

SUMMARY REPORT

SPARAGMITE PROJECT (N-82-5)

FOLLDAL VERK A/S - AMOCO NORWAY OIL COMPANY

DECEMBER 1984

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Summary and Conclusions

The sparagmite project entered its drilling phase in 1984. Altogether 2987 m were drilled. Most of the drilling was conducted on grid Brennvola. Several other holes were drilled on grids Langen, Tufsingdal, and Atna. Prospecting was conducted on grids that were established in 1983 and showed anomalous values detected by the geochemical soil surveys. In addition to that stream sediment anomalies that were detected by the regional surveys in 1982 and 1983 were followed up by prospecting. The program was run by Folldal Verk A/S in a joint venture with Amoco Norway Oil Company.

The project area is located between the Folldal project area and the border between Norway and Sweden, covering approx. 1750 sqkm. The project target was sandstone-hosted Pb, Zn, Ag-mineralization which occurs in basal sandstones of Eo-cambrian age. These sandstones, or sparagmites, extend throughout Norway and Sweden along the eastern edge of the Caledonian mountain system. They host several lead deposits in Sweden, including Laisvall and Vassbo. They occur near the contact of the sparagmites with the Precambrian basement.

The diamond drilling in 1984 was based on detailed ground follow-up work that was conducted in 1983. On grids Brennvola and Langen 20 holes were drilled, totalling 2645 m. A sandstone hosted lead mineralization was intersected. The two best sections were 7.20 m with 0.8% Pb and 5ppm Ag and 5.20 m with 1.2% Pb and 5ppm Ag. The two holes lie more than 100 m apart. A paleogeographic map of the granitic basement was designed that indicates a continuation of the mineralization into a protected area. Further diamond drilling is recommended at this property. The drilling on other grids did not result in the discovery of any possible economic mineralization.

On grids Nekkjölen, Littlefjellet, and Tverrlivola prospecting was conducted that was based on geochemical soil anomalies obtained by the follow-up surveys in 1982. No ore mineralization was found.

Several geochemical stream sediment anomalies were investigated that were still left to follow-up from the regional surveys

in 1982 and 1983. This work was conducted on map sheets Stugu-
sjö, Brekken, Tyllidal, and Sollia. Neither these investigations
led to any discovery of economic mineralizations.

1. Introduction

The sparagmite project that was started in 1982 entered its drilling phase in 1984. The work in 1984 was based on detailed grid follow-up work from 1983. Most of the drilling was conducted at the Brennvola property. In a few areas follow-up work was conducted based on the results of the regional stream sediment surveys obtained in 1982 and 1983.

The project target was sandstone-hosted Pb, Zn, Ag - mineralization. Several mineralizations of this type are known in this geological environment in Norway, and several deposits, one currently in production, are known in Sweden.

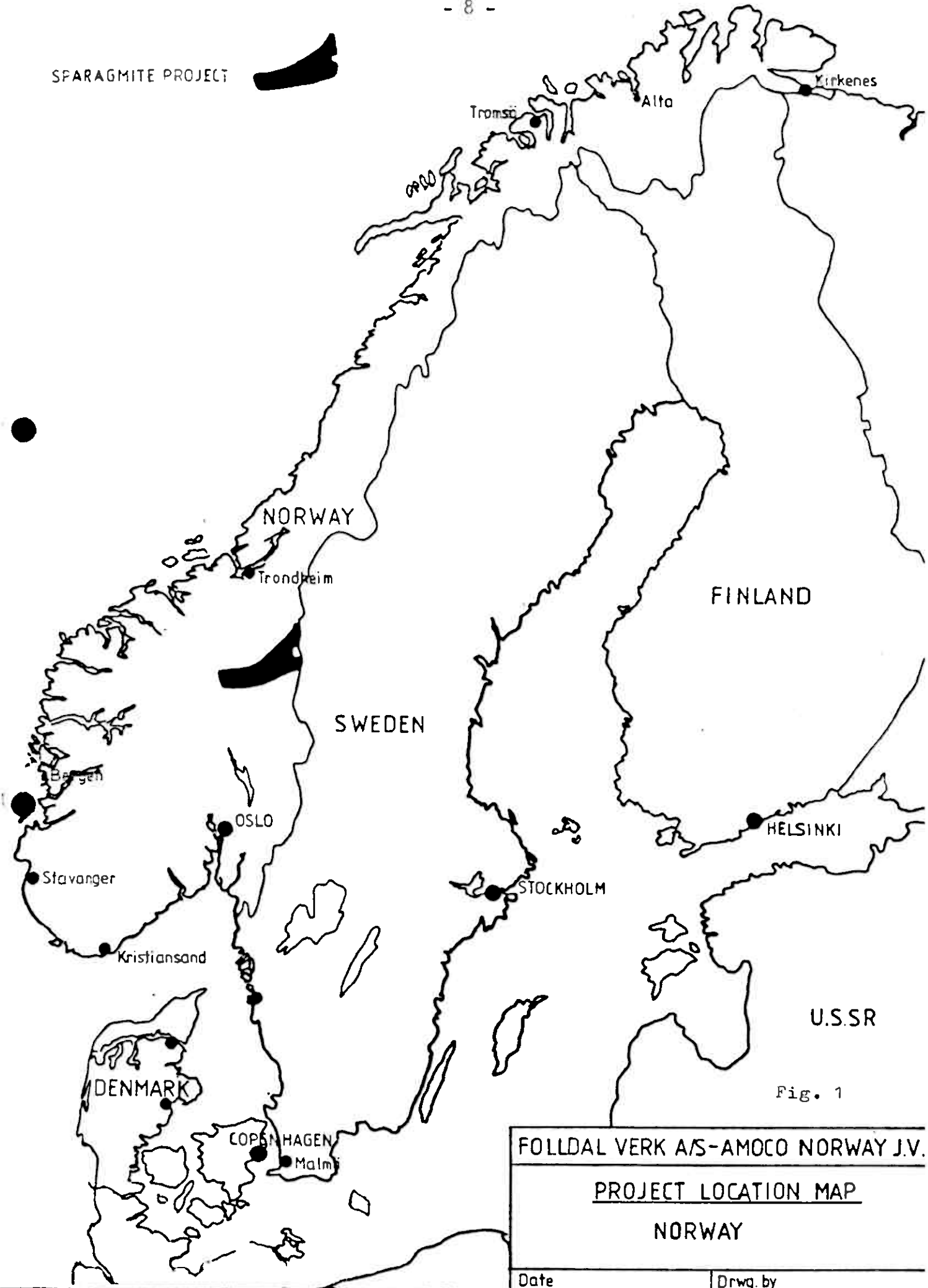
The work conducted in 1984 resulted in the discovery of a sandstone-hosted Pb,(Ag) - mineralization at the Brennvola property that warrants further diamond drilling in 1985. In the Atna area interesting indications for this type of mineralization were found, too.

The staff for 1984 was very limited. I. Killi and his IP-crew conducted the geophysics. Olav Bakke, geologist at Folldal Verk, helped in the project since the beginning of 1984, especially with geological mapping in the Atna and Brennvola areas and the drilling during winter/spring at the Langen and Brennvola properties. A quarternary-geologist from the University of Oslo was hired for a few days and one geology student from Trondheim helped mapping and prospecting during some weeks in the summer. All diamond drilling was done by Terranor A/S, Trondheim.

2. Location and Access

The project area is centered at 62°15' lat. and 11°00' long. It is located between the Folldal project area and the border between Norway and Sweden, approx. 250 km north of Oslo (Fig. 1). The main service supply centers are Tynset in the north of the central part and Røros in the northeastern part. The area is crossed by numerous small, sometimes paved secondary roads. The railway line Oslo-Røros-Trondheim runs along the west and

SPARAGMITE PROJECT



northwest sides of the area. The town of Røros is serviced daily by jet flights from Oslo and Trondheim.

3. Regional Geology

The Eocambrian sandstones and quartzites, or sparagmites, stretch along the eastern border of the Caledonian mountain system through Norway and Sweden (Fig. 2). They represent the initial detrital deposition in the early stages of development of the Caledonian geosyncline. The lead-zinc deposits, of which the Laisvall deposit in Sweden is at present in production occur as stratabound lenses within the sandstones and quartzites, generally close to the contact with the Precambrian basement, and along the flank of Precambrian paleohighs in particular.

The Laisvall deposit is the largest known of this type in Scandinavia. The mineralization mainly consists of galena, sphalerite, pyrite, fluorite, and barite. The deposit contained 80 mm tons of ore with 4.3% Pb, 0.6% Zn and 9 g/t Ag. Another deposit, Vassbo, the production of which was finished in 1982, had initial reserves of 3 mm tons of ore with 5.7% Pb, 0.3% Zn, and 18 g/t Ag.

Hydrocarbons have been noted in association with the sulfides and are one of the factors pointing to the similarity of deposition to oil field brines. It is assumed that the metal bearing solutions were low sulfur oil field brines which moved upslope from the Caledonian geosyncline until they came in contact with sulfur-rich solutions near the edge of the basin and around Precambrian paleohighs.

In another genetic model for sandstone lead deposits it is postulated that lead was released during weathering from the underlying basement either directly or via formation of continental arkoses. Ground water may then have carried the lead into marine sandstones, where a reducing environment caused precipitation of galena.

The project area is situated in the southern part of the Eocambrian sandstone belt and is stretching over a length of

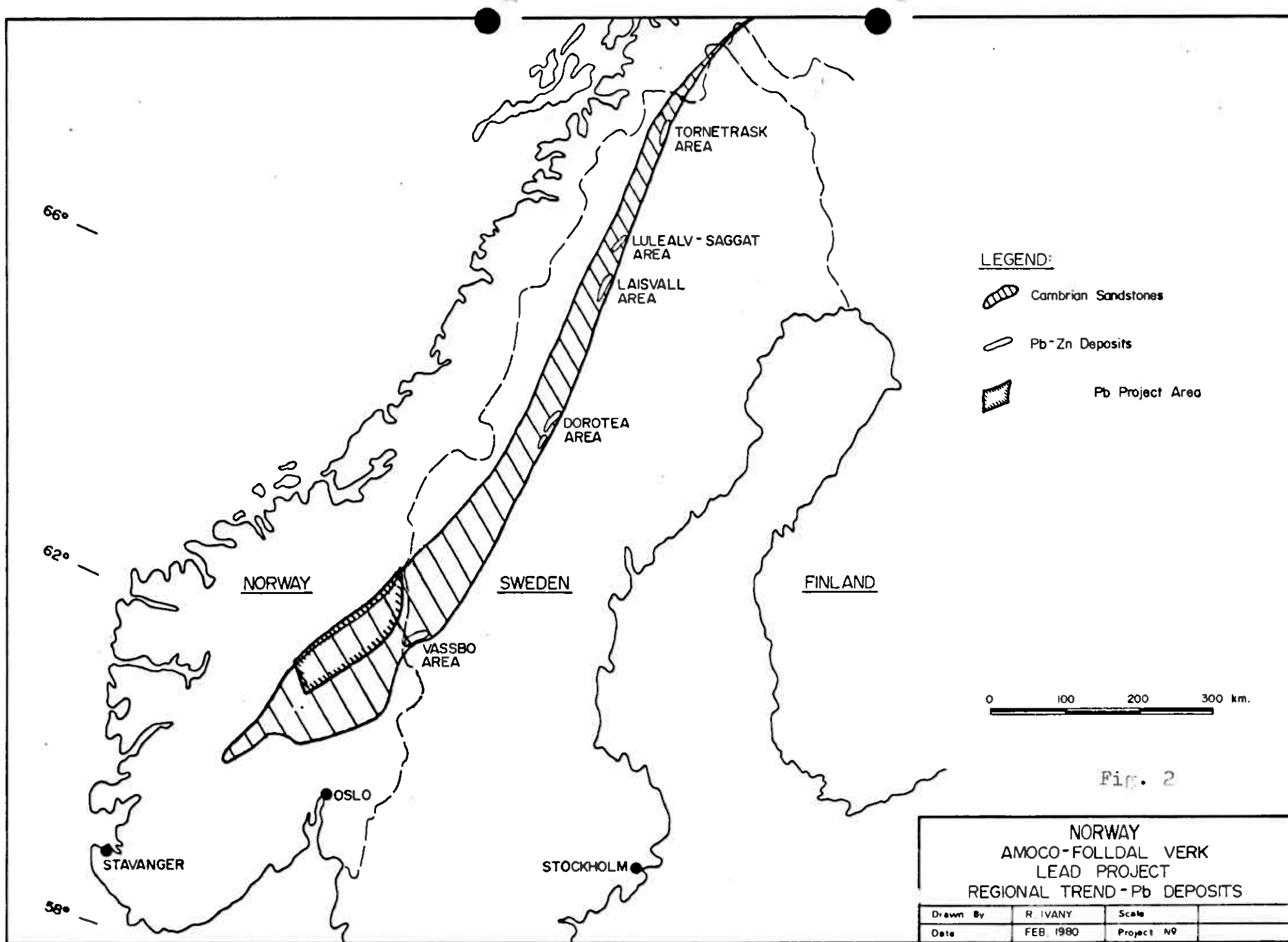


Fig. 2

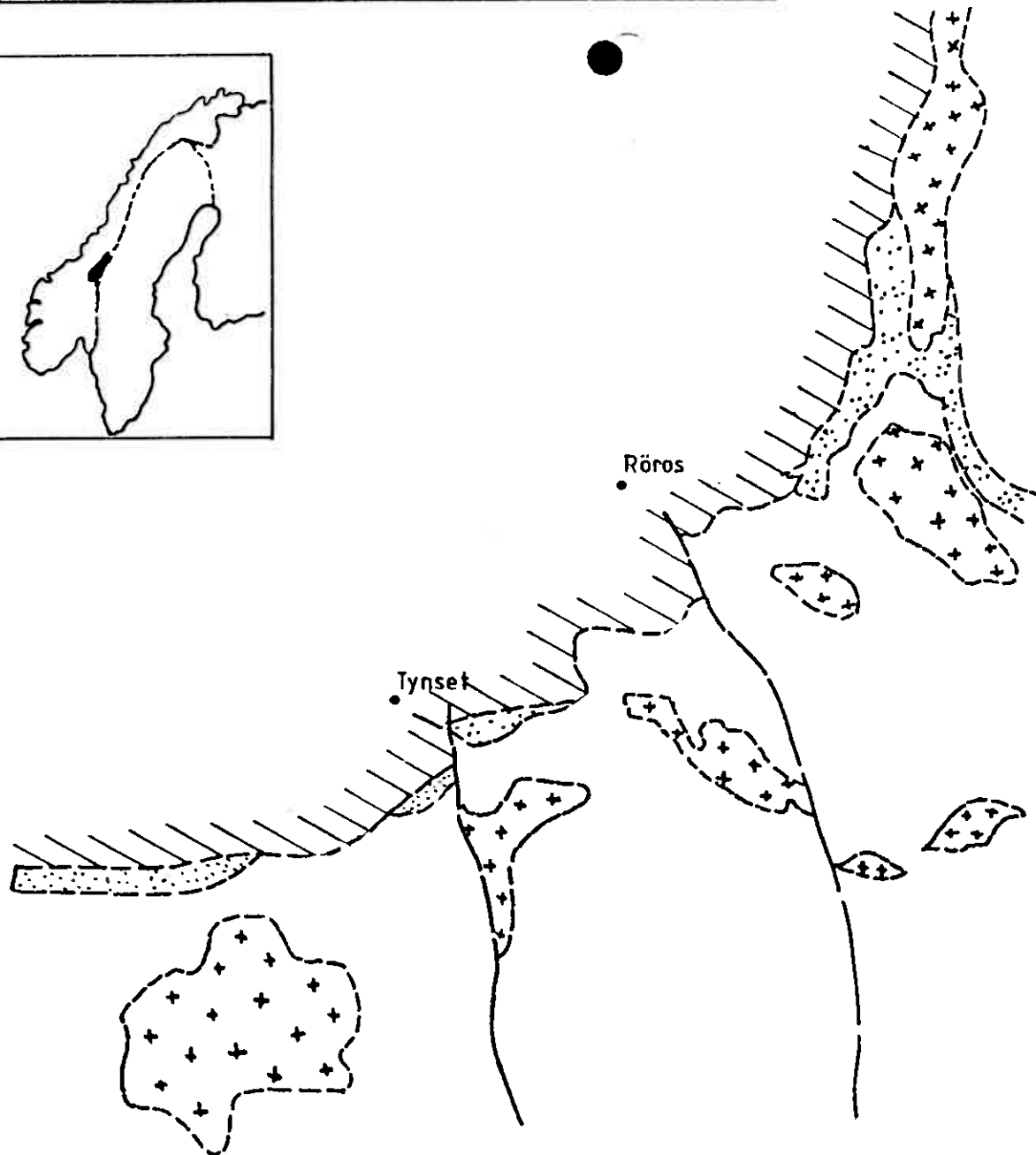
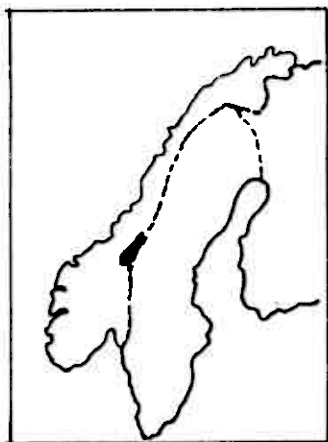
NORWAY
AMOCO-FOLLDAL VERK
LEAD PROJECT
REGIONAL TREND - Pb DEPOSITS

Drawn By	R IVANY	Scale	
Date	FEB 1980	Project NO	

140 km parallel to the edge of the Caledonian mountains. A number of outcropping paleohighs that are formed by granites and porphyritic rocks, are exposed (Fig. 3). From the SW to the NE they are called the "Atna-Window", the "Finstad-Window", and the "Vigelen-Window". In between these windows there are to be found several other outcrops of Precambrian basement. In many places the basement is overlain by a thin layer of conglomerates or tillites which represent the basal part of the sparagmites. The sparagmites are mostly grey meta-arkoses and are often interlayered with schists or black schists, and sometimes with limestones, too. The augengneiss that is believed to be a mylonitized and recrystallized arkose, occurs close to the thrust plane of the "Trondheim-Nappe" that consists mostly of metavolcanics and metasediments. All rocks were subjected to regional metamorphism. A large part of the project area is covered by moraine from the last glaciation period.

Previous known Pb, Zn - mineralizations can be found in two places within the project area. One old small Pb, Zn, Ag - mine is located west of Tufsingdal, about 30 km southeast of the town of Os, in the central part of the project area. The mineralization is associated with black schists and quartzites and consists of pyrite, pyrrhotite, galena, sphalerite, and little chalcopryrite. The ore was mainly mined because of the silver content in the galena. Data about the tonnage are not available. Another Pb, Zn, Ag - mineralization is located at the northeastern shore of the Gruvsjøen-lake, about 10 km northeast of the town of Brekken in the northeastern part of the project area. Here a trench was made that dates back to 1910. The mineralization consists of a silver-rich galena, sphalerite, pyrite, pyrrhotite, and little chalcopryrite. The associated rocks are light grey, quartzitic rocks and black schists. A Cu(Ag)- mineralization can be found at Brydal, southeast of Tynset, where a 70 m long zone within the sparagmites is covered by secondary copper minerals. Bornite, chalcopryrite, pyrite, and little chalcocite can be observed finely disseminated within the sandstones.

Much of the outcrop area of the sparagmites is associated with thrusting and nappe structures, with movement from the north-



LEGEND:

-  PRECAMBRIAN
-  AUGÉN GNEISS
-  QUARTZITES & PHYLLITES
-  CALEDONIAN VOLCANICS & SEDIMENTS

20 Km

Fig. 3

FOLLDAL VERK A/S-AMOCO NORWAY J.V.

SPARAGMITE Pb
Project

Date

Drwg. by

west. Therefore not all of the exposure of those sandstones is in place and the contact with the Precambrian basement is often a thrust contact. If one of the above mentioned ore genesis models is valid, then the best area for exploration would be in autochthonous sediments around paleohighs, that means where the basal conglomerates or tillites are in contact with the granites. Both the Laisvall and the Vassbo deposits are described as occurring close to Precambrian paleohighs. Seen from a more detailed point of view they occur in weak basement depressions.

4. History and Previous Exploration

In the summer and fall of 1982 a regional stream sediment survey was carried out by Folldal Verk/Amoco J.V. Detailed follow-up work was conducted on 22 different grids as a result of this survey in 1983. Very little information is available about previous work in the project area.

One small Pb, Zn, Ag - mine is located west of Tufsingdal, about 30 km southeast of the town of Os, in the central part of the project area. The mining activities date probably back to the beginning of this century. In 1983 the area around this old mine was covered by a grid as a part of this survey with geological mapping, soil sampling, and partly a VLF-survey. This mine was investigated earlier by A/S Sulfidmalm. No information is available from this work.

Another Pb, Zn, Ag - mineralization is located at the northeastern shore of the Gruvsjöen-lake, about 10 km northeast of the town of Brekken, in the northeastern part of the project area. Here a trench was made in about 1910. A few tons of ore were taken out and brought to Falun in Sweden where the ore was processed. Folldal Verk/Amoco J.V. investigated this property as a part of the sparagmite project in 1982/83 by detailed geological mapping, soil geochemistry, and VLF. Altogether 6 diamond drill holes were drilled in this area.

Another little trench can be found at a copper/silver mineralization near Brydal, south of Tynset. This property was also

investigated by Folldal Verk/Amoco J.V. in 1983 by grid follow-up work and four diamond drill holes.

Most of the exploration for lead has apparently been concentrated along the south side of the project area, at the erosional contact of the Eocambrian sparagmites and the underlying Precambrian basement. The Geological Survey of Norway (NGU) has conducted most of the investigations in this area with a regional stream sediment program, follow-up soil sampling, geophysics, and drilling between 1968 and the early 1970's. Several lead prospects were discovered as a result of this work but none of sufficient grade for commercial use.

5. Activities 1984 with Recommendations for Future Work

5.1 Follow-up work and drilling at the Brennvola property

The Brennvola property is located at the northern end of the large lake Femund (grid location map no. 8). Grid Langen is located closeby. The area is relatively difficult to access. A tractor road, in bad condition, is the easiest access on land. The closest road for public traffic is about 5 km away. During the summer 1984 the area was mostly entered by boat. The Brennvola grid is located close to the border of the Femund National Park which is surrounded by a protected area, about 2 km wide.

During the summer 1983 two boulder trains, the boulders containing disseminated galena mineralization, were discovered in the area. This resulted in further investigations as soil sampling, VLF, and geological mapping on grids Langen and Brennvola. This work was followed by an IP survey in late fall 1983 that covered parts of the boulder trains and their cut-off areas. The anomalies obtained by this survey were tested by drilling during spring 1984.

On grid Langen three holes were drilled (total 196.30 m) on line 350 E to test two separate IP-anomalies that were detected close to the boulder train. All holes were drilled down to the Precambrian granitic basement without hitting any galena

mineralization. Within the sedimentary sequence a narrow graphitic horizon was detected in hole 84-LAN-2, which might have caused the anomaly. In the overburden a layer of clay was found that might have caused some uncontrolled IP-effects.

On grid Brennvola four holes were drilled during spring (together 432.55 m). The first two holes were drilled on a wide IP-anomaly on line 3600 S. No reason for the anomaly was found. Both holes were drilled down to the granitic basement. After that a hole was drilled on a geochemical anomaly at 2100S-950W and one at the cut-off of the boulder train at 3480S-1340W. Both holes were negative. The drilling was finished then for the spring and more work was planned for the summer.

During winter/spring also several polished and thin sections of the mineralized boulders were investigated. A report by O. Bakke can be found in the appendix of this report. The conclusion of this investigation is that the lead mineralization is very similar to that at Laisvall. The rocks, however, have undergone a higher metamorphism which caused a stronger remobilization of galena than at Laisvall.

After the snow had gone a quarternary geologist from the University of Oslo was hired in order to find out possible source areas for the two boulder trains. His report is included in the appendix. The conclusion is 1. that the source of the mineralized boulders lies SE of their cut-off points, and 2. that the kind of glacial transportation of the boulders in both the trains might have been different. The boulder train at Langen was probably transported from relatively far (more than 5 km). The length of the transport of the mineralized boulders on grid Brennvola is more unsure: 0.5-5 km or more than 5 km. If the source of the boulders was 5 km or more towards SE, their origin would lie within the National Park or close to its border.

During late June and early July the Brennvola grid was extended by a few lines towards SE with subsequent soil sampling, prospecting, and geological mapping. No results of greater significance were obtained.

During July an IP survey was run, covering the area southeast of the boulder train on grid Brennvola between its cut-off and the protected area. Every second grid-line was surveyed using dipol-dipol, with $a=50$ m, and $n=1-6$. Several anomalies were detected that warranted drilling.

Diamond drilling started during the middle of July and was finished in the middle of November. Thirteen holes were drilled (together 2016 m). The most important IP-anomalies were tested. It was found out that all the anomalies were caused by graphitic schists. Many of the holes were drilled down to the granitic basement. However, disseminated galena mineralization was intersected for the first time in drill hole 84-BRV-8 in a coarse grained arkosite at a depth of 113 m close to the border of the protected area. The mineralized zone is stratigraphically located below two horizons of graphitic schists. Several other holes were drilled in this area. The best sections with disseminated galena mineralization were found in drill holes no. 84-BRV-11 with 7.2 m of 0.8 % Pb, and less than 5 ppm Ag, and 84-BRV-14 with 5.2 m of 1.2 % Pb and 5 ppm Ag. Zn occurs only as traces. These holes lie about 100 m apart (in strike direction). The zone is at least 150 m wide but the sections in the side zones are very narrow (0.2-0.4 m). The mineralization is hosted only within coarse to medium grained arkosites probably due to the higher permeability in contrast to the overlying quartzites that are much finer grained. The extension of this zone towards SE could not be tested because of the protected area.

