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Field Relations, Petrography and K-Ar Age Determinations on Magmatic Rocks from Neuschwabenland, Antarctica

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Summary: The Proterozoic country rock at Ahlmannryggen consists of flat lying basaltic to andesitic lava flows and sedimentary rocks intruded by dioritic sills (Borgmassivet Intrusives). The suites display a typical platform cover. K-Ar age determinations gave maximum ages of about 1200 Ma on the magmatic rocks. All these suites were intruded by Proterozoic dikes dated also at about 1200 Ma. Locally the Proterozoic rocks have a slaty cleavage grading into mylonitic texture which strike parallel to the Jutul Penck graben. Such tectonic structures were dated at 525 Ma using syntectonic white micas.
Evidence of the break-up of Gondwana during the Early Jurassic/Triassic is given by dikes at Ahlmannryggen and lava flows, dikes and sills at Vestfjella. At Ahlmannryggen the initial rift phase is documented by the development of the Jutul Penck graben and the intrusion of the 200—250 Ma continental-tholeiitic dikes striking parallel to the graben axis. The lava flows, dikes and sills at Vestfjella represent a later stage of the Gondwana break-up at about 180 Ma that probably reflects the initial stage of the opening of the Weddell Sea.

Zusammenfassung: Die proterozoischen Gesteinsabfolgen im Ahlmannryggen bestehen aus flachliegenden basaltischen bis andesitischen Laven sowie Sedimentgesteinen, die von dioritischen Sills (Borgmassivet Intrusiva) intrudiert werden. Sie repräsentieren typische Plattformgesteinsabfolgen. K/Ar Altersbestimmungen an den Magmatiten ergaben Maximumalter um 1200 Ma. Ähnliche Alter wurden auch an magmatischen Gängen ermittelt, die in die Plattformgesteine eingedrungen sind. Die proterozoischen Abfolgen können lokal von einer Schieferung durchzogen sein, die in mylonitische Strukturen münden kann. Diese tektonischen Strukturen streichen parallel zum Jutul Penck Graben und konnten anhand synektonisch gesproßter Hellglimmer mit 525 Ma datiert werden.
Die frühjurassische/triassische Gondwanaaufspaltung ist im Ahlmannryggen durch magmatische Gänge und in Vestfjella durch Laven, magmatische Gänge und Sills dokumentiert. Im Ahlmannryggen ist die initiale Riftphase mit der Entstehung des Jutul Penck Grabens und der Intrusion der parallel zur Grabenachse streichenden tholeiitischen Gänge mit Altern um 200—250 Ma verknüpft. Die Laven, Gänge und Sills Vestfjellas mit Altern um 180 Ma repräsentieren eine spätere Phase der Gondwanaaufspaltung und stehen möglicherweise in engem Zusammenhang mit der beginnenden Öffnung des Weddell Meeres.

1. INTRODUCTION

Western and central Neuschwabenland is situated between two significant rift zones, the Jutul Penck graben to the east and the Weddell Sea to the west (Fig. 1). The geology of this region is of great importance to the understanding of the geotectonic setting of this part of Antarctica in eastern Gondwana and the crustal evolution before the break-up of Gondwana. Furthermore the development of the Ross Orogeny in the Weddell Sea sector is still open to question. The areas studied in western and central Neuschwabenland deal with the central and NE Ahlmannryggen and the Boreas and Robertskollen nunataks as well as the northern nunataks of Vestfjella (Fig. 1). The geochronological studies were aimed at determining the age of the magmatite complexes occurring in these areas.

At Ahlmannryggen previous authors determined a Precambrian age for the exposed magmatites. The effusive rocks outcropping in the northeastern Ahlmannryggen and the intrusive rocks exposed in the central and northwestern yielded ages of about 1700 Ma, 1000—1200 Ma, and 800—900 Ma, respectively (WOLMARANS & KENT 1982). Whether these episodes were characterized by three different magmatic events or reflect one magmatic episode of 1700 Ma overprinted by two thermal events at 1000—1200 Ma and 800—900 Ma is, however, still unknown. An age of 192 Ma was determined for one Mesozoic dike (WOLMARANS & KENT 1982).

Works previously published on the rock sequences in Vestfjella were restricted to the southwestern areas of this region. Only HJELLE & WINSNES (1972) have petrographically and structurally described the magmatite sequences of southern and northern Vestfjella. Initial K/Ar whole-rock analyses on samples from northern Vestfjella yielded an age of 220 Ma for a dolerite sill and of about 400 Ma for a lava flow (KRYLOV in HJELLE & WINSNES 1972). These ages also provided a basis for the first age classification of the volcanite sequence (CRADDOCK 1972).

