SURVEY OF
THE NORWEGIAN STATE'S MINING RIGHTS
1980

NGU report no. 1650/53A

Pyrite deposits in the Stavfjord area with particular reference to the Grimeli and Vågedalen deposits in Askvoll, Sogn and Fjordane County

Geological Survey of Norway

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Summary:

In conjunction with surveys of the Norwegian Government's mining rights, geophysical VLF and CP measurements, geological mapping work and diamond drilling (Pack Sack) were conducted during the period 1976-80 at the Grimeli and Vågedalen pyrite deposits.

This report will present an overview of the known pyrite deposits in the Stavfjord area, devoting special discussion to the Grimeli and Vågedalen deposits. The report is based largely on previous works.

On an uncertain basis a deposit size of 1.5 and 0.7 million tonnes has been estimated for Grimeli and Vågedalen, respectively, with 2-4% Cu + Zn. This is too little to be of economic interest.

None of the other pyrite deposits are promising, and the Stavfjord area is considered of little interest in the context of pyrites.

Keywords		
	Bedrock geology	Diamond drilling
	Ore geology	S, Cu, Zn
	Geophysics	*Geological Survey of Norway* *The Library*

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1. INTRODUCTION

In connection with a survey of the Norwegian government's mining rights at the Grimeli pyrite deposit, geological mapping was done in the Grimeli-Vågedalen area in summer 1980 and scattered inspections in the surrounding areas. In autumn 1978 VLF anomalies linked to the Grimeli and Vågedalen deposits were sampled with lightweight diamond drilling equipment.

This report presents an overview of the known pyrite deposits in the Stavfjord area with particular reference to the Grimeli and Vågedalen deposits, based partly on the results of the diamond drillings.

2. PREVIOUS WORKS

The Stavfjord area's Cambro-Silurian rock types have been the object of bedrock geology surveys by Kolderup (1921, 1928), Skjerlie (1969a and b, 1970 and 1974), Gale (1975) and Furnes et al. (1976). Skjerlie's work from 1974 in particular is extensive and presents a classification of the rocks into a number of groups, formations and individual units. Gale (1975) demonstrates that the greenstones (diabases) in the Grimeli formation represent ocean floor-type basalts. Furnes et al. (1976) classify the rock series into a more complex plate-tectonic context on the basis of geochemical studies of greenstones.

In the case of the ore deposits a number of older reports are available, dealing with the Grimeli and Svanøy deposits. For Svanøy the results of these surveys have been updated by Jensen (1965), who additionally assesses the deposit on the basis of geological mapping and electromagnetic measurements; and for Grimeli, by Stensrud (1976). Stensrud's works, which are an NTH dissertation (for USB), present a geological overview of the Grimeli area and describe mineralogical and chemical traits of the ore mineralizations. In addition, under the aegis of USB, VLF measurements (Singsaas 1978), Pack Sack drillings on VLF anomalies at Grimeli and Vågedalen in 1978, and CP measurements at Grimeli and Vågedalen in 1980 (Rønning 1981) have been carried out.

3. GEOLOGICAL OVERVIEW

The pyrite deposits in the Stavfjord area are associated with Cambrian-Silurian rocks, bordering to the east on pre-Cambrian and Devonian, and to the south on pre-Cambrian rocks. The main geological features are shown in Drawing 1.

<u>Devonian rocks</u>
The Devon deposits to the east consist of sandstones and conglomerates belonging to the Kvamshesten Devonian field.

<u>Cambrian-Silurian rocks</u>
The Cambrian-Silurian rock series comprises greenstones and pillow lavas, gabbros, serpentinites, tuffs (trasses), greywackes and limestones. Skjerlie (1974) divides these rocks into five groups: the Håsteinen (oldest), Stavenes, Lower Herland, Upper Herland and groups. In turn these groups are divided into a number of formations and subunits (Dwg. 1).
The Grimeli, Vågedalen and Svanøy deposits are located within the rocks of the Stavenes group, in the Grimeli and the Moldvær formations, respectively. The Grimeli formation

consists mainly of greenstones and pillow lavas while the Moldvær formation represents a more tuff-rich extrusive development and consists chiefly of green slates. The transition between these formations is gradual (Furnes et al. 1976).

Furnes et al. (1976) have put forward a plate tectonic model based on greenstone geochemistry and general geological interpretations, suggesting that the basalts lowest down the sequence (the Grimeli formation) are of the tholeiitic ocean floor type, whereas the uppermost basic lavas, of a calcalkaline and alkaline chemistry, were formed in an island arc environment.

Pre-Cambrian rocks
To the south and the east of the Cambrian-Silurian area, mangeritic rocks assumed to be of pre-Cambrian age occur in a thrust nappe (the Dalsfjord Nappe), which had advanced beyond Cambrian-Silurian and pre-Cambrian rocks during the Cambrian-Silurian age (Furnes et al. 1976).

Structural geology
In the Stavfjord area five deformation phases (Skjerlie 1974) have been demonstrated: Fl, associated with the overthrust of the Dalsfjord Nappe; F2, associated with the formation of the Stavfjord anticlinal; and three later deformation phases (F3-F5). These fold structures are described in detail by Skjerlie (1974).

4. THE ORE DEPOSITS

4.1. Grimeli

Introduction

The Grimeli deposit was operational during the periods 1759-82, 1851-1906 and 1914-19. Production stood at 300-1,100 tonnes ore a year, with 3.5-4.5% Cu on average (Stensrud 1976). The deposit was worked in 3 places: the West, Lower and Upper mines.

The Grimeli area’s rocks and pyrite mineralizations have been described by Stensrud (1976).

Geological description
The bedrock in the Grimeli area consists of greenstones and pillow lavas with sprinklings of meta-hyaloclastic breccias (breccia structures associated with pillow formation), porphyric greenstone, lime-rich meta-greywacke and meta-gabbro (Dwg. 3). These rocks are usually slightly schistose. The transitions between gabbro, greenstone, pillow lava and meta-hyaloclastic breccia are often gradual and unclear, especially in the slaty sections.

In some areas the greenstones take on a granular appearance, due to a pronounced content of 3-4 mm amphibole grains. These "granular greenstones" (Dwg. 2) bear a great similarity to fine-grained gabbros, referred to by Skjerlie (1974) and Stensrud (1976) as subvolcanic gabbros.

At a number of levels the pyrite mineralizations occur as irregular impregnations, strips, veins and solid bands of magnetic pyrite, iron pyrite, copper pyrite and zinc blende or sphalerite, linked to greenstone, pillow lava and meta-hyaloclastic breccia. The thickness of the mineralized sections and zones varies from a few mm to several metres, extending up to 2 km

in length. The largest of the zones is clearly shown by the VLF anomaly picture (Singsaas 1979 and Dwg. 3).

The ore mineralizations vary greatly in both sulphide content and composition. Irregular transitions from solid iron pyrite ore to solid iron pyrite-magnetic pyrite-copper pyrite-zinc blende ore, and to small pyrite strips, veins and impregnations, are common.

At the point of the mines, the rocks in the ore zone show a tendency to be more markedly schistose than the surrounding greenstones and pillow lavas. Small folds in the ore are common, with amplitudes ranging in size from 10-20 cm to 2 m, axial direction WNW/ESE and varying plunge. These folds can probably be linked to Skjerlie's (1974) F3 phase (Stensrud 1976). The pyrite mineralizations show a tendency to mobilize and deposit in knee-folds.