After most of the holes were drilled, a paleogeographic map was designed showing the surface of the granitic basement. The paleogeography can be important for the mineralization control as most of the Laisvall-type mineralizations are situated at the flank of paleohighs, but in very particular in minor "low"-structures. The designed map showed that the Brennvola grid covers for a large part a paleovalley between two granitic paleohighs in the east and in the west. It shows also that the discovered Pb-mineralization is located in the lowest part of this depression and that this "low" continues

towards the SE into the protected area, plunging still deeper in this direction. Therefore, the best potential for finding further mineralization, hopefully with better grades, is in the protected area.

For next year's activities it is proposed to apply for a permission to drill in the protected area. A short fence could be drilled on line 6300 S crossing the axis of the indicated paleoclaw. If the results should be positive the extension of the mineralized zone must be tested further towards SE, towards the National Park, following the low-structure. All holes, or most of them, should be drilled to the basement. For this at least 1500 m of diamond drilling will be necessary.

As the mineralized boulders on grid Brennvola show partially very good grades (some over 10 % Pb) it can be expected that 1. the grades of the mineralization could get better towards SE and 2. that the mineralization is coming to surface somewhere in this area. Therefore the chances for finding an ore-body of reasonable grade and size within the protected area must be seen as present. Of course the possibility exists that this mineralization extends into the National Park.

5.2 Investigations at the Atna property

The Atna property is located in the southwestern part of the project area not far from the main road Folldal-Atna.

In early summer some geochemical stream sediment anomalies were investigated by prospecting in an area closeby. On the road into this area some rusty boulders lying beside the road were found. The boulders proved to contain finely disseminated galena. Soon more boulders were found that were mineralized, mostly dark quartzites that contained finely disseminated galena and/or sphalerite. Often galena and sphalerite occurred on remobilized quartz veins. A grid was established in this area and subsequent mapping, boulder tracing, a VLF survey, and soil sampling were conducted. Altogether 610 B-horizon soil samples were taken. Most of the area is covered by moraine and only very few outcrops were found.

Within the grid area sedimentary rocks occur as conglomerates, quartzites, and arkosites dipping gently towards SW as was found out later by oriented taken drill core samples. The rock units are lying on the southern flank of the Precambrian Atna-Window. Whether the rocks lie autochthonous on the basement or not could not be proved.

Regional geological mapping was carried out around the grid in scale 1 : 50 000. It was found out that mineralized boulders with galena and sphalerite are spread over a large area around the established grid but they are concentrated within the grid area. The Pb- and Zn-contents of the mineralized boulders were mostly low, however, only rarely exceeding 1 % Pb (Table 1).

Table 1: Contents of Cu, Zn, Pb, and Ag of mineralized boulders in the Atna area

Sample no.	Cu	Zn	Pb	Ag	(ppm)
ATB-1	76	475	2433		
ATB-2	15	1118	2496		
ATB-3	45	526	1010		
ATB-4	61	4122	677		
ATB-5	46	123	<120		
ATB-6	28	159	1890		
ATB-7	31	212	<120		
ATB-9	32	3525	15024	6	
ATB-11	16	361	354		
ATB-12	16	1886	4146		
ATB-13	16	1304	699		
ATB-14	15	4214	114		
ATB-15	15	366	255		
ATB-16	44	5567	109	1	
ATB-17	16	1311	116		
ATB-18	16	2566	2132	1	
ATB-19	16	59	452		
ATB-20	15	678	220		
ATB-21	15	1339	1306		
ATB-22	16	213	340		
ATB-23	15	776	978		
ATB-24	32	361	230		
ATB-25	29	774	13302	15	
ATB-36	119	149	<120		
ATB-39	65	297	15340	5	
ATB-40	64	235	6850	3	
ATB-41	78	514	23683	10	
ATB-53	16	1500	410	0.5	< 2 ppb Au

The same quarternary geologist who did some work at the Brennvola property was hired in order to find possible source areas of the mineralized boulders. His report is included in the appendix. His conclusion is that the boulders, which are mostly very angular, are of very local derivation.

Within the grid area two major trends of geochemical anomalies for lead were detected with values up to 1000 ppm Pb. Both trends run parallel in NW-SE direction.. Higher Zn values could be detected further downhill. An IP survey that crossed the geochemically anomalous zones was conducted along five grid lines. Several coincidences of IP/geochem. anomalies were found. Two outcrops with lowgrade disseminated galena mineralization were found within the grid.

Diamond drilling was conducted in November. Five holes were drilled (together 237 m). Four of the holes were drilled to test the combined IP/geochem. anomalies at three different sites (holes 84-ATNA-1 to 4). It was found out that the anomalies were caused by graphitic schists that were rich in lead. Some grains of galena were found in one of the holes within the graphitic schists. The fifth hole (84-ATNA-5) was drilled on a geochemical Pb-anomaly that was located outside the two main trends. This anomaly coincides with a VLF-anomaly. Closeby an outcrop is located with a dark quartzite that contains some finely disseminated galena. At this hole the reason for the anomaly could not be found.

During the regional geological mapping around the grid area a zone with chalcopyrite and galena disseminations with elevated contents of Ag was found within conglomerates. This zone is located at Ledsageren. Samples were taken where the ore-minerals were best visible. Results from the assays can be seen in Table 2. The length of this zone is about 1 km but not all of the conglomerates were sampled yet.

The Atna area must be seen as an area that is highly anomalous in heavy metals, especially in lead. However, not a single sample that was found in the area (boulder or outcrop) was or came close to ore grade. Since the drilling results were negative, the grades at the Ledsageren mineralization low

and scattered, and no boulder with ore grade was found, it is proposed to finish the investigations in the Atna area.

Table 2: Contents of Cu, Zn, Pb, Ag, and Au in some selected samples of the conglomerate at Ledsageren

sample no.	Cu	Zn	Pb	Ag (ppm)	Au (ppb)
84-LED-1	580	20	280	2	2
84-LED-2	340	14	78	1.5	4
84-LED-3	900	1900	6000	12	2
84-LED-4	6500	40	64	13	160
84-LED-5	110	370	4100	5.5	2
84-LED-6	3800	26	110	14	6

5.3 Follow-up work on other grids established in 1983

Tufsingdal:

The Tufsingdal property is located about 30 km southeast of the town of Os (no.10 on the grid location map). In 1983 a grid was established that covered an area around the old Tufsingdal Pb,Ag-mine. This work was a result of stream sediment anomalies that were detected in this area in 1982. The grid area covers sediments that lie on the flank of a small granitic paleohigh. The grid follow-up work comprised soil sampling, geological mapping, and for a part a VLF-survey.

On grid line 800 S two geochemical soil anomalies for Pb were detected that coincide with VLF anomalies. Prospecting and detailed mapping was conducted in this area and a narrow zone with impregnations of pyrite, galena, and sphalerite was found. in the striking continuation of the western of the two anomalies. After that an IP survey was conducted on this line that showed a very high anomaly at station 400 W that was with high probability caused by graphite and a weak anomaly on the flank of the strong one. The weak anomaly was centered at station 650 W where also the western geochemical soil anomaly was located. A hole was drilled at grid coordinate 840 S-575 W towards this anomaly. The drill core contained a thick series of graphite schists that contained some traces of chalcopyrite and sphalerite. After this hole was drilled

no further investigations were conducted on this grid.

Nekkjölen:

At the Nekkjölen property (no. 18 on the grid location map) a large grid was established in 1983. It covers a sedimentary sequence in the east and the Precambrian basement of the Finstad-Window in the west. This work was a result of the detection of stream-sediment anomalies, mainly for Cu. During the summer of 1983 two localities with Cu-mineralizations were discovered and several geochemical soil anomalies for Cu in the area of one of these occurrences, an old trench that contained massive chalcopyrite.

This area was covered by an IP survey during summer 1984 on altogether 4 lines and on one line further towards south where a low grade disseminated Cu-mineralization with bornite was found. On none of the lines surveyed a drill target could be found. None of the few IP anomalies was coinciding with any of the geochemical anomalies.

On the northern end of the grid a few weak Pb soil-anomalies were detected in 1983. This area was prospected during the summer of 1984 without that any mineralization could be found.

Littlefjellet:

The littlefjellet-grid is located in the Brekken area in the northern part of the project area (no. 2 on the grid location map). The grid was established in the summer 1983 based on the detection of Pb- and Zn-anomalies in stream sediments. Some anomalies for Pb in soils were detected on lines ONS and 150 N between 100 W and 200 W.

During the summer of 1984 this area was investigated in detail by prospecting. Small amounts of galena were found within fine-grained quartzites in narrow cracks. The same feature had been observed before in places on grid Gruvsjöen. These occurrences of galena are undoubtedly of no economic importance. Apart from galena, also chalcopyrite was observed in very small amounts within the sediments.

Tverrlivola:

The Tverrlivola-grid is also located in the Brekken area (no. 1 on the grid location map). The work that was conducted at this property was based on the detection of stream sediment anomalies. The geochemical soil survey of 1983 indicated some slight anomalies for Pb on lines 1050 N, 1200 N, and 1350 N, between 100 E and 600 E.

In the summer of 1984 detailed prospecting was conducted in this slight anomalous area. It was found out that augengneisses dominate this part of the grid. No ore mineralization or traces of galena could be found.

5.4 Follow-up work on some stream sediment anomalies detected in 1982 and 1983

During the summer 1984 several geochemical anomalies that were detected by the regional stream sediment surveys were followed-up by prospecting.

Anomaly just east of lake Rien:

In the northern part of the project area a stream sediment anomaly for Pb, Zn, and Ag was detected on map sheet Stugusjö at 6 49600/69 62600. It is located only a few hundred meters away from the eastern shore of lake Rien.

Below (downstream) of the anomaly no outcrops are present. Above it there occur several outcrops of augengneisses that are overlain by sparagmites. The general strike direction is E-W with a weak dip towards N. Several boulders that are mineralized with pyrite could be found. The reason for the Pb, Zn, and Ag anomalies is unknown, however.

Anomaly 3 km east of lake Rien:

Two samples with high contents of Pb, Zn, and Ag were found on map sheet Brekken at 6 52750/69 60800 and 6 51 900/69 60300.

Two types of sparagmite, a green and a dark grey one, occur in the area. These are overlain by augengneisses. The strike and the dip angles are strongly varying. The rocks are tecto-

nized and small scale folded. An elevated content of pyrite was found in the rocks above the anomaly. The reason for the Pb, Zn, and Ag values could not be found.

Anomalies 1.25 and 3 km southwest of Volldalshögda:

Several anomalous samples for Pb, Zn, and Ag were detected in two parallel creeks southwest of Volldalshögda on map sheet Brekken, very close to the Swedish border. Several outcrops of sparagmites were found at the northern one of the creeks at Ruttjörnane. The strike direction is in general NW-SE with a gentle dip towards NE. Several boulders of sparagmite with a high pyrite content could be found. The reason for the anomalies was not found.

Anomaly 5 km northwest of Littlefjellet:

Very high anomalies for Zn (up to 2700 ppm) were detected in a creek about 5 km northwest of Littlefjellet on map sheet Brekken. The values for Zn are increasing streamupwards. The highest value was found at the cut-off of the anomaly. The creek is in general looking very rusty with obvious precipitated Fe- and Mn-oxides and -hydroxides. Several outcrops of a greenish sparagmite could be observed. Just above the cut-off of the anomaly a small side-creek is coming into the main creek. Its source area can be found in a swamp that is located about 200 m east of the main creek. Around this swamp one can find several rolls of old reindeer fence that is in process of weathering since many years. The source of the high Zn-anomalies might therefore be contamination. To make sure that this was the reason for the anomaly the whole creek was sampled again with stream sediments. This time the sediments were sieved wet in the field. The grain size of the samples obtained by this method is probably somewhat larger than this obtained from bulk samples. The analytical results showed that the Zn and Pb values were lower this time, but anomalous, too, with the cut-off at the same sample site as observed before. Fe and Mn showed very high values (up to 7.1 % acid extractable Fe). This fact might be an additional factor for the formation of the anomaly caused by the coprecipitation

of Zn, Pb, and Ag with Fe- and Mn-oxides and -hydroxides. In the outcrops around in the anomalous area no ore mineralization was found.

Anomaly 3 km east of Langhøa:

On map sheet Tyllidal high anomalous values for Cu, Pb, Zn, and Ag were detected in a stream about 3 km east of Langhøa. Follow-up prospecting of this anomaly showed that it is located within the granitic basement of the Finstad-window. Some grains of pyrite could be found some hundred meters above the anomaly. Other ore minerals could not be found.

Anomaly 1.75 km east of Klettseterklettan: (sheet Tyllidal)

The anomalous area is totally covered by swamp. Only one outcrop of sparagmite could be found closeby. No ore mineralization could be observed.

Anomaly 4 km south of Klettseterklettan:

Anomalies for Pb, Zn, and Ag were found in a stream 4 km south of Klettseterklettan on map sheet Tyllidal. The stream drains an area that is located close to the contact of the sparagmites with the granitic basement of the Finstad-window. Outcrops of sparagmites could be found within the anomalous area but no ore mineralization could be discovered. Several possible sources of contamination as fences etc. are present in the area.

Anomaly 3.7 km southeast of Gråhögda:

An anomaly for Pb and Zn was detected 3.7 km southeast of Gråhögda on map sheet Sollia. Follow-up prospecting showed that the anomaly is located within the granites of the Atna-window. A relatively high background of Pb within the granite might cause this anomaly as no ore minerals could be found. Further prospecting in the area led to the discovery of some PbS-mineralized boulders, leading to the investigations on grid Atna.

6. Land Status

All claims held will be dropped by the end of 1984 except one claim group that covers the Brennvola occurrence and its possible extension towards southeast.

Appendices

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DDH No.				Azimuth		Started		Directional surveys									
Property				Angle		Finished		Depth		Azim.		Dip					
Co-ord.				Depth		Logged by											
1-350 E - 125 S				90°		O. Bakke											
								Interval		Assays							
From		To		Description				From		To		Cu	Mo	Pb	Zn	Au	Ag
0		30,00		<u>Overburden</u>													
				From 0 to 16 m. moraine with big(up to 5 m) blocks,													
				which often are angular.													
				From 16 to 21.5 m clay with some small stones.													
				From 21.5 to 28.5 m moraine with small blocks.													
30,00		34,00		<u>Unsorted clayrich sparagmite.</u>													
				The rock is grey and fine grained (possible re-													
				crystallized). Quartz-rich lensoid pebbles with													
				dark minerals between. The pebbles seems to be													
				pressed together and the matrix squeezed out to													
				thin bands(less than one mm.) surround them. The													
				size of the pebbles rang from 1 to 3 mm in length.													
				Bands enriched in carbonate are found throughout.													
				MIN: Thin(less than 1 mm) joints filled with fine													
				grained massive py and po are found throughout < 0.5%													
				At 33.40 m it is a lense of massive po that is													
				0,5 cm wide and 5 cm long.													

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From	To	Description	DDH No. Lax. 2/84	Interval		Assays					
				From	To	Cu	Mo	Pb	Zn	Au	Ag
		to 20.00 m. These joints are open space fillings (quartz and carbonate), which also carry considerable amounts of pyrite(possible also marcasite). The biggest of these, is a massive pyrite open space filling at 19,90 m. It is 0,5 cm wide and more than 10 cm long. A lot of primary depositional structures such as small foldings and "varvning". The rock has probable a little contents of graphite, which are surely identified at 15,90 m. Together with some pyrite the graphite of this section could very well be the reason for the IP effect.									
		MIN: Thin concordant joints of disseminated pyrite are found throughout in addition to the open space fillings. Together they do not constitute more than 1% of the rock. The last 4 m of this section is more pyriterich than the rest.									
27,80	27,91	<u>Sandstone</u>									
		The rock is coarse grained(0,5 to 2 mm) and consists of grey quartz grains floating in a white matrix.									
		The quartz grains which seldom are seen in contact with each other, are mostly well rounded, but angular									

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From	To	Description	DDH No. Lan 2/84	Interval		Assays					
				From	To	Cu	Mo	Pb	Zn	Au	Ag
		grains are also found. The matrix is probable a carbonate-bearing sericite.									
		MIN: No sulphides are found									
27,91	48,50	Quartzite									
		This section consists of light grey and darker layers of quartzite. The contact between these two types are generally very irregular. The lighter one seems to follow joints in the darker. The contact is probable chemical. The light sections are found at: 28,90-30,25 m, 30,87-31,30 m, 31,43-32,22 m and 43,07-47,60 m. A dark red mineral are found at 28,95 m.									
		This is probable rusty quartz.									
		The section is cut by two joints which are filled with clay. These are found from 35,95 to 36,07 m and from 40,26 to 40,32 m. The joints are bowth concordant.									
		The rock has a lot of silica filled joints from 33,80 to 43,07 m. Near the contact between the lighter and the darker quartzite at 43,07 m, there are a lot of bands with a light green mineral that probable is sericite.									

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From	To	Description	DDH No. <u>Lan 2/54</u>	Interval		Assays					
				From	To	Cu	Mo	Pb	Zn	Au	Ag
		Small (up to 5cm wide) bands of sandstones (same as above) are found throughout. In the last one meter of this section it is possible to see quartz grains in the quartzite, and it has a more banded habitus. MIN: Traces of py and po are found at joints. Darker spots in the light quartzite can be explained by traces of fine grained galena.									
48,50	51,70	<u>Conglomerate</u>									
		Grey matrix with boulders of white and grey quartzites. The matrix is a coarse grained sandstone. The quartz grains are very well rounded and the diameter range from 0.5 to 10 cm. The contact with the overlying and underlying quartzites are both sharp. MIN: No visible sulphides.									
51,70	52,70	<u>Quartzite</u>									
		The first part (51,70 to 52,38 m) is a light grey quartzite (same as above) and the last part of this section is a dark quartzite. A banded habitus is found in the first part, with layers of sericite and silica. These bands are probable formed by									

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D.C. - No.		Lan 3/84		Azimuth		Started		Directional surveys					
Property		Langen		Angle		Finished		Depth	Azim	Dip	Depth	Azim	Dip
Co-ord		L 350 E - 550 S		Depth		Logged by							
				90°		O Bakke K Krause							
				66,05 m									
From		To		Description		Interval		Assays					
						From	To	Cu	Mg	Pb	Zn	Au	Ag
0	32,00			Overburden									
32,00	44,56			Siltstone									
				The rock is grey and fine grained (possibly re-crystallized). Quartz-rich lensoid pebbles with dark minerals between. The pebbles seem to be pressed together and the matrix squeezed out to thin bands (less than 1 mm) surround them. The size of the pebbles range from 1 to 3 mm in length. Bands enriched in carbonate are found throughout. CA: 90°.									
				MIN: Traces of py at joints.									
44,56	44,77			Sandstone									
				The rock is coarse grained (0,5-2,0 mm) and consists of grey quartz grains floating in a white matrix. The quartz grains which seldom are seen in contact with each other, are mostly well rounded, but angular grains are also found. The matrix is probably a carbonate-bearing sericite.									

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DDH No		Azimuth		Start		Directional surveys					
BRV-02-84				7 01 14		Depth	Azim	Dip	Depth	Azim	Dip
Property		Angle		Finished							
BRENNVOLA		90°		04 04 84							
Co-ord		Depth		Logged by							
1 3600 S, 1450 W		115,30 m		O Bakke M Krause							
From	To	Description	Interval		Assays						
			From	To	Cu	Mn	Pb	Zn	Au	Ag	
0	7,50	Overburden									
7,50	103,00	Sparagmite									
		7,50-19,48 : Medium grained and with finer grained layers. This is a medium grained, grey rock with some few pebbles of quartz (ranging in size from 0,2-1 cm).									
		Lighter sections from 7,50 to 9,15 m and from 16,50 to 17,60 m.									
		MIN: Up to 1 cm thick and 5 cm long lenses of pyrrhotite (disseminated but rich, less than 1 %). CA = 80 - 85%									
		19,48-33,50 : Fine grained sparagmite.									
		This is a light grey, fine grained rock. The last 2 m of this section have some oblong pebbles of quartz.									
		MIN: Traces of pyrrhotite as small lenses, and traces of pyrite on joints. At 30,80 m it is a small grain of a silvercoloured mineral. With the help of a binocular it seems that this is hematite.									
		33,50-103,00 : Coarse grained sparagmite.									

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B.D.M. No.	BRV 03-84	Assault	Started	10 04 84	Directional surveys							
Property	Brennvola	Angle	Finished	13 04 84	Depth	Asym	Dip	Depth	Asym	Dip		
Co-ord.	2100 -S, 950 -W	Depth	Logged by	O. Bakke M. Krause								
From	To	Description	Interval		From	To	Cu	Mn	Pb	Zn	Au	Ag
0.00	3.00	Overburden										
3.00	36.05	Sparagmite										
		This is a light grey medium grained section. Bedding is common. There is a more siltrich section from 3.00 to about 12.00 m where it gradually is going over to the sparagmite. Brown weathering on joints are usual in the first 10 m of this core. At about 10 m there are up to 1% py in a clayrich carbonaceous zone. More quartzitic sections are found from 9.60 m to 10.00 m and from 4.10 m to 5.80 m.										
		A new siltrich section is starting gradually at about 30.00 m, and continue to the end of this section.										
		This section which is slightly darker contains also some carbonate. CA: 70° to 90°										
		MIN: Traces of disseminated pyrite are found throughout.										
36.05	65.62	Quartzite										
		Light grey very fine grained section. The section										

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D.C.H. No.	BH-84-BRV-5	Azimuth	./.	Started	13.07.84	Directional surveys							
Property	Brennvola	Angle	90°	Finished	17.07.84	Depth	Azim.	Dip	Depth	Azim.	Dip		
Co-ord	4500 S-590 V	Depth	139,30 m	Logged by	M. Krause	The drill site is located 710 m above sea level.							
From	To	Description				Interval		Assays					
						From	To	Cu	Mo	Pb	Zn	Au	Ag
0	6,50	Overburden											
		boulders of light and dark coloured sparagmites.											
6,50	9,40	schist											
		Dark grey-greenish, fine grained, well bedded schist.											
		Contains some very thin (mm-thick) layers of black fine-grained material (graphite). No visible ore mineralization.											
		a = 45°-80° varying.											
9,40	26,00	quartzite											
		Grey coloured, fine grained quartzite, containing numerous narrow quartz veins.											
		Mineralization: The rock contains py and po, predominantly py that is often bound to the quartz veins. The content is about 1 %, sometimes a little bit higher. a = about 80°.											
		This rock type is going gradually over in											
26,00	30,50	sparagmite											
		middle grained arkose, contains often some clay material in narrow beds or in cracks. a = 80°.											

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D.D.H. No.		Azimuth		Signed		Directional surveys							
Bh-84-BRV-7		-/-		26.07.84		Depth	Azim	Dip	Depth	Azim	Dip		
Property		Angle		Finished		the drill site is located 715 m above sea level							
Brennvola		90°		02.08.84									
Co-ord		Depth		Logged by									
4800 S/500 V		166.00 m		M. Krause									
From	To	Description				Interval		Assays					
						From	To	Cu	Mo	Pb	Zn	Au	Ag
0	10,00	Overburden a = angle of bedding to core axis											
10,00	11,70	Greenish schists											
		Greenish schists, well bedded, fine grained rock type,											
		containing several bands of ankerite that are parallel the											
		bedding: a is varying between 50-80°											
11,70	66,00	Graphite schists.											
		Graphite schist that in parts is very rich in graphite,											
		contains numerous lenses of pyrite and pyrrhotite. In some											
		parts the content of graphite is very low and only present											
		as strips in a schistose rock type as at 12,30 - 12,80 or											
		14,30 - 16,05. a = 80° throughout the whole section. At the											
		base the graphitic schists are going gradually over into											
		sparagmite. Here the rock is schistose with a very few stripes											
		of graphitic material. This rock type corresponds with the											
		slightly graphitic schists at the top of the drill holes											
		5 and 6.											

