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KLUBBVATNET AREA

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SUMMARY

As a part of the ARCO exploration programme for the Proterozoic Rombak Window in North Norway, the Klubbvatnet area was recontoured during five weeks in the period July-September 1984. Field work, carried out mainly from fly camps by 1-2 geologists, comprised geological mapping at 1:20,000 and sampling of mineralized localities.

The investigated area comprises a belt of slightly metamorphosed supracrustals intruded by 1700-1800 Ma old granites. These rocks belong to the Svecokarelian mobile belt of the Precambrian Baltic Shield. The encountered supracrustals are dominated by graywackes with intercalated black shales, sedimentary breccias, various quartz rocks and andesitic lavas. A marine, deep water depositional environment characterized by an uneven, block faulted bottom topography and exhalitic emanations is proposed.

The area contains widespread iron-zinc-lead mineralization. The largest sulphide concentrations occur in two c. 4 km long rust zones roughly conformable to the bedding. These zones host disseminated iron sulphides and slightly remobilized pyrrhotite, sphalerite, galena and minor chalcopyrite, mainly of sub-economic grade. Analyses of mineralized samples indicate a typical Zn/Pb ratio of 2/1 and interesting contents of silver and gold. The mineralization is believed to be of marine exhalative origin.

The geological environment and the encountered mineralization are regarded as good indicators on a zinc-lead deposit with beneficial silver-gold of the massive sulphide type. Thus follow up work comprising both regional and detailed work is recommended.

CONTENTS

SUMMARY

1. INTRODUCTION.....	1
2. PHYSIOGRAPHY.....	3
3. PREVIOUS INVESTIGATIONS.....	4
4. GEOLOGY.....	5
1. Regional Geology.....	5
2. Geology of the Klubbvatnet Area.....	5
3. Graywackes.....	6
4. Black Shales.....	6
5. Sedimentary Breccias.....	7
6. Andesitic Volcanics.....	8
7. Quartz Rocks.....	9
8. Undifferentiated Supracrustals.....	10
9. Granites.....	10
10. Gabbro.....	11
11. Caledonian Rocks.....	11
12. Structural Geology.....	11
5. MINERALIZATION.....	13
1. Introduction.....	13
2. Ytre Sildvikskardet.....	14
3. Durmålsfjellet.....	16
4. Blåisvatnet.....	16
5. Klubbvatnet.....	17
6. Hunddalsbotnen.....	23
7. Leirvatnet.....	25

6.	DISCUSSION.....	26
1.	Regional Considerations.....	26
2.	Depositional Environment.....	27
3.	Mineralization.....	29
7.	CONCLUSION AND RECOMMENDATIONS.....	32
8.	REFERENCES.....	34

MAPS

1.	Norway, location map. Scale 1:8 mill.....	36
2.	Rombaken, geol. map. Scale 1:250,000.....	37
3.	Klubbv. Area, locality map. Scale 1:80,000.....	38
4.	- - , geol. map. Scale 1:20,000..Enclosure.	
5.	- - , min. sub-areas. Scale 1:80,000.....	39
6.	- - , sample map. Scale 1:20,000. Enclosure	
6B.	- - , rock geochem. - selected samples. Scale 1:20,000	
7.	- Sub-area, min. map. Scale 1:10,000.....	40
8.	- - , trench map. Scale 1:1,000.....	41

TABLES

1.	Overview of rock geochem., Klubbvatnet area.....	42
2.	Summary of rock geochem., Klubbvatnet sub-area.....	43
3.	Summary of scree chip samples, Klubbdalen.....	44
4.	Klubbdalen trenches. Analytical values.....	45

FIGURES

Figs. 1 - 9.....	46-51
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1. INTRODUCTION

Reconnaissance prospecting in 1983 of the Rombaken Window, North Norway, had revealed gold and base metal anomalies in stream sediments and pan samples from the area between Leirvatnet and Rombaksbotn (maps 1-3). Furthermore, a geophysical Digheem survey flown in May 1984 had outlined a number of magnetic and electromagnetic anomalies in the same area. The purpose of the 1984 field work was to follow up on these anomalies by means of geological mapping combined with the search for and sampling of mineralized localities. This work was part of a larger exploration programme carried out in the Rombak Window by ARCO.

In the period 15/7-10/9 the author spent a total of 32 field days in the area, part of the time accompanied by N. Bang (Klubbvatnet-Hunddalsbotn-Durmålsfjellet) and O. Skaldebø (Ytre Sildvikskardet-Rombaksbotn), and assisted in turn by T. Haug, S. Vassmyr and T. Blomlie. Work was carried out from fly camps at Klubbvatnet, Hunddalsbotn and Leirvatnet and in September by car from Narvik. 27/9-28/9 trenching was carried out at Klubbvatnet together with T. Blomlie and O. Jonsen (from Leonard Nielsen og Sønner). Joint camps were established with a geophysicist (P. Abildgaard) at Klubbvatnet and Hunddalsbotn, and with a geochemist (J. Baron) at Klubbvatnet. Visitors in the field comprised B. Flood (project supervisor), T. Robyn, A. Geyti, F. Vokes and Anaconda (Denver) executives.

The following work was accomplished:

- Mapping at scale 1:20,000 of c. 40 km².
- Collection of 113 chip, grab and scree samples. The geochemical team collected additional 40 chip samples, mainly from scree boulders.
- Collection of 15 stream sediment samples.
- Blasting of 5 trenches, total 31 m and 14 samples.

2. PHYSIOGRAPHY

The Klubbvatnet area is here defined as a 5 x 20 km NNW-SSE orientated belt of supracrustals which stretches from Leirvatnet in the South to Rombaksbotn in the North (map 3). Klubbvatnet centrally located in the area is situated at $68^{\circ}21'N$ - $17^{\circ}45'E$, 17 km SE of Narvik. Apart from the birch covered slopes of Rombaksbotn, the area is situated above the timber line (500 m) and has a near alpine topography with up to 1633 m high mountains and several small glaciers. Exposure is generally good. The South slope of Rombaksbotn is crossed by the Narvik-Kiruna railroad and hosts the only roads of the area.

The 1984 summer weather was what appears to be the normal for this part of the world, i.e. cool with rain and/or fog 80% of the time and 20% fair weather. During the last week of August, 10-20 cm snow covered areas above 800 m. However, most of this snow melted again in September. The latter month was dominated by sunny weather with light frost.

3. PREVIOUS INVESTIGATIONS

The geology of the Rombak Window has been described by Vogt (1941) and Gustavson (1974 a). The area is covered by two geological maps at scale 1:100,000 (Vogt, 1950; Birkeland, 1976), and one map at scale 1:250,000 (Gustavson, 1974 b).

The mineralization at Ytre Sildvikskardet has been described by Torgersen (1935), Singsaas (1977) and Lindahl (1978).

ARCO work in 1983 is documented in internal reports covering geophysics and heavy mineral geochemistry (Abildgaard et al., 1983), geology and mineralization (Dalen and Martinsen, 1983), stream sediment and rock geochemistry (Flood, 1984 a) and is summarized by Flood (1984 b).

In addition to the present report, ARCO 1984 work on geophysics, geochemistry and heavy minerals in the Klubbvatnet area is reported by Abildgaard (1984 a,b), Dvorak (1984), Flood (1985) and Skeldebø (1984).

4. GEOLOGY

1. Regional Geology.

The Klubbvatnet area is part of the Precambrian Rombak tectonic window in the Scandinavian Caledonides (map 2). The window consists of supracrustals intruded by granites, syenites and gabbros. These igneous rocks show Rb-Sr ages of c. 1707/1780 Ma (Heier and Compston, 1969; Gunner, 1981), i.e. ages corresponding to the Svecokarelian (Hudsonian) orogenesis of the Precambrian Baltic Shield.

The supracrustals are low-grade, psammitic-pelitic metasediments with minor carbonates, and intermixed mafic to felsic metavolcanics. They have been divided tentatively into four units by Dalen and Martinsen (1983), (map 2). These rocks have been correlated with supracrustals in the Skelefte District situated in Sweeden 300-400 km further South (Vogt, 1941).

2. Geology of the Klubbvatnet Area.

A geological map of the Klubbvatnet area at scale 1:20,000 is presented as map 4. The designation of the mapped units is based on field observations only, as no microscopic investigations have been carried out in this study. As the supracrustals are slightly to moderately metamorphosed (mainly in greenschist facies), they should correctly be prefixed meta-. For the sake of convenience, this prefix has been omitted. A short description of the rock types follows.

3. Graywackes.

Graywacke is by far the most common rock type among the supracrustals with an apparent thickness of more than 5 km. The graywackes consist of a monotonous repetition of 10-200 cm thick sedimentary units consisting of a dominant layer of grey, coarse-medium-grained sandstone grading upwards into a thinner layer of blackish silt-clay rock. ^(fig. 1) The graywackes of the Klubbvatnet area correspond to the brownish-grey graywackes of Haugfjellet. These rocks have earlier been mapped as quartz-biotite schists.

A mesoscopic inspection of the sandstone reveals quartz, biotite and feldspar as the main minerals. Locally the quartz occurs as 1-2 mm large, bluish phenoclasts of possible volcanic origin. North of Klubbvatnet graywackes with such blue "eyes" seem to grade into clearly volcanic rocks. Most of the biotite seems to be of metamorphic origin. Graded bedding with scour and fills at the base of the unit is the universal structure in these sediments. Furthermore, various rip-up clasts and rare small-scale cross bedding have been observed.

4. Black Shales.

Minor amounts of dark, fine-grained pelitic rocks are interbedded with the graywackes. The pelites may also form several metres thick, rusty weathering bands which are often strongly sheared and metamorphosed to phyllites or mica schists. Typically, they contain disseminated graphite and iron sulphides.

These rocks are relatively abundant West of Blåisvatnet, at Durmålsfjellet, at the West end of Klubbvatnet and at the East end of Leirvatnet. However, the shaley horizons of the Klubbvatnet area are never so thick and extensively developed as the main shale horizon at Haugfjellet.

