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An outline of the geology of the Nunataks between Eastern Wohlthat Range and Schirmacher Hills, Central Queen Maud Land, East Antarctica

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Abstract

A group of eight nunataks projects out of the polar ice between the Schirmacher hills in the north and the' Gruber massif of Wohlthat mountains in south, in the central Queen Maud Land of Antarctica. These nunataks were geologically examined and an attempt has been made to compare and correlate some of their geological aspects with those of the Schirmacher hills, the Gruber massif and the Petermann area.

Introduction

The Schirmacher hills and the Wohlthat mountains are the two main rock exposure areas in the central Queen Maud Land of East Antarctica. These are separated by a vast stretch of polar ice sheet (Fig. 1), almost entirely concealing the bed rock between the above mentioned outcrop areas, except for a few exposures, in the form of several nunataks. They stand out as isolated knolls, individually occupying small areas, the largest (Starheimtind nunatak) being about 10 sq km in area.

Geology

Four different lithological units have been identified in eight nunataks which are in relative proximity to the Schirmacher hills as compared to Wohlthat mountains (Fig. 2). The lithology of each of these nunataks is given below:-

Nunataks	Lithology
1. Tallaksenvarden	Leucocratic gneiss: Quartz-feldspar ± biotite ± garnet gneiss; Melanocratic gneiss: Biotite-feldspar-quartz ± garnet ± sillimanite gneiss and basic sills.
2. Stenersenknatten	Leucocratic gneiss: Quartz-feldspar ± biotite ± garnet gneiss.

3. Hauglandtoppen	Melanocratic gneiss: Biotite-feldspar-quartz ± garnet gneiss
4. Andersensata	Metabasite.
5. Baalsrudfjellet	Leucocratic gneiss: Quartz-feldspar ± biotite ± garnet gneiss with intercalated calc-silicate rock; Melanocratic gneiss: Biotite-feldspar-quartz rj: garnet ± sillimanite gneiss and basic sills.
6. Sonstebynuten	do————————
7. Starheimtind	————do————
8. Pevikhornet	Leucocratic gneiss: Quartz-feldspar ± biotite ± garnet gneiss with intercalated calc-silicate rock; basic sills.

