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Mindex ASA

Mineralexploration in Kleivaasen area, Nisservatnet, Southern Telemark, Norway

By

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april 1998

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Introduction

The Mindex ASA´s Kleivaasen concession of the Nissedal area (59°09'08"N-59°11'03"N and 8°32'05"W-8°34'05"W) in Southern Telemark (fig. 1) Norway has over a 2-week period, 30/8–12/9 1997, been geologically prospected and covered geophysically by ground-survey magnetic anomali measurements. One week of rain made restrictions to the field work.

The Kleivaasen project was initiated on account of following known features:

1) A large positive aeromagnetic anomali with a broadly oval outline and a maximum more than 51500 gamma at Kleivaasen-Vevreitjønna area.
2) The occurence of two formerly mined iron formations, the Søftestad low-Ti banded iron-formation and the Veneli iron-vein. Furthermore several "skjerp" has been recorded which contain iron-cobber-nickel sulfides.
3) That Nisser rocks predominantly consist of different kinds of volcanics and intrusives.
4) The complex folding and shearing of the complex (Mitchell, 1967).

The main task was to structual analyse and locate any potential mineralizations, in particular gold-cobber (-nickel) associations possibly associated with iron-horizonts or quartz-veins.

I connection with the prospecting work 22 stream sediments was taken, but these are not included in this report because they have not been analyzed yet.

Field work

The rock were investigated by:

1) Reconnaissance and detailed geological mapping in scale 1:5000
2) Sampling of hand specimens and evt. chips of mineralized rocks, which were analysed for trace elements of economic interest, i.e. Cu, Pb, Zn, Ag, As, Sb, Bi and Mo. + Au
3) Sampling of stream sediments in 2 µm fractions, which have not yet been analyzed.
4) Ground-magnetometric measurements to establish borders and variations of interest (Mindex report by K. S. Jensen, 1997)

Previous Work

The geology of the Nissedal area has been thoroughly presented by Mitchell (1967). The Nissedal complex constitutes an outlier of metamorphosed volcanic, intrusive and sedimentary rocks completely surrounded by Setesdal granitic gneisses (Mitchell, 1967; Dons, 1960).

The most thorough works done on the Nisser complex are:

1) Detailed investigations on the Søftestad iron-ore deposit (Vogt (1895, 1910), Kvien (1961) and Mesfun (1996).The first two authors prefer a exhalative origin af the iron ore, while Mesfun suggests a hydrothermal replacement. The Veneli iron-vein is [illegible] by Mitchell (1967).

2) Geological mapping and petrographic investigations of the western part of Nisser complex is done by Mitchell (1967) in the light of Foslie´s observations. Further investigations has been done by Carter et al. (1984).

3) Structural analysis is done by Cramez (1969) and Bielak (1983).

4) Stream sediment sampling and analysis is carried out by Ekremsæter (1983).

5) Fieldwork in the light of economic geological investigations has been carried out by Bech & Grahl-Madsen (1983).

The Kleivaasen area

The Kleivaasen area consists of a variety of altered volcanic and intrusive rocks (fig. 2), which is metamorphosed to low amphibolite facies and folded intensively.

Volcanics:

Metabasalt is a very dark grey to black, fine grained rock with relict primary structures. Essential components are amphibole, plagioclase feldspar, biotite and minor Fe-oxides, sphene , chlorite and apatite. Primary volcanic structures comprise cavities, quartz-sulfide-, amphibole and feldspar-infilled amygdules and pyroclastic material typically dominated of amphibole and biotite. More or less recrystallized and seriticed plagioclase-phenocrysts are present on regular basis.
Finegranied, massive amphibolite of same composition (+ minor scapolite) as the metabasalt is interfingering with the metabasalts and are suggested of metabasaltic origin.

Fine- to medium grained intermediate rocks is recognized by the dark to light grey and bluish colors and appear in thin, alternating bands between acid volcanics and metabasalts/finegrained amphibolites. Primary volcanic structures such as quartz-sulfide and feldspar infilled amygdules is often present. The rocks are composed of quartz, plagioclase feldspar, amphibole, biotite-chlorite and subordinate microcline, sphene and Fe-oxides. Geochemical analyses show that these rocks can be classified as intermediate rocks (Thomsen, in prep.).

