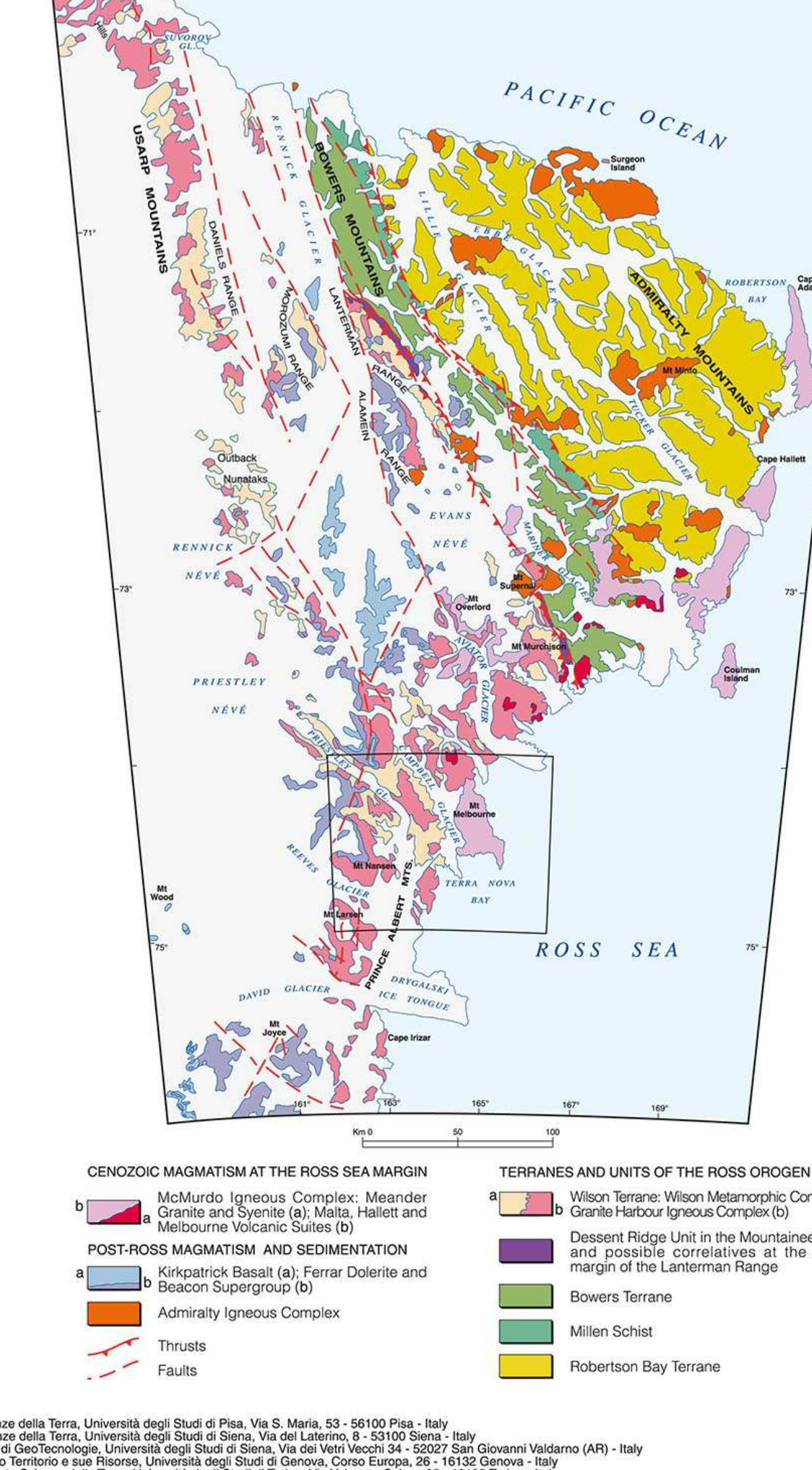
Wce CHARNOCKITE-ENDERBITE (Wce)
Medium-to coarse-grained massive rocks ranging in composition from diorite (enderbite) to tonalite (charno-enderbite) and locally preserving intrusive relations to metasedimentary granulite. On the basis of regional and structural data a Neoproterozoic age for the Wce is inferred.

Wgr METASEDIMENTARY GRANULITE (Wgr)
Orthopyroxene-garnet ± cordierite metasedimentary granulite hosting concordant meta-igneous "older" enderbite sheets decimeter to meter thick. For granulite-grade metamorphic events a Neoproterozoic age is inferred.

SYMBOLS

- Geological boundary.
- 26 a, b: Bedding, (a) inclined, (b) vertical.
- 30 a, b: Regional schistosity and cleavage, (a) inclined, (b) vertical.
- 30 a, b: Magmatic fluidality, (a) inclined, (b) vertical.
- 26 a, b: Mineral and stretching lineation, (a) plunging, (b) horizontal.
- 30 a, b: Fold axis, (a) plunging, (b) horizontal.
- 26: Crenulation fold axis.
- Thrust; teeth on overthrust side.
- Post Early Jurassic thrust
- Fault; ticks (on the downthrown side) or arrows where the sense of motion is known.
- Crater, sink-hole, caldera rim.
- Spatter and cinder cone.
- Active volcano (fumarolic activity).
- Fossil plants.
- Granulite relics
- Kyanite occurrence in quartz vein

TECTONIC SKETCH MAP OF NORTHERN VICTORIA LAND



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GIGAMAP
GERMAN-ITALIAN GEOLOGICAL ANTARCTIC MAP PROGRAM
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MOUNT MELBOURNE