5. Sedimentary Breccias.

More than hundred metre thick horizons of sedimentary breccias occur in spatial association with the volcanics centrally in the area. The breccias consist of angular, up to 15 cm large fragments of sandstone and shale derived from the graywackes and swimming in a sandy matrix. As fragments and matrix are very similar, the breccias are best recognized on weathered surfaces, where the slightly harder and lighter fragments are distinguishable from the matrix. In tectonized zones, e.g. at the East end of Klubb dalen, the breccias are tectonically stretched. On a small hill North of Klubbvatnet, the matrix is rich in chaotic, non-orientated, mm-long feldspar lathes of probably volcanic origin.

A similar rock type is exposed in a small outcrop along the road in Ytre Sildvikskardet, 600 m a.s.l. At this locality the breccia is 3 m thick with up to 15 cm long clasts. It is obviously an intraformational breccia which upwards grades into normal graywacke. Another breccia type occurs SE of Rombaksbrua. It is characterized by abundant mm to few cm large quartz fragments or schlieren and quartz veinlets in the local mafic volcanics. Only one clastic fragment was observed here.

6. Andesitic Volcanics.

Intermediate volcanic rocks occur in two belts. The eastern belt is known from the Hunddalsbotn area. Its possible continuation to the South and North has not been investigated. The western belt of volcanics stretches from Hunddalsbotn to West of Blåisvatnet, where it seems to die out. The volcanics appear as distinct magnetic anomalies on the Dighe maps. As such an anomaly appears on Fjellheimen, the western volcanic belt might continue towards NNW and possibly link up with comparable volcanic rocks SE of Rombaksbrua.

The rocks are fine-grained, massive and dark with characteristic round, up to 5 cm large amygdales of quartz and also amygdales or phenocrysts of hornblende. According to Vogt (1950), the volcanics West of Blåisen are of andesitic or dacitic composition. Gustavson (1974) gives the following composition of a sample of vesicular lava from this area: Essential minerals are green hornblende, biotite and probably acid plagioclase; accessories are sphene, epidote, chlorite and quartz.

A small outcrop of porphyritic volcanics interbedded with graywacke and garnet-quartz rocks was observed West of Blåisvatnet. It forms a 3-4 m thick zone of rusty weathering, dark, fine-grained rock with c. 1 cm long feldspar phenocrysts. Also, agglomerates have been reported from SE of Rombaksbrua and from the coast of Ytre Sildvik by Lindahl (1978).

7. Quartz Rocks.

Various types of quartz-dominated rocks were observed in the Klubbvatnet area. They were termed rusty, whitish and garnet-quartz rocks in the field.

The rusty weathering quartz rocks are the most common type. In western Hunddalsbotn they form a c. 200 m wide rust zone together with intermixed graywackes and a horizon of fragmental rocks of possible felsic pyroclastic origin.(fig. 2). The quartz rocks are here graphitic and contain varying amounts of disseminated iron sulphides. In the North slope of Klubb-dalen reddish weathering quartz rocks with disseminated pyrite are interbedded with the graywackes at several localities. The horizon of rusty, dark quartz rocks NE of Durmålsfjellet likewise contains disseminated iron sulphides.

The whitish quartz rocks occur in a restricted area SW of Blåisvatnet, where they seem to interfinger with the surrounding andesites. The rock is typically a greyish-white, fine-grained, massive quartz rock with characteristic rectangular joints. It appears to be very homogeneous. The only obvious structure is rare, local banding including bands of few mm large brownish dots with a quartz core. (fig. 3). Such spotted quartz rocks were observed North of Klubbvatnet and West of Blåisvatnet.

Restricted outcrops of garnet-quartz rocks occur in central Klubb-dalen and West of Blåisvatnet. They are fine-to medium-

grained quartz rich rocks with 5-10% red garnets, varying amounts of hornblende, often several per cent disseminated pyrite and, at one locality in Klubb dalen, greenish mica. These rocks form up to 8 m thick beds interlayered in the graywackes.

In Klubb dalen, immediately North of the main river, the 1-3 mm large garnets form mm-thick bands which delineates a primary bedding with slump structures. Just South of the river these rocks host a 20 cm thick, conformable band with 1-3 mm thick layers of magnetite.

8. Undifferentiated Supracrustals.

Areas not visited in the field, but marked as quartz-biotite schists on older maps, are shown as undifferentiated supracrustals on map 4.

9. Granites.

Most of the Rombak Window is underlaid by granite. Two types can be distinguished: A coarse-grained, grey microcline granite (Rombak granite) and a medium-grained, grey microcline granite (Sildvik granite). They surround the supracrustals and both types also occur as fingers in these rocks, most commonly North of Leirvatnet.

The finger NE of Klubbvatnet is of Sildvik granite, whereas the sheet between Leirvatnet and Hunddalsbotn consists of Rombak granite with chilled margins. The granites surrounding the supracrustals were not investigated.

10. Gabbro.

Gabbros were met with in two small areas: NE of Rombaksbrua and North of Leirvatnet. The latter is coarse-grained. The first is a medium-to coarse-grained bitotit-hornblende gabbro (Gustavson, 1974 b).

11. Caledonian Rocks.

These rocks were not visited in the field. According to Gustavson (1974 b), they comprise a Cambro-Silurian sequence consisting of autochthonous conglomerates and sandstone overlain by three nappes overthrust towards ESE.

12. Structural Geology.

The primary bedding (S_0) observed in the graywackes is typically dipping steeply towards the East and striking NNW-SSE to NW-SE. At some localities, e.g. Durmålsfjellet, more East-West striking beds occur, and steep westernly dips also exist. Facing, as determined by graded bedding and scour and fills, is mainly westernly.

Schistosity (S_1) and cleavage are often slightly more North-South directed than the bedding. The relationship between S_0 and S_1 is well illustrated at the upper lake of Klubbaldalen. Here a $150^\circ/80^\circ$ NE bedding is cut by a $0^\circ/80^\circ$ E schistosity with increasing intensity from East to West, and in the main rust zone to the West the primary bedding is totally obliterated. Likewise, an excellent outcrop of sedimentary breccia in this zone at the waterfall further West displays pronounced

stretching of the clastic fragments in a $0^{\circ}/50^{\circ}\text{E}$ direction. In general, the schistosity is strongly developed in certain zones, some of which are shown as shear zones on map 4. Here the rocks occur as phyllites or mica schists, often with a characteristic phyllitic sheen and occasional crenulation cleavage.

In the supracrustals North of Leirvatnet no primary structures are preserved. The rocks are here all transformed to schists with minor migmatic domains.

Dalen and Martinsen (1983) proposed a tilting to near vertical of the supracrustals during a Precambrian fold phase with contemporaneous development of axial plan cleavage, whereas they regarded the effects of the Caledonian folding as uncertain and probably minor. In 1984 small-scale folding with amplitudes in the dm-m range was observed at several localities. Some are drag folds, others are open folds with variable axial dips. A larger, near isoclinal fold is outlined by the granite finger North of Leirvatnet.

A distinct, near vertical and North-South striking reverse fault is visible in the South slope of Klubbaldalen. It probably continues across the valley, but has not been observed with certainty on the North slope. Other, less obvious, mainly North-South directed faults are indicated on map 4.

5. MINERALIZATION

1. Introduction.

A number of mineralized localities exist in the Klubbvatnet area. They are dominated by iron sulphides, but in addition often contain significant amounts of zinc, lead and silver along with some copper and gold. For descriptive purpose six mineralized sub-areas are distinguished (map 5).

Before the 1984 field season, mineralization was known from only one of the sub-areas (Ytre Sildvikskardet); the other sub-areas appeared as geochemical and/or geophysical anomalies. As the 1984 investigations were of reconnaissance character, the intensity of sampling varies from sub-area to sub-area, resulting in a rather non-homogeneous sample material. Consequently, the compilation of analytical results from the various sub-areas presented in table 1 should be regarded as hints or tendencies only. For the same reasons, the median values are used as the best indicators of overall metal contents.

Most of the collected samples show visible mineralization. They have been analysed for Zn, Pb, Cu, Au, Ag, As, Sb and Fe by the ARCO Tucson lab. A complete list of the analytical results are found in Flood (1985). In the following description of the mineralized sub-areas, sample numbers in brackets (without the prefix 840-) are used as localizers, cf. map 6.

2. Ytre Sildvikskardet.

A zinc-lead mineralized zone stretches from the coast at Kuberget towards SSE over some 4 km to an altitude of c. 600 m in Ytre Sildvikskardet. This zone has been investigated by trenching and tunnelling at various periods during the last hundred years (Torgersen, 1935; Dalen and Martinsen, 1983). In 1976 the mineralization was reinvestigated by NGU (Lindahl, 1978). At this occasion two holes (total 47.7 m) were drilled. The best intersection contained 7.0% Zn and 0.52% Pb over 3 m.

In 1984, the SE part of the mineralized zone was observed during a traverse along the new road to Indre Sildvikvatnet. It appears as a c. 50 m wide, $155^{\circ}/80^{\circ}$ NE orientated, rusty weathering, sheared zone with several small trenches in the local graywacke. Towards SSE the zone seems to die out. Towards the NNW it was met with again at the East bank of the Ytre Sildvikskardet river, where the NGU drill sites are located.

The mineralization consists of cm to dm thick schlieren of semi-massive to massive sphalerite, galena and pyrrhotite with minor pyrite and chalcopyrite (5502) set in wider rust zones of disseminated mineralization dominated by iron sulphides (5501). Traces of bornite, tetrahedrite-tennantite, arsenopyrite, molybdenite and probable boulangerite have been reported by Lindahl (1978), who also mentions the existence of a stratiform magnetite-bearing horizon in the area. Where-

as the main rust zone seems to be concordant with the NNW-SSE striking bedding of the graywackes, the semi-massive sulphide schlieren are often conformable with the more northerly orientated schistosity.

