*Geogr. Fis. Dinam. Quat.*
*20 (1997), 219-223, 4 figg., 1 c.*

ALESSANDRO BIASINI (*), PAOLO OSSO (**) & MARIA CRISTINA SALVATORE (**)

# GEOMORPHOLOGICAL SKETCH MAP OF THE MOUNT DICKASON AREA (VICTORIA LAND, ANTARCTICA) MAPPED BY AERIAL PHOTOGRAPHS

ABSTRACT: BIASINI A., OSSO P. & SALVATORE M.C., *Geomorphological sketch map of the Mount Dickason area (Victoria Land, Antarctica) mapped by aerial photographs*. (IT ISSN 0391-9838, 1997).

This short note illustrates the results of some investigations carried out using aerial photographs and satellite images and aimed at the compilation of thematic maps at different scales of Victoria Land (Antarctica). In particular, a geomorphological map at a scale of 1:50,000 of a 900 km$^2$ area including Mount Dickason has been drawn. The map, in this article at a scale of 1:80,000 and simplified, was produced in the framework of a cartographic project of the National Program for Antarctic Research, aimed at the compilation of a 1:250,000 geomorphological map series of Victoria Land.

KEY WORDS: Geomorphological Mapping, Photogeology, Mount Dickason, Victoria Land, Antarctica.

RIASSUNTO: BIASINI A., OSSO P. & SALVATORE M.C., *Schizzo geomorfologico dell'area del Mount Dickason (Terra Vittoria, Antartide) da fotografie aeree*. (IT ISSN 0391-9838, 1997).

In questa nota breve sono illustrati i risultati di alcune indagini svolte attraverso l'impiego di fotografie aeree e subordinatamente immagini da satellite, finalizzate alla realizzazione di cartografia tematica della Terra Vittoria del Nord (Antartide). In particolare si tratta di una carta geomorfologica in scala 1:50.000 di un'area estesa per circa 900 km$^2$ in prossimità della base italiana di Baia Terra Nova e comprendente l'area del Mount Dickason. L'elaborato realizzato, qui mostrato in forma semplificata alla scala circa 1:80.000, rientra nell'ambito di un progetto di cartografia del Programma Nazionale di Ricerche in Antartide finalizzato alla realizzazione di una collana di carte geomorfologiche della Terra Vittoria in scala 1:250.000.

TERMINI CHIAVE: Cartografia Geomorfologica, Fotogeologia, Mount Dickason, Terra Vittoria, Antartide.

(*) *Dipartimento di Scienze della Terra, Università degli Studi di Roma «La Sapienza», p.le A. Moro 5 - 00185 Roma.*
(**) *U.O. Gla 23 del Pnra, c/o Dipartimento di Scienze della Terra, Università degli Studi di Roma «La Sapienza», p.le A. Moro 5 - 00185 Roma.*
*This work was carried out in the framework of the Italian Programme for Antarctic Research, core project «Glaciology and Paleoclimate», Enea/University of Milano, 1993.*

## FOREWORD

A useful starting point for the elaboration and production of cartographic maps in the Terra Nova Bay area (North Victoria Land) is the analysis of relief and glaciers. In this regard the research group of Pnra, which works at the Dipartimento di Scienze della Terra at the University of Rome «La Sapienza» has undertaken, for a good number of years, studies and research in the production of geomorphological cartography. This work, both in synthesis as well as in detail, has been dedicated to mapping an area of approximately 30,000 km$^2$ of Victoria Land and the creation of a data base run on Gis.

In this article the preliminary results of analysis, through aerial photographic data, are presented and have given rise to a geomorphological map at a 1:50,000 scale (Biasini & *alii*, 1996). The map in question is part of a cartography project undertaken by Pnra to create a series of geomorphological maps of North Victoria Land at a scale of 1:250,000 (Biasini & *alii* 1992, 1994; Baroni & *alii* 1995; Salvatore, 1995).

The investigated area (fig. 1) is situated in the region of the Bay of Terra Nova and is the centre south sector of the Deep Freeze Range, a large mountainous area between the valley of the glaciers Priestley and Campbell. This area extends approximately 900 km$^2$ between latitudes 74° 16' and 74° 38' S (a little to the North of Mount Dickason as far as Browning Pass to the South) and is bordered by the outlet glaciers Campbell to the East and Priestley to the West.