Geophysics

The Grimeli area was VLF surveyed in 1978 (Singsaas 1979) and a number of conductive zones identified in the actual mine area and 2-3 km eastwards in the direction of Vågedalen. East of the mines are 2 anomaly zones extending 1 and 2 km, respectively. The zones' mother lode is exceptionally exposed outside of the actual mine area.

In 1980 CP measurements were taken in the mine area (Rønning 1981). The measurement results show that the West and Lower mines are linked to the same pyrite zone while the Upper Mine is linked to two separate ore zones. The measurement results indicate that the ore zone near the Lower Mine extends down to a depth of about 600 m with a horizontal extent of 450 m. For the Upper Mine the corresponding figures are 600 and 380 m.

Diamond drilling

The two long and intensely conductive VLF anomalies east of the mine area were sampled with a Pack Sack hole in each (Dwg. 5, Appendix 2).

Both show some concentration of 1-3 mm thick pyrite veins and strips parallel to the slatiness of the rock in addition to a good deal of very fine-grained magnetic pyrite impregnation. In hole 2 the rock is a greenstone and in hole 3 mainly green slate with elements of more quartz-rich parts with a sedimentogenous characteristic, presumably tuffogenic material mixed with greywacke sediments. The base metal content is insignificant. In drill hole 3 one metre was analyzed with the richest mineralization, yielding 0.02% Cu and 0.04% Zn (sample 5028, Appendix 2).

Appendix 4 was placed as near as possible to the Upper Mine in order to sample the ore zone (Dwg. 3). The hole was positioned on the basis of the picture generated by the VLF interpretation (Singsaas 1979). After CP measurements had been taken, the VLF data were re-interpreted (Rønning 1981). The re-interpretation indicates that the Upper Mine has been worked in two different zones. Drill hole 4 probably cut into the northernmost of these, which is the zone that seems to be the least interesting, incidentally, judging from earlier operations. The rock is a fine-grained, solid greenstone with plenty of 1-3 mm thick veins with epidote (pistacite), some calcareous spar (calcite) and odd grains of pyrite (Dwg. 5). The bottom part of the drill hole (stratigraphically highest according to regional up/down criteria, Stensrud 1976) has a deal of pyrite impregnation. Two solid pyrite zones, with a thickness of just 5 cm here, consist of 0.5-5.0 mm sized iron pyrite crystals in a matrix of copper pyrite, magnetic pyrite and some zinc blende. The distance between the zones is 125 cm and the rock is a clotitic green slate also found under the pyrite zones. Characteristic of the section between the massive pyrite

zones and the two metres most proximal below is an irregular network of veins and mobilized aggregates of magnetic and copper pyrites, something not found in the other drill holes. The average grade above 4 m is 0.23% Cu and 0.08% Zn (samples 5029-5032, Appendix 2).

Deposit size and grades

According to Tiedemann (1929) the ore thickness towards depth averages 2 m for the Upper Mine and 5 m for the Lower and West mines, with impregnation sections of up to 6-8 m. Based on observations above ground and from the accessible parts of the mine installations, the ore thickness varies, according to Stensrud (1976), from 2-3 dm (solid ore) to 1.5 m (solid ore and impregnation). The CP anomaly picture indicates that ore zones in the Lower/West mines are a plate 450 m wide and 600 m long along the dip (60°). For the Upper Mine the corresponding figures are 380 m and 600 m. With an estimated average thickness of 1 m (2-4% Cu + Zn), this is equal to a total deposit size of some 1.5 million tonnes, including the volume of ore extracted. On the basis of the superficial indications this is an optimistic estimate. Nevertheless, there is no ignoring the possibility of the deposit getting richer towards depth, as Tiedemann (1939) has claimed. Diamond drilling will be needed to clarify this question.

Conclusion

The size of the occurrence, estimated at 1.5 million tonnes for the Lower/West and Upper mines, is too small to be able to offer any basis for economic exploitation. The possibility of the deposit having 2-4% Cu + Zn and being considerably larger than the 1.5 million tonnes calculated is small. In order to obtain additional information about deposit size and grades, diamond drilling will have to be done. In all likelihood, however, the calculated tonnage represents a maximum estimate, and additional surveys are not recommended.

The other pyrite zones in the area seem to be of no economic interest.

4.2. Vågedalen

Introduction

On the west side of Vågedalen, 7 km east of Grimeli and in the same greenstone/pillow lava series, along a zone with alternating greenstone and green slate, four small galleries have been worked in an approx. 0.5 m thick pyrite zone. Mining was probably done in connection with the last of the operating periods at Grimeli (1914-19).

Geological description

The rocks in the area are greenstones with odd, distinctive schistose, calcareous green slate layers (calcareous tuffites), pillow lavas with tendencies to meta-hyaloclastic breccias, and some elements of gabbro. As usual the greenstones are fine-grained, having grain sizes (amphiboles) of 3-4 mm in some sections. These greenstone variants are difficult to tell apart from fine-grained saussuritized gabbros, and hence the generic term "granular greenstone" has been used (Dwg. 2 and 4). The rocks are consistently more slaty than at Grimeli.

The description of the Vågedalen deposit is based on material from the galleries and one drill hole, BH-1, which intersects the ore zone somewhat further west than the galleries (Dwg. 4 and 5, Appendix 2).

The ore resembles the Grimeli deposit, but has certain distinctive features, consisting of 1-5 mm thick strips of iron pyrite with odd massive pyrite zones up to 0.5 m thick spread over an approx. 10 m thick zone in greenstone and tuffite. The massive pyrite zones consist of

idiomorphic iron pyrite grains 0.1-3 mm in size in a matrix of carbonate and zinc blende. There is also some copper pyrite together with zinc blende. The high zinc content and carbonate content distinguish Vågedalen from the Grimeli deposit.

Geophysics

During the VLF measurements in 1978 (Singsaas 1979) an approx. 1 km long, intensely conductive main zone was detected, coinciding with the ore zone to which the mines are linked, and a number of smaller, mildly conductive zones (Dwg. 4).

The CP measurements in 1980 (Rønning 1981) have shown that the conductive zone at the mines extends down to an estimated depth of 500 m with lengthways extension of approx. 900 m.

Deposit size and grades

In the richest section of the drill hole across an analyzed sampling length of 1 m, 1.00% Cu and 2.10% Zn (sample 5027, Appendix 3) were detected, and above 7 m in thickness the grades are 0.26% Cu and 0.46% Zn (calculated from 6 m analyzed core, samples 5022-5027). Based on observations at the mine installation the thicknesses of solid ore do not appear to exceed 0.5 m. In addition, a number of smaller 1 mm to 2-3 cm thick pyrite strips and veins and an irregular impregnation occur. The overall ore thickness at the mine installation is estimated to be a maximum of 1 m with 2-4% Cu + Zn on average (the grade estimate is very uncertain). Judging from the CP measurements, the ore zone extends down to a depth of 500 m. Extending 900 m lengthways, this gives a total ore volume of approx. 0.7 million tonnes, putting the thickness across the entire zone at an average of 0.5 m. Based on the superficial indications, this is an optimistic estimate.

