Polarforschung 79 (1), 39 – 42, 2009

Permian Sedimentary Cover, Heimefrontfjella, Western Dronning Maud Land (East Antarctica)

by Wilfried Bauer[1]

Abstract: In the northern Heimefrontfjella, ten sites are known where relics of a Permian sedimentary cover are preserved. The sedimentary rocks contain micro- and macro flora, proving an early Permian age. Flora and sedimentology are indicative for a cold climate deposition in a fluviomarine environment, immediately after ice retreat at the end of the Permocarboniferous glaciation. The present exposure pattern is a result of early Cretaceous block faulting, related to the beginning Gondwana break-up.

Zusammenfassung: In der nördlichen Heimefrontfjella sind an zehn Stellen Reste eines permischen Deckgebirges aufgeschlossen. Die Sedimentgesteine enthalten eine Mikro- und Makroflora, die ein frühpermisches Alter der Schichten belegen. Flora und Sedimentologie sind typisch für eine kaltzeitliche fluviomarine Ablagerung, unmittelbar anschließend an die permokarbone Vereisung. Das heutige Verbreitungsmuster der Deckgebirgsreste spiegelt eine frühkretazische Bruchtektonik beim beginnenden Zerfall Gondwanas wider.

INTRODUCTION

A sedimentary cover, composed of diamictites, sandstones, siltstones, coaly shales, and thin coal seams is exposed at ten localities in the northeastern part of Heimefrontfjella, shown on the sheets Vikenegga, Bjørnnutane and Gramkroken. They unconformably overly the crystalline basement and dip with 3-4° southeastward. Table 1 summarizes general information about lithology, thickness, and references to these outcrops.

The Permian cover rests on a striated surface with a moderate palaeorelief. The maximum thickness (160 m) is preserved at Schivestolen (Fig. 1, no.1); in all other outcrops the Permian cover has been eroded to a few meters. The erosion predates at least in parts the Jurassic; at Bjørnnutane 2 m vitrified sandstone are exposed between the basement and a Jurassic basalt flow (Fig. 1, no.5).

The sedimentary strata contain shaly layers, which yielded a relatively rich and well preserved palynoflora as well as macroscopic plant fossils (Fig. 2). The macro flora remains were interpreted as a cold climate assemblage, suggesting an uppermost Carboniferous to early Permian age (PLUMSTEAD 1975). Also the palynomorphs indicate a periglacial freshwater environment. On the basis of these palynologic analyses, the age of the basal strata of "Locality A" and Lidkvarvet has been narrowed down to the early Permian, i.e. Asselian to Artinskian (LARSSON et al. 1990, LINDSTRÖM 1995). A fossil fauna is represented only by ichnofossils. Some, not very well preserved specimens in the shales at "Locality B" have been identified as *Beaconichnus darwinum* (Fig. 3; pers. comm. Bernd Weber).

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Manuscript received 28 January 2009; accepted in revised form 20 July 2009

The sedimentary cover of the Heimefrontfjella is part of the Upper Palaeozoic Beacon Supergroup (MCKELVEY et al. 1970). Equivalents of these strata in western Dronning Maud Land have previously been named Amelang Plateau Formation in Kirwanveggen (WOLMARANS & KENT 1982).

SEDIMENTARY ENVIRONMENT

The most complete and intensively studied section of the Amelang Plateau Formation is the Schivestolen section, where three units are recognizable (POSCHER 1994):
(i) A basal diamictite facies,
(ii) a dropstone-bearing siltstone facies, and at the top
(iii) a coal-bearing sandstone facies. The sedimentary rocks of other outcrops in Heimefrontfjella represent correlates of units 1 and 2 of the Schivestolen section, unit 3 is only known from Schivestolen and Haukelandnuten (Fig. 1, nos.1,2). The following sections give a brief description of units 1 to 3, more detailed descriptions and profiles are given by POSCHER (1988, 1992, 1994) and LARSSON & BYLUND (1988).

Unit 1: The thickness of the basal diamictites is 80-300 cm, depending on the pre-depositional topography. The size of single, subangular boulders (mainly gneisses) is 10-50 cm. Thin lenses of silty and sandy layers define a poor bedding. The facies interpretation of the basal diamictites as glacial is based on provable contact with the glacially abraded and striated basement as well as striated and faceted clasts in the diamictites. A palaeo-ice flow direction of 335° ±10° was determined from the striated basement at Haukelandnuten (Fig. 1, no.2).