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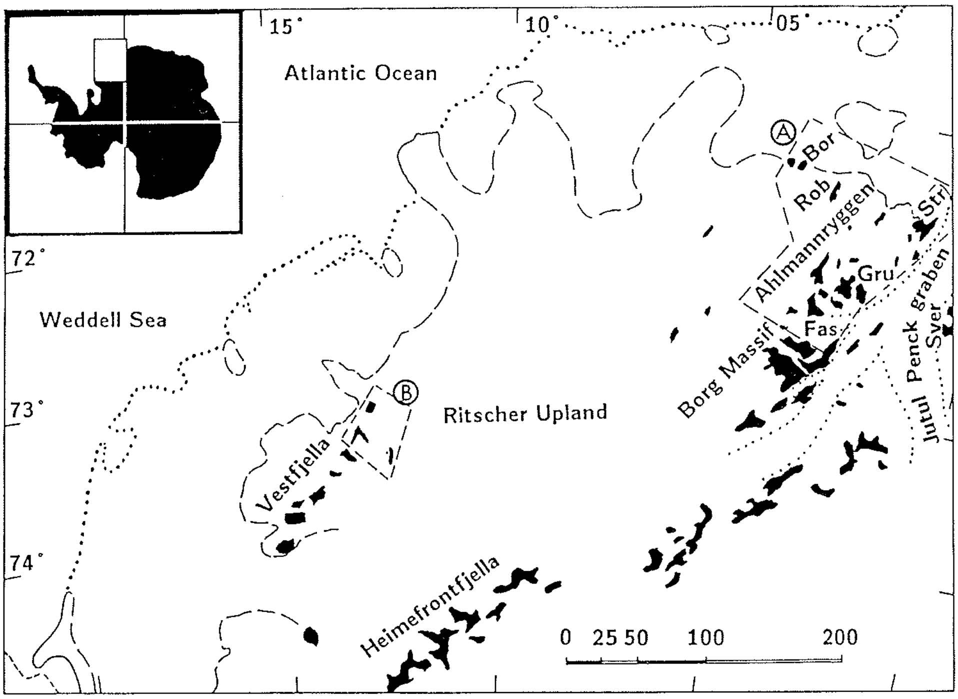

Fig. 1: Areas of investigation. A area of investigation at Ahlmannryggen (field saison 1983/84). **Bor** Passat-Boreas nunataks; **Rob** Robertskollen nunataks; **Gru** Grunehogna area, **Str** Straumsnutane. **B** area of investigation at Vestfjella (field saison 1982/83).

Abb. 1: Untersuchungsgebiete: A Ahlmannryggen (Feldsaison 1983/84). **Bor** Passat-Boreas Nunataks, **Rob** Robertskollen Nunataks, **Gru** Grunehogna, **Str** Straumsnutane. **B** Nördliches Vestfjella (Feldsaison 1982/83).

Other K-Ar whole-rock analyses on samples from dikes and lava flows from southwestern Vestfjella yielded 154—172 Ma and 200—695 Ma, respectively (FURNES & MITCHELL 1978, FURNES et al. 1982, FURNES et al. 1987).

2. FIELD RELATIONS AND PETROGRAPHICAL STUDIES

The following mineral abbrevations were used: ol = olivine, plag = plagioclase, opx = orthopyroxene, cpx = clinopyroxene, chl = chlorite, hbl = hornblende, bio = biotite, Ti-bio = Titanium-rich biotite.

Ahlmannryggen

The most conspicuous regional structure in central Neuschwabenland is the Jutul Penck graben, which was interpreted as a rift structure by NEETHLING (1970, 1972). On the western margin of this graben, the nunataks of the northeastern Ahlmannryggen (Straumsnutane region Fig. 1) extend over 60 km in a NNE-SSW direction and are composed of Precambrian amygdaloidal andesitic lava flows in which pillow lavas and thin layers of quartzitic tuffite are intercalated (Fig. 2). The total thickness of this sequence is about 860 m (WATTERS 1972). The thickness of the mostly horizontal individual lava flows varies from less than one meter up to 55 m. In addition to small portions of pseudomorphically replaced ol + opx, the flows contain high amounts of devitrified glass and partially porphyritic plag + cpx + opaque minerals. The lavas have all been altered by extensive epidotization, chloritization, and sericitization. Sediment intercalations display typical shallow-water structures, such as ripple marks, mudcracks, and cross-bedding.