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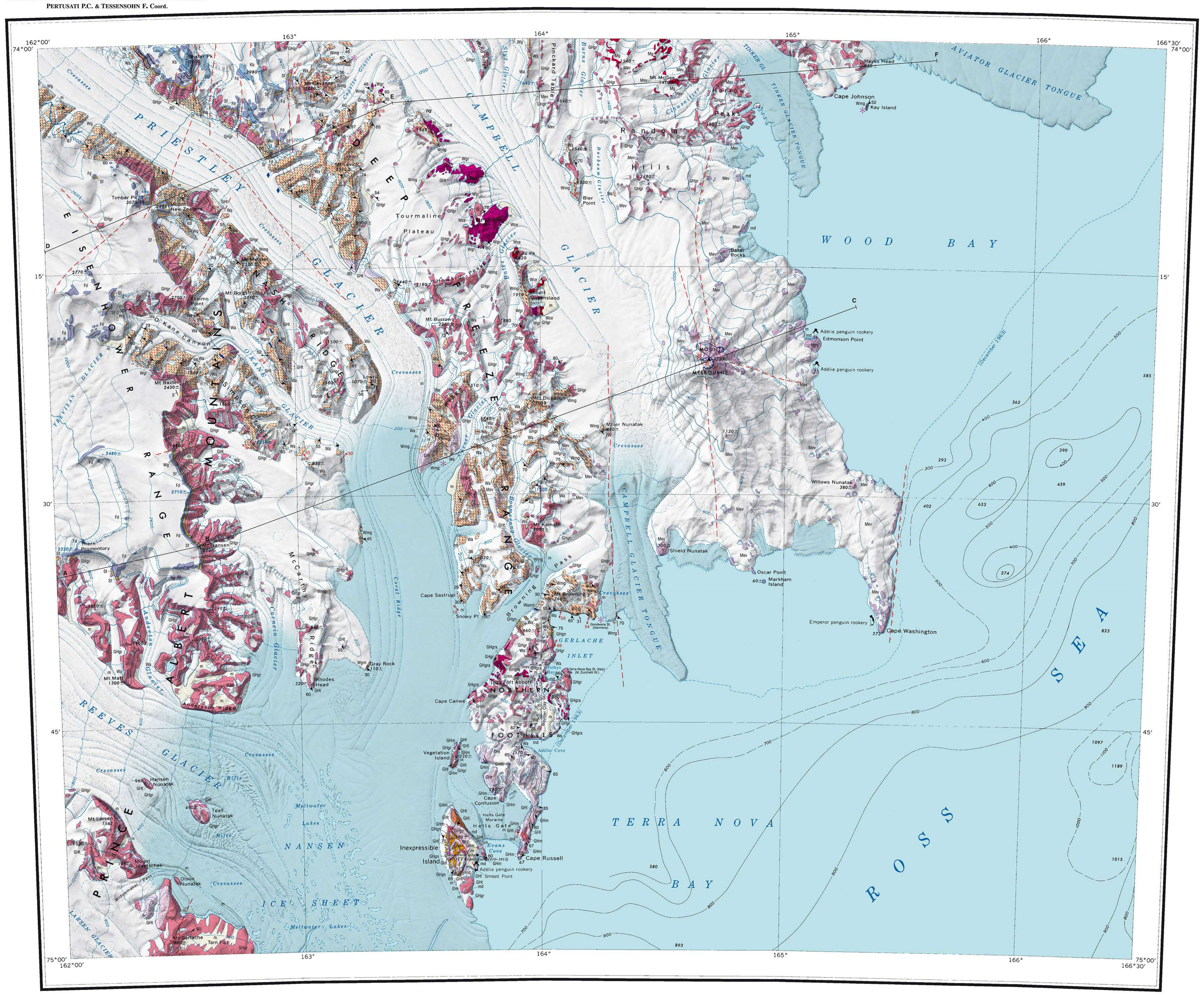

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SCALE 1:250,000

5 0 5 10 15 20 Statute Miles

5 0 5 10 15 20 25 30 Kilometres

Lambert Conformal Conic Projection - Standard Parallels 72°40' and 75° 20' - Contour Interval 200 Meters - Datum is mean sea level

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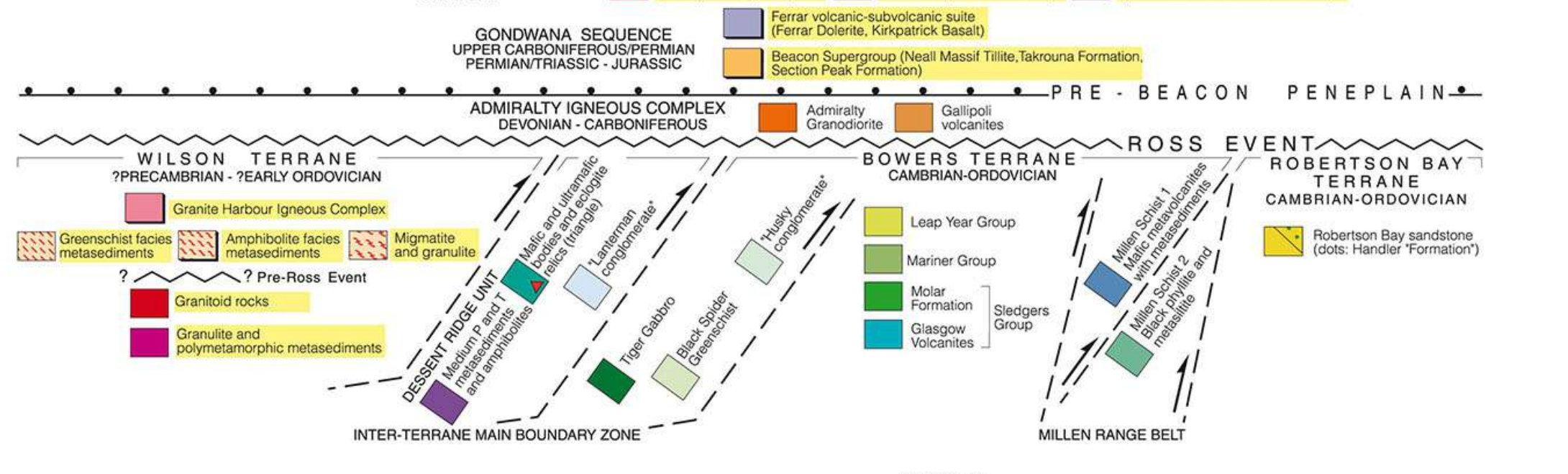
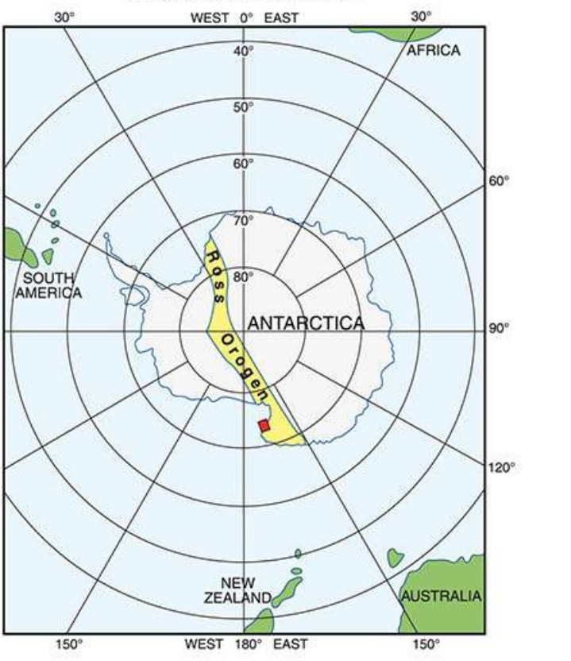
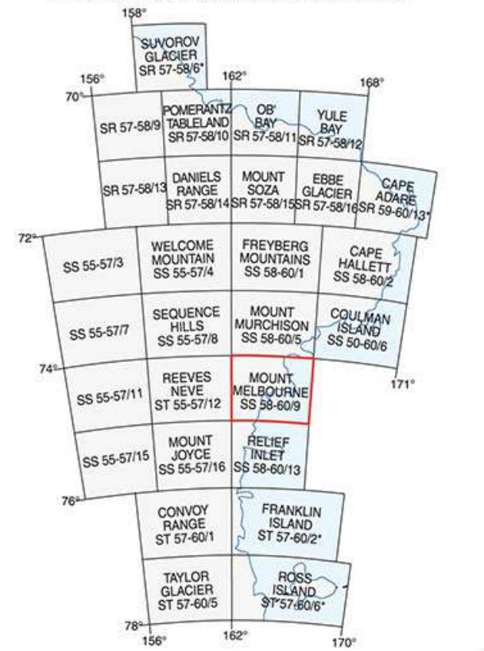
SYNOPTIC TABLE OF STRATIGRAPHIC AND TECTONIC RELATIONSHIPS IN NORTHERN VICTORIA LAND
Units occurring in the quadrangle are highlighted in yellow