A group of smaller trenches with the same type of mineralization was encountered 100-200 m South of Rombak station (5505), and similar indications exist at the entrance to a water tunnel c. 600 m a.s.l. (5503). Where the road crosses the main river, rust zones (5506) appear to be attached to a $005^{\circ}/80^{\circ}\text{E}$ fault zone in the river bed. Several additional rust zones with few cm thick lenses of massive sulphides occur along the road further down towards the fjord (5507-08).

A continuation of the main mineralized zone in the supracrustals NW of the fjord has been reported by Torgersen (1935). Only one insignificant mineralization was observed during a hasty traverse of this area. It is a max. 1 m thick rusty horizon concordant to the bedding in the graywackes and containing a little disseminated iron sulphide (4250). The rusty coastal cliff West of Raudbergan appears to represent a fault parallel to the coast.

The analytical results from the 1984 samples confirm the existence of irregular zinc-lead mineralization with some silver and minor copper and gold (table 1).

3. Durmålsfjellet.

The Dighem geophysical survey revealed distinct magnetic and electromagnetic anomalies at Durmålsfjellet. During reconnaissance follow up of the area, two old, few metres deep adits were observed on the North slope of the mountain, and two old trenches were found east of the mountain.

The investigated mineralization consists of 1-2 m thick, concordant horizons of semi-massive pyrrhotite associated with black shales and perhaps also with felsic volcanics. Analyses of five grab samples from this mineralization show no significant contents of base or precious metals (table 1). Neither do analyses of three chip samples from a rusty quartz rock horizon with disseminated sulphides NE of the mountain show anything of interest.

4. Blåisvatnet.

The area West of Blåisvatnet comprises graywackes with abundant NNW trending rust zones which correspond to strong geophysical anomalies. This area is separated from andesites further West by a NNW striking shear zone.

The rust zones are typically ten metres wide and consist of graphitic slate with varying amounts of iron sulphides and a little galena. It is not known, whether they continue further to the NNW and possibly link up with the mineralized zones at Ytre Sildvikskardet, nor is it known, whether they continue towards SE and link up with the mineralization of the Klubbvatnet area.

A galena-bearing grab sample (5509) from a c. 3 m wide, $160^{\circ}/65^{\circ}\text{E}$ orientated rust zone at the West coast of the lake is rich in Pb (11.1%), Ag (98.3 ppm) and Au (1.08 ppm). Three other samples from similar rust zones (4248, 5512-13) are only slightly elevated in Pb (max. 423 ppm), Ag (max. 1.9 ppm) and Au (max. 0.065 ppm).

A 5-10 m wide zone of garnet-quartz rock with sporadic contents of hornblende and pyrite was observed over perhaps 100 m strike length ($160^{\circ}/80^{\circ}\text{E}$) in the graywackes near the sheared contact towards the andesites. A composite sample from this zone (5510) shows elevated contents of Pb (400 ppm), Zn (358 ppm) and Au (0.165 ppm).

5. Klubbvatnet.

The 1983 geochemical survey revealed significant lead, zinc, copper, arsenic and gold anomalies in stream sediments as well as gold anomalies (max. 8 gold grains) in pan samples from the Klubbvatnet sub-area. Due to a steep topography, the geophysical coverage is incomplete. The most distinct geochemical anomalies occur in the valley East of the lake, in this report called "Klubbaldalen" (figs 4,5). Relatively detailed follow up work was carried out in this area.

A 500-600 m thick unit of andesitic volcanics is exposed on both sides of Klubbaldalen, but is missing in the valley floor. The unit shows a relative displacement of 600-700 m in a westernly direction on the North side of the valley. This

might be due to the disruption of a flexural fold in the andesites by an ESE trending fault through the bottom of the valley. Furthermore, graywackes, sedimentary breccias, various quartz rocks and a 5-15 m thick sheet of medium-grained granite are exposed in the valley (map 4).

The encountered mineralized localities (A-H) in Klubbaldalen are shown schematically on map 7 and summarized in table 2. In addition to the biased geological sampling, a systematic sampling of the scree cones of the East and North slopes of Klubbaldalen was performed. The sample sites have a lateral spacing of c. 50 m and are situated in the lower part of the scree cones. At each sample site chips were collected from the largest scree boulders inside a diameter of 5 m. The association between these samples and outcropping mineralization is indicated on map 7 and in table 3.

Locality A (Upper lake).

The well-bedded graywackes East of the upper lake of Klubbaldalen host rare, 10-50 cm thick, concordant or pene-concordant rusty horizons with disseminated sulphides (fig. 6). Analyses show elevated base metal contents and sporadic traces of gold in these horizons (table 2).

Locality B (Main rust zone).

A c. 200 m wide, NNW trending, sheared rust zone crosses the steep eastern slopes of the valley (fig. 7). It consists mainly of mica schists with a pronounced 170° - 010° / 60° - 80° E schis-

tosity. Evidence from numerable scree boulders as well as from accessible outcrops points towards widespread mineralization in this zone over at least 1500 m along strike. The typical mineralization consists of mica schist with mm-to few cm-sized schlieren of massive pyrrhotite, sphalerite and galena with minor pyrite and chalcopyrite. Total sulphide contents in mineralized samples often exceed 10 vol%, of which pyrrhotite normally is the dominant mineral.

Analysis shows 3-4% combined Zn-Pb along with 5-10 ppm Ag and c. 0.1 ppm Au in the best mineralized samples. The zinc content is approximately twice as high as the lead content, both in outcrops, in grab sampled scree boulders and in chipped scree boulders (tables 2,3).

Locality C (Gossan zone).

At this locality, a low ESE orientated ridge displays a gossan of limonite crusts on the slope towards a shallow lake (fig. 8). As the site possibly hosts the intersection between a North-South and a WNW-ESE orientated fault, it was trenched in order to reach fresh mineralization. For practical reasons the three 1 m deep trenches (total 22 m) are located along the crest of the ridge over a distance of 55 m (map 8).

- Trench I yielded only little fresh rock. It is mica schist with $040^{\circ}/55^{\circ}\text{E}$ joints and 5-10% sulphides as schlieren of pyrrhotite with minor sphalerite and galena.

- In trench II the rock is fresh (fig. 9). It is a quartz-rich sandstone with a dominant joint direction of $110^{\circ}/65^{\circ}$ NNE and 10-20% disseminated sulphides, mainly pyrrhotite and pyrite with minor sphalerite and galena. The trench also contains a 2-5 cm vein ($035^{\circ}/80^{\circ}$ E) with massive sphalerite and galena (5547).
- Trench III revealed only little fresh rock and no good exposure. The rock type is the same as in II, but sulphide contents are lower, perhaps 3-5%.

The channelled chip samples from the trenches are relatively rich in iron, but base metal contents do not exceed one per cent (table 4). In average, zinc contents are 4-5 times higher than lead contents. Gold values are low, but rather consistent. A high silver value (219 ppm Ag) occurs in the massive sphalerite-galena veinlet.

Locality D (Minor rust zone).

A c. 10 m wide, 020° /near vertical orientated, rusty weathering shear zone is exposed 125 m WNW of loc. C. It resembles the main rust zone both in rock type (mica schist) and mineralization (schlieren of pyrrhotite, sphalerite and galena). The zone is sporadically mineralized over at least 300 m towards NNE (4174).

Two trenches 30 m apart (total 9 m) were excavated across visually mineralized parts of the zone (map 8). They exposed

alternating zones of mica schist and sheared sandstone (020° - 035° / 85° E). The channelled chip samples show the best values in trench V: 2% combined zinc-lead, 4.4 ppm silver and 0.185 ppm gold over 2 m (table 4). The other half of this trench is extremely low in metals (analytical error ?). The zinc contents are approximately 1.5 times higher than the lead contents.

Locality_E_(SE_Corner).

Mineralization is known from scree boulders and one outcrop below the steep cliffs in the SE corner of Klubbdalen. The outcrop is hosted in a 010° / 85° E shear zone in graywackes near the contact to andesite. It is a c. 2 m long and up to 20 cm wide lens conformable to schistosity and consisting of rather massive sphalerite and galena with minor pyrite and chalcopyrite in a gangue of fluorite-calcite-quartz (4203). Nearby several, mm-thick concordant and discordant veinlets occur.

Similar boulders with dm-thick veins of fluorite and calcite and conspicuous coarse galena are relatively common in the scree cone below this locality. This indicates the existence of several additional veins in the near vertical cliff above the described outcrop. Some of the mineralized boulders consist of mm-banded hornblende schist with conformable bands of calcite-fluorite-quartz and minor disseminated chalcopyrite, pyrite and galena (4180).

This vein-type mineralization deviates geochemically from the previously described mineralization. It is characterized by relatively high contents of lead (several per cent), silver (max. 260 ppm), gold (detected in all samples, range 0.026-0.847 ppm), whereas zinc (typically a few hundred ppm) and arsenic (all values <10 ppm) are relatively low.

Locality_F_(Garnet-quartz rock).

Garnet-quartz rocks with disseminated pyrite are exposed in a 40 x 8 m outcrop 30 m NW of loc. D. On the weathered surface mm-thick, 110° striking bands of red garnet delineate primary bedding with slump structures. Nearby, on the South side of the main river, other few metres thick horizons (100° - 110° / 60° - 80° S) of garnet-quartz rock with occasional contents of hornblende and greenish mica are interbedded with the graywackes. A few metres from the South bank of the river, the sequence hosts a conformable, c. 20 cm thick horizon with several few-mm thick bands of magnetite (4191).

Analysis shows raised gold values (max. 0.156 ppm), but low base metal-silver-arsenic contents in the garnet-quartz rocks.

Locality_G_(Rusty quartz rocks).

Scree boulders and scattered outcrops of rusty weathering quartz rocks are common on the North slope of Klubbdalen. These rocks contain approximately one per cent disseminated pyrite. Analysis shows elevated contents of zinc (1229 ppm) and lead (707 ppm) in a chip sample (5704) collected near

the contact towards andesite. A low, but consistent gold content (c. 20 ppb) is indicated by the scree chip samples.