Acid volcanics is composed of quartz, plagioclase feldspar, microcline and minor amphibole, sphene, Fe-oxides and white mica. They occur as fine- to medium grained, pure white, light grey to reddish, finebanded rocks alternating with the intermediate and basic rocks in a cm to 100 m scale. Cavities and small phenocrysts that can not always be seen in hanspecimens, microflowbanding and pyroclastic material may seem to appear. Geochemical analyses show that these rocks can be classified as dacitic to rhyolittic rocks (Thomsen, in prep.).

All the volcanic rocks is interpreted as originally flows or pyroclastic rocks, in particular tuffs.

Intrusives:

The metagabbro is a medium to coarse grained, black to dark grey rock with seriticized plagioklas-phenocrysts in subofitic texture with hornblende. It is often seen in conjunction with medium- to very coarse grained amphibolites of same composition. The metagabbro and the amphibolites is

normally nonmagnetic to slightly magnetic and consist of plagioclase feldspar and amphibole with subordinate biotite, scapolite, apatite, Fe-oxides and sphene.

Quartz-feldspar pegmatite is present to a lesser extent in the northern part of the area than in the southern. Quartz-aplites is typical seen as smaller unregular or oblong zones in the quartzo-feldspar pegmatites, but in the triangle of Kleivaasen-Vevreitjønna-Skarstjønn several large (fx. e.g. lok. 98 at c. 200x50 m) and clearly intrusive quartz-aplites occur.

Finegrained, mafic dolerites with calcite-chlorite phenocrysts is seen locally and don´t carry any minerals of economic importance.

South of the concession area at Nissedal village to Frovatnet and Øytjønn occur an finegrained, green amphibole-chlorite rock.

Structures:

The Nisser rocks constitute a very complex system of folds and is very difficult to envisage because of the moderate exposure of the area.
[redacted]

The overall trends of the Kleivaasen area is (see fig. 2):

A) SW-NE strikes with SE dips in the area W of Kleivaasen, Lauvdalsfjell, Bakkebufjell and Hæsnetten. The same trend is seen south of the concession area at Nissedal village to Frovatnet and Tingststöåsen.
B) Approximately E-W strikes with S dips between Kleivaasen and Hæsnetten.
C) NW-SE strikes and typical SW dips at Gysjefjell and Bjønntjønn.
D) Complex folding W of Gysjefjell, Tveitane and N of Vevreitjønna.
E) The larger pegmatites have overall N-S or NNW-SSE lineaments.

Numerous, thin fractures is filled with quartz, feldspar, amphibole, biotite, epidote, Fe-oxides and minor sulfides. The overall longitudinal directions is concentrated in two trends relative to N: 120-140° and 55-90°.

Small scale thrusting appear locally in same directions as the fractures, and often makes *en echelon* arrangements. Dextral as well as sinistral thrusting is present. "Horns" do occur in pegmatitic veins in coarse amphibolite.
Local shearzones are often recognized by the unregular banding of very long white and greenish zones. Shearfractures is most clearly seen in the basic volcanics.

Results of economic interest

The geochemical analyses show 3 samples of interest: 399262 (lab.no. 83), 399266 (lab.no. 85) and 399273 (lab.no 91). These samples all contain anomalous higher amounts of Cu, Ag and Au.

Sample	Rocktype	Cu (ppm)	Ag (ppm)	Au (ppb)
399-262	intermedate rock with many Q-veins	1560	0,9	10 / 7
399-266	quartz-cpy vein in intermediate rock	5900	2,2	53 / 55
399-273	silicified zone in metabasalt	860	0,5	12 / 12

In all 3 samples the higher values may be due to thin sulfide-bearing quartz-feldspar veins.
In comparisation the finegrained amphibolites with 2-4 % chalcopyrite observed in the field; sample 399267 (lab.no. 86) and 399268 (lab.no 87) yield Cu-values at 380-385 ppm and no anomalous Au.

The investigations gives following conclusions:

1) No iron-, sulfide or gold-deposits have been found, but a Au or Cu-deposit cannot be outruled, because of the anomalous values present and the results of Arco Norway (Bech & Grahl-Madsen, 1983).

