Geology of Gjelsvikfjella and western Mühlig-Hofmannfjella, Dronning Maud Land, east Antarctica

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Ohta, Y., Tørudbakken, B. O. & Shiraishi, K. 1990: Geology of Gjelsvikfjella and western Mühlig-Hofmannfjella, Dronning Maud Land, east Antarctica. *Polar Research 8*, 99–126.

As a part of the Norwegian Antarctic Research Expedition 1984/85, geological mapping was performed in Gjelsvikfjella and western Mühlig-Hofmannfjella, Dronning Maud Land. The northern part of Gjelsvikfjella is dominated by the Jutulsessen metasupracrustals which have been intruded by a major gabbroic body and several generations of dykes. To the south the metasupracrustals gradually transform into the Risemedet migmatites. In western Mühlig-Hofmannfjella the bedrock is dominated by the large Svarthamaren Charnockite batholith. The batholith is bordered by the Snøtoa metamorphic complex outcropping to the south and west in Mühlig-Hofmannfjella and it is characterized by a high content of partly assimilated country rock inclusions. Mineral paragenesis and geothermometry/geobarometry suggest a two-stage tectonothermal-igneous history with an initial intermediate pressure, upper amphibolite to granulite facies metamorphism followed by high temperature transformations related to the charnockite intrusion. The age of the initial tectonothermal event is probably about 1,100 Ma. Geochronological work in the present study (Rb/Sr whole rock) gave an age of 500 ± 24 Ma for the Svarthamaren Charnockite, interpreted to record the age of crystallization. Late brittle faulting and undeformed dolerite dykes outcropping in Jutulsessen are believed to be related to Mesozoic crustal stretching in the Jutulstraumen-Pencksøkket Rift Zone to the west.

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The studied area is located to 2°-5°35′E and 71°46′-72°15′S, on the eastern side of the Jutulstraumen-Pencksøkket Rift Zone (J-P RZ) (Neethling 1972) which separates a Proterozoic platform to the west and high-grade metamorphic areas to the east (Fig. 1). The J-P RZ is a key tectonic structure in correlating this part of Antarctica with the southeastern part of Africa (Grantham et al. 1988).

Metamorphic rocks in the study area were first described by Roots (1953) and widespread reconnaissance mapping was undertaken by Soviet geologists (Ravich & Soloviev 1966), who also carried out radiometric dating on the rocks (Ravich & Krylov 1964). A 1:1.5 million scale geological map has been edited by Roots (1969) in the Antarctic Map Folio Series.

The H.U. Sverdrupfjella area to the southwest has been described by Hjelle (1972). He recognized three lithological units, of which the Sveabreen Formation (granitized gneisses and migmatites of upper amphibolite facies) and the Rootshorga Formation (psammo-pelitic, metamorphosed supracrustals) extend into the present area.

Grantham et al. (1988) have described the geology and petrology of northern H.U. Sverdrupfjella in detail. They separated various igneous rocks from Hjelle's lithostratigraphic formations and carried out some age determinations. The oldest obtained age is about 900 Ma (Rb-Sr whole rock) from conformable granitoids in the gneisses. Late tectonic granites are about 470 Ma (Rb-Sr whole rock). The highest grade metamorphism, possibly a late magmatic stage, is determined to about 850°C and 9–11 kb. Most rocks were metamorphosed under conditions of about 560°–690°C and 5–6 kb, followed by a retrograde overprinting. An alkaline complex near the J-P RZ has been dated to about 182 Ma (40Ar-39Ar) and 170 Ma (Rb-Sr, Allen 1990), indicating young extensional activity along the rift zone.

According to Ravich & Krylov (1964), western Mühlig-Hofmannfjella consist of high-grade metasupracrustals of pre-Riphean ages and a

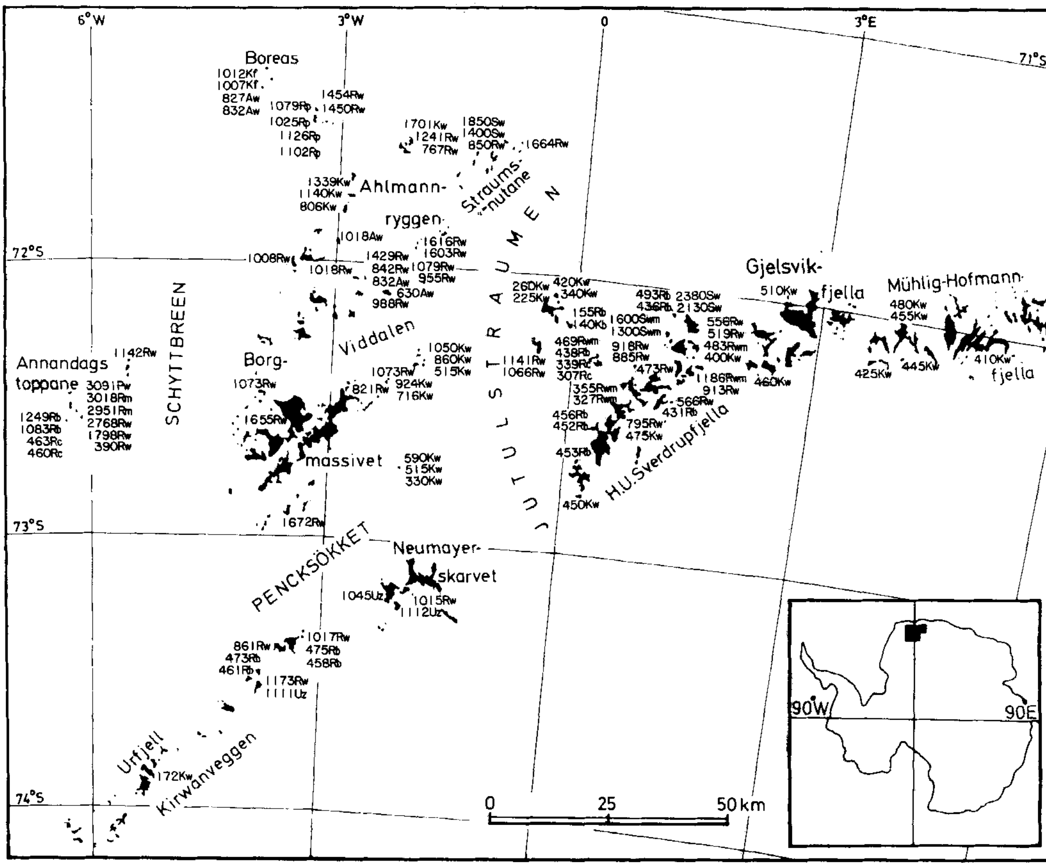

Fig. 1. Distribution of exposures in western Dronning Maud Land. The study area is in the eastern part of the map. Numbers: radiometric ages in million years (Ma) obtained by various methods (Ravich & Krylov 1964; Krylov 1972; Wolmarans & Kent 1982; Moyes 1989). Analytical methods: P: Pb/Pb, U: U/Pb, R: Rb/Sr, S: Sm/Nd, A: 40Ar/39Ar, K: K/Ar. Analysed samples: w: whole rock, b: biotite, m: muscovite, p: phengite, c: chlorite, z: zircon, f: feldspar, wm: whole rock-mineral.

granite-granosyenite complex. Their K/Ar and Rb/Sr whole rock ages range from 400 to 480 Ma, with a 510 Ma age from Gjelsvikfjella.

The Norwegian Antarctic Research Expedition 1984–85 mapped the main part of Gjelsvikfjella and western Mühlig-Hofmannfjella.

Description of regional geology

Gjelsvikfjella

In Gjelsvikfjella the geological mapping covered Jutulsessen, Risemedet and Terningskarvet. The southwestern parts, including southwest Jutulsessen, Nupskammen and Von Essenskarvet were not visited, but distant observations were made from Terningskarvet towards these areas (Fig. 2).

Three major lithologic units have been recognized:

—Metagabbros in northeastern Jutulsessen
—Jutulsessen metasupracrustals
—Risemedet migmatites

Three subordinate dyke types were also recognized:

—Aplite-pegmatite dykes
—Metabasic dykes
—Mesozoic dolerite

Metagabbros

The metagabbro in Jutulsessen occurs as an intrusive body about 7 km long and 1 km wide.

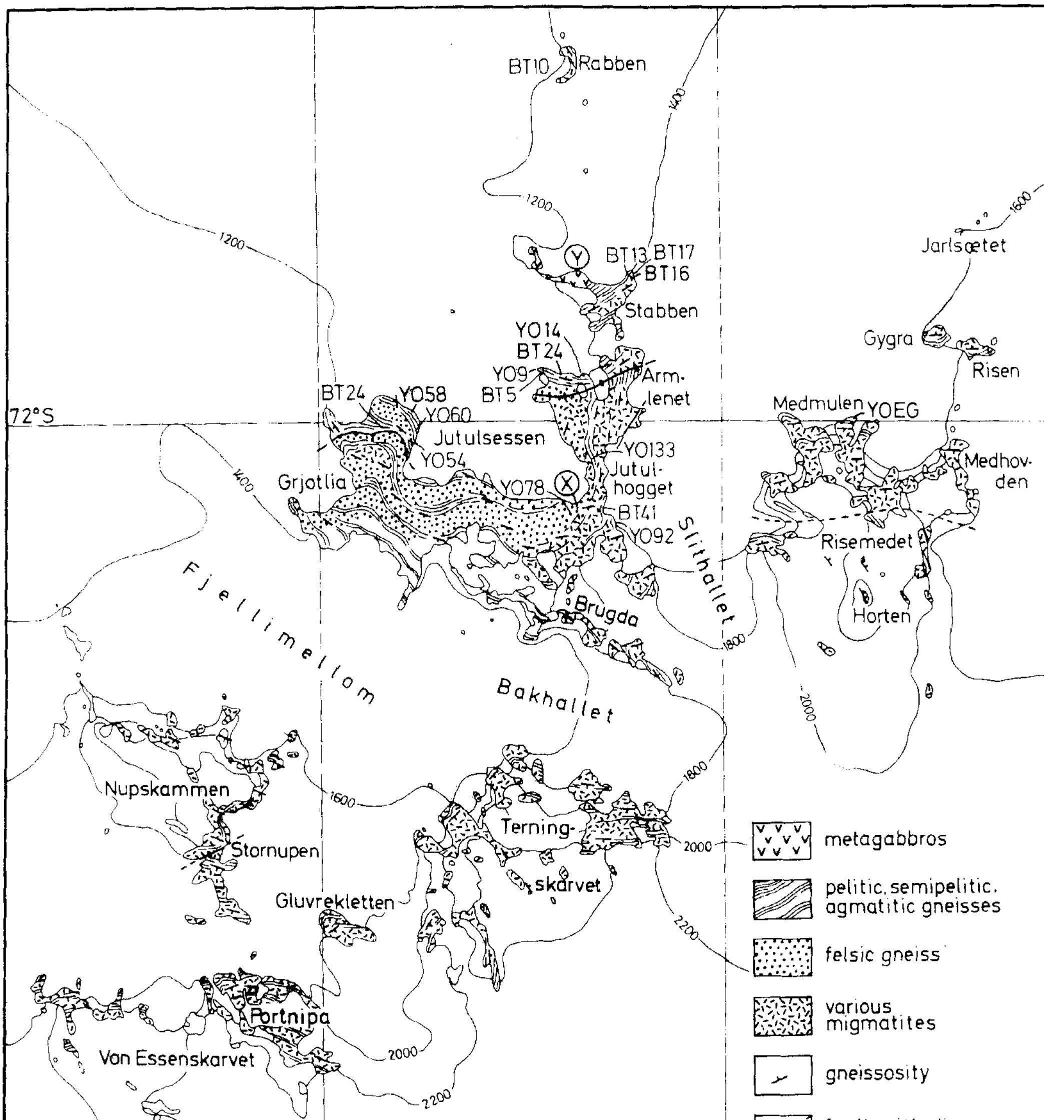

Fig. 2. Geological map of Gjelsvikfjella, including distant observations by binoculars on the northern side of the Fjellimellom-Bakhallet glaciers, Nupskammen, Gluvrekletten and Von Essenskarvet. X and Y in circle: localities of the dated samples (ref. Table 8), BT-, YO-: localities of samples in Tables 2, 3 and 4.

The rocks are medium-grained, melanocratic, hornblende-biotite gabbro, locally coarse-grained, with no preferred orientation of the minerals. These rocks include fine-grained cogenetic, rounded xenoliths with randomly oriented biotite, and are cut by numerous pink to white, aplite-pegmatite dykes, generally less than 0.5 m thick. Most dykes show gentle dips to the southeast, although some have steep dips. Similar dykes are closely associated with the gneisses and migmatites.