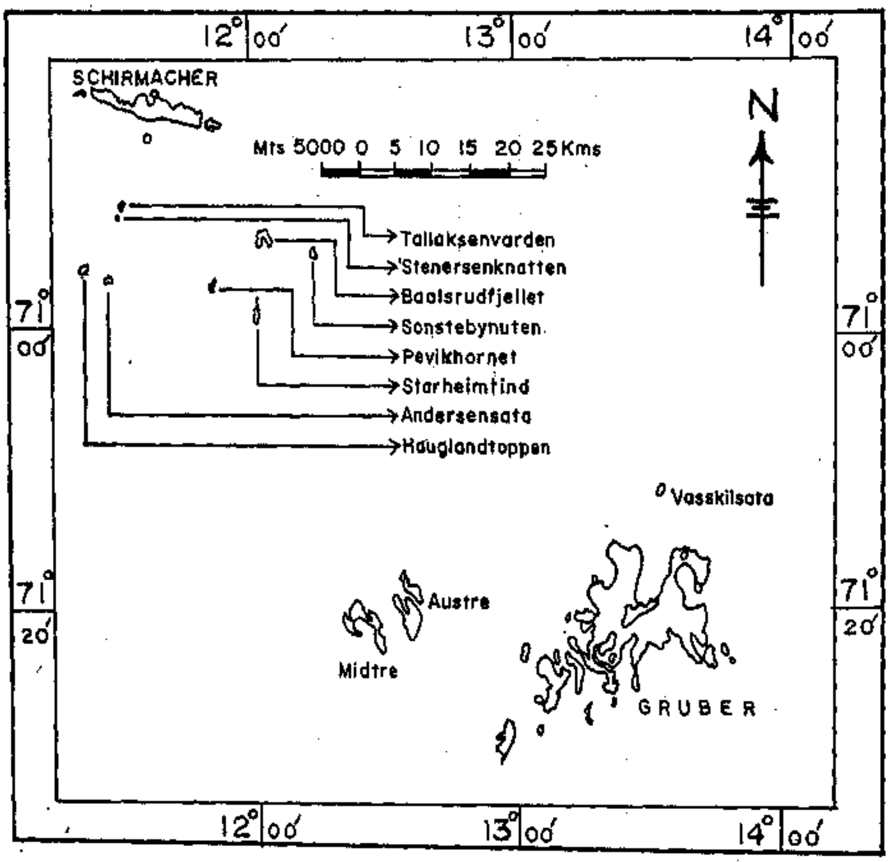

Fig 1. Map showing the location of Nunataks examined

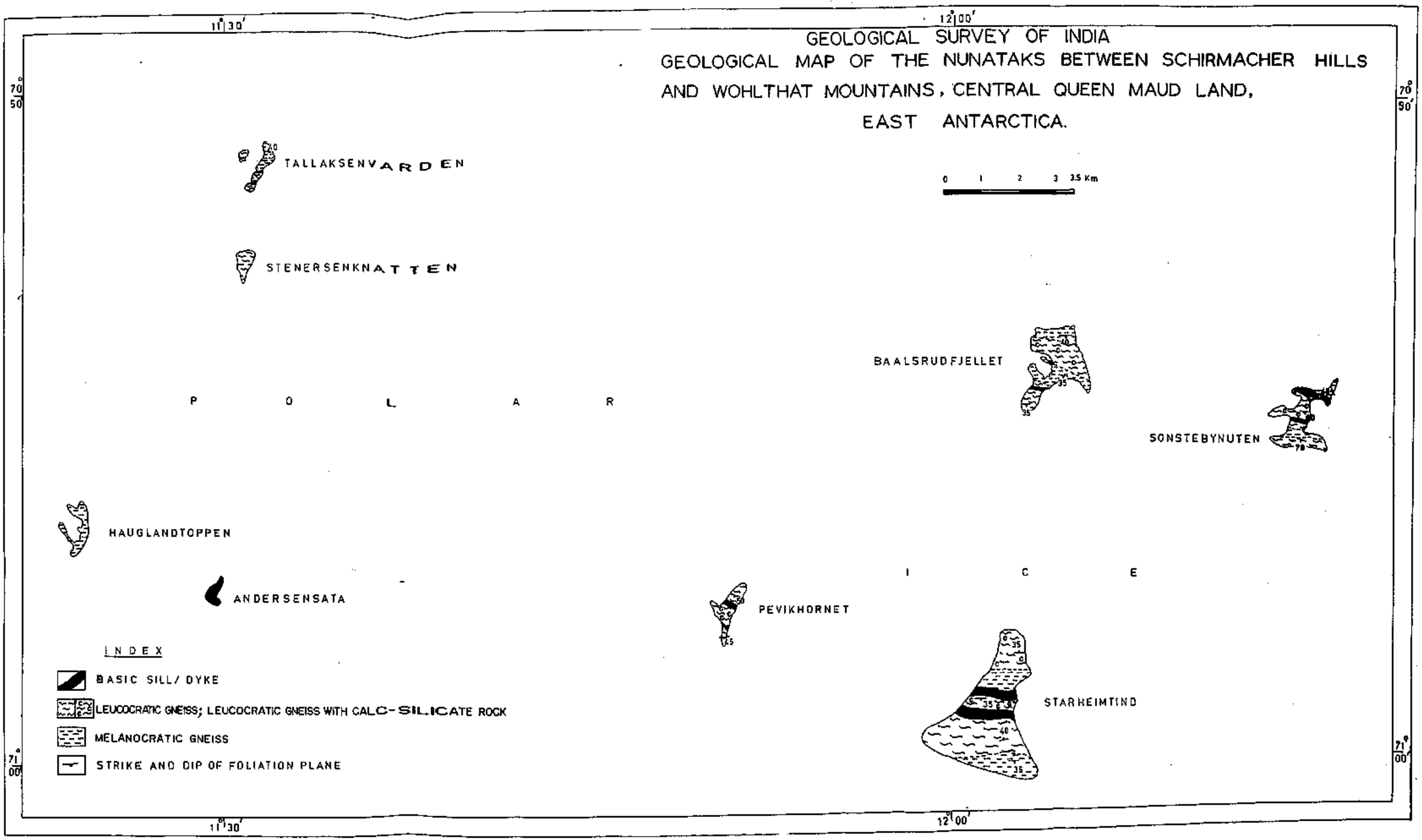
GEOLOGICAL SURVEY OF INDIA
GEOLOGICAL MAP OF THE NUNATAKS BETWEEN SCHIRMACHER HILLS AND WOHLTHAT MOUNTAINS, CENTRAL QUEEN MAUD LAND, EAST ANTARCTICA.
0 1 2 3 3.5 Km
TALLAKSENVARDEN
STENERSENKNATTEN
HAUGLANDTOPPEN
ANDERSENSATA
BAALSRUDFJELLET
SONSTEBYNUTEN
PEVIKHORNET
STARHEIMTIND
P O L A R I C E
11°30′
12°00′
70°50′
71°00′
INDEX
BASIC SILL/ DYKE
LEUCOCRATIC GNEISS; LEUCOCRATIC GNEISS WITH CALC-SILICATE ROCK
MELANOCRATIC GNEISS
STRIKE AND DIP OF FOLIATION PLANE

