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Oversikt over geologien i Holla-området og Melteig-området.

I Holla ble boret et huu i 1981 med meget god og high grade mineralisering av niob (2-4 % er indikert), samt påvisning av tantal og fosfor. Funnet er knyttet til en magnetisk-geokjemisk anomali.

Melteig er av interesse for apatitt,nefelin og niob, men har lavere prioritet.

Det foresås mer boring og utvikling av geologisk info i Holla for leting etter tilsvarende forekomster i Fen

FEN PROJECT

UPDATE ON GEOLOGICAL PROGRESS

(UMN FEN REPORT NO. 03)

By. S. D. Olmore
Union Minerals Norge A/S
April 1982

SDO/imr

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S. Krogh: p. 8.

TABLE OF CONTENTS

	Page
Introduction	1
Detailed Geology of the Holla Anomaly and Vicinity	1
General	1
Description and Classification of Rock Units in Drill Hole No. 81-1	1
Quartz-Aegirine Fenite	1
Syenitic Fenite	2
Hollaite	2
Søvite	2
Silico-Søvite	4
White Carbonate Dikes	4
Rauhaugite Dikes	4
Apatite-Mica Lamprophyre	5
Geologic Interpretation of the Holla Area	11
Some Exploration and Economic Considerations	12
Detailed Geology of the Melteig-Briskmyr Area	13
General	13
Rock Units	13
Medium-Grained Granite	13
Quartz Aegirine Fenite	13
Syenitic Fenite	15
Melteigite	15
Tinguaite	16

TABLE OF CONTENTS (continued)

	Page
Urtite and Ijolite, Undivided	16
Silico Søvite	19
Explosion Breccia	20
Damkjernite	20
Bostonite	22
Structure	22
Exploration Targets	22
Conclusions	23
Recommendations	24
References Cited	24
Appendix A - Writtern Summary of Drill Hole No. 81-1	26
Appendix B - List of Abbreviations Used on Drill Logs and Maps	32
Appendix C - Assays of High-Grade Mineralization in Drill Hole No. 81-1	34
Appendix D - Microprobe analysis of Phlogopite from drill hole 81-1, by H. Qvale.	40

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TABLES

		Page
Table 1	Microprobe analysis of niobium rich oxide phase from drill hole 81-1, By I. Hultin and R. Haugen	10
2	Petrography of selected fenite, syenite and dike rock samples from Melteig area	14
3	Partial whole-rock chemical analysis for selected major and minor elements for Melteigite-related basic rocks and fenite	17
4	Petrographic scan of selected samples of melteigite and related rocks	19
5	Microprobe analysis of a single crystal of nepheline from urtite pegmatite.	21

FIGURES

		Page
Figure 1	Diagram showing distribution of principal rock units in drill hole no. 1.	3
2	Sketch of core relations of mineralized zone in drill hole no. 81-1	6
3	Photomicrographs in plane-polarized light of typical niobium mineralization from mineralized zone	8
4	Photomicrograph of pyrochlore (?) grain in both polarized and reflected light.	9
5	Variation in molecular CaO-MgO-Al_2O_3 for melteigite and related ijolite and urtite.	18

PLATES

Plate I	Diamond Drill Hole Log Hole No. 81-1, Holla Area
II	Geologic Sketch Map Melteig/Briskmyr Area
IIA	Magnetic map (overlay) for Melteig/Briskmyr Area
III	Geologic Sketch Map of the Holla Anomaly and vicinity
IV	Geological Sketch Section and Magnetic Profile near drill hole No. 81-1.

All plates are found at end of report except IIA which is attached in a map tube.

INTRODUCTION

This progress report provides a partial review of the present state of geologic knowledge of two important areas within the Fen carbonatite complex. The Holla area was drilled in the fall of 1981 and some extraordinarily high-grade niobium mineralization was discovered which makes the Holla area [1]) a high priority exploration target. The Melteig area is an important portion of the complex, because an understanding of it is critical to understanding the geology at Fen. Some previous reports of niobium mineralization in the Melteig area also required a further looking into, thus justifying the detailed investigation presented here.

A better understanding of the two above areas brings us further towards the goal of an overall geologic understanding of the complex. Our principal goal is to identify economic targets and understand the controls on mineralization.

DETAILED GEOLOGY OF THE HOLLA ANOMALY AND VICINITY

General

In the autumn of 1981 a 385-meter hole at - 45° and bearing S 70°W, was drilled in the Holla magnetic-geochemical anomaly (See plate III for location). The drill proposal for that hole (J. W. Keim, oral communication, Management committee Meeting, May 6, 1981) (Mørk and Olmore July 17, 1981)[(*2)] was based upon anomalous niobium and tantalum values obtained in the vicinity of a 52,000 gamma magnetic anomaly (Carstens April 30, 1981). As it turned out, several zones of niobium and tantalum mineralization were defined, one of possible economic value.

What is presented here is an updated version of the geology and economic potential of the Holla area based upon detailed drill hole logging, geophysical measurements, petrography, and chemical analyses and a reinterpretation of the geology of the area (Plates III and IV). This information is a guide for additional drilling.

Description and Classification of Rock Units in Drill Hole No. 81-1.

Quartz-Aegirine Fenite

Quartz aegirine fenite is developed in medium-grained granitic gneiss as the result of thermal and hydrothermal alteration. A green alteration assemblage of chlorite, sphene and aegirine typifies this facies in drill core. The gneiss has been thoroughly fractured (crackled and broken) allowing the development of predominant aegirine to form veinlets and dikes.

(*1) The Holla area received its name from the nearby partly restored 12th Century stone church.
(*2) The interested reader is referred to this report which outlines some of the Fenco-Union Joint venture management committee decisions which helped formulate a decision to drill.

A few non-fractured zones show weak foliation. Fenite is dominant in the drill hole from about 331 meters to the end of the hole at 385 meters (Figure 1).

Syenitic Fenite

Syenitic fenite (Bsy) a term used by Vartianien (1980) is medium to coarse-grained and consists dominantly of K-feldspar, albite, chlorite, aegirine and biotite. One variety is made up of large, irregular crystals of pink, perthitic K-feldspar partly replaced by albite. The coarse variety probably correlates with the pulaskitic syenite of Sæther (1957, p. 24-25). Syenitic fenite occurs intermittently in the drill hole from about 203 meters to about 334 meters, with the main zone between 255 meters and 285 meters (Figure 1).

Hollaite

Hollaite (Ch) is a dark, basic silicate rock composed of variable amounts of biotite, sphene, calcite, pyroxene, chlorite, apatite, albite and riebekite. Mixed textures and variable mineralogy typify the rock, a feature that was first noted by Brøgger (1921). Most commonly the rock is laced with an irregular network of søvite veinlets give the unit a somewhat bizarre, marbled texture. This rock unit is correlative with carbonate-flooded fenite mapped in the vicinity of the Hydro Steinbrudd (Olmore, 1980, p.7), and basic silicate rocks underground in the Tuftestollen (Olmore, 1981, p.19).

Hollaite is a hybrid phase that is thought to have evolved through metasomatic processes that developed at the interface between søvite magma and syenitic fenite or quartz-aegirine fenite wall rocks. Textural evidence in drill core suggests that the hybrid formed from quartz aegirine fenite and syenitic fenite through metasomatic alteration processes. Locally hollaite is very coarse grained, consisting dominantly of hornblende and augite, and lacks the characteristic marbled appearance. In these localities textural indications are that metasomatic hollaite was perhaps mobilized to a fluid state. Hollaite occurs intermittently in the stretch of core between 114 meters and 330 meters.

Søvite

Søvite (Ds) is a white to light gray to pink calcite-dominanted, foliated rock that varies in texture from medium to coarse-grained. Principal minerals are biotite, magnetite, apatite, fibrous amphibole and pyrochlore. See also Olmore, 1981.

