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The Antarctic Expedition GANOVEX VI: Introduction to Field Results

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1. INTRODUCTION

The Ross Sea area (in the Pacific sector of Antarctica) is particularly suitable for investigations on the structure and evolution of the Antarctic lithosphere. The present structure of the lithosphere is largely characterized by the existence of a large continental rift, a feature that allows the study of the initial processes of lithospheric thinning associated with continental split and break-up. This stage is highly relevant for the later formation of a new ocean. The Ross Sea rift system which is active within an apparently stable and aseismic plate is comparable in size to the Basin and Range province of North America and the East African rift. For an intracontinental system it is unique for the asymmetry of the shoulder uplift.

The evolution of the West Antarctic lithosphere to its present stage is characterized by:
a) the generation of new crust at the active Gondwana margin bordering the Pacific or its predecessor and
b) the fragmentation of the lithosphere which finally led to the present mosaic of crustal blocks. Both processes can be studied well in the working area.

1.1 *Generation of new crust in West Antarctica*

The Antarctic Ross Orogen forms one of the longest preserved segments of the mobile zones along the Pacific outer rim of Gondwana. This margin was active from the late Precambrian on. In the Ross Sea area, Precambrian and lower Paleozoic rocks form the basement of the Transantarctic Mountains. Metasediments and migmatites of the Wilson Group crop out mainly in the western inland areas of North Victoria Land and probably continue south to the region of the Dry Valleys in South Victoria Land. Adjacent to the east in North Victoria Land, the basement is formed by the very low grade rocks of the Bowers Supergroup and the Robertson Bay Group (Fig. 1).

These three units occur in zones separated from each other by faults and are often regarded as tectonostratigraphic terranes. However, all three terranes were deformed and metamorphosed during the Ross Orogeny in the Early Ordovician. At the same time, granites were formed in the Wilson Terrane. At this time the various terranes had already been welded to the outer rim of Gondwana. To provide further evidence for this assumption it was planned for GANOVEX VI to compare the age of deformation in the three terranes by Ar/Ar dating of newly formed micas in the folded rocks. Only if there are large differences in the age of deformation, the terranes should be regarded as truly exotic. Another approach related to the same question is the geochemical and geochronological comparison of Devonian stitching granites which intrude all three terranes along the north coast of North Victoria Land.

The mode of attachement of the three terranes (strike-slip accretion or subduction accretion) is still much in the debate. During GANOVEX V a series of thrustplanes had been discovered in Oates Land and the Terra Nova Bay region. These thrusts can better be explained by subduction than by strike-slip movements. Because of the importance of these structures more detailed investigations were planned for GANOVEX VI.

Since Italian scientists have discovered lower crustal granulite rocks in the Terra Nova Bay region there was

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renewed interest in the problem how to distinguish relict shield rocks from high grade metamorphic rocks of the Ross Orogen. Because of the later Ross overprint dating of the relict rocks is only possible by the U/Pb method on zircons. Therefore a sampling program was set up for this expedition.

Petrographical and geochemical investigations for later p-T determinations were devoted to the problem of granite/migmatite relations and the question whether there is an older generation of Granite Harbour Intrusives (around 530 Ma), apart from the bulk of the granites which have intrusive ages around 500 Ma.

1.2 *Fragmentation of the West Antarctic Lithosphere*

The following evolutionary steps can be distinguished in the Ross Sea area:

a) Ferrar volcanism as part of a Gondwana-wide break-up event.
b) Basin formation possibly related to Andean back-arc processes.
c) Separation of Tasmania/New Zealand from Antarctica.
d) Extensional processes within the Antarctic plate resulting in the formation of the Ross Sea rift and the Transantarctic Mountains.

Significant problems related to the fragmentation of the lithosphere and to be addressed by GANOVEX VI included:

- Nature and thickness of the crust beneath the Transantarctic Mountains.
- Geometry of the faultplane bounding the basins of the Ross Sea rift from the rift shoulder of the Transantarctic Mountains.
- Time of major uplift of the Transantarctic Mountains.
- Age and episodicity of rift volcanism.
- Local structure of the lithosphere derived from mantle xenoliths.
- Nature of the lithosphere and the underlying mantle as derived from isotope investigations of plutonic and volcanic rocks.
- Recent heatflow in the rift shoulder as compared to the Ross Sea.
- Style of young tectonism in the Transantarctic Mountains.
- Crustal gradient between Ross Sea and Polar Plateau as derived from regional gravity data.
- Integration of subglacial and submarine areas by aeromagnetic surveys.
- Under-ice-morphology inland of the Transantarctic Mountains as derived from radio-echo-sounding.
- Glacial geology in relation to uplift.