Fig. 2

Gneisses: The gneisses are. mainly of two types—leucocratic gneisses and melanocratic gneisses. Gneissosity of the leucocratic gneisses is defined, in general, by the preferred orientation of streaks of mafics present in these rocks and alternate bands of quartz-feldspar aggregates. Few quartz grains are found to be elongated, their long axis being parallel to the S-plane. The leucocratic gneisses are characterised by high percentage of quartz and feldspar content. In addition to these, they contain some amount of garnet and/or biotite. Zircon and apatite are common accessory minerals in these rocks. At places these leucocratic rocks are granitic in texture, for example, at Baalsrudfjellet.

Petrographic studies have revealed that the feldspars are plagioclases as well as microclines. Presence of some perthite is also noted (Fig. 3). Plagioclases are sodic in nature. Their composition, determined by Michel Levy method shows, 0 to 10% of anorthite content in them. Biotite is mostly present as secondary mineral after garnet and is masked by its own dark colour. Chlorite forming after biotite is also present as a minor phase.

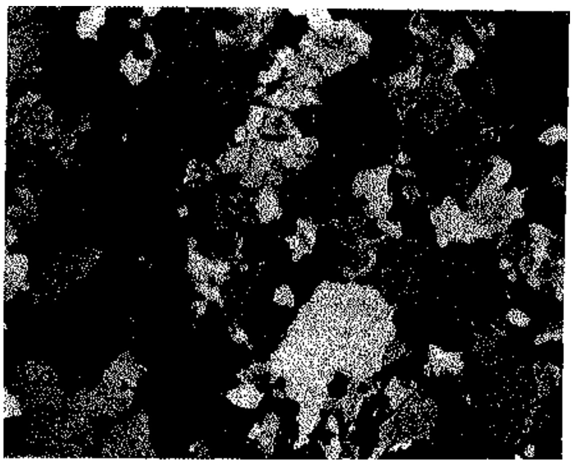

Fig. 3. Photomicrograph showing perthite in leucocratic gneiss (CN x *30)*

The melanocratic gneisses are essentially composed of abundant biotite with subordinate amounts of quartz and feldspar. Garnet and/or sillimanite are common occurrences in some of these rocks. Sillimanite needles are occasionally seen in hand specimens also.

Under the microscope, the darker variety of gneisses show an assemblage of biotite-quartz-perthite-plagioclase-hornblende with apatite and zircon as accessory minerals. Chlorite is present as a secondary phase. Biotite flakes are dark brown and often masked by their own colour. Igneous affinity of the rock is exhibited by pronounced growth of myrmekitic texture (Fig. 4).