Locality_H_(Andesites).

No significant mineralization was encountered in the andesites. Analyses of a few samples with a little disseminated pyrite from North of the valley show only slightly raised zinc and lead values and no detectable contents of precious metals. These observations are confirmed by the scree chip samples, with the exception of one value on 75 ppb Au (4572).

6. Hunddalsbotnen.

This sub-area hosts significant geophysical anomalies, gold-lead anomalous stream sediments, and gold-bearing pan samples.

A c. 200 m wide, NNW-SSE orientated rust zone corresponding to a distinct Dighem anomaly crosses the valley near the eastern shores of Basejávri. It consists of alternating horizons of quartz rocks and graywackes (fig. 2). The quartz rocks contain disseminated iron sulphides and graphite and possibly a pyroclastic horizon. Eight chip samples collected across the zone North of the main river returned the following max. values: 114 ppm Zn, 155 ppm Pb, 127 ppm Cu, 0.009 ppm Au, <0.5 ppm Ag and 38 ppm As. On the slope South of the river the zone hosts a $0^{\circ}/60^{\circ}W$ sheared zone mineralized over a width of at least 25 m with graphite, pyrite and sphalerite. A composite sample from this zone yielded 1412 ppm Zn and 196 ppm Cu (4240). Further up the South slope a little galena was observed in floats.

A Dighem anomaly on the South slope of the Hunddalsbotnen further East corresponds to small outcrops of a 4-5 m wide, 130° trending zone of graphite schist with some pyrite and traces of sphalerite, galena and chalcopyrite (4242). A nearby large granite boulder hosts a 1-2 cm thick vein of massive pyrrhotite-galena with 0.8% Pb and 47.9 ppm Ag (4243). Visible gold occurs in pan samples from the two rivers draining this slope (Skaldebø, 1984).

Further East a $010^{\circ}/80^{\circ}$ W orientated rust zone is exposed in the river bed near the contact to andesite. This zone corresponds to another Dighem anomaly. It consists of silicified graywacke with small scale folding and disseminated iron sulphides, graphite and a little galena. A chip sample (4247) shows 2485 ppm Pb and 1492 ppm Zn.

A major rust zone occurs in the mainly andesitic supracrustals near the granite contact, 1200-1300 m a.s.l South of Hunddalsbotnen. During a short visit this area was mostly snow covered. However, a composite sample of rusty, sulphide-bearing vesicular andesite (4244) contains 2617 ppm Zn, and a grab sample from a perhaps 50 cm thick silicic zone with a little disseminated galena (4246) contains 1.3% Pb, 15.6 ppm Ag and 0.149 ppm Au.

Two composite samples from pyrrhotite-bearing scree boulders collected South of Basejávri are only slightly enriched in zinc (max. 576 ppm) and copper (max. 353 ppm).

7. Leirvatnet.

The slopes North of the East end of Leirvatnet contain both Dighem anomalies and stream sediment anomalies of gold, copper, lead and arsenic.

The gold anomalies probably origin from either a local sheet of coarse-grained granite, or from a major rust zone in c. 1300 m a.s.l. This 300 x 400 m rusty area was traversed and sampled (6 chip samples and 3 grab samples). It consists of mica schist containing a few metres wide zone of porphyry. Only disseminated iron sulphides were observed, and the collected samples are low in both base metals and gold (max. 0.010 ppm Au). However, scree boulders from another, NNE orientated rust zone further East contain a little pyrrhotite and 0.111 ppm Au (4209).

A North-South trending horizon of graphitic schist near the lake is slightly enriched in lead (424 ppm), zinc (198 ppm) and arsenic (85 ppm), whereas a nearby rust zone with disseminated pyrite contains 158 ppm As (4206). A pan sample from a small river draining this area assayed 0.315 ppm Au, but contains no visible gold (Skaldebø, 1984). The Dighem anomalies correspond to the zones of graphitic schist.

6. DISCUSSION

1. Regional Considerations.

The Precambrian geology of North Sweden, i.e. the metamorphic complex starting some 50 km East of the Rombak Window, has recently been reviewed by Witschard (1984). North Sweden is built up of Archean gneiss and Proterozoic supracrustals and granitoides.

Witschard distinguishes between (1) an Archean consolidation phase (c. 2,700 Ma ago), (2) a tensional episode characterized by incipient rifting (c. 2,000-1,900 Ma) followed by (3) a complex episode of reactivation corresponding to the peak of the Svecokarelian orogeny (c. 1,900-1,800 Ma) and (4) a later episode of consolidation and granitization. ^(c. 1,800-1,700 Ma) Important base metal deposits (Skelefte district, Bergslagen, etc.) of marine exhalative origin are associated with acid volcanics and sediments in the lower part of the Svecokarelian supracrustal sequence.

The described tectonic evolution is regarded by Witschard as phases of basement reactivation comparable to ensialic mobile belts in other parts of the world. This is in contradiction to the plate tectonic models proposed by other authors (cf. Lundqvist, 1979). Such models comprise island arc systems with NW-SE trending subduction zones dipping NE below an Archean continental block.

The supracrustals in the Rombak Window comprise a mixed volcanic sedimentary sequence. The volcanics are bimodal and occur both as flows and as pyroclastics. The sediments are marine and predominantly psammitic-pelitic with minor carbonate intercalations. The correlation between the various supracrustal outliers in the window as well as their relation to the contemporaneous supracrustals in Sweden remains uncertain. However, the overall tectonic setting is presumably as outlined above.

2. Depositional Environment.

The dominant rock type of the Klubbvatnet area - the graywacke- consists of monotonously repeated graded units. These units are interpreted as incomplete Bouma sequences. Such sediments of flysch type are typically deposited in deep water by turbidity currents. The lack of shallow water structures (mud cracks, extensive current bedding, ripple marks, etc.) confirms the deep water origin of these sediments. The interbedded horizons of black shale were probably deposited in stagnant water bodies during prolonged periods of quiescence without supply of coarse detrital material.

The sedimentary breccias are likewise regarded as subaqueous mud flow deposits. They probably formed by gravity flowing or slumping along steep submarine slopes and thus indicate an uneven bottom topography. Such gravity flows can be triggered by violent events as earthquakes or volcanic eruptions. The latter possibility is indicated by the spatially association

between the andesitic volcanics and the sedimentary breccias and by the occasional volcanic appearance of the matrix of the latter. As no volcanic fragments were observed in the breccias, their deposition were associated with the initial volcanism.

The quartz rocks are critical for the elucidation of the general depositional environment of the Klubbvatnet area. Due to a mineralogy dominated by quartz and a general lack of meso-macroscopic structures, they can not be properly classified on field evidence. One or more of the following origins appear most likely: Exhalitic cherts, acidic volcanics or quartz sandstones.

An exhalitic origin is most likely for the garnet-quartz rocks. Their contents of garnet and magnetite seem to be of metamorphic rather than of clastic origin. In case of an exhalitic origin, a high manganese content can be expected in these minerals. An origin as exhalites or as acidic volcanics would be in accordance with the deposition in a deep water basin with an uneven, fault controlled bottom topography and volcanic intercalations as proposed above.

If the rocks, or some of them, are proper quartzites i.e. derived from mature costal sands, and intermixing between deep and shallow water deposits exists. Such an environment could indicate a back arc setting with interfingering contributions from an island arc (graywackes, andesites) and from a continent (quartzites).

The andesites are believed to represent submarine flows. The rock type is typical of subduction zones. However, Witschard (1984) relates the contemporaneous volcanics in North Sweden (the Porphyry Group) not to a subduction zone, but to a regime of deeply fissured and fragmented crust, i.e. to interacratonic tensional tectonics.

To sum up, a mainly deep water depositional environment characterized by oblong, fault bounded basins and active volcanism existed in the Klubbvatnet area. Whether the regional setting was one of tensional or compressional tectonics is uncertain, but the first possibility is indicated by recent research in North Sweden.

3. Mineralization.

The main, slightly remobilized zinc-lead mineralization is hosted in a 50-200 m wide rust zone with disseminated iron sulphides. Such a zone stretches some 4 km towards SSE from Kuberget. A similar zone runs parallel with the andesites through eastern Klubbdalen towards NNW and probably links up with the shaley mineralization West of Blåisvatnet, i.e. it stretches over another c. 4 km. Whether these two zones link up with each other South of Ytre Sildvikskardet remains to be proved, but appears likely. In any case, abundant surface zinc-lead indications occur scattered over several kilometres strike length, although mainly of sub-economic grade. The geochemical pattern is one of zinc dominance over lead with a typical Zn/Pb ratio of 2/1, and significant silver contents. Copper and gold are subordinate, but present.

The stratabound character, the association with deep water sediments and possible exhalitic cherts, the element combination zinc, lead, copper, silver, gold, all points towards a marine exhalative origin for the mineralization. Such mineralization typically shows element zonation of Cu-Zn-Pb-Ba outwards, a feature which has not been observed in the investigated area. However, the Zn/Pb ratio does show some variation and closer investigations may reveal a pattern. Likewise, the samples have not been analysed for barium, an element which like cherts, often forms hallos around massive sulphide deposits.

The fluorite-calcite-galena veins of SE Klubbdalen probably represent late remobilisations. Comparable veins are known from Haugfjellet and from Katterat East of the investigated area (Torgersen, 1935).

As to the two trenched mineralized localities in the bottom of Klubbdalen, the western one hosts remobilized sulphides in a shear zone which cuts the primary bedding at a right angle. Whether the mineralization at the trenched gossan is fault related or not remains uncertain.

The little known indications in the volcanics South of Hundalsbotnen show an interesting combination of intermediate volcanics and precious metals.

The semi-massive to massive pyrrhotite mineralization at Dur-

målsfjellet and Basejávri is of no immediate economic interest due to the low base-precious metal contents. On the other hand, this mineralization confirms the existence of mineralizing systems over prolonged periods.

