A GLACIO-GEOLICAL RECONNAISSANCE OF THE SOUTHERN PRINCE
ALBERT MOUNTAINS, VICTORIA LAND, ANTARCTICA

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Abstract: In the Southern Prince Albert Mountains three levels of glacial erosion and/or deposition are recognized: summit plateaux, terraces at 100–400 m below the summit plateaux and ice-cored moraines just above the present ice surface. Microfossil-bearing Sirius Formation till of wholly volcanic provenance mantles the summit plateau of Mt. Billing (1600 m). Similar till occurs on summit plateaux at Griffin Nunatak (2200 m), and at Ricker Hills (1650 m). The Sirius Formation is absent from younger and lower glacially-cut terraces. Tills on these terraces and younger ice-cored moraines contain both basement and Beacon Supergroup erratics. Reworked microfossils show the Sirius Formation at Mt. Billing to be no older than 2.5–3.0 Ma. The degree of weathering of the summit plateau tills shows them to be older than all other glacial events or deposits. Valley incision, at least in part a consequence of Late Cenozoic uplift, postdates deposition of the Sirius Formation at Mt. Billing and the similar tills mantling the summit plateaux.

Key words: glacial history, Sirius Formation, Cenozoic uplift, valley incision, ice-cored moraine

Introduction

During the sixth German Antarctic North Victoria Land Expedition 1990/1991 (GANOVEX VI), we carried out a glacio-geological reconnaissance of the Southern Prince Albert Mountains. It was a first step towards reconstructing the glacial history of the area, and to find evidence of the relationship between Cenozoic mountain uplift and this glacial history.

The area consists of a large number of nunataks which rise stepwise to the southwest from an altitude of 800 m near the

Fig. 1. Location map of research area. In black: nunataks, stippled: ice-cored moraines. (Partly based on Carmignani et al., 1988).

coast to 2300 m inland (Fig. 1). A row of glacially rounded nunataks runs parallel with the coast. They consist of basement rocks, varying from Late Precambrian to Early Paleozoic metamorphics and Cambrian-Ordovician Granite Harbour Intrusives. The inland area is formed by scattered flat-topped nunataks which are surrounded by vast areas of ice. These nunataks are the remnants of a tableland of the Jurassic Ferrar Group which consists of Kirkpatrick lavas and Ferrar dolerite sills, alternating with rafts of sandstone of the Paleozoic and Mesozoic Beacon Supergroup (Skinner and Ricker, 1968; Wörner, in press). They rest unconformably on the Precambrian/Paleozoic basement, which is only exposed near the coast. The sub-Beacon or Kukri Peneplain and the volcanic strata dip about two degrees to the west, resulting in the subhorizontal summit plateaux of the nunataks.

Levels of Glaciation

In the inland region three levels of glacial erosion and/or deposition are recognized as follows (Fig. 2): i) Summit plateaux rising 500 to 600 m above the present ice surface.

ii) Glacial terraces occurring between 150 m and 400 m above the present ice surface.

iii) Ice-cored moraines existing up to 50 m above the present ice level. In addition to the differences in elevation this threefold division is based on morphology, degree of weathering, and till provenance.

Summit plateaux

Most of the nunatak summits are formed by Kirkpatrick basalts (Skinner and Ricker, 1968). Till blankets on the plateaux are at least 100 cm thick, and form desert pavements. The surface rocks are wind-polished, but due to strong weathering large parts have crumbled away and only small patches of the varnish are left. Large polygons have formed in the desert pavement. Clasts with diameter up to 40 cm in the till are sub-rounded and sometimes striated. They are probably derived from the Ferrar Group only, since no rocks other than volcanics have been found. Although the clasts in the tills of the different summit plateaux have the same composition and degree of weathering, the fine component is rather different. At Griffin Nunatak (2260 m) the till matrix is quite coarse and reddish in color. At Mt. Billing (1600 m) and Ricker Hills (1650 m) it is finer and brown to grey in color.