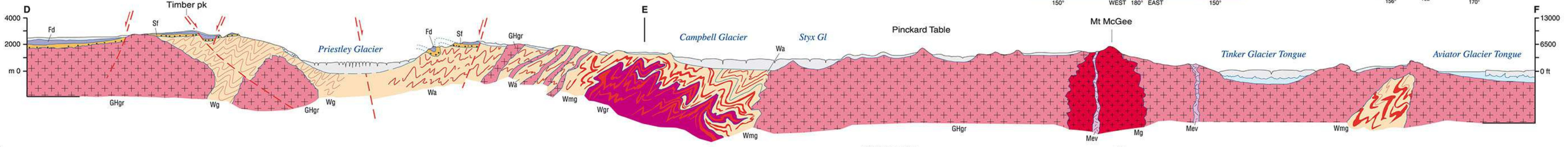

McMURDO IGNEOUS COMPLEX
CENOZOIC
Meander Intrusive Complex (alkali-gabbro, syenite)
Acidic, dominantly peralkaline volcanites (Malta volcanites)
Basic, dominantly alkaline volcanites (Melbourne and Hallett volcanites)
GONDWANA SEQUENCE
UPPER CARBONIFEROUS/PERMIAN
PERMIAN/TRIASSIC - JURASSIC
Ferrar volcanic-subvolcanic suite (Ferrar Dolerite, Kirkpatrick Basalt)
Beacon Supergroup (Neall Massif Tillite,Takrouna Formation, Section Peak Formation)
PRE - BEACON PENEPLAIN
ADMIRALTY IGNEOUS COMPLEX
DEVONIAN - CARBONIFEROUS
Admiralty Granodiorite
Gallipoli volcanites
ROSS EVENT
WILSON TERRANE
?PRECAMBRIAN - ?EARLY ORDOVICIAN
Granite Harbour Igneous Complex
Greenschist facies metasediments
Amphibolite facies metasediments
Migmatite and granulite
? Pre-Ross Event
Granitoid rocks
Granulite and polymetamorphic metasediments
DESSENT RIDGE UNIT
Medium P and metasediments and amphibolites
Mafic and ultramafic rocks and eclogite relics (Lanterman range)
"Lanterman conglomerate"
Tiger Gabbro
Black Spider Greenschist
"Husky conglomerate"
BOWERS TERRANE
CAMBRIAN-ORDOVICIAN
Leap Year Group
Mariner Group
Molar Formation
Glasgow Volcanites
Sledgers Group
Millen Schist 1 Mafic metavolcanites with metasediments
Millen Schist 2 Black phyllite and metasiltite
ROBERTSON BAY TERRANE
CAMBRIAN-ORDOVICIAN
Robertson Bay sandstone (dots: Handler "Formation")
INTER-TERRANE MAIN BOUNDARY ZONE
MILLEN RANGE BELT