7. CONCLUSION AND RECOMMENDATIONS

It is concluded, that good indications on a massive sulphide type zinc-lead deposit with interesting silver-gold contents exist in the Klubbvatnet area. Thus continued investigations along the following lines are recommended:

- Microscopic investigation of the 1984 samples. Special attention should be paid to the quartz rocks and to possible free gold.
- Continued scale 1:20,000 reconnaissance mapping and exploration of the supracrustals not covered in 1984. Special emphasis should be given to possible volcanics on Fjellheimen and to the continuation towards NNW and SSE of the main rust zone.
- A structural analysis of the whole Klubbvatnet area. This task is made difficult by the apparent lack of good markers apart from the andesites.
- Follow up on the main rust zone of the Klubbdalen-Blåisvatnet area. Work should comprise detailed geological mapping and geochemical sampling; also ground geophysics in the limited areas accessible for this type of work. The mineralization should be intersected by 100-200 m deep diamond drillholes at several localities selected during the detailed work. As a base for the field work a 1:5,000 or 1:10,000 topographical map with 20-25 m contours should be prepared aerophotogrammetrically before the start of the field season. In general, snow/ice cover will be a problem on the

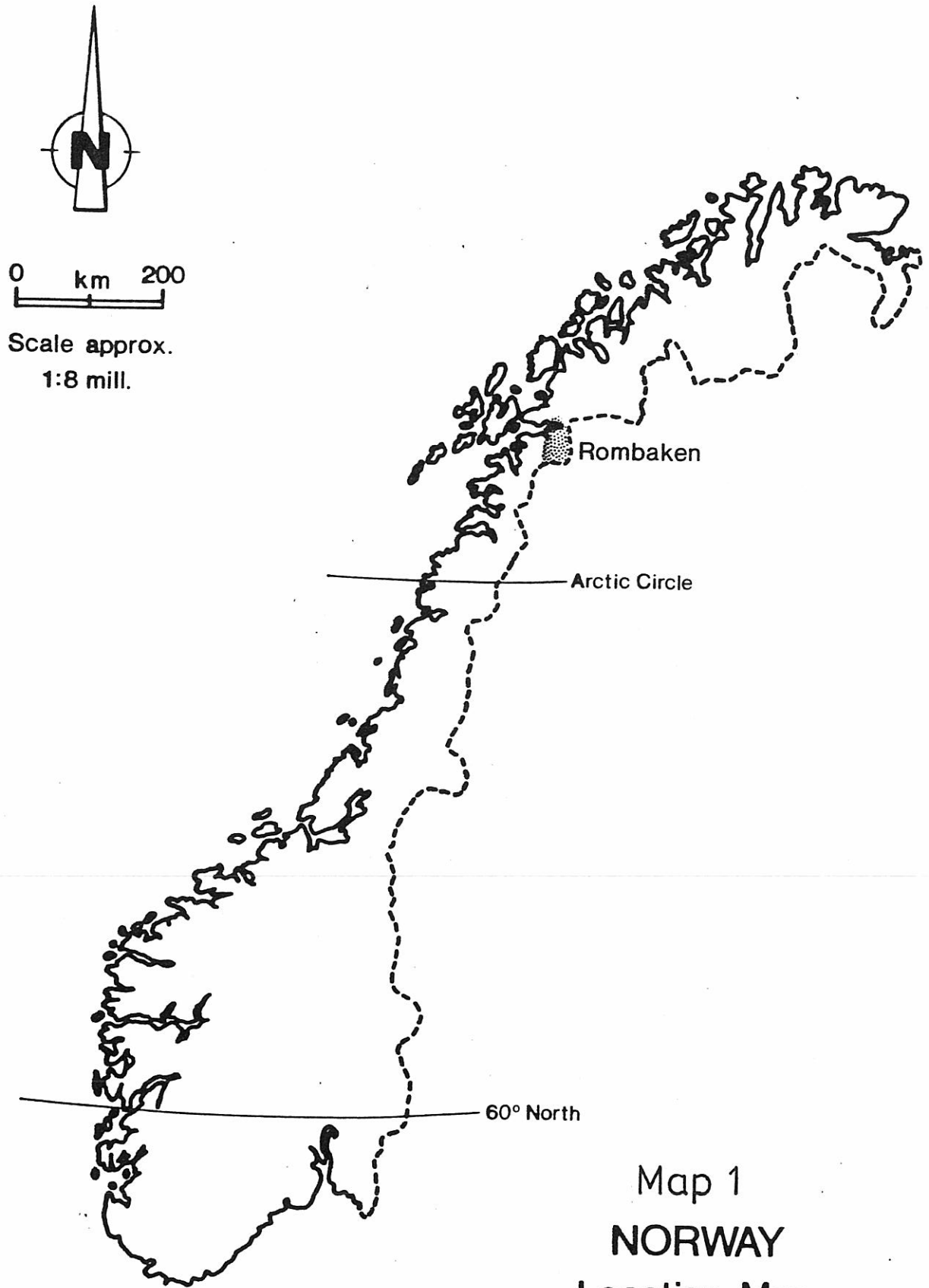
mountain ridges, as will the steepness of the exposures in Klubb dalen.

- Mapping and sampling of the rusty volcanics South of Hunddalsbotnen.
- Additional reconnaissance follow up on the gold-bearing pan samples and zinc-mineralized shear zone of SW Hunddalsbotnen.

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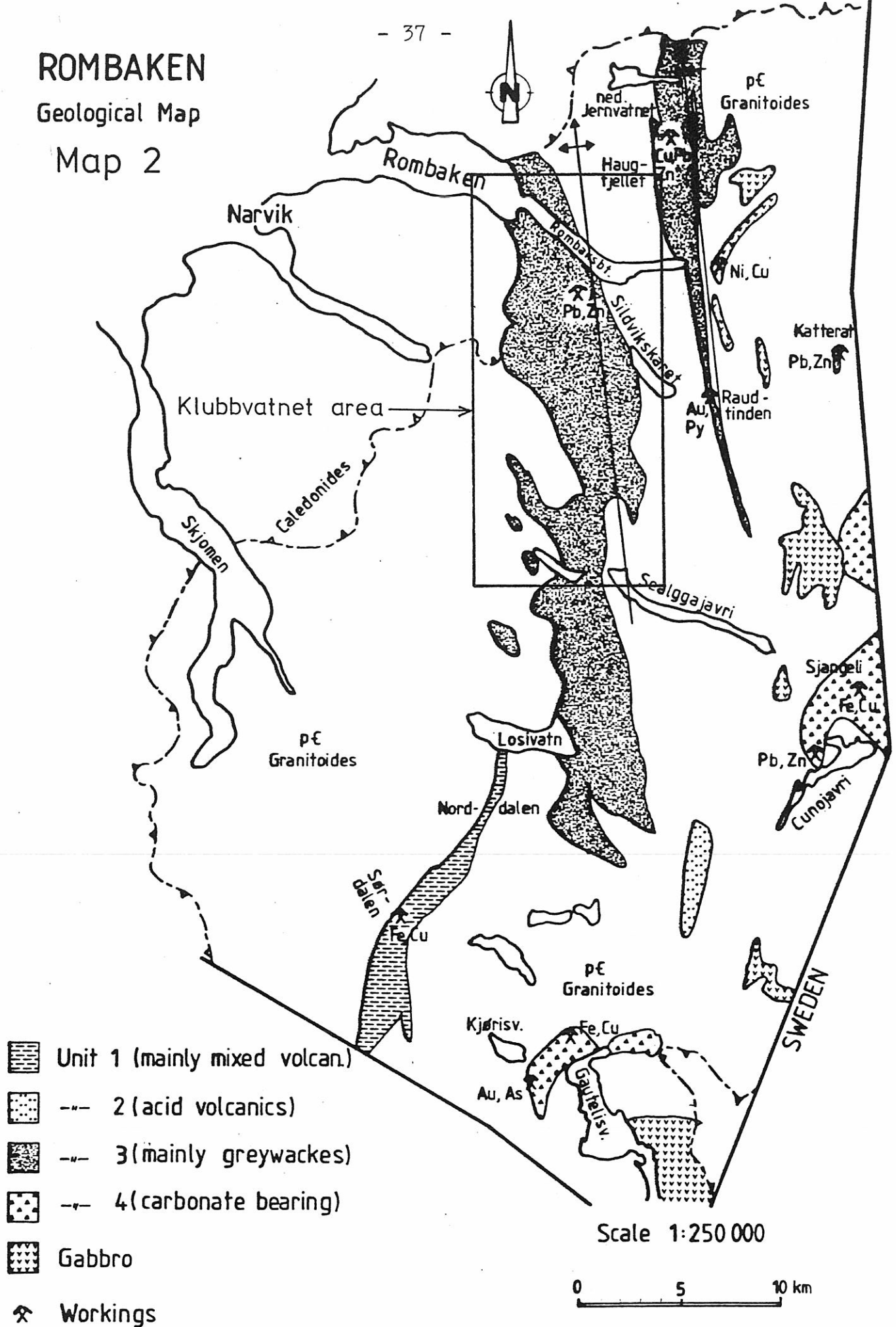
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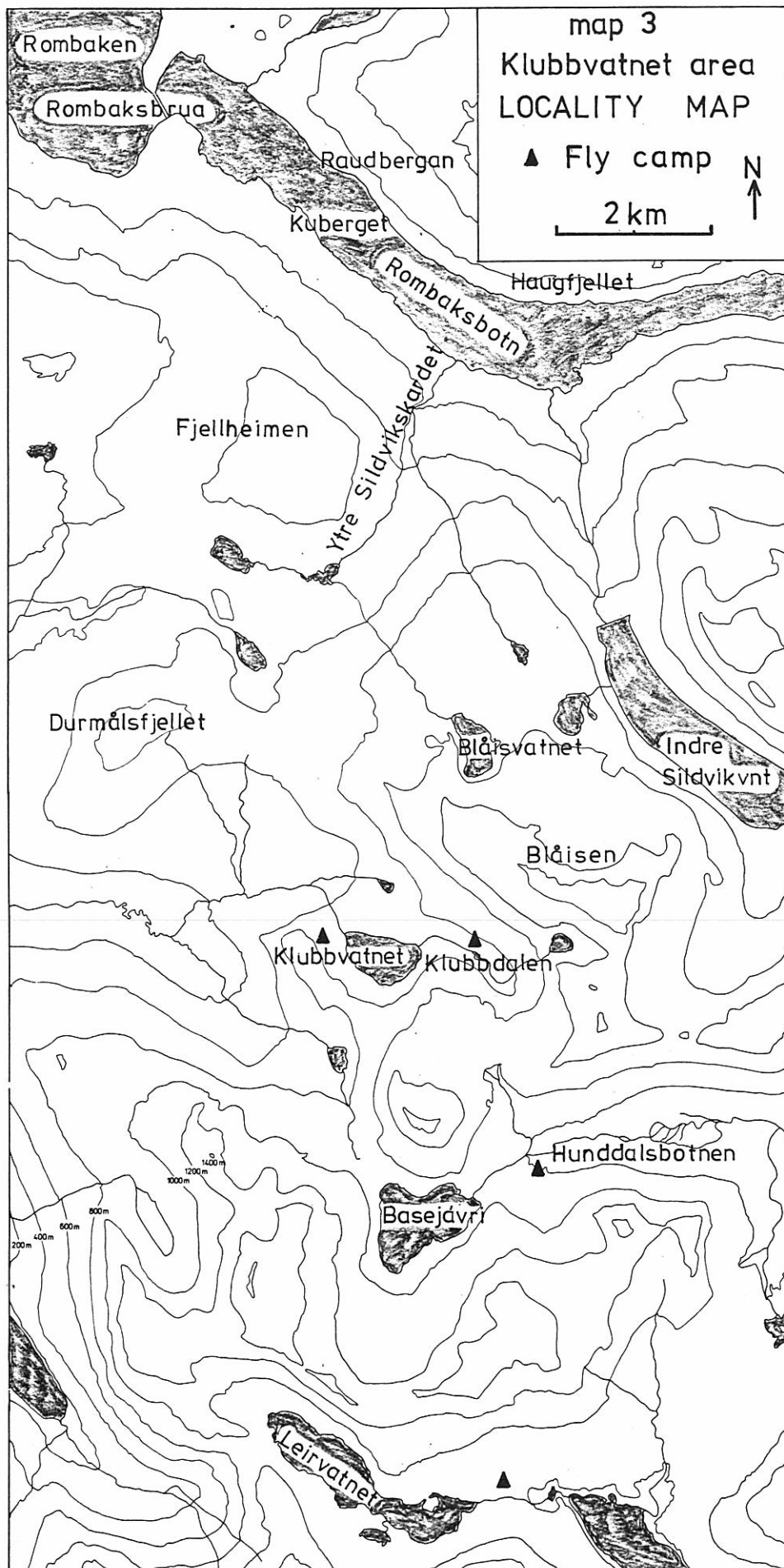