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D.D. No.		Azimuth		Started		Directional surveys					
84-ERV-10		-		27.8.84		Depth	Azim	Dip	Depth	Azim	Dip
Property		Angle		Finished		The drill site is located 695m above sea level					
Brennvola		90°		30.8.84							
Co-ord		Depth		Logged by							
54008-750V		95.50m		Krause							

From	To	Description	Interval		Assays						
			From	To	Cu	Mc	Pb	Zn	Au	Ag	
0	5.00	Overburden									
5.00	12.40	<u>Quartzite</u>									
		very fine grained, grey coloured, quartz rich rock type. Contains often milk-quartz schlieren that are up to 5 cm thick. Beside this often layers of clay rich material can be observed. In these sections often pyrite and pyrrhotite can be observed. $\alpha=80^\circ$									
12.40	28.00	<u>Graphitic schists</u>									
		Dark grey coloured, quartzitic schists, that contain numerous narrow stripes of graphitic material. $\alpha=80^\circ$									
28.00	58.00	<u>Quartzite</u>									
		Grey coloured, very fine grained, quartz rich rock type. Contains often narrow veins of milk-quartz and layers of clay rich material. At about 41-44m the rock is very rich in clay material, greenish coloured, and contains some pyrite (less 1 %)									
58.00	95.50	<u>Sparagmite</u>									
		Grey coloured arkosite. More feldspathic and coarser grained than the quartzites but in some shorter sections quite quartzitic, too. $\alpha=70-80^\circ$. Contains numerous narrow veins of milk-quartz. At 67.60-68.70 conglomeratic section that contains quartz pebbles that are up to 1 cm in size. From									

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D.D.H. No.		Azimuth		Started		Directional surveys					
		-		27.9.84		Depth	Azim	Dip	Depth	Azim	Dip
Property		Angle		Finished		The drill site is located 202m above sea level					
Brennvola		90°		1.10.84							
Co-ord		Depth		Logged by							
5400S-380W		185.80m		Krause, Rakke							
From	To	Description	Interval From To	Cu	Mo	Pb	Zn	Au	Ag		
0	5.00	<u>Overburden</u>									
5.00	39.40	<u>Quartzite</u> light green coloured, fine grained quartzite, very pure in some sections, contains numerous layers of green coloured clay material, α=90°, conglomeratic section at 35.70-39.40 that contains up to 2cm large elongated quartz pebbles									
39.40	42.50	<u>Graphitic schists</u> quartzitic, schistose rock type that contains numerous narrow stripes of graphitic material, sometimes carbonaceous layers, α=80-90°,									
42.50	59.20	<u>Quartzite</u> light to dark green coloured, in parts very pure quartzite, very fine grained, α=70-80°, between 52 and 55m several very narrow bands with graphitic material, at 52.00-52.20 breccia with up to 4cm large fragments of milk-quartz, matrix consists of coarse grained pyrite									
59.20	81.70	<u>Graphitic schists</u> graphitic schistose rock type that is in parts very rich in graphite, often visible pyrite and pyrrhotite, α=80°									
81.70	101.00	<u>Quartzite</u> grey coloured, very fine grained quartzite, α=90°, is going gradually over into:									

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D.D. No		Azimuth	Started	Directional surveys					
84-BRV-15		-	19.10.84	Depth	Azim	Dip	Depth	Azim	Dip
Property		Angle	Finished	The drill site is located 703m above sea level					
Brennvola		90°	29.10.84						
Co-ord		Depth	Logged by						
5250S-375W		185.40m	Krause						

From	To	Description	Interval		Assays					
			From	To	Cu	Mo	Pb	Zn	Au	Ag
0	5.40	<u>Overburden</u>								
5.40	26.60	<u>Quartzite</u>								
		light green-grey coloured, fine grained rock type, contains often narrow clay-rich layers causing the greenish colour of the rock, $\alpha=80^\circ$								
26.60	38.50	<u>Graphitic schists</u>								
		quartzitic, fine grained rock type that contains many stripes of graphitic material, well bedded, $\alpha=80^\circ$								
38.50	46.70	<u>Quartzite</u>								
		as 5.40-26.60								
46.70	77.70	<u>Graphitic schists</u>								
		typical graphitic schists, partly rich in graphite, contains numerous quartz schlieren, pyrite and pyrrhotite lenses, $\alpha=80-90^\circ$								
77.70	92.00	<u>Quartzite</u>								
		gray coloured, fine grained rock type, contains numerous narrow veins of milk-quartz, in some sections								
		light grey coloured and very pure quartzite, goes gradually over into sparagmite at about 92m.								
92.00	179.40	<u>Sparagmite</u>								
		medium to coarse grained arkosite, contains usually pyrite and pyrrhotite, often containing narrow clay-rich layers, conglomeratic section at 157.30-								

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D.D.H. No.	84-BRV-17	Azimuth	-	Started	12.11.84	Directional surveys								
Property	Brennvola	Angle	90°	Finished	15.11.84	Depth	Azim	Dip	Depth	Azim	Dip			
Co-ord	4800S-800W	Depth	141.30m	Logged by	Krause	The drill site is located 700 m above sea level								
From	To	Description				Interval		Assays						
						From	To	Cu	Mo	Pb	Zn	Au	Ag	
0	9.40	Overburden												
9.40	135.00	Sparagmite												
		The rock is comparison to the sparagmite in the former drill holes much more coarse grained and in sections even slightly conglomeratic. It is a medium grey coloured arkosite that is in general not well bedded. Pyrite and more rarely pyrrhotite are visible throughout the whole section. They occur predominantly on cracks but can also be found disseminated. The content of pyrite and pyrrhotite is in general below 1%. The rock is generally medium to coarse grained. At 23-25m it is slightly conglomeratic. At 50.00-50.50 it is fine grained, quartzitic, and light grey coloured. Here it contains several greenish clay layers. $\alpha=80^\circ$. Another very coarse grained section can be found at 65-66m. Several dark grey coloured clay layers could be observed at 77.60-77.80. A coarse conglomerate with elongated quartz pebbles, up to 2cm in size was found at 110.00-112.60m. The grain size of the sparagmite decreases below this conglomerate. PbS mineralization was not observed.												
135.00	139.65	Quartzite												
		Light grey coloured, fine grained quartzite that contains a little pyrite on cracks. The lower 10cm are brecciated.												

DIAMOND DRILL LOG

FOLLDAL VERX A/S

PAGE 2

[illegible]

FOLIO DAL VERDE A/S

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DIAMOND DRILL LOG

FOLLDAL VERK A/S

PAGE 2

From	To	Description	Interval		Assays					
			From	To	Cu	Mc	Pb	Zn	Au	Ag
		TUP-1-84 quartz ratio varies quite a lot. Generally there is more feldspar in the last part of this section. The change of the colour in this rock type is probably mostly caused by the change of graphite content. Min: Traces of pyrite and pyrrhotite on joints. ca 35°								
27.90	86.30	<u>Graphite schists</u> This is a dark grey to black strata with white strongly folded thin bands (mostly less than 0.2cm wide) of calcite and quartz. The strata is cut by some quartz/calcite veins that are up to 15cm wide. The graphite content varies quite a lot and is getting higher from the top towards a maximum at 81.80 m. The last 2m of this section are not so rich in graphite. Min: 1-3% pyrrhotite as bands (up to 1cm wide, massive) and spots more at the top than at the base of this section. Traces of sphalerite as up to 2cm large spots in the quartz/calcite veins. Traces of galena as a few small grains in the qtz/calc. veins. Traces of chalcopyrite in contact with pyrrhotite and as separate grains in the quartz/calcite veins. Traces of pyrite on joints and in cavities. c.a. at 40m=45° and at 80m=80°								
86.30	91.85	<u>Quartzite</u> Medium grained quartzite. The first part of the section is slightly darker than the rest and the contact with the overlying strata is diffuse. The last part of the section is strongly banded and looks like a gyllonite with green very fine grained material. Min: Traces of pyrite on joints, c.a. 90°								
91.85	95.15	<u>Conglomerate</u>								

DIAMOND DRILL LOG

FOLLODAL VERK A/S

PAGE 3

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FOOD AND VERMICELI

PAGE 1

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DIAMOND DRILL LOG

FOLLDAL VERK A/S

PAGE 1

DDH No	84-ATNA-2	Azimuth	-	Started	2.11.84	Directional surveys					
Property	Atna	Angle	90°	Finished	3.11.84	Depth	Azim	Dip	Depth	Azim	Dip
Co-ord.	144W-13N	Depth	40.50m	Logged by	O. Bakke						

From	To	Description	Interval		Assays						
			From	To	Cu	Mo	Pb	Zn	Au	Ag	
0	6.50	<u>Overburden</u> (glacial drift)									
6.50	11.40	<u>Tillite?</u>									
		The matrix of this tillite is a coarse grained arkose. It is red coloured due to a consid-erable content of red feldspar. Within this arkose there are a few mostly well rounded quartz pebbles (up to 5cm long) and some small layered fragments of clay. These clay fragments are mostly not more than 1cm thick and 5cm long. Two thin horizons rich in pebbles and clay fragments are found at 8.20-8.50 and 9.25-9.55. Within these horizons there are some pebbles that are not rounded. No visible mineralization.									
11.40	40.50	<u>Sparagmite</u>									
		Layered and banded medium to fine grained sparagmite. The colour varies very much from brownish through red and grey towards almost white. The white and red layers are almost homogenous whereas the grey and brownish ones are mostly banded. C.a. varies from 90° to approx. 70°. The average strike direction, measured at orientated core at 4 different places is 172° with the dip towards west. One carbonaceous layer is found at 27.00-27.10 and it is very similar to those found in hole 84-ATNA-1. A few pebbles of quartz and jasper (up to 5cm long) are found throughout the whole section. No visible ore mineralization. 40.50 e.o.h.									

FOLDAL VERK A/S

PAGE 5

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FOLLODAL VERK A/S

PAGE

[illegible]

FOLLDAL VERK A/S

PAGE

D.C. No.		84-ATNA-5		Azimuth		-		Started		2.11.84		Directional surveys							
Property		Atha		Angle		90°		Finished		3.11.84		Depth		Azim.		Dip			
Co-ord		600E-513N		Depth		40.50 m		Logged by		O.Bakke									
From		To		Description								Interval		Assays					
0		8.00		Overburden															
				glacial drift and road filling material															
8.00		40.50		Sparagmite															
				This is a medium grained grey arkose interbedded with some darker and finer sections. A few fragments of up to 5cm long. quartzitic material is found throughout. There are quite a few rust filled open space joints especially from about 18m to 22m. The darker almost quartzitic sections are found from 11.10-13.40 and from 15.40-16.50. C.A. at 12m is about 60-70°. One oriented taken core sample showed a dip of 35° towards the south (165°). That means that the strike direction is about 65°. No sulfides are found in this core.															
				40.50 e.o.h.															

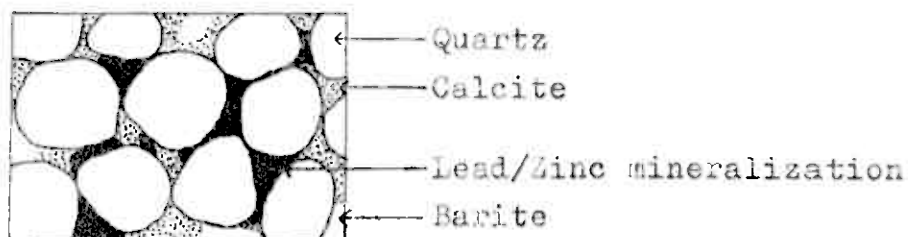
MICROSCOPICAL OVERVIEW OF THE MINERALIZED BOULDERS IN THE BRENNVOLA AREA, AND COMPARISON WITH THE LAISVALL-TYPE MINERALIZATION.

In the 1983 field season it was discovered high grade-mineralized boulders in the Langen-Brennvola area of the sparagmite project (N-82-5). These boulders were analyzed for zink, lead, copper and silver. Only lead and silver showed anomal values. The lead values ranged from 1 to 13,6 % and the silver values ranged from 0,10 to 1,55 oz/tonn. Both thinn sections and polished sections were made for some of the boulders.

In hand specimens the type of mineralization found in the boulders seems very similar to that of the Laisvall-type. Galena, together with pyrite, can be found disseminated throughout the whole sparagmite, following bedding planes, or partly also as "spothy galena" (KRAUSE 1984).

In both the Laisvall deposit and the Brennvola mineralized boulders, the mineralization seems dependent on the porosity of the hoste rocks. In the Laisvall-type, the porosity available is always sufficient for economic mineralization, because the hoste rock is a sandstone which have well rounded grains. The mineralization appears as sediment together with barite and carbonate in the sandstone (fig 1).

Fig 1.



The Brennvola/Langen mineralization is situated in a arkose that is influenced by tectonic activity. This means that the porosity is not obtained by the primary rounding of the grains, but of secondary porosity made by the tectonic activity. In thinn sections such mineralizations are observed in small faultings, between cruched feldspar grains and in "law pressure areas" near big quartz grains. A lot of indications of tectonic

activity are observed from microscopic to macroscopic scale. Macroscopic graphite horizons indicate tectonic activity. Mesoscopic such indications are found as small faultings and banding of the rocks. Microscopic "evidences" of such features are found as microfaultings of feldspar grains, granulation of quartz grains, strongly undulating quartz, oval quartz and feldspar grains and small mineralized faultings which are almost parallel to each other.

Mineralogical the host rocks of Brennvola/Langen mineralization is quite different from the Laisvall deposit. The main minerals of the Brennvola/Langen host rock are: 50-80 % quartz, 10-30 % sericite and 5-30 % feldspar (mostly microcline). Although no fluorite or carbonate minerals are found in the microscope, these minerals are detected in hand specimens, but both as minor contents of the bedrock. At Laisvall these minerals are common together with barite. The mineralogy of the host rocks seems to be of less importance than the porosity. Therefore at this stage of the investigations little attention is made on the mineralogy of the host rock.

The ore mineralogy is more interesting since one distinct difference from the Laisvall-type of deposit is observed. At Brennvola/Langen mineralization the zinc values are very low, where as in Laisvall sphalerite is one of the main ore minerals (The average Zn grade is 0,44 % at Laisvall deposit).

Whether the probable ore at Brennvola/Langen is economic or not, is probably as much dependent of high Ag grade as of high Pb grade. Encouraging Ag values of up to 1,55 oz/ton (55 g/ton) is reported from assays of the boulders from Brennvola. The silver of the Brennvola/Langen mineralization appears most probably as a content of the galena, since no other silver bearing minerals are observed and the Pb-Ag ratio are constant for all assayed boulders. The other main ore mineral is pyrite, which appears in a clearly different way than galena. Pyrite is found as disseminated euhedral grains in all the investigated thin and polished sections. In some of them pyrite is enriched in selected bands. It is important to be aware of this difference in behavior of pyrite and galena. In fact it may turn out to be no correlation of the mineralization of these minerals.

One of the polished sections from Brennvola (B.V.S. 3),

which is taken from a rusty zone of the bedrock, shows only pyrite mineralization. Such mineralizations are found in a lot of boulders and outcrops in the whole grid.

The texture and mineralogy of the Brennvola boulders and the Langen boulders seems very similar. The quartz content of the Langen host rock is though slightly higher than in the Brennvola boulders, but this does most probably have little or no influence on the mineralization.

When taking the other known Norweegian sandstone hosted Lead-deposits (Osen and Snertingdal) into account, the similarity to the Brennvola mineralization seems good both in mineralogy and in depositional environment. See table 1.

TABLE 1:

	Brennvola Norge	Laisvall Sverige	Osen Norge	Snertingdal Norge	Vassbo Sverige
Size(million metric tons)	?	80	0,1	1.0	5
Pb-grade(%)	4,6'	3,5	3,0	1,5	5,5
Zn-grade(%)	TRACES'	0,44	0,2	0,02	0,6
Ag-grade(ppm)	15,6'	9,0	?	?	18,0
Pb/Pb+Zn	100,00'	0,89	0,94	0,99	0,90
Ag/Pb (ppm/%)	3,4'	2,6	?	?	3,3
DEPOSITIONAL ENVIRONMENT:					
Along precambrian windows	X				
Along the marginal area of the L.Cambrian epicontinental		X	X	X	X
In autochthonous sediments	X"	X	X	(X)	X
Host rock	Arkose	Sandstone	Sandstone	Sandstone	Sandstone
Meters above basement	40-60 m"	28-74 m	3-10 m	?	10-35 m
Caped by shallow marin sed.	X"	X	X	X	X
Restricted to paleolows	(X)"	X	?	?	X
Vertical zonation (Cu:Zn:Pb)		X	X	(X)	X
Remobilization during tectonism into cracks and joints	X	X	X	X	?
Weathered basement	X"	X	X	?	(X)
Sialic basement	X	X	X	X	X
Depth from surface	110-150 m"	50-160 m	0-75 m	?	10-20 m
HOST ROCK MINERALOGY					
Quartz	50-80%	83.0%	X	X	X
Feldspar	2-30%	1.0%	?	?	?
Sericite	10-30%	?	?	?	?
Calcite	TRACES	1.3%	?	?	X
Fluorite	TRACES	0.6%	?	?	?
Barite		1.4%	?	?	X
Phyllosilicates	10-30%	10.0%	?	?	?
Galena	0-8%	1.7%	X	X	X
Sphalerite	TRACES	0,7%	X	X	X
Pyrite	0-15%	0,2%	?	?	?
TiO ₂ -minerals	TRACES	0,4%	?	?	?

'Average of the assayed boulders.

"Data from the mineralization discovered in 1984.

?Data not available.

Together eight thinn sections and eight polished sections were made from the mineralized boulders at Brennvola and one thinn section and one polished section were made from the mineralized boulders at Langen. In addition to these one thinn and one polished section were made from a pyrite mineralized outcrop at Brennvola. Some brief notes from the microscopic investigations follows:

THINN SECTIONS:

B.V.S. 1

62% Quartz

20% Sericite

10% Microcline + Plagioclase

8% Opaque minerals

No chemical assays are run for this boulder.

Texture: The thinn section shows big(up to 4 mm) well rounded quartz grains floating in a ground mass of small recrystallized quartz grains, sericite and opaque minerals. Microcline and Plagioclase appear both as groundmass and as separate fragments.

QUARTZ: The mineral appears in a bimodal way, as big(up to 4 mm) well rounded grains and as small(less than 0,05 mm) recrystallized grains in the ground mass. The big grains do always appear separated from each other. At the brim of the big grains there are often found rugged grains of smaller and partly recrystallized grains. At least a part of the small quartz grains are formed by totally smashing of bigger grains. The quartz is strongly undulating.

SERICITE: Appears throughout the whole ground mass, but are more abundant in some parts compared with quartz.

MICROCLINE: Appears as well rounded grains with diameter up to 0,3 mm.

PLAGIOCLASE: The mineral is not surely identified, because it in these very bad thinn sections easily is misinterpreted by microcline with weakly developed pericline twinnings.

OPAQUE MINERALS: Appear as fillings between quartz and feldspar grains. It seems that opaque minerals are less common in parts of the section which is rich in sericite.

B.V.S. 2

- 78% Quartz
- 15% Sericite
- 2% Microcline
- 1% Unidentified phase
- 5% Opaque minerals

No chemical assays are run for this boulder.

TEXTURE: The thin section shows big oblong quartz grains floating in a ground mass of small partly recrystallized quartz grains, sericite and opaque minerals.

QUARTZ: Appears as big (up to 4 mm) oblong grains and as small cataclastic grains (less than 0,05 mm). Corresponding to BVS 1, but with not so good rounding of the grains.

SERICITE: Appear as ground mass and are enriched in some selected bands through the section. Some small grains of light mica (probably muscovite) can be separated from the sericite.

UNIDENTIFIED PHASE: Small (less than 0,1 mm) grains of an unknown phase are observed.

B.V.S. 3

- 50% Quartz
- 10% Microcline
- Plagioclase
- 30% Sericite
- 10% Opaque minerals

No chemical assays are run for this rock sample. This sample is taken from an outcrop of a pyrite disseminated zone in the eastern part of grid Brennvola.

Texture: Similar to BVS 1, but with slightly smaller grain size of the biggest quartz grains (up to 0.2 mm in diameter).

QUARTZ: Appear in a bimodal way, as big (up to 0.2 mm) well rounded grains and as smaller (less than 0,05 mm) mylonitic aggregats. The internal grain boundary of the smaller grains seems casual.

Mosaic texture



A cataclastic mosaic texture, which is common in the matrix of the sparagmite.

MICROCLINE/PLAGIOCLASE: Appear in the same way as the big quartz grains, but they are not so well rounded. Most of the feldspar is probably microcline.

SERICITE: Appear in the matrix in this section.

OPAQUE MINERALS: Euhedral pyrite grains are seen spread out in the whole section. The grain size rang from 0,05 to 0,2 mm. Some subhedral grains appear in the same way as pyrite, these may partly be aggregates of galena. In one corner of the section it is found a red mineral which appear to replace other minerals. That mineral may be gothite. The pyrite grains in this area have a red surface due to oxidation.

B.V.S. 4

60% Quartz
15% Microcline
10% Sericite
15% Opaque minerals

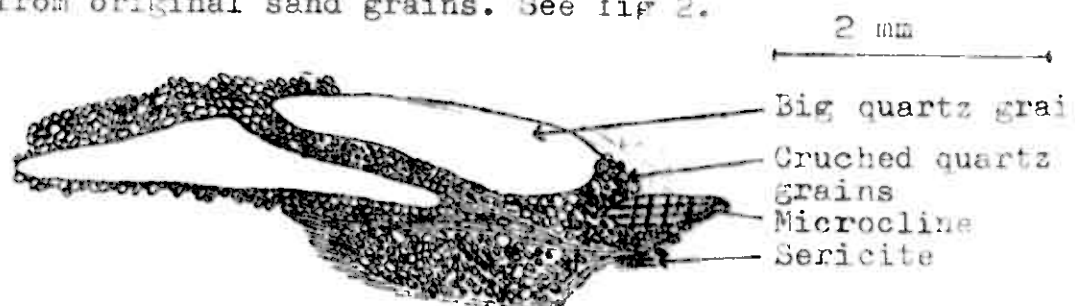
The chemical assays of this boulder showed: Cu: nil, Zn: nil, Ag: 0,39 oz/ton, Pb: 4,06%.

Texture: This section shows a banded texture. Some bands are heavily mineralized, some are enriched in microcline and other bands consists of intergranular fine grained (less than 0,02 mm) quartz. Between these bands, there are oblong big (up to 5 mm) grains of quartz which often have inclusions of smaller quartz grains.

QUARTZ: The mineral appear in a bimodal way as big (up to 5 mm) oblong grains and as recrystallized smaller grains with an intergranular texture. The texture shows that the original sandstone has been exposed for stress. The originally rounded and big grains have been pressed together and also been exposed for longitudinal forches. In addition to this, they have been more or less cruched. The banded texture is probably also due to this external stress.

It is not understood whether this cruching (possibly together with chemical influence) have been completed and than been through a new growth of quartz, or if the big quartz grains are remnants from the original sand grains. The very strong undulating quartz, imply that the mineral have been exposed for stress. Some of the bigger grains (probably all) are for sure remnants from original sand grains. See fig 2.

Fig 2.



MICROCLINE: The mineral appear concentrated in some bands as up to 1 mm big crushed and rounded grains. Microfaultings with intrusion of small quartz grains and sericite are common. In spite of this, the mineral shows no sign of alterations. Plagioclase may also be present.

SERICITE: Appear as long bands on joints between the big quartz grains.

OPAQUE MINERALS: Most of these minerals are found on a 0,5 cm thick band and constitute up to 50% of this band. The grain size rang from 0,01 to 0,1 mm. The biggest grains shows euhedral cubs(pyrite) and the smaller are more irregular. In spite of heavey mineralization it is still clearly disseminated. This band rich in opaque minerals is probably caused by a tectonic remobilization and enrichment, because the wallrock is allmost free of opaque minerals. Rust is common in conection with concordant joints. In hand specimen this is seen as a redish colour of the minerals.

B.V.S. 5

- 50% Quartz
- 12% Sericite
- 30% Feldspar(Microcline)
- 8% Opaque minerals

The chemical assays of this boulder showed: Cu: nil, Zn: nil, Ag: 0,10 oz/ton, Pb: 1,24%.

Texture: This thinn section shows big porphyroclasts of feldspar and quartz floating in a matrix of serisite and crushed and recrystallized quartz. Disseminated porphyroblasts of opaque minerals are found throughout.

QUARTS: Appear as partly rounded and partly oblong grains that are up to 2 mm long, and as small intergranular grains (less than 0,02 mm) which makes remnants of bigger grains. Paralell to concordant joints there are masses of small intergranular grains within the bigger. Joints which are normal to the layering, have less such crushed materials.

SERICITE: This mineral appear as ground mass, and is enriched in some smaller parts.

MICROCLINE: This mineral appear as often rounded porphyroclasts with a grain size ranging from 0,2 to 1 mm. Feldspar without twinnings appear as oblong c uched grains (partly sericite-

altered along joints). See fig 3.

OPAQUE MINERALS: These minerals are found disseminated throughout the whole section, both as euhedrale porphyroblasts (pyrite) and as joint-fillings (matrix for quartz and feldspar). Rusty sulphides appear in some smaller parts of the section. At these parts it seems that the opaque minerals have had an increase in volume. See fig 4.

Fig 3.

Radial fracturing around pyrite grains due to the growth of the pyrite.

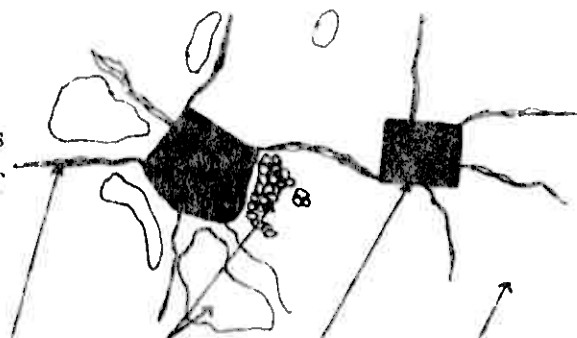
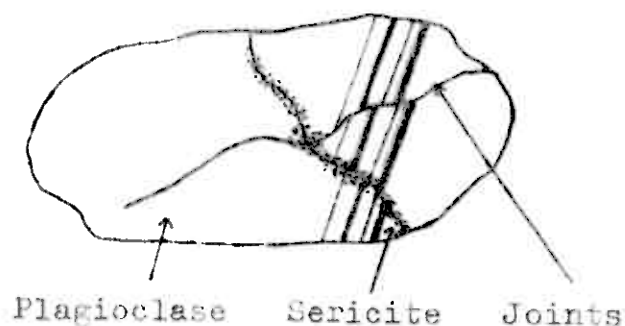


Fig 4.

Microfaulting in Plagioclase with sericite alteration along joints.



B.V.S. 5

60% Quartz

20% Microcline + Feldspar (Orthoclase)

15% Sericite

5% Opaque minerals

No chemical assays are run for this boulder.

Texture: This section shows a foliated texture with oblong quartz grains in a matrix of granular small quartz grains and sericite. The biggest grains are up to 2 mm long.

QUARTZ: Appear in the same way as in BVS. 5.

MICROCLINE: The mineral appears as well rounded porphyroclasts which are up to 0,5 mm. Feldspar (without twinnings) appear as oblong crushed grains (partly with sericite alteration along joints).

SERICITE: Appear as groundmass together with granular quartz

throughout the whole section.

OPAQUE MINERALS: Appear mostly as (joint fillings) groundmass for quartz and feldspar, but some euhedral pyrite grains are found throughout the whole section. One band with crushed microcline is observed (see fig 5)

Fig 5.

Mineralized
microcline band.



At this band it seems that the crushing of microcline grains have given rise to an "ore brain" (The obtained pore space are filled with ore minerals). Note that the crushed microcline have got a far bigger grain size than the crushed (recrystallized) quartz grains. This may mean that the feldspar make better "ore brains" than the quartz (We get a bigger pore space).

