

## 16. Structural Observations in the Robertson Bay Terrane and Their Implications

By Georg Kleinschmidt\*

North Victoria Land consists of three terranes: (i) the predominantly gneissic Wilson Terrane to the west, (ii) the chiefly meta-volcanic Bowers Terrane in the centre, and (iii) the Robertson Bay Terrane to the north-east (Fig. 1). The latter comprises turbidites of the probable Cambrian Robertson Bay Group, which were metamorphosed and folded during the Ross Orogeny (approximately 500 Ma). They are intruded by the granitic Admiralty Intrusives 360 Ma ago.

During GANOVEX VI, structural measurements were taken in the northern part of the Robertson Bay Terrane, the area around the Champness Glacier was rechecked (Fig. 1).

In the area measured, almost upright, steeply NE verging, open folds of some 100 m in amplitude characterize the style of the mainly single phase deformation. This confirms earlier observations in the adjacent areas of the Robertson Bay Terrane to the south and to the east. In accordance with the vergence, cleavage in average is dipping steeply to the south-west ( $s_1 = 251/85$ , dip directions by CLAR compass.). Fold axes are plunging between  $20^\circ$  to the SE and  $20^\circ$  to the NW (average  $130/10$ ).

The measurements were averaged for three subareas: eastern division = Dunedin Range and Quam Heights; central division = Hedgpeth Heights and eastern GANOVEX Range; western division = GANOVEX, Stille and Glückauf Ranges (see Fig. 1). A regional comparison shows that both  $s_1$  and  $B_1$  values change continuously from E to W (Tab. 1, Fig. 1). The continuity is interrupted only by the structural data from the area around the Robertson Bay.

The rocks of the northern Robertson Bay Terrane were also extensively sampled during GANOVEX VI, in order to confirm the uniform low-grade metamorphism (BUGGISCH & KLEINSCHMIDT 1991) and its character of rather high pressure (KLEINSCHMIDT et al. 1991). Both require an extensive tectonic cover of the Robertson Bay Terrane in the order of at least 10 to 15 km (BUGGISCH & KLEINSCHMIDT 1991), perhaps even 30 km (KLEINSCHMIDT et al. 1991). Evidence of internal thrusting, imbrication or duplex formation could nowhere be found within the Robertson Bay Terrane, so that an allochthonous tectonic cover must be postulated, i.e. nappe tectonics. Nappe tectonics can be verified by the detection of nappe thrust planes and/or klippen consisting of allochthonous rocks.

Thrusting of the Bowers Terrane onto the Robertson Bay Terrane was described first by CROWDER (1968), later on by WRIGHT & FINDLAY (1984) and GIBSON & WRIGHT (1985). These descriptions concern regions very close to the main mappable boundary between Bowers and Robertson Bay Terranes and do not deal with nappe tectonics.

Klippen are not described so far in northern Victoria Land. But because of the required tectonic cover of more than 10 to probably 30 km, we searched systematically in the field - and in the literature - for eventual klippen: JORDAN et al. (1984) mention meta-volcanic rocks (Glasgow Volcanics of the Bowers Terrane) from 3 km north-east of Mt. Bruce. They are separated from the main Bowers Terrane by so-called Millen Schists, which belong to the Robertson Bay Terrane or form a peculiar main unit (JORDAN et al. 1984, FINDLAY & FIELD 1983). This area was re-investigated now during GANOVEX VI. The meta-volcanics comprise newly discovered ul-

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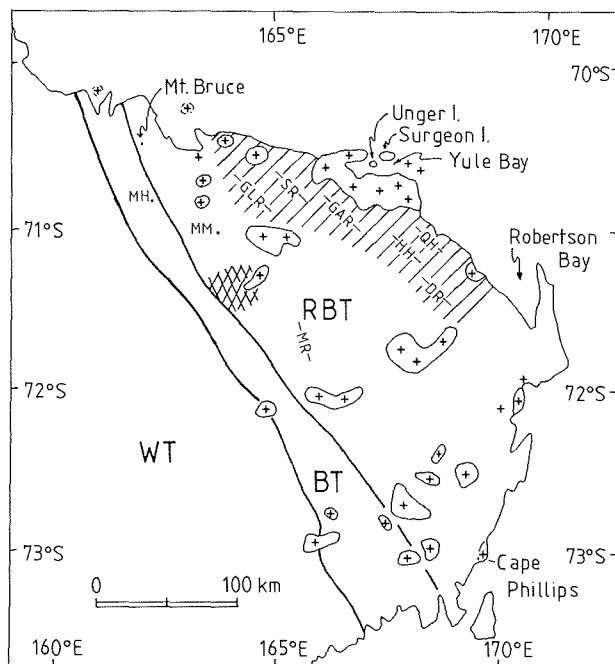


Fig. 1: North Victoria Land; WT = Wilson Terrane, BT = Bowers Terrane, RBT = Robertson Bay Terrane, + Admiralty Intrusives, /// Area studied, XXXX Area re-checked (Champness Glacier area), DR = Dunedin Range, GAR = GANOVEX Range, GLR = Glückauf Range, HH = Hedgpeth Heights, MH = Mt. Hager, MM = Mt. Mulach, MR = Mirabito Range, QH = Quam Heights, SR = Stille Range.