2) The sulfides (chalcopyrite, pyrrhotite, bornite and pyrite) is typically associated with very thin cross-cutting and subconcordant veins. This is most clearly seen in the volcanics, especially the basic to intermediate types. At first sight the Cu-mineralization seem dissiminated, but at closer look the vein-association can be observed. Polished sections show that chalcopyrite replace the host minerals and thin sections reveal tiny hydrothermal alteration-veins.
The veins together with the quartz-sulfide (chalcopyrite, pyrite) amygdules in the basic to intermediate tuffs indicate that mineralization has happened after the solidification of the rocks probably by hydrothermal fluids.

3) An unregular sulfide-epidote veinzone striking WSW-ENE is seen in a coarse amphibolite between Vikbukta and Svokollen. Pegmatitic magnetite, pyrite, chalcopyrite and pyrrhotite is yielding anomalous Cu- (448-1531 ppm) and Ni-values (203-2571 ppm) (Thomsen, in prep.).

4) The volcanics typically contain dissiminated magnetite, possibly stratabounded, and are therefore quite magnetic.

5) A vein of pure ilmenite is observed in coarse amphibolite just N Venli mineentrance (Thomsen, in prep). Geochemical analysis from the Venli iron-vein (399274) don't yield any anomalous values.

6) The nonmagnetic metagabbroes and medium- to very coarse grained amphibolites is most likely not to be related to the large aeromagnetic anomali. In thin sections the Fe-oxides clearly have replaced host minerals (Thomsen, in prep.).

7) Pegmatitic magnetite in association with sphene and chlorite is observed in quartz-aplite (loc. 98).

8) South of Hæsnetten a quartz-magnetite breccia is observed, which contain 3326 ppm Cu (Thomsen, in prep.).

Recommendations

1) If the large aeromagnetic anomali is to be a target of further investigations, the volcanic rocks and the vein-system must be mapped. The reason for this is the unmagnetic nature of the metagabbroes and coarse amphibolites together with the numerous thin Au- and Cu-sulfide-carrying veins in the volcanics, which might be associated with the anomali.

2) If the stream sediments sampled in the concession area shows economic interesting values, it might be of interest to pursue this.

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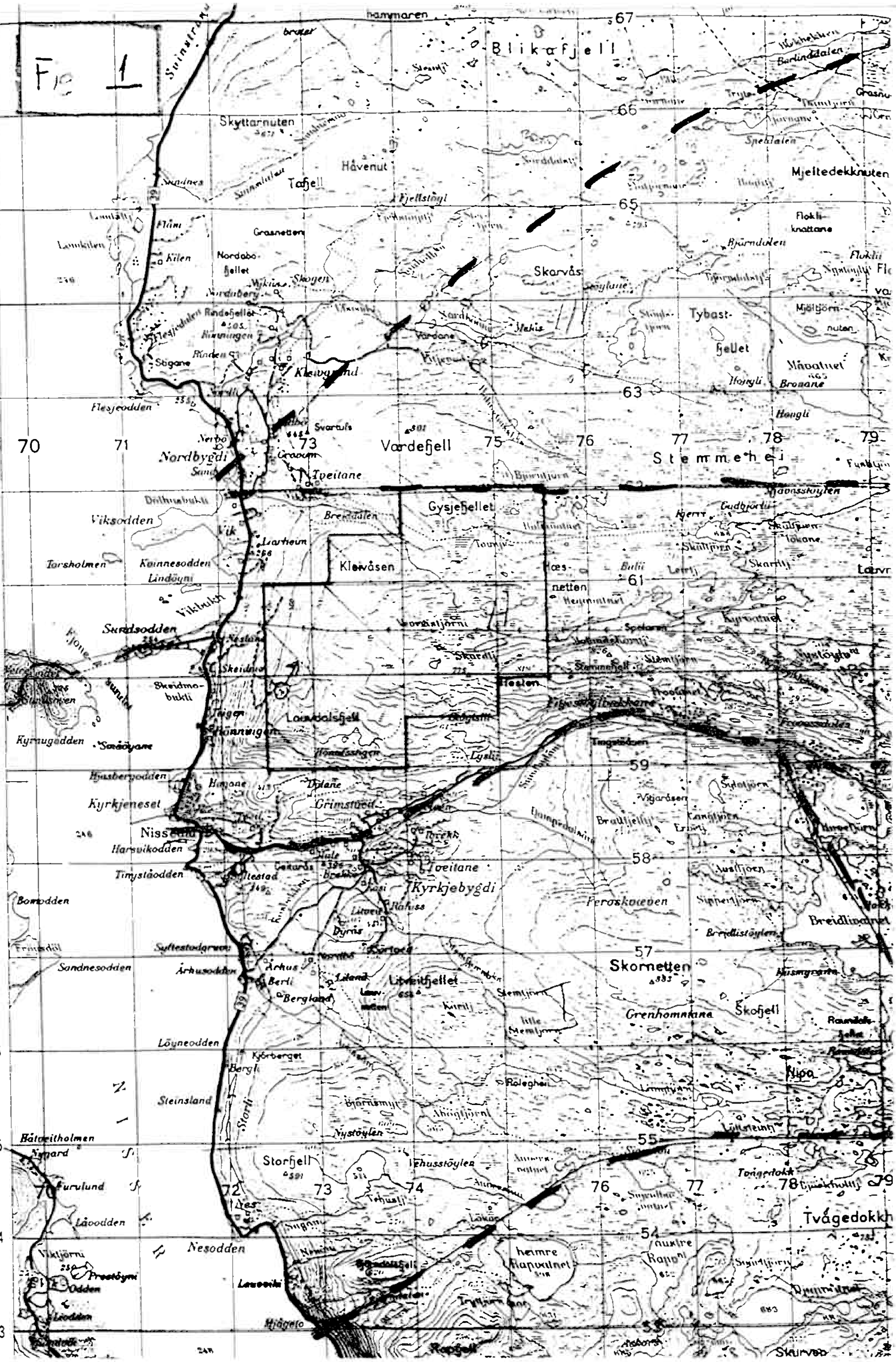

