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Paleozoic Accretion at the Paleopacific Margin of Antarctica

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1. INTRODUCTION

The configuration of northern Victoria Land forms at present the best base for a discussion of the Paleozoic accretionary history of the Antarctic Shield because of
— the relatively good and numerous rock exposures,
— the position near the Pacific margin of the East Antarctic Craton,
— the relatively good level of knowledge, and
— the concentration of research activities during the last 10 years
(e. g. GANOVEX I—IV, North Victoria Land Project of the United States and New Zealand).

The basement of northern Victoria Land consists of three main structural units, for which the term "terranes" has become established, though not necessarily with the connotation of "suspect", "exotic" or "allochthonous terranes". The three terranes are from SW to NE (Fig. 1):

A) the Wilson Terrane, built up of metamorphic rocks ranging from greenschist facies up to anatexis and migmatization. The age of the protoliths of the gneisses, mica schists or calc silicate rocks is not known. The deformation is polyphase, the metamorphism, at least in parts, too.

B) the Bowers Terrane, containing a large variety of rocks formed during the Cambrian to Ordovician periods ("Bowers Supergroup") including conglomerates, quartzites, limestones, turbiditic sandstones, and most of all volcanics of a tholeiitic composition (primitive island arc or back arc-like, not MORB according to WEAVER et al., 1984). The metamorphism of the Bowers Terrane is mainly of a very low grade, sometimes reaching the greenschist facies. The deformation is mostly singlephase as shown by open folds and corresponding cleavage.

C) the Robertson Bay Terrane, comprising a flyschoid turbidite sequence of Eocambrian to Cambrian age. The metamorphism here is of a very-low grade just reaching the greenschist facies in some localities at the western margin. The rocks are generally folded in a simple open, and weakly NE-verging manner, and are usually well cleaved.

The boundaries between the terranes are rather well defined (Figs. 1 and 2). The age of deformation and metamorphism is, apart from some irregularities, around 500 Ma (ADAMS & KREUZER 1984). The three terranes are affected by intrusions of granitic plutons: The Cambro-Ordovician Granite Harbour Intrusives are restricted to the Wilson Terrane, the Devonian-Carboniferous Admiralty Intrusives are concentrated in the Robertson Bay Terrane, but occur in the others as well (VETTER et al. 1983, TESSENSOHN 1984).

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2. GEOTECTONIC MODELS

The following three principal models have recently been suggested to explain the present configuration of NVL and its geotectonic development in terms of Paleozoic accretion at the proto-Pacific margin of Antarctica and of role and function of the Ross Orogeny. WEAVER et al. (1984) explain the terranes of NVL as allochthonous slivers transported to their present position by large-scale dextral strike-slip faults crossing each other. In a second paper the same authors (BRADSHAW et al. 1985) enlarge the number of suspect terranes by dividing the Wilson Terrane into Daniels and Lanterman Terranes and by separating a Millen Terrane from the Robertson Terrane. GIBSON & WRIGHT (1985) start off in their model with westward directed subduction which is then followed by accretion of an unknown exotic terrane or microcontinent, which since then has disappeared. KLEINSCHMIDT & TESSENSOHN (1987) argue for generally westward directed subduction in several episodes, each accompanied by an eastward jump of the subduction zone.

3. GEOLOGICAL CONSTRAINTS

Any model has to take into account the following geological constraints:

— The Wilson Terrane consists of two belts of contrasting metamorphic history (GREW et al. 1984): a