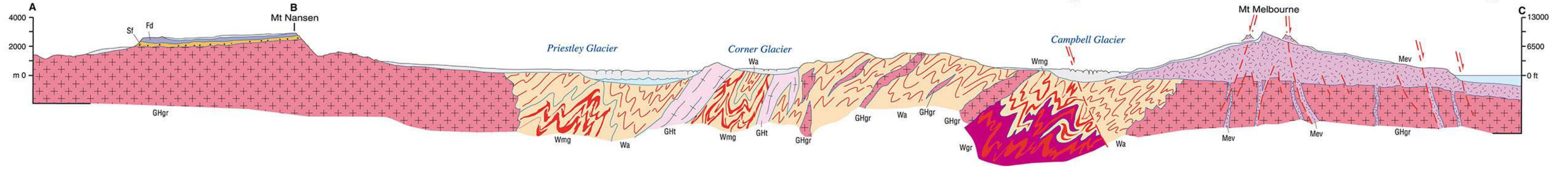
LOCATION DIAGRAM



INDEX TO ADJOINING SHEETS







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GEOLOGICAL OUTLINES

PREVIOUS WORK

James Clark Ross was the first to discover the Transantarctic Mountains, the Ross Sea, the Ross Ice Shelf, and landing a crew on Possesion Island to sample volcanic and granitic rocks. James Clark Ross also reached the southernmost volcanic Franklin Island (1840). In the 1900 the Borgkrevink's Second expedition, landed on Possesion Island, Coulman Island, Mount Melbourne, Franklin Island and Ross Island. The collected bed rocks were Tertiary volcanics. In the 1901 landing and sampling collections were made during Scott's First Expedition (Ferrar 1907). The first to visit the Mawson-Pristley region were David, Mawson (Geologists) and Mackay (Physician) of Shackleton's British Antarctic Expedition (1907-09). David's party on foot, manhauling their sledges from Cape Royds crossed the ice tongues of Mawson and David Glaciers, the Nansen Ice sheet, ascended through Backstair Passege to the Polar Plateau, finally reaching the South Magnetic Pole. During the journey they visited rock outcrops at Prior Island, Cape Irizar, Backstair Passage, Mount Crummer (David in Skackleton 1909), reporting on Mount Nansen, Eisenower Range, the presence of sediments now included in the Beacon Group (Gair 1964). Substantive geological work in northern Victoria Land was done by the Northern Party of Scott's Second Expedition (1910-13). Scott's Northern Party surveyed the area around Terra Nova Bay in 1912, before being forced to winter-over in a snow-cave on Inexpressible Island (Priestley, 1914, 1915; Smith & Priestley, 1921). In the 1960s several New Zealand field parties (Ricker, 1964; Gair, 1967; Nathan & Schulte, 1968; Skinner end Ricker 1968a, b; Adamson, 1971; Nathan, 1971) surveyed northern Victoria Land (NVL) and this quadrangle, establishing the overall framework of regional geology (see Gair et al., 1969, and Nathan & Skinner, 1972, for geological maps and discussion on earlier work). During the 1981-82 International NVL Project, New Zealand and USA geologists (Stump, 1986) investigated the field relations, petrology and geochemistry of the Paleozoic granitoids (Borg et al., 1986, 1987) and the Jurassic tholeiites (Elliot et al., 1986). During the 1982-83 season, NVL was visited by the GANOVEX III German expedition (Roland, 1984). Investigations focused on the geology and petrology of the metamorphic basement complex in the Mountaineer Range (Kleinschmidt et al., 1984), on regional patterns of metamorphism (Grew et al., 1984) and especially on the geology and tectonic implications of the newly discovered continuation of the Bowers Structural Zone (Adams & Kreuzer, 1984; Gibson et al., 1984; Tessensohn, 1984). The GANOVEX Team (1987) also produced a 1:500,000 geological map of NVL. In the 1984-85 season the aeromagnetic survey by GANOVEX IV covered part of NVL (Durbaum et al., 1989; Damaske et al., 1989); though the work focused on geophysical investigations, some geological activities were carried out (Roland et al., 1989) and resulted in a geological map of the area between Outback Nunataks and Reeves Gl. (Schubert & Olesch, 1989). Since the 1985-86 season Italian geologists investigated the region between David Gl. and Mariner Gl, and a 1:500,000 geological map of the same area (Carmignani et al., 1987) was produced. The German and Italian expeditions of the following years triggered the publication of a number of papers; contributions by Ghezzo et al. (1987), Lombardo et al. (1987), Brotzu et al. (1988), Armienti & Tripodo (1989), Biagini et al. (1989a, 1989b), Lanzafame & Villari (1989), Lombardo et al. (1989), Muller et al. (1989), Vita et al. (1989), Armienti et al. (1990), Fitzgerald and Gleadow (1990), Stackebrandt & Thiedig (1990), Talarico et al., (1992), Antonini et al. (1994), Castelli et al. (1994), Musumeci et al. (1994a, b), Palmieri et al. (1994), Rocchi et al. (1994), Salvini & Storti (1994), Tessensohn (1994), Vita-Scaillet et al. (1994), Henjes-Kunst & Kreuzer (1997), Ricci & Tessensohn (1997), Scambelluri et al. (1997), Tessensohn & Lombardo (1997), Musumeci & Pertusati (2000), Rocchi et al. (2004), Musumeci et al., (2006), Pertusati et al., (2006), Bomfleur et al., (2007), Bomparola et al. (2007), Giacomini et al. (2007), Schöner et al., (2007), Goodge & Fanning (2010), Bomfleur et al., (2011), Schöner et al., (2011), are related to this quadrangle.

SHORT DESCRIPTION OF GEOLOGY

The Mount Melbourne quadrangle encompasses an Early Paleozoic metamorphic and granitic basement, and a flat-lying cover spanning from Carboniferous - Permo-Trias to Quaternary times, with large stratigraphic gaps. The Early Paleozoic basement consists of the Wilson Terrane (WT), and includes low- to medium-high grade metamorphic rocks of Precambrian -?Cambrian age, intruded by large bodies of the Late Cambrian-Early Ordovician Granite Harbour Igneous Complex. The WT was deformed and subjected to metamorphism in the Early Paleozoic Ross Orogeny (Late Cambrian - Early Ordovician) with development of east-verging thrusts and folds developed under amphibolite- and greenschist facies conditions. After the Ross Orogeny the area was uplifted and eroded. After the Devonian Admiralty - Gallipoli magmatic event, the area was further uplifted and eroded. On the resulting peneplain surface, the deposition of a Carboniferous - Permian moraine of Gondwanian pertinence occurred (Neall Massif Tillite). Both the basement and the tillite were covered by the sedimentation of the Section Peak-Takrouna sandstone (Beacon Supergroup). These in turn were covered by large flows of the Jurassic Kirkpatrick Basalt. The coeval Jurassic Ferrar Dolerite formed sills chiefly along the basal Beacon horizon. The youngest event in the area was the emplacement of the Cenozoic McMurdo igneous complex, which consist of the older Meander intrusive suite and of the younger Melbourne alkali-volcanic suite.

LITHOSTRATIGRAPHY

WILSON TERRANE

The Wilson Terrane metamorphics include greenschist and amphibolite facies metasediments (the Wilson Monometamorphic Complex), and granulite facies metasedimentary and igneous rocks (the Wilson Polymetamorphic Complex)

Wilson Monometamorphic Complex

Greenschist facies metasediments (Wg) consist of low-grade metasandstone, slate, phyllite and metalimestone, often contact metamorphosed (Priestley Formation auct.), that crop out along the northwestern side of Priestley Gl., in the O'Kane Canyon area and in minor outcrops at the head of Styx Gl. on the northeastern side of Campbell Glacier. Major metalimestone lenses occur north of Mt. Baxter.

Amphibolite facies metasediments (Wa) are fine- to medium-grained biotite micaschist and quartz-biotite paragneiss (Priestley Schist auct.) exposed in the western side of the Deep Freeze Range, at Nash Ridge, Simpson Crags and Styx Glacier (east side of Campbell Glacier). Major marble and calc-silicate lenses occur along O'Kane Glacier and in the northwestern corner of Gerlache Inlet.