In the central Ahlmannryggen (Grunehogna area, Fig. 1) located 50 km to the south no lava flow occur; the

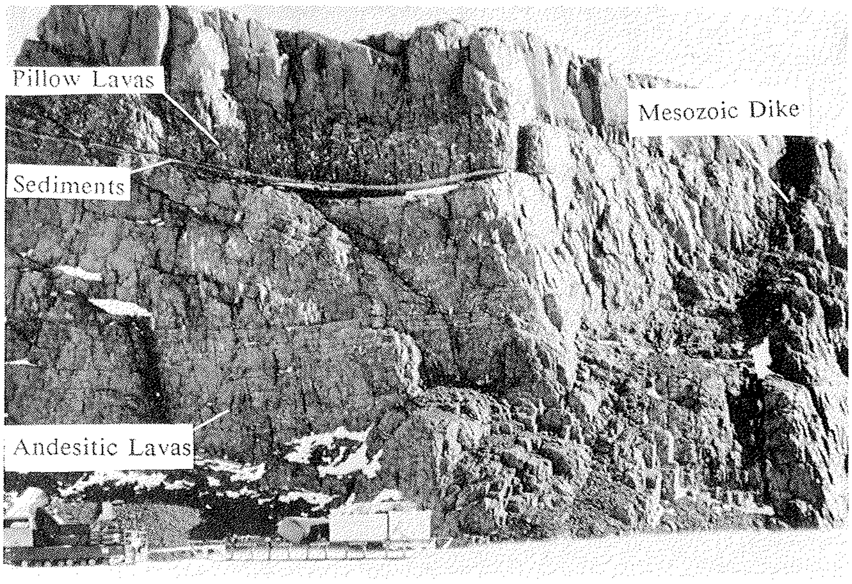

Fig. 2: SE wall of Snökallen at Straumsnutane. Hight of wall approximately 400 m.

Abb. 2: SE-Wand des Snökallen in Straumsnutane. Wandhöhe ca. 400 m.

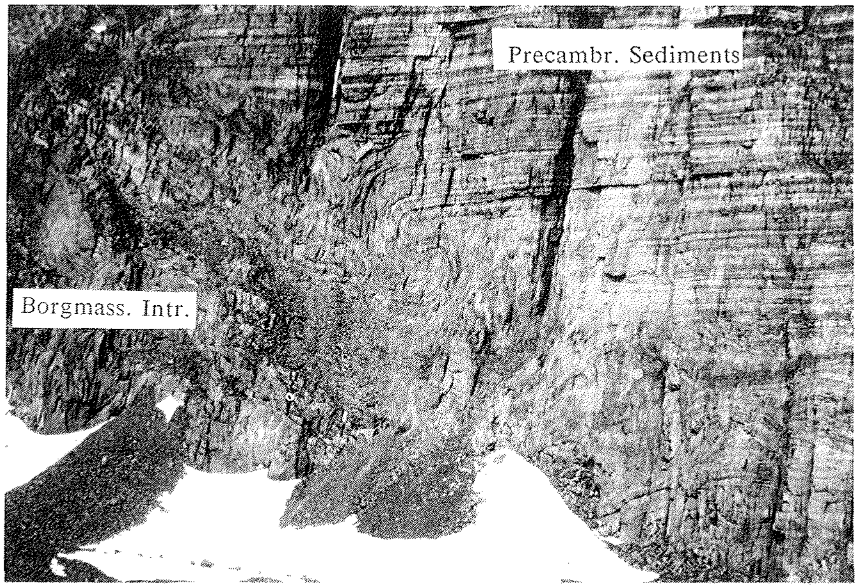

Fig. 3: NE wall of nunatak 1265 at Grunehogna. Height of wall approximately 300 m.

Abb. 3: NE Wand von Nunatak 1285 von Grunehogna. Wandhöhe ca. 300 m.

mountain chains here are composed of Precambrian, horizontal, shallow-water sediments, intruded by the Borgmassivet Intrusives (Fig. 3). These intrusions are mostly horizontal dioritic sills up to 200 m thick showing in-situ differentiation (crystal fractionation of ilmenite, plag). Xenoliths of sedimentary origin within the sills show characteristics consistant with the formation of small amounts of partial melt in the contact to the magmatic rocks. Quartz grains probably derived from sedimentary rocks are extremely corroded. The majority of the sills has been intensively altered. The only preserved magmatic mineral phases are plag (sericitized and albitized) + cpx with opx exsolution lamellae + opaque minerals. The formerly glass-rich groundmass has been replaced by white mica + chl + green hbl + myrmekite. Biotite is usually related to ore-minerals. The same petrographic characteristics were determined in the sill at Passat and Boreas nunataks (Fig. 1) in the northwestern Ahlmann-ryggen (where only the sill is exposed, but the sedimentary country rock is eroded).