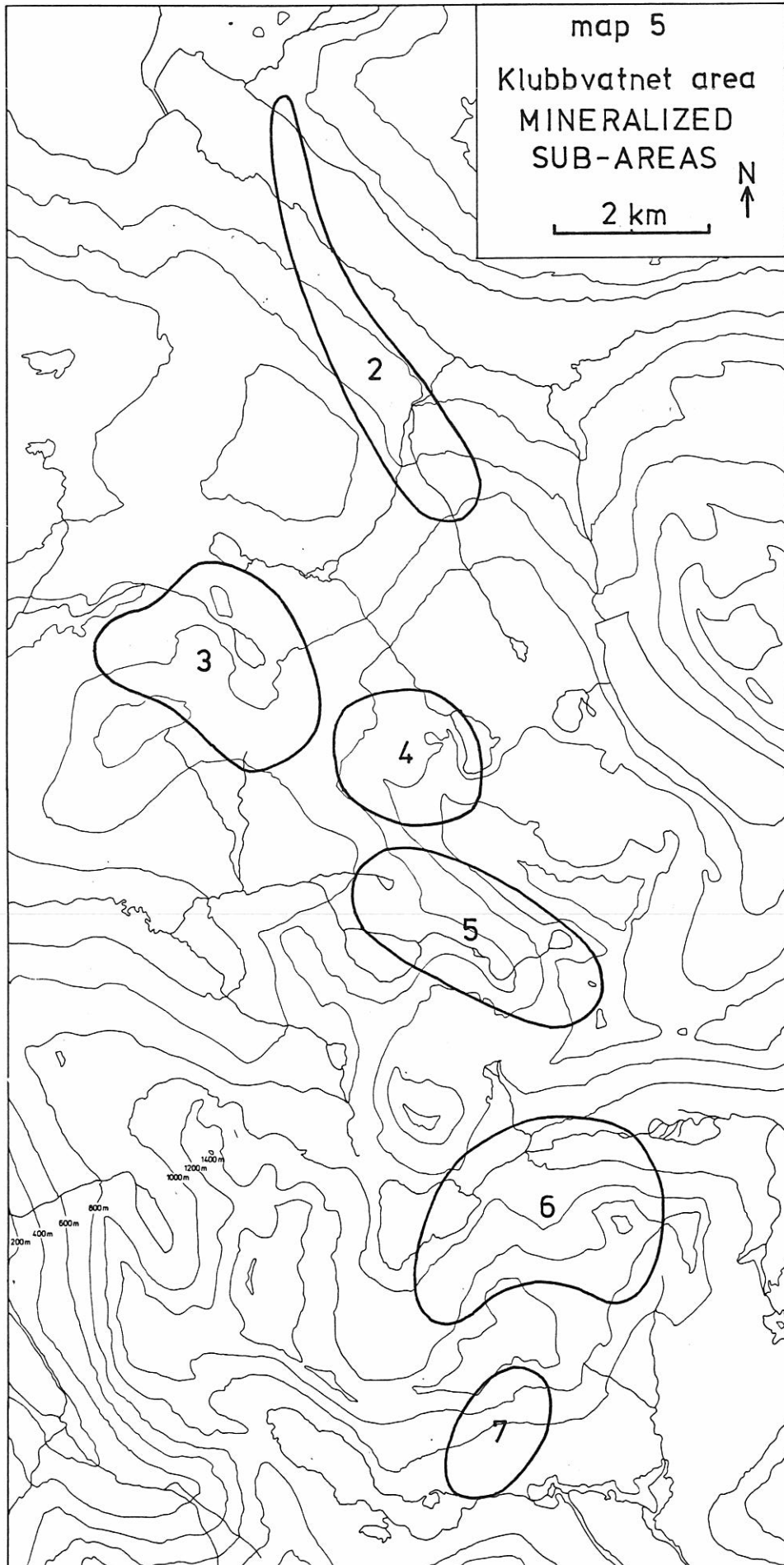
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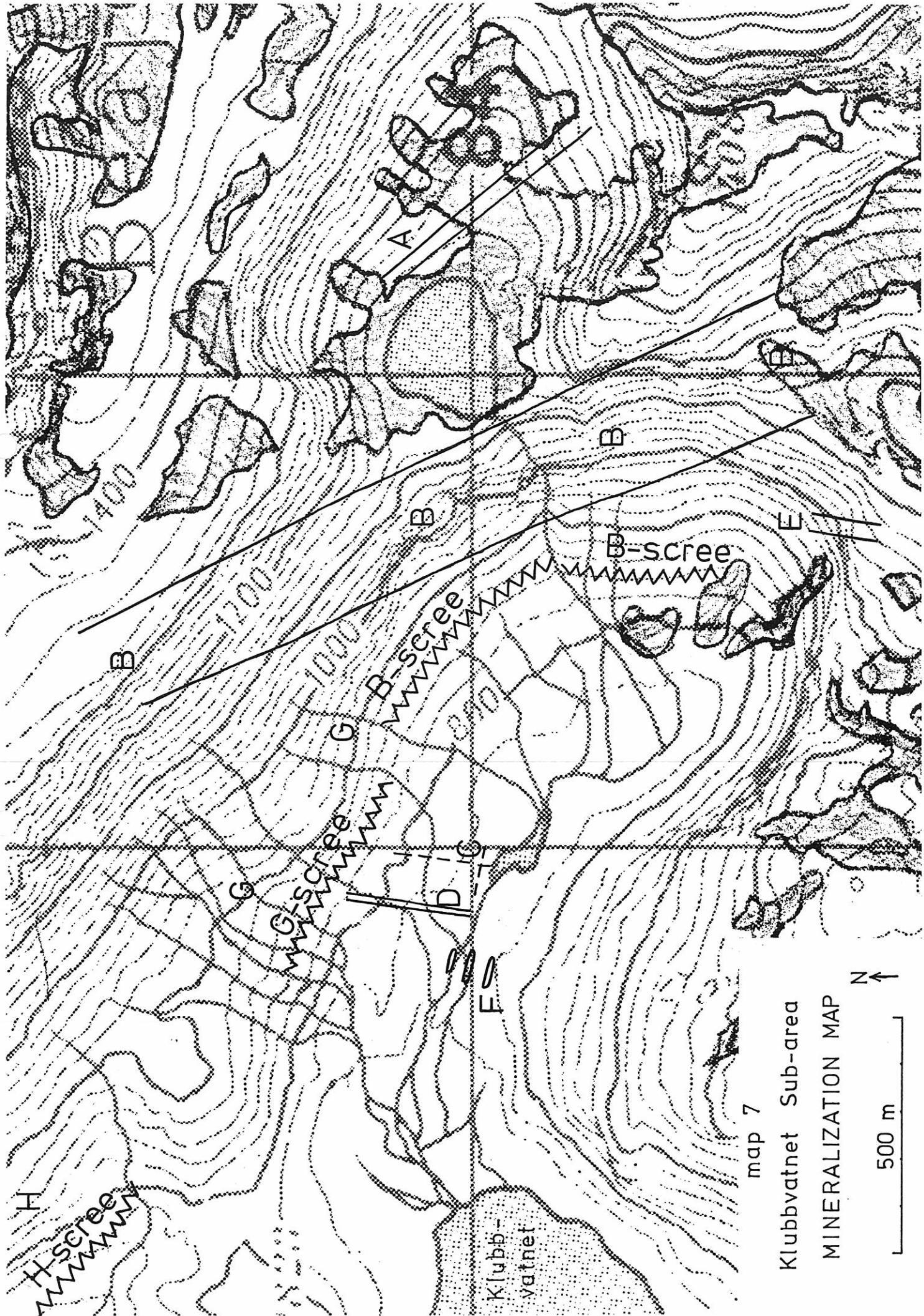
Geological Map