Fig 1
Blikafjell
Skyttarnuten
Håvenut
Tafjell
Mjeltedekknuten
Skarvås
Tybast-
fjellet
Nordbygdi
Vardefjell
Stemmehei
Gysjefjellet
Kleivåsen
Viksodden
Vik
Lauvdalsfjell
Kyrkjeneset
Nissedal
Kyrkjebygdi
Skornetten
Litveitfjellet
Storfjell
Steinsland
Tvågedokk
Nesodden
heimre Rapvatnet
Breidlivatnet
Sundsodden
Grimstaul
Tveitane

APP. A

Sample list of Kleivåsen area

Number	Area	Type	North	West	Alt.	Rock	Strike/dip	Lineation	Width	Loc. no.	Description	Magnetic
399-228	NIS	RGB	6562038	473754	32V	Metabasalt	Ca.360/90			T-2	Zone in tuffidic metabasalt with Fe/Fe-Cu sulphides. Limonite coated.	Moderatly
399-255	NIS	RGB	6560235	474281	32V	Quartz-aplite in Quartz-feldspar pegmatite				T-2	Medium-grained quartz-zone with magnetite in intrusive quartz-feldspar pegmatite.	very
399-256	NIS	RGB	6560148	473633	32V	Vesicular metabasalt	238/76 N			T-1	Fine-grained, dark grey rock with disseminated magnetite and vesicles of quartz-feldspar.	very
399-257	NIS	RFL	6560533	472563	32V	Intermed. tuff (evt. basalt)				T-3	Fine-grained and -banded tuff-rock with sulfides in thin biotite-bands (< 2 mm). Disseminated magnetite.	very
399-258	NIS	RGB	6560611	472649	32V	Vesicular metabasalt	24/38E 20/30 E			T-4	Several flow-boundaries with variable and sometimes grading content of vesicles. Disseminated magnetite.	very
399-259	NIS	RGB	6560825	472807	32V	Quartz-hornblende vein	130/?		ca. 5 cm	T-5	Quartz-hornblende-albite vein with chalcopyrite, pyrite and olivine.	no
399-260	NIS	RGB	6560932	472893	32V	Intermediate rock (andesite ?)	71/32 S			T-6	Fine-grained, dark grey rock with albite-phenocrysts in trachytoid texture. Disseminated magnetite.	very
399-261	NIS	SED	6560533	472563	32V	SED				T-3	Sample from small stream (< 0,5 m wide).	
399-262	NIS	RGB	6560932	472893	32V	Intermed. bja. (andesite ?)	71/44 S		?	T-7	Fine-grained, grey rock with plenty veins, som både skærer og følgher foliationen. Disseminated magnetite.	very
399-263	NIS	SED	6560950	472982	32V	SED.				T-8	Contain sulfide-grains. Sample from 1 m wide stream.	
399-264	NIS	SED	6561029	473055	32V	SED.				T-9	Contain sulfide-grains. Sample from 0.5-1 m wide stream.	
399-265	NIS	RGB	6561143	473085	32V	Intermediate rock (andesite ?)				T-9	Fine-grained, grey rock with vesicles containing chalcopyrite, magnetite and minor pyrite.	very
399-266	NIS	RGB	6560840	472760	32V	Quartz-hornblende vein	172/88 W		5-10 cm	T-10	Quartz-hornblende-vein with chalcopyrite, pyrite, magnetite and epidote ? No wall rock alteration.	if magnetite is present