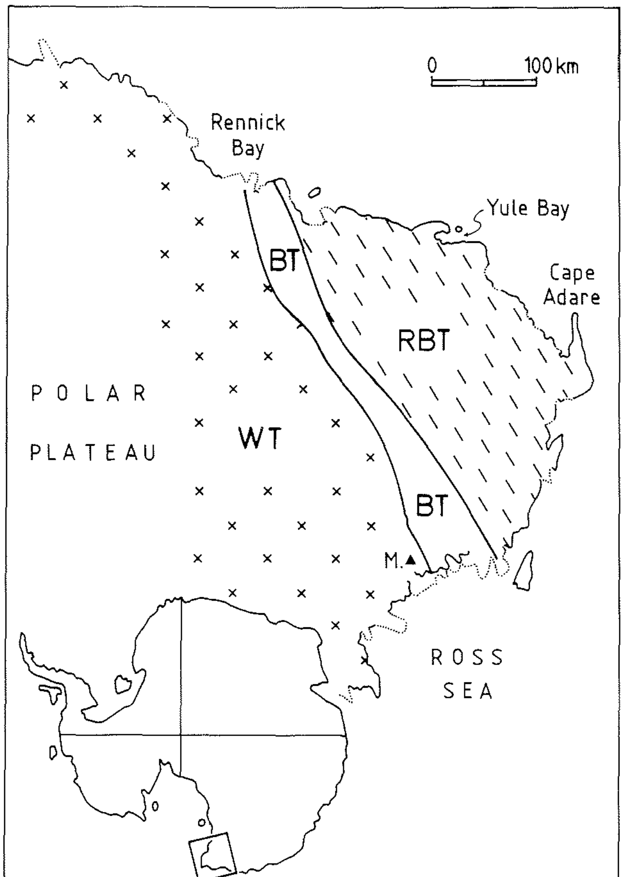

Fig. 1: The three terranes of northern Victoria Land: WT Wilson Terrane, BT Bowers Terrane, RBT Robertson Bay Terrane (M Mt. Murchison).

Abb. 1: Tektonische Terranes von Nord Victoria Land: WT Wilson Terrane, BT Bowers Terrane, RBT Robertson Bay Terrane, (M Mt. Murchison).

Fig. 2: Mt. Murchison viewed from the east. Bowers Terrane in the foreground east of the dashed line, Wilson Terrane west of that line. The base and slopes of Mt. Murchison consist of gneisses, the summits of granitic rocks overriding the gneisses.

Abb. 2: Mt. Murchison von Osten gesehen. Das Bowers Terrane nimmt den Vordergrund östlich der gestrichelten Linie ein, das Wilson Terrane liegt dahinter im Westen. Die Basis und Flanken des Mt. Murchison sind aus Gneisen aufgebaut, die Gipfel aus Graniten, die auf die Gneise überschoben sind.

western low pressure/high temperature belt characterized by the paragenesis andalusite, cordierite, cordierite + muscovite and migmatites, and an eastern medium pressure belt characterized by kyanite, mainly as relics. The distribution of these critical minerals (Fig. 3) closely resembles the pattern of "paired metamorphic belts" at continental margins next to a subduction zone (MIYASHIRO 1973).

— The distribution of the Granite Harbour Intrusives in the Wilson Terrane forms a similar pattern of paired belts (VETTER & TESSENSOHN 1987; Fig. 3): S-type granitoids with Sr-initials between 0.712 and 0.716 in the west, I-type granitoids with ratios of 0.707 to 0.709 in the east. According to PITCHER (1982) such S- and I-type belts accompany subduction zones.

— The eastern boundary of the Wilson Terrane, especially in the Lanterman Range, is accompanied by a train of ultramafic and mafic lenses several tens of meters in size (KLEINSCHMIDT et al. in press; Fig. 4). These bodies may be regarded as relics of an ophiolitic belt.

— In another strip, immediately to the east of these ultramafic lenses, rather peculiar conglomeratic rocks occur (Fig. 5). They contain in an amphibolitic matrix clasts of varying size (from a few cm up to >1 m), of varying shape (angular, rounded and often strongly flattened), and of varying origin (mainly metamorphic, but also granitic). These rocks (Husky Conglomerate and Dessent Conglomerate) may be interpreted as olisthostromes or even as a mélange.

— The last penetrative generation of folds (F_3, in parts F_4) within the Wilson Terrane shows clear vergence towards the east (Fig. 6).

