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Postboks 3021, 7002 Trondheim

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Forfatter Olav Limyr		Dato 17.02 1983	Bedrift Folldal Verk A/S, Norske Fina A/S	
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Sammendrag During 1982 the joint venture Norske Fina A/S - Folldal Verk A/S rented the claims in the area from the government. The tailing from the Knaben II mine was sampled, and at the same time the old mines and major showings in the area were visited. The above mentioned investigations and descriptions of the area were studied and compared with own fieldobservations. It has been demonstrated that a lens with heavy mineral enrichment exists within the tailing. The grade and tonnage of this lens is too low to be of any economic potential. No further work is recommended.				

JOINT VENTURE

FOLLDAL VERK A/S - NORSKE FINA A/S

KNABEN GRUVOR

EKSPLORATION WORKS 1982



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FINA

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Postboks 3006
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Stabekk. 17. februar 1983
Deres ref.
Vår ref. Mining - OL/Lo

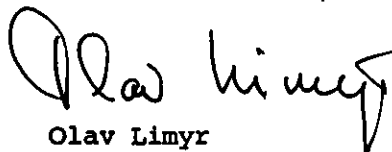
Vedr.: Håndgivelsesavtale Ørsdalen og Knaben Gruvor

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Ørsdalen, Exploration Works 1982.

Knaben Gruvor, Exploration Works 1982.

Med hilsen
for NORSKE FINA A/S


Olav Limyr

vedlegg

KNABEN

Previous work

The Knaben area is the oldest and largest molybdenum mining district in Norway (Map 1). From 1885 to 1972 the district produced 18.800 tons of MoS_2 from 8,8 mill tons of ore.

A detailed account on the geology and mineralization in the Knaben district is presented in Bugge (1963). The mine-geologist from 1970 to 1973 summarized the prospection and exploitation work undertaken in the district prior to the closure of the mine (Gustavsen, 1973). He also prepared a detailed geological/mineralization map in scale 1:5000 of the Knaben area. From 1979 to 1981 Sydvaranger A/S did extensive exploration in the area (Gvein & Rui, 1980 and Gvein, 1981).

Activities

During 1982 the joint venture Norske Fina A/S - Folldal Verk A/S rented the claims in the area from the government. The tailing from the Knaben II mine was sampled, and at the same time the old mines and major showings in the area were visited. The above mentioned investigations and descriptions of the area were studied and compared with own field observations.

Geological setting

In the Knaben district it is possible to discriminate between various rocktypes.

The most frequent rocktype is from old time called red granite. Actually it is an orthogneiss. It is a massive, pink, coarse-grained rock with a vague foliation and granitic composition. The foliation is due to elongated kalifeldspar grains, platy quartz and a minor content of biotite.

The other important rocktype is the grey gneisses. They are found as concordant layers and lenses in the red granite. Three varieties of the grey gneisses can be discriminated. A light grey, finegrained, well foliated or banded biotite-hornblende gneiss often with a minor content of iron-sulphides. Along strike the biotite-hornblende gneiss is transitional into augengneiss, which is a grey, coarsegrained, vaguely foliated gneiss with characteristic large blastoporphyrtes of kalifeldspar. The augengneiss also contains a minor amount of biotite and iron-sulphides. Associated with the leucocratic gneisses it is frequent to find concordant lenses or bands of amphibolite.

A rare rocktype is discordant amphibolites which are migmatized and contain folded quartz-feldspar mobilizations. Such an amphibolite can be followed from just north of the open pit at Knaben II and towards SE (Map 2). A hornblende foliation in the amphibolite is oriented $10-20^{\circ}$ SSE.

In connection with the mineralizing episode the above mentioned rocktypes were altered and quartz veins were formed. These new-formed rocks shall be described below.

Various post-tectonic rocks also occur in the area. Their age-relation to the mineralizing episode is not well understood. They comprise coarsegrained, discordant, subvertical pegmatites and finegrained, discordant aplites.

The youngest geological episode is the intrusion of E-W striking subvertical dolerites up to 10 m thick and several km long.

The red granite predominates in the Knaben area. The grey gneisses are mainly found within a 100 to 300 m thick horizon which also contains many thin layers and lenses of red granite (Map 2 and Map 3). A distinct marker layer has not been mapped out and therefore the detailed structure of the gneiss horizon is not well known. It was mentioned above that the augengneiss is

transitional into biotite-hornblende gneiss. It is characteristic that the augengneiss predominates in the area from Knaben II to Kvina, as the biotite-hornblende gneiss mainly is found in the area south of Knaben II. The grey gneisses are also found as scattered layers and lenses enclosed in the red granite, and especially in the area below the main gneiss horizon.

The general strike of the gneiss is N-S with deviations of up to 30 degree. The dip is 20-50° E. Isoclinal folding and minor dragfolding have been observed a few places. The small variation in strike/dip of the gneiss is due to open folding. The orientation of the gneiss foliation are plotted in Fig. 1 to Fig. 4. It is possible to recognize two foldaxes. One dipping 25° to 30° SE and one dipping c. 10° S. Individual open folding structures have been measured at Ørnehommen and Knaben I and on the structural map of Knaben II (Map 3). The measurements (Fig 5) define all the approximate same foldaxis, which dips c. 35° SE. The 10° S dipping axis has not been identified in individual foldstructures, but it is identical with the plunge of the orebodies at Knaben II and Kvina (see below).

Mineralization, types

The most frequent oreminerals in the Knaben area are molybdenite, chalcopyrite, pyrrhotite and pyrite. Several types of mineralization can be recognized.

Disseminated MoS_2 in various altered rocktypes is the most important type. The most frequent type is the so called gangfjell. It is a bleached red granite enriched in quartz. The bleaching is caused by the break-down of the feldspar with seritization in the core of the grains and albite formation at the rim. The enlarged quartz content is mainly found in diffuse quartz veinlets. Molybdenite is found disseminated in the gangfjell often associated with the quartz. In addition to MoS_2 the gangfjell also contains 200 to 400 ppm Cu in the form of chalcopyrite. The upper part of the Knaben II orebody was gangfjell, and 0,5 to

1,0 mill tons contained 0,3 to 0.5 % MoS_2 . It must be noted that large volumes of gangfjell contains no molybdenite. Where amphibolite has underwent alteration there is formed a massive glimmerite. At Knaben I glimmerite is formed at the bottom of a folded amphibolite, and it is impregnated with MoS_2 (Table 1).

Mineralized quartz veins represent an other important type of mineralization. Two variations can be discriminated. The first is thin (less than 0,5 m thick), concordant quartz veins which occur enclosed in gangfjell, glimmerite, red granite and in the grey gneisses. Molybdenite and traces of chalcopyrite is concentrated at the contact of the veins. Swarms of quartz veins in gangfjell make up the low grade mineralization in the lower part of the Knaben II orebody. The other type of quartz vein comprises the metre-thick veins at Kvina, upper Reinshommen and possible also Knaben I. In addition to quartz the veins also contain feldspar, hornblende and biotite. Molybdenite and chalcopyrite are found disseminated in the veins. The Mo/Cu ratio is 2 to 3 times less than in the gangfjell, but still above 1.

A third type of mineralization, comprising semi-massive sulphides is found above the Knaben II orebody within the gneiss horizon, and above the Kvina orebody also within the gneiss horizon. Semi-massive sulphide accumulations are found in concordant and discordant veins of brecciated hostrock. Individual veins are up to 0,5 m thick. Pyrrhotite predominates with minor amounts of chalcopyrite, pyrite and molybdenite. The Mo/Cu ratio is less than 1, and characteristic this type also contains minor amounts of silver (Table 1).