B.V.S. 7

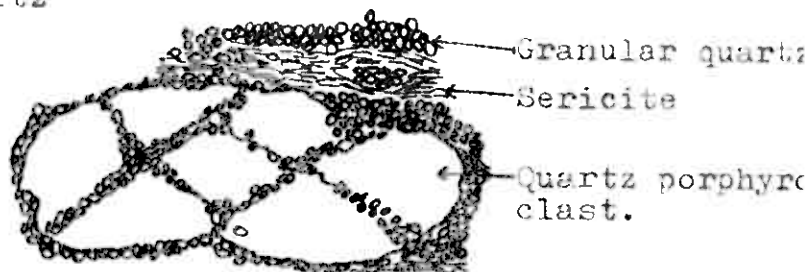
60% Quartz
16% Microcline
20% Sericite
4% Opaque minerals

The chemical assays of this boulder showed: Cu: nil, Zn: traces, Ag: 0,13 oz/ton, Pb: 1,00%.

The description of this thin section is the same as for BVS. 6, but with more crushing (less porphyroclasts) and more separation of sericite and granular quartz. The grain size of the biggest quartz grains are up to 4 mm. Pretty examples of granular crushing of quartz are found in this section. See fig 6.

Fig 6.

Fracturing of a quartz
porphyroclast
2mm



The ore minerals are enriched in areas of much pore space.

B.V.S. 8

50% Quartz
20% Microcline + Feldspar
20% Sericite
4% Opaque minerals

No chemical assays are run for this boulder.

The description of this section is the same as for BVS.7. The mineralization appear at joints and especially at joints in the feldspar grains.

B.V.S. 9

65% Quartz
10% Microcline + Feldspar
30% Sericite
5% Opaque minerals

The chemical assays of this boulder showed: Cu: nil, Zn: traces, Ag: 0,30 oz/ton, Pb: 3,79%

The description of this thin section is the same as for BVS. 7, apart from that there are less porphyroclasts and they are seldom more than 0,5 mm long. The ore minerals are mostly concentrated in a 3 mm thick band of fine crushed quartz.

POLISHED SECTIONS:

(100% means all the opaque minerals in the section.)

B.V.S. 1

95% Galena
5% Pyrite
Aksess Sphalerite
Aksess Chalcopyrite?

GALENA: The mineral appear as separated anhedral grains, and as joint-fillings. The grain size vary from less than 0,01 mm up to 1 mm.

PYRITE: The mineral appear as euhedral to subhedral grains with grain size ranging from 0,02 to 0,2 mm.

SPHALERITE: The mineral appears as small rounded inclusions in the galena. The grain size is between 0,01 and 0,05 mm. The mineral is isotropic and inner reflections are not visible.

CALCOPYRITE: The identification is very unsertant, but calcopyrite may be present.

B.V.S. 2

97% Galena

3% Pyrite

Description same as BVS. 1.

B.V.S. 3

100% Pyrite

+ One rusty band with iron hydroxides.

PYRITE: The mineral appear as euhedrale to subhedrale grains spread arund in the whole section.

B.V.S. 4

90% Pyrite

10% Iron hydroxides or galena

Description same as BVS.3. The iron hydroxides may be Gothite, but is hard to identify because of the very bad polished section. 4,06% Pb does however indicate that it is galena.

B.V.S. 5

20% Galena

80% Pyrite

Aksess Sphalerite?

This section shows "pore space fillings of galena", which are up to 2 mm wide. Pyrite appear as euhedrale to subhedrale grains randomly distributed throughout the whole section. The grain size is up to 0,4 mm. Sphalerite? appear as small inclusions in the pyrite. The mineral has grey colour and is darker than galena. It is isotropic or almost isotropic, and has no inner reflections.

B.V.S. 6

60% Galena

20% Pyrite

20% Iron hydroxides

Aksess Sphalerite

Galena appear in the same way as in BVS. 5. Pyrite appear as subhedrale to anhedral grains spread around in the whole section. In most cases the grains are partly replaced by iron-hydroxides(probably gothite). Relict structures from pyrite are sometimes seen in the gothite. The gothite is anisotropic, reflectance same as sphalerite, grey and relief same as pyrite. Sphalerite? appear in the same way as in BVS.5.

B.V.S. 7

85% Galena
8% Hematite?
5% Iron hydroxides
2% Pyrrhotite

Galena appears as in BVS: 5. Then there are probably at least three facies of ironoxides. One of them is probably hematite, and another is gothite. Replacement structures are common. In addition to these, there are probably a few grains of iron sulphides(Pyrrhitite).

B.V.S. 8

83% Galena
15% Iron hydroxides
2% Sphalerite

Galena appear as small(0,05 mm) "porespace-fillings". Iron hydroxides are seen as "cloude" in joints and in some places it seems partly to replace galena. Sphalerite is found as one 0,01 mm oblong grain.

B.V.S. 9

50% Pyrite
50% Galena
+ Iron hydroxides

No espessial comments on this polished section.

CONCLUDING REMARCS:

The preparation of both the thinn and the polished sections are very bad. With better sections we would probably have got much more information out of this investigation.

April 1984

Siv. ing. O.Bakke

MICROSCOPICAL OVERVIEW OF MINERALIZED BOULDERS AND OUTCROPS IN THE ATNA AREA

In the 1984 field season it was discovered mineralized boulders in an area approx. 10 km. NW of Atna station in the sparagmite project(N-82-5). After this discovery a follow-up grid was established, and a regional block survey together with geological mapping was carried out in the surrounding area. This survey revealed a lot of weakly mineralized boulders and a few weakly mineralized outcrops. Some of these boulders and rock samples from the outcrops, were analyzed for zinc, lead, copper and silver and some for gold. The best individual values of these elements was respectively: 0,56%, 2,37%, 0,65%, 15 ppm and 160 ppb.

Together 12 thin and 12 polished sections have been made. 9 of them from mineralized boulders and 3 from an outcrop of a Cu-Pb mineralized conglomerate at Ledsageren, about 2 km south of the grid.

The rock type of all the boulders belong to the Vangsås formation. Roughly estimated rock compositions from the microscopical investigation are plotted in fig 1. next side. They show that the mean composition of the boulders is a subarkose or a feldspatic quartzite, and that the Ledsageren mineralization is situated in a more feldspatic and clayrich rock-type. The composition of boulder no. 2 and 4, are not representative of the mineralized boulders, because similar mineralized boulders are not found anywhere else in the area.

The mineralization appear in two different ways: as disseminated often spotty matrix material, and as remobilized mineralization on quartz veins. In both cases the mineralization appear mainly in a dark feldspatic rock, although it has also been observed in an almost white and pure quartzite(sample no 42). The microscopic investigation has revealed a very simple mineralogy. The major ore mineral of the disseminated type is galena and the remobilized type contain often either galena or sphalerite. Pyrite do always accompany the ore mineralizations.

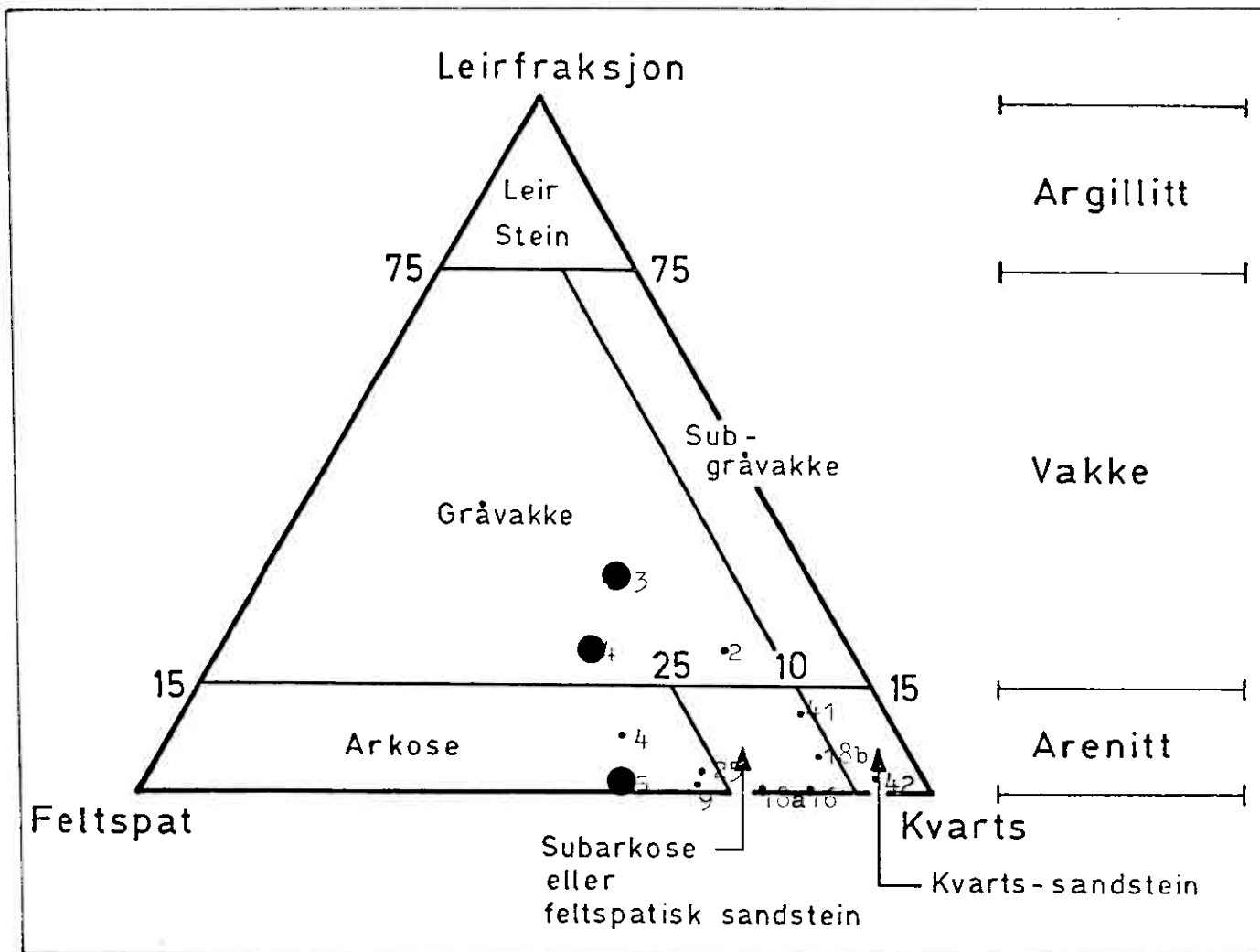


Fig. 1. Klassifikasjon av epiklastiske sedimenter.
Modifisert etter Pettijohn (1961).

- Boulders from Atna with sample number
- Rock samples from Ledsageren with sample number

The investigations of the thinn sections showed that most of the rock have a quite immature habitus with clasts that are only partly rounded, has a high feldspar content (as microcline) and has a considerable content of clay minerals. This support the genetic model, which was put forward by J.P. Nystuen in 1982, that Vardal member of the Vangsås formation was deposited near the margin of a tectonically active basin. Nystuen has given a comprehensive outline of the basin's evolution. This evolution is illustrated by conceptual models in Fig. 32-39.

For further studies on this subject, I recommend the paper of J.P. Nystuen: "Late Proterozoic Basin Evolution on the Balto-scandian Craton: the Hedemark Group, Southern Norway" N.G.U. No 372.

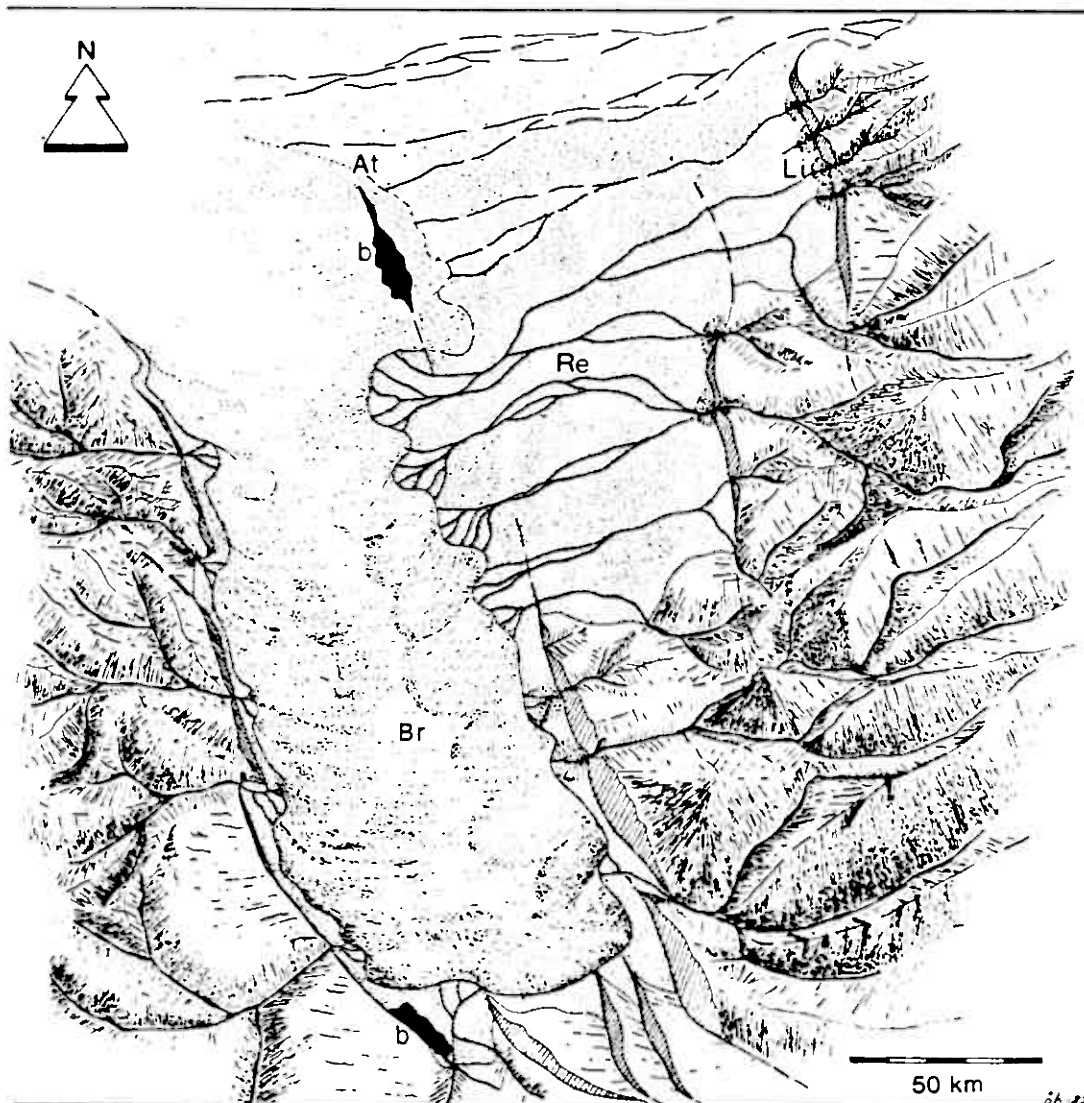


Fig. 32. Model of the Hedmark Group basin in the time prior to the Varanger Ice Age and the deposition of the Biri Formation. Br = Brøttum turbidite basin, Re = Rendalen braided plain, Li = Lillesjøberget alluvial fans, At = Arna coastal and shallow-marine sands, b = basalts of local extent associated with fissure eruptions. The evolution of the central northern and northeastern part of the basin is shown in the simplified conceptual diagrams in Figures 33–39. In these diagrams lateral facies variations are strongly condensed and the vertical scale is much exaggerated.

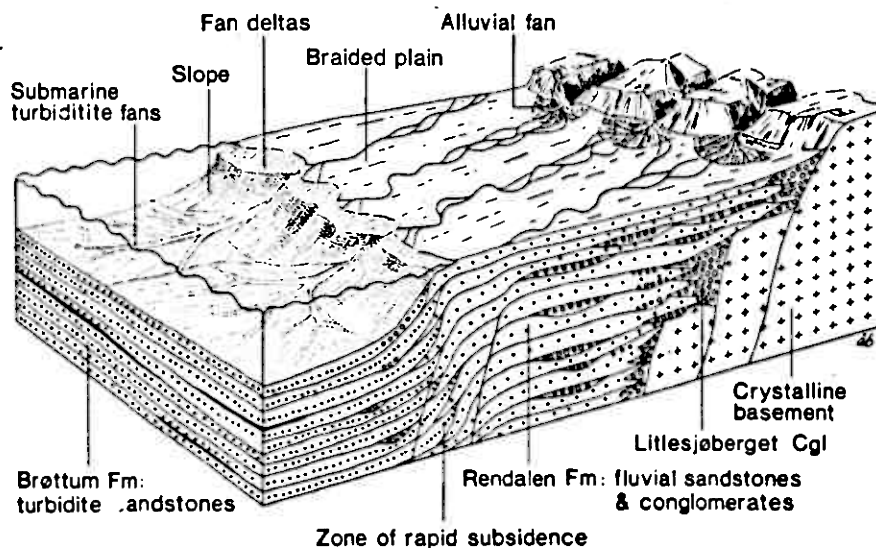


Fig. 33. Sedimentation of the Rendalen and Brøttum Formations, east to the right, west to the left.

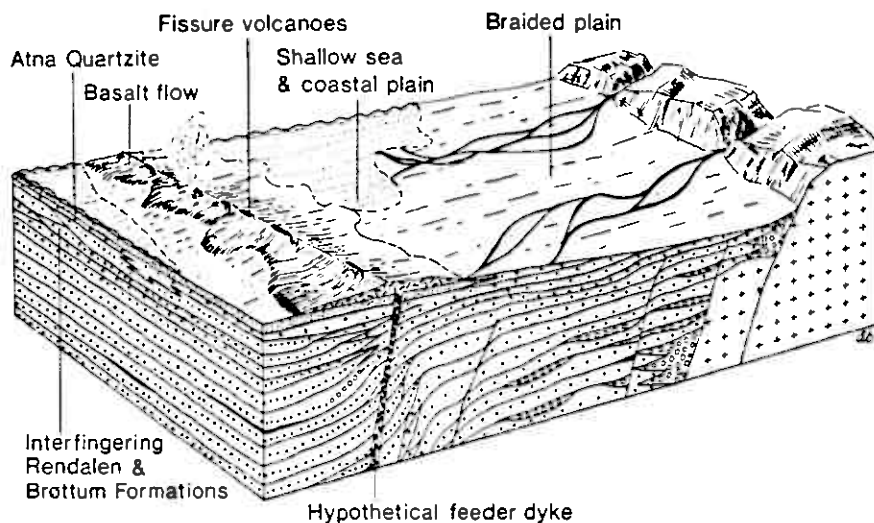


Fig. 34. Local basalt eruptions and deposition of the Atna Quartzite in the northern central part of the basin.

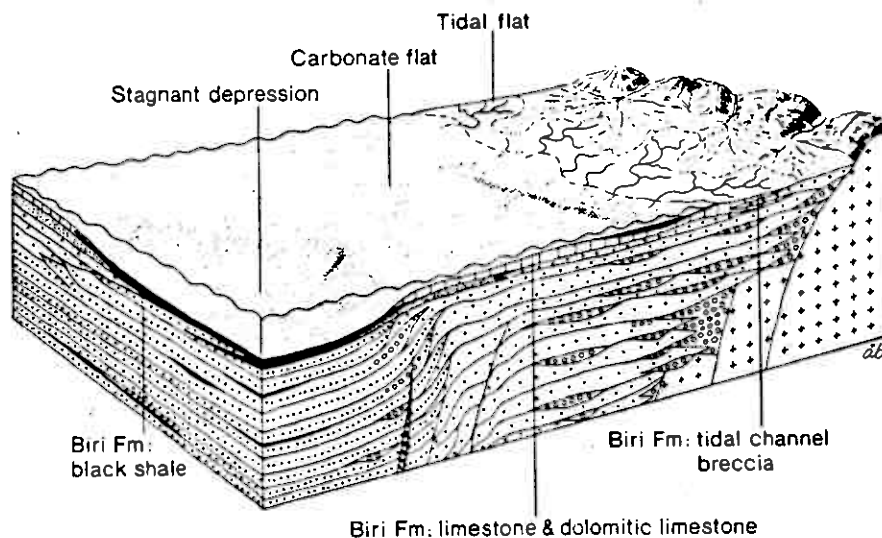


Fig. 35. Early depositional phase of the Biri Formation. This area, and those shown in the following figures, is thought to be located south of the volcanic area in Fig. 34.

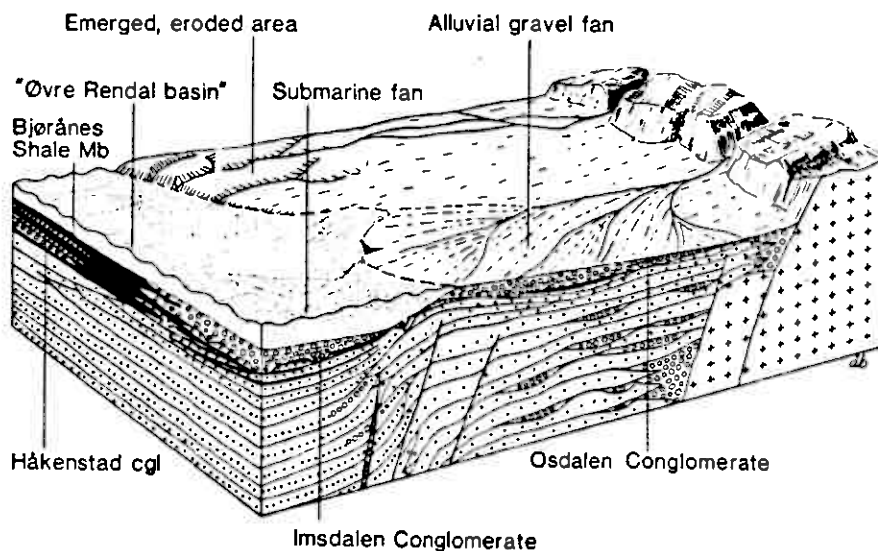


Fig. 36. Deposition of the Osdalen and Imsdalen Conglomerate and sedimentation of the Bjørånes Shale Member (Biri Fm) in the secondary 'Øvre Rendal' basin. Intermittent influx of coarse-clastic sand and gravel into the secondary basin has given rise to turbidite sandstones and the local Håkenstad conglomerate.

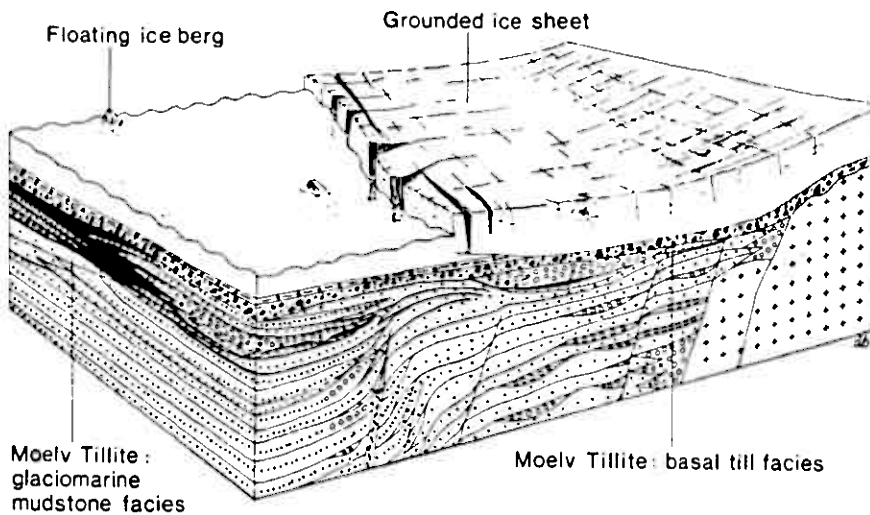


Fig. 37. Deposition of the Moelv Tillite during the Varanger Ice Age. The ice sheet is shown in a retreating phase with sedimentation of glaciomarine mud above basal till.

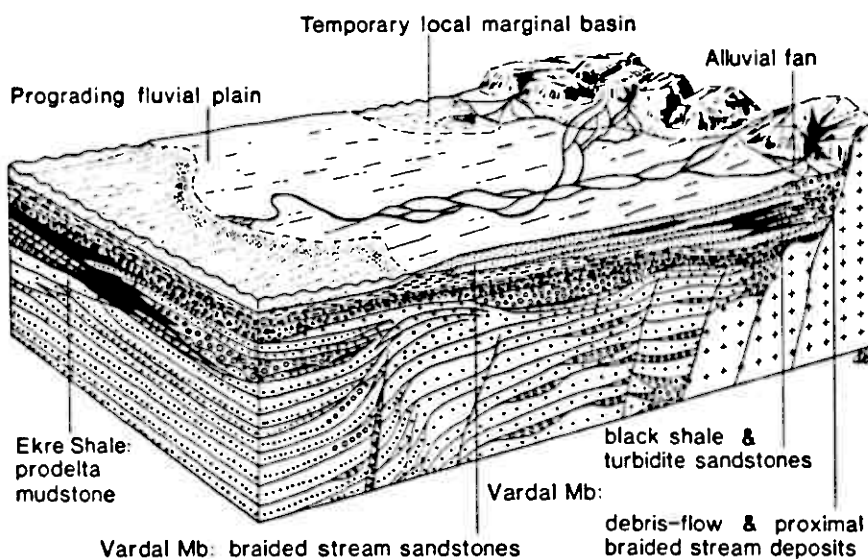


Fig. 38. Progradation of deltas and braided plains during deposition of the Ekre Shale and the Vardal Sandstone Member (Vangsås Formation). Marginal facies in the east consist of subaqueous gravity flow deposits and black shale, overlain by alluvial fan sediments.