The main constituent minerals of the metagabbro are green hornblende, often dusty with opaques, and commonly including granular clinopyroxene grains. Fresh dark brown biotite flakes are sometimes bent. Plagioclase has normal zoning with andesine-oligoclase composition, and shows blocky and/or wavy extinction. The coarse-grained gabbroic facies contains a large proportion of clinopyroxene and locally carries olivine. Small grains of apatite, sphene and opaques are the accessories.

The contact to the Jutulsessen metasupracrustals is intrusive and a wedge of the metagabbro, about 100 m wide, cuts the latter north of Stabben.

Fine-grained xenoliths, consisting of primary prismatic plagioclase and granular clinopyroxene, may be a doleritic early facies of the metagabbro. Pale green hornblende surrounds the clinopyroxene grains. Randomly oriented, overgrowing dark brown biotite may be due to secondary changes, when the rock was captured as xenoliths.

An ore-rich phase which is developed in connection with the later aplite-pegmatite dykes consists of more than 80% magnetite and coarse-grained microcline, plagioclase and subidiomorphic quartz. Small amounts of biotite and muscovite surround the ore grains.

Table 1. Lithostratigraphy of the Jutulsessen metasupracrustals.

Mesozoic dolerites		
Aplite – pegmatites		
Metagabbro		
Basic dykes and sheets		
Jutulsessen metasupracrustals (c. 4,500 m) (lateral change into the Risemedet migmatites)	Upper succ. (700 m)	felsic, migmatitic gneisses with biotite rich and basic paleosomes
	Middle succ. (2,200–2,600 m)	felsic gneisses with micaceous gneisses and agmatites (500 m)
		pink felsic gneiss and agmatites (1,800 m)
		felsic gneiss (300 m)
		three sequences of micaceous gneiss with thin biotite rich layers (400 m)
	Lower succ. (1,300 m)	micaceous banded gneisses (550 m)
		felsic gneisses with basic paleosomes (150 m)
		dark biotite gneisses (150 m)
		micaceous gneisses (80 m)
		dark biotite gneisses (200 m)
		felsic gneisses (150 m)

Jutulsessen metasupracrustals

Micaceous and felsic gneisses are the main constituents of this lithological unit (Table 1). The gneisses are found in the northern half of Jutulsessen, and extend to the east, across the Slithallet glacier to Medmulen. The metagabbro discordantly cuts these rocks in the north, whilst on the southern side a gradational transition is observed to the Risemedet migmatites. A steep E-W trending fault, the Armlenet Fault, offsets the rocks in northern Armlenet.

a) Lower succession

An approximately 4.5 km thick succession of gneissose and schistose rocks is exposed in the cliffs of Grjotlia in western Jutulsessen. The lower succession, 1.3 km in thickness, which consists of alternating felsic and micaceous gneisses, occurs below a layer-parallel shear fault in this area.

The micaceous gneisses are mainly biotite-bearing rocks with or without garnet. The other main minerals are microcline, quartz and plagioclase (An15-23 with normal zoning) (Tables 2 and 3). The most biotite rich gneisses form thin layers and contain strongly pinitized cordierite and hercynite, both occurring as inclusions in later andalusite. Reddish brown biotite, with TiO_2 contents up to 4.4 wt%, is stable in most rocks; locally it displays symplectite texture with fibrous sillimanite (Tables 2 and 3). Garnet-biotite clusters of cm size in a plagioclase matrix are often observed in the biotite rich gneisses. The cores of the clusters are composed of flaky, brown biotite (TiO_2 approximately 1.5 wt%) and granular garnet. Most garnet grains are strongly fragmented and are usually free from inclusions, but a few contain biotite and quartz inclusions. The garnet has a Mg content which decreases, while the Fe and Mn contents increase from centre to rim, suggesting a retrograde readjustment of

Table 2. Metamorphic mineral assemblages of the micaceous gneisses from Gjelsvikfjella, Jutulsessen metasupracrustals.

	sil	ky	and	cord	sp	ga	hb	mus	bi	pl	kf	qz	il	rut
BT5									x	x	x	x	x	
BT13							x		x	x	x	x	x	
YO14						x			x	x	x	x		
YO58						x		x	x	x	x	x		
YOEG		x		x		x			x	x	x	x	x	
YO14B		x			x	x			x	x		x		x
BT41	x					x			x	x	x	x		
YO54	x						x		x	x	x	x		
YO133	x			x	x			x	x	x	x	x	x	x
YO58B	x		x	x	x	x			x	x	x	x	x	

Accessories: apatite, zircon, allanite, monazite and secondary sphene, epidote, chlorite and sericite.
Muscovites (mus) listed are large lepidoblastic flakes (not alteration products). Magnetite may exist and has not been discriminated from allanite.

the rim composition. Porphyroblasts of plagioclase and microcline augen are occasionally developed in the micaceous gneisses. Myrmekitic plagioclase also occurs occasionally. Sphene, apatite, zircon, graphite and monazite are the accessories.

The most biotite rich rock, containing domains

Table 3. Representative microprobe analyses of metamorphic minerals from the rocks of the Jutulsessen metasupracrustals. Localities of the samples in Fig. 2.

	YO58B: garnet biotite gneiss, Grjotlia					
	garnet		biotite			sp
	core	rim	core	flaky	pseudm.	in ga
SiO_2	38.32	36.89	35.62	35.41	34.62	0.02
TiO_2	0	0	3.29	3.20	2.71	0.09
Al_2O_3	21.56	21.06	18.75	18.75	19.56	59.70
Cr_2O_3	0.14	0.06	0.06	0.12	0.03	0.19
FeO*	32.29	35.26	18.68	18.40	17.33	34.31
MnO	1.20	2.51	0.05	0.04	0	0.18
MgO	6.12	3.60	11.41	11.26	11.14	4.16
CaO	1.20	0.92	0	0	0	—
Na_2O	0	0	0.28	0.21	0.25	—
K_2O	0	0	9.04	8.83	9.05	—
ZnO	—	—	—	—	—	1.37
Total	100.83	100.30	97.18	96.22	94.69	100.02
Kation ratio						
O	12	12	22	22	22	4
Si	2.999	2.970	5.291	5.301	5.251	0.001
Ti	0	0	0.367	0.360	0.309	0.002
Al	1.988	1.998	2.709*	2.699*	2.749*	1.982
			0.573**	0.609**	0.748**	
Cr	0.009	0.004	0.007	0.014	0.004	0.004
Fe	2.113	2.374	2.320	2.303	2.198	0.808
Mn	0.080	0.171	0.006	0.005	0	0.004
Mg	0.714	0.432	2.526	2.513	2.519	0.004
Ca	0.101	0.079	0	0	0	0.175
Na	0	0	0.081	0.061	0.074	—
K	0	0	1.713	1.686	1.751	—
Zn	—	—	—	—	—	0.028
XMg	0.253	0.154	0.521	0.522	0.534	0.178

FeO* = total Fe as FeO, Al* = Al^{IV}, Al** = Al^{VI}, XMg = Mg/Mg + Fe in all analyses.

Feldspars
single separated grains in the matrix, unless specified.
pl: An = 27.9, Ab = 71.3, Or = 0.9 and An = 26.1, Ab = 73.5, Or = 0.4

Table 3. (continued)

	YO14: garnet biotite gneiss, SW of Stabben				
	garnet		biotite		
	core	rim	matrix	flaky[1]	in ga
SiO_2	37.40	36.36	34.39	35.29	33.72
TiO_2	0.01	0	3.10	1.78	0.61
Al_2O_3	20.82	20.56	16.61	17.09	21.80
Cr_2O_3	0	0	0.07	0.05	0.17
FeO*	32.56	33.38	21.57	21.41	19.71
MnO	2.53	6.34	0.27	0.12	0.25
MgO	3.81	2.22	9.12	9.68	8.25
CaO	2.29	1.30	0.02	0.01	0.01
Na_2O	0	0	0.06	0.05	0.05
K_2O	0	0	9.34	9.45	8.31
Total	99.42	100.16	94.55	94.93	92.88
Kation ratio					
O	12	12	22	22	22
Si	3.009	2.967	5.374	5.465	5.244
Ti	0.001	0	0.364	0.207	0.071
Al	1.975	1.977	2.626*	2.535*	2.756*
			0.433**	0.585**	1.240**
Cr	0	0	0.009	0.006	0.021
Fe	2.191	2.278	2.819	2.773	2.564
Mn	0.172	0.438	0.036	0.016	0.033
Mg	0.457	0.270	2.125	2.235	1.913
Ca	0.197	0.114	0.003	0.002	0.002
Na	0	0	0.018	0.015	0.015
K	0	0	1.862	1.867	1.649
XMg	0.173	0.106	0.430	0.446	0.427

Feldspars
pl: An = 23.3, Ab = 75.1, Or = 1.6
and An = 15.8, Ab = 82.9, Or = 1.4

flaky[1]: very thin biotite flake near garnet.

	YOEG: garnet biotite gneiss, Medmulen				
	garnet			biotite	
	core	rim*	rim**	coarse	small[1]
SiO_2	38.48	37.35	38.51	34.59	35.54
TiO_2	0.04	0	0	4.20	2.86
Al_2O_3	21.43	20.30	21.72	15.42	15.72
Cr_2O_3	0.01	0.04	0.05	0	0.23
FeO*	25.92	31.48	26.79	24.15	22.59
MnO	0.57	1.90	0.43	0.07	0.07
MgO	6.13	2.23	7.06	8.42	9.09
CaO	7.11	5.37	4.66	0.02	0.11
Na_2O	0	0	0	0.01	0.04
K_2O	0	0	0	8.99	8.73
Total	99.69	98.67	99.22	95.87	94.98
Kation ratio					
0	12	12	12	22	22
Si	3.002	3.036	3.005	5.384	5.519
Ti	0.002	0	0	0.492	0.334
Al	1.970	1.944	1.998	2.616*	2.481*
				0.213**	0.396**
Cr	0.001	0.003	0.003	0	0.028
Fe	1.691	2.140	1.748	3.144	2.934
Mn	0.038	0.131	0.028	0.009	0.009

Table 3. (continued)

Mg	0.713	0.270	0.821	1.954	2.104
Ca	0.594	0.468	0.390	0.003	0.018
Na	0	0	0	0.003	0.012
K	0	0	0	1.785	1.729
XMg	0.297	0.112	0.320	0.383	0.418

rim* = adjacent to plagioclase
rim** = adjacent to sillimanite
small[1]: thin biotite flake around garnet

Feldspars

	pl	pl	pl	pl	kf
An	44.3	40.4	46.3	50.8	0.3
Ab	54.8	59.0	53.2	48.6	0.5
Or	0.9	0.6	0.5	0.6	99.2

A kyanite grain occurs as inclusion in the garnet.