Throughout the area there is a morphology with numerous cirques, ridges and horns; the smaller glaciers drain into the Priestley and Campbell glaciers.

In the territory of the Bay of Terra Nova glacier deposits of different ages have been distinguished (Denton &

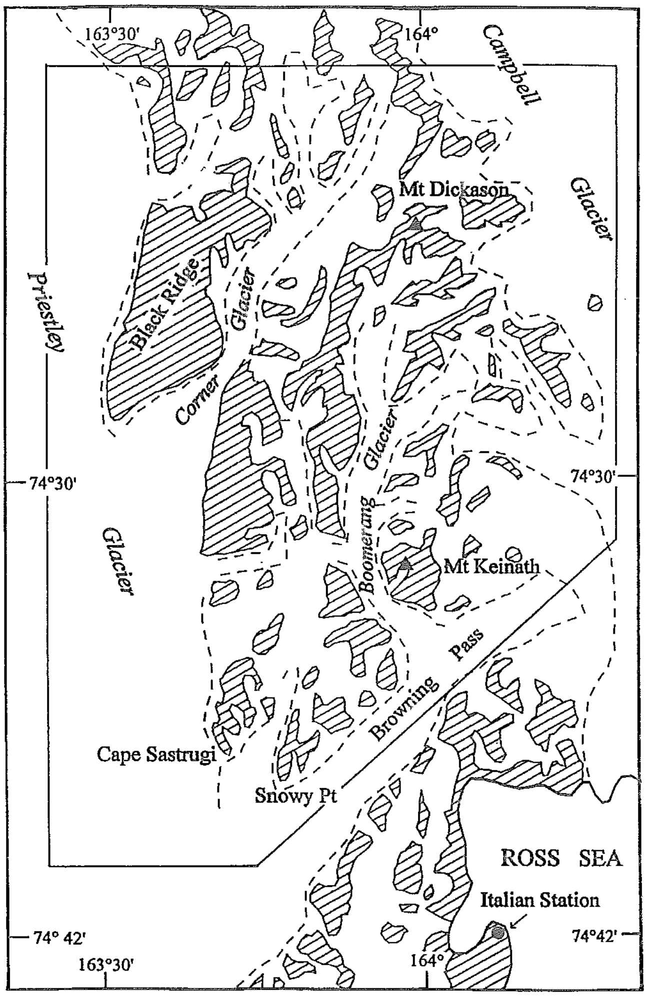


FIG. 1 - The investigated area and the Italian Terra Nova Bay Station: the ice-free areas are hatched and the boundary of main glaciers are evidenced with dashed lines.

Huges, 1981). The best conserved and most widespread is the Terra Nova drift (Orombelli & *alii*, 1991) corresponding to the «younger drift» of Stuiver & *alii* (1981) and the Terra Nova I drift of Orombelli (1986). It was probably left by thickened outlet and local glaciers flowing into a marine based ice sheet. It has been attributed to the Late Wisconsin and correlated with the Ross Sea Ice Drift.

Older glacial sediments and scattered erratics are to be found at a higher elevation and can be referred to at least two older glaciations (Orombelli, 1991), indicated as Older Drift.

In the studied area, the Terra Nova drift is present throughout the Black Ridge area and its upper boundary is represented by a moraine ridge, at about 850 m altitude. The Terra Nova drift also occurs on the southern slope of Mount Keinath (1090 m) up to an altitude of 580 m, where it is in contact with the Older Drift (Orombelli & *alii*, 1991), also present at Black Ridge.

## METHODOLOGY

Investigations were carried out mostly through the study and interpretation of B/W panchromatic aerial photographs taken by the US Navy during the fifties and sixties. The photographic coverage, called Trimetrogon Antarctica (Tma), was done using a Trimetrogon system, which allows the attainment of one vertical and two lateral high oblique photographs along one flight line.