Local enrichments of magnetite and fibrous amphibole make up as much as 40% of the rock (Plate I) and are intergrown with calcite indicating a primary magmatic texture. On the average søvite contains 1-6% magnetite and locally contains 20% magnetite. Blue-green, fibrous amphibole is more restricted in distibution and locally constitutes as much as 40% of the rock. Apatite content varies from 1-5% of the rock; biotite is coarse to fine-grained and varies from 1-10% of the rock.

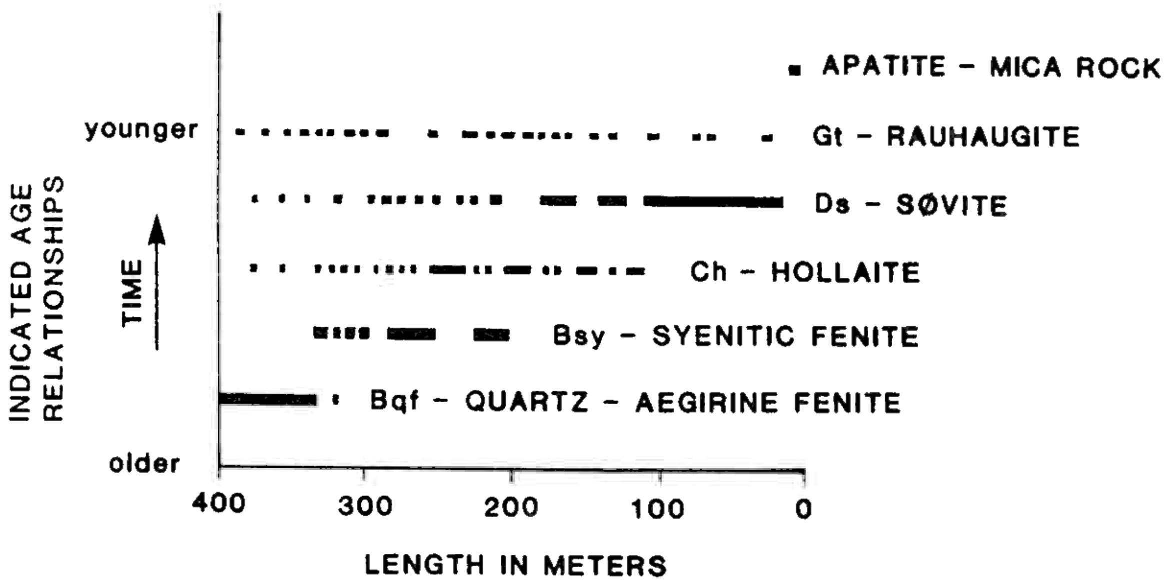


Figure 1. Diagram showing distribution of principal rock units in drill hole no. 81-1. The indicated relative age of crystallization or consolidation of each of the units is based upon cross-cutting relationships. Note that this sequence of events is also substantiated by detailed mapping of these units in the Tuftestollen and vicinity (Olmore, 1981).

Zoned .5-1mm pyrochlore/columbite grains are locally common and tend to increase in abundance in direct proportion to an increase in the adundance of fibrous, blue-green amphibole. Pyrochlore/columbite mineralization also tends to be localized near contacts with hollaite and later rauhaugite dikes (Plates I and IV).

The variable texture and mineralogy of the unit may be related to primary magmatic segregation and zoning during crystallization.

Søvite is the dominant rock unit from 11 to 184 meters and occurs as dikes of variable width below 184 meters. Much søvite also occurs in the hollaite zones where it has pervaded the rock in hairline veinlets and altered syenitic fenite.

Silico-Søvite

Silico-søvite (Dsc) occurs as thin, dark, foliated, silicate-rich søvite dikes that cut through quartz-aegirine fenite and syenitic fenite. Similar dikes have been mapped in roadcut along Ulefossveien and occupy approximately the same position with the main body of søvite as they do in drill hole 81-1.

Minerals present are albite, biotite, and calcite in roughly equal portions, along with apatite, opaques, and an unidentified anisotropic high-index mineral. The dikes are few in number and occur in the interval from 280-372 meters.

These dikes may have been formed by the injection of silicate-contaminated søvite.

White Carbonatite Dikes

White carbonatite dikes (Gw), also of limited extent in the drill hole, consist of white, fine-grained ankerite (?) along with less than 1% of combined pyrrhotite and pyrite. The dikes are barren of silicates, yet they have well developed hollaite margins. White dikes cut søvite as evidenced in outcrop along Ulefossveien (Olmore, 1981, Figure 5).

The source of the dikes is unknown, but they appear to be of roughly the same age as rauhaugite and they may represent distal portions of such igneous masses.

Rauhaugite Dikes

Rauhaugite dikes are of two types in the drill hole. One variety (Gt) is typical of dikes found in the Tuftestollen (Olmore, 1981, p.36) and consists dominantly of fine to medium-grained gray ankerite, or dolomite, green apatite, pyrite and pyrrhotite. The other variety (Gyg) is typically yellowish gray, medium-grained and apatite-bearing and has not been identified as a separate unit previously. Both types are thought to be co-magmatic with søvite as indicated by a composite relationship as borders on søvite dikes. They also occur without søvite as single, thin dikes, commonly on the order of 2 to 25 cm wide. As observed in the Tuftestollen (Olmore, 1981, Fig. 17) where the dikes cut søvite, patches of pink alteration and albitization of primary texture and structure are developed. The cumulative total thickness of rauhaugite dikes in the drill hole does not exceed 20 meters, but the fact that the dikes are spatially associated with niobium mineralization gives them a much greater importance than their volume would indicate. It is thought that these dikes correlate with the rauhaugite type 1 of Sæther (1975).

Apatite-Mica Lamprophyre

Apatite-mica lamprophyre (Eam) 3) has never been previously registered or recognized as a separate rock unit in the Fen region, despite thorough geologic examination of the Fen Complex by numerous geologists. It is thought to be the youngest intrusive in the drill hole 81-1. It is of particular interest because of its high niobium content. The unit is known with certainty only to occur in the first ten meters of the drill hole (Figure 2), but it may correlate with a few late mineralized dikelets mapped down the hole between 223 and 225 meters (Plate I) and is here designated as yellowish-gray rauhaugite (Gyg).

A descriptive log of the strongly mineralized core interval of apatite-mica lamprophyre diagrammed in Figure 2 is as follows:

2.5-3m

Mica-apatite rock, 2-3 mm flakes of euhedral mica set in a marbled apatite matrix. Salt and pepper specked texture. Apparent banding at 10^{o} to core axis. Local pods of white to gray sugary apatite, marbled texture common. Apparent lamprophyric texture (*3) in places.

3-4m

Søvite inclusion from 3.2-3-5m, locally pink søvite patches mixed with gray, banded apatite rock. Dark mica rock has marbled textures. Common earthy, brown patches with niobium mineralization.

4-5m

Sharp contacts with søvite indicate that mica-apatite rock is late, søvite patch is an inclusion.

3) Citations from Williams, Turner and Gilbert (1954, p. 84-85) defining "The Lamprophyres" are appropriate: "All (lamprophyres) carry euhedral mafic minerals, commonly of two generations; many lack feldspar..."; "The magmas from which most lamprophyres evolved were rich in carbon dioxide, sulphur, phosphorous, and water vapor..."; All carry much iron, lime, magnesia, and alkalies, and almost all are either basic or ultrabasic".

SKETCH OF CORE RELATIONS OF
MINERALIZED ZONE IN DRILL HOLE 81-1
S.D. OLMORE
FENCO-UNION MINERALS NORGE
JOINT VENTURE
25/3/82.