BT16: granulitic gneiss, NE Stabben

	opx	biotite	hornb.	cumming.
SiO_2	50.86	36.81	48.73	54.28
TiO_2	0.05	4.49	1.00	0.03
Al_2O_3	0.54	14.35	6.63	0.39
Cr_2O_3	0	0.02	0.04	0
FeO*	27.62	17.56	13.77	22.90
MnO	0.65	0.04	0.20	0.53
MgO	19.60	13.46	14.88	18.44
CaO	0.35	0.04	10.79	0.70
Na_2O	0.02	0.21	0.99	0.07
K_2O	0	8.90	0.34	0
Total	99.69	95.88	97.37	97.34
Kation ratio				
O	6	22	23	23
Si	1.956	5.529	7.123	7.942
Ti	0.001	0.507	0.110	0.003
Al	0.024*	2.471*	0.877*	0.058*
	0	0.069**	0.266**	0.009**
Cr	0	0.002	0.005	0
Fe	0.888	2.206	1.683	2.802
Mn	0.021	0.005	0.025	0.066
Mg	1.124	3.014	3.243	4.022
Ca	0.014	0.006	1.690	0.110
Na	0.001	0.061	0.281	0.020
K	0	1.705	0.063	0
XMg	0.559	0.577	0.658	0.589

Feldspars
pl: An = 48.3, Ab = 51.2, Or = 0.5
and An = 41.5, Ab = 58.1, Or = 0.4

BT24: amphibole gneiss, E Jutulsæter

	garnet core	garnet rim	opx	cpx	biot.	hornbl.	cumming.
SiO_2	39.79	36.61	48.75	49.58	36.29	43.09	51.37
TiO_2	0.13	0.02	0.04	0.12	3.66	1.61	0.02
Al_2O_3	21.25	20.76	0.44	0.74	14.78	9.42	0.33
Cr_2O_3	0.01	0	0.01	0.02	0	0	0.03
FeO*	25.73	30.14	37.32	15.66	19.21	21.13	30.58
MnO	1.12	2.32	1.09	0.39	0	0.27	0.83

Table 3. (continued)

MgO	4.10	2.23	10.84	8.90	11.05	7.81	11.49
CaO	9.20	6.57	0.84	21.12	0.07	10.65	0.82
Na_2O	—	—	0	0.20	0.01	1.51	0.02
K_2O	—	—	0	0	9.24	0.67	0
Total	99.33	98.65	99.33	96.73	94.31	96.16	95.49
Kation ratio							
O	12	12	6	6	22	23	23
Si	2.988	2.979	1.982	1.981	5.594	6.692	8.000
Ti	0.008	0.001	0.001	0.004	0.424	0.188	0.002
Al	1.980	1.991	0.018*	0.019*	2.406*	1.308*	0*
			0.004**	0.016**	0.279**	0.416**	0.060**
Cr	0.001	0	0	0.001	0	0	0.004
Fe	1.701	2.051	1.269	0.523	2.476	2.744	3.983
Mn	0.075	0.160	0.038	0.013	0	0.036	0.109
Mg	0.483	0.270	0.657	0.530	2.539	1.808	2.668
Ca	0.779	0.573	0.037	0.904	0.012	1.772	0.137
Na	—	—	0	0.015	0.003	0.455	0.006
K	—	—	0	0	1.817	0.133	0
XMg	0.221	0.117	0.341	0.503	0.506	0.397	0.401

Feldspars

	pl^1	pl^2	pl^3
An	48.1	44.7	52.4
Ab	51.0	54.4	46.9
Or	1.0	0.9	0.7

pl^1: core, pl^2: rim, pl^3: adjacent to garnet.
Ga-pl and hb-pl symplectites occur locally.

with and without quartz, occurs as restite in a migmatitic gneiss (Tables 2 and 3). In the quartz bearing domains garnet porphyroblasts are converted into a biotite, plagioclase assemblage. Biotite, rutile, ilmenite and hercynite (Mg/Fe + Mg = 0.22, ZnO = 0.6 wt%) also occur as inclusions in garnet. The Mg/Fe + Mg ratios of the central parts of the garnet are as high as 0.28, whereas that of the biotite, which is constant and independent of the texture and assemblages, is 0.50–0.53. Biotite inclusions in the garnet have slightly higher ratios of about 0.55. Plagioclase compositions in the matrix are An14 to An17. In the quartz-free domains aggregates of sillimanite, hercynite (Mg/Fe + Mg = 0.15–0.19, ZnO = 1.4 wt%), plagioclase (An23-27), biotite and small amounts of muscovite, chlorite, rutile, ilmenite and secondary kaolinite are found. Hercynite is also found as scattered inclusions in large biotite flakes. Andalusite occurs as porphyroblasts, surrounded by hercynite-plagioclase aggregates. These are overgrown by biotite which is chloritized along the margins. Sillimanite is partly converted to muscovite. The described textural relationships of andalusite and sillimanite may indicate a late temperature increase under relatively low pressure conditions.

The felsic gneisses contain less than 5% dark brown lepidoblastic biotite in a granoblastic matrix consisting of microcline, plagioclase and quartz. Plagioclase grains sometimes have albite rims and myrmekitic texture. Small amounts of pink garnet occur in some aplitic gneisses. An isolated small grain of orthopyroxene has been found in a felsic gneiss, coexisting with antiperthitic plagioclase.

The basic rocks always occur as blocky paleosomes in the felsic and banded biotite gneisses and such agmatitic gneisses form distinct layers of some tens of metres in thickness. The basic rocks show varying degrees of disruption, ranging from conformable lenses to torn apart dykes or sheets, indicating their emplacements at different stages of the tectonothermal history. Their textures also vary, ranging from completely recrystallized granoblastic amphibole gneiss to weakly recrystallized igneous fabrics. The granoblastic amphibolitic gneisses consist of alternating bands of hornblende-biotite-plagioclase and clinopyroxene-plagioclase-quartz (Tables 3 and 4). Some bands have abundant garnet porphyroblasts in polygonal plagioclase domains. The compositional profile of the garnet shows that the Mg/Fe + Mg ratio decreases towards the margins

(Fig. 3a). Brown hornblende is replaced by green amphibole around its margins and orthopyroxene is converted to cummingtonite, which coexists with the green hornblende (Tables 3 and 4). Subangular basic paleosomes commonly consist dominantly of prismatic hornblende which often includes clinopyroxene grains. Most hornblende, however, displays a coarse-grained lepidoblastic texture which is associated with plagioclase of andesine-oligoclase composition, and is overgrown by biotite. One basic paleosome displays garnet-plagioclase clusters, whilst some garnet porphyroblasts are partly overgrown by a hornblende-clinopyroxene-plagioclase mosaic. Brownish green hornblende of this rock has both ortho- and clinopyroxene inclusions.

Table 4. Metamorphic mineral assemblages of the amphibolites from the Jutulsessen metasupracrustals.

	opx	cpx	hb	bi	pl	kf	qz	il
YO78			x	x	x		x	x
YO9			x	x	x	x	x	
BT17		x	x		x		x	x
YO60		x	x	x			x	x
BT10		x	x	x	x	x	x	
BT24	(x)	x	x		x			x
YO60	x	(x)	x	x	x			x
YO92	x	x	x	x	x	x	x	x

BT24 includes garnet and cummingtonite.
Accessories: apatite, zircon, allanite and secondary epidote, zoisite, muscovite, chlorite, sphene.
BT16 (Table 3) has a similar assemblage to YO92 and secondary cummingtonite surrounding hornblende.
( ): almost totally converted into hornblende and possibly plagioclase.

b) Middle succession

Above the layer parallel shear fault about 2,600 m of the middle succession are exposed. The lower 700 m dominantly consist of felsic gneisses, but include three layers, 50–150 m thick, of fine-grained, garnet-bearing, micaceous gneisses. Some mica rich layers are fine-grained and schistose, whilst others have feldspar porphyroblasts.

The middle 1,800 m are dominated by pink felsic gneisses, often granitic in composition. Several layers of agmatite, including basic and biotite rich paleosomes, occur concordantly in the gneisses. The basic paleosomes are aligned in some places, and indicate that the original trend of the dykes was oblique to the gneissosity, while others are concordant lenses.

The upper 500 m of the middle succession contain two layers of banded biotite gneisses and several thin agmatitic layers in felsic gneisses. These rocks form the western ridge of Grjotlia, and extend along the southern ridge of Jutulsessen. The felsic gneisses in the upper part of the middle succession have a more granitic composition than those described in the lower part. The matrix is microcline rich and plagioclase

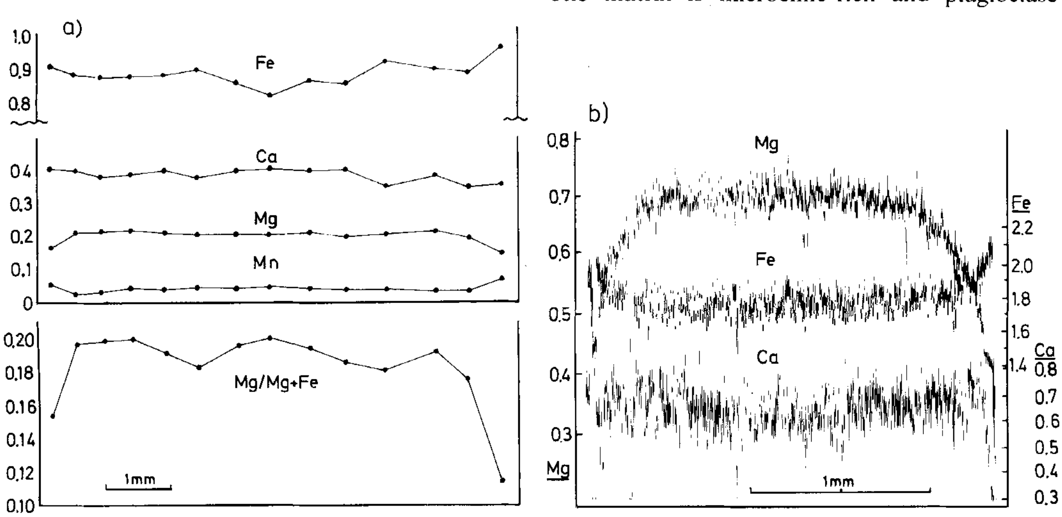

Fig. 3. Compositional profiles of garnets: a) from a garnet amphibolite (BT24, ref. Tables 3 and 4), eastern part of Jutulsessen; b) from a garnet biotite gneiss (ref. Tables 2 and 3), northern Medmulen, eastern Gjelsvikfjella.

grains, mainly oligoclase, are commonly myrmekitic. Biotite, which is the only major mafic constituent, shows signs of chloritization around the margins. Disruption and rotation of basic and biotite rich paleosomes and modal increase of microcline may indicate that parts of the felsic gneisses were mobilized in this area.

c) Upper succession

The upper succession, which is more than 700 m in thickness, is dominated by felsic-granitic gneisses. The succession extends from the western ridge of Grjotlia to Jutulhogget to the east, where it forms a cliff approximately 500 m high. The micaceous and agmatitic layers are rare, and become more felsic, shadow-like discontinuous lenses. The felsic gneisses laterally change into granitic migmatites of various textures, and increase in thickness towards the north. Some basic paleosomes are enriched in biotite, and display ptygmatic folds.

The upper gneisses extend to Brugda where the thickness is estimated to be more than 500 m. Various migmatites are present in Brugda and in the eastern side of Jutulsessen, and these rocks are similar to the Risemedet migmatites.

Garnet-biotite gneisses and agmatites with basic paleosomes make up the middle part of the eastern slope of Armlenet. These rocks are interlayered with granitic lenses, and have a thickness of about 700 m. Stabben, a distinct tower in northeastern Jutulsessen, is composed of a relatively homogeneous, coarse-grained granite with sharp contacts to the gneisses and migmatites. Aplites in this area often contain small grains of red garnet. Some garnet-biotite gneisses have small prismatic sillimanite.

Felsic gneisses occur in western Armlenet and northern Stabben, whilst the area south of Stabben is dominated by various migmatites. In western Armlenet the succession consists of an approximately 500 m thick unit of felsic gneiss, interbedded by numerous agmatite layers and overlain by a garnet-biotite gneiss of 100 m thickness and a 200 m thick felsic gneiss. The basic paleosomes are enriched by hornblende and converted into small hornblendite bodies some tens of cm in size. An alternation of plagioclase porphyroblastic biotite gneiss and granitic gneiss occurs between the two peaks of Stabben. These rocks laterally grade into agmatitic and shadow-like migmatites northeast of Stabben.

A biotite rich gneiss from northeastern Stabben has granoblastic ortho- and clinopyroxene with reddish biotite. Antiperthitic plagioclase and partly mesoperthitic orthoclase are common in this rock. A basic paleosome in the same area has granular clinopyroxene and ortho-pyroxene-biotite aggregates in a complex symplectite texture. Plagioclase shows irregular compositional domains in each grain. Pale green, poikiloblastic hornblende includes clinopyroxene grains, and is partly converted into cummingtonite during a retrograde process.

The Rabben nunataks 10 km north of Jutulsessen are composed of coarse-grained, biotite and hornblende gneisses, each 20–30 m thick. Dark, biotite rich boudins represent an older basic rock, whereas fine-grained schistose amphibolite is younger. A 7 m wide metagabbro dyke cuts the gneisses. A 100 m thick, regularly banded biotite gneiss occurs in the southern part of Rabben. A separated small nunatak to the south consists of granitic gneiss.