The grey gneisses with a low content of iron-sulphides and occasionally also traces of molybdenite and chalcopyrite represent a fourth type of mineralization.

Locality	Rock description	Mo (ppm)	Cu (ppm)	Ag (ppm)	Au (ppm)
Knaben II	Gangfjell with MoS ₂ -bearing quartz vein	1.2 %	260	< 2	< 0.1
300 m E of Knaben II	Semi-massive sulphides in biotite-rich rock	380	1.7 %	14	< 0.1
Reinshommen	Quartz vein with disseminated chalcopyrite and molybdenite	1200	5300	8	< 0.1
Knaben I	Glimmerite with c. 10 % disseminated molybdenite	13.7 %	320	< 2	< 0.1
Kvina	Glimmerite and quartz vein rich in molybdenite	19.6 %	360	< 2	< 0.1
Kvina	Quartz-hornblende vein with disseminated MoS ₂ and CuFeS ₂	1000	1700	< 2	< 0.1
Cu-skjerp east of Šmalvatn	Semi-massive sulphides in quartz-feldspar rock	380	3.0 %	65	< 0.1
Gursli	Anorthosite with disseminated molybdenite	1.7 %	280	< 2	< 0.1
Gursli, Mysse-skjerpene	Semi-massive sulphides in feldspar rock	5500	2200	< 2	< 0.1

Table 1 Analyses of rocksamples from the Knaben and Gursli areas.

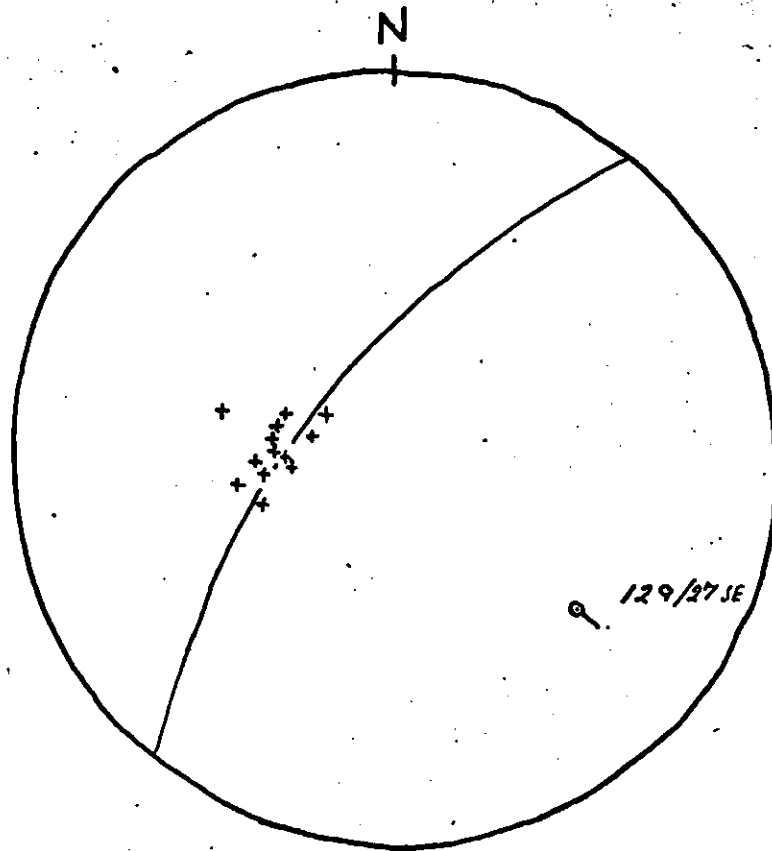


Fig. 1 Foliation measurements and constructed foldaxis from the area south of Knaben II to Reinshommen.

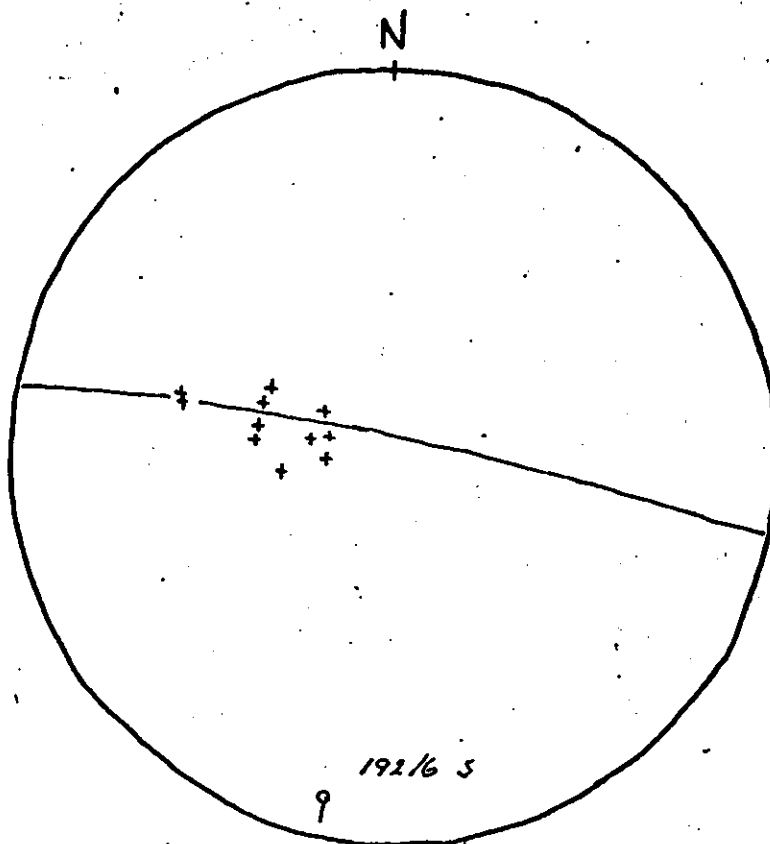


Fig. 2 Foliation measurements and constructed foldaxis from the area between Reinshommen and Knaben I.

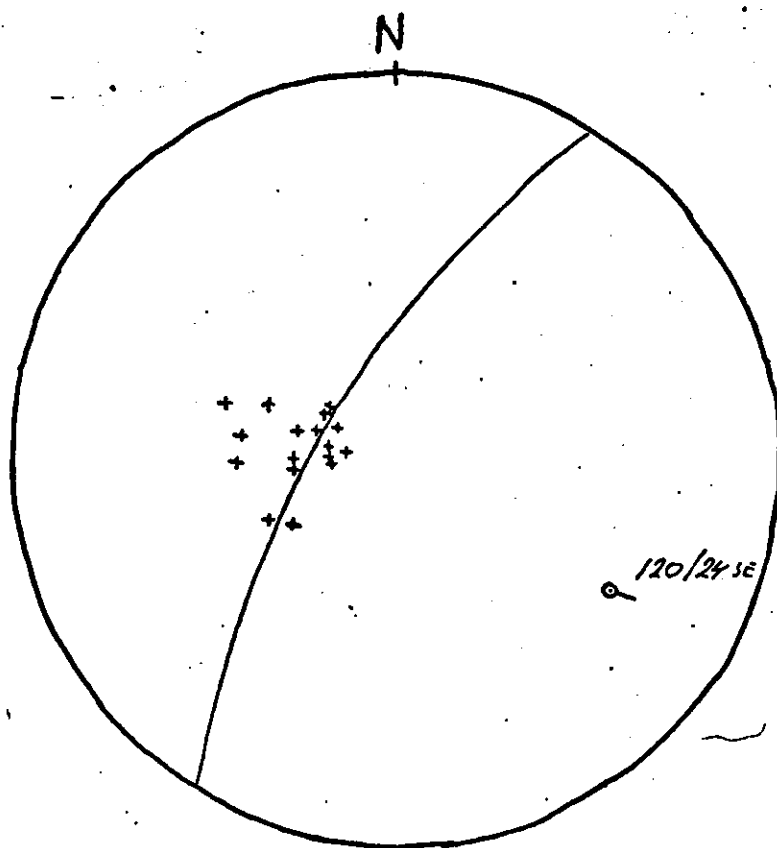


Fig. 3 Foliation measurements and constructed foldaxis from the area between Knaben I and Smalvatn.