Migmatite gneisses (Wmg) consist of stromatic migmatite with minor agmatitic varieties, of hornblende gneiss including some small and irregular amphibolite layers (Borsi et al., 1995), and of calc-silicate horizons alternating with fine-grained biotite gneiss. Migmatite gneisses crop out at Mt Meister and Black Ridge along the Priestley Glacier and in the eastern side of the Deep Freeze Range from Gerlache inlet in the south to Mt Cavaney in the north. Small outcrops are at Bier Point and Kay Island in the NE part of the quadrangle.

The protoliths of all the metasediments seem to belong to a unique very thick sequence of fine - to medium-grained siliciclastic sediments with rare interlayered carbonate rocks of Precambrian-?Cambrian age that underwent metamorphic re-equilibration at different metamorphic grades during the Ross Orogeny (Carmignani et al., 1987; Lombardo et al., 1987; Casnedi & Pertusati, 1989; Skinner, 1989; Castelli et al., 1997). The thickness of the sequence cannot be evaluated accurately because of the complicated tectonic structure, but a minimum thickness (without taking into account the Priestley Schist) can be assumed to be more than 2000 m. The sedimentary evolution can be interpreted in terms of periferal foreland basin development and was probably connected with the Kanmantoo Basin of S Australia.

The paleontological record is scant and not totally reliable. The occurrence of palynomorphs comparable to Precambrian acritarchs (Ribecai, 1991) suggests a possible Precambrian age for the Priestley Formation; fragments of probably gasteropods and possibly echinoderms (Casnedi and Pertusati, 1991) suggest a lower Cambrian age. The age of Kanmantoo Group is constrained by 526±4 Ma U-Pb age data on zircon from a tuff near the top of the underlying Normanville Group and by the age of the oldest sinkynematic granites intruded in the Kanmantoo Group at 516 Ma. Post kynematic granite dykes gave an age of c. 510 Ma (Chen & Liu, 1996). These ages imply that the Kanmantoo Group was deposited very rapidly, probably in the Late Cambrian and in less than 10 million years (Flottman et al., 1998).

Detrital muscovites from the Priestley Formation of Foolsmate Gl. yelded total fusion ages of single flakes ranging from 500 Ma to 1,6 Ga with a pronounced clustering in the 560-620 Ma range. These ages constrain the lowest limit of deposition of the Priestley Formation in the area at 550-560 Ma (Calonaci et al., 2002) and suggest a more reliable Early Cambrian depositional age as previously hypothesized by Casnedi & Pertusati (1991).

Wilson Polymetamorphic Complex

The Wilson Polymetamorphic Complex includes both granulite facies rocks of igneous parentage (Charnockite-Enderbite) and metasedimentary granulites (Talarico & Castelli, 1995; Talarico et al., 1995).

Charnockite-Enderbite (Wce) are medium-to coarse grained massive rocks ranging in composition from diorite (enderbite) to tonalite (charno-enderbite) and locally preserving intrusive relations with respect to metasedimentary granulite. On the basis of regional, structural and thermo-barometric data a Neoproterozoic age for the Wce is inferred.

Metasedimentary Granulite (Wgr) is a sequence of orthopyroxene-garnet ± cordierite granulites hosting concordant sheets decimeter to meter thick of meta-igneous "older" enderbite. A Neoproterozoic age is inferred for granulite-grade igneous and metamorphic events.

The structural evolution of the Wilson Terrane was coupled with a high temperature/low pressure synkinematic metamorphism, which in the monometamorphic complex is prograde from greenschist facies (chlorite-biotite zone) in the Priestley Formation to amphibolite facies with development of migmatites (garnet - cordierite - K-feldspar zone) in the Priestley Schist. The prograde transition from andalusite to sillimanite-bearing assemblages defines an anticlockwise PT path and the occurrence of kyanite - quartz-bearing veins is consistent with a nearly isobaric retrograde evolution (Palmeri et al., 1994). According to Skinner and Estrada (2002) the growth of kyanite might be related to local overpressure conditions within fluid-filled quartz veins. In the Polymetamorphic Complex, mineral assemblages in the relict granulites (Talarico & Castelli 1995) give evidence of an early intermediate pressure metamorphism (7-8 kbar, 700° - 800°C) of Neoproterozoic age, overprinted by a low pressure/high temperature metamorphism, under amphibolite facies condition (5 kbar, 600°C) of Ross age. The estimated metamorphic conditions for the monometamorphic complex range from P <2.5 kbar and T = 300°- 450°C in the chlorite-biotite zone to P = 4.5 kbar and T = 700°-750°C in the garnet - cordierite - K-feldspar zone, with a corresponding geothermal gradient of 45°- 55°C/km (Talarico et al., 1992). Both the monometamorphic and polymetamorphic complexes are characterised also by development of migmatites in the highest-grade metamorphic rocks. The pattern of isograds and the distribution of metamorphic zones in the Deep Freeze Range are nearly parallel to the structural grain, with the metamorphic grade increasing across strike. To the west of Priestley Glacier in the Nash Ridge-Simpson Crags area metamorphic grade increases along and across strike with a dome-like arrangement of isograds characterised by medium- and high-grade metamorphic rocks contouring a zone of low grade rocks extending from Mt. New Zealand to the O'Kane Canyon (Talarico et al., 1992).

Granite Harbour Igneous Complex

The geological observations and reconnaissance mapping of North-Central Victoria Land by New Zealand parties, summarized by Gair et al.,1969 and Nathan & Skinner 1972, showed that three Batholiths crop out in this region: 1) the northern, dominantly granitic-granodioritic, Campbell-Aviator Batholith (Nathan 1971) between Campbell glacier and Mountaineer Range; 2) the central, strongly composite, Terranova Batholith comprising the plutonic suites exposed at Terra Nova Bay and in the Deep Freeze Range(Skinner 1972, 1983b,c).The composition of these plutons range from syenogranite to quartz-monzonite but mafic rocks (quartz-diorite and gabbro are locally abundant). Ultramafic Ol-Opx rocks occur in the mafic Boomerang pluton (Skinner 1972); 3) the much larger South Victoria Land Bathotlith cropping out between Priestley and David Glaciers and farther S well beyond the mapped area. In the Eisenhower Range and further S this batholith is characterized by the association of the foliated syn-tectonic Larsen granodiorite with post tectonic granite. The three batholiths represent a tipically calc-alkaline orogenic suite and the dominant rock type is metaluminous biotite granite and granodiorite. The three batholits are comparable in age and composition to the Cambrian - Ordovician Granite Harbour Intrusives of the Central Transantarctic Mountains (Gunn & Warren,1962), a typically calk-alkaline orogenic suite.