Granitic gneiss with thin layers of garnet-biotite gneiss and agmatite with basic paleosomes are present to the east in Medmulen, Medhovden and Gygra-Risen at the northeastern edge of Gjelsvikfjella. Some biotite rich paleosomes in this area have large poikiloblastic garnets with inclusions of kyanite, ilmenite, rutile, potash feldspar and plagioclase (An51). A compositional profile of the garnet shows a convex shape for Mg with a decrease near the margins (Fig. 3b). Sillimanite rarely occurs in contact with garnet and plagioclase in the matrix.

d) Original rocks of the Jutulsessen metasupracrustals

Complex deformation and metamorphic recrystallization make estimation of protolith rocks difficult and uncertain. However, the occurrence of Al-silicates, cordierite and garnet in dark micaceous layers may suggest originally argillaceous to sandy sediments. A possibility of acid volcanic rock origin for the felsic gneisses cannot be ruled out. Basic rocks probably originated from both syn- and late-tectonic basic dykes and sheets.

e) Metamorphic conditions

The metamorphic mineral assemblage in the pelitic gneisses commonly includes biotite and garnet. Sillimanite has been found to be a major constituent in some rocks (Tables 2, 3 and 4). Occurrence of kyanite as inclusions in garnet (Tables 2 and 3, sample YOEG) indicates an intermediate pressure facies series for the prograde process. Orthopyroxene occurs in some silica undersaturated rocks, suggesting the maximum metamorphic grade is transitional from upper amphibolite facies to granulite facies. Cordierite and hercynite in some rocks may reveal a pressure fall after the metamorphic climax.

Andalusite porphyroblasts found in a silica undersaturated gneiss are replacing an older garnet-biotite assemblage, and are overgrown by sillimanite and biotite. The sillimanite is partly converted into muscovite. These reactions reveal a high temperature facies metamorphism following a cooling period after the older metamorphism, which is probably related to a thermal event during the emplacement of large masses of charnockite, which will be described later.

For the calculation of the maximum metamorphic conditions, geothermometry and geobarometry were applied. Normally, garnet has a high content of Ca and Mn and biotite has distinctive amounts of Ti. Therefore, garnet-biotite geothermometry is not applicable for most rocks. However, a central part of the garnet and its inclusion biotite from a gneiss of Grjotlia gave a temperature range of 650–750°C by the calibration given by Thompson (1976). The garnet-rutile-sillimanite-ilmenite (GRAIL) geobarometer (Bohlen et al. 1983) for the same rock gave 8 ± 1 kb at ~760°C.

Rocks from Sverdrupfjella to the west of Gjelsvikfjella were examined for comparison, using the samples collected by Hjelle in 1970–71. In this area orthopyroxene has not been found in intermediate and basic rocks, suggesting that the metamorphic grade did not reach granulite facies. A garnet porphyroblast has sillimanite and quartz inclusions, and indicates upper amphibolite facies. Garnet-biotite geothermometry (Thompson 1976) gave 750°C for the central part of the garnet, the geobarometry of Newton & Haselton (1981) yielded about 7 kb at ~750°C and GRAIL gave 8 kb at ~750°C for a garnet and its inclusion biotite. These calculations and the lack of orthopyroxene show a transition from upper amphibolite facies to granulite facies, which is similar to that of the rocks of Gjelsvikfjella. These results are somewhat higher than those obtained by Grantham et al. (1988): 560–690°C and 5–6 kb for the main metamorphism in northern H.U. Sverdrupfjella. An ultramafic rock sampled in this area shows late magmatic conditions of 850°C and 9–10 kb. The metamorphic conditions calculated for the rocks in the areas from Kirwanveggen to middle Mühlig-Hofmannfjella are summarized in Fig. 4.

Risemedet migmatites

This migmatite complex is defined as a lithologic unit. The Jutulsessen metasupracrustals show gradational transition to the Risemedet migmatites in the south. Banding in biotite gneisses gradually disappears and biotite is concentrated in thin seams in granitic-aplitic rocks. The latter contain microcline and plagioclase. Plagioclase has albite rims and well developed myrmekite texture. The thick felsic gneisses around Jutulhogget show a very faint gneissosity of irregular orientation and basic dykes show strong ptygmatic folds and rotated fragments, indicating mobilization of the felsic gneisses. The gneisses in the middle part of the eastern slope of Armlenet have agmatitic and shadow-like paleosomes in a medium-grained granitic gneiss. Gneissosity is locally difficult to detect. Similar migmatites occur in the eastern side of Stabben.

The basic paleosomes in the gneisses change into more biotite enriched conformable layers, having distinct amounts of microcline and quartz. Some basic rocks in Armlenet cut the gneissosity of both gneiss paleosomes and granitic metatect and include angular blocks of granite. The basic rocks themselves are cut by aplite and pegmatite dykes.

Migmatites with streaky, shadow-like and biotite rich paleosomes occupy the Risemedet and Horten areas. Similar rocks are probably also present in Medhovden based on distant observation. The modal content of hornblende is exceeded by biotite in the basic paleosomes. Orthoclase perthites are often present in both gneissic and basic paleosomes. The gneissic paleosomes lose their clear sharp boundaries to the granitic metatect, and gradually transform into homogeneous granitic rock.

Migmatite varieties also make up most of Terningskarvet. Biotite gneiss-rich layers, about 100 m thick, and granitic migmatite are mappable units in the area. The biotite gneiss is often feldspar porphyroblastic and strongly folded, and contains many basic paleosomes. A massive

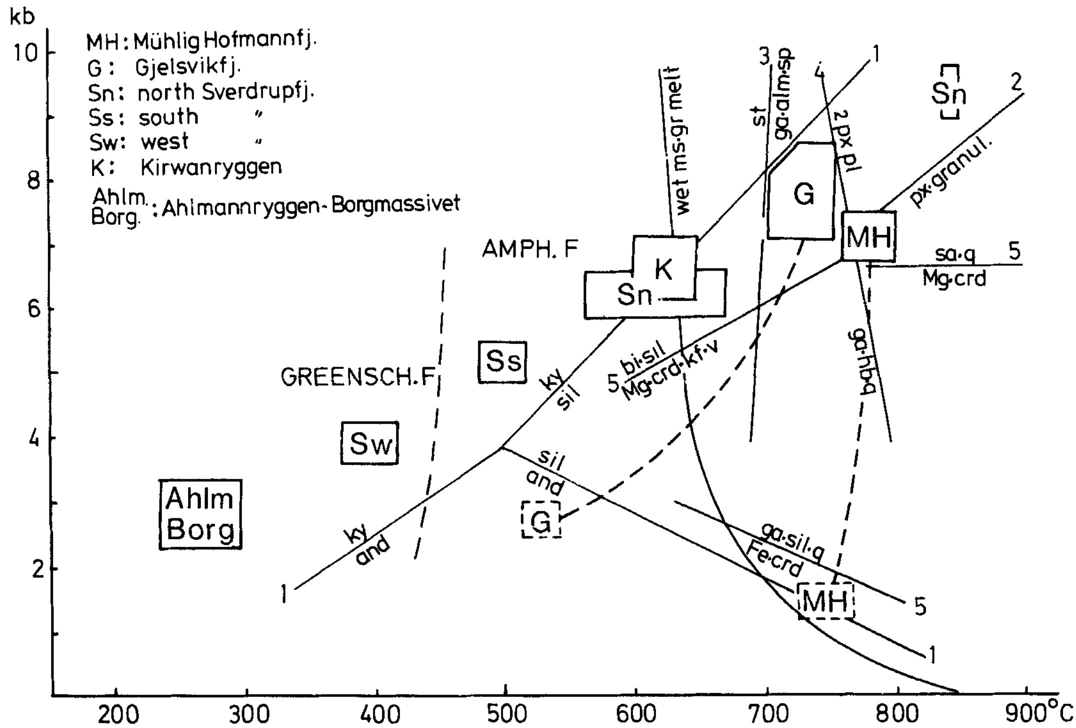

Fig. 4. Pressure-temperature conditions of the metamorphic rocks from western Dronning Maud Land. Ahlmannryggen-Borgmassivet: Wolmarans & Kent (1982); Kirwanveggen and H. U. Sverdrupfjella: Wolmarans & Kent (1982), Grantham et al. (1988), Allen (1990); Gjelsvikfjella and Mühlig-Hofmannfjella: present study.

Reference curves: 1. Holdaway (1971), 2. Ringwood & Green (1966), 3. Richardson (1968), 4. Percival (1983), 5. Holdaway & Lee (1977). Broken curves: estimated retrograde conditions.

diorite, about 200 m wide, occurs concordantly in the granitic migmatites in the southwestern part of Terningskarvet.

A plagioclase porphyroblastic biotite schist occurs in the same area, alternating with garnet-bearing aplite layers and schistose amphibolites. These rocks form a km wide, large paleosome in the migmatites. The granitic metatects are rich in pink coloured microcline, and contain as much as 5% biotite. The basic paleosomes have clino-pyroxene inclusions in hornblende grains and biotite overgrows on the hornblende. Medium-grained oligoclase is the main constituent and no hydration of mafic minerals has been observed.

Gneisses and granitic layers, some tens to a few hundred metres thick, were traced by binocular observation on Nupskammen, Von Essenskarvet and the southwestern side of Jutulsessen, and the observed outlines are shown in Fig. 2.

Geological structures of Gjelsvikfjella

a) Mesoscopic structures

All rocks of the Jutulsessen metasupracrustals show distinct gneissosity represented by differentiated layering and preferred orientation of mafic minerals. The gneissosity is considered to be the result of the main period of deformation and metamorphism. The observed orientation of the foliation is summarized on the equal-area lower hemisphere stereographic projection for six subareas in Gjelsvikfjella (Fig. 5).

Some layers, cm to dm thick, include isolated isoclinal folds, indicating that the gneissosity is a transpositional foliation. Compositionally distinct units, some hundreds of metres thick and with 5–10 km lateral persistency, can be considered to reflect differences in primary lithologies to some extent. Some granoblastic basic rocks are com-

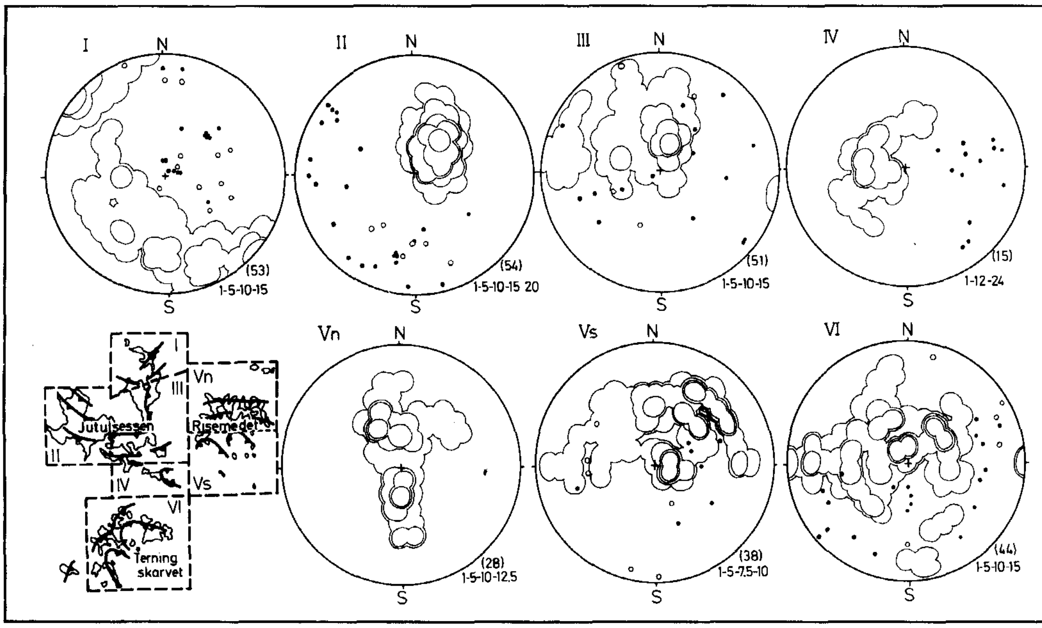

Fig. 5. Stereographic projections, lower hemisphere, of foliations and lineations from Gjelsvikfjella. Division of the subareas and general structures are shown in the inserted map. ( ): number of measured foliation poles; 1-5-10: percentage of the contours for the foliation plots; solid dot: mineral lineation; open circle: fold axis.

pletely conformable with the gneissosity of surrounding rocks. These are believed to represent pre-metamorphic basic sheets or dykes. Basic rocks with clinopyroxene in hornblende show oblique alignment to the gneissosity, and are interpreted as syn-metamorphic intrusions.

The isoclinal folds are refolded by later tight folds which represent the main phase of deformation (D_2). The isoclinal folds therefore indicate a strong deformation, D_1, prior to the main recrystallisation phase D_2.