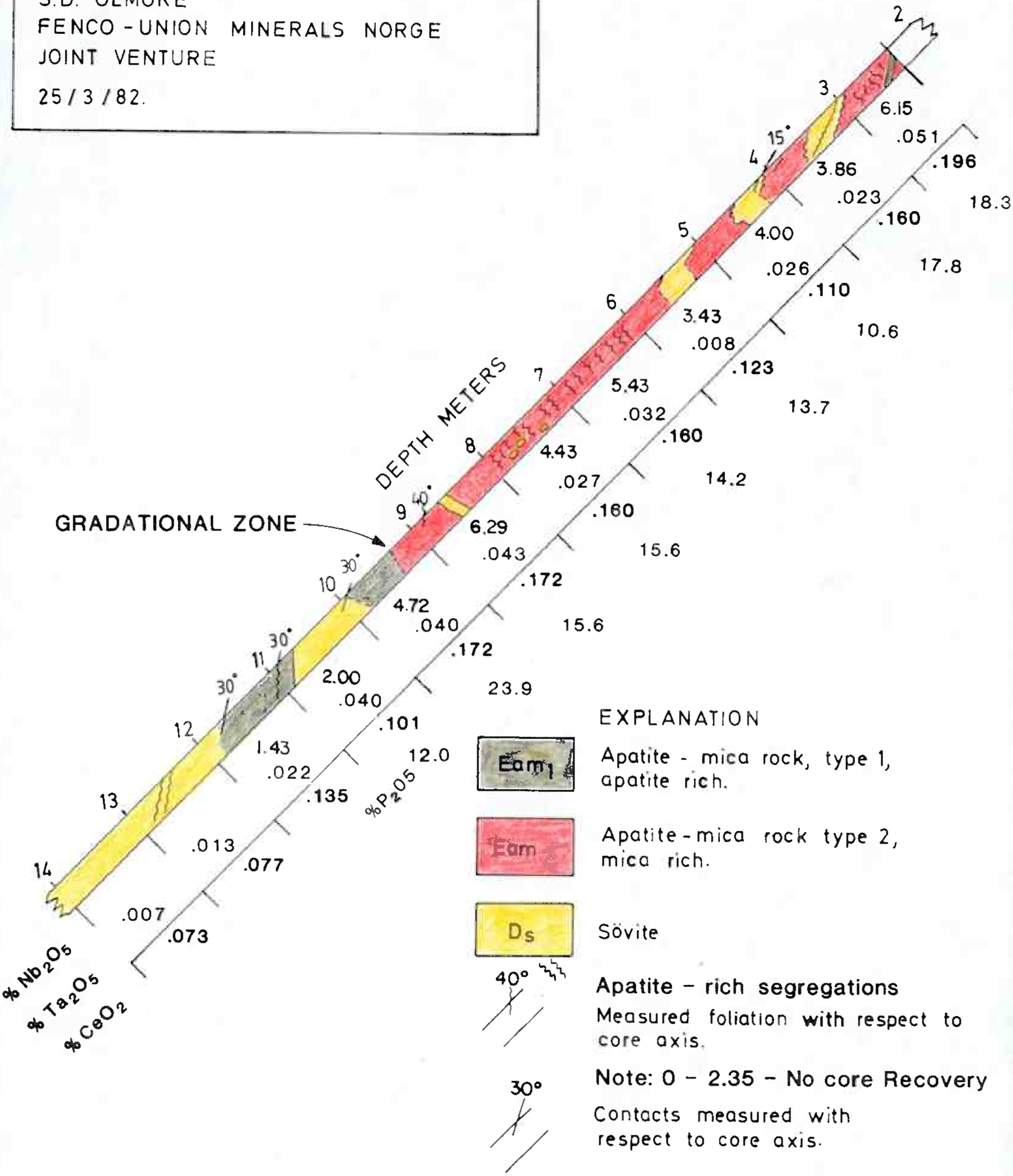


Figure 2
S.D.OLMORE

5-6m

Søvite inclusion 5-5.5m, 5.5-6m -- mica-apatite rock. Flakes of euhedral mica to 1cm, mixed with gray, fine-grained apatite-rich zones.

6-7m

Best developed interval of mica-apatite rock. Flakes of euhedral mica to 1cm; mixed with gray, fine-grained apatite-rich zones.

7-8m

Coarse mica-apatite rock with segregations of earthy, fine, columbite (?) grains, slightly resinous, alternating coarse and fine bands.

9-10m

Coarse-grained for the first 20cm, then grades to a finer-grained, gray-green rock. Patch of pink søvite at the end. Mica-apatite dominant.

10-11m

Dominantly pink søvite with gray-green apatite rock cutting across in last 25cm.

11-12m

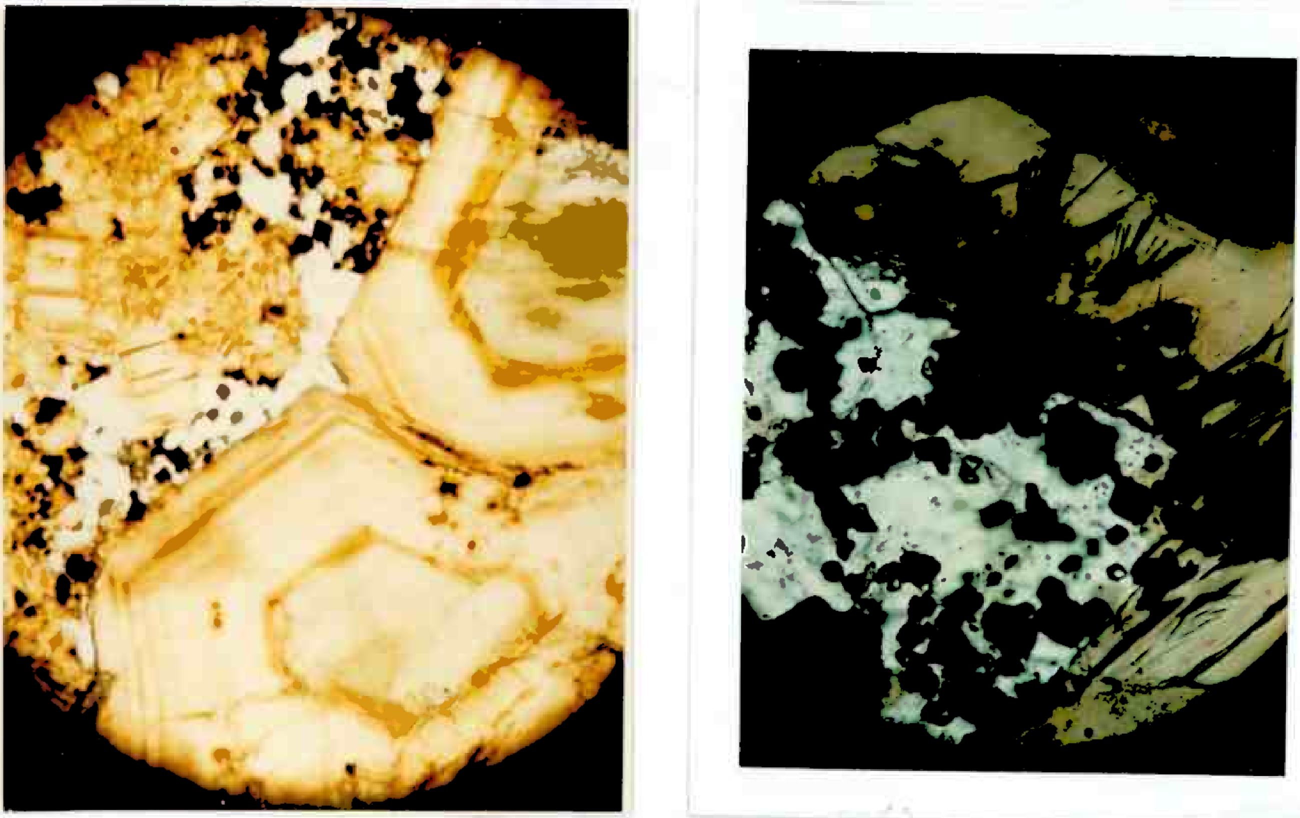
Greenish-gray apatite-rich rock, medium-grained, cuts søvite at 30^{o} to the core axis.