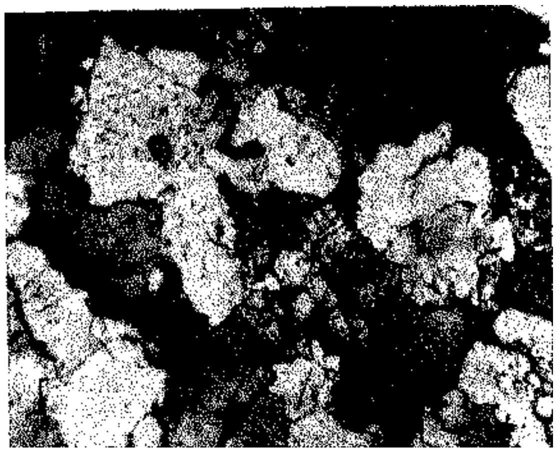

Fig. 4. Photomicrograph showing myrmekitic texture in the gneisses (CN x 45).

Basic rocks: Basic rocks occur mainly in the form of intrusive sills and in some cases as dykes. The nunatak Andersensata almost entirely comprises doleritic rocks showing preferred orientation of feldspar laths and hornblende prisms. Among the intrusives, several lamprophyre occurrences have been noticed in Sonstebynuten and Pevikhornet nunataks. These have been discussed in detail under Singh et *al*, (pp 109-119) in this volume.

Calc-silicate rocks: Calc-silicate rocks are best exposed as intercalated layers with the gneisses of the nunatak Sonstebynuten and are chiefly composed of calcite, olivine, tremolite, vesuvianite and opaque ores. The olivine is colourless under the microscope indicating that compositionally it is rich in Mg. Megascopically these rocks are leucocratic with a granular texture and apparently containing few grains of garnet and pyroxene as well.

Other Nunataks

In addition to the nunataks described above, a few more crop out further south. Prominent among these is Vasskilsata (71°12'S: 13°32'E) rising out of the ice about 14 km north of Gruber massif and comprising augen gneiss, basic granulitic rock and pyroxenite; and the Austre and the Midtre nunataks lying just north of Petermann ranges comprising gneisses, basic granulites and quartz-syenites (Fig. 5). In view of their proximity to the main mountain chain, their geological set-up has been described in this volume along with description of general geology on a regional scale (Kaul *et aL,* pp 57-97).

Lithology of Nunataks vis-a-vis Adjoining Exposures

A lithological comparison of the rock types exposed in the group of eight nunataks thus far discussed, with those of the Schirmacher hills and the Gruber massif, leads to following observations:-