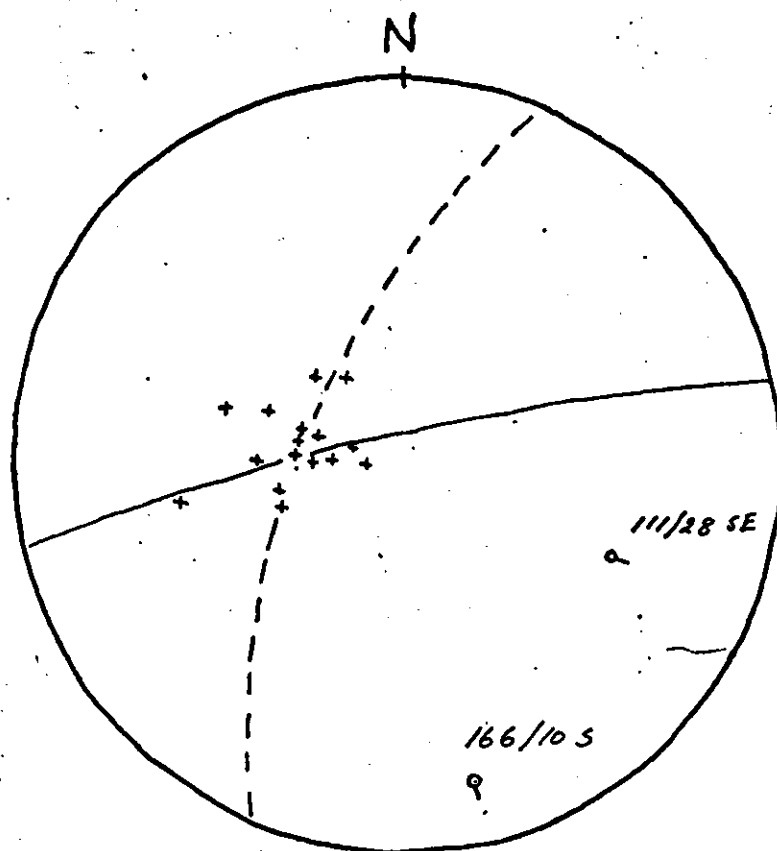


Fig. 4 Foliation measurements and constructed foldaxes from the area around Kyina.

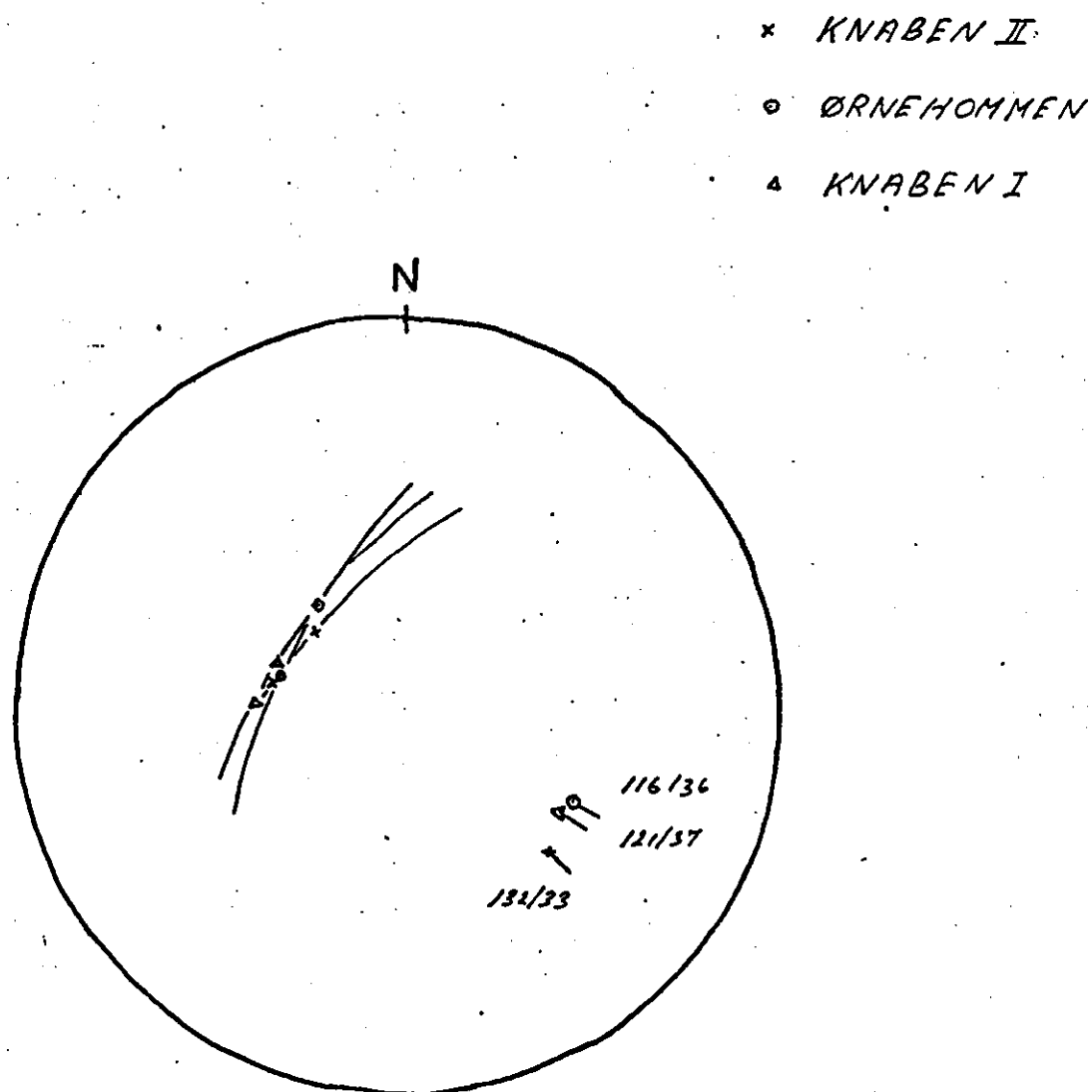


Fig. 5 Orientation of the flanks of the ore controlling fold structures at Knaben I and II and Ørnehommen. The foldaxes are constructed.

Mineralization, description of localities

Mining has taken place from a few large mines and many small mines and showings. The most important ones are described below.