Conclusion

The deposit is unlikely to be substantially bigger than the calculated 0.7 million tonnes with 2-4% Cu + Zn on average, and additional surveys are not recommended.

4.3. Svanøy

Svanøy pyrite deposits, which consist of two nearby deposits, were in operation in the 1860s and 1880s, and during the periods 1905-07 and 1911-20. In total some 36,000 tonnes ore were produced, averaging 43% S and 1.75% Cu (Jensen 1965).

The deposits are at the top of the Moldvær formation (Dwg. 1) in an area with greenstones, tuff-like chlorite schists and gabbros.

The pyrite mineralizations occur as cm-thick layers in the green slate/greenstone rocks, banded alternation between solid iron pyrites and impregnation being a characteristic feature. Deformation of the ore and mobilizations of magnetic pyrite/copper pyrite and zinc blende, which are common at Grimeli, are less pronounced, judging from the waste rock dump material.

The deposits were described by Jensen (1965), who on the basis of geological observations and electromagnetic measurements (slingram ground measurements) concludes by saying the deposits are too small to be of economic interest. According to Jensen, however, odd EM anomalies have not been satisfactorily explained.

4.4. Other mineralizations

In the area between Grimeli and Vågedalen and east of Vågedalen, a number of insignificant pyrite/rust zones have been observed in more or less schistose greenstone rocks. These zones appear to consist of weak iron pyrite and magnetic pyrite impregnations.

The most obvious of the rust formations observed, which are marked out on drawing 2, are:

East of Vågedalen

1. 1-3 dm thick rust zone in schistose greenstone, discontinuously traceable for approx. 100 m.
2. 0.5 m thick rust zone in greenstone with signs of pillow structures and meta-hyaloclastic breccia. Some smallish rust spots 1 cm - 1 dm in size occur over a total thickness of 3-4 m. The zone is discontinuously traceable for approx. 150 m.
3. Odd, scattered, insignificant rust spots dm in size.
4. 2-3 dm thick rust zone in schistose greenstone. The zone can be traced less than 50 m.
5. 0.5 m thick rust zone in schistose greenstone. The zone can be traced less than 50 m.

West of Vågedalen

6. Some rust in loose boulders of schistose greenstone.
7. Up to 2 dm thick, disconnected rust formations in schistose greenstone.

East for Grimeli

8. Some rust in loose boulders of granular greenstone.
9. Several, up to 2 dm thick, discontinuous rust zones in an area of alternating occurrence of the customary greenstone and granular greenstone.
10. Irregular, slight rust formations in granular greenstone.

In the road-cuts in the Vågane-Flokenes-Merkesvik district, odd insignificant iron pyrite/magnetic pyrite impregnations have been observed in greenstone (partly schistose). Just by the lake at Merkesvik (UTM -998207) is a small, water-filled mine. The mineralization consists of 1-5 mm thick crack-fillings of magnetic pyrite and copper pyrite as well as an even, weak impregnation of iron pyrite and magnetic pyrite, linked to relatively flat-lying, gently folding greywacke sediments. By means of intensified gradual transitions, the greywackes indicate greenish slates (tuffs). The deposit is insignificant.

In the border area between the Stavenes group and the Lower Herland group, at Ramnefjell just north of Kviteneset in Stongfjord, there are hefty mineralizations of magnetic pyrite and iron pyrite in part. According to Skjerlie (1970) the mineralizations can be traced over a length of 300 m and are between 5 and 10 m thick. The deposit, which is practically devoid of copper and zinc, is of no economic interest.

5. ORE GENESIS

The regional geological conditions in the Stavfjord area, which have been comprehensively recorded by Skjerlie (1974) and placed in a plate tectonic context by Furnes et al. (1976), form the principal framework for the formative environment of the pyrite deposits.

It is generally accepted that pyrite deposits similar to Grimeli, Vågedalen and Svanøy occurring in volcanogenic environments are formed as a result of precipitation from ferriferous

and metalliferous solutions discharged onto the ocean floor. The pyrite zones' irregular occurrence at different levels indicates that, during periods of greenstone volcanism, in several places and at a number of times, solutions have flowed out into the seawater, with the resultant and rapid precipitation of sulphide minerals. It is possible that the network of magnetic-copper-pyrite veins found in Bh-4 represents a stringer zone for the ore solutions that formed the pyrite ore in the Upper Mine.

Whereas the Grimeli and Vågedalen deposits are linked to the Grimeli formation's ocean floor-type greenstones and pillow lavas—Vågedalen, with a certain content of calcareous tuffs—the Svanøy deposit is linked to the consistently more tuff-like rocks of the Moldvær formation representing a later development. It is interesting here to notice that at the same time as Vågedalen is clearly zinc dominated as compared to Grimeli, what we have is also a characteristic element of carbonate, both in the rocks and as a matrix in the solid ore. This indicates different conditions at the time of deposition and possibly also dissimilarities in the metal content of the ore solution.

6. EVALUATION AND CONCLUSION

The geophysical surveys (VLF and CP), Pack Sack diamond drillings and geological surface indications indicate that the Grimeli and Vågedalen deposits may total 1.5 and 0.7 million tonnes ore, respectively, at maximum. The average grades may be of the order of 2-4% Cu + Zn.

Great uncertainty is associated with these estimates. The tonnage estimate in particular is too great rather than too small, if anything. Additional information about deposit size and grades will require diamond drilling.

Taking the available material as a starting point, both the Grimeli and the Vågedalen deposits appear too small to be exploitable and additional surveys are not recommended.

The Svanøy deposit has previously (Jensen 1965) been assessed as uneconomic on the basis of geophysical and geological observations.

The same conclusion can be adduced for all the other known pyrite mineralizations in the Stavfjord area.

[Signed]	[Signed]
Are Korneliussen	Morten Often
Government Geologist	Government Geologist

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GOVERNMENT'S MINING RIGHTS

NGU assignment: 1650/53A
Appendices: 1
Page: 1

Application date **Licence applied for** **Licence issued** **Claim no.**	**Qty.**	**Claim: ID no.** **location**	**Sample face**	**Notes**
01.06.76	4	74/1976-TB Grimeli B 1 250,000 75/1976-TB Grimeli B 2 250,000 76/1976-TB Grimeli B 3 250,000 77/1976-TB Grimeli B 4 250,000	Py, Cu Py, Cu Py, Cu Py, Cu	
  <u>03.07.14</u> 03.07.14	 10	<u>Svanø mines</u> <u>GM-113-1914-TB</u> Eikeskogen Mine SW <u>GM-114-1914-TB</u> Eikeskogen Mine NE <u>GM-115-1914-TB</u> Rundhaugen Mine SE <u>GM-116-1914-TB</u> Rundhaugen Mine NW <u>GM-117-1914-TB</u> Kvalstadmyren no. 41 <u>GM-118-1914-TB</u> Kvalstadmyren no. 43 <u>GM-119-1914-TB</u> Sandkvien no. 32 <u>GM-12 0-1914-TB</u> Moralaupet <u>GM-121-1914-TB</u> Kirkeledet no. 11 <u>GM-122-1914-TB</u> Svanø båtnøst no. 60	 Py Py Py Py Py Py Py Py Py Py	

APPENDIX 2

Drill core description and analysis results, Grimeli and Vågedalen

The drill core description was prepared by M. Often and A. Korneliussen. The analyses were performed by NGU (atom absorption, assignment 150/79).