— The same trend of tectonic transport is documented by thrusts within the Wilson Terrane. The most

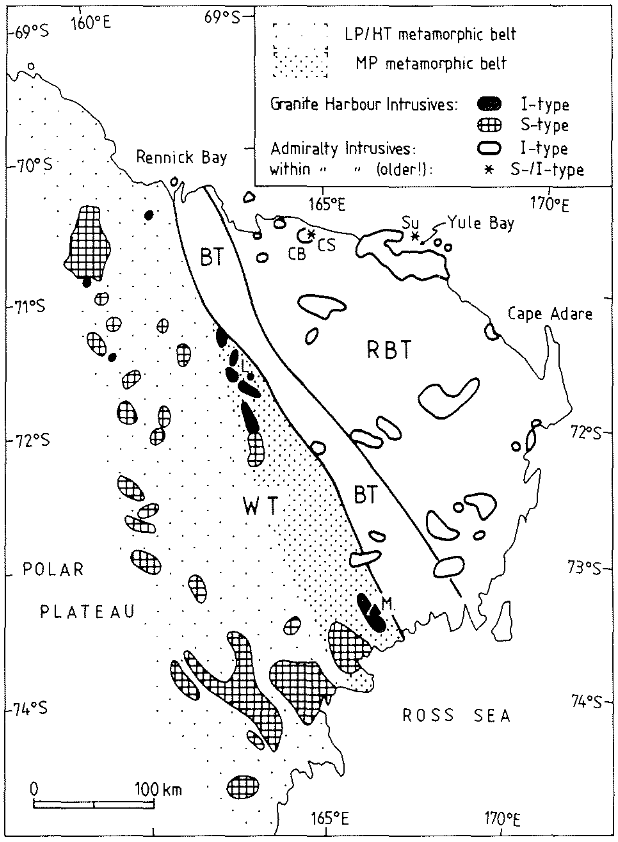

Fig. 3: Paired metamorphic and magmatic belts of the Wilson Terrane and distribution of younger Admiralty Intrusives (CB Cooper Bluff, CS Cooper Spur, Su Surgeon Island, L Lanterman Range, M Mt. Murchison).

Abb. 3: Gepaarte metamorphe und magmatische Gürtel im Wilson Terrane und Verbreitung der jüngeren Admiralty Intrusionen (CB Cooper Bluff, CS Cooper Spur, Su Surgeon Island, L Lanterman Range, M Mt. Murchison).

spectacular example can be found at Mt. Murchison (Fig. 2). The base of the massif is formed by the Dessent Formation, where thrust planes have been described in kyanite-bearing schists (KLEINSCHMIDT et al. 1984). The boundary to the tectonically next higher unit can be traced on the map as a plane with shallow dip to the west. The eastern flanks of the Murchison Massif consist of gneisses, whereas the two summits and the upper western slopes consist of granites overriding the gneisses.

— The boundaries between the terranes are also partly developed as thrusts. They form steep west-dipping reverse faults at the Wilson Terrane/Bowers Terrane boundary in the eastern Lanterman Range (GIBSON 1984) and within the Mountainer Range (KLEINSCHMIDT et al. 1984), accompanied by an overprint of greenschist facies metamorphism. At the Robertson Bay Terrane/Bowers Terrane boundary in the northwestern Victory Mountains, however, there is an undulating thrust developed which generally has a shallow dip to the west (FINDLAY & FIELD 1983, WRIGHT & FINDLAY 1984).

All these points argue for the geodynamic model given by KLEINSCHMIDT & TESSENSOHN (1987):

— An early Ross subduction of oceanic lithosphere and its obduction as ophiolitic relics together with the creation of contrasting metamorphic belts;

— the accretion of the island arc of the Bowers Terrane during the main Ross stage and a jump of the subduction zone eastwards, accompanied by HT/LP metamorphism in the whole Wilson Terrane