Knaben II is the largest mine (Map 2). From 1918 to 1972 it has produced 18.000 tons of MoS_2 from 8,6 mill tons of ore. The orebody is rulerformed with a length of more than 1300 m, a width of up to 400 m and a thickness of up to 40 m. The orebody is situated within the red granite below the gneiss horizon. The oreplane is concordant with the structure of the gneisses and forms an open anticlinal structure (Map 4'). The long axis is dipping $10-15^\circ$ S. There is a pronounced zonation within the orebody with molybdenite-bearing quartz veins in gangfjell in the lower part and disseminated molybdenite in gangfjell in the upper part. The later with higher grades than the first. The Knaben II orebody is well-investigated with diamond drilling, and it is estimated that there remains 5 mill tons of ore with 0,15 % MoS_2 in the lower part of the orebody.

The Kvina orebody was mined from 1908 to 1955. The production totalled 230 tons of MoS_2 from 100.000 tons of ore. As with Knaben II the Kvina orebody is rulerformed. The maximum dimensions are 240 m x 80 m x 16 m. The orebody occurs enclosed in red granite below the main gneiss horizon. The oreplane ($22^\circ/30^\circ$ E) is concordant with the structure of the red granite, and the long axis is dipping c. 10° S. Molybdenite and chalcopyrite are found at the contact of and disseminated in metre-thick quartz veins and pegmatites. The continuation at south has never been diamond drilled. There is drilled one hole 150 m east of the Kvina orebody, and it does not show any mineralization.

Knaben I is the oldest mine in the area. From 1885 to 1939 it produced 570 tons of MoS_2 from 80.000 tons of ore. Knaben I is situated in the lower part of the gneiss horizon (Map 2). The orebody is found below a syncline in amphibolite. The flanks

are oriented $18^{\circ}/37^{\circ}$ E and $180^{\circ}/41^{\circ}$ E. The foldaxis of the structure is dipping 37° SE. The orebody is only 100 m long and has been followed 25 m below the surface, which corresponds to a down-dip length of 45 m. Molybdenite is found disseminated in glimmerite and associated with quartz veins. The extend of underground exploration is not known. Relevant diamond drilling from the surface comprises one hole (4.1). There is not reported any mineralization in this hole, and it may be placed to far to the south to catch up a possible continuation of the ore in the direction of the foldaxis.

Ørnehommen mine produced 4,2 tons MoS_2 from 2000 tons of ore. The deposit is situated below a syncline in biotite-gneiss enclosed in red granite and well below the main gneiss horizon. The flanks are oriented $14^{\circ}/36^{\circ}$ E and $50^{\circ}/38^{\circ}$ SE. The mineralization type is quartz veins in gangfjell.

For description of the many smaller mines and showings, see Bugge (1963).

Discussion/conclusion

The formation of altered rocks, the formation of quartz veins and sulphide accumulations and the occurrence of a zonarity pattern with the variation in the Mo/Cu ratio and the distribution of silver values point to the existence of migrating hydrothermal solutions in the area during the mineralizing episode.

The structure of the gneiss controlled the distribution of the hydrothermal solutions. Anticlines and synclines formed during open folding have acted as sites for alteration and precipitation of quartz and the oreminerals.

Knaben II is formed within an anticlinal structure (Map 4), and this obvious facilitated the formation of a very elongated and large orebody. The only other orebody with an elongated geometry is the Kvina deposit. It is proposed that the zonarity

seen in Knaben II is the result of cooling of Mo-bearing hydrothermal solutions migrating upwards along the axis of orebody. It is further proposed, that the oretype at Kvina represents formation at an even lower temperature. This opens the possibility, that an orebody of a Knaben II model may be found south of Kvina Map 2. It is interesting to see, that the only drill-hole in the area (D 1) has 10 to 15 m with traces of molybdenite at the expected depth.

Knaben I and Ørnehommen are found below synclinal structures. They seem not to have the same elongated geometry, but characteristically these deposits seem to have a higher grade than the type in anticlinal structures.

It shall be noted that the total amount of molybdenite per metre in the Kvina/Knaben I area equals the amount in the Knaben II area, namely 50-100 tons MoS_2 /metre. Therefore, in the Kvina/Knaben I area it is only a question of finding a structure which was able to concentrate the molybdenite. Such a structure could very well exist at depth in the continuation of the Kvina orebody.

THE TAILING AT KNABEN II

Introduction

During the mining period at Knaben II (1918 - 1972) a total of 8,6 mill tons of ore with 0,21 % MoS_2 (0,13 % Mo) was mined and milled. The tailing was in the entire period discharged at the east end of Lille Knabetjern. First Lille Knabetjern was filled and later also most of Store Knabetjern (Map 5). The tailing contains minor amounts of Mo and Cu in the form of molybdenite and chalcopyrite. The Mo-content depends on the mill-head grade and the recovery. The recovery has increased from perhaps 70-80 % during the first years of operation with high grade ore (0,3 % MoS_2) and up to 90 % at the time when the mine was closed. The expected content would then vary from 800 to 150 ppm MoS_2 . The Cu-content corresponds to the original content of Cu in the ore, and it is 200 to 400 ppm.

The background idea for sampling the tailing was twofold:

- To identify tailing deposited during the first years of operation with the expected high Mo-content.
- To identify areas with heavy mineral enrichment where molybdenite and chalcopyrite would be concentrated.

Activities

The sampling program was limited to the Lille Knabetjern bassin. Two profiles approximate 200 m apart and both parallel with the assumed flow direction was sampled. On each profile, holes - 50 m apart - were sampled for each metre (Map 5 and Map 6). The sampling was done with a 1 m iron-tube, which mounted with rods was hammered down in the sand 1 m at a time. A total of 252 samples were collected from 21 holes (Table 2). In most holes it was possible to reach the bottom of the tailing pond. Each sampled weighed c. 1 kg. It was blended and c. 200 g was sent for Mo-analysis (Table 3). One heavy-mineral sample

Drillhole	Length	Sample numbers	Terminated in:	Remarks
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PROFILE 1 Totally 117 samples

0	4.4 m	1 - 5	Peat	Started 1.5 m below surface of tailing
25	10.6	1 - 11	Peat	
75	17.7	1 - 18	Peat/stone	
125	16.0	1 - 16	Stone	
175	16.0	1 - 16	Soil	Not drilled through ?
225	18.0	1 - 18	Sand	
275	15.9	1 - 16	Soil	
325	10.5	1 - 11	?	
375	5.9	1 - 6	Peat	

PROFILE 2 . Totally 131 samples

0	4.5	1 - 5	Peat
50	13.0	1 - 13	Soil
100	20.2	1 - 20	Sand
150	15.3	1 - 16	Peat/sand
200	16.6	1 - 17	Soil
250	11.8	1 - 12	Stone
300	6.8	1 - 7	Peat
350	8.3	1 - 9	Peat
400	11.7	1 - 12	Peat/sand
450	10.5	1 - 11	Peat
500	8.9	1 - 9	Peat

Hole A , at the NW-corner of the football field. Totally 4 samples

-	3.9	1 - 4	Peat
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Table 2 Sample list from the sampling of the tailing