It is still unclear whether the effusive complexes at Straumsnutane, Passat-Boreas sill and the Borgmassivet Intrusives can be temporally correlated.

Slightly inclined dikes (Fig. 4) with a coarse-grained texture crosscut the magmatic and sedimentary country rock. They are characterized by partly intensive alteration (mineral contents: ol + cpx + plag + Ti- bio ± basaltic hbl + opaques). It is striking that these dikes have generally imposed a strong contact metamorphism on the country rock. Some of these dikes have been tectonically deformed and, just like the Precambrian country rock, show a slaty cleavage. Particularly in these zones alteration has completely obliterated the original magmatic mineral composition. In zones of lesser tectonic deformation albitization and slight sericitization of plagioclase are the only effects of alteration. The magmatic mineral composition of the dikes consists of plag + cpx + ol + Ti-bio + opaques ± opx.

Along the escarpment on the western margin of the Jutul Penck graben a slaty cleavage, striking parallel to the graben axis with transitions into mylonitic textures was observed in the lava flows at Straumsnutane. Some of the abovementioned dikes are also included into the mylonitization. The mylonitization is marked by the tectonic formation of chlorite and white mica that is strongly oriented in the s-planes. The vesicles of the magmatic rocks have been elongated in the s-planes and their secondary mineral fillings of quartz and calcite are partly recrystallized. The twinning lamellae of nonrecrystallized calcite are partially deformed similar to kink bands.

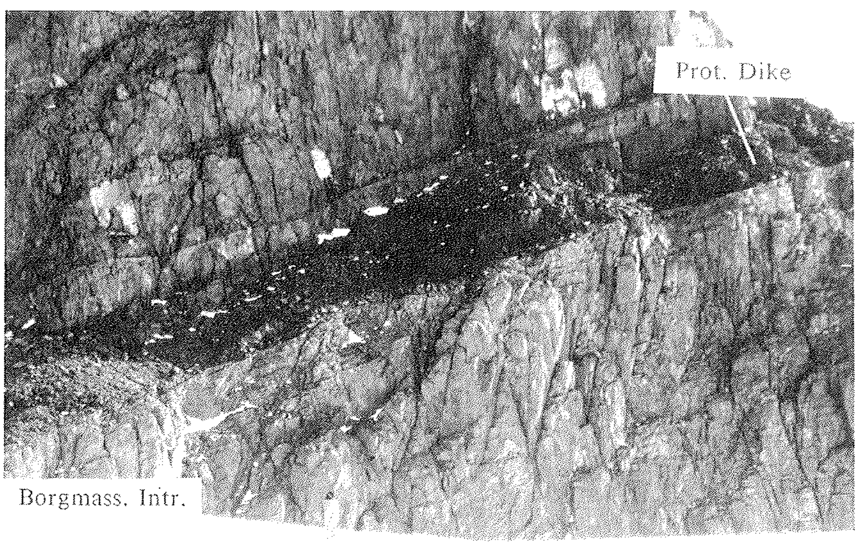

Fig. 4: E wall of Grunehogna nunatak. Height of wall approximately 350 m.

Abb. 4: E-Wand des Grunehogna Nunataks. Wandhöhe ca. 350 m.

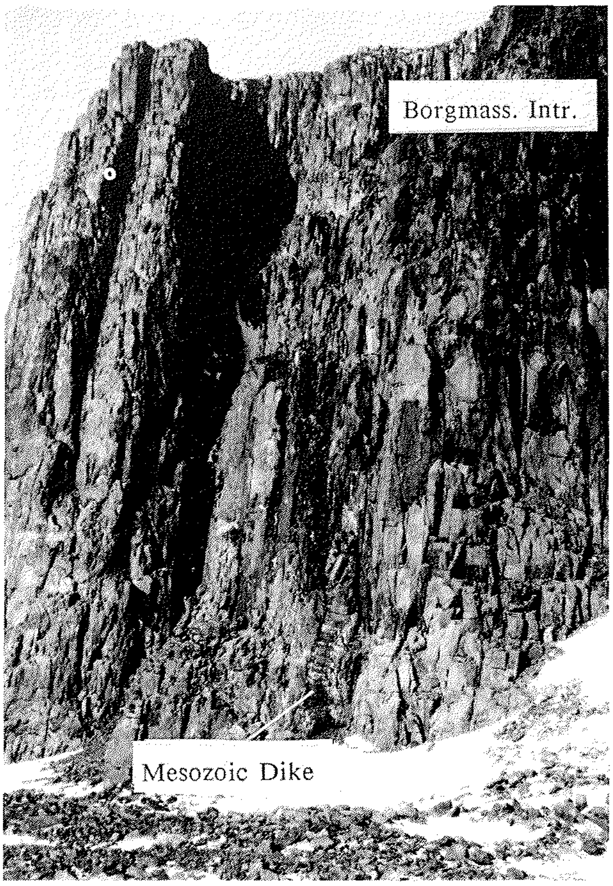

Fig. 5: N wall of Grunehogna nunatak. Height of wall aproximately 250 m.