399-267	NIS	RGB	6560930	472958	32V	Felsic tuff				T-11	Fine-grained, grey rock with minor sulfides and disseminated magnetite. An intrusive quartz-feldspar pegmatite is seen in contact with the rock.	moderat to very
399-268	NIS	RFL	6560941	473120	32V	Massive metabasalt				T-12	Fine-grained, massive, black grey rock with chalcopyrite, både porphyric and associated with small whitw veinlets (< 1 mm). Disseminated magnetite.	very
399-269	NIS	SED	6560724	472966	32V	SED.				T-14	Contain sulfide-grains. Sample from small stream (30-40 cm wide).	
399-270	NIS	RGB	6560874	473228	32V	Massive basalt with few vesicles	74/50 S			T-16	Fine-grained, dark grey basalt with disseminated magnetite and biotite. The rock is sometimes silicified. No sulfides is observed.	very to ex-treme
399-271	NIS	RGB	6560921	473250	32V	Vesicular basalt/inter-mediate rock	79/55 S			T-17	Minor sulfides associated with the quartz-feldspar vesicles. Disseminated magnetite.	extreme
399-272	NIS	RGB	6560939	473364	32V	Vesicular metabasalt	89/49 S			T-18	Fine-grained, massive rock with minor sulfides associated with the vesicles. Disseminated magnetite.	very to ex-treme
399-273	NIS	RGB	6560100	472341	32V	Silica-feldspar vein-zone in vesicular basalt			< 5 cm	T-25	Chalcopyrite in the zone. Disseminated magnetite is seen in the vesucular basalt.	very in the basalt
399-274	NIS	RGB	6559684	472439	32V	Quartz-magnetite-biotit-titanite-apatite (?) aplite-vein	43/50 SE (uncertain)		20-40 cm	T-31	Intrusive vein with massive magnetite in metagabbroic host-rock. Venli-mineentran-ce. Biotite-pegmatite krystals is often present. No wall-rock alteration.	extreme
399-275	NIS	RGB	6559797	472478	32V	Quartz-feldspar-magneti-te vein	60/? E		8-10 cm	T-32	The vein following foliation of the meta-gabbroic host-rock.	extreme where mt
399-276	NIS	SED	6559925	472789	32V	SED.				T-33	Sample from beneath 2 converging streams (ca. 1 m wide).	
399-277	NIS	SED	6558895	474660	32V	SED.				T-34	Sample from small stream (0,5-1,0 m wide).	
399-278	NIS	RCH	6559809	472477	32V	Magnetite-feldspar-quartz-vein	148/48 W (dip uncer-tain)		1-3 cm	T-35	Some wall-rock alteration with magnetite in unmagnetic metagabbroic host-rock.	extreme