The most common mesoscopic fold axes coincide with the mineral lineations defined by preferred orientation of mafic constituents. These are formed during the main deformation-metamorphism, D_2, together with the formation of gneissosity and differentiated layering. These mesoscopic linear structures have by later deformation (D_3) been rotated into a wide large girdle along the maximum gneissosity girdle in the type locality of the Jutulsessen metasupracrustals in Grjotlia (subarea II in Fig. 5). Similar rotations of the lineations are seen in the diagrams for subareas III and VI, but the axes of rotation are oblique to the axes defined by the gneissosity girdles. The D_3 deformation resulted in a kind of dome-basin structure, as shown by the general trends of gneissosity in the inserted map of Fig. 5. The wide girdle deviations of lineation in subareas I, II, III and IV can be explained by the rotation during the D_3 migmatization.

b) Faults

A distinct fault, the Armlenet Fault, occurs in northern Armlenet (Fig. 2). It has an E-W strike, subvertical dip and a downthrow to the south. The fault plane itself is not directly exposed, but appears to be manifested by a narrow discrete break buried beneath a 10 m wide zone of scree cover. The northern side of the fault forms a 150 m high vertical cliff, with two types of basic dykes present. One type is a disrupted and folded biotite amphibolite which was possibly emplaced during the migmatization. The second type consists of a network of unmetamorphosed dolerite of possible Mesozoic age. From the dip change of the gneissosity across the fault it is considered that the fault intersects the crest of a regional antiform. The eastern extension of the fault probably passes between Medmulen-Medhovden and Gygra-Risen and the gneissosity in these two areas also shows opposing dips. The occurrence of many basic dykes along the fault and its structural relationship to the major regional structures suggest that this fault may have been initiated during the late stages of the D_2 deformation episode, and was subsequently reactivated during the Mesozoic.

A NE-SW striking fault, dipping 60° eastwards, occurs about 2 km south of the Armlenet fault (Fig. 2), and cuts strongly migmatized gneisses. This fault separates an easterly dipping western block from a westerly dipping eastern one, but its strike is oblique to that of the gneissosity. This fault may be a splay fault of the Armlenet fault.

A 3–5 m wide shear zone was observed in the middle part of the eastern ridge of Grjotlia (Fig. 2). Cataclastic structures are developed, but no associated retrograde metamorphism has been identified. This fault is nearly parallel to the compositional layering in the biotite rich gneisses and the sense of displacement is unknown.

c) Fold structures

There is no structural discordance between the Jutulsessen metasupracrustals and the Risemedet migmatites, and their gneissosities define an oval, incomplete dome structure, the Jutulsessen dome, with its axis elongated in a NW-SE direction (subareas II, III and IV).

The Armlenet Fault cuts the northern part of the dome. North of the fault the gneiss-migmatites form a steep northeast trending fold (subarea I).

The gneissosities in the Medmulen-Medhovden area have roughly E-W strikes and moderate southern dips, while those of the Gygra-Risen area have northern dips. This may show an open anticline with an E-W trend between the two areas.

An asymmetric, NW-SE trending antiform occurs around the Horten nunatak with 50°–60° SW dips in the western limb and 60°–75° NE dips in the eastern limb. The eastern limb of this fold can be followed into a synform to the east of Horten, where the opposite flank dips about 10°–15° to the west. These structures have not been observed on the northern cliffs of Medmulen-Medhovden which lie in the strike direction of the folds. The antiform is therefore probably terminated in Risemedet as an elongate dome.

A small open synform with a NW-SE trend and a southeasterly plunging axis occurs in the southeastern part of Brugda. This synform is a subordinate structure on the southern slope of the Jutulsessen dome.

A major SE plunging synform occurring in Terningskarvet is divided in two by a small antiform around the highest part of the nunataks. The axes of these folds plunge to the SE, subparallel to those in Brugda and Horten. Compositional layers include many isoclinal folds indicating that they are of D_1 structure. The folds described above are from the D_2 deformation, with some later rotation by the D_3 deformation.

Geological event history in Gjelsvikfjella

The following successive events can be recognized from the petrographic and structural observations:

1) Argillaceous and sandy sedimentary rocks may be protoliths for the dark micaceous gneisses occurring in the Jutulsessen metasupracrustals. Felsic gneisses may alternatively have been derived from acidic volcanic rocks. We cannot exclude that it is possible to discriminate between some plutonic rocks in the metasupracrustals.

2) Strong deformation resulted in the formation of isoclinal and tight folds and transpositional foliation (D_1 and D_2 phases of deformation). The deformation phases were associated with major metamorphism under upper amphibolite to granulite facies conditions. Increasing temperature or P_{H2O} led to regional migmatite formation especially in the southern areas.

3) Regional open fold structures (D_3) refolded the earlier folds into dome-basin-like structures. Metagabbro intrusions are associated with the D_3 deformation phase and the emplacement of basic, aplitic and pegmatitic dykes took place in the later stages of this phase.

4) Brittle activation of the Armlenet Fault.

5) Emplacement of the Mesozoic dolerite dykes associated with brittle deformation – reactivation of the Armlenet Fault.

Western Mühlig-Hofmannfjella

Our mapping covered the area from Skigarden (4°30′E) to Ahlstadhottane (5°30′E) along the northern escarpments of western Mühlig-Hofmannfjella. Reconnaissance observations were made to the south (Fig. 6).

The Svarthamaren charnockites and the Snøtoa metamorphic complex dominate in the area. The former intrude into the latter. The term char-

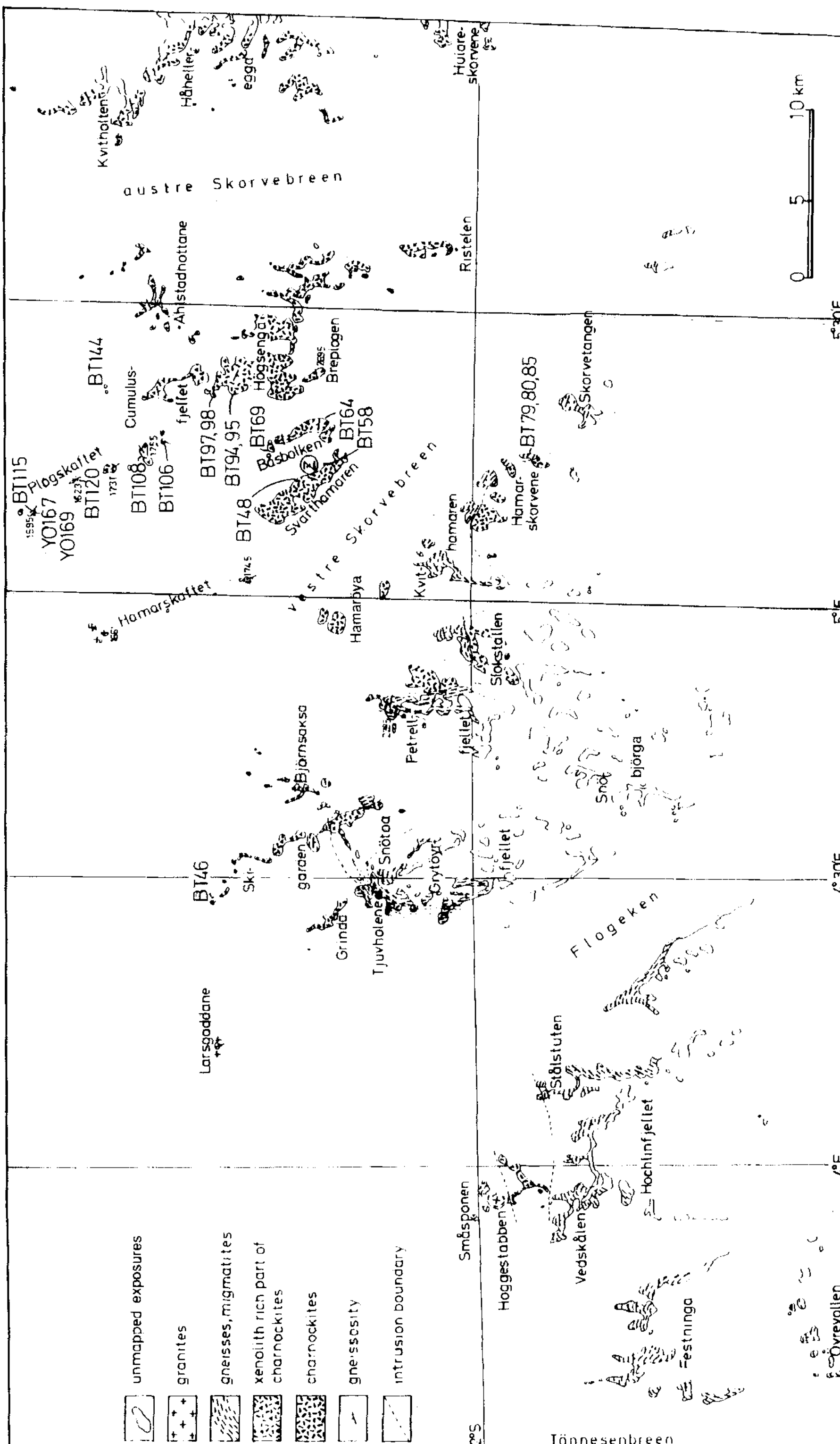

Fig. 6. Geological map of western Mühlig-Hofmannfjella, including distant binocular observations. Z in circle: locality of the dated samples (ref. Table 9); BT-, YO-: localities of samples in Tables 5, 6 and 7.

nockite is used for rocks with orthopyroxene and mesoperthite as essential constituents, which have a dark brownish-green colour due to the felsic constituents. Some varieties have biotite and hornblende as main minerals. The charnockite intrusion will be described from west to east.

Skigarden-Snøtoa area and the area to the west

The Skigarden and Bjørnsaksa nunataks are mainly composed of coarse-grained, dark charnockite (Fig. 6). The rocks have large idiomorphic crystals of orthoclase mesoperthite, a large modal content of biotite and both ortho- and clinopyroxene are present. Plagioclase grains are often antiperthitic.

Isolated pale coloured blocks, up to 50 m across, mainly of heterogeneous granitic composition, often with gneissic and basic paleosomes, are included in the charnockite mass. Size and frequency of the granitic xenoliths increase to the south. A one km wide, vertically dipping xenolith rich zone of charnockite occurs in southern Skigarden. The zone has a roughly E-W strike, and forms the boundary to the shadow-like migmatites of Snøtoa (Fig. 7). Small gneiss and granite blocks have diffuse margins and the adjacent charnockite shows a red coloured contact zone, cm to dm wide, probably formed by assimilation.

The migmatites of Snøtoa, commonly with shadow-like and streaky paleosomes and sometimes agmatitic, have an E-W strike, dip moderately to the south and display upper amphibolite facies mineral assemblages (Table 5). Parts of the Snøtoa migmatites form a sheet about 500 m thick in the charnockite.

A similar sheet-shaped occurrence of charnockite and migmatites was observed in the northern cliff of Tjuvholene, northern Grytøyrfjellet. In these mountains dark granulitic rocks contain sheets of granitic rocks with relatively sharp contacts. Grinda nunataks to the north of Tjuvholene consist entirely of charnockite. A zone from southern Skigarden to western Grytøyrfjellet can be regarded as an intrusive transition zone between a large charnockite mass to the north and metamorphic rocks to the south.

Fig. 7. Contrasting mountain shapes between the charnockite (pinnacles) and the Snøtoa metamorphic complex (massive mountains); Skigarden in front and Snøtoa in the background.

Table 5. Metamorphic mineral assemblages of the gneisses and migmatites of the Snøtoa metamorphic complex.

	sil	ga	sp	co	opx	cpx	hb	bi	pl	kf	qz	il
BT80		x						x	x	x	x	x
BT79							x	x	x	x	x	x
BT58						x	x	x	x	x	x	
BT97					x		x	x	x		x	x
BT95					x	x		x	x	x	x	
BT108					x	x	x	x	x	x	x	x
BT120	x		x					x	x	x	x	x
BT104			x			x		x	x		x	x
BT94			x	x				x	x	x		
BT85			x	x	x	x		x	x			x

Accessories: apatite, zircon, allanite, monazite and secondary epidote, sphene, serpentine, chlorite, vermiculite, hematite.
Sample YO169 (Table 6) has the same assemblage as sample BT95.
Sample YO167 (Table 6) has the same assemblage as BT97, but the content of opx is very small.

West of Flogeken

A dark charnockite, more than one km wide, occurs to the south of Hoggestabben (Fig. 6), and has E-W strikes and steep dips. Hoggestabben consists of a granitic migmatite with banded gneiss relics. Weakly banded granulitic rocks dominate in Hochlinfjellet.

Distinct banded gneisses, a few km wide, occur in the northern part of Vedskålen. A 15 m thick skarn layer has been observed in its eastern part. Towards the western part of Vedskålen the banded gneiss is replaced laterally by a granulitic granite.