Unit 2: The overlying, 12 m thick siltstone sequence is composed of well-stratified siltstones and pale micaceous sandstones. POSCHER (1994) assumes glacial to periglacial conditions during the deposition of these strata, which are substantiated by sedimentary structures, such as dropstones and ice-dump tills. A decrease of dropstones and an increase of phytoclasts to the top of this unit suggest a change from a glacial to a periglacial palaeoclimate. At the outcrops 5 and 7 in XU-Fjella, sedimentary rocks rest directly upon the striated crystalline basement. There, pale, micaceous sandstones with large boulders represent the siltstone facies. Parallel small furrows, probably produced by floating ice-bergs sliding on the ground, were found within these strata at Storsveenfjellet, which indicates shallow water conditions.

Unit 3: The coal-bearing sandstone facies forms the third unit at the top of the sequence. At Schivestolen it comprises 140 m of light-brown to white, feldspar-rich sandstones with thin coal seams, at Locality A (Fig. 1, no.2) only 2 m of this unit

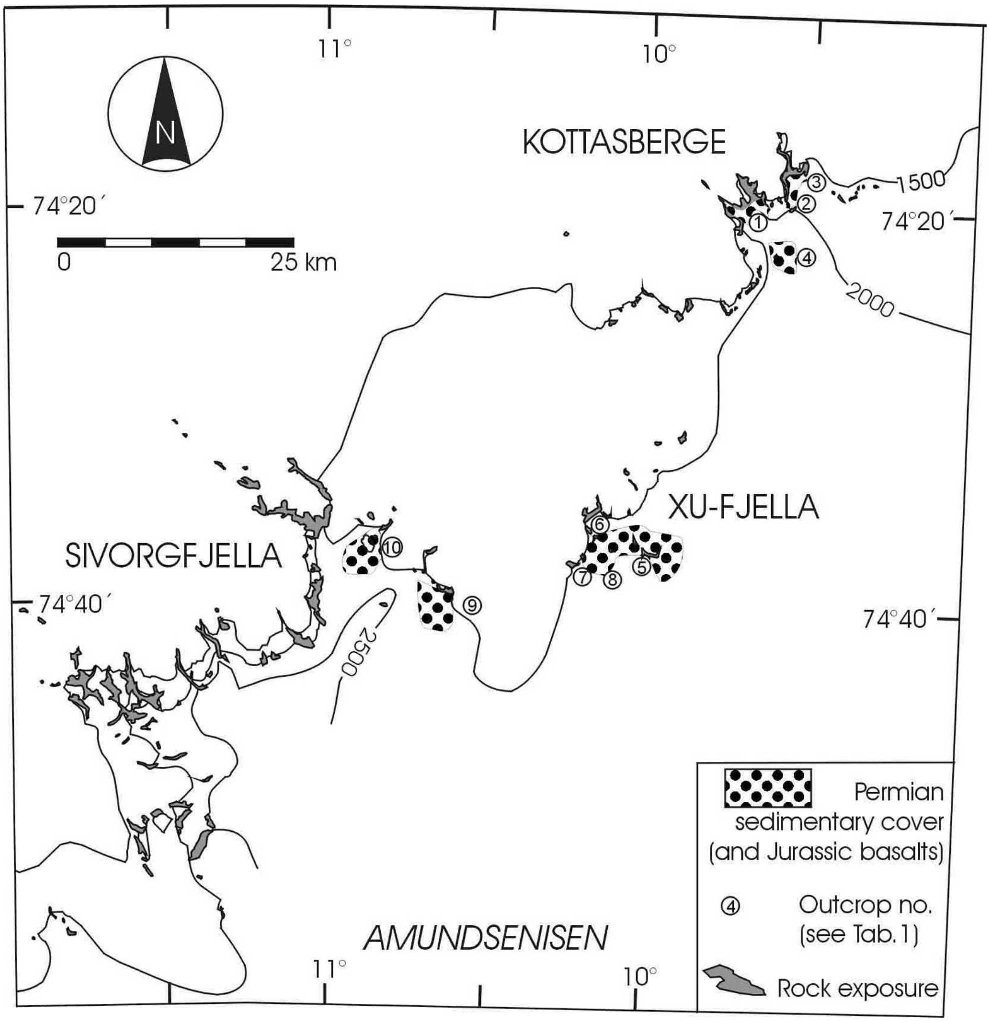

Fig. 1: Exposures of Permian sedimentary rocks in the NE Heimefrontfjella.

Abb. 1: Aufschlüsse des permischen Deckgebirges in der nördlichen Heimefrontfjella.