Abbreviations:

gø	greenstone
gøsk	green slate
fink	fine-grained
sk	schistose, schistosity
pa	parallel
irreg.	irregular
ksp	calcite
kv	quartz
imp	impregnation
mk	solid pyrite
kst	pyrite strips
py	iron pyrite
po	magnetic pyrite
cp	copper pyrite
sl	zinc blende

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Vågedalen

DRILL HOLE NO. 1		CLAIM: 983181	
Incline	70 degrees	X	890 W
Direction	N185 deg.	Y	510 N
Length	13.5 m	Date: 4.3.81 Sign. M.O., A.K.	

Depth	No. m	Core loss	Description of rock type		Sample no.	Analysis results					
			Desig-nation	Characteristics		% Cu	% Zn	ppm Pb	ppm Na	ppm Co	ppm Ag
-.5	. 5		gø	fine-grained mildly schistose, diffused 1-5 mm thick kst. on sk.	5021	.09	1.04	15	100	40	10
-2.2	1.7		“	like 0.0-0.5							
-2.4	.2		gøsk.	intensely sk., chlorite rich							
-2.7	.3		gø.	dense with 1-3 mm thick kst.							
-3.0	.3		“	mildly sk.							
-3.1	.1			“ “	5022	.35	.27	15	80	45	2
-3.2	.1		mk	sucrosic py., some ksp.							
-3.8	.6		gø	diffuse 1-3 mm kst. (py)							
-4.0	.2		“	diffuse kst. and irreg. imp. of po, py, cp, odd 1 cm size cp. mobilizates, py, cp, odd 1 cm size cp. mobilizates, odd pyrite veins cutting across sk.							
-4.2	.2		“	like 3.8-4.0							
-4.7	.5		gøsk.	sk., some ksp., possibly ksp. with pyroclastic material mixed in	.023	.15	.03	10	80	35	1
-5.0	.3		gø.								
-5.1	.1		“								
	.6	-5.7									
-6.0	.3		“	dark, solid							
-6.2	.2		“	“ “							

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Vågedalen

DRILL HOLE NO. 1		CLAIM: 983181	
Incline	70 degrees	X	890 W
Direction	N185 deg.	Y	510 N
Length	13.5 m	Date: 4.3.81 Sign. M.O., A.K.	

Depth	**No. m**	**Core loss**	**Description of rock type**		**Sample no.**	**Analysis results**					
			Desig-nation	**Characteristics**		**% Cu**	**% Zn**	**% Pb**	**% Na**	**% Co**	**% Ag**
6.2-6.7	.5		gø.	mildly sk.	5024	.03	.16	15	95	40	0
-6.8			“	sk., dense with 1-5 mm kst. (py)							
-7.0	.2		“	in places, mildly sk., odd kst.							
-7.9	.9		“	“ “ “ “ “	\ 5025	.01	.08	20	110	40	0
	.1	-8.0									
	.3	-8.3			5026	.04	.10	25	120	50	1
-8.9	.7	-9.0	gøsk.	some ksp., odd 1-10 mm kst.							
-9.2	.2		“	“ “ “ “ “							
-9.35	.15	9.2-9.3	mk.	sucrosic py. sl, cp, some ksp.							
-9.6	.25		gø.	dense with kst., some ksp.	5027	1.00	2.10	240	55	345	3
-9.65	.05		mk.	some ksp.				•			
-10.0	.35		gø.	mildly sk., odd kst.							
-12.3	2.3		“	mildly sk.							
-12.7	.4		“	mildly sk., odd 1-5 mm kst.							
-13.5	.8		“	mildly sk., some ksp.							

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Grimeli

DRILL HOLE NO. 2		CLAIM: 926184	
Incline	68 degrees	X	3300 E
Direction	N200 deg. E	Y	1900 N
Length	18.10 m	Date: 4.3.81 Sign. M.O., A.K.	

Depth	**No. m**	**Core loss**	**Description of rock type**		**Sample no.**	**Analysis results**					
			Desig-nation	**Characteristics**							
.0-18.1	18.1		gø.	sk., rust on cracks, odd 1-2 cm quartz veins, odd 1 mm kst. (py, Po).							
2.2-2.4			core loss								
3.6-3.9			“								
4.8-5.0			“								
8.1-8.3			“								
12.8-12.9			“								
17.2-17.3			“								

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Grimeli

DRILL HOLE NO. 3		CLAIM: 914184	
Incline	75 degrees	X	2100 E
Direction	N190 deg. E	Y	1870 N
Length	14.20 m	Date: 4.3.81 Sign. M.O., A.K.	

Depth	**No. m**	**Core loss**	**Description of rock type**		**Sample no.**	**Analysis results**					
			Desig-nation	**Characteristics**							
.0-1.6			gøsk.	chlorite-rich, partly very light, probably tuff with elements of greywacke sediments							
-3.3			‘‘	banded on mm-cm-dm scale with greenish (tuff) and light (greywacke) strata. Odd 1-3 mm thick pyrite veins, both longitudinally and transversally to sk.							
-6.6			‘‘	diffuse 1-3 mm thick kst. (pa. sk.) and intersecting veins (po), diffuse kv. veins							
-6.7			‘‘	dense network of 1-3 mm thick kst. (po).							
-11.0			‘‘	gradual transitions between gøsk. (tuff) with lighter bands (greywacke) and a more solid variant of rock (greenstone). Moreover, diffuse 1-3 mm thick kst. and irregular veins occur along the entire length							

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Grimeli

DRILL HOLE NO. 3		CLAIM: 914184
Incline	75 degrees	X 2100 E
Direction	N190 deg. E	Y 1870 N
Length	14.3 m	Date: 4.3.81 Sign. M.O., A.K.

Depth	**No. m**	**Core loss**	**Description of rock type**		**Sample no.**	**Analysis results**					
			Desig-nation	**Characteristics**		**% Cu**	**% Zn**	**ppm Pb**	**ppm Na**	**ppm Co**	**ppm Ag**
11.0-12.0	1.0		gøsk.	as for 0.0-12.0	5028	.02	.04	15	45	45	0
-14.3	2.3										

GEOLOGICAL SURVEY OF NORWAY

GEOLOGICAL DRILLING REPORT CHART

ASSIGNMENT : 1650/53A PLACE: Grimeli

DRILL HOLE NO. 4		CLAIM: 912185
Incline	70 degrees	X 1930 E
Direction	N172 deg.	Y 2010 N
Length	7.5 m	Date: 4.3.81 Sign. M.O., A.K.

Depth	No. m	Core loss	Description of rock type		Sample no.	Analysis results					
			Desig-nation	Characteristics		% Cu	% Zn	ppm Pb	ppm Na	ppm Co	ppm Ag
.00-2.00	2.00		gø.	f., dark							
-2.30	.30		“	“ “							
-2.50	.20		“	odd 1-3 mm kst.							
-2.55	.05		mk.	PV	5029	.26	.10	20	55	290	1
-2.80	.25		gø.	dense with irreg. kst. and imp. (po, cp)							
-3.06	.20		“								
-3.35	.35		gøsk.	chlorite-rich, diffuse pyrite grains							
-3.45	.10	_ —.	“	dense with 1-10 mm pyrite veins	5030	.28	.07	30	55	390	2
-3.75	.30		“	chlorite-rich							
-3.80	.05		mk.	py, po, cp							
-4.00	.25		gø-								
-5.00	1.00		gøsk.	diffuse 1-10 mm kst. and irreg. mobilizations of py, po and cp.	5031	.10	.03	15	50	70	1
-5.20	.20		“	as for 4.00-5.00							
-5.70	.50		“	network of 1-4 mm pyrite veins (po, cp)							
-5.80	.10		“		5032	.28	.13	20	60	160	1
-5.90	.10		it	pyrite impreg.							
-6.00	.10		gø.								
-7,50	1,50		“	diffuse pyrite impreg.							