Festninga further to the west (Fig. 6) is dominated by granitic migmatites with some distinct layers of banded gneisses and agmatites. These rocks have a roughly E-W strike and gentle to moderate southward dips. The banded gneiss-migmatites in Festninga and Øvrevollen are probably the continuation of the Jutulsessen metasupracrustals and the Risemedet migmatites of eastern Gjelsvikfjella.

Petrellfjellet and Hamarskorvene areas

Petrellfjellet to the south of Skigarden (Fig. 6) has outcrops of granulitic metamorphic rocks along the northwestern foothills, on the northern ridge (with the 2,285 m peak) and the eastern part. Dark charnockite which makes up the northern tip of the eastern ridge is a roughly concordant layer to the migmatites, and has a nearly E-W strike and 20°–40° southward dips. Another charnockite in southern Petrellfjellet overlies the metamorphic rocks. Hamarøya and a nunatak to the south are composed of massive charnockite.

Granulitic migmatites with some banded gneiss and agmatite layers with E-W to ENE-WSW strikes and 10°–60° southward dips occupy Slokstallen and Kvithamaren (Fig. 6). These rocks were also observed in Hamarskorvene to the southeast, where the banded gneisses consisted of pink feldspar porphyroblastic biotite-garnet gneiss, felsic gneiss, agmatitic migmatite with basic paleosomes and pink aplitic gneiss layers. Some of the pink gneisses are augen gneiss and mylonite gneiss. Ptygmatic folds are frequently observed in the gneisses and migmatites. An approximately 5 m thick, coarse-grained marble layer, containing diopside-wollastonite-grossular aggregates, occurs in the gneisses.

Coarse-grained mosaic texture of subangular hornblende and plagioclase has been preserved in an agmatitic basic paleosome found in the agmatitic basic rocks. The rock consists of plagioclase, An 38-26, normally zoned, biotite, ortho- and clinopyroxene and quartz with accessory ilmenite and apatite. Randomly orientated, yellowish brown biotite is dominant, and replaces orthopyroxene in places. Irregularly shaped orthopyroxene with fine lamellae of clinopyroxene is decomposed into biotite-quartz aggregates. This rock is considered to be a basic intrusion which was emplaced after the formation of the gneisses, but prior to the intrusion of charnockite.

These banded granulitic rocks and upper amphibolite facies rocks seem to dominate in the southern part of western Mühlig-Hofmannfjella and are continuous with those of Gjelsvikfjella. The charnockite extends eastwards from Vestre Skorvebreen.

An isolated nunatak to the north, Larsgaddane, is composed of homogeneous, coarse-grained pink granite, with large idiomorphic potash feldspar phenocrysts. This may be a large xenolith in the charnockite, granitized charnockite or possibly a younger intrusive.

Hamarskaftet

The northern nunatak of Hamarskaftet, 1,661 m high (Fig. 6), consists of pink granite with small feldspathized gneissic paleosomes. The southern nunatak, 1,745 m high, is composed of dark charnockite, while a small nunatak about 1.5 km to the north consists of migmatite with shadow-like paleosomes including biotite gneiss blocks. The migmatites may be part of a large xenolith in the charnockite.

Plogskaftet

Occurrences of gneiss-migmatite-granite xenoliths in charnockite are well demonstrated in these nunataks (Figs. 6 and 8). The northernmost nunatak, 1,595 m high, is composed of a streaky migmatite including tightly folded, biotite-hornblende gneiss. Charnockite intrudes along joints in the gneiss, crosscutting the gneissosity. This gneiss mass may be a large block enclosed in the charnockite.

Another type of xenolith which occurs in this nunatak is medium-grained granoblastic gneiss containing Fe-rich minerals (Tables 5 and 6). The rock consists of orthopyroxene, biotite, plagioclase, potash feldspar quartz and ilmenite. The orthopyroxene is a ferrosilite relatively rich in Mn (En = 18.5, Fs = 77.2, Rh = 2.0, Wo = 1.9) and the biotite is rich in FeO and TiO_2 (28.65 and 4.85 wt%, respectively). Plagioclase shows weak zonation from An32 to An28. Another granulitic rock sample of this xenolith type contains ortho- and clinopyroxene, biotite, antiperthitic plagioclase, ilmenite and monazite. The orthopyroxene is broken down to biotite and quartz around its margins. Two-pyroxene geothermometry (Wood & Banno 1973) yields 780°C for this rock. The high-temperature mineral assemblages possibly resulted from re-equilibration due to the thermal influence of the charnockite on the original granulite facies assemblages.

The 1,623 m high nunatak reveals typical occurrences of charnockite dykes cutting migmatites of shadow-like, agmatitic and ptygmatic types. Biotite rich and basic gneisses occur as numerous paleosomes in the migmatites, showing various degrees of granitization. Homogeneous white granite is also found as xenoliths in the charnockite. One biotite rich gneiss paleosome has a garnet-sillimanite assemblage. Many aplite and pegmatite dykes cut the migmatites and numerous joints are filled by leucocratic veins. The charnockite cuts all rocks described above with sharp contacts. Only a few, narrow white veins are injected along joints in the charnockite and these are probably the end products of the charnockite consolidation. A weak foliation is revealed by the alignment of subidiomorphic potash feldspar crystals in the charnockite.

Fig. 8. Occurrence of xenoliths of gneisses and migmatites in the charnockite, Plogskaftet.

The three middle nunataks, 1,731 m, 1,625 m and 1,755 m high, also show good examples of xenolithic occurrences of gneisses, migmatites and granite in the charnockite (Fig. 8). Many angular blocks, up to 50 m across, are aligned in the charnockite along its gentle, west dipping weak foliation. Even small xenoliths of some dm size have sharp angular outlines.

Charnockite dykes, cutting agmatitic migmatites, are exposed on the northern face of the 1,755 m high nunatak. Both granitic metatect and gneissic paleosomes are sharply transected by white pegmatites and all these rocks are again cut by dark charnockitic dykes. Along the margins of the charnockite fine-grained chilled facies, about 1 m in width, are locally developed.

The southernmost nunatak consists of dark charnockite in its western half, whilst a homogeneous, white potash feldspar granite occurs in the eastern part. Several dykes of charnockite cut

Table 6. Representative microprobe analyses of thin-sections from the Snøtoa metamorphic complex and the Svarthamaren charnockite batholith (ref. Tables 5 and 7). Sample localities are shown in Fig. 6.

	BT104, charnockite, Høgsenga		
	ol	cpx	hornblende
SiO_2	29.69	48.22	37.95
TiO_2	0	0.03	0.97
Al_2O_3	0	0.92	11.64
Cr_2O_3	0.04	0	0.03
FeO*	68.61	28.18	32.25
MnO	1.81	0.62	0.26
MgO	0.32	0.93	0.56
CaO	0	20.47	10.46
Na_2O	0	0.25	1.68
K_2O	—	—	1.41
Total	100.47	99.61	97.22
Kation ratio			
0	4	6	23
Si	1.000	1.985	6.246
Ti	0	0.001	0.121
Al	0	0.015*	1.754*
		0.030**	0.504**
Cr	0.001	0	0.004
Fe	1.932	0.970	4.439
Mn	0.052	0.022	0.036
Mg	0.016	0.057	0.137
Ca	0	0.903	1.844
Na	0	0.020	0.536
K	—	—	0.296
XMg	0.008	0.056	0.030

FeO* = total Fe as FeO, Al* = Al^{IV}, Al** = Al^{VI}, XMg = Mg/Fe + Mg in all analyses.

Feldspars

pl: core: An = 33.6, Ab = 65.3, Or = 1.1
rim: An = 29.9, Ab = 69.3, Or = 0.8

	BT95: gneiss xenolith in charnockite, Høgsenga					
	opx	cpx		hornblende		biot.
		grain	lamell.	poiki	to opx	
SiO_2	48.59	50.00	50.01	42.91	39.94	37.65
TiO_2	0.09	0.06	0.13	0.37	1.21	3.20
Al_2O_3	0.23	0.58	0.77	8.34	10.22	12.42
Cr_2O_3	0.02	0.10	0.04	0.03	0.02	0.08
FeO*	40.23	19.57	19.77	21.45	27.80	20.34
MnO	1.51	0.63	0.63	0.32	0.13	0.19
MgO	8.53	7.46	7.44	8.76	3.85	11.57
CaO	0.82	20.40	20.49	10.97	10.71	0.02
Na_2O	0	0.23	0.34	1.62	1.66	0.07
K_2O	0	0	0	1.41	1.63	9.18
Total	100.02	99.03	99.62	96.18	97.17	94.72
Kation ratio						
0	6	6	6	23	23	22
Si	1.993	1.982	1.973	6.730	6.423	5.811
Ti	0.003	0.002	0.004	0.044	0.146	0.371
Al	0.007*	0.018*	0.027*	1.270*	1.577*	2.189*
	0.004**	0.009**	0.009**	0.272**	0.360**	0.071**
Cr	0.001	0.003	0.001	0.004	0.003	0.010
Fe	1.380	0.649	0.652	2.813	3.739	2.626
Mn	0.052	0.021	0.021	0.043	0.018	0.025
Mg	0.522	0.441	0.438	2.048	0.923	2.662
Ca	0.036	0.867	0.866	1.843	1.845	0.003

Table 6. (continued)

Na	0	0.018	0.026	0.493	0.518	0.021
K	0	0	0	0.282	0.334	1.808
XMg	0.274	0.405	0.402	0.421	0.198	0.503

Feldspars
pl: core: An = 32.6, Ab = 65.2, Or = 2.2
rim: An = 32.4, Ab = 65.2, Or = 2.4
poiki: poikiloblastic
to opx: contact with orthopyroxene

YO167: gneissic xenolith in charnockite, N Plogskaftet

	opx	biotite
SiO_2	47.22	34.90
TiO_2	0.03	4.85
Al_2O_3	0.32	13.12
Cr_2O_3	0.07	0
FeO*	43.69	28.65
MnO	1.12	0.14
MgO	6.00	5.08
CaO	0.82	0.01
Na_2O	0.05	0.01
K_2O	0	8.75
Total	99.32	95.51
Kation ratio		
0	6	22
Si	1.988	5.582
Ti	0.001	0.583
Al	0.012*	2.418*
	0.004**	0.056**
Cr	0.002	0
Fe	1.539	3.832
Mn	0.040	0.019
Mg	0.377	1.211
Ca	0.037	0.002
Na	0.004	0.003
K	0	1.786
XMg	0.197	0.240

Feldspars
pl: core: An = 30.4, Ab = 68.3, Or = 1.3
rim: An = 29.0, Ab = 70.2, Or = 0.8

opx: En = 18.9, Fs = 77.2, Rh = 2.0, Wo = 1.9

YO169: gneissic xenolith in charnockite, N Plogskaftet

	opx	cpx	biotite
SiO_2	49.33	51.07	36.66
TiO_2	0.11	0.11	5.05
Al_2O_3	0.34	0.64	13.17
Cr_2O_3	0	0	0.08
FeO*	33.53	14.44	19.62
MnO	1.20	0.51	0.16
MgO	13.85	10.66	10.84
CaO	0.81	21.09	0.06
Na_2O	0	0.29	0.05
K_2O	0	0	9.20
Total	99.17	98.81	94.89
Kation ratio			
0	6	6	22
Si	1.973	1.981	5.641
Ti	0.003	0.003	0.584

Table 6. (continued)

Al	0.016*	0.019*	2.359*
	0	0.010	0.029
Cr	0	0	0.010
Fe	1.122	0.468	2.525
Mn	0.041	0.017	0.021
Mg	0.826	0.616	2.487
Ca	0.035	0.876	0.010
Na	0	0.022	0.015
K	0	0	1.806
XMg	0.424	0.568	0.496

Feldspars
pl: An = 27.8, Ab = 70.9, Or = 1.2
and An = 26.9, Ab = 71.9, Or = 1.2

the granite and the contact is partly sheared with a 5–10 cm wide mylonite zone. Fe-rich, medium-grained charnockite from this area consists of fayalite (Fa = 99), hedenbergite (En = 2.5, Fs = 50.5, Wo = 47), plagioclase (An35-26 from centre to rim), quartz, ilmenite and magnetite (Tables 6 and 7). The quartz-fayalite-magnetite assemblage from this rock gave $fo_2 = 10^{-(10-15)}$ bars and 750°C (Wones & Gilbert 1969) as the formation conditions for the charnockite.

Svarthamaren to Ahlstadhottane

The high mountains in this area are exclusively composed of charnockite (Fig. 6). Weak foliations are locally present and they generally show NW-SE strikes and moderate westward dips to the west of Svarthamaren and eastward dips to the east of Båsbolken.