12-13m

Medium-grained grayish-white søvite.

The relative proportions of apatite and mica along with niobium mineralization (pyrochlore (?)) are quite variable in the rock. A point count (1000 points) sample of the apatite-rich phase (Type 1, Figure 2), at 9.6m yielded the following mineral percentages: 66.3% apatite, 23.3% zoned phlogopite/biotite, 5.2% pyrochlore and unknown high index minerals .5%, 4.7% calcite. In contrast, the mica-rich phase (Type 2, Figure 2) (largely phlogopite), represented by sample taken at 6.35m yielded these point count (1000 points) results: 4.8% apatite, 73.8% phlogopite, 17.3% pyrochlore and some unknown high index minerals, 4.4% calcite.

The niobium mineralization is not well defined at present. There appear to be at least two phases present that occur together. The average grain size is about .05m but it varies from about .02mm to .01mm in the mica-rich variety (Figures 3 and 4). These small grains are extremely difficult to examine in thin section. They are light gray in reflected light, and opaque in transmitted light. They might be one of several niobium-bearing phases, and it can be said only that they are oxides.



3A

1 mm (apprx.)

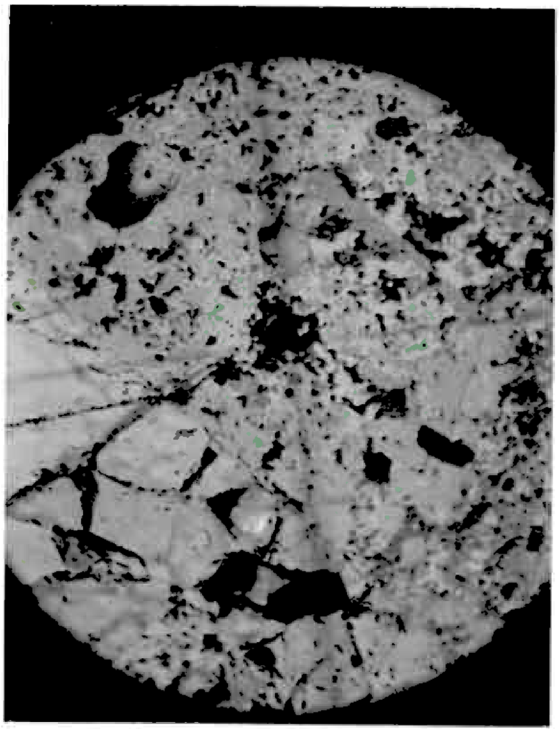
3B

.5 mm (apprx.)

Figure 3.

pyrochlore and fersmite

Photomicrographs in plane-polarized light of typical high grade niobium mineralization in drill hole 81-1 at 8.35 meters (3A) and at 6.35 meters (3B). 3A shows opaque (metamict) disseminated grains of pyrochlore (?) distibuted around large, euhedral, zoned, phlogopite grains. The white-appearing grains are apatite. Note metamict haloes around ca. .01mm grains included in phlogopite. The green cores of the phlogopite are more Mg rich than the more Fe-rich outer, brown zones (see Appendix D, microprobe analyses by H. Qvale). 3B shows disseminated pyroclore (?) in clear, white apatite and brown phlogopite. Also note the probable "sagenitic" rutile needles developed in phlogopite.



.5 mm (appx.)

Figure 4.

fersmite and columbite)

Photomicrograph of polished thin section from hole 81-1 at 9.6 meters. Photo taken in mixed plane-polarized and reflected light. The gray area is a portion of an isometric, euhedral spinel which may be largely pyrochlore. There are two prominent phases within this grain. The light-gray phase is anisotropic and appears to partly replace a medium gray isotropic phase. The medium-gray phase contains abundant internal reflections. The brownish gray appearing mineral is apatite.

In the apatite-rich phases the grain size of the niobium mineralization is much coarser and approaches 1mm. (It might be also pointed out that the mineralization is much lower grade in the apatite-rich phase). A typical large, euhedral 1mm grain with isometric symmetry is depicted in Figure 4. Quantitative microprobe analyses by Ivar Hultin and Ragnar Haugen (18/3/82) on a few grains that are dark gray in reflected light (from the mineralized core interval at 7.9 meters) are listed in Table 1.

	Grain 1	Grain 2	Grain 3	Grain 4	Grain 5
FeO	0.179	.241	.376	.226	.000
MnO_2	.040	.050	.246	.011	.064
CaO	15.820	16.795	17.343	16.580	15.951
TiO_2	3.820	2.207	2.904	4.007	3.936
Nb_2O_5	75.057	78.218	78.240	78.150	75.734
Ta_2O_5	.228	1.472	.400	.310	.284
SnO_2	.061	.074	.000	.135	.152

Table 1. Microprobe analysis of five separate "spinel" grains from 81-1 core at 7.9 meters. Analysis by I. Hultin and R. Haugen 18/3/82, Geological Museum, Tøyen, Norway.

Note that the very high percentage of Nb_2O_5 leads Hultin (personal communication, 3/82) to speculate that the mineral phase may be other than pyrochlore.

The anomalously high content of Nb_2O_5 is inconsistent with lower values reported for pyrochlore (see, for example Van der Veen, 1963, and Mariano, 1980). At present the classification of the niobium-bearing phase(s) in the rock must be left open (Hultin, 3/82, personal communication).

The change from green to brown color of phlogopite micas reflects change in Mg/Fe ratios as indicated by electron microprobe scans (12 points) on the two large, zoned phlogopite phenocrysts depicted in Figure 3 by H. Qvale (4/82, Appendix D). In a paragenetic sense, the mica appears to have crystallized early and changes in the Mg/Fe chemistry of the parent magma is perhaps reflected in these zonal differences. A few phlogopite crystals contain inclusions of pyrochlore and where this occurs metamict halos are developed.

The two point count values of apatite of 66.3% and 4.8% represent extremes and reflect the inhomogeniety of the igneous mass. It is estimated that the entire interval considering apatite-rich and apatite-poor varieties will average 35-40%. (Apatite is easiest to recognize under CL with its characteristic violet luminescence resulting from Eu^{+2} activiation, Mariano and Ring, 1974. The relatively high cerium values of the assays suggests but in no way proves that apatite may also be enriched in light REO's.

Geological Interpretation of the Holla Area

A geologic interpretation for the Holla area is depicted by the attached geologic map and cross-section (Plate III and IV).

The overall geologic structure may be one of a zoned appendage of søvite magma that has intruded and altered Precambrian gneissic country rocks. The following sequence of events is postulated: The mechanism of emplacement, at least initially,may have been explosive. High-temperature søvite magma of low viscosity and rich in volatile constituents is thought to have explosively forced its way into Precambrian country rocks. A large shock zone of brecciated rock is thought to have formed about the magma chamber. The shock zone was then penetrated pervasively by søvite magma and the Precambrian gneiss fragments were converted first to syenite and then to hollaite by thermal and hydrothermal processes. Peripheral to this shock zone a zone of thermal recrystallization of the granitic gneiss and an addition of alkalis took place to produce syenite and pulaskite. Outward from the syenite-pulaskite zone ordinary quartz-aegirine fenite was developed largely as the result of ingress of hydrothermal fluids through outward-extending fractures produced during the initial fracture event. A similar zonal pattern of development was mapped in the Tuftestollen area (Olmore, 1981, Plates I and II).

Indications are that the søvite magma chamber may be zoned, but the drill hole only pierced through a portion of it and the picture is assymmetric at present. The late rauhaugite and dolomite dikes may be late, internal phases of the søvite magma. Indications are that there is an enrichment with Mg and Fe in the later carbonatite phases. Thus fractional crystallization and internal separation of a magma that differs significantly in composition from the magma of outer zones is suggested. The cross-cutting intrusive phase (mica-apatite rock) may be a residual accumulation in the central portion of the søvite body. The enrichment of this late rock unit in niobium, phosphorous, cerium, fluorine, tantalum, heavy elements and water may be analogous to the later residual pegmatitic phases of silicate systems. (This concept is also considered reasonable by T.L. Sverdrup of A/S Sydvaranger, personal communication, 3/82).