Abb. 5: N-Wand des Grunehogna Nunataks. Wandhöhe ca. 250 m.

Quartz displays undulatory extinction and deformation bands, in addition to initial recrystallization.

The Precambrian sequences and their tectonic structures described above were intruded by a further dolerite dike generation that is, if at all, only slightly altered. Most of these dikes are ± vertical (Fig. 2 and 5) and favourably intruded preexisting faults. They show a fine-grained, partially porphyritic texture. Their mineral composition consists of plag + porphyritic cpx + finegrained cpx + opx + ol + opaques ± glass. There are no indications of differentiation by crystal fractionation. Xenoliths which show some similarities to basement rocks were observed in several of these dikes. The contact metamorphic xenoliths are rich in quartz, prehnite, epidote, babingtonite, and calcite. In these fine-grained, partly porphyritic dolerites there are no indications of tectonic deformation so that these rocks must be younger than the cleavage and local mylonitization.

Northern Vestfjella

The nunataks in the northern part of Vestfjella (Fig. 1) extend over 50 km in a NNE-SSW direction. Mainly the Plogen and Basen massifs were the object of investigation here, in addition to the nunataks Fossilryggen, Puggelryggen, Salryggen, and Dagvola. The outcropping rocks of this area consist of horizontal or slightly SW-dipping (10° at Plogen) vesicle-rich basalt flows (Fig. 6) with intercalations of subordinate picrite, pyroclastics, and thin tuffitic, contact-metamorphosed quartzites. Subaerial magmatism can be presumed due to the collective field observations, particularly pahoehoe lavas, the red colouring of the lava surfaces and the lack of pillow lavas. The thickness of the volcanic sequence is unknown since neither the top nor the base of the sequence is exposed; yet, thickness of >1000 m can be assumed. These effusive stacks are crosscut by numerous dolerite

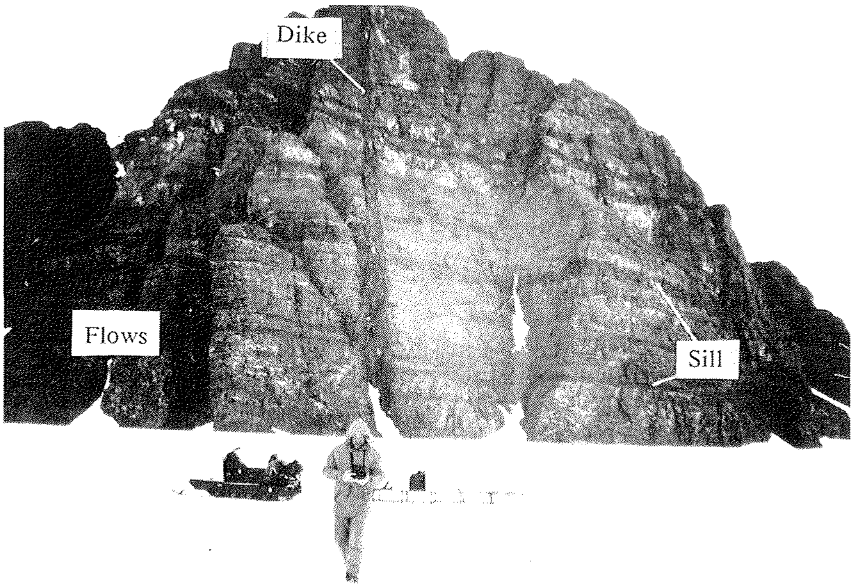

Fig. 6: Part of the NE wall of the Plogen massif at N Vestfjella. Height of wall approximately 600 m.