Abb. 1: Nordvictorialand, WT = Wilson Terrane, BT = Bowers Terrane, RBT = Robertson Bay Terrane, + Admiralty Intrusiva, /// Untersuchungsgebiet, XXXX überprüftes Gebiet (Champness Glacier Bereich), DR = Dunedin Range, GAR = GANOVEX Range, GLR = Glückauf Range, HH = Hedgpeth Heights, MH = Mt. Hager, MM = Mt. Mulach, MR = Mirabito Range, QH = Quam Heights, SR = Stille Range.

tramafic rocks and are surrounded by mylonitic, strongly deformed and quartz-veined Millen Schists, which are interpreted obviously as the widely outcropping tectonic boundary between the Bowers and Robertson Bay Terranes. Therefore, the meta-volcanics north-east of Mt. Bruce would represent a klippe of the Bowers Terranes upon the Robertson Bay Terrane. A very similar situation occurs some 47 km south (7 km north-east of Mt. Hager; JORDAN et al. 1984).

Another occurrence of meta-volcanic rocks apparently deriving from the Bowers Terrane is situated within the Robertson Bay Terrane, actually within a pluton of Admiralty Intrusives within the Robertson Bay Terrane, 135 km off the main Bowers Terrane: Unger Island in the Yule Bay (Yule Bay Pluton). The island's rocks are described as „closely comparable“ to Glasgow Volcanics (TESSENSOHN 1984). Cleavage measurements ( $s_1 = 205/50$  to  $215/55$ ) corroborate former data (TESSENSOHN et al. 1981: 130/60 SW).

The estimated stratigraphic thickness of the Bowers Supergroup comes to 5100 m plus roughly the same amount of the stratigraphically following molasse-like Leap Year Group (GANOVEX-TEAM 1987). Even if the effective thickness of Bowers Terrane as tectonic cover upon Robertson Bay Terrane may slightly exceed 10 km, additional cover units are required: a share of gneisses from the Wilson Terrane seems reasonable and necessary.

Surgeon Island is close to Unger Island and consists nearly totally of orthogneiss (see KLEINSCHMIDT et al. this volume) forming geochemically, structurally and in age a foreign body within the Yule Bay Pluton (VETTER et al. 1983). It was interpreted as a huge raft (as Unger Island), brought along from a supposed basement underneath the Robertson Bay Group (GANOVEX-TEAM 1987, KLEINSCHMIDT et al. 1987).

The interpretation of Surgeon Island as a klippe deriving from the Wilson Terrane is supported by the following points:

- a) Large en echelon quartz tension gashes near the top of Unger Island indicate a tectonic transport of a hanging unit towards NE.
- b) The Yule Bay Pluton is the largest pluton of Admiralty Intrusives in North Victoria Land (minimum diame-

|    | Region                                 | s <sub>1</sub>  | Sym<br>bol | B <sub>1</sub>   | Sym<br>bol | Reference                      |
|----|--|-----------------|------------|------------------|------------|--------------------------------|
| NE | Robertson Bay                          | 250/85          | a          | 330/25           | A          | KLEINSCHMIDT &<br>SKINNER 1981 |
|    | Dunedin Range,<br>Quam Heights         | 200/80          | b          | 295/10           | B          | GANOVEX VI                     |
|    | Hedgpeth Heights                       | 215/80          | c          | 305/05           | C          | GANOVEX VI                     |
|    | SW Admiralty<br>Mountains              | 215/70<br>35/75 | d          | 120/15<br>315/20 | D          | FINDLAY &<br>FIELD 1982        |
|    | Glückauf, Stille,<br>GANOVEX<br>Ranges | 40/90           | e          | 135/10           | E          | GANOVEX VI                     |
|    | Mirabito Range                         |                 |            | 150/05           | F          | KLEINSCHMIDT &<br>SKINNER 1981 |
| SW | Mt. Mulach                             | 225/60          | g          | 150/20           | G          | KLEINSCHMIDT &<br>SKINNER 1981 |

Table 1: Structural data from the Robertson Bay Terrane, taken NE-SW across strike; symbols refer to Fig. 2.

Tab. 1: Strukturdaten aus dem Robertson Bay Terrane, quer zum regionalen Streichen von NE nach SW. Buchstabensymbole beziehen sich auf Fig. 2.