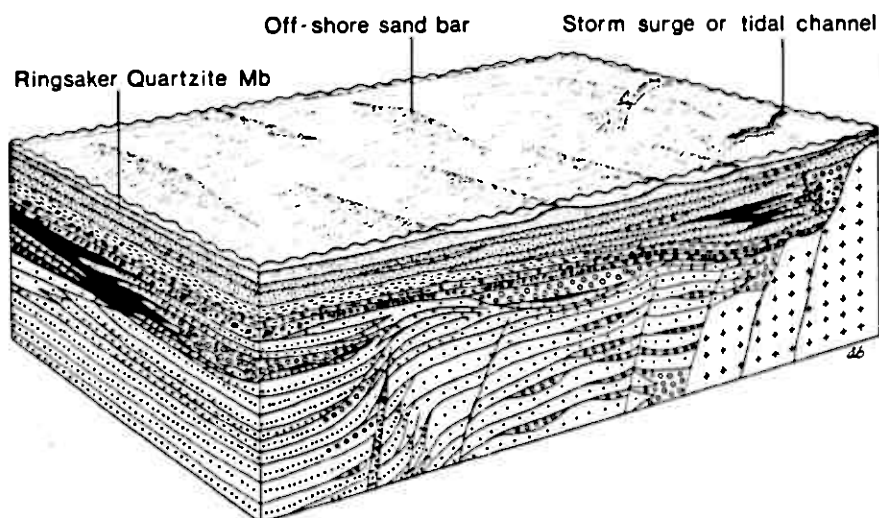


Fig. 39. Deposition of the Ringsaker Quartzite Member (upper member of the Vangsås Formation) in Early Cambrian time. The quartz sand was also deposited on to the denuded crystalline basement to the east, far beyond the old tectonic basin margins.

Since the mineralogy of the host rocks seems to have limited influence on the mineralization little attention is made on it. One important fact however, is that the ore minerals seems to have a spatial relation to crushed feldspar grains, and that it is almost abundant in rocks with a clayrich matrix. This indicate that the porosity of the rock is one of the most important factor in the distribution of the ore minerals. The primary porosity between the detrital grains is mainly occupied with clay minerals but the post depositional porosity obtained by the crushing of feldspar grains are available for deposition of ore minerals. When the quartz grains are exposed for stress, they seems to form granular smaller grains with very little pore space between the individual grains. Ore minerals are also in some sections spatial related to open space fissurs.

The secondary quartz veins with remobilized ore minerals are sometimes associated by carbonate.

The mean grades of the 29 assayed boulders are: Cu: 39,5 ppm with Q_n 32,71, Zn: 1309 ppm with Q_n 1452,43 and Pb: 3790 ppm with Q_n 6149,90. Boulders with the highest Zn or Pb values were assayed for Ag which rang from 1 to 15 ppm. The Pb/Ag, Zn/Ag and Pb+Zn/Ag ratios are all varying very much. This may partly be caused by inaccurate Ag values and partly because we have assayed to few of the boulders for Ag.

The samples from the Ledsageren mineralization is collected from different parts of the mineralization which makes it difficult and very speculativ to pick out any trends.

Some brief notes from the microscopical investigation follows:

Section no: 84-ATB-4

35% Microcline + (Aksess)Plagioclase

55% Quatz

8% Sericite

2% Opaque minerals 1% Sphalerite

1% Pyrite

The chemical assays of this rock-sample showed: Cu 61ppm, Zn 4122ppm and Pb 677ppm.

TEXTURE: This rock shows a matrix beared coarse grained arkose with partly rounded porphyroclasts.

Quartz: The mineral appear in a bimodal way, both as porphyroclasts and as crushed granular matrix material. The grains are partly rounded, and the size rang from 0,2 to 5 mm. Sometimes the porphyroclasts have inclusions of small granular quartz grains which follow joints. The quartz in the matrix material is very fine grained(less than 0,01 mm).

Microcline: The mineral appear as porphyroclasts in the same way as the quartz, but often more cracked. The cracked feldspar grains are often excellent ore brines. Microcline may also be present in the matrix material, but are not detectable with ordinary microscop.

Plagioclase: The mineral is only detected as one 0,5 mm big porphyroclast. It is often hard to distinguish it from microcline, which makes the quantitative measurements unreliable.

Sericite: The mineral is mostly restricted to joints where it appear together with very fine grained quartz.

Pyrite: The mineral apper as up to 0,4 mm big subhedrale to anhedrale grains which are very contaminated by transparante minerals. Most commonly it appear as very small(0,01 mm) irregular shaped grains. Birds eyes textures are common.

Sphalerite: The mineral appear as randomly distributed irregular shaped grains throughout the whole section. The grain size are commonly about 0,1 mm.

Section no: 84-ATB-9

67% Quartz

29% Microcline

1% Sericite

3% Opaque minerals 1% Pyrite

1% Sphalerite

1% Galena

The chemical assays of this rock-sample showed: Cu 32ppm, Zn 3525ppm, Pb 15024ppm and Ag 6ppm.

TEXTURE: This is a medium grained homogeneous arkose with partly rounded grains. It has a bimodal habitus, with porphyroclasts (up to 0,5 mm) floating in a matrix of granular fine grained quartz(approx. 0,05 mm).

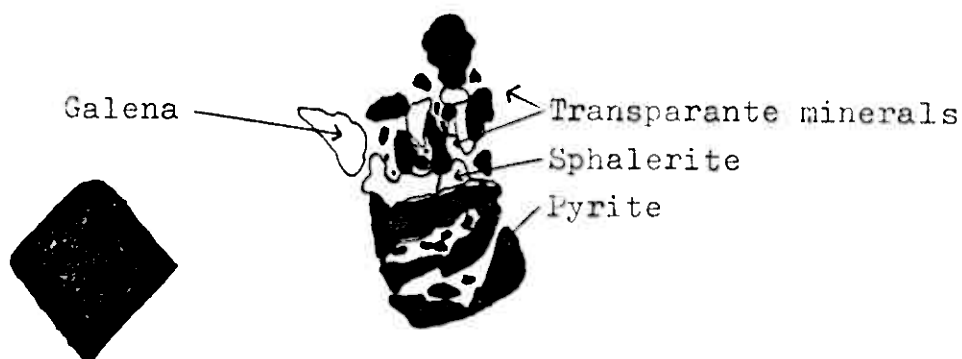
Quartz: The mineral appear as porphyroclasts and as granular matrix material.

Microcline: The mineral appear in the same way as the quartz porphyroclasts. The mineral is sometimes partly altered

Sericite: A few flakes are observed in the matrix.

Pyrite: The mineral appear as euhedrale to subhedrale grains which usually are about 0,1 mm big. In some places the grains seems crushed. See fig 2.

Fig. 2.



Sphalerite: This mineral appear as anhedral grains, which are from 0,01 to 0,1 mm big. The border against host rocks are usually concave. The mineral dominate in other parts of the section than galena, but in spite of this they are seen in contact with each other in a few places.

Galena: The mineral appear in the same way as sphalerite, but usually separated from it.

Section no: 84-ATB-2

61% Quartz

18% Sericite

13% Microcline

2% Plagioclase

3% Carbonate

1% Clorite

Aksess Biotite?

3% Opaque minerals 1% Pyrite

1% Galena

1% Sphalerite

The chemical assays of this rock-sample showed: Cu 15ppm, Zn 1118ppm and Pb 2496ppm.

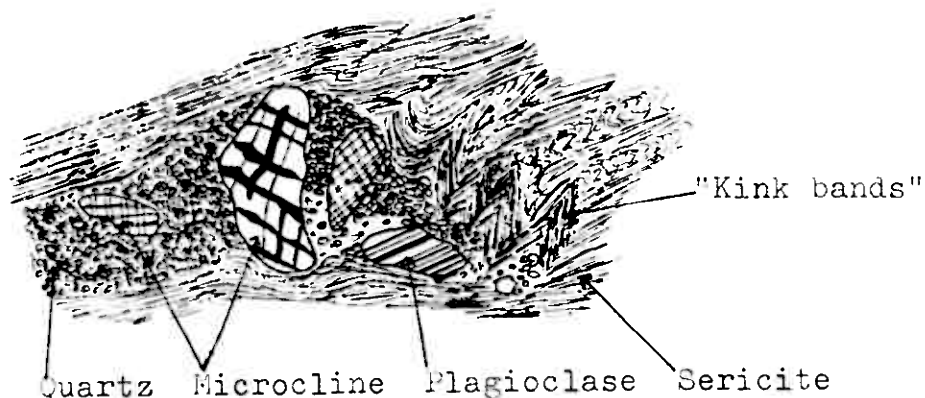
Texture: This section shows a banded texture. The bands consists of crushed granular small quartz grains, sericite, bands of bigger cracked feldspar grains and bands enriched in carbonate.

Quartz: The mineral appear in a bimodal way, as small granular

crushed grains and as bigger cracked grains. Both the big (up to 2mm) and the small (up to 0,1 mm) are strongly undulating.

Sericite: Appear as bands through the whole section. The mineral is often folded and in some places kink bands are developed, specially in "low pressure areas" see fig 3.

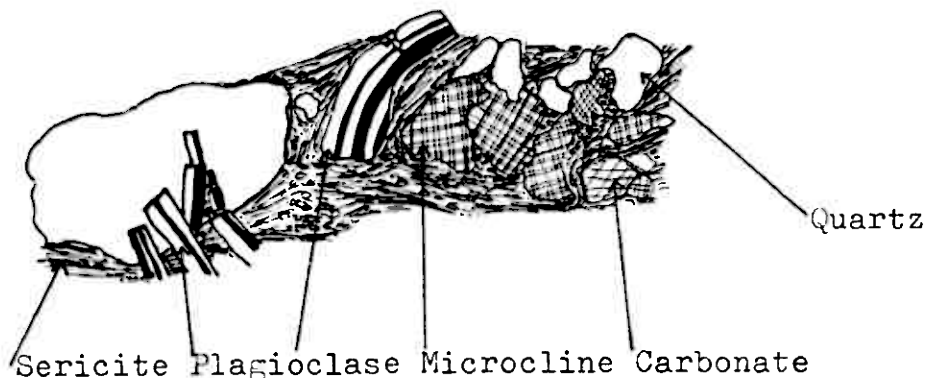
Fig 3.



Microcline: The mineral appear as porphyroclasts throughout the whole section, but are enriched in selected bands. The grain size rang from 0,2 to 2 mm. Bigger grains are always cracked.

Plagioclase: The mineral appear as lists which cut into big quartz and microcline grains, and as individual porphyroclasts. The grain size rang from 0,1 to 0,5 mm. In some places the twinnings are curved. See fig 4.

Fig 4.



Carbonate: The minerals appear as matrix in selected bands.

Clorite: This mineral is observed in only one place in this thinn section. It appear as a big (up to 1mm) clast with individual grains(lists), which are up to 0,5 mm long. The mineral has 1.order interferenscolours, but near the grain-bondaries they are often anomale.

Biotite: Identification of this mineral is very unreliable, but some small grains (up to 0,02 mm) of a light green mineral with a weak pleokroisme may be biotite.

Pyrite: The mineral appear as euhedrale to anhedrale grains in selected bands. The grain size rang from 0,01 to 0,4 mm.

Galena: The mineral appear as irregular shaped grains which are up to 1mm big

Spherite: The mineral appear in one band, in the same way as galena, and often in convex contact with galena.

Section no: 84-ATB-16

83% Quartz

10% Microcline

4% Orthoclase

1% Plagioclase

Aksess Zircon

Aksess Sericite

2% Opaque minerals 1% Sphalerite

1% Pyrite

TEXTURE: This is a medium grained homogeneous arkose, with partly rounded grains. It has a bimodal habitus, with porphyroclasts (up to 0,5 mm) floating in a matrix of granular fine grained quartz. The rock is cut by secondary veins of quartz and orthoclase.

Quartz: The mineral appear as porphyroclasts, matrix material and as vein fillings.

Microcline: The mineral appear as porphyroclasts.

Plagioclase: This mineral is found in the same way as microcline

Orthoclase: The mineral appear as anhedrale 0,5 mm big grains together with quartz in veins. It has no twinnings and is often partly altered. The identification is uncertain.

Zircon: A few rounded (0,05 to 0,2 mm) grains of zircon are found throughout the whole section.

Sericite: A few small flakes are observed.

Sphalerite: Appear as randomly disstribuated anhedrale grains, which are up to 0,1 mm big. It is also observed as inclusions in pyrite.

Pyrite: Appear as euhedrale to subhedrale grains which are from 0,01 to 0,2 mm big. In some places it is crushed. See fig 2.

The chemical assays of this rock-sample showed: Cu 44ppm, Zn 5567ppm, Pb 109ppm and Ag 1ppm.

Section no: 84-ATB-18a

77% Quartz

20% Microcline

1% Plagioclase

Aksess Sericite

2% Opaque minerals 1% Sphalerite

1% Pyrite

Aksess Galena

The chemical assays of this rock-sample showed: Cu 16ppm, Zn 2566ppm, Pb 2132ppm and Ag 1ppm.

TEXTURE: This is a quartz-rich arkose very similar to 84-ATB-9 and 84-ATB-16. The matrix beared porphyroclasts are just partly rounded.

Quartz: The mineral appear as porphyroclasts which are up to 2 mm big. In addition it is the main matrix mineral, where it is found as granular crushed small(0,01 mm) grains.

Microcline: The mineral is found as irregular shaped porphyroclasts, which are up to 2 mm big. Some of the grains are partly altered and some of them have poorly or not developed microcline twinnings. This may mean that some of the grains which are interpreted as microcline actually are Orthoclase.

Plagioclase: This mineral appear in the same way as microcline.

Sericite: A few grains of fine grained light mica are found throughout.

Sphalerite: This mineral appear as anhedral grains throughout the whole section. The grain size are up to 0,1 mm.

Pyrite: This mineral appear as subhedral to euhedral grains which usually are less than 0,02 mm, but grains up to 0,2 mm is found in some places.

Galena: The mineral is just observed in two anhedral 0,1 mm long grains.

Section no: 84-ATB-18b

81% Quartz

10% Microcline

5% Sericite

2% Plagioclase

Aksess Zircon

2% Opaque minerals 1% Sphalerite

1% Pyrite

Aksess Galena

For chemical assays, see 84-ATB-18a.

TEXTURE: This thin section shows a bimodal habitus with porphyroclasts of quartz, microcline and plagioclase (up to 0,5 mm big) which are partly rounded, floating in a matrix of crushed quartz, microcline and sericite.

Quartz: The mineral appears as partly rounded porphyroclasts and as granular ground mass, with clast size up to 0,2 mm. The quartz is strongly undulating.

Microcline: The mineral appears as irregular shaped porphyroclasts. In some grains the microcline twinnings are not developed. This means that some of the grains may be orthoclase. Some of the grains are partly altered.

Plagioclase: The mineral appears in the same way as microcline.

Sericite: Appears as matrix material. In addition some bigger flakes of light mica (up to 0,5 mm) are observed.

Zircon: There are found a few grains of well rounded (0,1 mm big) zircon in this section.

Opaque minerals: The opaque minerals appear in the same way as in section no. 84-ATB-18a.

Section no: 84-ATB-25

69% Quartz

25% Microcline

3% Sericite

2% Plagioclase

Akness Calcite

Akness Zircon

1% Opaque minerals 1% Pyrite

Akness Sphalerite

Akness Galena

The chemical assays of this rock-sample showed: Cu 29ppm, Zn 774ppm, Pb 13302ppm and Ag 15 ppm.

TEXTURE: This rock shows a bimodal texture, with big (up to 2 mm) clasts floating in a matrix of sericite and crushed granular quartz.

Quartz: The mineral appears both as porphyroclasts and as granular matrix material.

Microcline: The mineral appears as porphyroclasts which are often cracked.

Sericite: Fine grained light mica are found as a part of the matrix.

Plagioclase: The mineral appears in the same way as microcline. The An-content is low, corresponding to an oligoclase.

Calcite: The mineral are detected at a few places, but may constitute a considerable part of the matrix as fine grained material(submicroscopic).

Zircon: A few grains of well rounded grains of zircon are found. they are up to 0,2 mm big.

Pyrite: The mineral appear as up to 0,3 mm big subhedrale grains randomly disstribuated throughout the whole section.

Sphalerite: The mineral appear as randomly dis tributed irregular shaped grains throughout the whole section. The grain size is commonly about 0,1 mm.

Galena: A few rains are detected. They appear in the same way as sphalerite.

Section no: 84-ATB-41

75% Quartz

10% Microcline

10% Sericite

1% Plagioclase

Aksess Zircon

4% Opaque minerals 3% Galena

1% Sphalerite

Aksess Pyrite

The chemical assays of this rock-sample showed: Cu 78ppm, Zn 514ppm, Pb 23683ppm and Ag 10ppm.

TEXTURE: This rock has a layered habitus. One layer has clasts which are from 0,1 to 2 mm big, floating in a matrix of crushed quartz and sericite. Another layer consists of smaller porphyroclasts commonly about 0,2 mm big, floating in a matrix of mainly sericite. Some layers carry very little sericite, and they are the richest mineralized layers(maybe up to 10% Pb).

Quartz: The mineral appear as porphyroclasts with a big rang in grain size(from 0,2 to 2 mm). The clasts are often well rounded.

Microcline: The mineral appear as porphyroclasts in the same way as quartz.

Plagioclase: The mineral appear in the same way as microcline.

Sericite: Sericite is most common in the finest grained layers, but are found throughout.

Zircon: A few small(0,1 mm) rounded grains are observed.

Galena: The mineral appear as anhedrale grains which often have concave borders against host rock minerals. The grain size rang from very small(submicroscopic) to 2 mm.

Sphalerite: Appear in the same way as galena.

Pyrite: The mineral is found as a few euhedrale small(0,05 mm) grains.

Section no: 84-ATS-42

89% Quartz

5% Microcline

2% Sericite

1% Calcite

1% Plagioclase

Akess Chlorite

3% Opaque minerals 2% Galena

1% Pyrite

Akess Sphalerite

This rock-sample is not analysed.

TEXTURE: This is a medium grained(up to 1 mm) feldspathic quartzite. It has a bimodal habitus, with well rounded quartz and feldspar clasts floating in a matrix of crushed granular quartz. The preparation of this thin section is very bad

Quartz: The mineral appear both as well rounded porphyroclasts, and as granular ground mass(0,1 mm).

Microcline: The mineral appear as well rounded porphyroclasts.

Sericite: The mineral is found as a part of the matrix material.

Plagioclase: The mineral appear in the same way as microcline.

Calcite: The identification is very uncertain, because at least a part of it may be contamination of a liquid below the cover-glas.

Chlorite: One aggregate of chlorite is found.

Galena: The mineral appear as anhedral grains, usually with a concave border to the host rock minerals. The grain size range from submicroscopic to 0,2 mm.

Pyrite: The mineral appear as euhedral to subhedral grains which are up to 0,2 mm big. In the microscop it does not seem to be any spatial connection between pyrite and galena, but in hand specimens pyrite and galena together gives it a spotty habitus.

Sphalerite: The mineral appear in the same way as galena.

LEDSAGEREN:

Section no: 84-LED-4

45% Quartz

30% Microcline

20% Light mica (Sericite)

2% Plagioclase

3% Cpaque minerals 3% Chalcopyrite

Aksess Galena

Aksess Sphalerite

The chemical assays of this rock-sample showed: Cu 6500 ppm, Zn 40 ppm, Pb 64 ppm, Ag 13 ppm and Au 160 ppb.

TEXTURE: This thinn section shows a matrix beared arkose. The matrix consists of crushed granular quartz grains, and the porphyroclasts consists of quartz, microcline and plagioclase. The rock is not very mature, since there are a lot of feldspar in it, and since the porphyroclasts are just partly rounded.

Quartz: The mineral appear both as partly rounded porphyroclasts and as crushed granular matrix. The grainsize of the porphyroclasts rang from 0,2 to 0,8 mm and the grainsize of the matrix quartz is commonly about 0,05 mm. The mineral is strongly undulating.

Microcline: This mineral appear together with quartz as porphyroclasts and approx. with the same grain size. The mineral is not observed as a component of the matrix.

Ligth mica(Sericite): The mineral appear as matrix material which almost always separate the porphyroclasts. Near big porphyroclasts and joints it is often folded. Some lists of ligth mica (Muscovite) are also found as porphyroclasts. These lists are probably products of totally altered plagioclase.

Plagioclase: The mineral appear in the same way as microcline. The An-content is probably law, corresponding to an oligoclase.

Chalcopyrite: The mineral appear as irregular randomly distributed grains.

Galena: The mineral appear in an intimate intergrowth with sphalerite.

Sphalerite: Appear in the same way as galena.

Section no: 84-LED-3

43% Quartz

24% Microcline

30% Sericite

Akses Zircon

3% Opaque minerals 1% Chalcopyrite

1% Galena

1% Sphalerite

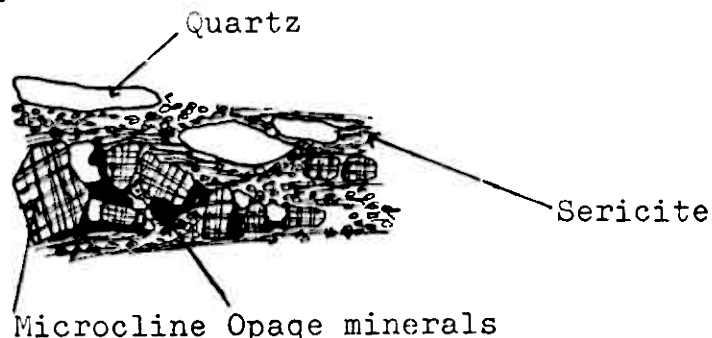
The chemical assays of this rock-sample showed: Cu 900 ppm, Zn 1900 ppm, Pb 6000 ppm, Ag 12 ppm and Au less than 2 ppb.

TEXTURE: This section shows a distinct banded rock-type. One part of the section consists of oblong quartz and microcline grains floating in a matrix of granular quartz and sericite. The other part consists of a finegrained foliated rock without porphyroclaster.

Quartz: The mineral appear as oblong (up to 1 mm long) grains and as granular fine grained (0,05 mm) matrix in the coarse grained part, and as more irregular shaped grains in the fine-grained part. The biggest grains of the fine grained part, are not more than 0,1 mm.

Microcline: The mineral appear together with quartz as porphyroclasts in the coarse grained part. One distinct difference in habitus between these two minerals, is that the microcline seems to be cracked and partly separated which gives them an irregular shape, on the other hand, the quartz always seems to have an oblong shape without cracks. This difference in behaviour when they are exposed for stress, has probably an important influence on the distribution of the ore minerals. See fig 5.

Fig 5.



At fig 5. we see that the opaque minerals seems to have an affinity to microcline which are probably caused by the "space" available and obtained by the cracking of the grains. Microcline is also a common constitute of the fine grained part of the

section where it appear in the same way as quartz.

Sericite: The mineral is most common in the fine grained part of the section. A few grains of lighth mica (up to 0,1 mm) are also found in the coarse grained part of the section.

Zircon: One 0,05 mm big rounded grain is observed.

Chalcopyrite: The mineral appear as randomly distributed irregular shaped grains enriched in one part of the section.

Galena: The mineral appear in an intimate intergrowth with sphalerite.

Sphalerite: Appear in the same way as galena.

Section no: 84-LED-5

47% Quartz

30% Microcline + Albite

20% Calcite

1% Lighth mica (Sericite

Aksess Plagioclase

2% Opaque minerals 2% Galena

Aksess Sphalerite

Aksess Chalcopyrite

The chemical assays of this rock-sample showed: Cu 110 ppm, Zn 370 ppm, Pb 4100 ppm, Ag 5,5 ppm and Au 2ppb.

TEXTURE: This section shows irregular shaped porphyroclasts of quartz and microcline floating in a matrix of crushed quartz and microcline, calcite and sericite.

Quartz: The mineral appear in a bimodal way, both as irregular shaped porphyroclasts (up to 2 mm) and as matrix material (less than 0,05 mm). The mineral is strongly undulating.

Microcline: The mineral appear as porphyroclasts in the same way as quartz, but are some places cracked. The opaque minerals seems to have an affinity to the cracked feldspar grains. This is probably caused by the "open space" available. The mineral has in some places a spotty habitus, which may be caused by a content of albite (spotty pertite). Weak alteration of the mineral is common.

Plagioclase: The mineral appear in the same way as microcline.

Lighth mica: Some grains of sericite are found throughout the whole section, and the grain size are up to 1 mm.

Calcite: The mineral constitute the main matrix material. In addition it appear as bigger grains or aggregates of grains which are up to 2 mm.

Galena: The mineral is enriched in one small part of the section where it appear as the main matrix mineral.

Sphalerite: Traces of sphalerite are found throughout the whole section.

Chalcopyrite: The mineral is found as one irregular shaped small grain(0,2 mm).

Decemper 1984

Siv. ing. O.Bakke

Folldal Verk A/S-AMOCO NORWAY J. V.

SPARAGMITE PROJECT N. 82.5
Grids Brennvola / Langen

En kvartærgeologisk vurdering

cand. real. Tom E. Henriksen

INNLEDNING

Etter avtale med geolog Krause ved Folldal Verk A/S ble det primo juni 1984 utført kvartærgeologisk registreringsarbeid i området nord for Femunden, Sør-Trøndelag fylke.

Oppdraget ble formidlet av Geografisk Institutt, UiO, v/prof. Sollid og rapporten utarbeidet ved instituttets laboratorium for fjernanalyse og temakartlegging.

Arbeidet besto i synfaring av løsmassedekket og de glacialgeologiske formelementene innen deler av kartbladet RØA, NGO's serie M711: 1719 I, 1:50 000. Etter flyfototolkning ble det framstilt en kartskisse (1:25 000) over det undersøkte området mellom Femundsåsen og Brennwola. Detaljstudier av morenematerialet ble gjort for å finne transportretning og -lengde av blokker med blyglansmineralisering i to distinkt adskilte blokktoget i området.