Abb. 6: NE-Wand des Plogen Massivs im nördlichen Vestfjella. Wandhöhe ca. 600 m.

dikes and sills (Fig. 6), which in contrast to the lava flows, have been hardly altered. The lava flows have been coloured green through conspicuous secondary mineralization (prehnite, pumpellyite, epidote, calcite, chlorite and quartz) bound in part to voids and gas vesicles and intensive pseudomorphic replacement of magmatic mineral phases as well as intensive sericitization and saussuritization of plagioclase whereas dikes and sills show no other alteration effects except for serpentinization and saponitization of opx (bastite) and slight albitization of plagioclase. Except for the difference in alteration intensity lava flows, dikes and sills have identical magmatic mineral composition. They are either aphyric or contain up to 5 vol% phenocrysts, which either swim as separate crystals in the mesostasis, or occur as glomerophyric aggregates. The phenocryst phases consist of: (1) cpx + plag, (2) cpx + plag ± ol ± opx, (3) ol + opx. The matrix consists of cpx + plag + opaque minerals.

The opaque mineralizations contain ilmenite + magnetite with ilmenite exsolution lamellae + chalcopyrite + pyrrhotite with pentlandite exsolution lamellae + secondary hematite. According to their magmatic mineral association differentiation mechanisms were dominated by crystal fractionation of ol, cpx, opx, plag producing basaltic andesites and picrites, respectively.

In the vicinity of these magmatic sequence Permian sediment sequences are exposed at Fossilryggen which have been described in detail by HJELLE & WINSNES (1972). These sediments, which were also intruded by dikes, are located at 730 m alt., whereas the probably post-Permian lava flows at Plogen and Basen crop out above ice surface at 300 m alt. It can hence be assumed that the NE-SW-oriented volcanite chain of Vestfjellas has sunk at least several hundred meters along a similarly oriented fault zone relative to the Fossilryggen. The dikes of this region predominantly strike NE-SW. Hence, there may be a correlation between the intrusion of the dikes and the abovementioned faulting, which may represent extension structures. The sporadic development of slickensides at the contact between the dikes and the country rock, the NW block being downfaulted, is noteworthy. It can thus be assumed that the abovementioned faulting outlived the intrusion of the dikes.

3. GEOCHRONOLOGY

K-Ar methods were used for age determinations. To delimit the effects of alteration to a minimum the freshest possible phases of plagioclase, groundmass, and comagmatic Ti-rich biotite were concentrated. It was also possible to separate white mica from a local mylonite zone. At least 33 analyses were carried out.

Ahlmannryggen

Ages of 1109 ± 33 Ma and 1183 ± 33 Ma were obtained from comagmatic Ti-bio of the coarsergrained dikes (Table 1). The oldest ages determined for plagioclase and groundmass from the lava flows at Staumsnutane and Borgmassivet Intrusives are also close to these values. All younger ages determined on samples of the Borgmassivet Intrusives and lavas at Straumsnutane are interpreted as ages of overprinting. These younger ages can be attributed to a tectono-thermal event which was dated at 522 ± 11 and 526 ± 11 Ma using syntectonically grown white mica from a local mylonite zone exposed at northern Straumsnutane (Table 1).

No. Sample		No. Site		Locality	Mineral	Rock type	t ± 1σ (Ma)	$^{40}Ar^* \times 10^{-6}$ cm^3/g STP	^{40}K (%)
SK	4	A	1	Snökallen	strongly sericitisized plag	flow	872 ± 25	225.00	5.2
SK	4	A	1	Snökallen	altered groundmass	flow	465 ± 16	54.50	2.6
SK	28	A	2	Snökallen	weakly altered plag.	flow	1115 ± 37	54.00	0.9
SK	36	A	3	Snökallen	altered groundmass	flow	460 ± 16	40.60	2.0
SK	36	A	3	Snökallen	strongly sericitisized plag.	flow	666 ± 22	124.00	4.0
820/237		A	15	Nunatak 820	weakly altered plag.	flow	1063 ± 36	178.00	3.2
820/237		A	15	Nunatak 820	altered groundmass	flow	699 ± 24	37.30	1.1
Gr	293	A	32	Grunehogna	plag.	Borgmassivet Intrusives	666 ± 26	22.40	0.7
Ro	318	A	39	Roberts-kollen	biotite (comag.)	dike	1109 ± 33	419.00	7.0
R0	318	A	39	Roberts-kollen	plag.	dike	751 ± 29	10.40	0.3
Gr	277	A	33	Grunehogna	weakly altered plag.	dike	842 ± 30	14.76	0.4
Gr	277	A	33	Grunehogna	groundmass	dike	1143 ± 39	31.57	0.5
Gr	277	A	33	Grunehogna	biotite (comag.)	dike	1183 ± 33	398.00	6.9
Ut	245	A	18	Utkikken	muscovite fraction <2 μm	mylonite zone	526 ± 11	97.90	4.6
Ut	245	A	18	Utkikken	muscovite fraction 2—6 μm	mylonite zone	522 ± 11	117.20	4.9
SK	74	A	23	Snökallen	fresh groundmass	olivine dike	281 ± 18	5.01	0.4
SN	107	A	5	Snökjeringa	fresh groundmass	dike	246 ± 20	2.46	0.2
Gr	293	A	32	Grunehogna	groundmass	olivine dike	202 ± 18	2.47	0.3

Tab. 1: K-Ar mineral ages of magmatic rocks and their mylonitic alteration products at Ahlmannryggen.