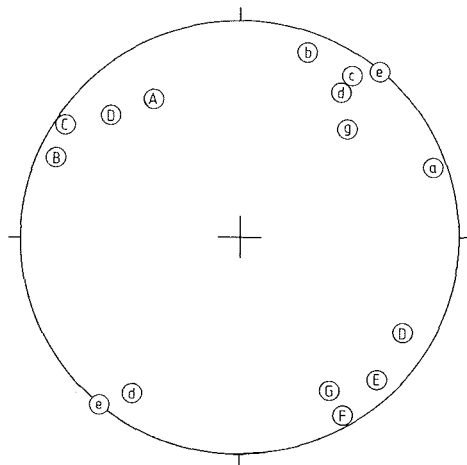


Fig. 2: Schistosity (s<sub>1</sub>: a-g) and fold axes (B<sub>1</sub>: A-G) in the Robertson Bay Terrane, maxima plotted in SCHMIDT net. For regional relationships and origin of data see Tab. 1.

Abb. 2: Schieferung (s<sub>1</sub>: a-g) und Faltenachsen (B<sub>1</sub>: A-G) im Robertson Bay Terrane. Maxima dargestellt im SCHMIDTSCHEN Netz. Zu regionalen Beziehungen und Datenquellen vgl. Tab. 1.

ter N-S = 45 km, E-W = 80 km). Therefore it seems plausible that it reached the (tectonic) cover and incorporated parts of its roof.

c) The early main structures of Surgeon (average s<sub>1</sub> = 205/60) and Unger Islands (average s<sub>1</sub> = 210/60) are parallel to the main structural trend of the Ross Orogen in entire North Victoria Land. This is best explained by a gently sinking of both the Unger and the Surgeon Island rafts.

d) If Unger Island represents a raft and belongs to the volcanics of the Bowers Terrane, it must derive from the

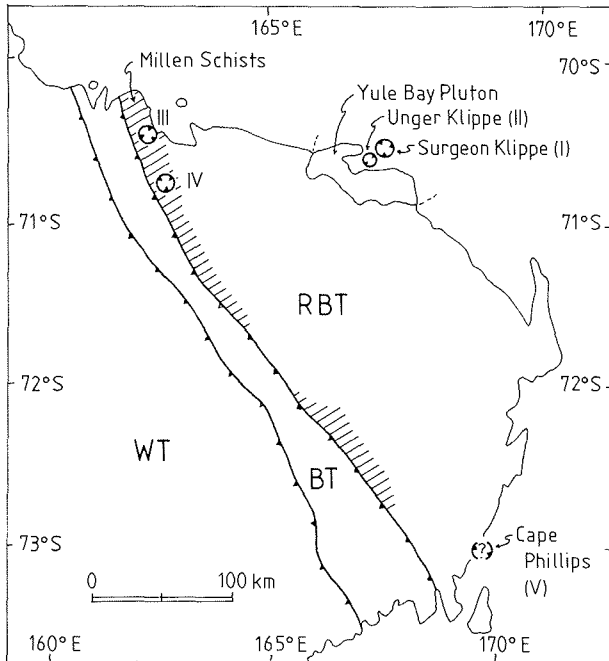


Fig. 3: Robertson Bay Terrane and possible klippen of tectonic cover.

(I) = possible klippe of WT = Surgeon Island; (II) = possible klippe of BT = Unger Island; (III) = possible klippe of BT 3 km east of Mt. Bruce; (IV) = possible klippe of BT 7 km east of Mt. Hager; (V) = klippen of WT (?) near Cape Phillips.

Abb. 3: Robertson Bay Terrane: Mögliche Klippen als Reste seiner tektonischen Überlagerung. (I) = mögliche Wilson-Terrane-Klippe auf Surgeon Island. (II) = mögliche Bowers-Terrane-Klippe auf Unger Island. (III) = mögliche Bowers-Terrane-Klippe 3 km östlich Mt. Bruce. (IV) = mögliche Bowers-Terrane-Klippe 7 km östlich Mt. Hager. (V) = fragliche Wilson-Terrane-Klippen bei Cape Phillips.

pluton's roof. If Unger Island sank down, Surgeon Island at the same time could not have been brought up from underneath the Robertson Bay Group.

e) The I-type character of the Admiralty Intrusives (BORG et al. 1987) indicates, that the Admiralty Intrusives did not derive from marked continental crust. The weak S-type tendency in the Yule Bay Pluton is explainable by the incorporation of continental material from above - like Surgeon Island.

Discussing the possibility that klippen sank down from roofs of Admiralty Intrusive plutons, one has to point to the large xenoliths in the Admiralty Intrusives north of Cape Phillips (GANOVEX-TEAM 1987).