PROFILE 1

<u>Sample No.</u>		<u>Mo ppm</u>	<u>Sample No.</u>		<u>Mo ppm</u>	<u>Sample No.</u>		<u>Mo ppm</u>
1-0	1	140	1-175	1	80	1-325	1	50
	2	170		2	50		2	80
	3	90		3	80		3	60
	4	180		4	130		4	80
	5	200		5	140		5	60
1-25	1	95		6	260		6	60
	2	100		7	170		7	80
	3	210		8	130		8	150
	4	480		9	230		9	90
	5	460		10	160		10	70
	6	420		11	180		11	80
	7	1100		12	160			
	8	520		13	100	1-375	1	40
	9	480		14	230		2	70
	10	330		15	320		3	90
	11	480		16	360		4	60
1-75	1	45	1-225	1	80		5	50
	2	50		2	50		6	110
	3	140		3	60			
	4	250		4	90			
	5	370		5	160			
	6	280		6	160			
	7	400		7	120			
	8	310		8	120			
	9	290		9	130			
	10	250		10	160	Hole A	1	45
	11	120		11	180		2	40
	12	70		12	160		3	18
	13	240		13	170		4	160
	14	310		14	130			
	15	110		15	130			
	16	80		16	90			
	17	80		17	130			
	18	110		18	160			
1-125	1	230	1-275	1	80			
	2	150		2	40			
	3	70		3	90			
	4	130		4	70			
	5	170		5	120			
	6	230		6	100			
	7	150		7	140			
	8	130		8	100			
	9	140		9	160			
	10	190		10	280			
	11	130		11	230			
	12	120		12	160			
	13	80		13	150			
	14	100		14	130			
	15	80		15	190			
	16	100		16	140			

Table 3 Analyses of the Mo-content in sand samples from the tailing at the Knaben II mine.

PROFILE 2

<u>Sample no</u>	<u>Mo (ppm)</u>	<u>Sample No.</u>	<u>Mo ppm</u>	<u>Sample No</u>	<u>Mo ppm</u>
2-0	1 160	2-150	1 130	2-300	1 80
	2 80		2 300		2 130
	3 170		3 250		3 90
	4 190		4 140		4 90
	5 150		5 380		5 130
			6 200		6 130
2-50	1 100		7 250		7 140
	2 350		8 270		
	3 380		9 220	2-350	1 130
	4 240		10 240		2 60
	5 480		11 220		3 70
	6 560		12 160		4 80
	7 760		13 170		5 130
	8 390		14 100		6 130
	9 450		15 130		7 130
	10 470		16 80		8 160
	11 400				9 230
	12 710	2-200	1 130		
	13 400		2 200	2-400	1 150
			3 130		2 60
2-100	1 210		4 100		3 70
	2 480		5 420		4 100
	3 430		6 250		5 90
	4 180		7 170		6 130
	5 430		8 240		7 100
	6 290		9 190		8 160
	7 160		10 240		9 240
	8 150		11 130		10 270
	9 220		12 140		11 290
	10 290		13 150		12 190
	11 170		14 150		
	12 140		15 120	2-450	1 190
	13 130		16 140		2 40
	14 90		17 210		3 80
	15 110				4 90
	16 140	2-250	1 180		5 90
	17 160		2 140		6 90
	18 180		3 80		7 90
	19 170		4 140		8 400
	20 160		5 300		9 270
			6 140		10 300
			7 220		11 220
			8 170		
			9 180	2-500	1 50
			10 240		2 90
			11 170		3 160
			12 160		4 130
					5 110
					6 220
					7 300
					8 280
					9 120

Table 4 Continued

has been panned from the tailing and analysed for various elements (Table 5).

Results

The Lille Knabetjern bassin contains c. 3,0 mill tons of sand. The distribution of Molybdenum is shown in Map 6 and Fig 6. The arithmetic average MoS_2 content is 0,030 % MoS_2 . A higher grade lens with 0,062 % MoS_2 occurs from 25 m to 125/225 m from the discharge point. The size of the lens is estimated to be 0,5 mill tons. The Cu-content is one half of the Mo-content (Table 5). This is in accordance with the expected content. Even in concentrates with c. 1 % Cu no Ag and Au are detected.

Conclusion/recommendation

It has been demonstrated that a lens with heavy mineral enrichment exists within the tailing. The grade and tonnage of this lens is too low to be of any economic potential. No further work is recommended.

Spectrographic analysis:

Fe, Si, Al and Ti	are in the range	0,5 %	to	5 %
Mn, Ca and Na	are in the range	0,05 %	to	0,5 %
Cr, Pb, V and Ni	are in the range	50 ppm	to	500 ppm
Co	is in the range	5 ppm	to	50 ppm
Mo	is approximately	2 %		
Cu	is approximately	1 %		

Analysis by atomic absorption:

Se	20	ppm
Te	< 1	ppm
Au	< 0,1	ppm
Ag	< 1	ppm

Table 5 Analysis of heavy-mineral concentrate panned from the tailing. The factor of enrichment is approximately 250 times.