From till mantling the plateau at Mt. Billing fragments of the marine diatoms Coscinodiscus and/or Thalassiosira sp. were recovered (Fig. 3). No foraminifera are present. From the plateau at Ricker Hills agates were sampled for $^{10}\text{Be}$ dating.

Glacial terraces

Glacially eroded terraces are present at the northeastern side of almost every nunatak. In general they lie 100–400 m below the level of the summit plateaux. Some of terraces form more or less shallow U-shaped valleys which open to the east, for instance at Mt. Joyce (1140 m) and at Mt. Billing (1420 m). Solifluxion terraces are formed on their valley slopes. Other glacial terraces occur at Ricker Hills (1460 m and 1290 m), and at Mt. Bowen (1660 m). A thin layer of till is present in their central parts with bedrock cropping out on their edges. Some of the edges are rounded due to glacial erosion, but most are sharp as they are bounded by steep cliffs cut by cirque headwalls. In Ricker Hills, striae and crescentic marks found at the summit plateau (1650 m) and

Fig. 2. Three levels of glaciation shown by (i) the summit plateaux of Griffin Nunatak (2260 m), (ii) lower glacial terraces cut in Ferrar Group and Beacon Supergroup and (iii) ice-cored moraines (center, middle distance). Foreground ice is approximately 1900 m. View towards southwest.
at the lower terrace (1290 m) indicate a paleo-ice-flow direction towards 45°.

The till surface shows a desert pavement, with large polygons up to ten meters in diameter. The surface rocks are windpolished, but there is a great variety in degree of weathering. Both shiny polished clasts and strongly pitted ones occur close to each other. Clasts below the surface are rounded and often striated. Most of the clasts in the till are Ferrar Group rocks, but erratics from the basement occur as well. Beacon Sandstones up to boulder size are present on almost every terrace. Large granite boulders only occur on Mt. Billing (at 1420 m, 180 m below the summit). On the terraces of Ricker Hills fragments of coal from the Beacon Group, up to boulder size are present, and amygdaloid and agate erratics from volcanic rock occur. The latter are probably derived from bedrock outcrops west of Ricker Hills, from Sheppard Rocks in the north to Brimstone Peak in the south (Wörner, personal communication). This agrees with the paleo-ice-flow direction as shown by the striae found at Ricker Hills.

**Ice-cored moraines**

Ice-cored moraines are often present on the northeastern side of the nunataks (Fig. 1). Griffin Nunatak (Fig. 2) and Ricker Hills (Fig. 4) partly surround the ice-cored moraines, which cover areas up to 25 km². They consist of a great number of shear moraine ridges with a pronounced dead ice topography. Ice-cored moraines also occur as remnants of medial moraines, on the northeastern side of Mt. Joyce, Mt. Billing, Mt. Bowen and Brimstone Peak (Fig. 1).

The ice-cored moraines rise up to tens of meters above the present ice level. The majority of the clasts are subrounded and often striated. Large angular blocks are located close to the mountain slopes, from which they probably have fallen down. Most of the clasts are derived from the Ferrar Group, but basement erratics occur frequently. Beacon Sandstone derived clasts, fragments of coal, and volcanic derived amygdaloid, agates and large zeolite crystals were also found. The surface boulders hardly show any weathering nor a windpolished patina.

An erratic study at the ice-cored moraines (1050 m) of Morris Basin, at the northeastern side of Ricker Hills (Fig. 4), showed that the ice-cored moraines were deposited by ice from the southwest. Furthermore petrified wood was found as an erratic in the ice-cored moraine. In this region *in situ* petrified wood has so far only been found in a rock outcrop (the Exposure Hill Formation) between Brimstone Peak and Ricker Hills (Wörner, in press and personal communication). This indicates a paleo-ice-flow direction to the northeast. This is affirmed by the presence of a roche moutonnée at the southwestern end of Morris Basin which also shows a paleo-ice-flow direction to the northeast.