GEOLOGICAL SURVEY OF INDIA

GEOLOGICAL MAP OF NUNATAKS, NORTH OF PETERMANN RANGE, WOHLTHAT MASSIF, EAST ANTARCTICA

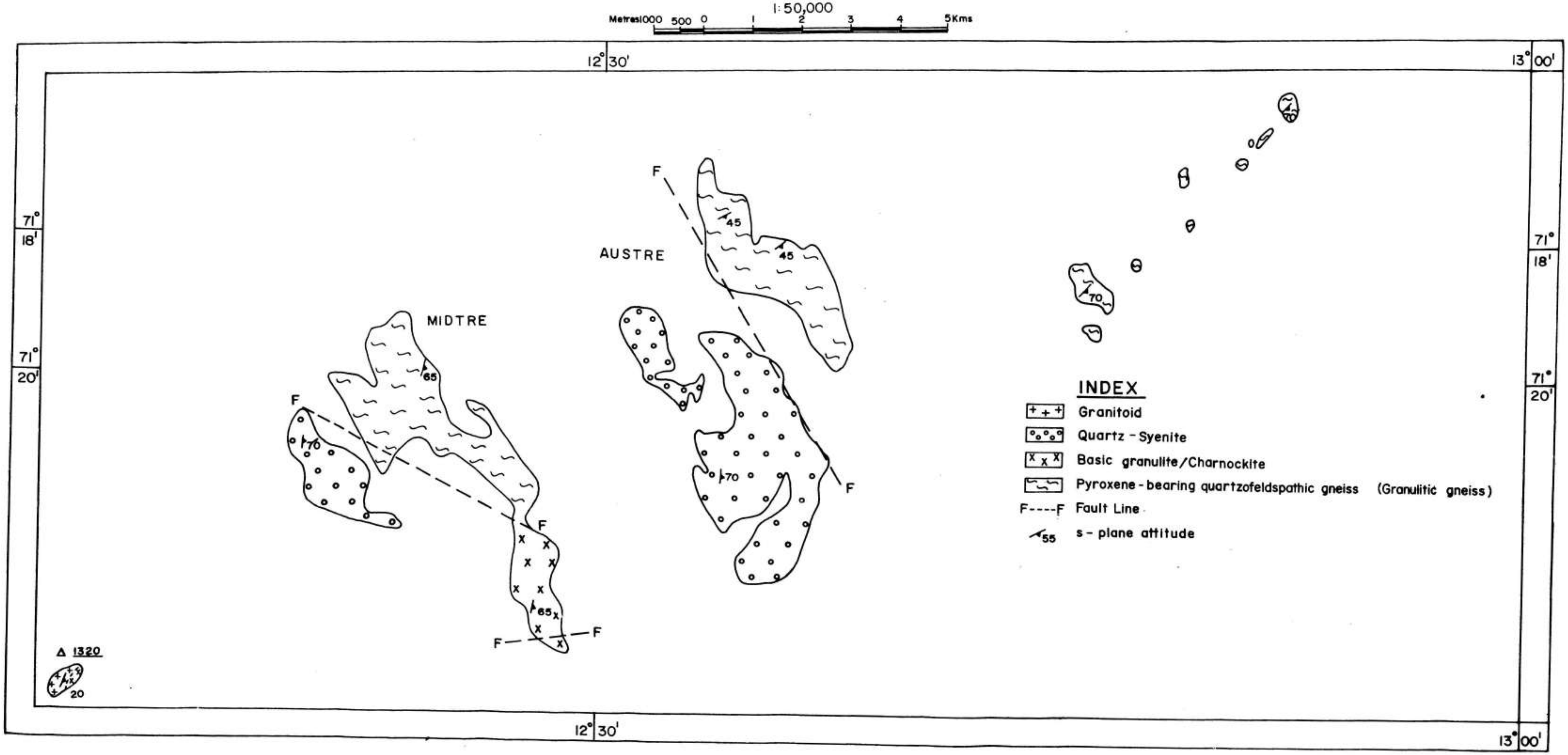

Fig. 5

Gneisses: The gneisses bearing quartz-feldspar-biotite ± garnet resemble the migmatite gneisses of Kaul er *al.* (1985a) and the leucocratic gneisses (Singh, 1986) of the Schirmacher hills. In the northern periphery of Gruber massif, similar granitic gneisses are exposed, but invariably showing the presence of a pyroxene-(ortho-or clino-) and/or an amphibole. The latter appears to be secondary after pyroxene. The darker gneisses of the nunataks with a mineral paragenesis biotite-feldspar-quartz ± garnet ± sillimanite are apparently akin to the microcline porphyroblastic gneisses of Kaul et *al. (op. cit.)* and biotite gneisses of Singh *(op. cit.)* as reported from westernmost part of the Schirmacher hills.

Calc-silicate rock: The calc-silicate rocks (Kaul *et* al., 1985 b) described as calc-gneisses (Sengupta, 1986) from the Schirmacher hills have the following assemblages:-

Plagioclase-diopside-sphene; diopside-garnet-plagioclase-quartz-calcite-sphene; calcite-scapolite-plagioclase-diopside-sphene±quartz; and calcite-diopside-garnet-scapolite-sphene-plagioclase-quartz. Petrography of the calc-silicate rocks of Sonsteby-nuten nunatak, however, reveals an assemblage of calcite-olivine-tremolite-vesuvianite-opaque ores. Calc-silicate rock horizon has not been identified in Gruber massif.

Mafic intrusive rocks: Mafic intrusive rocks are found in all the three outcrop regions under discussion. Raina et *al.* (1985) and Kaul *et al.* (1987), have discussed the occurrence of pyroxene-olivine basalt in Schirmacher hills. In contrast, the doleritic intrusives of nunataks and Gruber massif are either of the three types—tholeiitic basalt, high alumina basalt and alkaline basalt type.