Number of
samples

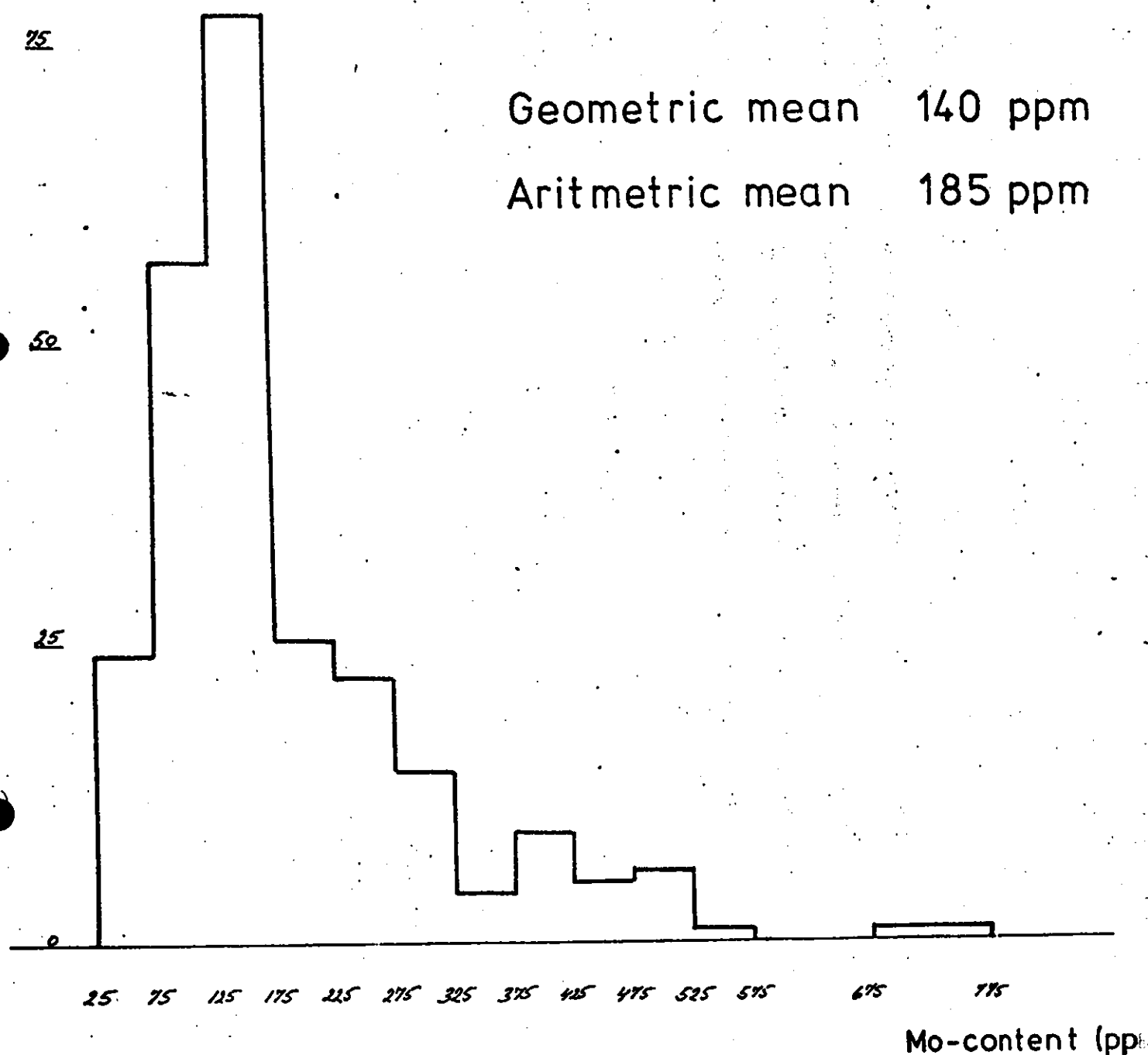
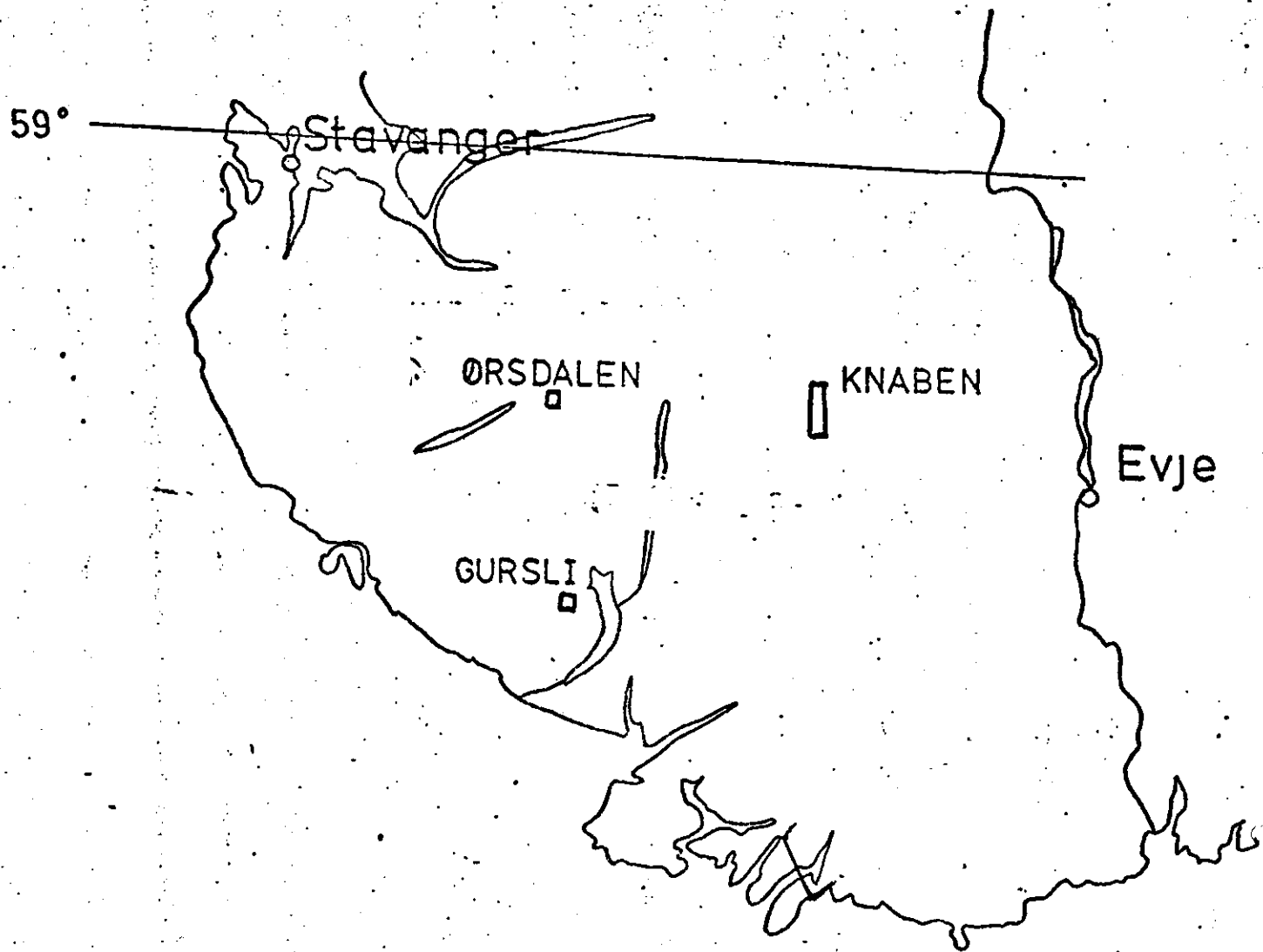


Fig. 6. Distribution of Mo-values in the Lille Knabetjern tailing pond. Total number of samples is 248.



MAP 1





NORSKE FINA A/S

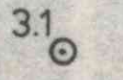




Locality map
SW - NORWAY

1:1000000

JLP oct 82

LEGEND

 RED GRANITE
 GREY GNEISSES MIXED WITH RED GRANITE
 GANGFJELL (BLEACHED RED GRANITE)
 DOLERITE

 DIAMOND DRILLHOLE, number 3.1, direction 287°, dip 60°, length 53.26 m.
 ADIT WITH MoS₂ SHOWING
 PROSPECTION PIT WITH MoS₂ SHOWING
 MoS₂ SHOWING
 STRIKE/DIP OF FOLIATION