The charnockite can be divided into two facies: a) a medium-grained, greenish grey rock with less than 10% mafic constituents (ortho- and clinopyroxene and locally biotite), b) a dark brown, coarse-grained rock, characterized by large idiomorphic potash feldspar crystals and smoky quartz.

These two facies show sharp contacts. The medium-grained variety is restricted in its occurrence to northern Svarthamaren, southern Cumulusfjella and the middle part of Høgsenga. Large amounts of deep green hornblende is the major mafic constituent. Ortho- and clinopyroxene are always present and often included in the hornblende. Pale coloured, irregular flame-like patches occur in the medium-grained charnockite with high angles to the weak foliation (Fig. 9). The flame-like patches do not display clear lithological differences to the dark charnockite, except for the colour of the felsic constituents. The centres of some flame domains are granitic in composition. These flames may have formed by late hydration of the charnockite or by assimilation of granitic xenoliths in the charnockite.

Small gneissic, migmatitic and granitic xenoliths occurring elsewhere in the charnockite show varying degrees of assimilation, revealed by various widths of the transition zone of the block margins. Isolated large granitic xenoliths, tens to hundreds of metres in size, are observed in the southeastern cliff of Svarthamaren, the northwestern tip of Båsbolken, the middle part of the western cliff and northeastern slope of Høgsenga, the southern and southeastern parts of Cumulusfjellet and the middle and eastern parts of Ahlstadhottane. The 2,695 m peak of southwestern Breplogen consists of granitic migmatites containing basic paleosomes and together they form a large xenolithic block in the charnockite. Some xenoliths show diffuse margins of white tint, but many others have very sharp angular

Table 7. Mineral assemblages of the Svarthamaren charnockite, Mühlig-Hofmannfjella.

	ol	opx	cpx	hb	bi	pl	kf	qz	il
BT46			x	x		x	x	x	x
BT48		x	x		x	x	x	x	x
BT98		x	x	x		x	x	x	x
BT106	x			x	x	x	x	x	x
BT104	x		x	x		x		x	x
BT115	x	x	x			x	x	x	x
BT69	x	x	x	x		x	x	x	x
BT144	x	x	x	x	x	x	x	x	x

Accessories: apatite, zircon, allanite, monazite and secondary epidote, sphene, serpentine.

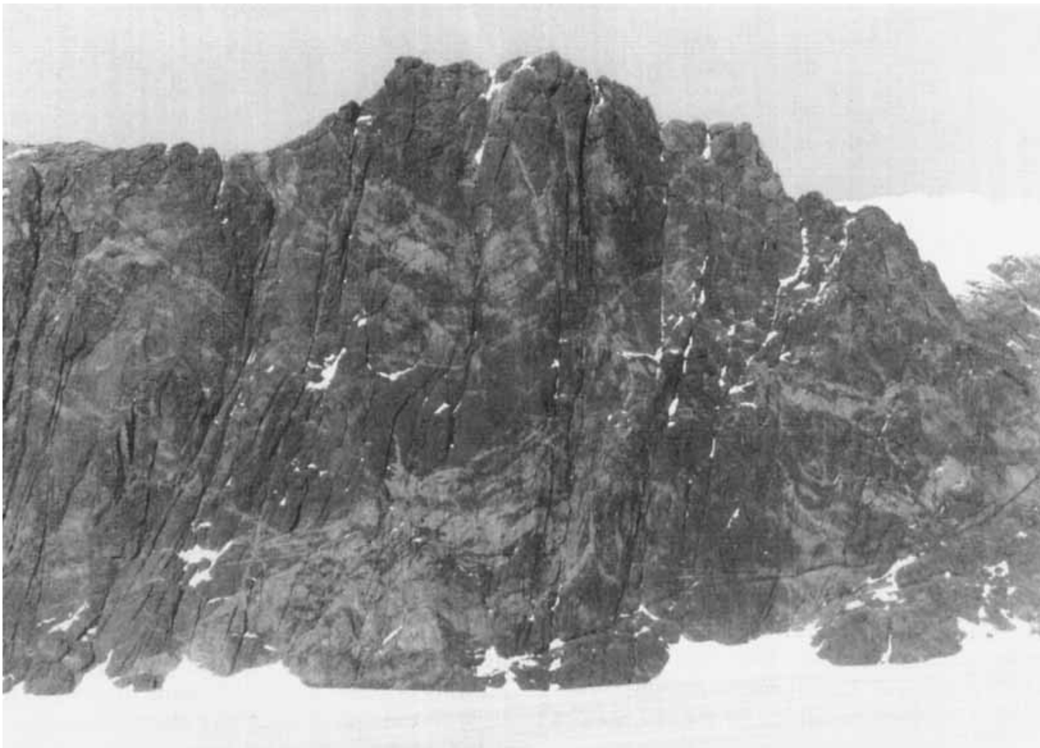

Fig. 9. Flame-like, pale coloured facies in the charnockite, Høgsenga.

block boundaries. A gneissic xenolith in the charnockite of Høgsenga consists of ortho- and clinopyroxene, dark green hornblende, brown biotite, plagioclase, potash feldspar, quartz and accessory ilmenite (Tables 6 and 7). Orthopyroxene with exsolved Ca-clinopyroxene (ferroaugite-ferrosalite) lamellae is surrounded by poikiloblastic hornblende. Clinopyroxene also occurs as individual medium-sized grains in the rock and the composition is similar to that of the lamellae. The hornblende is heterogeneous both in colour and composition within one grain. Two pyroxene geothermometry (Wood & Banno 1973) gave a possible blocking temperature of about 795°C for this rock.

Distant observation by binoculars from Ahlstadhottane and Breplogen to the mountains and nunataks to the east of Austre Skorvebreen shows that all visible exposures are dark red coloured charnockite.

Dyke rocks

Several different types of dykes, which cut the medium-grained charnockite, are well exposed in a 300 m high cliff in southern Svarthamaren:

1) The oldest dykes are agmatitic and irregularly shaped. They consist of biotite rich basic rock fragments of 10–20 cm size, and occur in a fine-grained, dark yellow, felsic granulitic matrix.

2) Yellowish felsic charnockite forms thin dykes, locally with pink-coloured seams in the centre.

3) A pink, impregnation-like aplitic rock forms irregular dykes. They cut the felsic charnockite dykes.

4) Hornblende rich basic dykes with large, white idiomorphic potash feldspar cut the pink aplitic dykes.

5) Dark coloured, basic dykes with biotite clusters cut the feldspar idiomorphic dykes.

These five types of dykes are considered to be emplaced during a late consolidation stage of the medium-grained charnockite.

There are two more types of sharply cross-cutting dykes:

6) Dark metabasite dykes, 3–5 m thick, are the most distinct dykes in the upper part of the cliff.

They can be followed in a distance of more than 3 km with a gentle dip to the south.

7) Grey aplite dykes cut the metabasite dykes, and sometimes form composite dykes with the latter.

Dyke types 6) and 7) do not show any mobilization, but they are moderately recrystallized. All dykes are cut by the coarse-grained, dark charnockite in the northern part of Svarthamaren. Svarthamaren is the only locality with such a high concentration of basic dykes in the medium-grained charnockite, which indicates that the area may be in a special structural position near the margin of the charnockite massif.

Summary of the geology in western Mühlig-Hofmannfjella

The observations in western Mühlig-Hofmannfjella show that a large intrusive charnockite complex, the Svarthamaren charnockite batholith, occurs in the northeastern part of the area. The main rock types are coarse-grained and medium-grained charnockite.

A westward projection of the coarse-grained charnockite extends from Svarthamaren to Skigarden. This projection splits into several major subconcordant sheets and dykes and they cut into the Snøtoa metamorphic complex along the eastern parts of Grytøyrfjellet and northern Hochlinfjellet. The coarse-grained charnockite has sharp cutting contact relationships to the medium-grained charnockite, showing that the coarse-grained charnockite is younger than the former.

The medium-grained charnockite includes a large proportion of xenoliths probably derived from the Snøtoa metamorphic complex. These xenoliths are assimilated to a varying degree. However, many xenoliths, even small ones, are almost devoid of assimilation and have retained their angular outlines at many localities. Strongly assimilated rocks are mostly of granitic composition. Partly assimilated gneissic and basic xenoliths commonly have white coloured margins in which the granulitic mineral assemblages are lost. White patches may also be hydrated charnockite by volatiles derived from the xenoliths.

The Snøtoa metamorphic complex occupies the high mountains in the southern part of western Mühlig-Hofmannfjella. On the western side of Vestre Skorvebreen the Snøtoa metamorphic complex contains granulite facies gneisses and migmatites which probably were partially recrystallized during the emplacement of the Svarthamaren charnockite batholith.

Geochronology

Previous works

Two distinctly different age provinces are separated by the J-P RZ in western Dronning Maud Land (Fig. 1). To the west of the rift zone Archean basement, 3,100–2,800 Ma old (Halpern 1970; Elworthy 1982), covered by almost undeformed 1,850–760 Ma old fluvial and volcanic sediments. To the east of the zone isotope data have been interpreted to record a regional metamorphic phase of 1,000–1,200 Ma (Elworthy 1982), coeval with the Bunger Orogeny of east Antarctica (Angino & Turner 1964; Deutsch & Webb 1964) and the Nimrod Orogeny of the Trans Antarctic Mountains (Grindley & McDougall 1969). Elworthy (1982) also interpreted a thermal event about 500–400 Ma old, comparable to the Ross Orogeny (Elliot 1975). Because the two provinces show such a contrasting history, different degrees of deformation and metamorphic grade, the J-P RZ is believed to be a deep crustal discontinuity with probably significant lateral displacement. The youngest igneous activity associated with the J-P RZ is a 155–140 Ma old nepheline syenite in the northeastern part of H.U. Sverdrupfjella. 170 Ma old Mesozoic dolerite lavas and dykes, similar to the Ferrar dolerite of the Trans Antarctic Mountains, are known from some places to the east of the zone.

The radiometric ages obtained until 1989 in western Dronning Maud Land are shown in Fig. 1. Both in Kirwanveggen (Wolmarans & Kent 1982) and H.U. Sverdrupfjella (Grantham et al. 1988) in the southwestern extension of the present area the older gneisses and migmatites have an age range from 1,186 to 861 Ma (Rb-Sr, whole rock and U-Pb zircon, Elworthy 1982; Moyes 1989). Elworthy (1982) interpreted some of these ages as the record of the main metamorphism, and inferred that the rocks had a relatively short history prior to the metamorphism, on the basis of low initial $^{87}Sr/^{86}Sr$ ratios. Granitic, intermediate and mafic intrusions from the same area fall in an age range from 918 to 519 Ma (Moyes 1989). Nearly all Rb-Sr mineral ages and K-Ar mineral and whole rock ages from Kirwanveggen in the west to Mühlig-Hofmannfjella in the east fall in a 550–330 Ma age range (Ravich & Krylov 1964; Krylov 1972; Elworthy 1982; Moyes 1989).

Location and description of the samples

Five types of rocks were sampled at three localities, x, y and z shown in Figs. 2 and 6. Each sample weighed 3–6 kg and explosives were used to obtain fresh rock samples.

Felsic gneiss of the Jutulsessen metasupracrustals. – Ten samples of felsic gneiss were collected from the middle succession of the Jutulsessen metasupracrustals. The bulk composition of the rock is granodioritic and the main minerals are oligoclase, microline, quartz and some biotite. The samples have only very weak gneissic fabric.

Metagabbro. – Nine samples of metagabbro were collected northwest of Stabben in the northeastern part of Jutulsessen. The metagabbro has a sharp intrusive contact to the Jutulsessen metasupracrustals. The samples were chosen to cover as many lithological varieties of the gabbro as possible. The mineral assemblage is plagioclase (andesine-oligoclase), pale green clinopyroxene, brown biotite, green hornblende and olivine in some samples. The modal composition varies considerably between the samples. Opaque minerals, sphene and apatite are the accessories. Clinopyroxene is partly converted into green hornblende. The lithological variation is believed to be caused by magmatic differentiation and successive hydrothermal processes, and original igneous textures are well preserved.

Charnockite. – This rock was sampled in southern Svarthamaren and care was taken to avoid the light coloured parts which may be contaminated facies with assimilated foreign materials. The nine samples collected are medium-grained, dark yellow-brown charnockite without preferred mineral orientation. These rocks have tabular potash-feldspar often with very small opaque inclusions, quartz, oligoclase, dark brown biotite, brown clinopyroxene and occasional orthopyroxene grains as the main constituents. The bulk composition is granitic to granodioritic.