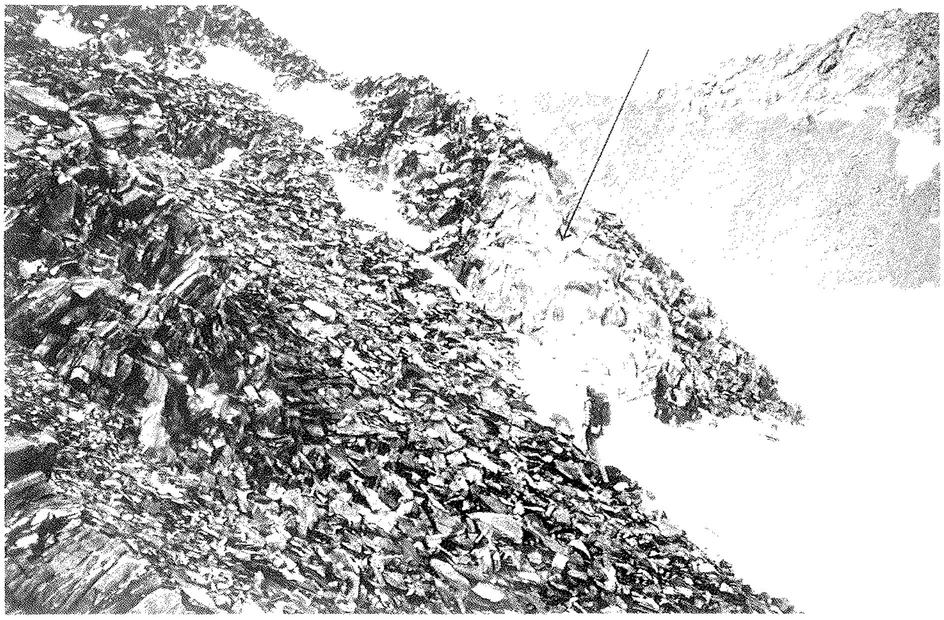

Fig. 4: Lense of serpentinized ultramafitite (arrow) surrounded by gneisses at the northern end of the Lanterman Range.

Abb. 4: Linse von serpentinisiertem ultramafischen Gestein (Pfeil) umgeben von Gneisen. Nordenge der Lanterman Range.

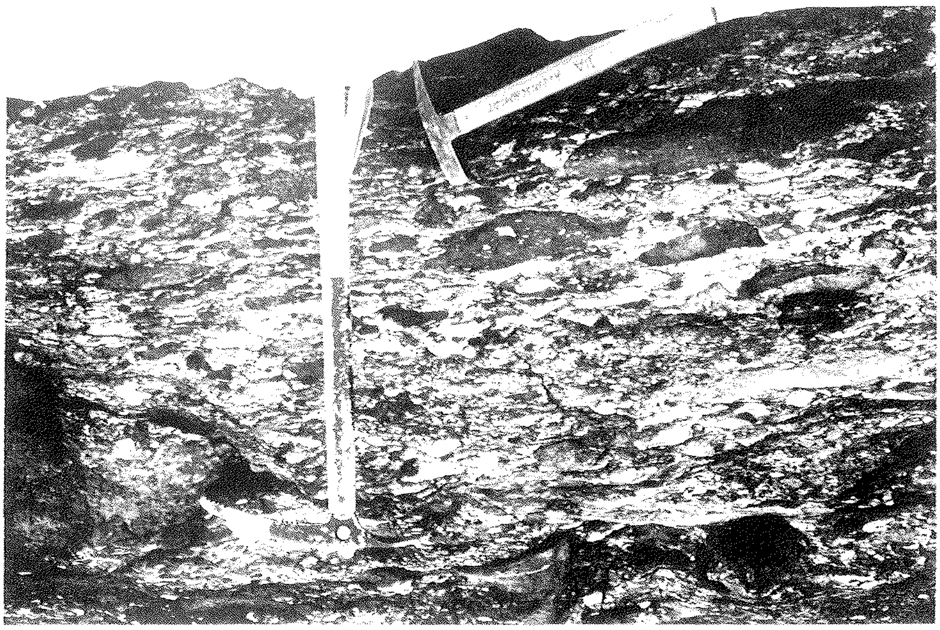

Fig. 5: The "Husky Conglomerate" at the eastern margin of the Wilson Terrane in the Lanterman Range, an olisthostrome or mélange?

Abb. 5: Das „Husky Konglomerat" am Ostrand des Wilson Terranes in der Lanterman Range, Olisthostrom oder Melange?