Some Exploration and Economic Considerations

Late stage Mica-apatite rock is regarded as an important carrier of pyrochlore mineralization in carbonatites by Mariano (1980, p.34). Mica-apatite lamprophyre similar to that defined here is described by Vartiainen (1980) in the Sokli carbonatite complex in northern Finland. However, probably the first author to record the correlation of pyrochlore (betafite) mineralization associated with mica-apatite rocks is van der Veen (1963, p. 168-170).

At Sokli up to 6% pyrochlore mineralization occurs in thin, maximum 200 cm wide ferriphlogopite-apatite dikes. As far as known there is nothing to suggest that the dikes at Sokli rival the ten-meter zone in drill hole no 81-1, but these similar dikes at Sokli are widely scattered in that complex (Vartiainen, 1980). Similarly, other dikes could occur in other areas at Fen, and could have gone unnoticed despite the 30,000 meters (Ø. Gvein, personal communication 3/82) of previous drilling; for mica-apatite rock in hand specimen is easily mistaken for the dark, basic silicate rock termed Hollaite. Thus, it may be predicted that rocks such as at the top of drill hole no 81-1 will be found in other portions of the Fen district.

It is impossible to make a geological assessment of the volume of the mineralized body at Holla based on one drill hole, but the following observations give an indication of size: (1) the dike is near vertical in attitude and has a width of about 6 meters; (2) two small, several-centimeter- wide, dikes of this rock may occur at the interval 223-225 meters, about 150 meters in both vertical section and in plan from the dike at the collar of the drill hole; (3) pronounced surface gamma radiation anomalies over the projection of the dike to the north and south have been registered, indicating a length of perhaps one-hundred meters; (4) a narrow magnetic low could also define an approximate north-south dike (Plate I).

DETAILED GEOLOGY OF THE MELTEIG/BRISKMYR AREA

General

The Melteig-Briskmyr area is an irregular, tongue-shaped satellitic body of basic silicate rocks which forms a topographic re-entrant in the southern portion of the fenitized border of the complex. (See index map, plate II).

The area is of exploration interest for several reasons. In the first instance, Brøgger (1921, p. 18) reports several anomalous values of niobium and tantalum which require verification. Secondly, several magnetic highs occur in the basic silicate rocks as indicated by Sæther's (1957) and Carsten's (1981) magnetic intensity maps. And, finally, it has been known for some time that the apatite is a possible source of phosphate and that the nepheline-rich rocks of the area are a potential source of raw materials for the glass industry.

A semi-detailed, interpretive geologic map of the region (Plate II) shows the scarcity of outcrops underlying the area of critical interest. Thus soil and float mapping are heavily relied upon in order to produce an interpretive map. The mapped distribution of basic silicate rocks differs little from Sæther's (1957) map, however, the location of outcrops and separation out of detailed relationships should be of benefit to present as well as future investigations.

Rock Units

Medium-Grained Granite

Medium-grained granite (Ag) is found in two outcrops in the extreme western portion of the Melteig area. Under megascopic examination the granite is clean appearing and apparently unfenitized. However, evidence of weak fenitization under the microscope and under CL is indicated by a few dark red luminescing cores of K-feldspar grains and also by small blebs and patches of introduced calcite (see sample No. F 00711, Table 2).

Quartz-Aegirine Fenite

(Bqf) forms a resistant, topographic rim bordering melteigite and related ultramafic rock units. Recognition of this unit in the field is based in the megascopic identification of quartz and introduced aegirine, the two key index minerals.

This rock unit is only partly recrystallized and altered by the metamorphic/metasomatic processes of fenitization. Pegmatitic pods and dikes are commonly oriented sub-parallel to foliation. Narrow cataclastic zones are well defined. Metasomatic introduction of aegirine enhances the definition of

ABBREVIATED LOCATION COORDINATES	ABBREVIATED SAMPLE NO.	NEPHELINE	AEGIRINE OR AUGITE	APATITE	SPHENE	K-FELDSPAR	CANCRINITE	RUTILE OR ZIRCON	WHITE MICA	CALCITE	CHLORITE	BIOTITE	PHLOGOPITE	MELANITE	ILMENITE	PYRITE	MAGNETITE	CHALCOPYRITE	ALBITE	HORNBLENDE OR RIEBEKITE	QUARTZ	
Y636 X111	694				P-	C		P-													P-	Bostonite, crse grained, altered, epidote, K-feld, clay
Y358 X524	703B					P				P	P									P+		Bostonite, epidote, strong alt, orbicular agglomerations of K-feldspar
Y283 X558	703A				P-	P		P-		P+	P	Pt				P-			P	P+		Bostonite, orbicular phenos of K-feldspar
Y161 X402	712		C		P	C		P-		P	P											Bostonite, twinned sphene, epidote
Y143 X438	713	C	C			C	P			P									C			Tinguaite, porphyritic texture, bladed Kfeld phenos
Y277 X524	703	?				C			P	P+	P-	P				P-	P?	-	P+	P+	P	Bostonite, strongly altered, arbicular phenos of K-feld
									QUARTZ - AEGIRINE FENITE/SYENITIC FENITE													
Y033 X186	711					A				P-	P	P-							P		P	Granite, med. grnd.
Y463 X401	689		P			A				P		P							-		C	Quartz fenite, coarse grained, aegirine veinlets
Y209 X509	700A		P			C				P+		P							P+		C	Intrusive bx w/inclusions of quartz fenite
Y218 X517	700		P+			C						P-									C	Intrusive breccia with inclusions of quartz fenite
Y291 X538	701		P+			C											?		Pt	P		Intrusive breccia, in fenite
Y720 X397	707		P+			a				P									C			Aegirine rich, albite replaces K-feldspar, syenitic
Y842 X360	708		P+	P		C				P									P			As above
Y321 X420	705		C			C				P+									P+			Intrusive bx, loaded w/aegirine
Y653 X349	682		P+		P	a								?					P+			K-feldspar - aegerine syenite
Y573 X120	695		a	P	P	C				P+									P+			K-feldspar - albite syenite
Y653 X406	681		P		P-	a	P?	P-		P-				P-	?				a			Aegirine-bearing syenite
Y553 X577	688	(P)	a	P	P	P+										P-?	P-?		P-			Transitional rock, malignite? mixed, both basic sil and fenite

Table 2 Petrography of selected fenite, syenite and dike rock samples from Melteig area, a 50%, C25-50%, p+ 10-25%, P1-10%, P- 1%.

(a 50% C 25-50% p+ 10-25% p 1-10% p- -1%)

TABLE 2

Precambrian foliation by its replacement of biotite. However, aegirine dominantly forms veinlets along hair-line fractures that have directions irrespective of foliation (see Plate II). The presence of aegirine veins and veinlets is taken as evidence that the rock underwent brittle fracturing prior to or incident to the ingress of fenitizing fluids.

Under the microscope, aegirine, blue amphibole, K-feldspar, calcite, chlorite, biotite, albite, sphene, quartz and rutile are observed in some specimens (for example F00678). Cataclastic texture is well exhibited by undulose extinction of quartz and twin displacements along microfractures. In some specimens cataclasis has all but been obliterated by recrystallization.

Under CL aegirine veinlets are bordered by halos of secondary alkali feldspar in which Fe^{+3} is present. Effects of fenitization appear to be concentrated along grain boundaries. Apatite possessing CL is present in some specimens.

Chemical analyses of two samples of quartz-aegirine fenite are plotted in Table 3.