Blokktoget var registrert av Folldal Verk A/S og hver blokk inntegnet på et kart (1:5000) med to grid: BRENNVOLA (BRV) og LANGEN (LA). Stedsreferanser vil heretter eneten bli gitt i gridkoordinater eller i UTM koordinater. Retninger angies i 400°, korrigert for missvisning.

Det foreligger en generell kvartærgeologisk beskrivelse av området ved en upublisert hovedfagsoppgave av Dagfinn Trømborg: "Isavsmeltingen i området rundt nordenden av Femunden" (1963).

KORT OM ISSKILLET OG ISAVSMELTINGEN

Etter Weichseltidens siste maksimum (18 000 BP) smeltet den over kilometertykke innlandsisen for det meste vertikalt ned i de sentrale delene av Sør-Norge (Mannerfelt 1945). Den lokale topografien hadde liten styring på isbevegelsen, det var breoverflatens helning, og dermed isskillets posisjon som bestemte strømningsmønsteret. Etter hvert som istykkelsen avtok ble terrengstyringen større, men i området rundt Femunden er relieffet for lite til å ha påvirket isbevegelsen før i den aller siste avsmeltingsfasen. I denne fasen var isen så tynn og akkumulasjonen av snø på brekulen så liten at bevegelsen nærmest var opphørt, i alle fall i de basale delene. De siste isrestene forsvant antagelig fra de høyereliggende bekkenene (Femunden-bassenget) for ca 8500 år siden.

Den vertikale nedsmeltingen førte også til at ende-, side- og midtmorener ikke gjenfinnes i dette området, unntatt der hvor et fjellmassiv har stått direkte i veien for isbevegelsen (Rendalsølen), eller i høytliggende områder med botnbreaktivitet (Rondane). De typiske glasiologiske formelementene fra iskulminasjonsonen og utover er: ROGENMORENER-DRUMLINER-FLUTING, se figur 1 og 2 (Sugden & John 1976, Aario 1977,

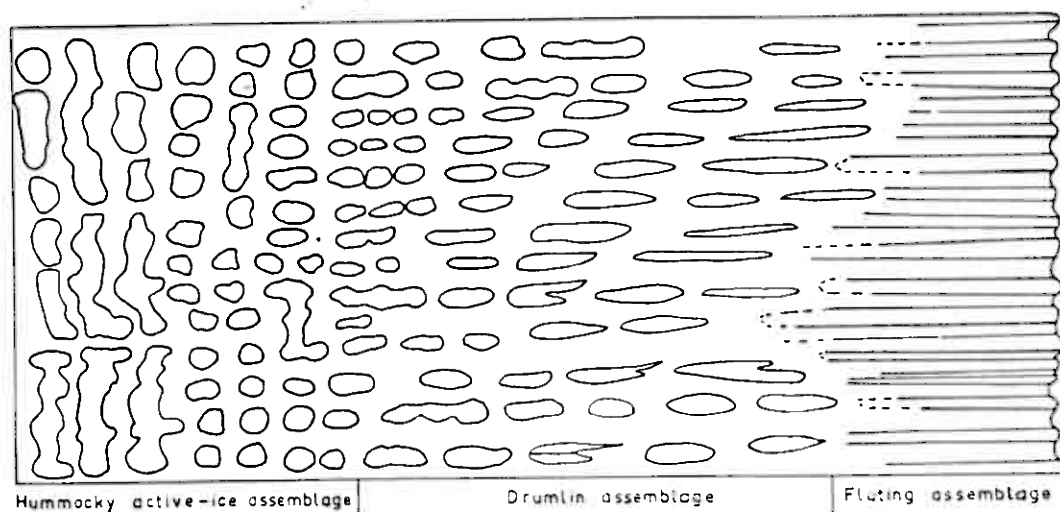
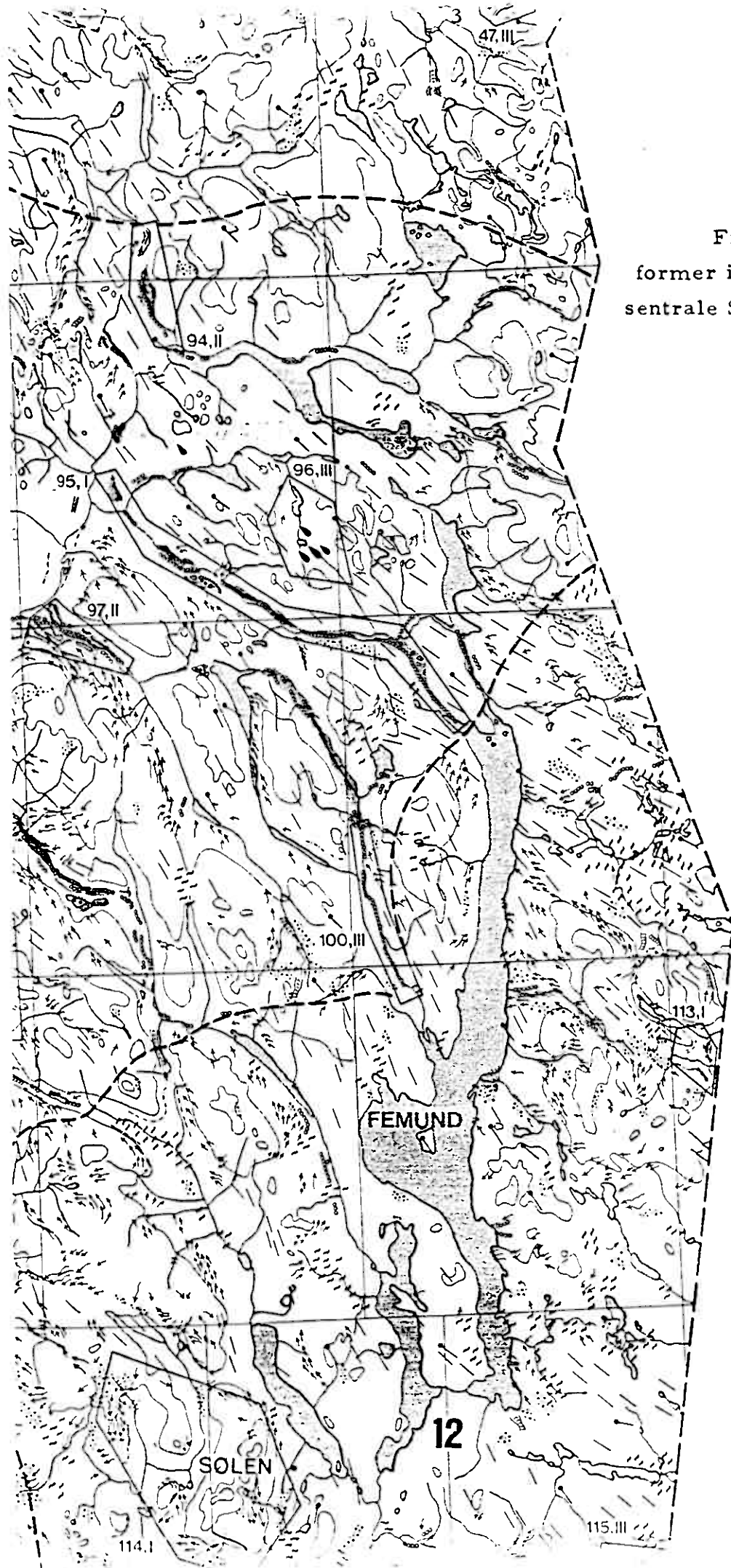


Fig. 1 A transitional series of active-ice assemblages: the fluting assemblage, the drumlin assemblage, and the hummocky assemblage. Flow was from left to right. Spiral flow predominates in the formation of flutings and linear drumlins, whereas up and down movement predominates in the formation of the hummocky member. Between the end members combinations of these flow patterns occur.

Fra Aario 1977

Fig 2: Kwartærgeologiske former i de østre delene av det sentrale Sør-Norge.

Sollid&Kristiansen 1983



- ISBREER (ETTER ØSTREM G. & ZIEGLER T 1969)
- SKURINGSSTRIPER 1. ELDRE 2. YNGRE
- PARALLELLE STRIPNINGER I OVERFLATA
- DRUMLIN
- ROGNEMORENER
- HAUGER I LOSMATERIALE
- ENDE- OG SIDEMORENER
- SPYLERENNE, SMAL
- SPYLERENNE, BRED
- GJEL, CANYON
- SPYLEFELT
- PASS FOR ISOIRIGERT DRENERING
- SETE
- ESKER
- TERRASSE OVERVEIENDE I GLASIFLUVIALT MATERIALE
- STOR GLASIFLUVIAL AVSETNING
- GRYTEMULL
- VIFTE

I tillegg kommer glasifluviale formelement som dreneringsspor (spylereenner, spylefelt, breelvløp) og, gjerne litt mer distalt, akkumulasjoner (esker, kame). Denne fordelingen er særlig klar innen kartbladet RØA (1719 I) hvor typiske rogenmorener i området ved Styggsjøane (UK 526167) taper seg mot nordvest i mer drumlinoide former og fluting. Mer distalt finnes de store eskersystemene Feragsryggen og Hådalseskeren.

Isbevegelsen i området ved nordenden av Femunden er tidligere kartlagt av Holmsen (1915, 1935) og Trømborg (1963). Dolomittisk kalkstein fra nedre Roastens elveos (UK 482159) er blitt ført ca 5km NV-over til Granbekkhøgda (UK 453185). Samtidig viser blokker fra trondhjemsfeltet (gabbroer, trondhemitt) at isbevegelsen minst en gang har vært motsatt av hva den var under istidens siste maksimumsfase. Det er antatt at for hver nedising vandret isskillet fra vannskillet i nord og sørover som vist på figur 3 (Sollid & Kristiansen 1983).

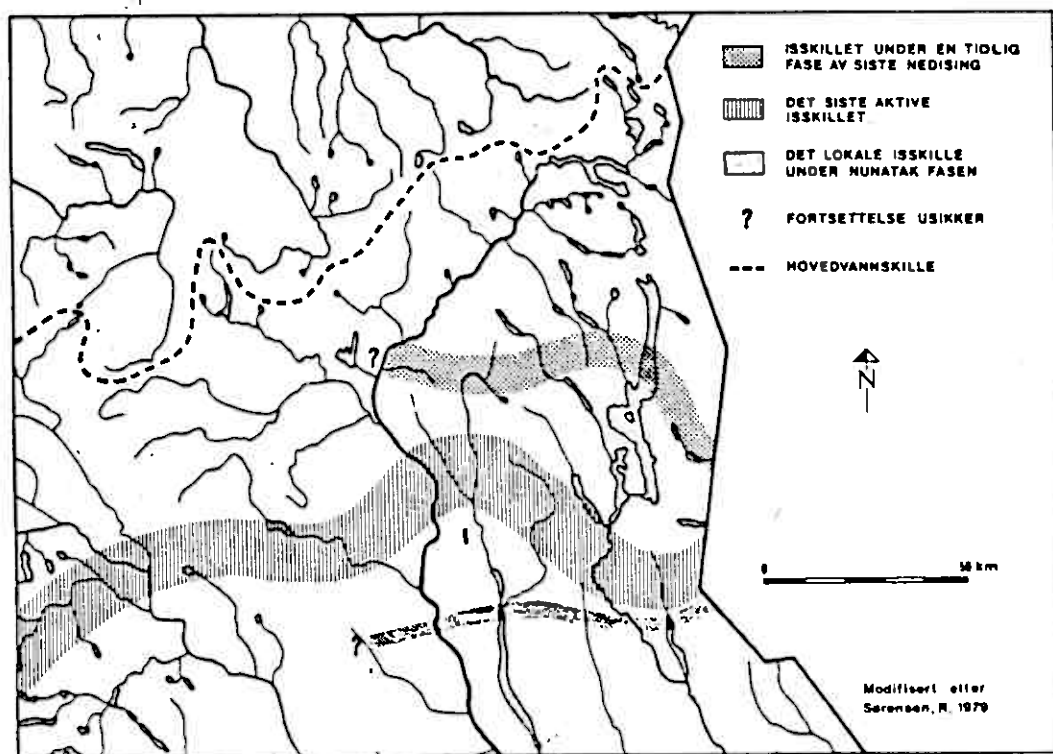


Fig 3: Flytting av isskillet under siste istid.

På svensk side bøyde isskillet av nordover langs glintranden og ble forskjøvet østover under istidens maksimum for så å trekke seg tilbake mot glintranden under avsmeltingsfasen (Lundqvist 1969).

Skuringsstriper er vanskelig å observere innen sparagmittområdet, bergartene forvitrer lett. I de få tilfeller hvor skuring er observert, gjenfinnes bare 1 generasjon striper, og de følger strukturetningen i fjellet. Skuringsobservasjoner ved blotningen på stien over Femundsåsen (PQ 492273) er ganske sikker og representerer antagelig siste isbevegelse i og med at den sammenfaller helt med flutingen i området. Alle (5 stk) skuringsfelter på lokaliteten og flutingen på Femundsåsens sørøstside viser en isbevegelsesretning på 145° (NV).

KORT BESKRIVELSE TIL KVARTÆRGEOLOGISK SKISSE (1 : 25 000) ØVER OMRÅDET FEMUNDSÅSEN-BRENNVOLA.

Kartleggingsmetodikk

Stereofotoanalyse (Interpretoskop, Zeiss Jena, 15x forstørrelse) på luftfotografier i målestokk ca 1:36 000 (Widerøe 650, 1963) ble utført først etter avsluttet feltarbeid. Inndelingen av jordartene etter genesis er gjort ved visuell bedømmelse i felt og ved flybildetolkning. Prøver av jordartene (P I - P V) for å understøtte kartleggingen er analysert etter metoder beskrevet i Selmer-Olsen (1954), og resultatene foreligger som vedlegg. Skissen og de formelementene som er beskrevet på denne, følger tilnærmet NGU's standard for kvartær-geologiske kart. Det henvises til NGU 347: Per Holmsen (1979): "Grunnlag i kvartærgeologi", for definisjon av begrepsapparatet.

Beskrivelse

Dalstrøket mellom Femundsåsen og Brennvola i N-enden av Femunden har ett rolig relieff med for det meste tykt morenedekke ($> 5m$) som enkelte steder er samlet i store rygger og hauger av uklar opprinnelse. I området ved Neset (PQ 502248) skyldes haugene i stor grad raviner- ing i særlig tykt bunnmorene dekke. Utgravingen i morenen har trolig skjedd i en sen fase av isavsmeltingen hvor den isrelaterte dreneringen synes å ha gått fra Syndervika (PQ 489235) nordøstover mot l. Langtja. (PQ 500265) og senere rett østover til Nordvika (PQ 515245). Drenerings- sporene gjenfinnes i dag som store breelvløp med særlig blokkrik bunn og som store raviner ut mot Nordvika.

Størstedelen av Femundsåsens sørøstside er dekket av meget tykk bunn- morene unntatt opp mot selve toppområdet hvor det er flere blotninger. Morenen virker uberørt og har kraftig fluting på overflaten (145°).

Tykkelsen på løsmassene her er uvanlig til norsk høyfjell å være (30 m i borhull) , og et kompakt blåleirelag midt i moreneprofilet kan tenkes å representere en interstadial (-glasial ?) (Lundqvist 1981).

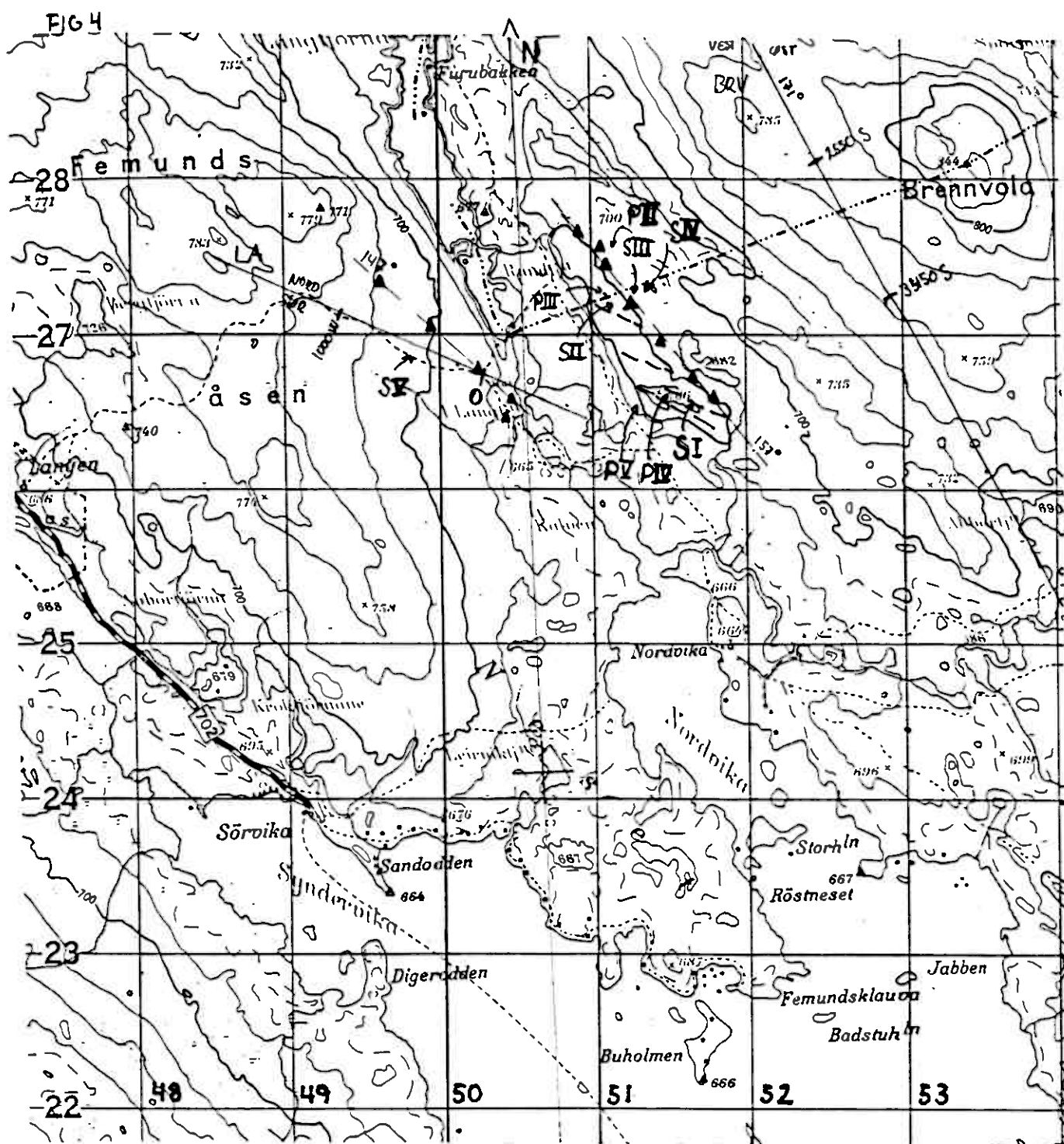
På østsiden av Nordvika og Langtjønna (PQ 488289) er morenedekket tilsynelatende tynnere med flere blotninger. Et borhull i Brennvola-gridet viser også bare 7 m med løsmasse. Forklaringen på denne forskjellen kan ligge i at det på Femundsåsen-siden oppsto en slags "påsmøringseffekt" mot det oppragende høydepartiet 783m (PQ 285276) fordi isbevegelsen her ble bremsset. Mens nede i daldraget, dvs på Brennvolasiden, gikk gjennomstrømningen av isen friere og dermed ble det ikke avsatt tilsvarende morenemektigheter her. Dette er antagelig også forklaringen på forskjellen i formelementer på de to sidene av akse Nordvika-Langtjønna. På vestsiden er det uberørt, tykt morenedekke eller ravinering i dette, og på østsiden finnes hauger og rygger med særlig blokkrik morene av rogentype eller med drumlinoid form.

Helt i nordenden av Femunden, Kalven (PQ 506257), ligger en morenerygge som er beskrevet uten noen genetiske implikasjoner av Trømborg (1963, s. 55). Ryggen må ansees å være av rogentypen. At den står alene og ikke i et felt av lignende morenerygger, skyldes antagelig at den ligger i ytterkant av rogenområdet som strekker seg SØ-over, inn mot iskulminasjonsområdet, til Rogen (Sverige). Formelementene synes å skifte etter plassering i forhold til iskulminasjonssonen (Sugden & John 1976, Aario 1977). Det er mulig at den nordre delen av Femunden lå slik i forhold til brekulminasjonssonen når bunnmoreneformene ble dannet at overgangen til drumlinoide former skjedde her. Ryggen med de mineraliserte blokkene som strekker seg fra PQ 518265 til PQ 507276, antas å være en slik drumlinoid form hvor de mange småryggene som utgjør hele haugkomplekset, sammenfaller godt med bevegelsen (145°). I myra øst for ryggen (PQ 518267) ligger et godt eksempel på en "crag & tail", også den i bevegelsesretningen.

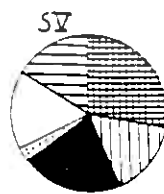
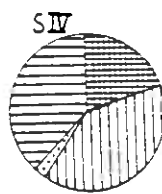
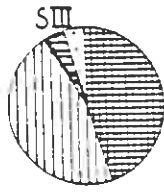
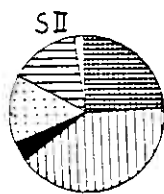
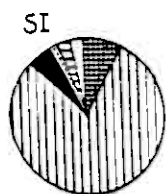
Haugen rett nord for gården Nordvika (PQ 513249) og flere hauger øst for denne (PQ 530253, PQ 533248), kan være overgangsformer mellom rogen- og drumlinmorener. Det kan heller ikke utelukkes at noen av dem er erosjonsrester tilsvarende det som finnes på Neset.

Østsiden av Langtjern er dominert av glasifluvialt materiale og av den tilhørende esker (kalt Feragsryggen av Trømborg, 1963). Eskeren er tydelig subglasial i det enorme blokker av ablasjonsmorene noen steder (ved trig.pkt. 677m, PQ 503278) dekker ryggen. Det er ikke mulig å spore eskeren sør for Rundtjern (PQ 504274), og det er sannsynlig at drenerings-sporene som finnes sør for l. Langtja., både på Femundsas-siden og på Brennvolasiden, har samlet seg i en akkumulerendes esker. Det er, som Trømborg (1963) påpeker, antagelig ikke mulig å finne eskeren ute i Nordvika da moreneryggen ved Kalven, som er dannet først, ville ha virket som en demning.

Vest for ryggen med de mineraliserte blokker ligger det i ca 680 m høyde ett glasifluvialt terrassenivå som også gjenfinnes sør for gården Nordvika, ved høgde 699m (PQ 529243). Store, kantete blokker i den glasifluviale grusen kan tyde på at det ikke er rene kame-avsetninger, men at terrassene har en subglasial opprinnelse, antagelig dannet i en sen fase av avsmeltingen.

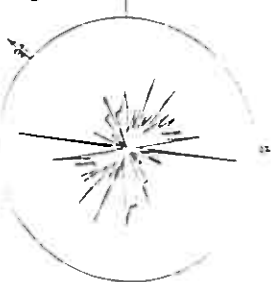


STEINTELLINGER 70

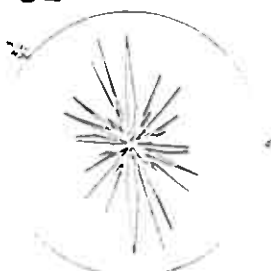


STEINORIENTERINGER 70

SI



SII



Lys grå sandstein



Grov kvartssandstein



Mørk finkornet sandstein



Mørk grå finkornet kvartsitt



Lys finkornet kvartsitt



Andre

MATERIALPRØVER : P I - P V

▲ Mineraliserte blokker

BLOKKTOG LANGEN

Blokktoget med 17 mineraliserte blokker ligger i sin helhet innen et typisk bunnmorene-landskap og togets lengderetning (147°) sammenfaller godt med påvist isbevegelse i området (145°). De mineraliserte sparagmittblokkene er store ($\frac{1}{2}$ - 9 m^3), kantrundet til rundet. Flere av dem er knust (skifrig) og delene flyttet fra hverandre, noe som utelukker postglasial frostaktivitet. Ingen viser skuringsstriper, men noen få har crescentiske brudd. En steintelling, S V (LA 350 E/100 S) skiller seg klart fra tilsvarende tellinger i Brennvola-gridet (se figur 4). Innslaget av mørk grå finkornet kvartsitt, hvit (melke-)kvarts og den røde/rosa-sparagmitten er her større enn lenger øst hvor den lyse sparagmitten og den grove kvartssandsteinen dominerer. Den store overdekningen uten blotninger gjør det ikke mulig å fastslå om morenen består av overveiende lokale bergartsfragmenter, men den varierte sammensetningen og store tykkelsen tilsier en morene hvor en vesentlig del (40-60%) er langtransportert, dvs. $> 5 \text{ km}$ (Boulton 1971, Sugden & John 1978). De mineraliserte blokkenes plassering nede i en 30 m tykk morene, tydelig kantrundet og knust, indikerer at disse tilhører den langtransporterte del av morenen. Bare de nederste 5-10 meterne av bunnmorenen på sørøstsiden av Femundsåsen vil kunne være av lokal opprinnelse ($< 1 \text{ km}$ transportlengde). Hvis leirlaget i borhullet på Langen-gridet er av interstadial -glasial) alder, vil den øvre moreneseksjonen ikke ha innslag av lokale bergartsfragmenter, se figur 5.