Appendix 3

Analysis results for samples from mine waste dumps at Grimeli, Vågedalen and Svanøy.

The samples were collected by A. Korneliussen (1980).

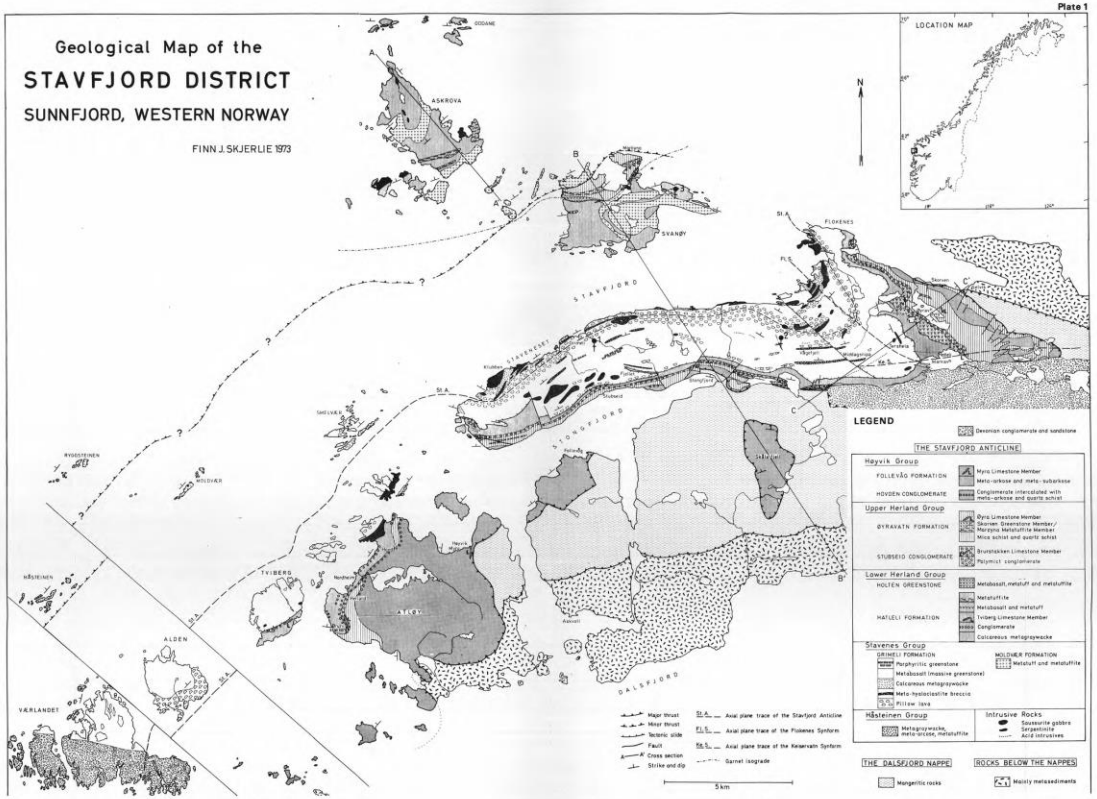
The analyses were performed with atom absorption (Cu, Zn, Pb, Ni, Co and Ag) and chemical (S) at NGU (assignment 144/80), and chemically (Au) at Lakefield Research of Canada Limited.

Sample no.	Analysis no.	Locality	% Cu	% Zn	ppm Pb	ppm Ni	ppm Co	ppm Ag	% S	ppm Au
11/80	5101	Grimeli	.05	.07	60	40	1,800	3	33.1	
13/80	5102	“	.35	.05	25	55	650	5	14.0	
15/80	5103	“	.26	.05	20	60	870	7	21.7	0.024
19/80	5104	“	.66	.21	25	145	975	11	33.0	
18/80	5105	“	.53	.07	25	73	1,600	9	27.4	
20/80	5106	“	.15	.24	25	76	1,850	5	32.3	
30/80	5107	Vågedal	.31	.40	400	70	410	21	38.0	.12
32/80	5108	“	.28	1.70	100	110	485	15	24.5	
250/80	5109	Svanøy	.02	.04	35	39	230	3	21.9	
252/80	5110	“	.01	1.10	90	30	35	<2	16.9	
253/80	5111	“	.01	.90	50	35	40	<2	27.2	
260/80	5112	“	.10	1.00	65	40	80	10	43.0	.074
261/80	5113	“	.15	3.70	1,000	45	155	13	47.0	
262/80	5114	“	.16	1.20	285	40	400	13	42.0	

Plate 1

Geological Map of the STAVFJORD DISTRICT SUNNFJORD, WESTERN NORWAY

FINN J. SKJERLIE 1973



ETTER SKJERLIE (1974)

FOREKOMSTENE GRIMELI, VÅGEDALEN OG SVANØY ER INNTEGNET (HENHOLDSVIS 1, 2 OG 3).

USB 1981 GEOLOGISK OVERSIKTSKART STAVFJORDSOMRÅDET ASKVOLL, SOGN OG FJORDANE	1:250000	TRAC. TPS.	MAI 1981
	1650/53A-01		

[Map already in --+-++-+*:]