Syenitic Fenite

Syenitic fenite (Bsy) a term used by (Vartiainen, 1980) is defined here as completely recrystallized granitic gneiss that is rich in aegirine, K-feldspar and albite. The unit is variable in texture and appearance and ranges from coarse-grained, K-feldspar-rich rock to a dark, non-descript aegirine-rich rock that tends to grade into meteigite. Contacts with melteigite are thus indistinct, except for a few dikelets seen to cut quartz egirine fenite.

Under the microscope (Table 2) principal minerals are aegirine and alkali feldspar (including both albite and K-feldspar). Secondary albite overgrowths are typical as is patchy replacement of K-feldspar by albite. Local albite flooding is observed where the rock consists dominantly of short stubby grains of albite.

Under CL it is observed that most K-feldspars are deep red and characteristically have borders of blue luminescing plagioclase. That the Fe^{+3} enrichment of K-feldspar grains has occurred in the presence of fenitizing solutions from the adjacent body of ijolite-urtite seems indisputable.

The chemistry of one typical specimen (F00695) is plotted in Table 3.

Melteigite

Melteigite (Cm) is best exposed along the roads leading to and from the Melteig farm house. Much of the area inferred to be underlain by melteigite on the geologic map is, unfortunately, covered by soil, cultivated crops, and indigenous vegetation; therefore, the map is, in part, based upon erosional features, soil characteristics and float.

uncertain - maps [illegible] be base more on geophysics.

Megascopic examination of texture is indicative of a medium to coarse-grained greenish-black plutonic rock. The texture is typified by bundles of bladed 2-10mm euhedral, green aegirine prisms enclosed in equant, 10-20mm grains of white to yellowish nepheline. Other minerals obvious in hand specimen are sphene and melanite. The latter is black with a sub-metallic to resinous appearance and occurs locally as large, irregular patches.

Melteigite has several textural varieties. At contacts with syenitic fenite it appears to be fine grained and equigranular, as at sample location F00679, indicating the possibility of a chilled border phase. At one locality outside the map area, a dike of melteigite cutting syenitic fenite with aegirine needles in sub-parallel alignment and oriented perpendicular to the contact was observed. This phenomenon has also been recorded by Lehijärvi (1961) in the alkaline district of Iivaara, Finland.

Under the microscope it is seen that primary minerals present are sphene, aegirine, nepheline, melanite, apatite, mica and calcite. Accessory minerals and minerals resulting from secondary replacement are cancrinite, zircon, white mica, chlorite, ilmenite, magnetite, pyrite and chalcopyrite (Table 4). Nepheline is commonly altered to cancrinite and white mica.

Several areas of strong deuteric alteration where nepheline is altered to white mica and cancrinite and mica (biotite) is altered to chlorite are noted on the map (Plate II). These areas may connect to form one large alteration zone. Deuteric alteration may be the common case with fresh unaltered rock the exception.

Chemical analyses of two altered specimens of meteigite are listed in Table 3 and Al_2O_3 - CaO - MgO ratios are plotted in Figure 5.

Tinguaite

Tinguaite (Ct) is known to occur as one small dike in the Briskmyr area (F00712). The rock exhibits porphyrytic texture in hand specimen with euhedral pink phenocrysts of K-feldspar and white, equant phenocrysts of nepheline imbedded in a fine grained, gray groundmass. Under the microscope the groundmass is seen to consist of plagioclase, aegirine and sphene.

It is possible that tinguaite represents the fine-grained dike equivalent to melteigite or a mixture of melteigite and syenitic country rocks.

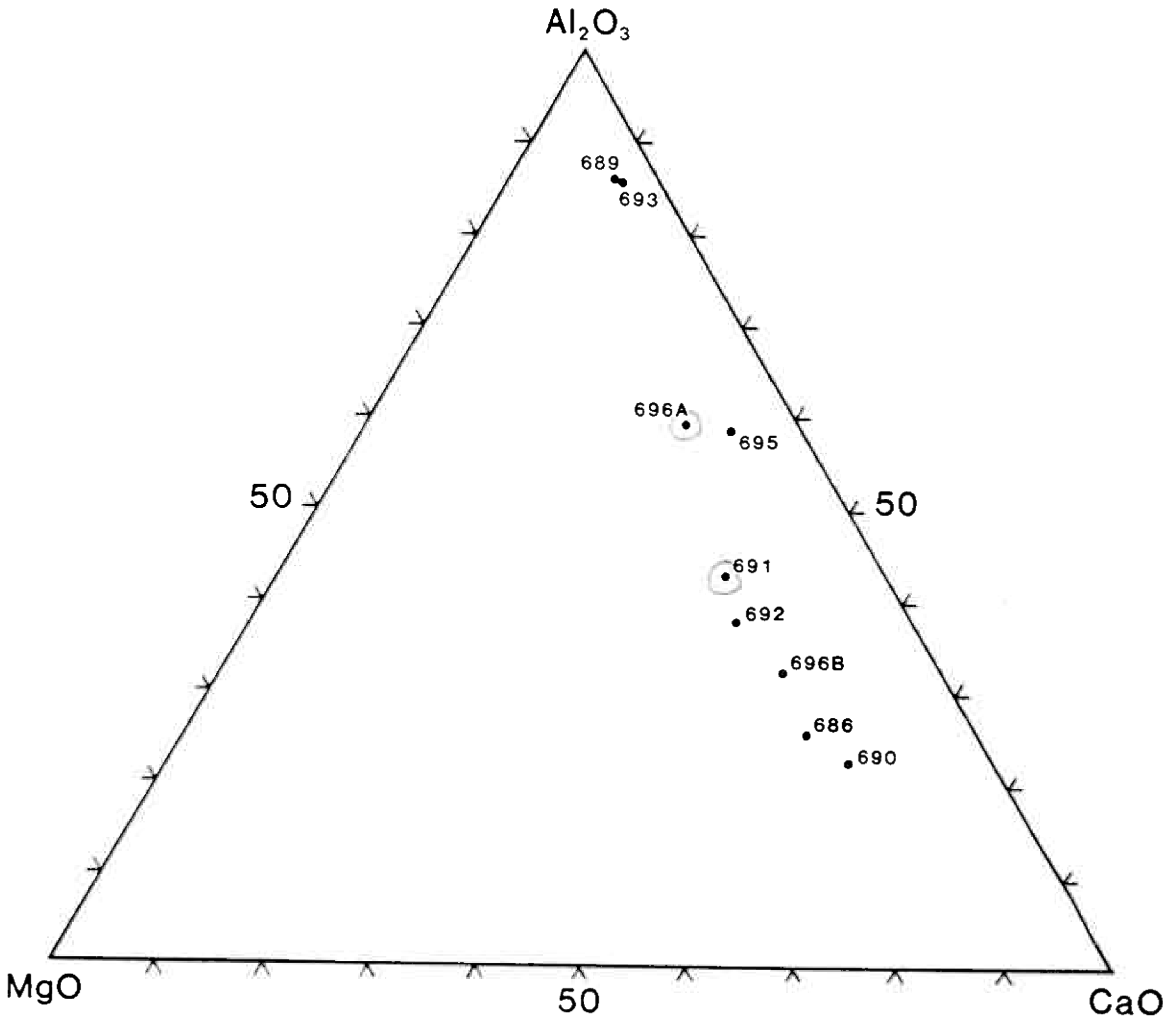
Urtite and Ijolite, Undivided

Urtite and ijolite, undivided (Cu) are inferred to lie beneath an approximate 50 x 200 meter oblong area on the geological map. These nepheline-rich intrusive phases occupy the larger percentage of the extreme southern portion of the melteigite intrusive body