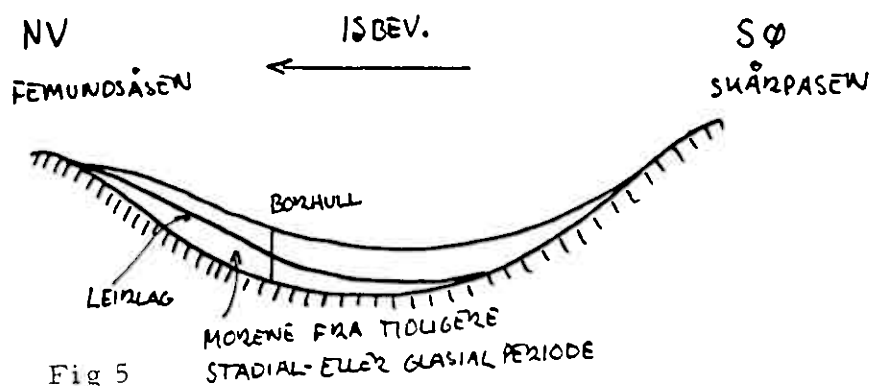


Fig 5

Det ansees som mest sannsynlig at morenematerialet på SØ-siden av Femundsåsen, i alle fall de øvre deler, består av materiale plukket og abradert fra de konvekse områdene som begynner ved Granbekkhøgda (UK 453184)-Skarpåsen(UK482199)-Gråvola(UK 506222). Inn mot is skillet vil isens avtagende eroderende evne sette en sydgrense for materialtransport i bunnmorenen et stykke inn i Sverige. Spesielt gjelder dette for de øvre deler av bunnmorenen som antagelig er avsatt under fasen med det siste aktive is skillet trukket langt mot syd, se fig. 3.

I Langen-gridet forekommer de mineraliserte blokkene med en klar begynnelse og slutt i ett bloktog som er ca 1300m langt og dessuten meget smalt (100m). I tillegg er blokkene store, hvilket også indikerer kort transportlengde (Sugden & John 1976). Undersøkelser av Haldorsen (1977) viser at blokkfraksjonen i bunnmorene føres langt (≥ 5 km) fra et kildeområde uten vesentlig uttynning. Dvs at hvis blokkene er langtransporterte ville det være ventelig å finne ett vesentlig lenget bloktog med større bredde, gjerne vifteformet og også med mindre blokker (20 cm). Disse forhold peker mot en kort transport av de mineraliserte blokkene i Langen-gridet (Minell 1978, Stewart & van Hees 1981).

Forklaringen på at blokktoget ser ut til å være både lang-og korttransportert, til fordel for teorien om lang transportavstand, kan være at de mindre blokkene (20 cm) ikke er funnet, og at disse er spredt utover et større område. Dessuten kan de mineraliserte blokkene som er funnet være fragmenter av noen få større vandreblokker som er blitt knust under en sen fase av isavsmeltingen og dermed spredt lite utover.

Mineraliserte blokker som ligger med noen få meters mellomrom, og som tydelig har vært én større blokk, understøtter dette.

BLOKKTOG BRENNVOLA

Toget med mineraliserte blokker ligger på proksimalsiden av en stor rygg av uklar opprinnelse. Også her har blokktoget, som er 1300m langt og 100 m bredt, en klart definert begynnelse og slutt. Men lengdeorienteringen (157°) er mer nordlig enn for blokktoget i Langen-gridet og sammenfaller ikke så godt med den generelle isbevegelsesretningen (145°). Blokkene er store ($1/4-5 \text{ m}^3$), kantete og ofte knust. Deres posisjon i forhold til den omtalte ryggen er usikker, men det synes klart at i alle fall noen av blokkene hører til (ligger oppe på) ryggen.

I felt kan ryggen umiddelbart se ut som en ablasjonsmoreneform i og med det uryddige omrisset og de store kantete blokkene. En naturlig genetisk klassifisering av formen ville være sprekkefylling i en stagnerende is. Ved flybildetolkning viser ryggen et helt annet utseende. Dens lengderetning (157°) er fortsatt litt på skrå i forhold til siste isbevegelsesretning (145°), men superponert på dette ligger 3-4 mindre rygger med en klar retningsorientering på 145° (Disse er tegnet inn med stiplet strek på kartskissen). Det antas derfor som sannsynlig at ryggen er av subglasial opprinnelse og kan defineres som en drumlinoid form dannet av en aktiv is i bunnmorenemateriale.

To retningsorienterings-analyser, etter Hay & Rahmann (1974) og Briggs (1979), fra toppen av ryggen (S I og S II i figur 4) gav ingen signifikante resultantvektorer. Glasifluvial aktivitet på ryggen etter dannelsen (P IV = "lakustrint" materiale utvasket fra ryggen) eller postglasiale utglidninger kan være årsaken til at steinene ikke viser forventet orientering parallelt isbevegelsesretningen. En steinorientering fra større dyp i ryggen må til for å avgjøre dette.

Steintellinger fra toppen av ryggen S I (BRV 3500 S/ 1500 W) SII (BRV 2550S/1650W), blandt de mineraliserte blokkene proksimalt for ryggen S III (BRV 2550S/1350W) og fra nærmeste eksponerte bunnmorene S IV (BRV 2550S/1300W) er heller ikke entydige. Prøvene langs stasjon BRV 2550S viser alle noenlunde likt innhold av grov kvartssandstein = 40-50 %, mens det i S I $\simeq$ 80% og i S V $\simeq$ 15 %. Dette kan tyde på at materialet både på toppen, ved foten av ryggen og i nærmeste bunn-

morene er av samme opprinnelse. At S I skiller seg ut i forhold til S II antyder videre at materialet ikke er avsatt ved en isbevegelse på 157° , se figur 6.

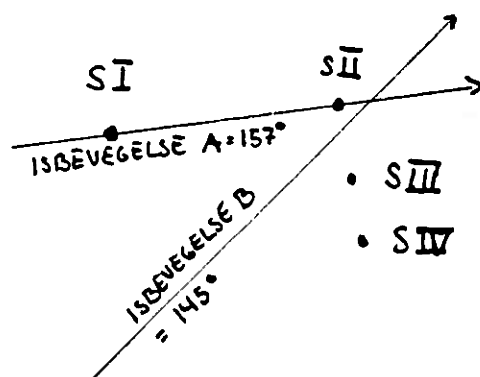


Fig 6

ISBEVEGELSE A:

$$S I = S II$$

$$S II \neq S III \neq S IV$$

ISBEVEGELSE B:

$$S I \neq S II$$

$$S II \simeq S III \simeq S IV$$

Det er ikke mulig på bakgrunn av steintellingen å si noe om transportlengden av de mineraliserte blokkene, til det er berggrunnsgeologien i området for oppstykket og lite kjent. Drumlinformer og rogenmorener og deres overgangsformer dannes i bunnmorene av lokal karakter (Lundqvist 1969, Aario 1977). Undersøkelser av Jørgensen (1977) viser at norske bunnmorener for det meste består av korttransportert materiale, etter ca 3km er fremmede bergartsfragmenter nede i 40 %. En vanlig norsk bunnmorene (dvs ca 5m tykk, blokkrik og med lite silt/leir) vil ha en gjennomsnittlig transportlengde på ca 5km.

De mineraliserte blokkene i Brennvola-gridet antas å være en del av den lokale bunnmorenen, og den kantete formen på blokkene antyder kort transportavstand. Med et morenedekke på ca 7m og med den kantrunden blokkene har, er det sannsynlig at de er transportert minst 500m (Minell 1978). Nærmeste konvekse område mot isbevegelsen er høydedraget (732m) vest for Abbortja (PQ 533258). Området Skarpåsen (UK 483199)-Gråvola (UK 506222) kan også være kildeområde, dette gir en transportavstand på ca 9 km.

Det er også mulig at blokkene kan tilhøre den langtransporterte delen av bunnmorenen, men knust ved avsetningen og virker dermed mer korttransportert. Blokkene kan også ha vært transportert et langt stykke englasialt og dermed beholdt sin kantethet hvis kildeområdet ligger høyere enn omgivelsene.

Som for blokktoget i Langen-gridet er utbredelsen av de mineraliserte blokkene uventet, spesielt når man antar at de er flyttet minst 500m av isen. For det første er alle blokkene relativt store og opptrer i et meget smalt bånd med en klar avslutning etter ca 1300m. For det andre ligger blokktoget her i en vinkel på ca 12° i forhold til den antatt siste isbevegelsesretningen. Noen fullgod forklaring på disse problem er ikke funnet.

Vinkelforskjellen blokktoget har med siste isbevegelsen, kan skyldes at hovedryggen ble avsatt under en tidligere fase av nedisningen hvor breskillet lå nærmere (over midtre deler av Femunden, se fig. 3) noe som gav en mer nordlig (157°) isstrømsretning. Det finnes ingen spor etter denne fasen i skuringsstriper. Senere, når iskulminasjonssonen trakk seg sør og østover, ble isens bevegelsesretning mer vestlig (145°) og de mindre ryggene på toppen av hovedryggen ble utformet. Den sterkt begrensede utbredelsen av mineraliserte blokker kan skyldes, som for Langen blokktoget, at blokkene er deler fra noen få nedknuste kjempeblokker.

En annen mulig forklaring på de mineraliserte blokkenes utbredelsesmønster kan ligge i deres relative vektoverskudd i forhold til andre umineraliserte blokker av samme størrelse, og at begge blokktogene ligger i en sone hvor terrenget går over fra å ha vært fallende med isoverflaten til flat- eller motbakketopografi.

KONKLUSJON

Blokketog Langen: Kan med stor grad av sikkerhet antas å være langtransportert (≥ 5 km). Kildeområdet vil sannsynligvis ikke ligge nærmere enn linjen Skarpåsen (UK 483199)-Gråvola (UK 506222)-Skebrofjelltang (UK 547203). Det er ikke utenkelig at blokkene stammer fra kjente forekomster av blyglansmineralisering i sparagmitt på svensk side av riksgrensen.

Blokketog Brennvola: Formelementer og tolkning av morenedekket transportavstand er her usikker. Hvis ablasjonsmorene utelukkes, vil blokkene ligge i korttransportert bunnmorene. Hvis de mineraliserte blokkene tilhører bunnmorenen, er de korttransportert, og kildeområdet vil sannsynligvis ligge i en avstand på 0,5-5,0 km. De konvekse områder som kan tenkes som kildeområde er høyden vest for Abbortja. (PQ 533258) eller høydepartiet Skarpåsen-Gråvola-Skebrofjelltang.

Hvis de to blokketogene har felles kildeområde, er blokkene antagelig langtransporterte (≥ 5 km), og blokkene i Brennvola-gridet må ha vært transportert englasialt eller blitt knust under avsetningen.

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Sedimentanalyse

Provenr.: **PI**

Innsamlingsdato: **7/6** 1984

Lokalitetsbeskrivelse: **BRV 1500 S / 2200 W**
TOPPEN AV FETAGSRYGGEN

Dyp i m: **0,5**

Formbeskrivelse: **ESKER**

Hydrometeranalyse

Materialtype: **GLASIFLUVIUM**

Innveid materialmengde: **g**

Fraksjon	Gram	%
> 64 mm		
> 32 "	90.8	100.0
> 16 "	56.3	92.3
> 8 "	73.0	87.5
> 4 "	91.7	81.2
> 2 "	121.9	73.4
> 1 "	214.9	63.0
> 0.5 "	412.3	44.7
> 0.25 "	97.1	9.5
> 0.125 "	11.3	1.2
> 0.063 "	2.6	0.2
< 0.063 "	0.0	0.0

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: **0.6** mm

So: **0.87**

Sk:

Mineralgrupper:

Merknader:

Blindern

20/6

1984

Sign. **T.H**

Sedimentanalyse

Prøvenr.: PII

Innsamlingsdato: 21/6 1984

Lokalitetsbeskrivelse: BRV 2400S/1500W

Dyp i m: 0.5

Formbeskrivelse: LITEN RYGG

Hydrometeranalyse

Materialtype: GLASIFLOVIUM

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "	6.3	100.0
> 8 "	42.5	99.2
> 4 "	125.5	93.6
> 2 "	146.4	77.3
> 1 "	86.8	58.2
> 0.5 "	243.1	46.9
> 0.25 "	111.0	15.2
> 0.125 "	4.9	0.7
> 0.063 "	0.6	0.1
< 0.063 "	0.1	0.0

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: 0.6 mm

So: 0.80

Sk:

Mineralgrupper:

Merknader:

Blindern

21/6 1984

Sign. T, H

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Geografisk institutt

Sedimentanalyse

Provenr.: PIII

Innsamlingsdato: 7/6 1984

Lokalitetsbeskrivelse: BQV 2580S/1650W

Dyp i m: 0.5

Formbeskrivelse: MORENENYGG, TOPP

Materialtype: MORENE

Hydrometeranalyse

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "	199.8	100.0
> 8 "	146.5	80.7
> 4 "	115.1	66.5
> 2 "	84.6	55.3
> 1 "	51.4	47.1
> 0.5 "	58.7	42.2
> 0.25 "	78.1	36.5
> 0.125 "	62.6	28.9
> 0.063 "	156.6	22.8
< 0.063 "	79.3	7.7

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: 1.3 mm

So: 1.77

Sk:

Mineralgrupper:

Merknader:

Blindern

21/6

1984

Sign. T. H

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Sedimentanalyse

Prøvenr.: P IV

Innsamlingsdato: 7/6 1984

Lokalitetsbeskrivelse: BRV 34505/1530W

Dyp i m: 0.5

Formbeskrivelse: MELLOW MONENENYGGEL

Hydrometeranalyse

Materialtype: SAND/SILT LOMME

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "		
> 8 "		
> 4 "		
> 2 "		
> 1 "	11.1	100.0
> 0.5 "	6.4	97.7
> 0.25 "	68.4	96.3
> 0.125 "	171.6	81.8
> 0.063 "	154.3	45.5
< 0.063 "	60.5	12.8

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: 0.07 mm

So: 0.30

Sk:

Mineralgrupper:

Merknader:

Blindern

21/6 1984

Sign. T. H

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Sedimentanalyse

Prøvenr.: P V

Innsamlingsdato: 7/6 1984

Lokalitetsbeskrivelse: BRV 3450 S/1820 W

Dyp i m: 0.5

Formbeskrivelse: TERRASSE

Hydrometeranalyse

Materialtype: GLASIFLUVIUM

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "	39.1	100.0
> 8 "	31.5	96.1
> 4 "	30.1	92.9
> 2 "	206.9	89.9
> 1 "	346.0	69.1
> 0.5 "	293.6	34.3
> 0.25 "	42.0	4.7
> 0.125 "	3.6	0.5
> 0.063 "	1.2	0.1
< 0.063 "	0.2	0.0

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger : Md : 0.7 mm

So : 0.51

Sk :

Mineralgrupper :

Merknader :

Blindern

21/6

1984

Sign. T.H

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Geografisk institutt

Sedimentanalyse

Provenr.: P VI

Innsamlingsdato: 7/6 1984

Lokalitetsbeskrivelse: BRU 3500S/1500W

Dyp i m: 0.5

Formbeskrivelse: MONWERY66, TOPP

Hydrometeranalyse

Materialtype: MONENE

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "	36.6	100.0
> 8 "	14.0	92.5
> 4 "	20.2	90.9
> 2 "	14.5	87.3
> 1 "	11.6	84.6
> 0.5 "	42.0	82.6
> 0.25 "	54.2	75.0
> 0.125 "	65.3	65.2
> 0.063 "	142.5	53.5
< 0.063 "	103.7	18.7

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: 0.06 mm

So: 1.10

Sk:

Mineralgrupper:

Merknader:

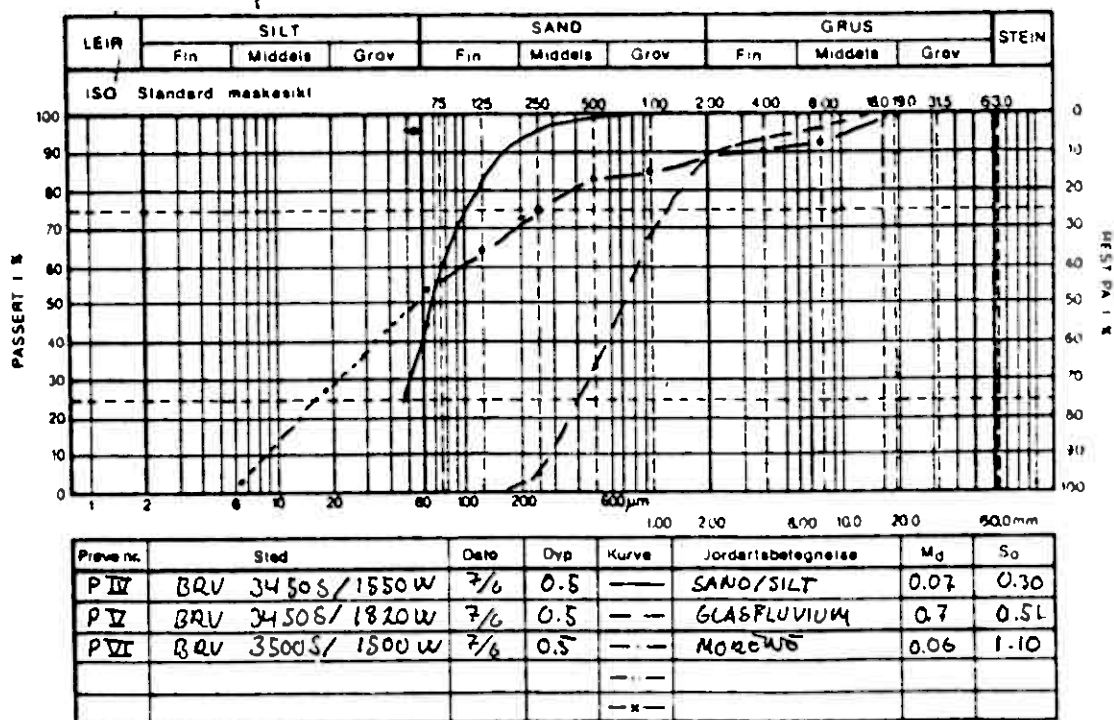
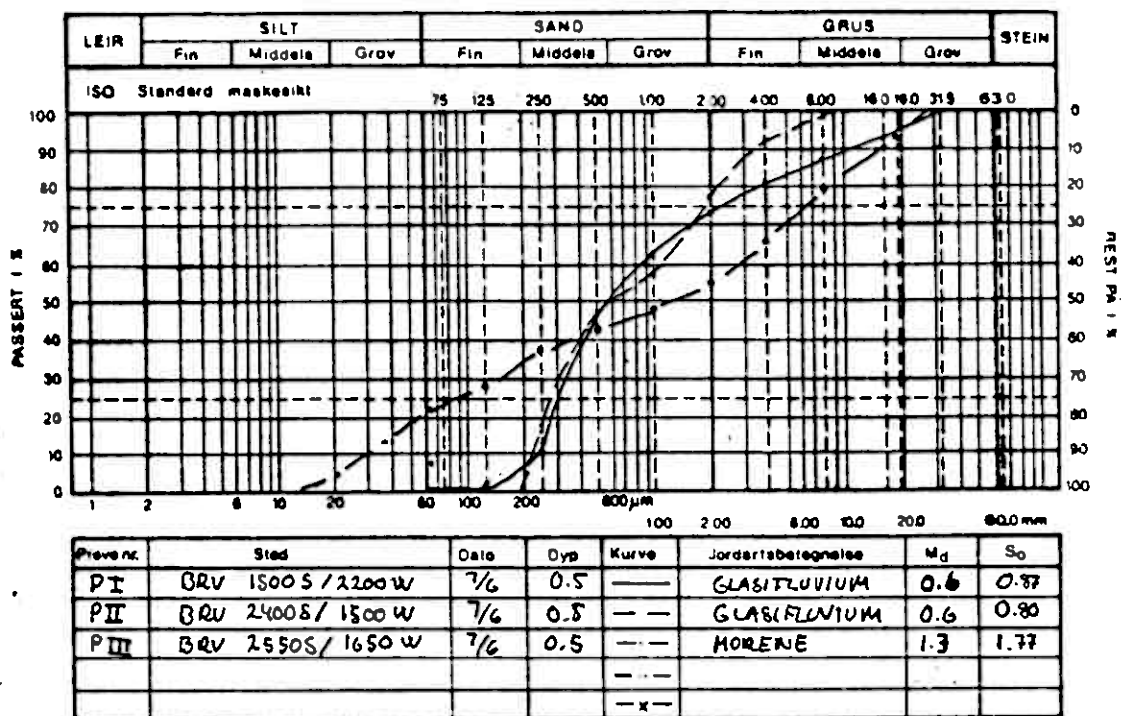
Blindern

21/6

1984

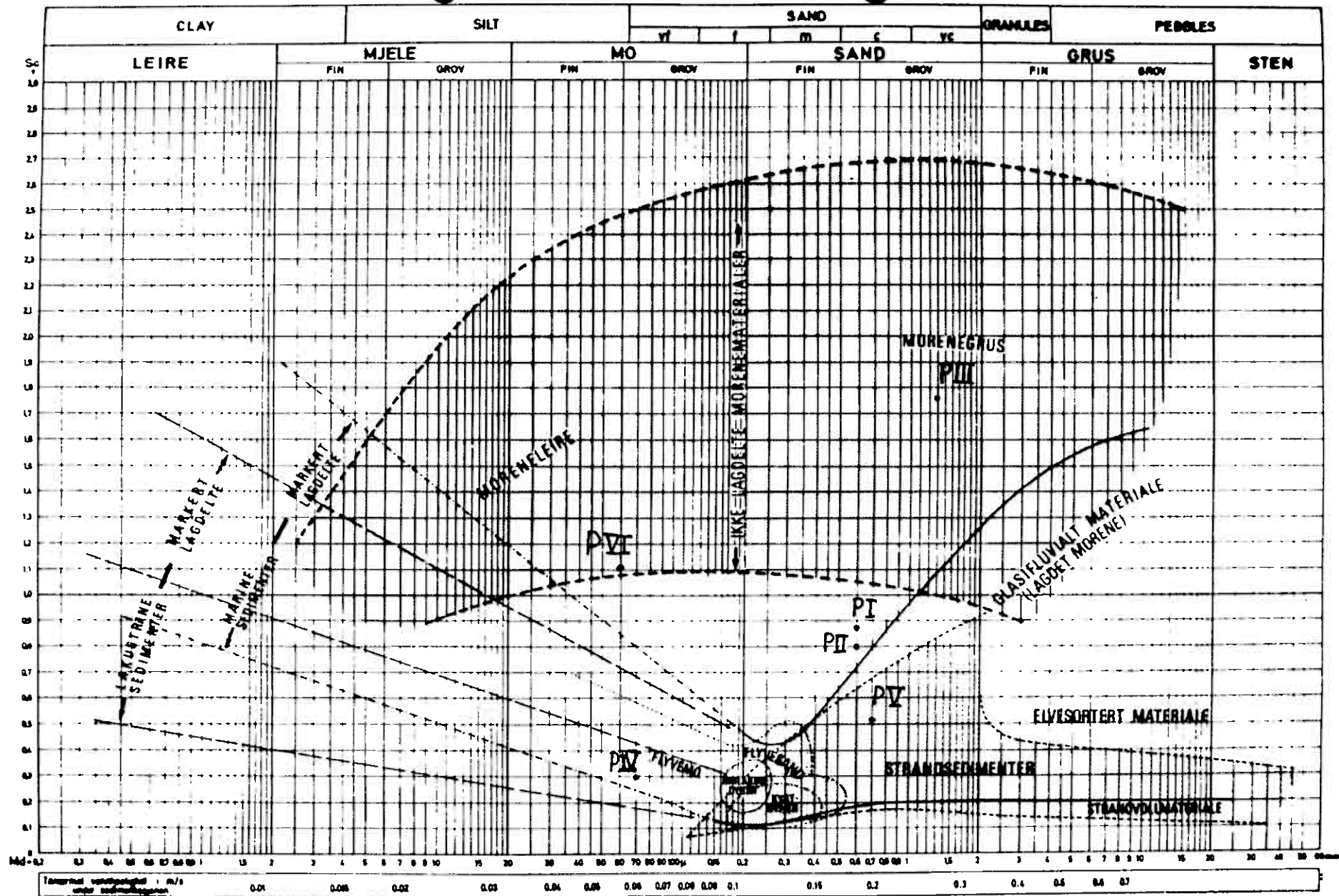
Sign. T. H

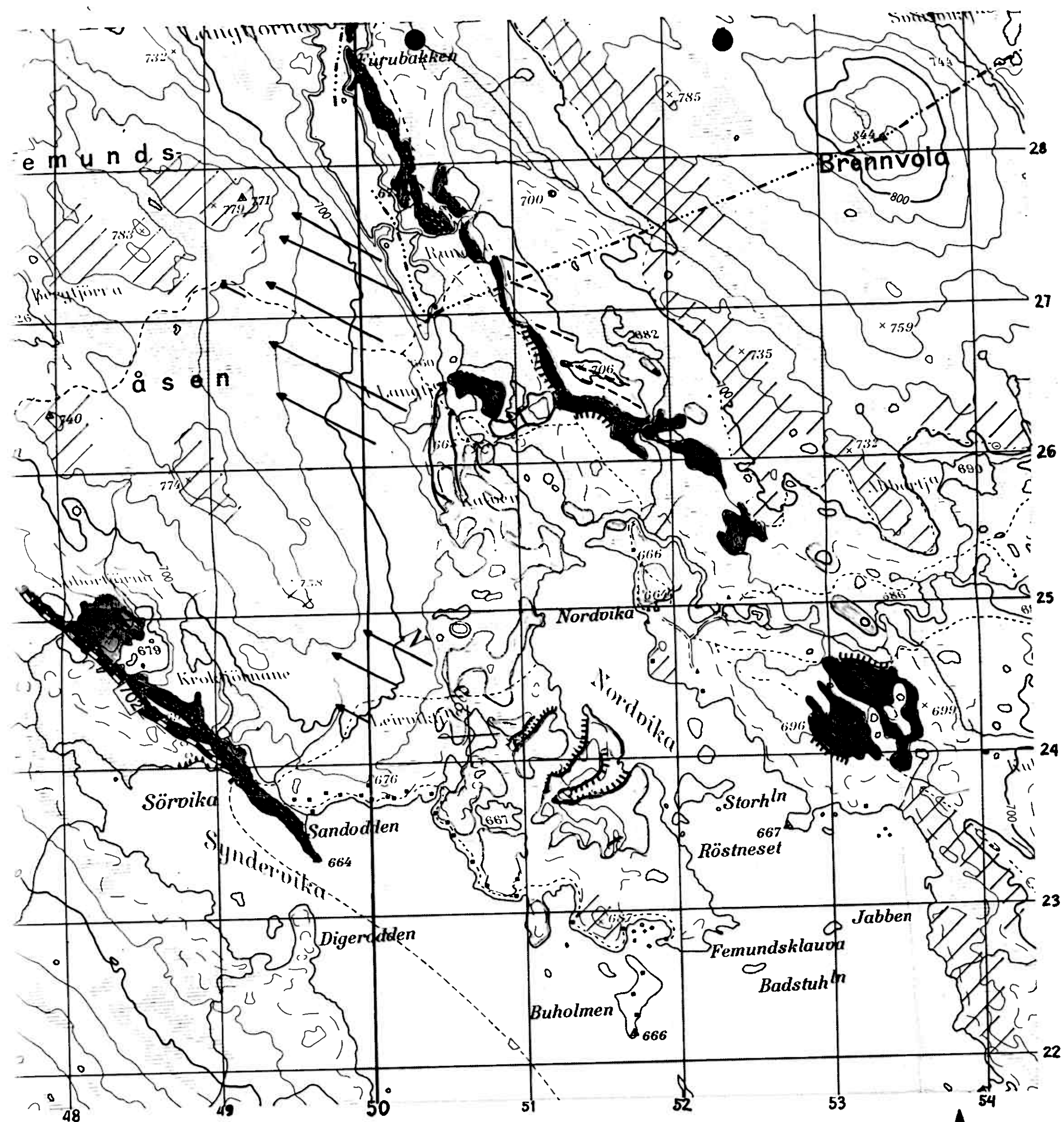
KORNFORDDELINGSKURVER



Sign

Ark nr





- ← FLUTING
- ~ BREVELÖP
- ▤ RAVINE
- ▦ TERRASSÉKANT
- SKURING

- MARKERT MORENEHAUG MED RETNINGSORIENTERTE RYGGER PÅ TOPPEN
- MARKERT MORENEHAUG
- CRAG & TAIL
- ▨ TYNT MORENEDEKKE

- ESKEK
- HAUGER AV GLASIFLUVIUM
- GLASIFLUVIUM

OPPTOGRAFERT FRA M711: 1719 I
1: 25 000

SANT NORD
FOR MIDTEN
AV BLADET

BEMERKNINGER ANGÅENDE MINERALISERTE BLOKKER I SOLLIA, ATNADALEN.