399-279	NIS	RGB	6560160	472930	32V	Quartz-hematite-hornblende-feldspar separation-zones				T-37	Typically medium-grained and associated with quartz-aplites and quartz-feldspar-pegmatites.	no
399-280	NIS	SED	6560151	473179	32V	SED.				T-40	Sample from small stream (0,5 m wide).	
399-281	NIS	RFL	6560617	473585	32V	Felsic tuff-rock	109/? uncertain			T-48	Banded magnetism responding to the contents of magnetite.	variable
399-282	NIS	RGB	6560419	474143	32V	Basic (basaltic) metatuff	69/40-60 S (uncertain)	69/? W		T-68	Fine-grained rock containing disseminated magnetite.	very
399-283	NIS	RGB	6560416	474250	32V	Metarhyolite	181/15 W			T-71	Fine-grained, grey-white and hard rock with dissiminated visible grains of magnetite	moderate to very
399-284	NIS	SED	6561519	472476	32V	SED.				T-78	Sample from small stream (< 0,5 m wide).	
399-285	NIS	SED	6561015	472261	32V	SED.				T-79	Sample from almost dryed out stream.	
399-286	NIS	RGB	6560504	471936	32V	Metagabbro with magnetite and pyrite				T-80	Visible magnetite grains. Pyrite is present in small veinlets.	moderate to very
399-287	NIS	RGB	6560691	472030	32V	Leuco-metagabbro with sulfides				T-81	Magnetite and minor sulfides (pyrite) is present. A silification-zone with variable sulfide- and magnetite is seen.	slightly to very
399-288	NIS	RGB	6560691	472030	32V	Quartz-hornblende-feldspar-magnetite-sulfide pegmatite veins	E-W			T-81	Very coarse-grained veins, especially the hornblende-grains. At least 7-8 veins is seen with pyrite and pyrrhotite. Epidote is present.	slightly to very
399-289	NIS	SED	6560602	472229	32V	SED.				T-82	Sample from almost dryed out stream.	
399-290	NIS	SED	6561810	473228	32V	SED.				T-83	Sample from Vikåna (3-4 m wide).	
399-291	NIS	SED			32V	SED.				T-85	Sample from 1-2 m wide stream at Fjorneferry crossroads.	
399-292	NIS	RGB	6559786	474611	32V	Quartz-feldspat-hornblende-magnetite pegmatite vein ?			20-30 cm	T-89	Maybe a result of mineral-separation from the metagabbroic host-rock.	only where magnetite
399-293	NIS	RGB	6560073	474912	32V	Feldspar-magnetite-biotite(-quartz) pegmatite vein	190/?		8-15 cm	T-93	The vein is seen in unmagnetic metagabbroic host-rock. Very coarse-grained rock.	
399-294	NIS	SED	6560430	475197	32V	SED.				T-96	Sample from small stream in bog-like landscape, but flowing. Width ca. 0,5 m.	
399-295	NIS	SED	6560063	473651	32V	SED.				T-106	Sample from 0,5-1 m wide stream.	
399-296	NIS	SED	6556514	474132	32V	SED.				T-108	Sample from smaller flow (1-2 m wide).	
399-297	NIS	SED	6558384	472451	32V	SED.				T-109	Sample from Bakkeåna river (3-6 m wide).	

399-298	NIS	SED			32V	SED.				T-111	Sample from small stream (< 0,5 m) at Fjome-ferry crossroads.	