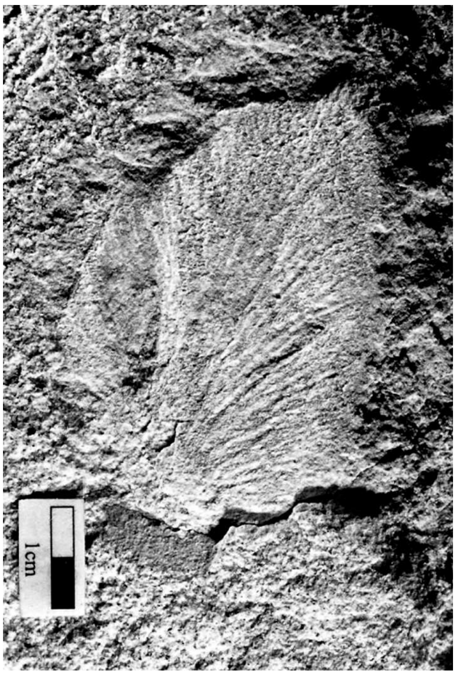

Fig. 2: *Gangamopteris cyclopteroides* FEIST from Locality B (see Tab. 1).

Abb. 2: *Gangamopteris cyclopteroides* FEIST von Lokalität B (siehe Tab. 1).

are preserved. This facies is dominated by fluvial fining-upward sequences, which start with few meters thick cross-bedded sandstones and terminate with few centimetres thick coaly shales or coal-seams. The uppermost 25 m are marked by channels, filled with reworked sediments and conglomerates (POSCHER 1988). The coal seams are composed (ash free) of 45 % vitrinite, 46 % inertinite, and 9 % liptinite (BAUER et al. 1997). The rank of the coal is sub-bituminous C, because it yielded an average vitrinite reflectance of 0.48 % (at 546 nm, oil immersion), which is the lowest rank of Permian coals from Antarctica. The rank increases to meta-anthracite in the vicinity of a Jurassic basalt sill. Additional illite crystallinity measurements were carried out on two pelitic samples from the top of the Schivestolen section. They yielded 0.484 ±0.134 and 0.392 ±0.112 $°\Delta 2\Theta$ respectively (measurements from the laboratory of the Dept of Geology, RWTH Aachen, Germany, BAUER et al. 1997), supporting that the sedimentary cover reached a relatively low thermal maturity. Unit 3 was deposited in a fluviatile to marginal marine environment. Coal seams and coaly shales were formed in swamps within an alluvial or outwash plane.

The entire sedimentary sequence corresponds to typical ice withdrawal sequences subsequent to Gondwana glaciation, comparable to type cycles of the Dwyka Group in South Africa (THERON & BLIGNAULT 1975). The outcrops in Heimefrontfjella represent relics of an originally widespread sedimentary basin from western Dronning Maud Land to the

No.	Locality	Known thickness, lithology	Altitude of basement a.s.l.	References
Kottasberge (sheet Vikenegga)				
1	Schivestolen	160 m section, basal diamictites, sand- and siltstones with thin coal seams	1960 m	JUCKES 1972, POSCHER 1988, 1992, 1994, BAUER et al. 1997
2	"Locality A" Haukelandnuten-SW	6 m, dropstone bearing sandstones, shales with plant fossils	2000 m	JUCKES 1972, POSCHER 1988, 1994, LARSSON et al. 1990
3	"Locality B" Haukelandnuten-E	4 m, sandstones and conglomerates	2000 m	JUCKES 1972
4	"Locality C"	4-6 m of sandstones	not exposed	JUCKES 1972
XU-Fjella (sheet Bjørnnutane)				
5	Bjørnnutane	2 m, vitrified sandstone	2350 m	JUCKES 1972
6	Storsveenfjellet	15-20 m, dropstone-bearing light sandstone, partly cross-bedded	not exposed	LARSSON & BYLUND 1988
7	Hauglandkleppen	5 m, cross-bedded sandstone with dropstones	2220 m	LARSSON & BYLUND 1988
8	Nunatak 2 km west of Bjørnnutane	2-3 m, coarse sandstone, vitrified at the top	not exposed	JUCKES 1972
Sivorgfjella (sheet Gramkroken)				
9	Lidkvarvet	10 m, light sandstones, red and yellow siltstones, ripple marks, cross-bedding, few dropstones	2300 m	JUCKES 1972, PATZELT & JACOBS 1991
10	Berggravrista	not accessible, under overhanging glacier	2150 m	

Tab. 1: Outcrops of the Permian strata and Jurassic basalt sills and flows in the Heimefrontfjella. Nos. refer to Figure 1.

Tab. 1: Liste des Aufschlüsse mit permischem Deckgebirge mit jurassischen Basalt-Sills und -Decken in der Heimefrontfjella. Die Nummern beziehen sich auf Abbildung 1.