De mineraliserte blokkene i Sollia ligger i en vanlig bunnmorene av " påsmøring /le -typen " , som finnes i alle våre større daler som går på tvers av isbevegelsesretningen. Disse morenene er typisk svært korttransporterte, men har som oftest innslag av langtransportert materiale med en glasifluvial forhistorie. Sammensetningen av morenen kan derfor være variert. Morenene er tykkere mot bunnen av dalen og kan her ofte være sammensatt av flere generasjoner avsetninger etter som isen beveget seg gjennom eller på tvers av dalen (se Bergersen & Garnes 1977 som følger vedlagt).

At Sollia ligger så å si rett under den antatt siste aktive iskulminasjonen gjør bildet meget komplisert.

Det ble ikke funnet skjæringer av en slik dybde at flere generasjoners morener kunne skilles ut. I det største snittet som ble funnet (lite sandtak langs ny tømmervei NP 885534, se figur) var morenen tydelig fluvialt behandlet, se prøvene A I- A III. Ved steintelling kunne det ikke finnes variasjoner i dypet ved grustaket, eller noen forskjell til morenen på sørsiden av dalen (NP 878512).

Steintellingen viste innslag av både trondhjemfeltets bergarter (godt rundet gabbro og trondhjemitt fra nord), grunnfjellsgranitter fra atnavinduet og røde sparagmitter fra øst. Det er sannsynlig at siste nedising begynte med en dalbrefase som utløpere fra Rondane, senere en isbevegelse fra nord når brekulen lå over vannskillet , og ventelig ingen bevegelse i bunnmorenematerialet når iskulminasjonen hadde vandret sørover til Atnaområdet. Mesteparten av morenematerialet er ventelig avsatt i perioden med isbevegelse fra nord, noe som gav en "påsmøring /le-effekt" i Sollia.

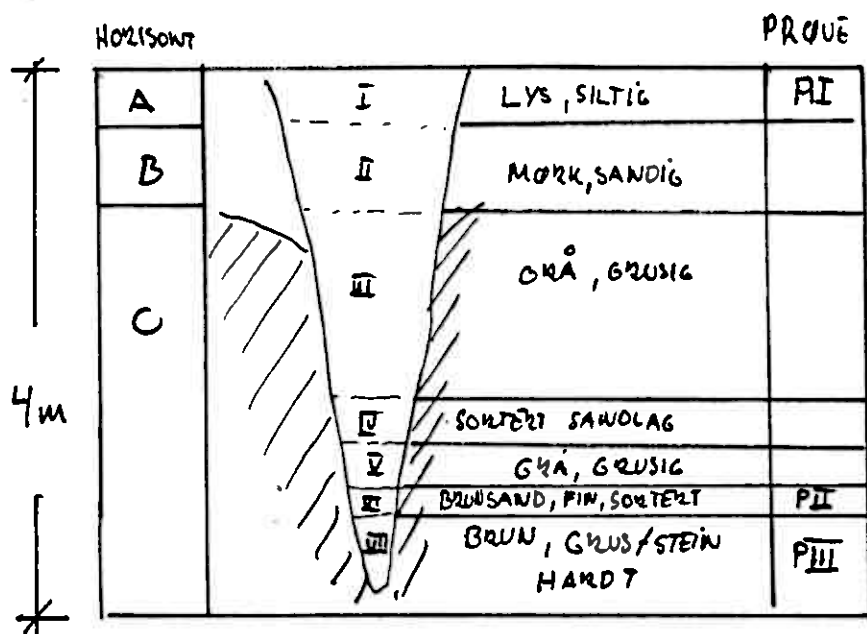
De mineraliserte blokkene var alle sterkt kantet og så lokale ut. På lokalitet 84-ATB 19 (NP 892527) virket det som om mineraliseringen var i blotningen. Langs veien ved NP 876525 var blotningen i veigrøfta meget lik de mineraliserte blokkene 84-ATB 22, 23, 24, 25 samme sted.

Blokkene 84- ATB 8,10 (NP 874525) ligger tydelig i frostsorbert materiale som antagelin har kommet opp fra bunnmorenen under.

Det kan ikke antydes noe kildeområde for de mineraliserte blokkene. Varierende isretninger og utrasninger av morenemateriale i dal-sidene umuliggjør dette. Men det ser ut til at de er korttransportert og ligner svært på bergarten som flere steder er blottet i Sollia.

Lykke til

Tom E Henriksen



GRUSTAK NP 885 534

Sedimentanalyse

Provenr.: AI

Innsamlingsdato: 11/16 1984

Lokalitetsbeskrivelse: ATNA, TYVI MORENEDEKKET
I DALSIDE

Dyp i m: 0.5

Formbeskrivelse: GRUSTAK

Hydrometeranalyse

Materialtype: MORENE

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm	297.2	100.0
> 32 "	297.2	84.1
> 16 "	297.2	68.2
> 8 "	83.4	52.3
> 4 "	131.3	47.8
> 2 "	126.6	40.8
> 1 "	101.3	33.9
> 0.5 "	304.6	28.6
> 0.25 "	178.4	12.2
> 0.125 "	36.9	2.7
> 0.063 "	9.8	0.7
< 0.063 "	3.6	0.2

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Beregninger: Md: 5.0 mm

So: 1.68

Sk:

Mineralgrupper:

Merknader: MORENEN ER TYDELIG VASUET
I OG MED AT FINMATERIALET
MANGLER

Blindern

20/16

19784

Sign. T.H

Sedimentanalyse

Provenr.: A II

Innsamlingsdato: 11/6 1984

Lokalitetsbeskrivelse: ATNA

Dyp i m: 2.0

Formbeskrivelse: GRUSTAK

Hydrometeranalyse

Materialtype: MONÉNE

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm		
> 32 "		
> 16 "		
> 8 "		
> 4 "	1.1	100.0
> 2 "	2.2	99.8
> 1 "	4.7	99.4
> 0.5 "	5.4	98.6
> 0.25 "	8.9	97.7
> 0.125 "	62.5	96.1
> 0.063 "	372.2	85.3
< 0.063 "	720.6	20.9

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Beregninger: Md: 0.04 mm

So: 0.38

Sk:

Mineralgrupper:

Merknader:

Blindern

21/6 1984

Sign. T. H

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Sedimentanalyse

Provenr.: A III

Innsamlingsdato: 11/6 1984

Lokalitetsbeskrivelse: ATNA

Dyp i m: 3.0

Formbeskrivelse: GRUSTAK

Hydrometeranalyse

Materialtype: MORENE

Innveid materialmengde: g

Fraksjon	Gram	%
> 64 mm	244.2	100.0
> 32 "	244.2	84.8
● 16 "	244.2	69.7
> 8 "	110.8	54.5
> 4 "	115.4	47.6
> 2 "	130.9	40.5
> 1 "	119.6	32.4
> 0.5 "	160.0	24.9
> 0.25 "	134.9	15.0
> 0.125 "	57.3	6.6
> 0.063 "	46.5	3.1
< 0.063 "	3.0	0.2

Tid	Avlesn. + 0.5	μ	Korr. %
37 s			
60 "			
105 "			
4 min			
15 "			
30 "			
60 "			
4 timer			
24 "			

Utrekninger: Md: 5.0 mm

So: 1.58

Sk:

Mineralgrupper:

Merknader:

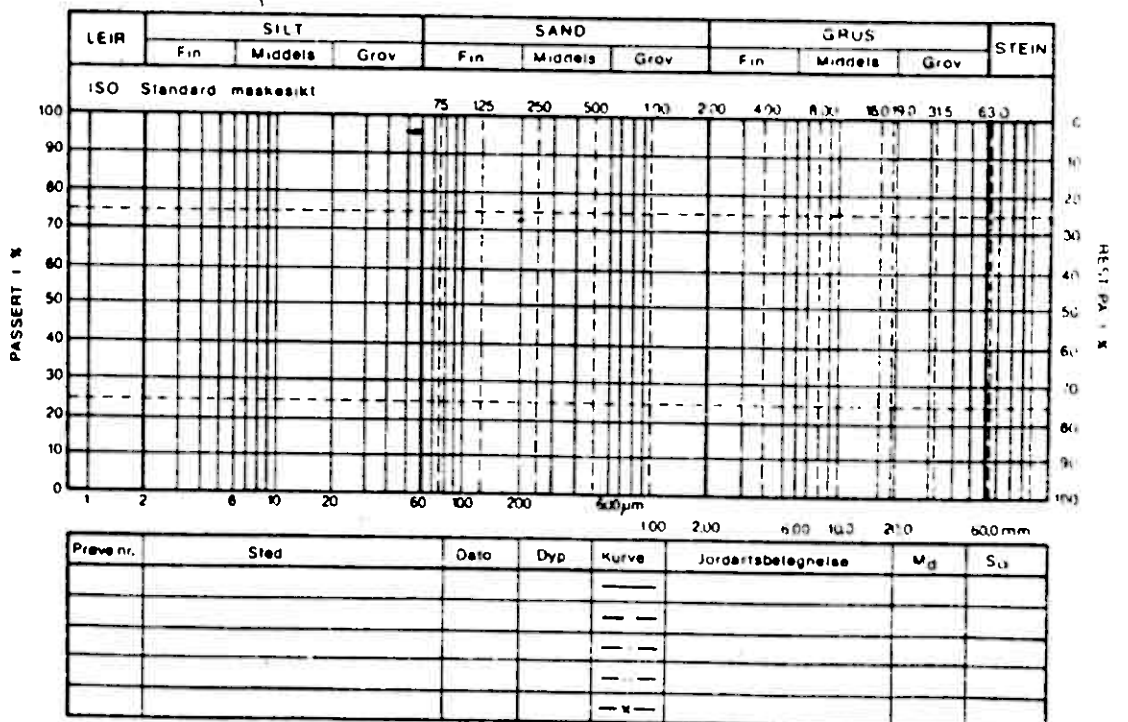
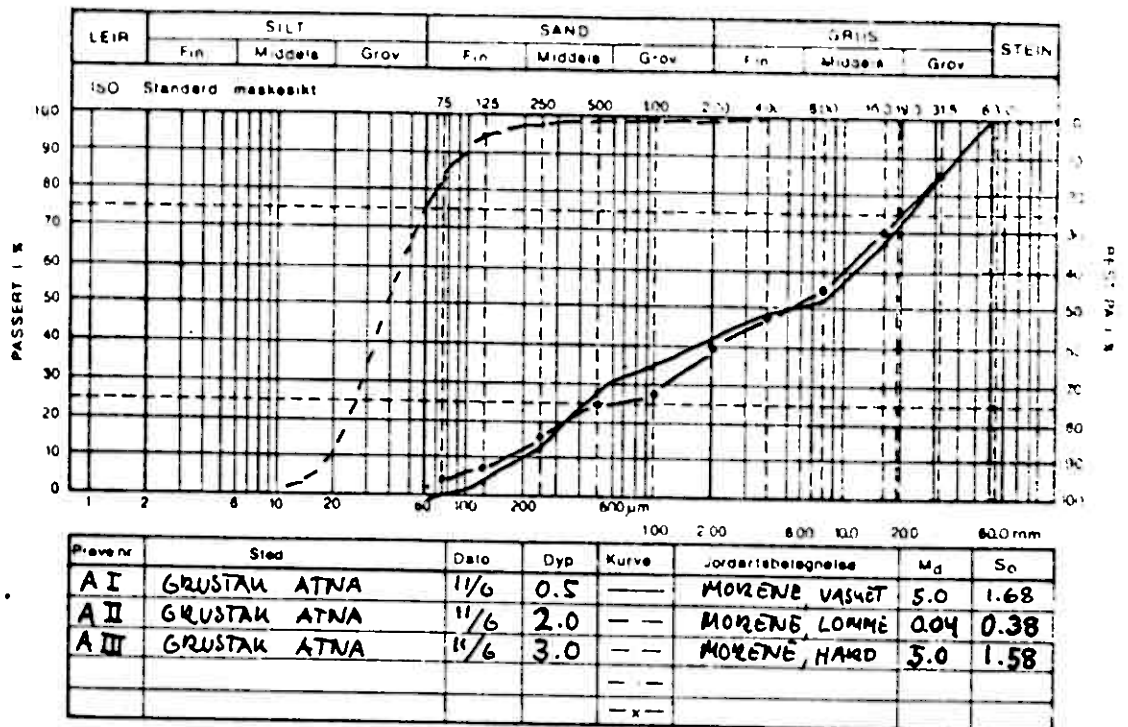
Blindern

21/6

1984

Sign. T.H

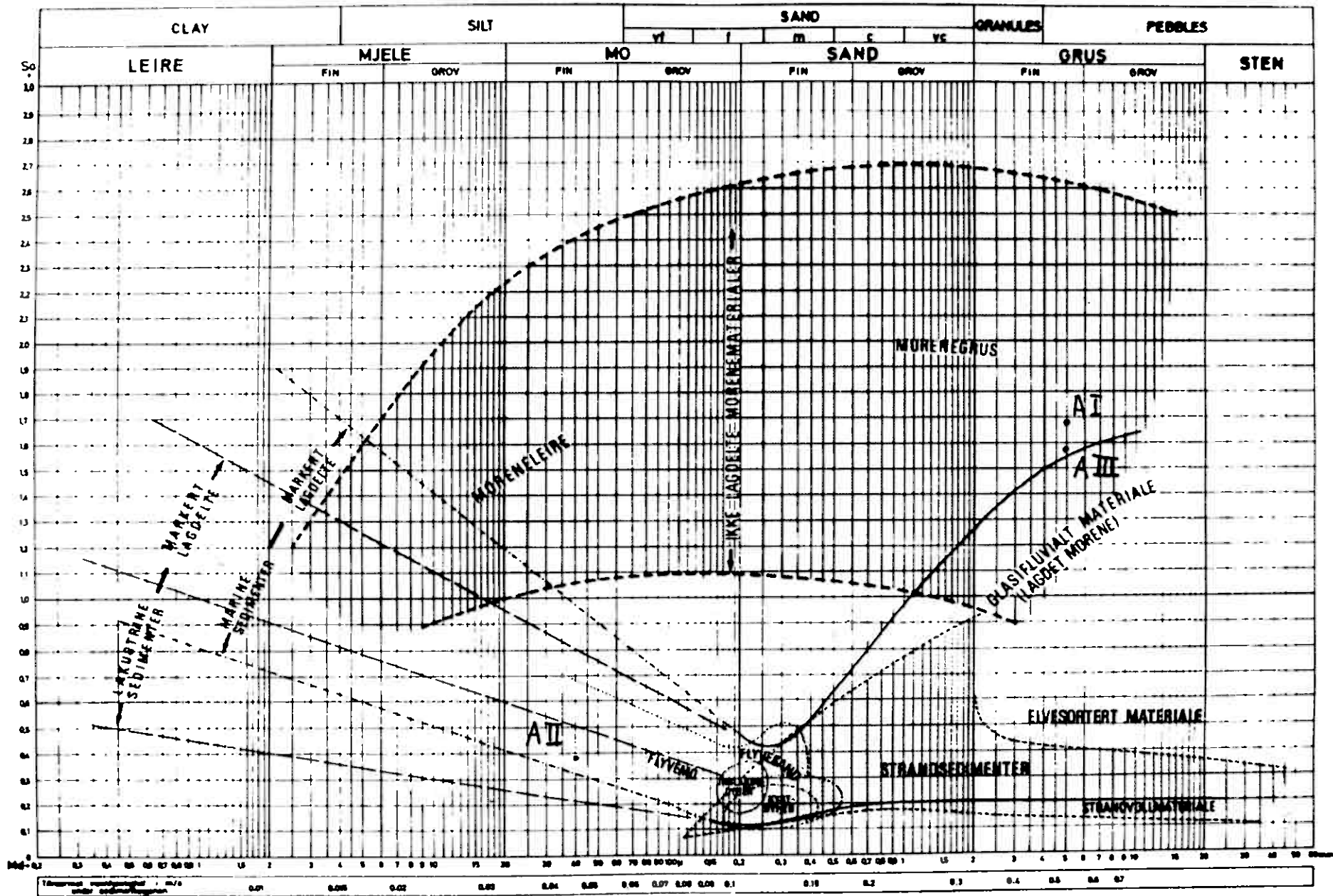
KORNFORDDELINGSKURVER



Sign

Ark nr

ATNA





Amoco Metals Company

7000 South Yosemite Street
Post Office Box 3299
Englewood, Colorado 80155
303 740 5000

March 2, 1984

Mr. A. W. Jackson
Amoco Norway Oil Company
Mining Division
c/o Follidal Verk
Lilleakerveien 2
1324 Lysaker
Postboks 308
Oslo, Norway

Dear Alvin:

This is a draft copy of my report on the IP results at Sparagmite.

I'm off to Mexico for two weeks and will tidy up the report when I get back. I don't expect any major changes in my recommendations regarding drilling and additional IP lines. But, I would like to make some comments on future surveys.

This should hold you for the time being.

Best regards,

A handwritten signature in cursive script, reading "E. J. Ballantyne, Jr." followed by a flourish.

E. J. Ballantyne, Jr.
Chief Geophysicist

EJB/ce

In November 1983, the Folldal Verk A/S-Amoco Norway J.V. sent several resistivity-induced polarization profiles from the Sparagmite project area to Englewood. Eight of the profiles were obtained with SGU equipment and four with an Elliot receiver and a Crone 250W transmitter. The profiles were taken from two grids: Langen and Brennvola. The lines are tabulated below.

<u>GRID</u>	<u>LINE</u>	<u>STATIONS</u>	<u>EQUIPMENT</u>
Langen	350E	650S- 200N	Elliot-Crone
	350E	550S- 150N	SGU
	100E	550S- 350N	SGU
	100W	500S- 500N	Elliot-Crone
	100W	450S- 600N	SGU
	300W	500S- 600N	Elliot-Crone
Brennvola	3150S	750W-2200W	SGU
	3450S	1000W- 50E	SGU
	3600S	1900W- 950W	Elliot-Crone
	3750S	2750W-2200W	SGU
	4050S	2750W-2200W	SGU
	4350S	2750W-2150W	SGU

(No data from 1050W to 1350W)

In all cases, the dipole length was 50m. The data taken with the SGU equipment expanded to an n of 3 and self- potential data were included. Data taken with the Elliot-Crone equipment expanded to an n of 6.

LANGEN GRID

Line 350E (Both Systems)

These data indicate two strongly anomalous zones.

The southern anomaly starts near 500S and is still anomalous at the end of the line to the south indicating a width of at least 150m. It is shallow, less than 50m (the dipole spacing), and has an intrinsic resistivity of 2000 m and a chargeability greater than 50 mv-sec/V. A drill hole is warranted. A vertical hole sited at 550S should adequately determine the source of the anomaly.

The northern anomaly begins near 75S and extends northward past the end of the line. It also appears shallow with similar resistivities and even higher chargeabilities than the southern anomaly. Although the data are limited for a complete interpretation, it is possible that the anomaly is confined to south of 50N. There appears to be a rock change of higher resistivity north of 100N. These two phenomenon may be a coincident, the mineralized zone being less resistive than the unmineralized rocks. A vertical hole sited at 25S is recommended.

This is one of two lines surveyed with both systems. While the resistivity data compare well, any resemblance between the two sets of chargeability data is purely coincidental. Since the Crone transmitter is much more powerful, the data using the Elliot-Crone system must be favored.

Line 100E (SGU)

These data indicate anomalous layer over the length of the line with the most anomalous region from 200S extending to the south past the end of the line. However, based on the comparative results on Line 350E and 100W, no drilling is recommended based on the SGU data.

Line 100W (Both)

The data in the southern half of the line, taken with the Elliot-Crone equipment are extremely noisy but indications are that the area is of little interest. However, an excellent anomaly is in the northern half, beginning at 250N and extending northward past the end of the line. The source of the anomaly appears to be approximately 50 meters deep. There are indications that the chargeability source is a layer with a finite thickness of 100 to 200 meters.

The anomaly is an excellent drill target. A drill hole located in the vicinity of 350N is recommended.

In contrast to the data taken with the Elliot-Crone equipment, the data from the SGU survey shows an anomalous layer at a depth of 50 meters over the length of the line. (The depth is determined from the resistivity data which are consistent with the Elliot-Crone resistivity data.) The most anomalous region is at 50S, which is a non-anomalous region as interpreted from the Elliot-Crone data. In the area of the anomaly described in the first paragraph, the SGU data are even less anomalous than on the rest of the line.

There is little doubt in the mind of this interpreter that the anomaly outlined by the Elliot-Crone survey, described in the first paragraph, is a valid anomaly and worthy of drilling. The lack of confirmation of the anomaly by the SGU equipment lead one to question all the data obtained by that equipment.

Nevertheless, the fact that the most anomalous area of the SGU survey coincides with a group of lead mineralized boulders could, in itself, warrant a hole. If one is sited in the vicinity, it should be placed at 50S.

Line 300W (Elliot-Crone)

The noise level is moderately high along this line. One anomaly appears on the line between stations 50S and 0. The depth to the

surrounding bedrock is 50m or less. The narrow width of the anomaly does not make it as an attractive drilling target as some of the other anomalies, but its proximity to the lead boulders increases its attractiveness.

BRENNVOLA GRID

Line 3150S (SGU)

A strong anomaly appears at 200W. There is an associated VLF anomaly. It is likely to be narrow but since it occurs at the end of the line it is difficult to be sure. It has a similar response to graphite.

A second IP and resistivity anomaly occurs on the extreme eastern end of the line at approximately 800W. Again, it is impossible to interpret due to a lack of data, but it is in the vicinity of a graphite band which is the likely source.

No drilling is recommended on this line.

Line 3450S (SGU)

A narrow resistivity, IP, and strong SP anomaly is located at 600W. This coincides with a mapped graphite zone. No other anomalies of interest are noted.

No drilling is recommended on this line.

Line 3750S (SGU)

A small resistivity and IP anomaly is noted at 2450W. Due to the limited amount of data, drilling is not recommended at this time. However, additional resistivity and IP with the Elliot-Crone equipment would resolve the validity of the anomaly.

Additional resistivity and IP work is recommended.

Line 3600S (Elliot-Crone)

The data on this line are extremely noisy, and IP readings were not obtained over much of the line. Nevertheless between 1200W and 1650W, IP readings, where they were obtained, are quite high. They are high on the $n=1$ dipole separation indicating a very shallow source. Drilling is warranted.

A vertical hole spotted between 1400W and 1500W is recommended.

Line 4050S (SGU)

An anomaly is present on the eastern end of the line but due to the lack of data, not much can be said. Impressions are that the anomaly is less than 50m at 2450W. Overburden appears to be deepening to the west.

Drilling is not recommended at this time but additional work with the Elliot-Crone equipment is warranted.

Line 4530W (SGU)

There is an obvious resistivity anomaly at 2400W with a not so obvious IP anomaly associated with it. The depth is interpreted to be slightly greater than 50 meters. There is the potential for a very high associated chargeability anomaly. Although drilling is not recommended due to inadequate data, there is enough encouragement to do additional IP work with the Elliot-Crone equipment.

Summary of Recommended Drill Hole Sites
(Priorities are 1=best and 3=least)

Langen Grid

<u>LINE</u>	<u>STATION</u>	<u>PRIORITY</u>
350E	550S	1
350E	25S	1
100W	350N	1
100W	50S	3
300W	25S*	3

Brennvola Grid

3600S	1450W	1
-------	-------	---

*Could be an angle hole

Summary of Recommended IP Lines (with Elliot-Crone Equipment)

Brennvola Grid

Line 3750S
Line 4050S
Line 4530W