At present a blue ice tongue occupies the relatively low lying basin. The ice tongue flows in southwestern direction into the basin, which is opposite to the general ice flow direction toward northeast (Fig. 4). We conclude that the ice-cored moraines in Morris Basin were deposited as lateral moraines by glaciers flowing through Morris Basin in a northeastern direction, and are not related to the present-day ice flow into the basin.

**Fig. 3.** Fragments of marine diatoms in a till found at the top of Mt. Billing (1600 m). Note the sand grains are angular.
Discussion and Conclusions

In a reconstruction of the glacial history of the research area the influence and amount of mountain uplift since the Middle Pleistocene has to be considered. We find indirect evidence of Late Cenozoic mountain uplift in the field.

The differences in till composition from the summit levels to the terraces and ice-cored moraines show that the provenance changed during the glacial history. Differences in degree of weathering of the deglaciated surfaces can be used as a relative age indicator, if regional circumstances are alike, for instance the same bedrock material. For the inland area we conclude that the summit plateaux have been ice-free for a longer period than the lower glacial terraces, as the former shows a stronger degree of weathering.

At the summit of Mt. Billing (1600 m) till containing fragments of diatoms comparable to those found in the Sirius Formation was found (Harwood, personal communication). This indicates that at least some time subsequent to 2.5-3.0 Ma (Barrett et al., 1991) the summit of Mt. Billing was covered by ice.

The diatom containing till has only been found on the summit plateau of Mt. Billing and it does not occur on the terraces at 100-400 m below the summits, nor on the ice-cored moraines. This indicates together with difference in degree of weathering that the formation of the terraces is younger than the till deposition of the "Sirius Formation" and the till was removed during the formation of these terraces.

Erratics from the basement rocks were found on the terraces and ice-cored moraines and were lacking on the summit levels. Brady and McKelvey (1983) suggest that the presence of basement-derived clasts in inland moraines, which are mainly composed of Ferrar Group rocks, could be explained by erosion and reworking of tillites older than Cenozoic. In our opinion, taking into account the regional geology, this is not the most plausible interpretation. The idea that the basement erratics could be derived from the Jurassic Mawson Formation (Brady and McKelvey, 1983), is something which has to be borne in mind. But as the granitic boulders at the terrace of Mt. Billing (1420 m) are striated they must be glacially transported following any possible derivation from this predominantly volcanioclastic unit. The absence of basement erratics on the summit plateaux and the absence of "Sirius Formation" on the glacial terraces and ice-cored moraines suggest that valley incision must have taken place, subsequent to the present nunatak summits becoming ice-free.

All the data support our assumption of a Late Pliocene and/or early Pleistocene valley incision. Since deposition of the till containing reworked marine diatoms no more than 2.5-3.0 m.y. old (Barrett et al., 1991), the ice has cut approximately 1500 m into the substratum. We believe that this valley incision is caused by mountain uplift. The presence of high elevated "Sirius Till" (1600 m) may support the idea that the Transantarctic Mountains have been lower at the moment of deposition (Behrendt and Cooper, 1991).

Erratics, striae and crescentic marks found on the glacially eroded surfaces indicate a paleo-ice-flow direction to the northeast, which is roughly parallel to the present drainage.

Webb et al. (1984) propose that the marine diatoms found in the Sirius Formation originate from the marine Wilkes-Pensacola Basins, located west of the Transantarctic Mountains. They have been transported by the East Antarctic Ice Sheet from these basins into the Transantarctic Mountains during the Late Pliocene. The microfossil-bearing till on Mt. Billing is the northernmost occurrence known so far of the Sirius Formation in the Transantarctic Mountains (Faure and Taylor, 1985; Harwood, 1983 and personal communication; Webb et al., 1983, 1984).

The absence of Sirius Till in Northern Victoria Land is in our opinion an additional evidence that this region was not overridden by the East Antarctic Ice Sheet during the Late Pliocene, but developed an individual ice cap instead (van der Wateren and Verbers, 1992).

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