Grey aplitic and dark basic dykes, cutting the medium-grained charnockite. – Two types of dyke cutting the charnockite in Svarthamaren were chosen for the isotope study. The gray aplitic dyke is the youngest dyke, and consists of oligoclase, microcline, brown-green biotite, green hornblende, quartz and opaque grains. The samples are uniform and have granodioritic bulk composition. The dark dyke (metabasite) has a basic bulk composition, and consists of oligoclase, dark brown biotite, clinopyroxene and accessory amounts of opaque grains and apatite. This rock is cut by the grey aplitic dyke and locally they form composite dykes.

Analytical techniques

Rb-Sr ratios were determined by X-ray fluorescence spectrometry. Measurements of unspiked 87Sr/86Sr were made on a VG Micromass 30 at Mineralogisk-Geologisk Museum, Oslo, using procedures similar to those described by Pankhurst & O'Nions (1973). Variable mass discrimination in 87Sr/86Sr was corrected by normalizing 88Sr/86Sr to 8.3754. The 87Rb decay constant used is $1.42 \times 10^{-11}y^{-1}$ and the regression technique was that of York (1969). Age and intercept errors are quoted at the 2 sigma level.

Results and discussion

Felsic gneiss, Middle Jutulsessen. – High Sr and relatively low Rb contents did not give a spread in the Rb/Sr ratios sufficient enough to allow an age calculation (Table 8). Therefore, only two samples were analysed for Sr isotope composition. The obtained 87Sr ratios, 0.70576 ± 0.00016 and 0.70482 ± 0.00018, may be regarded as maximum numbers of the initial 87Sr/86Sr ratio. Assuming an age of 1,100 Ma, referring to the results from H.U. Sverdrupfjella and Kirwanveggen, the calculated initial 87Sr/86Sr ratios for the two samples are 0.7029 and 0.7014 (Fig. 10). These are close to the lowest values which are geologically reasonable. Although no definite conclusion is possible, the calculation suggests that the felsic gneiss could fall into the same group as the gneisses dated in H.U. Sverdrupfjella, or be younger.

Metagabbro, northeastern Jutulsessen. – Very similar Rb/Sr ratios made age determination impossible for this rock (Table 8). The Sr isotopes were analysed in four samples and they show some scatter on the isotope diagram (Fig. 10). This scatter may be due to a slight disturbance

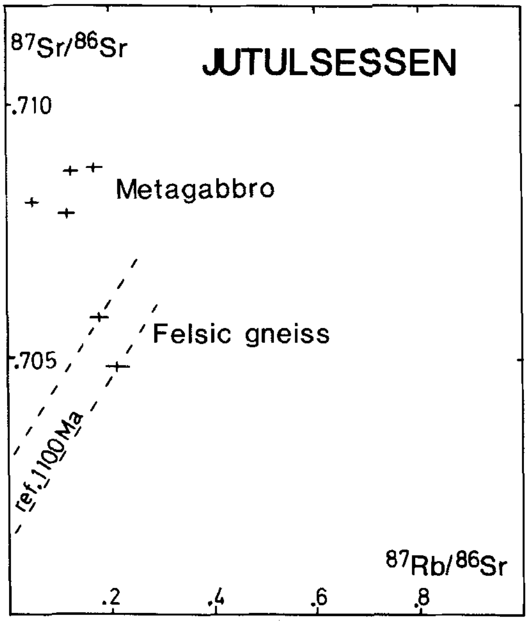

Fig. 10. Isotope diagram for the felsic gneiss of the Jutulsessen metasupracrustals and metagabbro (ref. Table 8).

of the isotope system. However, all samples show relatively high 87Sr/86Sr ratios from 0.70785 to 0.70874. This may indicate that a relatively high initial ratio can be inferred for the metagabbro. Such high initial ratios have commonly been obtained from the mafic rocks to the west of the J-P RZ, and have been interpreted by Elworthy (1982) and Barton & Copperthwaite (1983) to be due to an undepleted mantle source or crustal contamination.

Charnockite, Svarthamaren, Mühlig-Hofmannfjella. – Acceptable spread in the Rb/Sr ratios enabled whole rock age determination of the medium-grained charnockite (Table 9). The regression calculation gave an isochron age of 500 ± 24 Ma with M.S.W.D. = 1.64 (Fig. 11). This age is interpreted as the age of crystallization, and is regarded as the most reliable age for the emplacement of the large charnockite massif in Mühlig-Hofmannfjella (e.g. Ravich & Krylov 1964; Krylov 1972). This intrusion event is coeval to the Ross Orogeny of the Trans Antarctic

Table 8. Rb and Sr analyses of the felsic gneiss and metagabbro from Jutulsessen.

Felsic gneiss Sample no.	Rb*	Sr*	87Rb/86Sr	87Sr/86Sr	SE**
E5	83	1322	.179	.70576	.00016
E6a	95	1264	.217	.70482	.00018
E1	83	1294	—	—	—
E2	86	1281	—	—	—
E3	79	1278	—	—	—
E4	82	1269	—	—	—
E6b	95	1309	—	—	—
E6c	93	1294	—	—	—
E7	85	1170	—	—	—
E8a	95	1253	—	—	—
E8b	98	1290	—	—	—
E8c	111	1297	—	—	—
E9	63	1596	—	—	—
E10a	88	1132	—	—	—
E10b	91	1170	—	—	—
Metagabbro Sample no.	**Rb***	**Sr***	**87Rb/86Sr**	**87Sr/86Sr**	**SE****
A	46	790	.171	.70874	.00012
D1	114	2901	.113	.70785	.00014
D2	116	2697	.124	.70868	.00012
G	71	3816	.052	.70804	.00010
B	120	3208	—	—	—
C1	20	1408	—	—	—
C2	23	1308	—	—	—
F1	75	3464	—	—	—
F2	71	3846	—	—	—

*ppm **2 sigma

Table 9. Rb and Sr analyses of the charnockite and associated dyke rocks from Svarthamaren.

Charnockite Sample no.	Rb*	Sr*	87Rb/86Sr	87Sr/86Sr	SE**
H1	261	150	5.06	.74685	.00018
H2	264	156	4.92	.74580	.00014
H4	271	153	5.15	.74753	.00012
H5a	385	192	5.83	.75123	.00014
H5b	290	159	5.30	.74834	.00012
H6	226	159	4.13	.74004	.00002
H7	217	176	3.58	.73593	.00002
H8	205	158	3.77	.73796	.00002
H9	211	184	3.33	.73401	.00002
Grey aplitic dyke Sample no.	**Rb***	**Sr***	**87Rb/86Sr**	**87Sr/86Sr**	**SE****
J1	152	454	.970	.71527	.00002
J4	234	192	3.54	.73635	.00002
J7	151	456	.961	.71520	.00002
J9	153	448	.987	.71538	.00003
J3	149	464	—	—	—
J5	150	464	—	—	—
J6	151	452	—	—	—
J8	152	451	—	—	—
Dark dyke, Svarthamaren Sample no.	**Rb***	**Sr***	**87Rb/86Sr**	**87Sr/86Sr**	**SE****
K1	88	1694	.150	.70996	.00002

*ppm **2 sigma

Mountains. Evidence of deformation related to this orogeny in western Dronning Maud Land is so far restricted to the folding of the Lower Paleozoic sediments (the Urfjell Group), outcropping in southern Kirwanveggen (Aucamp et al. 1972).

A relatively high initial 87Sr/86Sr ratio of 0.71057 ± 0.00071 for the charnockite is probably related to crustal contamination, since many partly assimilated xenoliths of gneiss and migmatite have been observed along the marginal areas of the charnockite body.

Grey aplitic and dark basic dykes, Svarthamaren, Mühlig-Hofmannfjella. – No significant spread in Rb/Sr ratio, except for one sample, was obtained for the grey aplitic dyke and accordingly, only four samples were analysed for Sr isotope composition (Table 9). The results, together with the analysis of the dark basic dyke and a reference line corresponding to the charnockite isochron, are plotted in Fig. 12. From their crosscutting occurrence both types of dykes are younger than the medium-grained charnockite. In addition, the two kinds of dykes sometimes occur as composite dykes, suggesting their comagmatic derivation. No meaningful age, therefore, can be obtained for the grey aplitic dyke, or for any combination of this rock with the dark basic dyke. The scatter in the isotope diagram possibly reflects originally different initial Rb/Sr ratios, due to magmatic differentiation processes.

Conclusions

1. The bedrock of Gjelsvikfjella and western Mühlig-Hofmannfjella is essentially composed of two metamorphic-igneous rock units: firstly the Jutulsessen metasupracrustals and Snøtoa metamorphic complex and secondly the Svarthamaren charnockite batholith.

2. The age of the regional metamorphism could not be determined in the present study. However, it can be assumed to be about 1,100 Ma old from the structural and lithological continuities with the

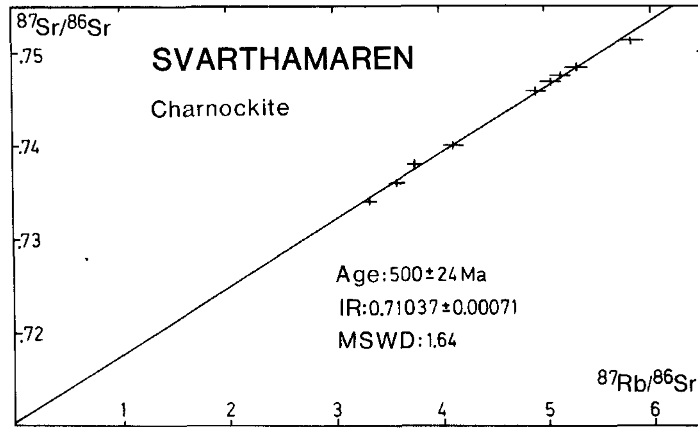

Fig. 11. Isotope diagram for the charnockite from southern Svarthamaren (ref. Table 9).

rocks of H.U. Sverdrupfjella and Kirwanveggen. Around 1,100 Ma is a possible age for the felsic gneiss of the Jutulsessen metasupracrustals.

3. The Snøtoa metamorphic complex consists of granulite facies banded gneisses and migmatites intruded by medium-grained charnockite. The medium-grained charnockite includes a large proportion of gneiss and migmatite xenoliths and intruded into the Snøtoa metamorphic complex about 500 Ma ago. Coarse-grained charnockite makes up the major part of the Svarthamaren charnockite batholith, which is extending far to the east of the mapped area. The cooling process after this thermal event is probably recorded in the mineral ages up to about 400 Ma.

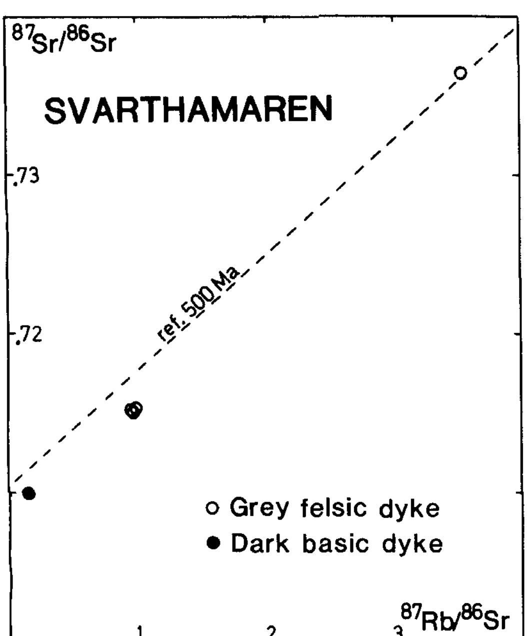

Fig. 12. Isotope diagram for the dykes from southern Svarthamaren (ref. Table 9).

4. The regional metamorphism was originally an intermediate pressure type, upper amphibolite facies to granulite facies. This was probably modified into a high temperature type facies by later thermal influence during the emplacement of the Svarthamaren charnockite batholith.

5. A similar two-stage igneous-metamorphic history is also known from eastern Dronning Maud Land from Sør Rondane to Prins Olav Coast by the studies of Japanese Expeditions (e.g. Shiraishi et al. 1987). Although the area in middle Dronning Maud Land from 6°E to 20°E has not been mapped in detail, this two-stage tectonic history seems to be common in Dronning Maud Land east of the J-P RZ.

Acknowledgements. – The authors would like to thank two anonymous reviewers and Alastair Allen for helpful suggestions and comments on the manuscript. Kurt Bucher-Nurminen and Håkon Austrheim read and commented on an early draft of the manuscript. We would also like to thank Anne Lund for her excellent handling of the word processor.

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