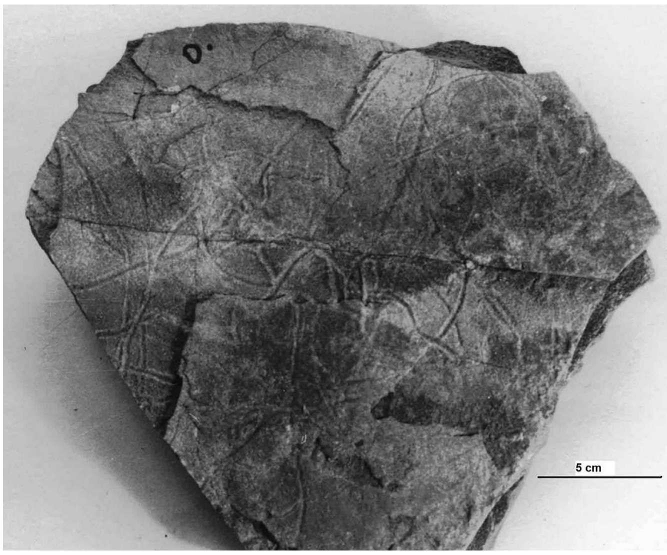

Fig. 3: Grey siltstone with numerous tracks of *Beaconichnus darwinum.* Lowermost part of the Permian at Locality B (see Tab. 1).

Abb. 3: Grauer Siltstein mit zahlreichen Kriechspuren von *Beaconichnus darwinum.* Unterster Abschnitt des permischen Deckgebirges bei Lokalität B (vgl. Tab. 1).

Pacific margin of Antarctica. Equivalents of these strata have also been found in Vestfjella (e.g. HJELLE & WINSNES 1972), Kirwanveggen (e.g. WOLMARANS & KENT 1982), the Theron Mountains and Whichaway Nunataks (BROOK 1972) and the Shackleton Range (TESSENSOHN et al. 1999). The results of detailed sedimentological studies (e.g. OLAUSSEN 1985, POSCHER 1992, 1994, WOLMARANS & KENT 1982) allow a combination of the Upper Palaeozoic post-glacial sedimentary environments in Kirwanveggen (continental), Heimefrontfjella (fluviatile to lacustrine), and Vestfjella (deltaic to marginal marine) to reconstruct a sedimentary basin, which shows similarities to facies conditions in southern Africa (VISSER 1989). The original thickness of the Permian strata cannot be estimated, but the low thermal maturity of organic clasts suggests a relatively thin cover for the Heimefrontfjella area in comparison to other areas with Beacon sediments. VEEVERS & SAEED (2007) dated detrital zircon from Locality A. The main age peaks cluster in two groups at 1140 to 880 Ma and 625 to 512 Ma. This represents a typical age pattern for the East African – East Antarctic Orogen (e.g. JACOBS et al. 1999). The provenance area is supposedly upslope in the interior of the Antarctic continent somewhere in the area of the Gamburtsev Subglacial Mountains (VEEVERS & SAEED 2007).

POST-PERMIAN HISTORY AND PRESENT EXPOSURE PATTERN

A stable platform may have existed in the Permian and Triassic with some pre-Jurassic erosion, which can be proven at least for the outcrop in Bjørnnutane, where only two meters of vitrified sandstone are preserved between the crystalline basement and the overlying Jurassic basalt flows. The next thermotectonic event is related to the beginning break-up of Gondwana, initiated by the Bouvet mantle plume in this sector of the supercontinent (WHITE & MCKENZIE 1989). Voluminous basalts probably covered the whole area that now makes up the Heimefrontfjella. JACOBS et al. (1992) and JACOBS & LISKER (1999) used apatite fission track dating to estimate the original thickness of the Jurassic lava pile. These apatite fission track data revealed that the Jurassic lavas must have been 1500 to

2000 m thick but were rapidly eroded since organic material in the Permian strata does not exceed vitrinite reflection values of 0.5% (BAUER et al. 1997). Rapid uplift in mid-Cretaceous times during plate reorganisation and the formation of the Antarctic continental margin led to block faulting with up to 3 km vertical offsets, producing the present relief (JACOBS & LISKER 1999).

ACKNOWLEDGMENTS

The expeditions to the Heimefrontfjella have been organized by the Alfred Wegener Institute for Marine and Polar Research (AWI) and were led by Gernot Patzelt (Innsbruck). We gratefully acknowledge constructive reviews by Franz Tessensohn, Andreas Läufer, Hubert Miller and Hans-Jürgen Paech. The mapping project was funded by the German Science Foundation (DFG), grants Sp235/8 and We488/27.

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