Stereoscopic coverage is incomplete and only part of the territory is visible through vertical photos. Other areas can be observed only on oblique photographs. Although these wide-angle views of the land are suitable for lithological and structural analysis, they do not permit analysis of details and background objects. The vertical aerial photographs, at a scale changing from 1:30,000 to 1:50,000, have a ground resolution of about 1 m and generally an overlap of 50% instead of the usual 60%. In some cases, because of the considerable difference in altitude within one strip, it is possible that a part of the area is not covered stereoscopically. The stereopairs analysis was carried out using a 3-15x zoom stereo viewer.

Existing maps of the area are the chorographic ones at a scale of 1:250,000 (U.S. Geological Survey, 1968), the geological maps at a 1:500,000 scale of the area between the David and Mariner Glaciers (Carmignani & *alii*, 1988) and of Northern Victoria Land (Ganovex Team, 1987) and finally the geological map at a 1:100,000 scale of the Mount Dickason and Mount Levick areas (Giudice & *alii*, 1991).

Transferring data onto the 1:250,000 chorographic map would have caused a considerable loss of information and, at the same time, very low precision in locating the elements to be represented. Photomosaics can be used as a temporary solution to the absence of topographic maps but it is important to bear in mind that the vertical Tma aerial photographs do not cover all the area investigated. Because of the absence of suitable topographic maps on which to transfer the photointerpretated data, a Landsat Thematic Mapper image, geometrically corrected and georeferenced at the laboratories of the Enea by M. Frezzotti, was used as a basic map at a scale of 1:50,000. Using this cartographic base map, already tested in other situations (Biasini & Salvatore, 1993; Biasini & *alii*, 1992, 1994), it was possible to produce the geomorphological map of the Mount Dickason area at a scale of 1:50,000.

The first step in producing the map was to analyze the geometrical features of the topographic surface (particularly the shapes of the ridges and slopes), to represent them by appropriate symbols and to compile a morphographic map first at a scale of 1:125,000 and then at a scale of 1:50,000 of the Mount Dickason area.

The interpretation of morphology follows that of morphography and it produced a map at a scale of 1:50,000. Glacial, periglacial, aeolian and gravitational landforms and deposits are represented on this map. Glacier features and hydrography are also shown. The map included in this paper (in pocket) is reduced to an approximate scale of 1:80.000 and the features are mapped in black and white and in a simplified and generalized fashion.

The resulting cartography was digitized (stored in vector files) by means of a Gis, with the aim of guaranteeing a structure of the data organized in levels. The structure of these data allows rapid revision and integration also through a relational type data base, as well as the output of geomorphological cartography (including ornated lines) by using a plotter or printer.

Computerized data offers a number of advantages among which the main one is to support the creation of cartographic maps with a data base for further studies and analysis. The different levels mentioned above permit the separate analysis of each level in order to obtain, for example, monothematic maps. This information could be easily placed on a network for exchange between researchers.

## GEOLOGICAL SETTING

The Southern region of the Deep Freeze Range is characterized by a series of septa of different grade metamorphites oriented towards NW-SE, which developed during the Ross Orogeny. These septa could be interpreted as a pattern of regional scale asymmetric antiforms and synforms as proposed by Carmignani & *alii* (1989), or as a series of structural blocks related to one another through a system of steeply dipping major tectonic surfaces (Giudice & *alii*, 1991). In the Late Ceinozoic regional brittle tectonics produced two main sets of regional faults with E-W to NW-SE and N-S orientations. The latter seems to influence the alignments of recent large volcanic centres and also explain the abrupt deviations of some outlet glaciers (Giudice & *alii*, 1991).

It is possible to distinguish three geological masses in the area examined. These are the metamorphic mass present in the Wilson Terrane, the Paleozoic Intrusive mass here represented by the Granite Harbour Intrusives and the Post Orogenic mass represented by the McMurdo Volcanics and moraines (Carmignani & *alii* 1989). These represent three different phases in the area of Victoria Land during which the crystalline base of metamorphites was formed (Metamorphic Complex) inserted in a Cambro-Ordovician mass of granitic rocks (Intrusive Paleozoic Complex). The North Victoria Land between the Permian and the Jurassic periods became a vast area of sedimentation followed by extensive tectonic activity during the Cretacic period, which continues to the present day.