Lamprophyres have not been reported so far from Schirmacher hills, but the description of a late-intrusive dyke from this area (Sengupta, 1986, pp. 201) which is composed of biotite and potash feldspar, with large flakes of undeformed biotite, together with its mode of occurrence, might assign it to a lamprophyric composition.

Quartz-Syenite: The Austre and Midtre nunataks lying in the vicinity of Petermann ranges comprise of a very coarse-grained brownish rock in which feldspars, quartz and pyroxenes, besides garnet, are the mineral phases. Chemical analysis of this rock shows a high amount of silica (Table II) closer to that of typical granites. The rock, however, also shows high K_2O indicating that it has a syenitic affinity. This rock, tentatively named as quartz-syenite, has not been encountered elsewhere in the studied area.

A comparison of Chemical Composition of the Rocks of Three Outcrop Areas in the Region

Representative chemical analyses of some of the rock types from the nunataks have been compared with the compositions of similar rocks exposed in Sehirmacher hills and Wohlthat mountains. The analyses are presented in Tables I, II and III showing whole rock compositions of gneisses, granitoids and quartz-syenites, and dolerites, respectively. It can be observed from these tables that:-

1. The silica content of the gneisses of nunataks is more or less equal to that of the gneisses of Schirmacher hills, decreasing with increasing amount of (Fe, Mg) in the rocks. Gneisses of Gruber massif are much less silicic.
2. Gneisses of the nunataks are high in K_2O-content as compared to those of Schirmacher hills and Gruber massif. K_2O/Na_2O ratio is around 2.0 for the gneisses of nunataks; around 1.5 for the gneisses of Schirmacher hills; and less than 1.0 for Gruber gneisses.
3. Total iron content is (a) least in the gneisses of nunataks; (b) intermediate in Schirmacher gneisses; and (c) maximum in Gruber gneisses.

Table I. Chemical Composition of Gneisses

	, 1	2	3	4	5	6	7	8
	N-113	N-105	N-114	2	5	14	G-18	G-23
SiO_2	71.12	73.25	66.46	61.47	63.88	73.36	58.89	52.01
TiO_2	0.49	1.00	C.59	2.77	0.81	0.39	1.15	0.35
Al_2Cy	13.35	14.00	16.03	15.18	18.00	15.77	13.72	18.52
Fe_2O_3	2.37^T	0.36	4.21^T	2.15	1.50	0.24	14.4/r	8.66^T
FeO	—	1.80	—	5.55	5.49	1.66	—	—
MnO	0.03	0.07	0.05	0.03	0.07	0.02	0.19	0.14
MgO	0.79	0.52	1.'23	2.39	1.91	1.76	0.53'	5.07
CaO	2.34	1.50	1.71	3.95	2.40	1.05	5.98	10.71
Na_2O	2.54	2.69	2.61	2.34	2.41	2.47	1.83	1.82
K_2O	4.79	3.46	5.25	3.53	3.48	3.00	1.81	0.49
K_2O/Na_2O	1.88	1.29	2.01	1.51	1.44	1.21	0.99	0.27

1. Leucocratic gneiss, Sonstebynuten Nunatak
2. Leucocratic gneiss, Baalsrudfjellet Nunatak
3. Melanocratic gneiss, Starheimtind Nunatak

4, 5, 6. Quartzofeldspathic gneisses, Schirmacher hills (after Chakraborty *et* al,, 1988)

7. Gneiss from gneissic zone, Gruber massif, Wohlthat mountains.
8. Gneiss from gneiss-basic granulite contact, Gruber massif, Wohlthat mountains.