NORSKE FINA A/S

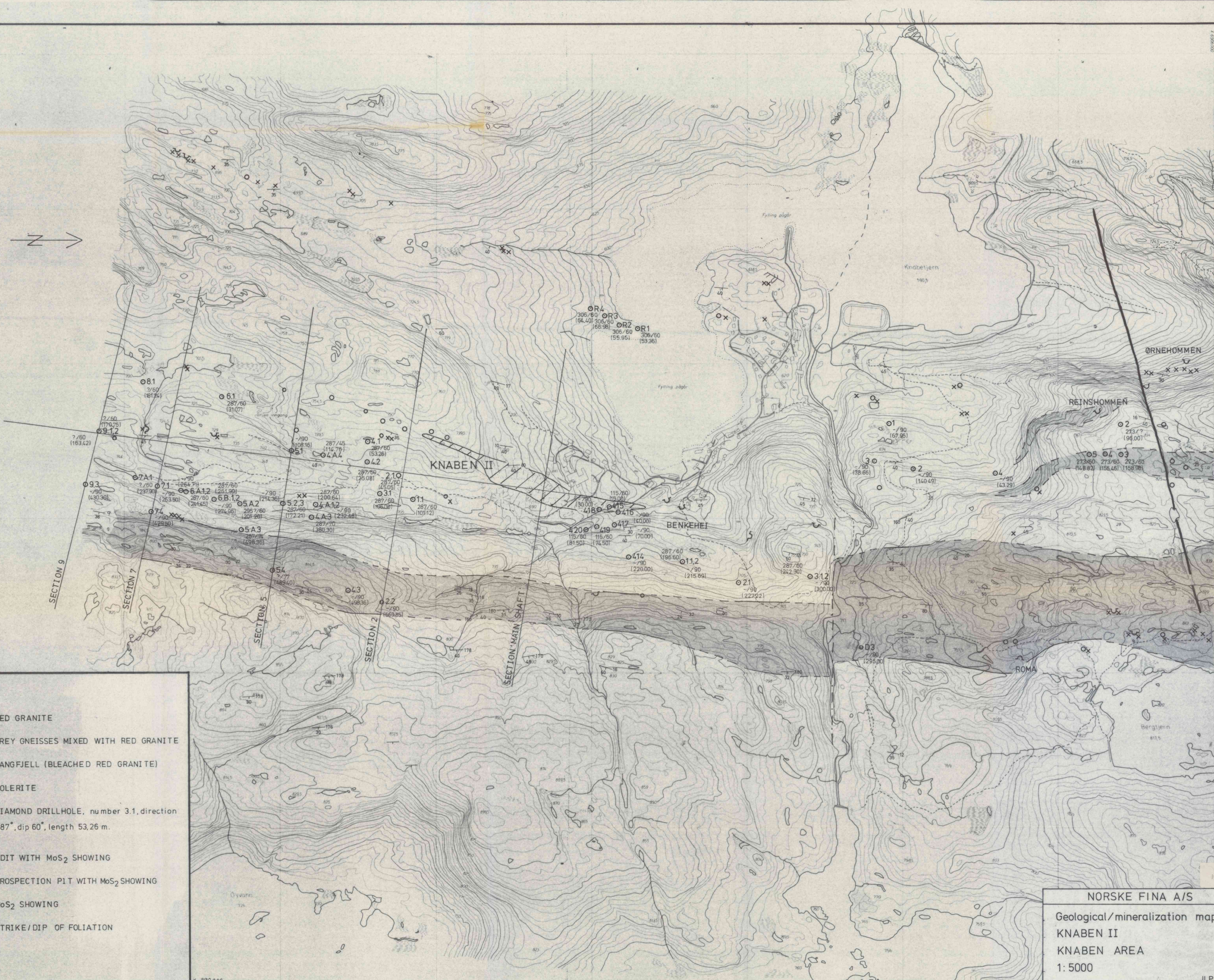
Geological/mineralization map

KNABEN II

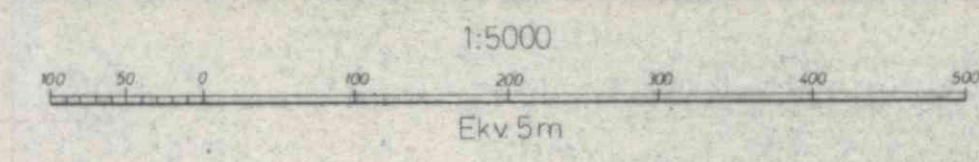
KNABEN AREA

1: 5000

JLP oct 82



Konstruert av Wideröes Flyveselskap 7/5
 etter fotografier opptatt aug. 1961



KNABEN GRUBER

2 00.151



LEGEND : see map of KNABEN II

after GUSTAVSEN 1970-1973

NORSKE FINA A/S

Geological/mineralization map

KNABEN I - KVINA

KNABEN AREA

1:5000

JLP oct 82

KNABEN GRUBER

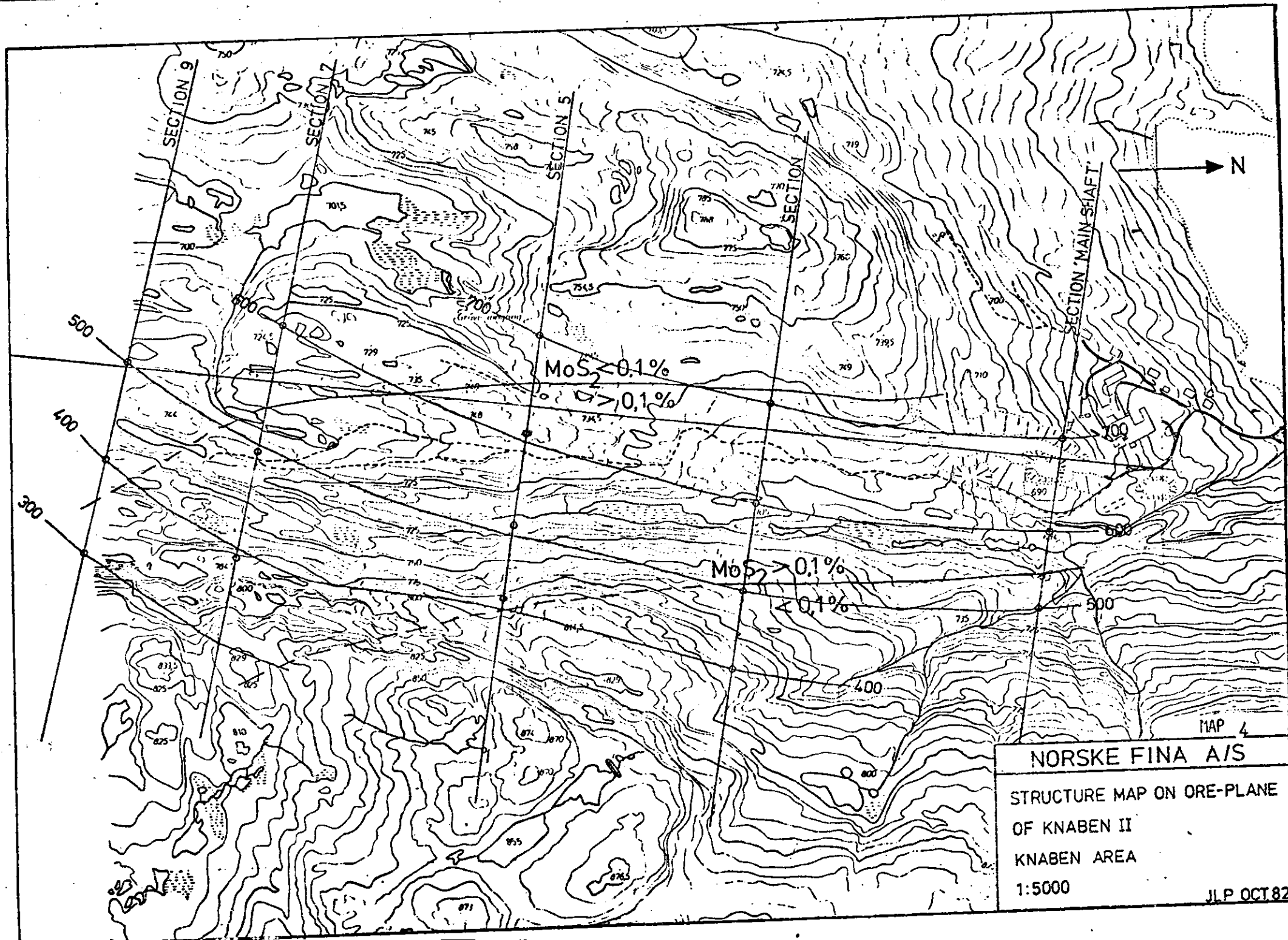
Bl. 1

K.M.00, 150

Kartlagt av Widerøe's Flyveselskap
etter fotografier opptatt aug. 1961