The relief of the Mount Dickason area largely consists of rocks of Wilson Terrane and subordinately of the Intrusive Paleozoic Complex. Small outcrops of McMurdo volcanics (Post Orogenic Complex) are present in the South East region of the area in the vicinity of the Campbell Glacier and Browning Pass.

The metamorphic rocks of the area (Wilson Terrane) can be divided into three types: a gneiss-migmatic sequence (Precambrian), a metasedimentary sequence in an amphibolitic facies called Priestley Schist and a metasedimentary low grade sequence called Priestley Formation (?Precambrian).The latter dominates the area in question, together with small outcrops of Priestley Schists, which in turn predominate the Western area of Black Ridge and the area of Cape Sastrugi. The relief of Mount Dickason are characterized by the presence of high grade metamorphites which are also common on many of the slopes oriented to the East which face the Campbell Glacier.

The large outcrop of the Intrusive Paleozoic Complex is represented by vast batolites of Mount Keinath. Other similar outcrops are found along the course of Corner Glacier: these are in mainly mineral and tonalite, syenogranite, monzogranite and granodiorite.

## GEOMORPHOLOGICAL FEATURES

The relief forms next to Mount Dickason, which are the highest in the area, have a typical alpine morphology characterized by cirques, horns and arêtes. Glacial flows from this relief towards the Campbell Glacier overcome morphological steps forming seracs which downstream often create wave ogives.

To the South of Mount Dickason, on the right hydrographic side of Campbell Glacier, remodelled cirques partially reoccupied by ice are present. These could have been caused by the development of the Mount Melbourne volcano which obstructed the final part of the Campbell Glacier in the valley which, like a dammed river, «overflowed» into the surrounding relief (Baroni & Orombelli, 1989).

The Boomerang Glacier which originates in the Southern slopes of Mount Dickason occupies the central sector of the area examined. It develops from North to South for about 15 km before merging into the glacier of Browning Pass (fig. 2).

Lateral and median supraglacial moraines are present along the whole course of the glacier, in particular in the vicinity of the right hydrographic side, where blue ice areas are present. There is supraglacial debris, on which there

FIG. 2 - Boomerang Glacier at the confluence with the Browning Pass and on the right Mount Keinath. Along the slopes avalanche tracks and cones are visible as well as temporary unfrozen lakes (Jan 1994) on the surface of the glacier. This aerial view is to the northwest.

are lakes and cones with an ice core, at the foot of a metamorphic outcrop in proximity to the convergence of a glacier which flows into Boomerang Glacier.

The relief developed between the Boomerang and Corner glaciers shows the influence of the geology of this area. In fact, ridges and valleys are in succession subparallel with a N-S trend, relative to the regional one (Giudice & *alii*, 1991; Carmignani & *alii*, 1989). On the sides modelled by glacial erosion, avalanche tracks and cones are frequently found. On the debris covering there are gelifluction terraces and periglacial polygons.

The batolite of Mount Keinath (1090 m) forms the south-east sector of the area examined. Like most relief below an altitude of 1100 m, its peak is rounded and flattened. The presence of evident forms of granite alterations presumes that they were formed in an old glacial expansion and were then no longer touched by ice (Baroni & Orombelli, 1989). On the southern slope of this relief, next to the convergence of the Boomerang Glacier with Browning Pass «*a widespread cover of Terra Nova drift .... in sharp contact with the older drift*» is present (Orombelli & *alii*, 1991). However this contact is not visible in the aerial photographs. A series of asymmetric crests to the North East of Mount Keinath divides Boomerang Glacier from Campbell Glacier. The outcrops are not so frequent here: snow covered glaciers and snowfields, aeolic landforms and deposits such as windscoop and snowdrift, which indicate NW-SE wind directions, are typical surface features.