CROWDER'S notice (1968) of „an island of medium-grade gneiss“ around the upper Champness Glacier suggests another klippe of Wilson Terrane within the Robertson Bay Terrane. The „island's“ position is 164° 10' E, 71° 28' S in CROWDER'S text, and 164° 10' E, 71° 32' S in his sketch map. All outcrops within a radius of 10 km around both locations have been re-checked, but gneiss could nowhere be found. In contrary it results that the western half of the re-checked area consists of Millen Schists (i.e. directly north-east of Leap Year Glacier), and the eastern half of contact-metamorphosed Robertson Bay Group.

## CONCLUSIONS

The uniform style of folding in the Robertson Bay Terrane requires a major detachment underneath the Robertson Bay Group. Another master fault on top of the Robertson Bay Group, i.e. a nappe thrust plane, which was demanded because of its degree, uniformity and character of metamorphism, is supported by possible klippen within the realm of the Robertson Bay Terrane, deriving from Bowers and Wilson Terranes.

## References

- Borg, S. G., Stump, E., Chappell, B. W., McCulloch, M. T., Wyborn, D., Armstrong, R. L. & Holloway, J. R. (1987): Granitoids of northern Victoria Land, Antarctica: Implications of chemical and isotopic variations to regional crustal structure and tectonics. - Am. J. Sci. 287: 127-169.

- Buggisch, W. & Kleinschmidt, G. (1991): Recovery and recrystallization of quartz and „crystallinity“ of illite in the Bowers and Robertson Bay Terranes (northern Victoria Land, Antarctica).- In: M.R.A. Thomson, J.A. Crame & J.W. Thomson (eds.), Geological evolution of Antarctica.- Cambridge Univ. Press: 155-159, Cambridge.
- Crowder, D. P. (1968): Geology of a part of North Victoria Land, Antarctica.- US Geol. Surv. Prof. Pap. 600-D: D93-D107.
- Findlay, R. H. & Field, B. D. (1982): Preliminary report on the structural geology of the Robertson Bay Group, North Victoria Land, Antarctica.- NZ. Antarct. Rec. 4 (2): 15-19.
- Findlay, R. H. & Field, B. D. (1983): Tectonic significance of deformations affecting the Robertson Bay Group and associated rocks, northern Victoria Land, Antarctica.- In: R.L. Oliver, P.R. James & J.B. Jago (eds.), Antarctic Earth Science.- Austral. Acad. Sci.: 107-112, Canberra.
- GANOVEX - Team (1987): Geological map of North Victoria Land, Antarctica, 1 : 500 000 - Explanatory notes.- Geol. Jb. B 66: 7-79.
- Gibson, G. M. & Wright, T. O. (1985): Importance of thrust faulting in the tectonic development of northern Victoria Land.- Nature 315: 480-483.
- Jordan, H., Findlay, R., Mortimer, G., Schmidt-Thomé, M., Crawford, A. & Müller, P. M. (1984): Geology of the northern Bowers Mountains, North Victoria Land, Antarctica.- Geol. Jb. B 60: 57-81.
- Kleinschmidt, G., Mazzoli, C. & Sassi, F. P. (1991): The pressure character of the low-grade metapelites from Robertson Bay Terrane and Bowers Terrane, northern Victoria Land (Antarctica). - Mem. Soc. Geol. Ital. 46: 283-289.
- Kleinschmidt, G. & Skinner, D. N. B. (1981): Deformation styles in the basement rocks of North Victoria Land, Antarctica.- Geol. Jb. B 41: 155-199.
- Kleinschmidt, G., Tessensohn, F. & Vetter, U. (1987): Paleozoic accretion at the Paleopacific margin of Antarctica.- Polarforschung 57: 1-8.
- Tessensohn, F. (1984): Geological and tectonic history of the Bowers Structural Zone, North Victoria Land, Antarctica.- Geol. Jb. B 60: 371-396.
- Tessensohn, F. et al. (1981): Geological comparison of basement units in North Victoria Land, Antarctica. - Geol. Jb. B 41: 31-88.
- Vetter, U., Roland, N. W., Kreuzer, H., Höhndorf, A., Lenz, H. & Besang, C. (1983): Geochemistry, petrography and geochronology of the Cambro-Ordovician and Devonian-Carboniferous granitoids of northern Victoria Land, Antarctica.- In: R.L. Oliver, P.R. James & J.B. Jago (eds.), Antarctic earth sciences.- Austral. Acad. Sci.: 140-143, Canberra.
- Wright, T. O. & Findlay, R. H. (1984): Relationships between the Robertson Bay Group and the Bowers Supergroup - New progress and complications from the Victory Mountains, North Victoria Land.- Geol. Jb. B 60: 105-116.