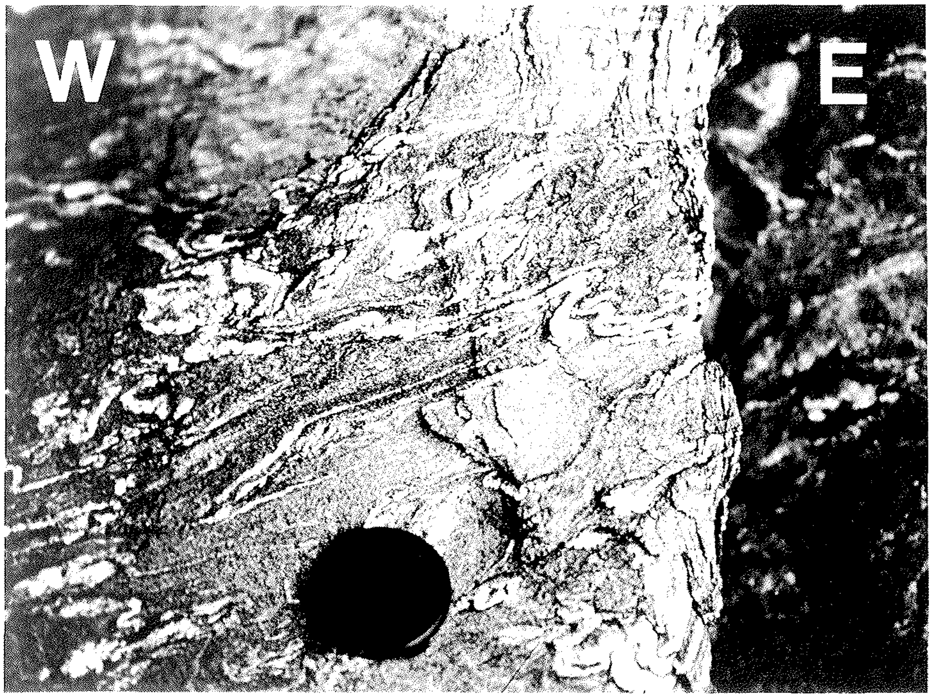

Fig. 6: East-verging F_3-folds near the eastern margin of the Wilson Terrane east of Mt. Murchison.

Abb. 6: Ostvergente F_3-Falten am Ostrand des Wilson Terranes östlich Mt. Murchison.

and the formation of paired magmatic belts;

— continuing or renewed eastward directed thrusting with related greenschist facies overprint;

— finally, in post Ross time, the generation of the I-type Admiralty Intrusives, interpreted by KLEINSCHMIDT & TESSENSOHN (1987) by a second eastward jump of the subduction zone.

But new results add difficulties and complications to the simple model:

— The evolution history of a chain of ultramafic bodies in the Lanterman Range is ambiguous (KLEINSCHMIDT et al. in press). About half of the bodies show prograde metamorphic development from a serpentinitic stage to the amphibolite facies. This would fit the above model. But the other half has arrived at the amphibolite facies by retrogression from granulite facies.

— Two intrusives in the Robertson Bay Terrane, the Cooper Spur granite and the granodiorite of Surgeon Island in Yule Bay, surprisingly yielded pre-Ross ages (VETTER et al. 1983). The Surgeon Island granodiorite in addition shows S-type characteristics in contrast to I-type characteristics of the Admiralty Intrusives (VETTER & TESSENSOHN 1987).

— There is an increase of continental character in the geochemistry and Sr initial ratios of the Admiralty Intrusives towards the NE (BORG 1984).