During the last twenty years petrographic and geochemical differences of regional significance have been described for these rocks in Victoria Land. Borg (1984), Borg et al. (1986), and Vetter & Tessensohn (1987) showed that these granitoids occur in two belts, an eastern and a western one, which trend NW-SE throughout the WT. The western belt is made up of S-type, peraluminous, two-mica and mainly K-feldspar porphyritic granite; coeval I-type hornblende granodiorite, diorite and tonalite form minor plutons and dykes. The eastern belt consists of I-type granodioritic to tonalitic intrusive rocks. Contrasting features are also in the isotopic signature of the two belts (Rocchi et al., 1994). The belts were interpreted as the magmatic signature of an active continental margin.

In the Mt Melbourne quadrangle magmatic intrusions and dyke networks belonging to the Granite Harbour Igneous Complex were emplaced within the mono and polymetamorphic complexes, The igneous rocks include a calc-alkaline (I-type) suite, (Ghezzo et al., 1987, Armienti et al., 1990), and a peraluminous (S-type) suite, this latter consisting of dykes and sills (Biagini et al., 1991). The metaluminous suite, ranging in composition from tonalite to granite with minor amounts of diorite and gabbrodiorite is the dominant association in this region. Its petrogenetic character ranges from high-K calc-alkaline to shoshonitic (Armienti et al., 1990). For this suite Rb/Sr and K/Ar mineral cooling ages (Borsi et al., 1989; Kreuzer et al., 1987) range from 487 Ma to 455 Ma. Their distribution reveals that the older ages (487 - 484 Ma) are restricted to shallow level intrusions in the Eisenhower Range (Mt. Baxter and Mt. New Zealand) while the deeper intrusions of the Deep Freeze Range have younger cooling ages (475 - 456 Ma) that are also closely comparable with the biotite Rb/Sr and K/Ar ages of metamorphic host rocks (Vita et al. 1991). Similarly, the peraluminous intrusions have Rb/Sr cooling ages of 481±10 Ma Armienti et al. 1990; Tonarini & Rocchi, 1994). The differences in cooling ages of both metamorphic and magmatic rocks from the Eisenhower and Deep Freeze Ranges have been attributed to diachronous post-metamorphic cooling probably linked to different uplift rates and/or block faulting (Armienti et al., 1990, Vita et al., 1991). Recent radiometric data (U/Pb on zircon) indicate that the emplacement sequence of the Granite Harbour Igneous Complex spanned nearly 30 Myr from 508 to 481 Ma (Bomparola et al., 2007).

Granite Harbour Leucogranite (GHl) consists of fine- to medium-grained muscovite-and biotite-bearing peraluminous leucogranite dykes and sills (Biagini et al., 1991). Large bodies crop out in the Northern Foothills and Inexpressible Island (Vegetation Unit; Rocchi et al. 2004) where a Rb-Sr muscovite-whole rock age of 475 ±5 Ma has been obtained (Di Vincenzo & Rocchi 1999). In the Deep Freeze range GHl are small sheets emplaced within medium- and high-grade Priestley Schist and/or intrusive rocks of the metaluminous suite. A Rb/Sr cooling age of 481±10 Ma has been reported by Armienti et al. (1990) and Tonarini & Rocchi (1994).

Granite Harbour Monzodiorite(GHm) consists of fine grained sills and dykes of mafic (monzodiorite) and intermediate (melamonzogranite) composition exposed in the Northern Foothills (Vegetation Unit; Rocchi et al., 2004).

Granite Harbour Granodiorite and Granite (GHgr) form the large intrusive massifs in the Deep Freeze Range - Prince Albert Mountains. Other large bodies crop out in the Random Hills and in the Northern Foothills (Mt. Abbott Unit; Rocchi et al., 2004). Ghgr range from fine-grained mostly equigranular granodiorite to coarse-grained inequigranular to strongly porphyritic monzogranite and syenogranite. For GHgr a Rb/Sr isochron of 508 ± 6 Ma obtained on the Mt. Abbott Granite (Northern Foothills) was reported by Armienti et al. (1990). Recently Rocchi et al. (2004) report an age of 495 ±4 Ma (U/Pb on zircon) that is regarded as the most reliable age of emplacement for this association.

Granite Harbour Tonalite, Diorite, Gabbro (GHt) consists of gabbro-tonalite-diorite-granodiorite suite. These rocks are often characterized by a SW dipping foliation, with magmatic to high temperature solid-state deformation features indicating a synkinematic emplacement (Musumeci & Pertusati 2000). The best exposures are at Nash Ridge, Simpson Crags and Boomerang Glacier. These rocks also crop out in the Northern Foothills (Confusion Unit; Rocchi et al., 2004) where tonalite rocks constitute a large intrusive body with minor occurrence of gabbroic rocks. For GHt an age range of 513-526 Ma has been reported by Rocchi et al. (2004) in the Northern Foothills.

Granite Harbour Gneiss (GHgn) consists of intensely deformed granite, tonalite and quartz-diorite with gneissic fabric conformably intruded in the Wilson Metamorphic Complex. This unit crops out in Inexpressible Island (Inexpressible Orthogneiss, Skinner, 1989) and the Gerlache Inlet (Gerlache orthogneiss). An age range of 517-531 Ma is regarded as a reliable emplacement age of the Inexpressible Orthogneiss (Rocchi et al., 2004).

BEACON SUPERGROUP

The base of the Beacon Supergroup is represented by a remarkable peneplain surface which is equivalent to, but younger than, the Kukri Peneplain as defined in the Dry Valleys (Barrett et al., 1986). Above this surface the clastic Beacon deposits unconformably rest on different lithotypes of the underlying basement. The Beacon Supergroup rocks occurring in this quadrangle is constituted by the Neall Massif Tillite and the Section Peak Formation (Collinson et al., 1986).

Neal Massif Tillite

These glacial and fluvio-glacial deposits (Nt), consist of massive or faintly bedded green sandy mudstone matrix-supported diamictite that rests on the Early Paleozoic basement and is covered by the Section Peak Formation. These rocks, whose thickness does not exceed 10-15 m, are only exposed in small outcrops in the western side of Shafer Peak (NW corner of quadrangle). For their stratigraphic position and lithological similarities with Neall Massif Tillite in the Freyberg Mountains quadrangle an Upper Carboniferous-Permian age is tentatively inferred.