T indicates total iron as Fe_2O_3

4. Gruber gneisses are highly calcic compared to both, the gneisses of nunataks and Schirmacher hills.
5. MgO-content of gneisses from nunataks and Gruber massif is appreciably low when compared with that of the Schirmacher hills.
6. Leucocratic gneisses from the nunatak Baalsrudfjellet are remarkably identical in chemical composition with the granitoid collected from Petermann area, except that the former is distinctly more potassic and richer in total alkali content.
7. The. quartz-syenite from Midtre nunatak is highly siliceous, more titaniferous, more ferruginous and richer in potash content as compared to the granitoid from Δ1320.
8. the dolerites of the nunataks are richer in silica and potash content, compared to those of Gruber massif and Schirmacher hills.
9. Titanium content in the dolerites of Gruber massif is high compared to that in the dolerites of odier two areas.
10. Dolerites of Gruber massif are poor in MgO-content but more ferruginous than the dolerites of the nunataks and basalts of Schirmacher hills.

Table II. Chemical Composition of Quartz-Syenites and Granitoids

	1	2
	N-118	N-119
SiO_2	72.24	75.92
TiO_2	0.41	0.25
Al_2O_3	13.33	12.75
Fe_2O_3	3.07[T]	2.52[T]
FeO	—	—
MnO	0.04	0.04
MgO	0.34	0.44
CaO	0.83	2.01
Na_2O	2.43	3.27
K_2O	5.25	0.72
K_2O/Na_2O	2.16	0.22

1. Quartz-syenite, Midtre Nunatak
2. Granitoid, A 1320 Nunatak, Petermann area.

T indicates total iron as Fe_2O_3

Table **III.** Chemical Composition of Basic Intrusives

	1	2	3	4	5
	N-108	N.-111	G-34	G-53	
SiO_2	53.80	50.98	48.80	47.00	44.65
TiO_2	1.09	1.45	3.36	3.45	2.24
Al_2O_3	14.92	11.83	12.07	11.92	10.42
Fe_2O_3	1.00	7.31^T	17.09^T	17.81^T	4.42
FeO	7.38	—	—	—	8.80
MnO	0.16	0.11	0.25	0.25	0.18
MgO	7.32	10.61	4.49	4.03	11.15
CaO	.6.34	5.50	9.75	11.20	12.05
Na_2O	1.74	1.39	2.03	1.63	2.94
K_2O	3.35	5.99	0.86	0.35	0.66

1. Dolerite, Pevikhornet nunatak
2. Dolerite, Sonstebynuten nunatak

3,4. Dolerite, Gruber massif.

5. Basic erratic, Schirmacher hills (after Raina *et al.,* 1985).

T indicates total iron as Fe_2O_3

Structure

Although detailed work on the structural aspects of the nunataks could not be carried out due to a very limited degree of rock exposure and other constraints imposed by difficult terrain conditions, the variation in the attitude of S-planes shows_lhat the rocks of the group of eight nunataks and those near the Wohlthat mountains, belong to different structural domains. In the former, S-planes defined by foliation, strike in nearly E-W direction, the attitude varying between WNW-ESE and WSW-ENE. Foliation planes dip at 35° to 50° either towards north or towards south. Only at Sonstebynuten nunatak, dips are higher i.e. 60° to 70° or even more. Further south, in the Petermann area of Wohlthat mountains general strike direction of foliation planes varies between NE-SW and NNE-SSW with a moderate to high angle of dip (40° to 70°) towards southeast or east.

Conclusion

It is evident that the eight nunataks in spatial proximity of Schirmacher hills, exhibit rock types which are identical, mineralogically, chemically and even structurally with those of Schirmacher hills. On the other hand, the nunataks lying far south in the Petermann area as well as the nunatak Vasskilsata near Gruber massif described in this volume (Kaul et *al.,* pp 57-97), are profoundly distinct by virtue of the mineralogy, chemical composition and structural disposition of their rocks.

It also appears that the rocks of these eight nunataks have been probably subjected to potash metasomatism to a degree that has not been attained even in the Schirmacher area, least of all in the Gruber massif and the Petermann areas. Even the dolerite intrusives of the nunataks are high in potash content compared to the dolerite intrusives in Gruber massif. There appears to be a general decrease in MgO-content of the rocks from Schirmacher hills towards south.

Acknowledgement

The authors wish to put it on, record that the interest and initiative of late Cdr. Bhandari of Indian Navy and his colleagues in flying in the dangerous areas, made it possible to reach the difficult and treacherous parts of the nunataks for geological study.

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