Map 2





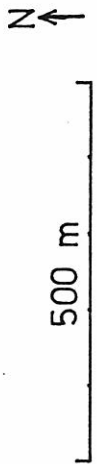




map 7

Klubbvatnet Sub-area

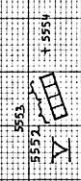
MINERALIZATION MAP



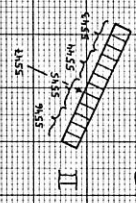
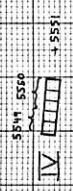
Trenches East of Klubbavannet

Blasied and sampled 27-28/9 1984

Map 8



Shear Zone



Gosjan

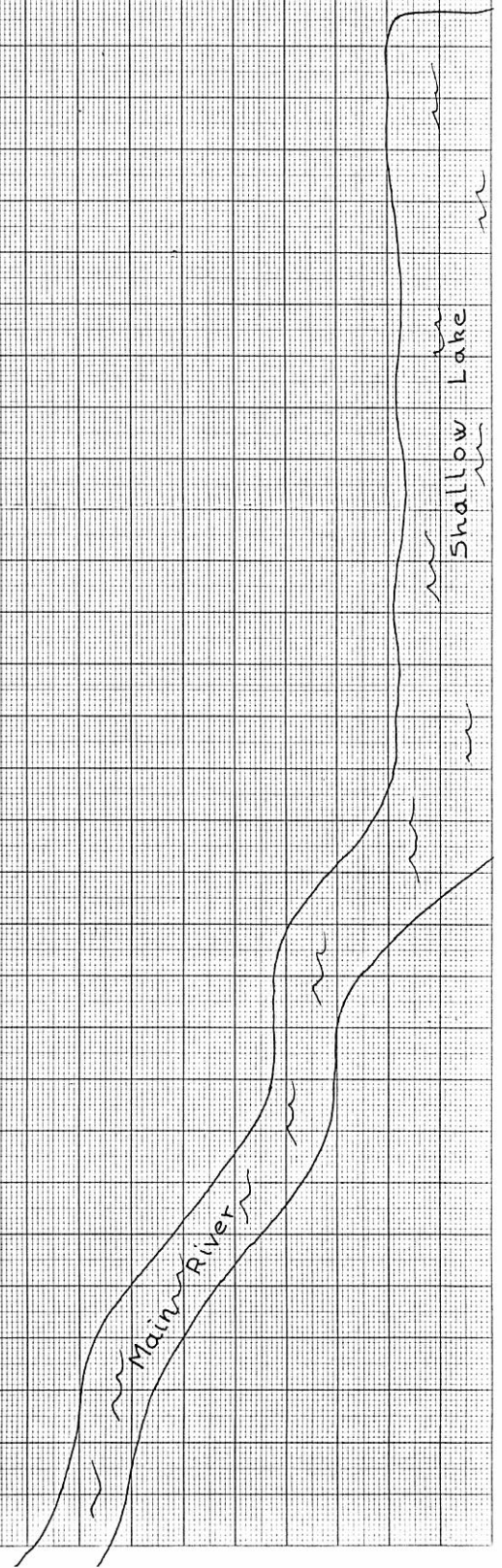
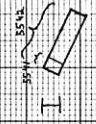


TABLE 1. OVERVIEW OF ROCK GEOCHEMISTRY, KLUBBVATNET AREA, 1984

Range and median in ppm. Comprises chip, grab and scree samples

Sub-areas	No. of samples	Zn	Pb	Cu	Au	Ag	As
2. Yt. Sildvikskardet	8	109-13,883 1997	60-7,717 2311	189-1,556 747	<0.005-0.238 0.021	<0.5-17.2 5.4	<10-159 19
3. Durmålsfjellet	11	42-444 110	14-684 37	29-142 66	<0.005-0.019 <0.005	<0.5-1.0 <0.5	<10-36 21
4. Blåisvatnet	8	147-420 225	21-110,873 164	14-207 97	<0.005-1.080 <0.005	<0.5-98.3 <0.5	<10-91 24
5. Klubbvatnet, samples geochemical	40	59-2,786 165	10-2,361 40	<10-454 50	<0.005-0.077 0.010	<0.5-2.3 <0.5	<10-588 22
5. Klubbvatnet, geochemical samples	52	43-136,408 447	24-82,388 1377	16-1,974 84	<0.005-0.847 0.022	<0.5-260.0 1.2	<10-606 16
5. Klubbvatnet trench samples, non-weighted	11	<10-13,192 1398	<10-12,626 274	<10-249 144	<0.005-0.185 0.009	<0.5-16.0 <0.5	<10-89 14
6. Hunddalsbotnen	18	45-3,471 114	<10-12,626 49	28-966 108	<0.005-0.149 <0.005	<0.5-47.9 <0.5	<10-479 27
7. Leirvatnet	18	<10-349 84	<10-424 29	<10-223 42	<0.005-0.111 <0.005	<0.5-3.5 <0.5	<10-158 19

TABLE 2. SUMMARY OF ROCK GEOCHEMISTRY, KLUBBVATNET SUB-AREA

x/Medians xx/Weighted averages and ranges in ppm

Locality	Number of samples	Zn	Pb	Cu	Au	Ag	As
x A-in situ	3	1457 (318-4597)	891 (146-3145)	179 (381-642)	<0.005 (<0.005-0.154)	1.9 (<0.5-12.1)	29 (11-64)
x B-in situ	7	862 (154-7816)	438 (28-12,878)	138 (32-381)	0.010 (<0.005-0.039)	<0.5 (<0.5-11.1)	27 (<10-114)
x B-boulders	8	14,405 (3515-26,401)	7560 (1048-24,616)	141 (67-213)	0.026 (<0.005-0.135)	6.5 (<0.5-17.3)	32 (<10-255)
xx C-22m trench	7	1629 (153-5241)	385 (26-1786)	151 (72-230)	0.019 (<0.005-0.062)	2.9 (<0.5-16.0)	15 (<10-89)
xx D-7m trench	3	5634 (1288-13,192)	3184 (851-7025)	125 (42-249)	0.057 (<0.005-0.185)	1.7 (<0.5-4.4)	21 (16-23)
x E-boulders, in situ	9	318 (138-116,924)	3,2417 (5877-82,388)	80 (16-1974)	0.055 (0.026-0.847)	27.1 (<0.5-260.0)	<10 (<10)
x F-in situ	5	105 (43-310)	49 (37-157)	65 (20-102)	0.069 (<0.005-0.156)	<0.5 (<0.5)	<10 (<10-92)
x G-in situ, boulder	3	150 (98-1229)	57 (50-707)	35 (29-59)	0.007 (<0.005-0.010)	<0.5 (<0.5-1.7)	16 (<10-18)
x H-in situ, boulder	4	257 (158-335)	72 (24-110)	36 (14-41)	<0.005 (<0.005)	<0.5 (<0.5)	30 (12-46)

TABLE 3. SUMMARY OF SCREE CHIP SAMPLES, KLUBBDALEN

Medians and ranges in ppm

Source mineraliz. ref. Map 7	Number of samples	Zn	Pb	Cu	Au	Ag	As
B	17	458 (152-2786)	200 (24-2361)	99 (33-454)	0.009 ($<0.005-0.077$)	<0.5 ($<0.5-2.3$)	29 ($<10-588$)
Mainly G	8	153 (94-301)	43 (27-142)	47 (24-278)	0.022 ($0.007-0.043$)	<0.5 (<0.5)	27 (40-72)
H	6	158 (130-265)	26 (18-302)	25 (21-27)	<0.005 ($<0.005-0.075$)	<0.5 (<0.5)	<10 ($<10-11$)

TABLE 4. KLUBBDALLEN TRENCHES

Analytical Values in ppm

Trench	Sample No	Length	Zn	Pb	Cu	Au	Ag	As	Sb	Fe%
I	4183	Surface sample	98	102	84	0.017	-	27	10	12.77
	5541	1 m	1738	26	144	0.007	-	89	20	6.51
	5542	6 m	1606	274	94	-	-	23	18	4.24
	Weighted average	6 m	1625	239	101	<0.005	<0.5	32	18	4.56
II	5547	selected sample	136,408	29,551	158	0.021	218.9	70	245	5.65
	5543	3 m	1398	319	198	0.017	3.2	14	37	11.27
	5544	3 m	5241	1786	185	0.062	16.0	11	48	10.60
	5545	3 m	413	32	192	0.015	-	-	40	9.48
	5546	3 m	153	161	230	0.009	-	-	117	13.96
	II E weigh.av.	6 m	3320	1053	192	0.040	9.6	13	43	10.94
	II W weigh.av.	6 m	283	97	211	0.012	<0.5	<10	79	11.72
III	5548	4 m	1118	33	72	0.012	<0.5	<10	28	3.81
IV	4182	1.5 m (Surface chips)	3553	2512	163	0.002	2.1	52	23	12.73
	5551	selected sample	10,315	8409	223	0.007	5.8	31	54	10.83
	5549	2 m	4594	2842	127	0.009	1.1	16	39	7.31
	5550	3 m	1288	851	42	-	-	23	25	3.42
	Weighted av.	5 m	2610	1647	76	0.006	0.6	20	31	4.98
V	5554	selected sample	42,026	32,404	922	0.031	19.8	49	81	11.10
	5552	2 m	-	-	-	0.007	-	-	-	0.02
	5553	2 m	13,192	7025	249	0.185	4.4	23	43	5.68

Note! For values below det.lim., 0.67 x det. lim. is used in calculated averages.