Black Ridge (fig. 3) is a large snow free spur of a largely triangular shape which separates the valley of the Priestley Glacier from that of Corner Glacier. The Western side which borders the Priestley Glacier seems to be a slope of glacial erosion 8 km long. On this side, as well as that facing the South East, bordering the Corner Glacier, avalanche tracks, at the end of which cones are found, are present on granite as well as metamorphic rocks. At the foot of both slopes supraglacial debris, on which dirt cones and boulders are found, are present. Frozen lakes are present

FIG. 3 - Southern slope of Black Ridge (background) and ice-core cones on the left moraine of Corner Glacier seen from south. The central cone is about 15 m high (Jan 1994).

FIG. 4 - Avalanche tracks and cones along the slope near the supraglacial lateral morain of the Corner Glacier. Mount Melbourne is in the background (Nov. 1994).

both on the supraglacial debris as well as between that and the slope; supraglacial frozen lakes are often found on the surface of the main glaciers.

The relief of Black Ridge towards the North is cut across by a dry valley, informally called «Wind Valley» because of the frequency and intensity of the katabatic winds which blow there. This is oriented roughly NW-SE: the Northern most part of the valley is suspended on the Priestley Glacier whilst the Southern part finishes in correspondence with the Corner Glacier. Inside this valley when the Corner Glacier flows into the Priestley Glacier it deposits a moraine attributed to the Terra Nova drift (BARONI & OROMBELLI, 1989). This moraine rests directly on the more weathered sediments of the Older drift (Orombelli & *alii*, 1991). The landscape around the dry valley is scattered with small depressions and glacial cirques. The whole area is characterized by detrital covering and glacial deposits moulded into gelifluction terraces. There are also frequent periglacial polygons with an average dimension of 20 m (Bondesan & *alii*, in press).

Towards East there is the Corner Glacier: its sources are on the relief of Mount Dickason and towards the East of Mount Burrows (about 15 km to the NW of Mt. Dickason, outside the map) as well as small glaciers that flow from the relief adjacent to the valley. The latter are mostly present on the slope of the hydrographic left and often give rise to seracs. The Corner Glacier flows for approximately 20 km in a valley strongly influenced by tectonics. In fact, the glacier flows in a straight line for 15 km in a NE-SW direction. However, in correspondence to the rocky spur of Black Ridge, some authors hypothesize that, due to the continuation of the Priestley fault (Skinner, 1989), the glacier deviates sharply to the South for 1 km and then returns to the original direction. Towards the end of the glacier the Corner valley widens. The surface of the glacier presents forms similar to wave ogives originating at the foot of a spectacular ice fall besides frequent and wide supraglacial lakes. In correspondence to the confluence with the Priestley Glacier, in the blue ice area, supraglacial medial moraines made up of boulders and blocks are present and there are also pressure ridges and crevasses.

The characterizing element of this glacier is the extensive supraglacial left lateral moraine. This is situated at the foot of a slope largely formed of metamorphic rocks and subordinately of granitic rocks. A considerable amount of detrital material of largish size and avalanche tracks are present along the slope made up of metamorphic rocks (fig. 4). The left supraglacial moraine extends for 3 $km^2$ and creates a hummocky morphology and numerous large ice-core cones (up to 15 m high). These are intersperted by many circular tarns which appear partially melted in the hot season. Other elongated lakes are also present between the slope and the moraine.

## REFERENCES


BARONI C. & OROMBELLI G. (1989) - *Glacial geology and geomorphology of Terra Nova Bay (Victoria Land, Antarctica).* Mem. Soc. Geol. It., 33 (1987), 171-193.

BARONI C., BIASINI A., BONDESAN A., DENTON G., FREZZOTTI M., MENEGHEL M., OROMBELLI G. & SALVATORE M.C. (1995) - *Geomorphology of the region covered on the «Mount Melbourne» topographic map (1:250,000), Victoria Land, Antarctica.* VII International Symposium on Antarctic Earth Sciences - Abstracts, Siena, 10 - 15 Settembre 1995, 24.

BIASINI A., FANUCCI O. & SALVATORE M.C. (1992) - *Geomorphology of the Priestley Glacier to Campbell Glacier transect mapped by aerial photographs (Victoria Land, Antarctica).* In: Yoshida Y., Kaminuma K., Shiraishi K. (eds): *Recent progress in Antarctica Earth Science.* Terrapub, Tokio, 721-726.