Geological Map of the
STAVFJORD DISTRICT
SUNNFJORD, WESTERN NORWAY

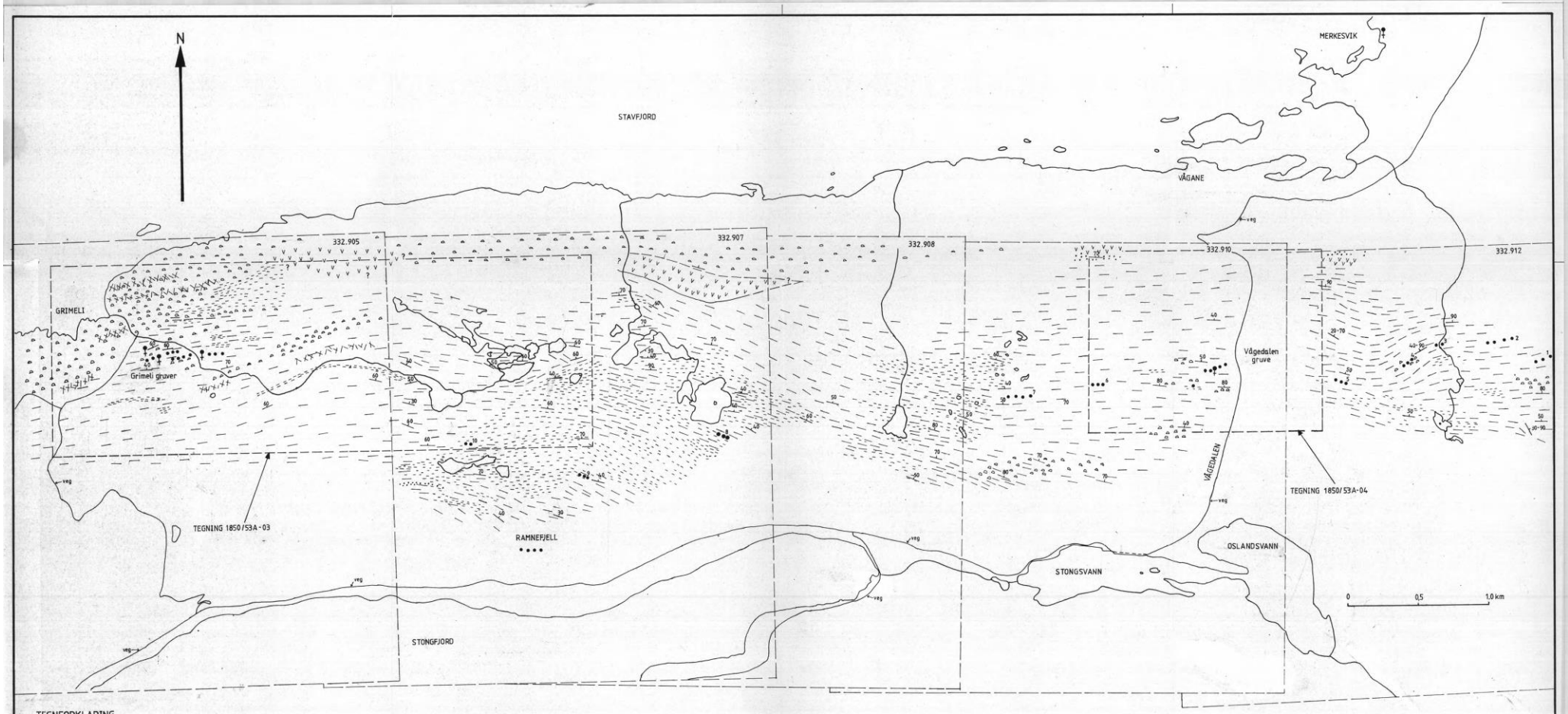
FINN J. SKJERLIE, 1973

[Legend:]

BASED ON SKJERLIE (1974)

THE GRIMELI, VÅGEDALEN AND SVANØY
DEPOSITS HAVE BEEN DRAWN IN
(♀1, ♀2 AND ♀2, RESPECTIVELY)

USB 1981 GEOLOGICAL KEY MAP STAVFJORD AREA ASKVOLL, SOGN AND FJORDANE	SCALE: 1:250,000	TRAC. T.P.S.	MAY 1981
	1650/53A-01		



TEGNFORKLARING

- GRÖNNSTEIN, TILDELS SKIFRIG
- KORNIG GRÖNNSTEIN, STEDVIS MED GRADVISE OVERERGANGER MOT FINKORNIG GABBRO, TILDELS SKIFRIG
- PUTELAVA
- META - HYALOKLASTISK BREKSJE
- GABBRO
- GRÅVAKKE
- SULFIDMINERALISERING 3: REFEFERANSENR. (KAP. 4.4.)
- NEDLAGT GRUVE
- STRÖK / FALL (60°)

Kartleggingen er utført på flybilder i målestokk 1:15000 (Norfly serie 332, inntegnet på kartet), og er forefatt med utgangspunkt i Skjerlies geologiske oversiktskart (1974, 1:100 000) og Stensruds geologiske kart over Grimeliområdet (1976, 1:5000).

USB 1981 GEOLOGISK KART GRIMELI - VÅGEDALEN ASKVOLL, SOGN OG FJORDANE	MÅLESTOKK 1:15000	MÅLT A.K., L.F. JULI - 80 TEGN. A.K. FEBR. - 81 TRAC. T.P.S. MAI - 81 KFR.	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 1650/53A-02	KARTBLAD (AMS) 1117 I, IV	

[Map, legend:]

GRIMELI

Grimeli mines

DRAWING 1650/53A-03

Vågedalen Mine

VÅGEDALEN

DRAWING 1850/53A-04

LEGEND

__ GREENSTONE, PARTLY SCHISTOSE

__ GRANULAR GREENSTONE WITH GRADUAL TRANSITIONS IN PLACES TO FINE-GRAINED GABBRO, PARTLY SCHISTOSE

__ PILLOW LAVA

__ META-HYALOCLASTIC BRECCIA

__ GABBRO

__ GREYWACKE

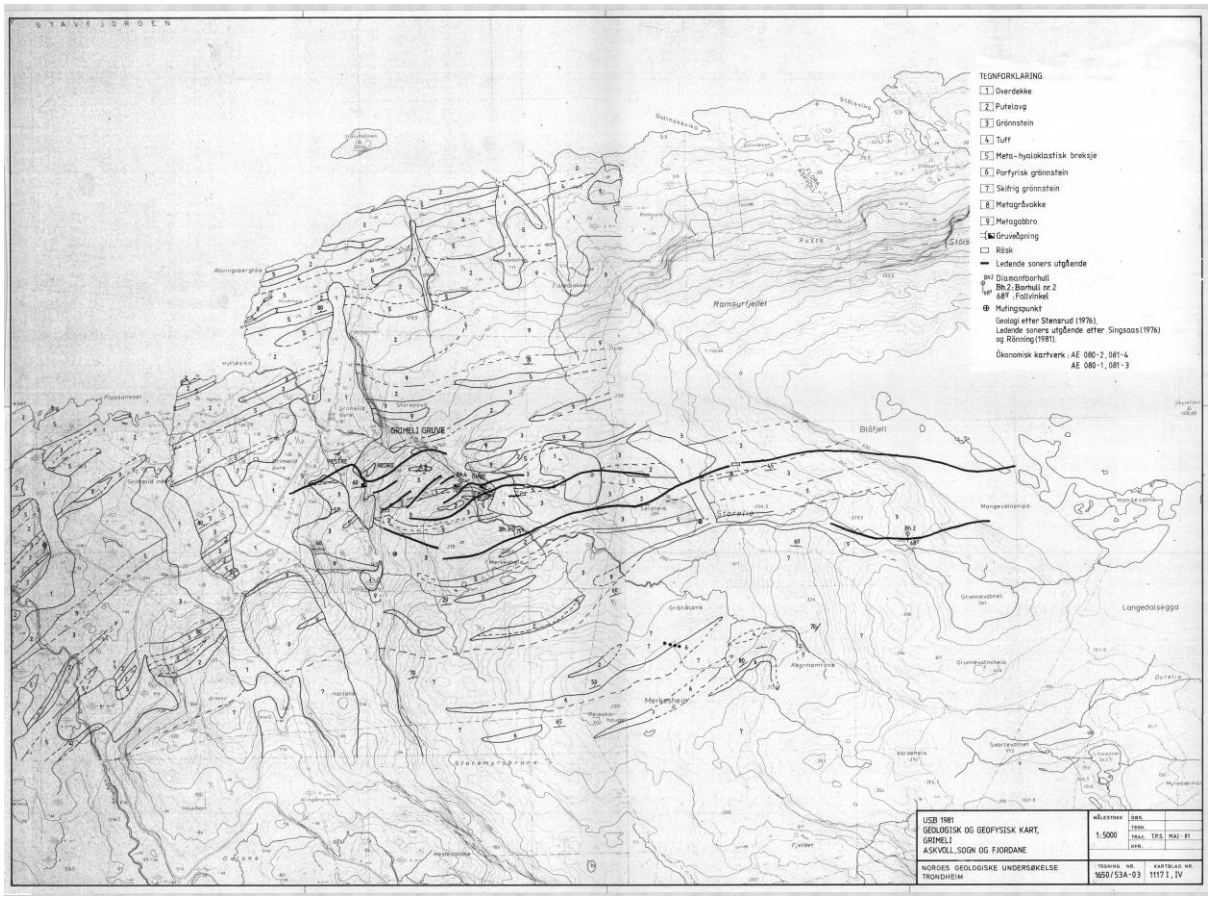
__ SULPHIDE MINERALIZATION
3-REFERENCE NO. (CH. 4.4)