1:5000
Ekv.5m

NAP 3

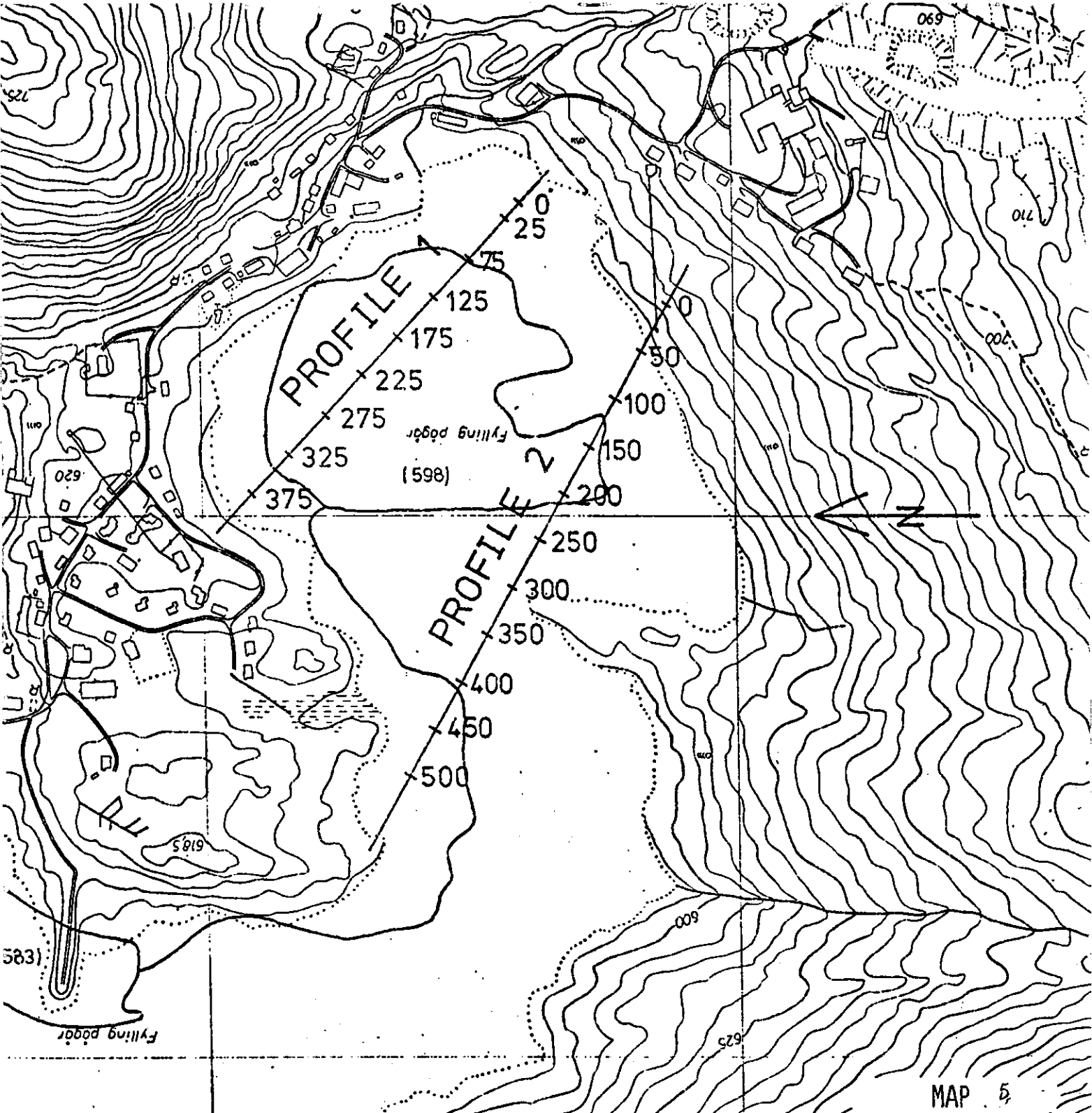


NORSKE FINA A/S

STRUCTURE MAP ON ORE-PLANE
OF KNABEN II
KNABEN AREA

1:5000

JLP OCT 82



MAP 5

NORSKE FINA A/S

Sampling of the tailing
Locality map
KNABEN
1:5000

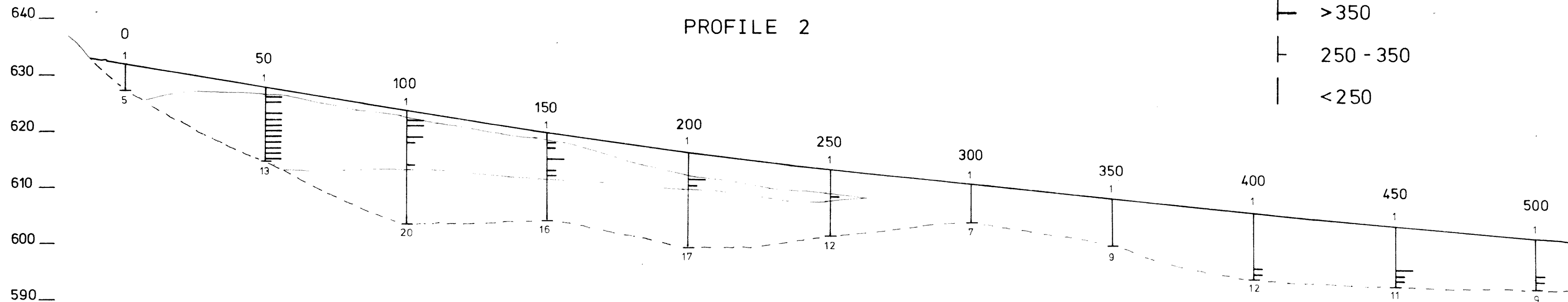
JLP sep 82

high grade lens :
1550 m², 350 ppm Mo

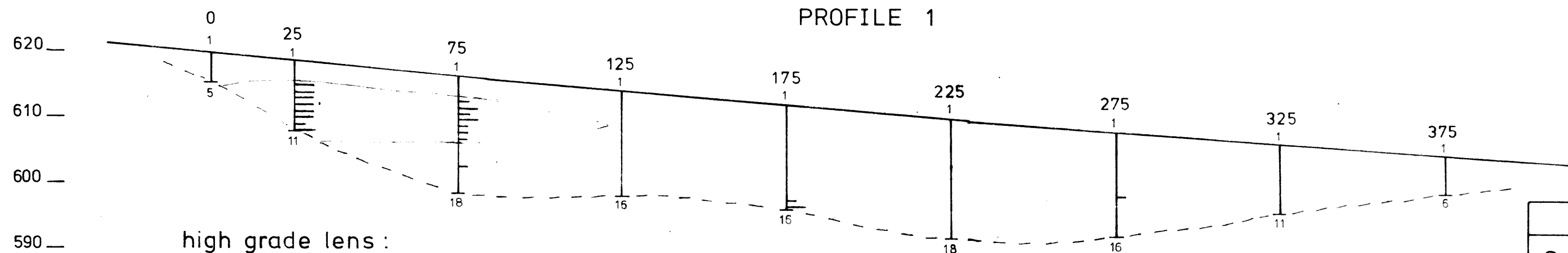
Mo-content in sandsamples (ppm)

└─ >350
└─ 250 - 350
| <250

PROFILE 2



PROFILE 1



high grade lens :
690 m², 430 ppm Mo

Map 6

NORSKE FINA A/S

Sampling of the tailing
Locality map/analysis
KNABEN

1:500 / 1:1000

JLP sep 82