Tab. 1: K/Ar-Mineralalter an magmatischen Gesteinen und deren Alterationsprodukten aus dem Ahlmannryggen

The fine-grained, partly porphyritic dikes at Ahlmannryggen were dated at 202 ± 18 Ma, 246 ± 20 Ma, and 281 ± 18 Ma (Table 1).

Vestfjella

Datings on magmatic samples from northern Vestfjella (plagioclase, groundmass, Table 2) yielded ages of 150—190 Ma with a distinct maximum at about 180 Ma for flows as well as dikes and sills. Only two older values (>200 Ma) found for one dike and one flow can have been caused by excess argon. One value of about 90 Ma determined for a lava flow of the Basen massif was obtained twice by a double Ar determination and is not interpretable in the geologic context.

4. DISCUSSION AND CONCLUSION

The extensive hydrothermal alteration of the majority of the Proterozoic basalts at Ahlmannryggen may have caused errors in the interpretation of the former K-Ar age determinations. It becomes clear that K-Ar whole rock datings are insufficient in solving age problems of altered basaltic rocks. K-Ar age determinations on magmatic mineral concentrates although being problematically in some cases provide more useful results. But K-Ar age determinations on concentrates of plagioclase and groundmass must be handled with care (see Table 1: sample no. Ro 318 and Gr 277). In comparison to plagioclase biotite gives much higher ages. In the Proterozoic rocks at Ahlmannryggen biotite ages are interpreted as crystallisation ages and all younger ages as ages of overprinting.

Sample No.		No. Site		Locality	Mineral	Rock type	t ± 1σ (Ma)	$^{40}Ar^{*} \times 10^{-6}$ cm^3/g STP	^{40}K (%)
Pl	41	A	2	Plogen	whole rock	flow	176 ± 10	6.02	0.9
Pu	32	A	8	Puggelryggen	whole rock	flow	325 ± 2[1]	3.25	0.2
Pl	45	A	14	Plogen	plagioclase	flow	189 ± 10	16.60	2.2
Pl	45	A	14	Plogen	groundmass	flow	148 ± 10	5.25	0.9
Pl	92	A	26	Plogen	plagioclase	flow	179 ± 13	11.80	1.6
Pl	92	A	26	Plogen	groundmass	flow	169 ± 13	2.93	0.4
Ba	77	A	19	Basen	groundmass	flow	90 ± 9[2]	3.23	0.9
Pu	33	A	10	Puggelryggen	plagioclase	dike	295 ± 19[1]	2.84	0.2
Pu	33	A	10	Puggelryggen	groundmass	dike	197 ± 10	8.57	1.1
Fo	195	A	7	Fossilryggen	plagioclase	dike	174 ± 13	3.38	0.5
Fo	195	A	7	Fossilryggen	groundmass	dike	183 ± 20	1.01	0.2
Pl	84	A	26	Plogen	plagioclase	dike	160 ± 16	2.96	0.5
Pl	84	A	26	Plogen	groundmass	dike	171 ± 15	2.95	0.4
Ba	60	A	18	Basen	groundmass	dike	180 ± 11	3.55	0.5
Pl	85	A	26	Plogen	groundmass	sill	174 ± 16	1.93	0.3

Tab. 2: K-Ar mineral ages of intrusive and effusive rocks from Vestfjella. 1) The high values are probably caused by excess argon, that can be derived from arcose xenoliths found in the vicinity of these dated dikes. 2) Error probably caused by K-assimilation from sediment xenoliths.

Tab. 2: K/Ar-Mineralalter an Intrusiv- und Effusivgesteinen von Vestfjella.

According to our investigations in the Proterozoic there is no evidence for more than one magmatic event at Ahlmannryggen. This activity probably took place around 1200 Ma. It can be assumed that the difference in age between the Proterozoic dikes, lava flows at Straumsnutane and the Borgmassivet Intrusives may be relatively small. The crystallization age of the Proterozoic dikes (at about 1200 Ma) represents the minimum age of the lavas and intrusive rocks and all the Proterozoic magmatic rocks of this region may be assigned to the same geodynamic event. Therefore an age of of about 800 Ma for the Proterozoic magmatic and sedimentary rocks at Ahlmannryggen (as believed by former authors) can be ruled out.