2. EXPEDITION CONCEPT

Based on these open questions the following 20 programs were formulated for the expedition (participating institutions in brackets):

1) Aeromagnetics over the Ross Ice Shelf to the east and south of McMurdo (BGR, AWI, USGS).
2) Aeromagnetics and airborne radio-echo-sounding over the Oates Coast, Lower Rennick Glacier (BGR, AWI, USGS).
3) Regional gravity survey on ice, Lower Rennick Glacier (BGR, USGS).
4) Radar-echo-sounding in support of gravity program, Lower Rennick Glacier (BGR).
5) Glacial geology on the flanks of the lower Rennick Glacier, Daniels, Morozumi, Everett ranges (RGD).
6) Geochronology of deformation events to compare three suspect Paleozoic terranes (BGR).
7) Tectonic transport at the deformed terrane boundaries, Bowers Mtns., Wilson Hills (Uni F).
8) Granite-migmatite relations in the Wilson Terrane, Daniels Range, Wilson Hills (Uni HB, WÜ).
9) Sampling of enigmatic granites in the Robertson Bay Terrane, Surgeon Island, Cooper Bluffs, Sputnik Island, Yermak Point (BGR).

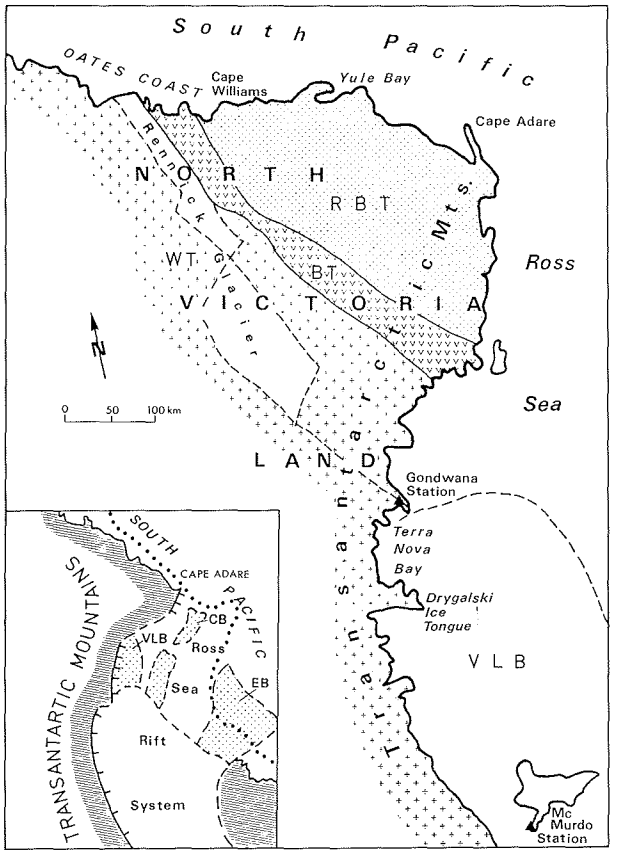

Fig. 1: Working area and important localities of GANOVEX VI in northern and central Victoria Land. Inset shows the tectonic setting of the area. BT = Bowers Terrane, RBT = Robertson Bay Terrane, WT = Wilson Terrane, CB = Central Basin, EB = Eastern Basin, VLB = Victoria Land Basin.

Abb. 1: Das Arbeitsgebiet von GANOVEX VI im nördlichen und zentralen Victoria-Land mit den wichtigsten Lokationen und einer Skizze des tektonischen Rahmens. BT = Bowers Terrane, RBT = Robertsob Bay Terrane, WT = Wilson Terrane, CB = Zentral Becken, EB = Ost-Bekken, VLB = Victoria-Land-Becken.