— The I-type character of the Admiralty Intrusives can be specified as "Caledonian type" (VETTER &

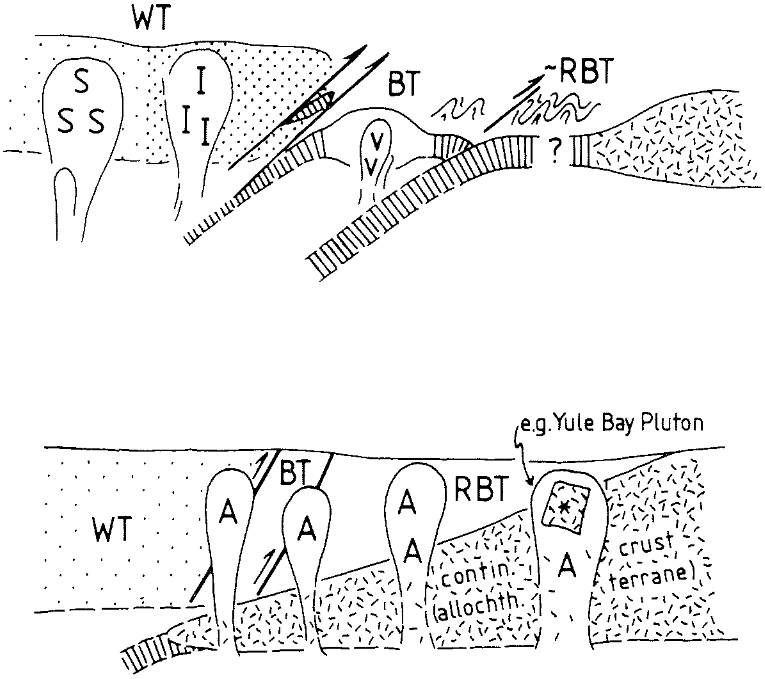

Fig. 7: Model of the final two stages in the accretionary evolution of North Victoria Land.
Above: Final stage of the Ross Orogeny: V accreted island arc of the Bowers Terrane. S belt of S-type Granite Harbour Intrusives (Wilson Terrane), which is roughly identical with the high temperature/low pressure metamorphic belt, I belt of I-type Granite Harbour Intrusives (Wilson Terrane), roughly identical with the relict medium pressure metamorphic belt.
Below: Stage of collision of Antarctica including the newly accreted Ross Orogen with an allochthonous continental sliver. Relics of this sliver preserved in the Cooper Bluff and Yule Bay plutons. A Admiralty Intrusives.

Abb. 7: Modell der beiden letzten Stadien der Akkretionsgeschichte Nord Victoria Lands:
Oben: Abschlußstadium der Ross Orogenese: V Angeschweißter Inselbogen des Bowers Terranes. S Gürtel von S-typ-Graniten der Granite Harbour Suite im Wilson Terrane, der ziemlich genau mit einem metamorphen Hochtemperatur/Niederdruck Gürtel zusammenfällt. I Gürtel von I-typ-Graniten der Granite Harbour Seite, der mit einem in Relikten erhaltenen metamorphen Mitteldruck-Gürtel koinzidiert.
Unten: Stadium der Kollision zwischen antarktischem Kontinent, einschließlich des erst kurz zuvor angeschweißten Ross Orogens, und einem allochthonen Mikrokontinent. Relikte dieses Kontinentalsplitters sind in den Cooper Bluff und Yule Bay Plutonen erhalten. A Admiralty Intrusions Suite.

TESSENSOHN 1987) which, according to PITCHER (1982), is generally associated with post-closure uplift.

4. CONCLUSIONS

The early Ross stage is characterized by a very complex subduction process involving oceanic lithosphere from different crustal levels. Subduction carried parts of this material down to high pressure conditions. Obduction then took the oceanic slivers of various origin back up and aligned them along the eastern margin of the Wilson Terrane. At the same time paired metamorphic belts were formed in this terrane.

The main-Ross stage resulted in the accretion of the Bowers Terrane with possible relics of a subduction complex preserved along the suture with Wilson Terrane. The Granite Harbour Intrusive bodies were formed in an inner S-type and an outer I-type belt (Fig. 7).

The post-Ross development produced post-closure intrusions within the Robertson Bay Terrane and Bowers Terrane. The Robertson Bay Terrane also preserved a few relics of a pre-Ross terrane or microcontinent east of Proto-Antarctica. Collision of this microcontinent with the Antarctic craton triggered the generation of the Admiralty intrusions.

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