__ DECOMMISSIONED MINE

__ STRIKE/DIP (60 deg.)

Mapping was done from aerial pictures on a scale of 1:15,000 (Norfly series 332) plotted on the map) and was carried out on the basis of Skjerlie's geological key map (1974, 1:100,000) and Stensrud's geological map of the Grimeli area (1976, 1:5,000).

USB, 1981 GEOLOGICAL MAP GRIMELI – VÅGEDALEN ASKVOLL, SOGN AND FJORDANE	SCALE: 1:15,000	SURVEYED A.K., L.F.	JULY '80
		DWG A.K.	FEBR. '81
		TRAC. T.P.S.	MAY '81
		KFR.	
GEOLOGICAL SURVEY OF NORWAY TRONDHEIM	DRAWING NO. 1650/53A – 02	MAP SHEET (AMS) 1117 I, IV	


STAVFJORDEN
TEGNFORKLARING
1 Overdekke
2 Putelavg
3 Grønnstein
4 Tuff
5 Meta-hyaloklastisk breksje
6 Porfyrisk grønnstein
7 Skifrig grønnstein
8 Metagråvakke
9 Metagabbro
Gruveåpning
Rösk
Ledende soners utgående
Diamantborhull
Bh.2 : Borhull nr.2
68° : Fallvinkel
Mutingspunkt
Geologi etter Stensrud (1976).
Ledende soners utgående etter Singsaas (1976)
og Rønning (1981).
Økonomisk kartverk : AE 080-2, 081-4
AE 080-1, 081-3
GRIMELI GRUVE
Ramsurfjellet
Blåfjell
Langedalsegga
USB 1981
GEOLOGISK OG GEOFYSISK KART,
GRIMELI
ASKVOLL, SOGN OG FJORDANE
1:5000
MÅLESTOKK
DRG.
TEGN.
TRAC. TPS. MAI - 81
GVR.
NORGES GEOLOGISKE UNDERSØKELSE
TRONDHEIM
TEGNING NR.
1850/53A-03
KARTBLAD NR.
1117 I, IV

[Map, legend:]

Grimeli Upper

GRIMELI MINE

Grimeli Upper

WEST LOWER UPPER

LEGEND

1 Overlay
2 Pillow lava
3 Greenstone
4 Tuff
5 Meta-hyaloclastic breccia
6 Porphyric greenstone
7 Schistose greenstone
8 Meta-greywacke
9 Meta-gabbro
__ Mine opening
__ Sough
__ Conductive zone outcrop

__ Diamond drill hole
Bh2: Drill hole no. 2
68g: Angle of incline

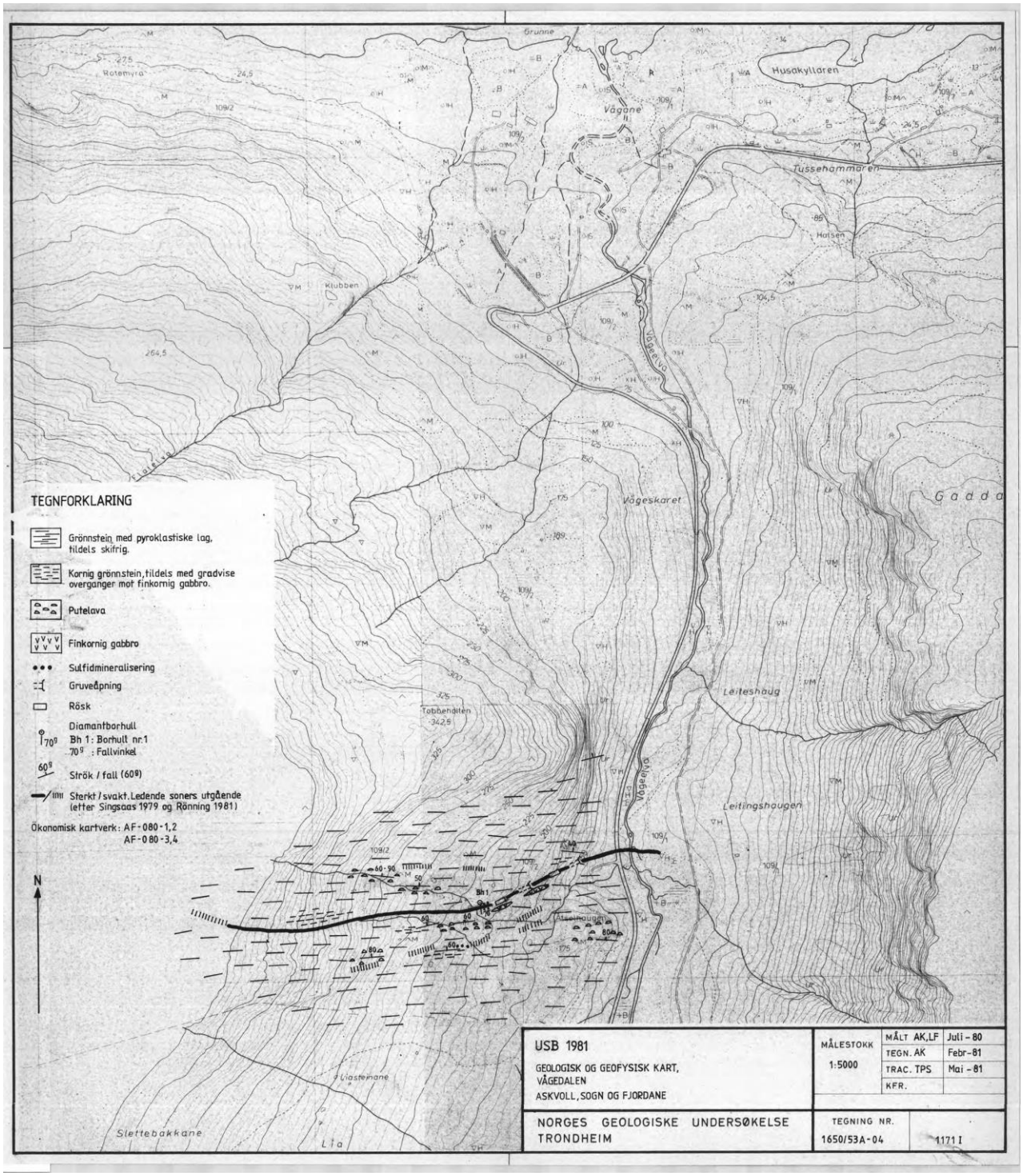
__Claim point

Geology based on Stensrud (1976)