10) Heat flow measurements on stagnant glacial plateaus south of the Reeves Glacier (BGR).
11) Gravity survey on ice and accompanying ice thickness determinations by radar, Terra Nova Bay area (BGR).
12) Inventory of Cenozoic structures in the Ross Sea coastal areas (ZIPE).
13) Dating of Cenozoic volcanics related to rift tectonism (BGR).
14) Distribution of Kirkpatrick lavas south of the Reeves Glacier (BGR).
15) Geochemistry and petrology of Jurassic and Cenozoic volcanic rocks (Uni MZ, Uni Napoli).
16) Mapping, petrography and dating of pre-Ross relicts (Uni MS).
17) Granite-migmatite relations in the Wilson Terrane, Campbell/Priestley Divide (Uni HB, Uni WÜ).
18) Major tectonic boundaries in the deformed Ross Orogen, Mt. Murchison, Mariner Plateau, S of Reeves Glacier (Uni F).
19) Glacial geology, Mt. Joyce, Archambault Ridge (RGD).
20) Fission track sampling of Cenozoic granites at the Ross Sea coast (Uni HB).

AWI = Alfred-Wegener-Institut für Polar- und Meeresforschung; BGR = Bundesanstalt für Geowissenschaften und Rohstoffe; RGD = Rijks Geologische Dienst (Netherlands); USGS = United States Geological Survey; Uni F = University of Frankfurt; Uni HB = University of Bremen; Uni MS = University of Münster; Uni MZ = University of Mainz; Uni WÜ = University of Würzburg; ZIPE = Zentralinstitut für Physik der Erde.

3. WORKING SCHEME AND FORCE MAJEURE EVENTS

The actual field work was structured into four different sections (Fig. 1):
a) Aeromagnetics in the McMurdo area (Nov./Dec. 1990).
b) Fieldwork around the Gondwana Station (Dec./Jan.).
c) Aeromagnetics and fieldwork at the Pacific coast around Cape Williams, lower Lillie Glacier (Jan. 1991).
d) Fieldwork in the Prince Albert Mountains south of the Drygalski Ice Tongue (Dec./Febr. 1991).

The fieldwork during the expedition was strongly affected by a number of adverse events:
- About a month delay in the arrival of the expedition aircraft because of bad weather en route;
- Damage of one helicopter beyond repair;
- Grounding of another helicopter because of technical problems;
- A difficult ice situation which kept the expedition vessel about 50 km away from the working area at the north coast;
- A fuel depot which had to be uncovered from 4 m of snow;
- Extremely bad weather during most of January with snow and fog in the coastal areas and strong katabatic winds inland;
- Complete damage of one of the fixed wing aircraft during the operation on a snow runway.

The combined effects of all these events brought the activities of some groups to a complete halt for some period of time, others had to reduce or change their programs, and almost all groups had to cope with some kind of emergency alterations and activities on an opportunity basis, sometimes in completely unexpected areas. Despite continuous bad weather the last period in February produced a rather continuous working program and some useful new results.

We are glad that, inspite of all these difficulties, we are able to present our field results here in a summarized form. More detailed interpretation will follow after the laboratory work on our samples will be completed.

4. Acknowledgments

Thanks are due to the Alfred Wegener Institute (AWI) for the cooperative support of the aerogeophysical survey in terms of logistics, scientific equipment and personnel; to the U.S. Antarctic Program (USAP) for the support during the transfer flights of the Polar-2 and Polar-4 aircrafts and the provision of the McMurdo facilities for the first part of the survey.

In a difficult situation in Antarctica, one is particularly thankful for the help of other groups active in the same area. We would particularly like to thank our Italian colleagues at Terra Nova Bay and Helicopters (N.-Z) for some unbureaucratic field support in a true Antarctic spirit; we would also like to thank the US personnel in McMurdo and Christchurch for the transport of urgently needed spare parts and for some medical cross-examinations of an injured person. The crews of HSF helicopters and the *Polar Queen* did a great job in recovering completely the damaged fixed wing aircraft, albeit in 4 single sections. As coordinator of the field activities I would like to express my personal thanks to all expedition members for keeping up their spirits in spite of the disappointment about the reduction of the planned programs. This made the remaining work possible.