Fig. 1. Typical graywacke with graded bedding and facing towards the right (West) of the picture. East of upper lake, Klubbaldalen.



Fig. 3. Whitish quartz rock with banded and spotted structures. Valley West of Blåisvatnet.



Fig. 4. View of Klubbhdalen from the West, June 18.



Fig. 5. View of Klubbhdalen from the West, August 1.



Fig. 6. Slightly discordant rusty horizon in graywacke.
East of upper lake, Klubb dalen.



Fig. 7. The NE side of Klubbaldalen with the main rust zone.



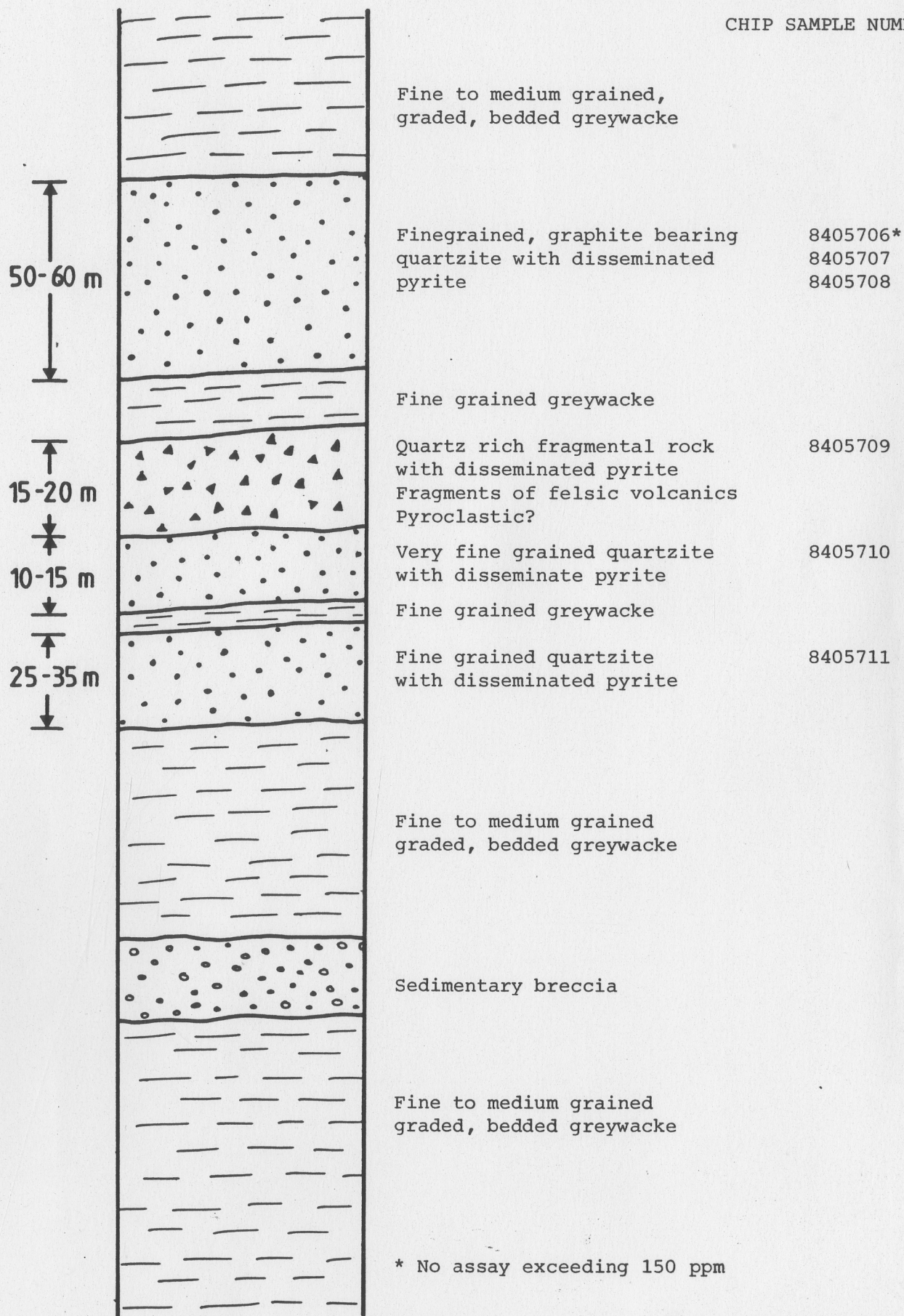
Fig. 8. Trenched gossan North of shallow lake, Klubbdalen.
Note person for scale.



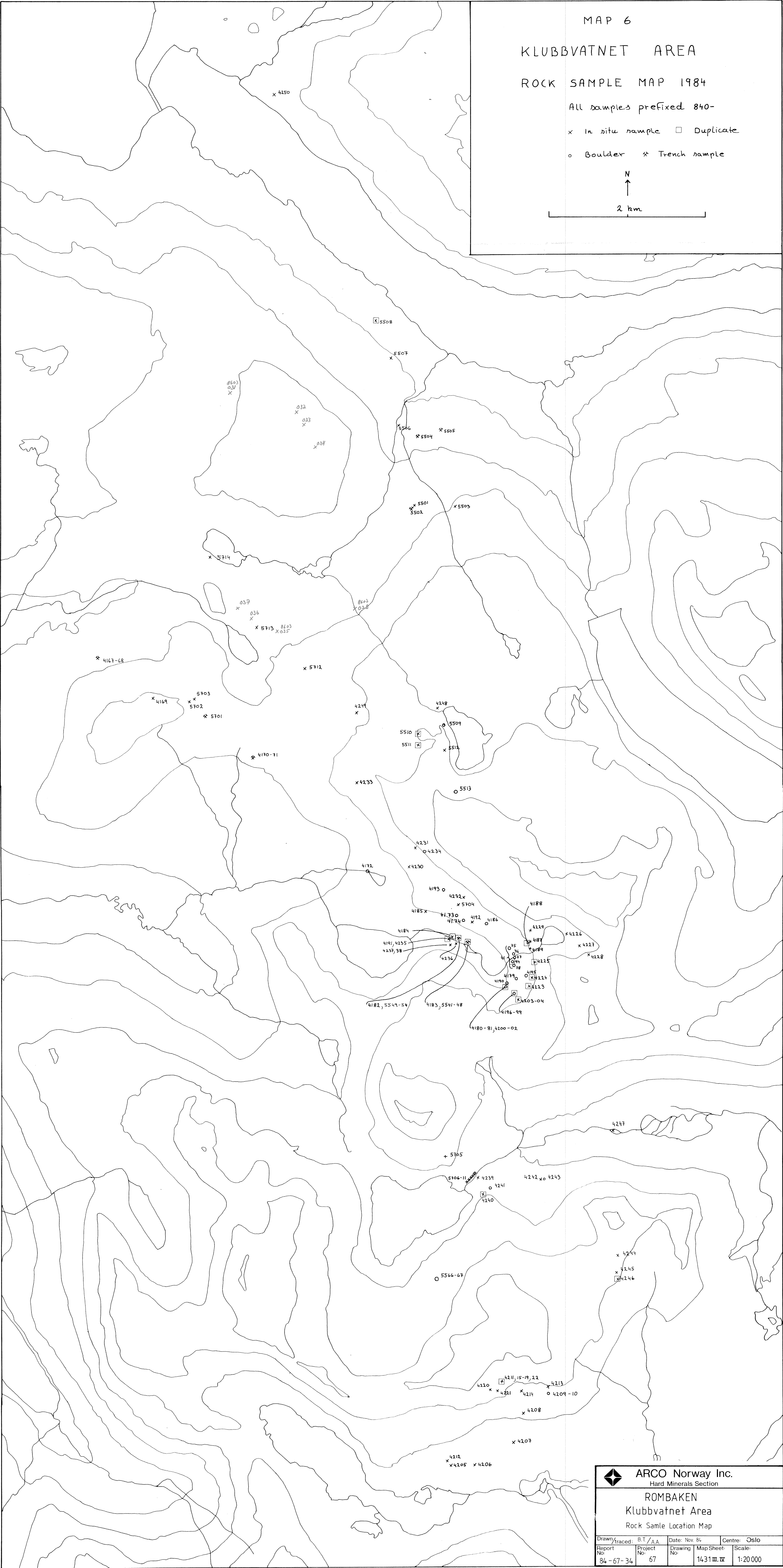
Fig. 9. Trench II, Klubbdalen.

SECTION AT BASEJAVRI IN HUNDDAL

CHIP SAMPLE NUMBERS



Thickness of individual beds are not in scale.
Thickness of mineralized beds are estimated.



MAP 6
KLUBBVATNET AREA
ROCK SAMPLE MAP 1984

All samples prefixed 840-
x In situ sample □ Duplicate
o Boulder * Trench sample



2 km

 ARCO Norway Inc. Hard Minerals Section			
ROMBAKEN Klubbvatnet Area Rock Sample Location Map			
Drawn/Traced: B.T./A.A.	Date: Nov 84	Centre: Oslo	
Report No: 84-67-34	Project No: 67	Drawing No: 1431 III, IV	Scale: 1:20 000

Klubbvann Area

Rock Geochemistry-Selected Samples

○ Scree Samples

◈ Grab Samples

▲ Grab Samples from Trench

Zn, Pb, Cu in %
Ag, Au in ppm

Map 6B