Conductive zone outcrop based on Singsaas (1976) and Rönning (1981)

Economic Map Series AE 080-2, 081-4
AE 080-1, 081-3

USB, 1981 GEOLOGICAL AND GEOPHYSICAL MAP GRIMELI ASKVOLL, SOGN AND FJORDANE	SCALE: 1:5,000	OBS.	
		DWG	
		TRAC. T.P.S.	MAY ‘81
		KFR.	
GEOLOGICAL SURVEY OF NORWAY TRONDHEIM	DRAWING NO. 1650/53A – 03	1117 I, IV	



USB 1981 GEOLOGISK OG GEOFYSISK KART, VÅGEDALEN ASKVOLL, SOGN OG FJORDANE	MÅLESTOKK 1:5000	MÅLT AK,LF	Juli - 80
		TEGN. AK	Febr-81
		TRAC. TPS	Mai - 81
		KFR.	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 1650/53A-04		1171 I

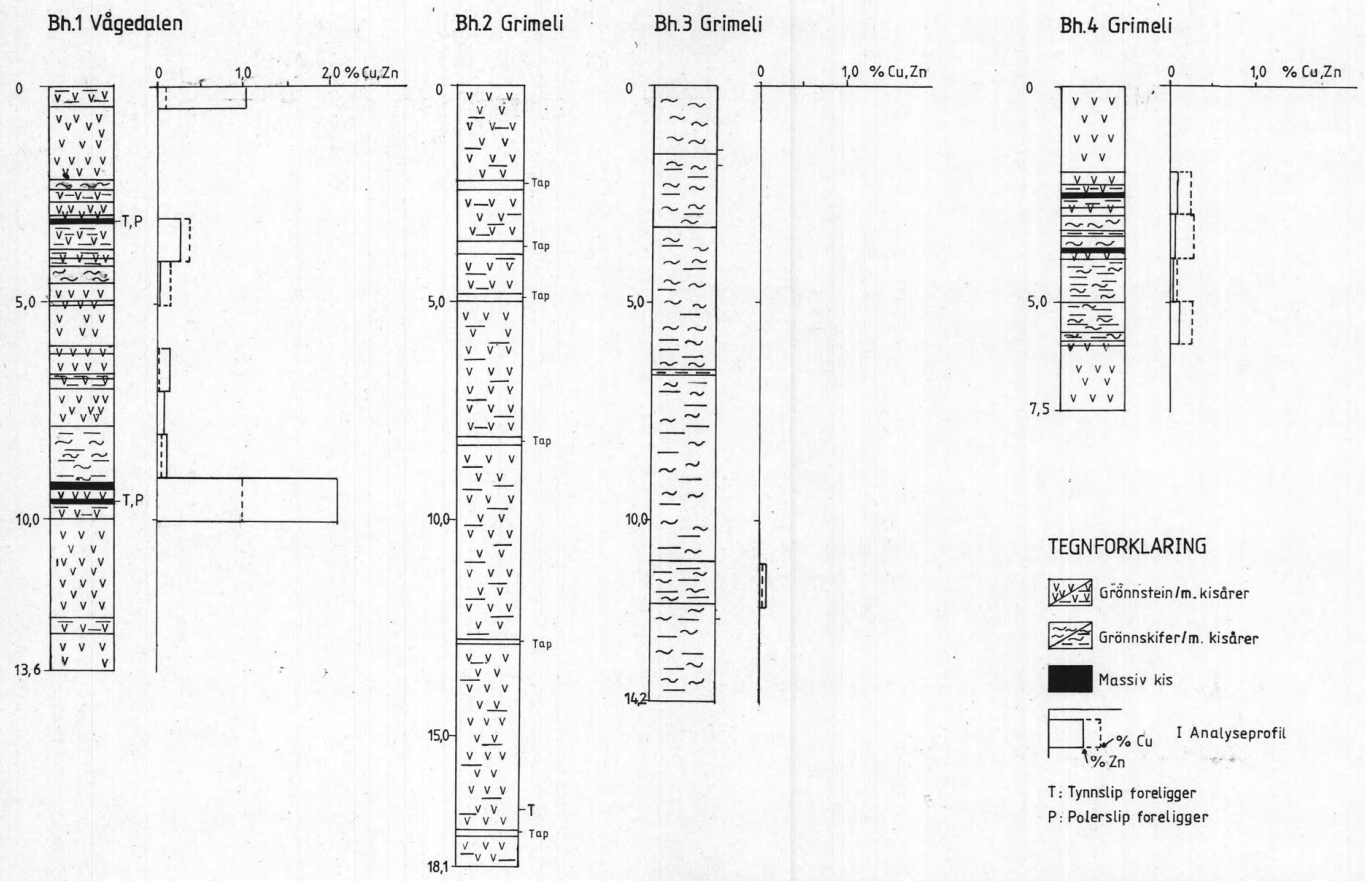
[Map, legend:]

LEGEND

__ Greenstone, with pyroclastic strata, partly schistose
__ Granular greenstone, partly with gradual transitions to fine-grained gabbro
__ Pillow lava
__ Fine-grained gabbro
__Sulphide mineralization
__Mine opening
__ Sough
__ Diamond drill hole
__ Bh1: Drill hole no. 1
__ 70g: Angle of incline
__ Strike/dip (60g/60 deg.)
__ Intensely/mildly conductive zone outcrop
(based on Singsaas, 1979, and Rönning, 1981)

Economic Map Series **AF 080-1, 2**
AF 080-3, 4

USB, 1981 GEOLOGICAL AND GEOPHYSICAL MAP VÅGEDALEN ASKVOLL, SOGN AND FJORDANE	SCALE: 1:5,000	SURVEYED A.K., L.F.	JULY ‘80
		DWG A.K.	FEBR. ’81
		TRAC. T.P.S.	MAY ‘81
		KFR.	
GEOLOGICAL SURVEY OF NORWAY TRONDHEIM	DRAWING NO. 1650/53A – 04	1117 I	



USB 1981 BORHULLSPROFILER GRIMELI OG VÅGEDALEN ASKVOLL, SOGN OG FJORDANE	MÅLESTOKK: 1:10	OBS.	
		TEGN. M.O, A.K	Mars - 81
		TRAC. T.P.S.	Mai - 81
		KFR.	
NORGES GEOLOGISKE UNDERSØKELSE TRONDHEIM	TEGNING NR. 1650/53A-05	KARTBLAD NR. 1117 I, IV	

[Diagram:]

Bh. = Drill hole

Bh.1 Vågedalen Bh.2 Grimeli Bh.3 Grimeli Bh.4 Grimeli

Tap = Loss

LEGEND

__ Greenstone with pyrite veins

__ Green slate with pyrite veins

__ Massive pyrites

__ I Analysis profile

T: Thin-ground section available
P: Polished section available

USB, 1981 DRILL HOLE PROFILES GRIMELI AND VÅGEDALEN ASKVOLL, SOGN AND FJORDANE	SCALE: 1:10	OBS.	
		DWG M.O., A.K.	MARCH ‘81
		TRAC. T.P.S.	MAY ‘81
		KFR.	
GEOLOGICAL SURVEY OF NORWAY TRONDHEIM	DRAWING NO. 1650/53A – 05	MAP SHEET (AMS) 1117 I, IV	