BIASINI A. & SALVATORE M.C. (1993) - *Impiego di immagini telerilevate nella geomorfologia antartica.* Ambiente Antartide, 5, 24-29.

BIASINI A., BISCI C., CAPUTO C., DRAMIS F., PUGLIESE F. & SALVATORE M.C. (1994) - *An approach to the geomorphology of Victoria Land, Antarctica.* Atti del VI Convegno Nazionale Associazione Italiana Telerilevamento, Roma 1-4 Marzo 1994, 235-238, 3 ff.

BIASINI A., OSSO P. & SALVATORE M.C. (1996) - *Morphology of the Mount Dickason Area (Victoria Land, Antarctica) mapped by aerial photographs and satellite images.* Congresso Nazionale di Glaciologia Antartica, Padova 11-12 Giugno 1996, «Materiali» Dipartimento di Geografia n° 19/1996, Università di Padova, 47 pp .

BONDESAN A., MENEGHEL M., SALVATORE M.C. & STENNI B. (in press) - *Periglacial polygons in the Terra Nova Bay Area (Victoria Land, Antarctica).* Atti del VII International Symposium on Antarctic Earth Sciences, Siena 10 - 15 Settembre 1995.

CARMIGNANI L., GHEZZO C., GOSSO G., LOMBARDO B., MECCHERI M., MONTRASIO A., PERTUSATI P.C., & SALVINI F. (1988) - *Geological map of the Area between David and Mariner Glaciers (Victoria Land - Antarctica).* Mem. Soc. Geol. It., 33 (1987).

CARMIGNANI L., GHEZZO C., GOSSO G., LOMBARDO B., MECCHERI M., MONTRASIO A., PERTUSATI P.C., & SALVINI F. (1989) - *Geology of the Wilson Terrane in the area between David and Mariner Glaciers, Victoria Land (Antarctica).* Mem. Soc. Geol. It., 33 (1987), 77-98.

DENTON H.G.& HUGES T..J. (1981) - *The last great ice sheets.* Wiley. New York, 484 pp.

GANOVEX TEAM (1987) - *Geological map of the North Victoria Land, Antarctica (1:500.000). Explanatory notes.* Geol. Jb., B 66, 7-79.

GIUDICE A., MAZZARINI F., SALVINI F. & STORTI F. (1991) - *Geology of the Mount Melbourne area, North Victoria Land, Antarctica: evidence from photointerpretative analysis.* Mem. Soc. Geol. It., 46 (1989), 505-514.

OROMBELLI G. (1986) - *La prima spedizione del Programma Nazionale di Ricerche in Antartide. Osservazioni geomorfologiche* Riv. Geogr. It., 93, 129-169.

OROMBELLI G. (1991). - *Glaciers and glacial morphology at Terra Nova Bay: an opportunity for significant studies on environmental and climatic global changes.* Mem. Soc. Geol. It., 46, 9-16.

OROMBELLI G., BARONI C. & DENTON G.H. (1991) - *The Late Cenozoic glacial history of the Terra Nova Bay Region, Northern Victoria Land, Antarctica.* Geogr. Fis. Dinam. Quat., 13 (2), 139-163.

SALVATORE M.C. (1995) - *Geomorphological map of the area between Mount Emison and Mills Peak mapped by aerial photographs (Victoria Land, Antarctica).* VII International Symposium on Antarctic Earth Sciences - Abstracts, Siena, 10 - 15 Settembre 1995, 332.

SKINNER D.N.B. (1989) - *Terra Nova Bay and Deep Freeze Range, The South Allochtonus border of North Victoria Land, Antarctica.* Mem. Soc. Geol. It., 33 (1987), 41-58.

STUIVER M., DENTON H.G., HUGHES T.J. & FASTOOK J.L. (1981) - *History of the marine ice sheet in West Anractica during the last glaciation: a working hypotesis.* In: Denton G.H. & Hughes T.J. (eds.), *The last great ice sheets.* Wiley, New York, 484 pp.

UNITED STATES GEOLOGICAL SURVEY (1968) - *Mount Melbourne.* 1:250.000 Reconnaissance Series. SS 58 - 60/9, Washington D.C.