Section Peak Formation

This clastic formation (Sf) forms a 30-50 m-thick sequence of arkosic sediments which lie above the peneplaned surface of the Early Paleozoic WT and is intruded by the Ferrar Dolerite. The Section Peak Formation crops out in the Eisenhower Range from Thern Promontory in the south to Timber Peak in the north, and at Shafer Peak north of Priestley Glacier. The finding of *Dicroidium odontopteroides* at the Vulcan Hills (Tessensohn & Mädler, 1987) confirms the already known Middle to Late Triassic age of this formation. However, in the Sequence Hills quadrangle, at Section Peak, the arenaceous sediments intruded by dolerite sills yelded a microflora assemblage suggesting an Early Jurassic age (Norris G,1965) In the same locality the Early Jurassic age is confirmed by Pertusati et al., 2006. These results reaffirm that the Section Peak Formation and consequently the Beacon Supergroup extend to Early Jurassic. Bomfleur et al., 2007, Bomfleur et al., 2011 and Schöner et al., 2011 confirm the Jurassic age of upper part of the Section Peak Formation. Moreover detrital zircon ages suggest that the deposition of the Section Peak Formation continued until the Early-Middle Jurassic (Goodge & Fanning 2010).

FERRAR VOLCANIC SUITE

Ferrar Dolerite

The Ferrar Dolerite (Fd) consists of tholeiitic dolerite sills and minor dykes, usually emplaced in the lower part of the sedimentary sequence of the Beacon Supergroup. Major outcrops are in the Eisenhower Range, from Thern Promontory in the south to Timber Peak in the north, and at Shafer Peak north of Priestley Glacier. In this locality the Ferrar dolerite is characterized by metre thick lenses of sandstone belonging to the Section Peak Formation, that are interlayered with the Ferrar Dolerite sills. A K/Ar age of 174±10 Ma has been reported for these rocks from the Mount Murchison quadrangle (Brotzu et al., 1989).

Kirkpatrick Basalt

In Mt Melbourne quadrangle, the Kirkpatrick Basalt (Kb) consists of metres to decametres thick subaerial lavas, randomly separated by thinner sedimentary volcanogenic interlayers and pillow lavas. These volcanic rocks crop out only north of Priestley Glacier in the Shafer Peak area. Beds and lenses of whitish marly siltstone, fine grained sandstone and minor black shale with flora relics mostly occur in the lower portion of the volcanic sequences.

K/Ar dates from the Mesa Range basalts (Mt. Murchison quadrangle) indicate 178 Ma as minimum age for the whole lava sequence (Elliot & Foland, 1986). A ^{40}Ar/ ^{39}Ar age of 174.2±1 Ma was obtained by McIntosh et al. (1986). At Shafer Peak, however, volcanoclastic strata attributed to Exposure Hill Formation (Elliot et al., 1986) include a 1 m-thick black shale unit which crops just below the basalt lavas. The shale bed implies a pause in volcanic activity and an interval of lacustrine sedimentation. Samples of the black shale yielded a rich and well-preserved microflora composed of spores and pollen characteristic of the Late Sinemurian-basal Pliensbachian APJ21 zone of Price (1997). This dating suggests that there was a significant time break of about 6 Ma between lacustrine deposition and basalt effusion (Musumeci et al., 2006). The same age (Lower Jurassic) for volcanoclastic and volcano-sedimentary sequence is reportet by Bomfleur et al., (2007), Schöner et al., (2007), Bomfleur et al., (2011), Schöner et al., (2011),

McMURDO IGNEOUS COMPLEX

This igneous complex comprises plutonic and volcanic rocks of alkaline affinity and bimodal composition. The plutonic rocks are the Meander Alkali-Granite and Syenite, the volcanic rocks are the Melbourne Alkali-Basanite to Trachyte/Rhyolite.The McMurdo igneous complex is associated to Cenozoic extensional tectonics related to the development of the Western Antarctic Rift system (Rocchi et al. 2002).

Meander Alkali-Granite and Syenite

These rocks (Mg) are dominantly monzonite-syenite with minor alkali-feldspar granite and gabbro. Several mafic dykes occur in the Random Hills area. An age around 38 Ma is attributed to the syenite and alkali granite; the dykes provided 32-38 Ma ages (Rocchi et al., 2002).

Melbourne Alkali-Basanite to Trachyte/Rhyolite

These rocks (Mev) are a variably differentiated alkaline volcanic suite forming scattered volcanic centres and a major composite strato-volcano (Mt Melbourne). The radiometric age of these rocks at the base of Cape Washington is 2.7 Ma; in the surrounding area it ranges from <2 Ma up to Present.

QUATERNARY DEPOSITS

Quaternary deposits, were grouped for mapping purposes, into: 1) Scree, glacial drift and moraine (m); 2) Marine deposits of pebble, gravel and sand (md); Holocene raised beach ridges are marked by dashed blue lines.

Quaternary deposits have been described in detail in specific papers (Baroni and Orombelli, 1989; 1991; Orombelli et al., 1990) and in geomorphological maps (Baroni et al, 2005a; 2005b).

Orombelli et al. (1990) differentiate two main Pleistocene drifts, informally named "Terra Nova Drift" or "younger drift" (corresponding to Terra Nova I drift in Baroni and Orombelli, 1989) and "older drift" (a complex glacial drift corresponding to Terra Nova II and III drifts in Baroni and Orombelli, 1989).

The "Terra Nova Drift" or "younger drift" is the most prominent of the drifts outcropping in the area. It consists of a massive, matrix-supported diamict, locally ice-cored. It is composed of generally very thin and discontinuous glacial (locally ice-contact) sediments, that can be observed on the lower part of the ice-free areas, up to elevations rising from the coast to the interior mountains (e.g. about 400 m on the Northern Foothills, 580 m at Mt. Keinath, 950 m at Black Ridge, at least 800 m at Andersson Ridge, 1400 m at Mt. Emison). Reworked marine fauna is widespread in the matrix at the Northern Foothills. Radiocarbon dates provide ages ranging from 25 to 23.5 ka BP that represent maximum ages for this deposit. Minimum dates from shells collected in marine sediments and penguin remains collected in ornithogenic soils further bracket the age of the Terra Nova Drift at ca 8 ka BP (Orombelli et al., 1990; Baroni and Orombelli, 1991, 1994; Baroni and Hall, 2004).