TABLE 3

	SiO_2	FeO_2	MgO	Al_2O_3	P_2O_5	Na_2O	TiO_2	K_2O	CaO	MnO	BaO	SrO	V_2O_5	Nb	Y	Th	S	La	Ce	Nd
BASIC SILICATE ROCKS																				
Cu 696A	39.30	5.40	3.20	20.03	1.78	15.30	1.33	3.12	10.60	0.14	0.03	0.08	0.02	0.026	0.007	0.005	0.08	0.012	0.020	0.015
Cu 696B	38.50	9.50	3.80	10.20	2.06	8.90	1.30	1.32	17.20	0.27	0.04	0.09	0.06	0.026	0.022	0.005	0.28	0.012	0.025	0.018
Cu 692	40.00	6.20	5.80	13.40	2.2	10.80	1.50	1.70	15.80	0.16	0.03	0.09	0.02	0.021	0.007	0.005	0.06	0.014	0.025	0.017
Cm 690	39.10	12.90	4.60	7.70	1.94	1.60	3.80	0.70	21.40	0.37	0.064	0.09	0.09	0.021	0.028	0.005	0.20	0.012	0.022	0.016
Cm 686	38.70	10.16	5.50	8.80	3.00	1.80	2.30	1.20	20.0	0.35	0.10	0.13	0.05	0.032	0.010	0.005	0.13	0.018	0.035	0.020
Cu 691	39.70	6.00	5.00	13.80	2.01	10.80	1.0	2.20	13.70	0.18	0.05	0.09	0.02	0.18	0.007	-0.005	0.05	0.011	0.018	0.012
QUARTZ - AEGIRINE FENITE AND SYENITIC FENITE																				
Bsy 695	54.30	5.91	1.46	12.10	0.78	8.07	0.52	5.28	7.13	0.31	0.30	0.09	0.05	0.029	0.005	-0.005	-0.5	-0.01	-0.01	-0.07
Bqf 693	66.53	3.22	0.45	11.72	0.11	9.95	0.42	2.64	1.54	0.10	0.11	0.03	-0.009	0.017	0.008	AA	AA	AA	AA	-0.01
Bqf 689	66.74	3.08	0.58	12.66	0.11	8.07	0.27	4.44	1.54	0.11	0.08	0.02	-0.009	0.017	0.005	AA	AA	AA	AA	AA

Table 3 Partial whole-rock chemical analyses for selected major and minor elements for nine samples of Melteigite-related basic rocks and Fenite rocks. (Analyses performed by S. Melsom, Sentralinstitutt for Industriell Forskning, 1981; X-ray fluorescence methods for minor elements and plasma Methods for major elements). Refer to Plate II for sample locations.



696A - Urtite
691 - Ijolite
692 - Melteigite
696B - Melteigite?
686 - Melteigite

690 - Melteigite
695 - Syenitic fenite
693 - Quartz-aegirine fenite
689 - Quartz aegirine fenite

Figure 5 Variation in molecular CaO-MgO-Al_2O_3 for melteigite, related ijolite and urtite, and quartz-aegirine fenite.

Note that sample No.s are shortened from F00696A, etc.

TABLE 4

Abbreviated Location Coordinates	Abbreviated Sample No.	Nepheline	Aegirine/Augite	Apatite	Sphene	K-Feldspar	Cancrinite	Zircon	White Mica	Calcite	Chlorite	Biotite	Melanite	Ilmenite	Pyrite	Magnetite	Chalcopyrite	Classification and Comments
Y589 X145	696B	P+	C	P	P		P+					P	P+					Fresh, loaded w/cancrinite, fine grained trace of albite
Y589 X145	696A	a	C	P	P			?		P-		P						Fresh Urtite, very coarse grained
Y623 X172	691	C	C	P	P		P-			P		P-	P-					Fresh Ijolite, Cancrinite replaces nepheline
Y622 X220	692	a	C	P+	P+		P-			P		P	P					Fresh Ijolite, some cancrinite, alteration of nepheline, perovskite
Y589 X236	685	a	C	P	P		P-			P-		P	P			P?		Equagranular Ijolite, sphene is abundant
Y616 X284	683	a	C	P	P			?		P			P		P-			Fresh Idolite or Urtite, Coarse grained
Y548 X345	690	(C)	a	P			P+	?	?	P	?		P		P-			Strongly altered melteigite, abd black melanite
Y684 X444	679	P	a		P	P+	P-			P	P-		P		P	?		Fresh, WK alteration medium grained
Y633 X515	676	(P+)	a	P	P-			?	?	P	?	(P)	P		P-			
Y626 X530	675	(P+)	a	P	P-	P-?	P	P-	P	P			P-	P-?	P-	P-?		Strong alteration
Y598 X532	686	(P+)	a	P	P-		P+			P			P-					Strongly altered melteigite
Y643 X548	673	(P+)	a	P+	P		P	P-	P	P	P+	P-	P	P-		P		Strongly altered melteigite
Y684 X444	680	(P+)	a	P+	P			?	P-	P			(P+)		P	P-		Fine grained melteigite w/granitic texture
Y667 X585	674	(P+)	a	P	P			P	P-	P	P	P-	P		P-	P-		Moderately altered melteigite
Y608 X633	684	(P)	a	P	P		P	P+		P	P-		P-		P-	P-		Strongly altered melteigite, yellow Cl mineral, abd sph, calcite vnts
Y549 X679	677	C	C	P	P+		P	P?	-	P	-	P	P-	P-	P-	P-	P-	Typical fresh melteig, abd sph

Table 4
Petrographic scan of selected samples of Melteigite and related rocks. a 50%, C 25-50%, C 25-50%, P+ 10-25%, P 1-10%, P- 1%. () means that mineral was present prior to strong alteration and replacement. Refer to Plate II for sample locations.

Megascopically the body consists dominantly of medium gray, coarse, pegmatitic segregations of nepheline intergrown with long blades of aegirine.

Under the microscope nepheline, aegirine, apatite, sphene, cancrinite, calcite, biotite, melanite, and perovskite are identified (Table 4). In one specimen (f00698), cancrinite is probably a primary magmatic mineral. One chemical analysis of nepheline by microprobe (T. Anderson, 1981) is listed in Table 5. Also with microprobe methods H. Qvale and S. Olmore (3/82) confirmed the presence of calcium and titanium-rich perovskite (sample F00692) apparently lacking niobium.

Silico-Søvite

Silico-søvite (Dsc) occurs anomalously as one small outcrop alongside the main road in the western portion of the map area at X140469-Y50049. The outcrop is particularly striking because it is a small mushroom-shaped protrusion above the surounding fenitic granitic gneiss.

Under the microscope it is seen that the average grain size varies from between 0.2mm and 0.5mm. Primary minerals are calcite and albite. Albite occurs as .05mm euhedral laths. Accessory minerals are biotite, pyrite and rutile (?).

Explosion Breccia

Explosion breccia (bx) consisting largely of rotated and comminuted fenite fragments crops out in the Briskmyr area. Only the central zone of intense brecciation is indicated on the map as intrusive breccia. Rotated fragments and blocks of quartz-fenite lying peripheral to this central zone are indicated by the random orientations of measurements of primary gneissic foliation.

Under the microscope the breccia is seen to consist of a fine-grained paste of quartz, microcline, aegirine and blue amphibole. The amphibole is thought to have formed retrogressively from aegirine as the result of low-temperature hydrothermal solutions filtering through the porous rock.

The breccia zone is spatially close to mapped patches of Damkjernite instrusive, and therefore a genetic connection is indicated, but not proved.

Damkjernite

Damkjernite (Id) crops out in two small patches in the Briskmyr area. One sample at locality F00709 is typical, consisting dominantly of rounded gneiss inclusions and coarse biotite phenocrysts.

Under the microscope phenocrysts of pyroxene and biotite are particularly evident along with inclusions of calcite and abundant aegirine needles. Opaques present are magnetite and pyrite. Xenocrysts of olivine with alteration borders are questionably identified along with small, ovoid 1 cm inclusions altered to biotite, aegirine and calcite.