The depositional environment of the sedimentary sequences in central Ahlmannryggen was largely fluvial with local marine embayments (BREDELL 1973, 1976, 1982, WOLMARANS & KENT 1982; FERREIRA 1986). The Borgmassivet Intrusives mainly were emplaced at shallow crustal levels because they show reactions with wet wall rock. The Straumsnutane basalts reflect largely subaerial lava flows. Local intercalations of pillow lavas suggest subaquous extrusions (marine or lacustrine: WATTERS 1969, 1972; KRYNAUW et al. in press). In spite of the effects of the Ross Orogeny (450—600 Ma) and the related tectonic deformation structures the Proterozoic magmatic complexes and the related sediments were only locally overprinted by subsequent tectonomagmatic activity and slightly affected by metamorphism. This is typical of a stable crustal region (shield, craton or platform). The platform rocks (granite and high metamorphic complexes) are exposed at Annandagstoppane situated South-West of Ahlmannryggen (2800 to 3200 Ma, HALPERN 1970, ALLSOPP published in WOLMARANS & KENT 1982). It is suggested that these basement rocks represent the basis of the volcano-sedimentary complex at Ahlmannryggen.

The development of the observed mylonite zones was caused by a tectono-thermal event dated at about 525 Ma and is believed to represent the Ross Orogeny proven for the first time in this region. This event was also established in Southern Africa named "Pan African" and may reflect the close spatial correlation between the eastern part of South Africa and Neuschwabenland in the Paleozoic.

At Ahlmannryggen only fresh groundmass concentrates of the Mesozoic dikes were geochronologically analyzed. The extremely low K-values indicate some analytical errors and may explain the high difference in the obtained K-Ar ages. Nevertheless, paleomagnetic investigations indicate an age of about 200—250 Ma (Trias) for these dikes (PETERS et al. in press).

At Vestfjella nearly identical ages for the fresh dikes and sills on one hand the altered flows on the other on plagioclase and groundmass concentrates may indicate that the lava flows were overprinted by the intrusion of dikes and sills and therefore overprinting ages for the flows were obtained. Paleomagnetic results of a significantly lower pole latitude for the flows in comparrison to the majority of the dikes also may indicate age differences (PETERS et al. in press). Nearly identical pole positions were found on Ferrar dolerites of Wright and Victoria Valleys (BULL et al. 1962) and Kirkpatrick basalts of Queen Alexandra Range (OSTRANDER 1971). But these pole positions definitely do not reflect an older crystallisation age for these basaltic rocks, because KYLE et al. (1981) determined an age of about 180 Ma by serveral geochronologic methodes (so these poles represent anomalous pole positions). Therefore it is concluded that the lava flows of Vestfjella (with their nearly identical anomalous pole positions) as well as dikes and sills have crystallization ages of about 180 Ma (in the contrary to the results of PETERS et al. in press).

In comparison to Ahlmannryggen an increase in number of dikes is observed in the lava flows of northern Vestfjella. Their total thickness in northern Vestfjella yields an extension of more than 4% in a NW-SE direction (SPAETH 1987). At Ahlmannryggen much smaller amounts of extension must be assumed based on the lower number of dike intrusions. This observation can be interpreted as indication of increase in crustal extension to the west toward the present continental margin. According to our investigations the Mesozoic Gondwana break-up must be interpreted as a two phases process. At Ahlmannryggen the initial rift phase is documented by the development of the Jutul Penck graben and the intrusion of the Triassic dikes along older lineaments striking parallel to the graben axis (SPAETH & PETERS 1984). The older lineaments of Ross Orogeny age were reactivated as extension structures. Probably some other graben systems proven by other authors in the Weddell Sea area (HINZ & KRAUSE 1982; HINZ & KRISTOFFERSEN 1987), Kirvanveggen (WOLMARANS & KENT 1982; KRYNAUW et al. in press) and Heimefrontfjella (pers. com. M. DEGUTSCH, F. THYSSEN, Münster, H. MILLER, Bremerhaven) may belong to this initial phase interpreted as a failed rift structure.

The lava flows, dikes and sills at Vestfjella may represent a later stage of the Gondwana break-up at about 180 Ma, that caused the opening of the Weddell Sea. The second phase may also be represented by the Explora Andenes Escarpment proven by HINZ & KRISTOFFERSEN (1987), because the dikes at Vestfjella strike parallel to this structure. In the Weddell Sea area the Explora Andenes Escarpment cuts older lineaments (HINZ & KRISTOFFERSEN 1987) probably belonging to the initial phase of the Gondwana break-up documented at Ahlmannryggen.

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