T.B. THOMSEN 1998

METABASALT & FINE GRAINED AMPHIBOLITE

INTERMEDIATE ROCKS

ACID VOLCANICS

VOLCANICS

METAGABBRO & MEDIUM TO COARSE GRAINED AMPHIBOLITE

QUARTZ - FELDSPAR PEGMATITE

INTRUSIVES

SCALE 1:10.000

ØKONOMISK KARTVERK

TELEMARK FYLKE

FOTOKART A/S

FYLKESKARTKONTORET I TELEMARK 1985

LAB. NO.	SAMPLE	Cuppm	Pbppm	Znppm	Agppm	As%	Sbppm	Bippm	Moppm	Au1 Geochem Auppb	Repeat Au1 Geochem Auppb	Weight
56	399206	75	14	15	0.7	-0.001	-5	-5	-2	-3		
57	399207	36	22	56	0.4	-0.001	-5	-5	-2	-6		
58	399209	47	7	50	0.2	-0.001	-5	-5	-2	-3		
59	399210	54	8	57	0.3	-0.001	-5	-5	-2	-4		
60	399211	305	3	145	0.6	-0.001	-5	-5	-2	-3		
61	399212	116	5	127	0.6	-0.001	-5	-5	-2	3		
62	399213	93	6	84	0.4	-0.001	-5	-5	-2	-3		
63	399214	27	20	102	-0.2	-0.001	-5	-5	-2	-3		
64	399215	30	7	46	-0.2	-0.001	-5	-5	-2	-3		
65	399216	46	5	13	0.2	-0.001	-5	-5	-2	-3		
66	399217	39	14	47	0.2	-0.001	-5	-5	-2	-3		
67	399218	218	-1	134	0.6	-0.001	-5	-5	-2	6	3	(25.00g)
68	399219	253	3	83	0.9	0.001	-5	-5	-2	-3		
69	399220	97	55	72	0.6	0.001	-5	-5	-2	10	-3	(25.00g)
70	399221	47	9	200	0.2	-0.001	-5	-5	-2	-3		
71	399222	119	9	87	0.3	-0.001	-5	-5	-2	-3		
72	399228	34	-1	47	-0.2	-0.001	-5	-5	-2	-3		
73	399251	64	51	101	0.6	-0.001	-5	-5	-2	-3		
74	399252	34	13	65	-0.2	-0.001	-5	-5	-2	-3		
75	399253	20	31	175	-0.2	-0.001	-5	-5	-2	-3		
76	399254	78	660	159	01.jun	-0.001	-5	-5	10	15	11	(25.00g)
77	399255	12	8	7	0.2	-0.001	-5	-5	-2	-3		
78	399256	148	-1	20	0.2	-0.001	-5	-5	-2	-3		
79	399257	85	2	33	0.2	-0.001	-5	-5	-2	-3		
80	399258	9	-1	19	-0.2	-0.001	-5	-5	-2	-3		
81	399259	87	2	45	-0.2	-0.001	-5	-5	-2	4		
82	399260	54	-1	24	0.2	-0.001	-5	-5	-2	-3		
83	399262	1560	-1	11	0.9	-0.001	-5	-5	-2	10	7	(25.00g)
84	399265	182	-1	14	-0.2	-0.001	-5	-5	-2	-3		
85	399266	5900	-1	46	02.feb	-0.001	-5	-5	-2	53	55	(25.00g)
86	399267	385	2	10	0.2	-0.001	-5	-5	-2	3		

↓ Klein-asen rock chip samples

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LAB. NO.	SAMPLE	Cuppm	Pbppm	Znppm	Agppm	As%	Sbppm	Bippm	Moppm	Au1 Geochem Auppb	Repeat Au1 Geochem Auppb	Weight
87	399268	382	-1	34	0.3	-0.001	-5	-5	-2	-3		
88	399270	54	-1	22	0.2	-0.001	-5	-5	-2	-3		
89	399271	10	-1	22	-0.2	-0.001	-5	-5	-2	-3		
90	399272	165	-1	46	-0.2	-0.001	-5	-5	-2	-3		
91	399273	860	-1	33	0.5	-0.001	-5	-5	-2	12	12	(25.00g)
92	399274	32	-1	73	0.3	-0.001	-5	-5	-2	-3		
93	399275	11	-1	58	0.3	-0.001	-5	-5	-2	-3		
94	399278	10	-1	45	0.3	-0.001	-5	-5	-2	-3		
95	399279	10	5	49	-0.2	-0.001	-5	-5	-2	5		
96	399281	60	2	58	-0.2	-0.001	-5	-5	-2	-3		
97	399282	7	-1	66	-0.2	-0.001	-5	-5	-2	21	-3	(25.00g)
98	399283	4	1	22	-0.2	-0.001	-5	-5	-2	-3		
99	399286	21	-1	23	-0.2	-0.001	-5	-5	-2	-3		
100	399287	23	4	41	-0.2	-0.001	-5	-5	-2	-3		
101	399288	201	-1	26	-0.2	-0.001	-5	-5	-2	-3		
102	399292	24	2	37	-0.2	-0.001	-5	-5	-2	-3		
103	399293	22	8	28	-0.2	-0.001	-5	-5	-2	-3		

Au analysis weight is 50gm except where indicated otherwise in brackets.