The "older drift" outcrops at elevations higher than the upper limit of the "younger drift". It consists of thin and discontinuous patches of strongly weathered glacial sediments, lacking constructional landforms. In places it occurs as scattered large boulders resting directly on bedrock or regolith. On the basis of cosmogenic surface exposure dating, this complex drift has been deposited by multiple Pleistocene glacial cycles, its age spanning the Early to Middle Pleistocene (Oberholzer et al., 2003) Holocene glacial deposits and well defined moraines are widespread near the margins of outlet glaciers, ice shelves, and small local glaciers. They generally consist of multiple subparallel ice-cored ridges or aligned hummocks documenting Holocene phases of glacial retreat and expansion (Baroni and Orombelli, 1994b).

Scree slope deposits are mainly to be found along the flanks of main glaciers, at the base of ice-free rocky slopes, where they merge into supraglacial debris and Holocene moraines.

Holocene raised beaches are carved from glacial drifts or rest directly on bedrock. They consist of berms of gravel and pebbles up to well-rounded blocks (e.g. Inexpressible Island, Adélie Cove, Tethys Bay near Mario Zucchelli Station and close to Campbell Glacier near Gondwana Station in the Terra Nova Bay area; Edmonson Point in Wood Bay). Fine-grained marine sediments containing *Laternula elliptica* and *Adamussium colbecki* are present at Evans Cove on Cape Russell peninsula and at Edmonson Point in Wood Bay. The age of raised beaches ranges from ca 8000 yrs BP to the present, based on radiocarbon dates of: 1) shells collected in situ in marine sediments, and 2) penguin remains collected in abandoned nesting sites and in relict colonies (Baroni and Orombelli, 1989; 1991; 1994; Orombelli et al., 1990; Baroni and Hall, 2004).

TECTONICS

ROSS TECTONICS

WILSON TERRANE

The distinctive structural lineaments of the Ross Orogeny in this region are NW-SE trending upright folds with well-developed axial planar cleavages and upthrusts, whereas large scale nappe structures are not observed. Structural evolution occurred through progressive deformation with two major D1 and D2 deformation phases (Carmignani et al., 1987; Casnedi & Pertusati 1989: Musumeci & Pertusati 2000). The D1 structures, deforming the sedimentary layering, are recognisable only in the lowest grade rocks, such as the Priestley Formation cropping out along the northwestern edge of the Priestley Glacier and at the head of the O'Kane Canyon. The D2 structures are well-developed in medium and high grade rocks of both the Priestley Schist and the Polymetamorphic Complex, whereas in low grade rocks they correspond to shear bands and crenulation cleavage zones. The main structural features can be summarised as follows: (1) NW-SE trending tight to isoclinal upright F1 and F2 folds gently overturned toward the NE. The fold axes plunge gently to moderately towards the NW or SE. (2) steeply dipping axial plane foliations, corresponding to a slaty cleavage (S1) in low grade metasediments (Priestley Formation) while S2 evolves from a crenulation cleavage to a well-developed schistosity in medium-high grade metamorphic rocks (Priestley Schist and Polymetamorphic Complex); (3) oblique to down-dip mineral- and stretching lineations. The former strike NW-SE and plunge gently to moderately toward NW or SE, the latter strike ENE-WSW and plunge moderately toward WSW; (4) NNW-SSE trending asymmetric F2 intrafoliar folds (centimetre to decimetre size) verging toward NE with axes plunging steeply toward NNW or SSE, (5) NNW-SSE and NW-SE trending ductile and ductile-brittle shear zones and/or fault zones dipping steeply to moderately toward the SW or NE, which are coeval or partly postdate the S2 schistosity. They are characterised by dextral strike-slip or oblique movement, the latter marked by NE or SW verging thrusting and associated dextral strike-slip. In the Deep Freeze Range most of the intrusive rocks are emplaced within tectonic structures (thrust faults, strike-slip shear zones) and show magmatic to solid-state foliated fabrics. These features are interpreted as evidence of synkinematic emplacement during the development of the D2 phase (Musumeci & Pertusati 2000). The resulting large scale structure of the Wilson Terrane in the Deep Freeze Range-Eisenhower Range consists of stacked folded units, bounded by strike-slip and/or reverse shear zones. U-Th-Pb ages on zicon and monazite and Ar/Ar ages on muscovite and biotite ranging between 450 - 410 Ma, give evidence that after the Ross orogeny, some ductile shear zones (Bier Point shear zone and Mt. Emison shear zone) have been reactivated in the Late Ordovician - Early Silurian (Di Vincenzo et al., 2007). Reactivation is interpreted as consequence of contractional tectonics associated to the Benambran Orogeny of the Late Ordovician-Late Devonian Lachlan Fold Belt of Australia.

POST - ROSS TECTONICS

The most striking and widespread feature related to the post-Ross tectonics is represented by the regional unconformity along the pre-Beacon peneplaned surface. This surface is the only record which testifies the renewal of post-Admiralty uplift and erosion of the Ross Orogen. The Mesozoic tectonic evolution was characterized by continental transcurrent faulting, which accommodated the transtensional movements between two symmetric areas of spreading, i.e. the SE Indian Ridge and the mid-Pacific (Tessensohn, 1994). This led to the development of normal fault systems and basins, the latter interpreted as pull-apart structures (Tessensohn, 1994). The Rennick Graben (Mt Murchison quadrangle and Freyberg Mts quadrangle) represents the best example of a pull-apart basin linked to Mesozoic transtension. Normal faulting, with vertical throws up to 600 m at the head of Campbell Gl. (Roland & Tessensohn, 1987), is the most prominent feature of Mesozoic tectonics. However, compressive structures consisting of southwest-verging folds and thrusts affect the Beacon sandstones in this quadrangle. South of the Shafer Peak-Mt Cavaney area, the Paleozoic basement and the Section Peak Formation are deformed by a NW-SE striking anticline and syncline gently overturned toward the southwest (cross section D,E,F). Moreover, NW of Timber Peak, the basement rocks and the sills of Ferrar Dolerite are thrust southwestward. Although no geometric relationship was observed in the field between the compressive and extensional structures, Tessensohn (1994) proposed that the compressive structures are linked to the strike-slip motions active during the development of the pull-apart basins.

A more recent extensional tectonics of Cenozoic age, associated to the emplacement of the McMurdo Igneous Complex and to spreading of the Ross Sea, is represented by N-S- trending normal faults exposed along the west side of Campbell Glacier and the Ross Sea coast (Cape Washington). The large apparatus of Mt Melbourne strato-volcano and other minor volcanic centres lie along two main NS trending normal faults (Gubellini & Postpischl, 1991).

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