ELMT	ZAF	%ELMT	%OXIDE	FORMULA
SI	1.005	19.615	41.960	4.084
TI	.829	.041	.060	.005
AL	.922	18.288	34.555	3.915
FE	.914	.490	.630	.051
MN	.808	.000	.000	.000
MG	.850	.084	.139	.020
CA	.962	.347	.486	.050
NA	.834	11.759	15.851	2.955
K	1.000	6.117	7.369	.904
O	.483	44.318	.000	16.000
TOTAL		101.059	101.058	

Table 5   Microprobe analysis of a single crystal of nepheline from urtite pegmatite from sample locality F00633 (Plate II). Analysis by T. Andersen (1981, Table 4).

Bostonite

Bostonite (Nb), a name applied by Brøgger (1921), occurs as brown-weathering, very fine grained, 5 cm to 1 m wide dikes that cut through aegirine-quartz fenite. The dikes tend to be oriented sub-parallel to foliation in the fenite, but this is by no means a fixed rule.

The microscope reveals that the primary mineralogy of the dikes has been subjected to intense deuteric alteration, yet the primary holo-crystalline "bostonitic" texture is preserved. Essential minerals present are K-feldspar, albite, and hornblende. Deuteric alteration appears to have formed calcite, chlorite, white mica and clay. Calcite locally comprises as much as 12% of the rock.

The dikes correlate with late dikes found in the Fen mines area that are of probable Permian age.

Structure

Foliation in quartz-aegirine fenite consistently strikes to the northeast and dips steeply northwest or southeast. In those zones of the granitic gneiss that have been converted to syenitic fenite or brecciated, foliation is unmeasurable with consistency.

Analysis of aerial photos and topographic maps along with some geologic evidence leads to the inference of a system of large, northwest-striking faults in the southwest portion of the mapped area. Evidence is best developed where a large lake has dammed up against a northwest-striking escarpment. (This is similar to sag ponds developed along large recent fault zones described elsewhere, for example, along the San Andreas in California). Also of importance is a patch of near-fresh medium grained granite in juxtaposition with brecciated quartz-aegirine fenite along the possible fault. Moreover, the approximately N 45° W strike of this hypothetical fault zone is conveniently sub-parallel to similar topographic breaks and faults mapped within the complex and on the northeast margin of the complex (Olmore 1980,1981).

The overall map pattern of the melteigite-ijolite-urtite body is discordant to all of the above-described fracture and foliation directions. The mass was probably emplaced pasively by assimilation or metasomatism of granitic gneiss without regard to the dominant northeast trend of the foliation in the gneiss.

Exploration Targets

Nioboum mineralization reported by Brøgger (1921, p. 18) Bjorlikke (1933, p. 153-154); and Sæther (1957, p 29) south of the Melteig Farm cannot be substantiated from information gathered thus far. The petrographic and geochemical data collected have not revealed the koppite of pyrochlore of previous investigations.

Stjernøy Nefelin
inneholder ca 2% mt. →

In several samples the mineral perovskite (which can contain up to about 16% niobium), has been identifed in small amounts, but microprobe analysis thus far does not indicate the presence of even trace amounts of niobium.

Potential of the area for drilling will be reviewed when available geochemical analyses are received.

There are three principal areas of anomalous magnetic response that also must be considered as possible exploration targets. Two of these are shown on Sæther's (1957) map and are confirmed by Carsten's (1981) survey, and all are plotted on an overlay for the geology (plates II anc IIA). The most promising of these anomalies, lying several hundred meters west of the Melteig farm house, could be the result of large magnetite concentrations in the melteigite. Another possibility is that a body similar to the Jacupirangite at Kodal, Norway (Bergstøl, 1972) with magnetite, apatite and possibly ilmenite segregations, lies here. Anomaly may also reveal Nefelinsyenit.

The large, amoeboid-shaped body of urtite and ijolite is of some interest because of its high nepheline content. One microprobe analysis of nepheline by Andersen (1981) indicates, an iron content of 0.490% (Table 5). Map relations indicate that a body of coarse, fresh, nepheline-bearing rock with dimensions of approximately 200 meters x 70 meters x 200 (?) meters could exist.

It may be worth drilling either the magnetic anomalous areas or the nepheline mineralization. Both.

CONCLUSIONS

High grade niobium mineralization has been discovered as the result of drilling in the Holla area. Indicated grades of such mineralization are on the order of 2-4% Nb_2O_5 along with strongly anomalous concentrations of tantalum and phosphate. At this time the volume of the mineralization is not known, but if one assumes that the mineralization is contained in a late, dike-like mass, an economic body could exist.

The accumulation of a niobium-mineralized, fluorine-rich, water-rich, phosphate-silicate igneous phase (Lamprophyre) may bear the same relationship to a compound søvite body as late pegmatite phases bear to parent granitic instrusive phases in pure silicate systems. Thus the genesis of this high-grade niobium mineralization may result from late-stage volatile enrichment in the interior portions of a crystallizing søvite body. Further investigations at Fen should be oriented toward understanding the genesis of this rock unit and testing the above hypothosis.

The source of the mineralized lamprophyre dike could be as much if not more of an interesting exploration objective (from the standpoint of volume) than the dike itself. Thus deep drilling shall be necessary to test this possibility.

RECOMMENDATIONS

The Fen exploration program should be immediately reoriented toward drilling out an assessing the grade and volume of high-grade niobium mineralization of the Holla area. An estimated 3000 meters of drilling will be required before a body can be proved. The geologic information developed should be used to design a thorough program of exploration for similar occurrences in the Fen complex.

Exploration of the lower-priority, Melteig area, which is of some interest for apatite, nepheline and niobium should be reserved for a later date.

REFERENCES CITED

Andersen, T. 1981, Mineralogy: Identifications and Chemistry of Fen minerals 1981. A preliminary report: FENCO Report III, 1981, 3 p.

Bergstøl, S., 1972, The Jacupirangite at Kodal, Vestfold, Norway: Mineral Deposita (Berl.) 7, p. 233-246.

Bjorlykke, Harald, 1933, Norwegishe Microlithmineralien ein Vorkomen von Mikrolith in Iveland, Setesdal,Norwegian: Norsk geologisk tidskrift, XIV, 1933, s. 145-161.

Brøgger, W. C., 1921, Die Eruptivgesteine des Kristianiagebietes, IV, Das Fengebeit in Telemark. Kong. Norske Vid. Selsk. Skr., I, Mat. Nat. KL No. 9, p. 1-408.

Carstens, C. W., 1981, Results from Mangetic Investigations of the Fen area in 1980: Elkem Engineering Division Report, 30 April, 1981, 6 p. and maps.

Lehijärvi, Mauno, 1960, The Alkaline District of Iivaara, Kuusamo, Finlnd: Geologinen Tutkimuslaitos, Bulletin de la Commission Gelogique de Finlande N:O 185, 62 p.

Mørk, K. and Olmore, S.D. 1981, Drilling Proposal for the Holla Magnetic Anomaly near Håtveit Creek, Fen Project: Fenco-Union Minerals Report, July 17, 8 p.

Mariano, A.N. and Ring, P.J., 1975, Europium-Activated Cathodoluminescence in minerals: Geochemica et Cosmochimica Acta, Pergamon Press, v. 39, pp. 649-660.

Mariano, A.N., 1980, Pyrochlore and Columbite at the Fen: Private report, 35 p.

Olmore, S.D., 1980, Progress Report, 1980 Field Season, Fen Project: Union Minerals Norge A/S, 19 p. (UMN FEN REPORT NO. 01).

Olmore, S.D., 1981, The Geology of the Northwestern Sector of the Fen Mining District: A Progress Report, Union Minerals Norge A/S, 62 p., (UMN FEN REPORT NO. 02).

Sæther, E., 1957, The Alkaline Rock Province of the Fen Area in Southern Norway: Det Kongelige Norske Videnskabers Skrifter, No. 1, Trondheim, 150 p.

Van der Veen, A.A., A Study of Pyrochlore: Verh. Kon. Nederlands Geol. Mijnbou., Gen, Geol. Se., 22.

Vartiainen, Heikki, 1980, The Petrography, Mineralogy and Petrochemistry of the Sokli Carbonatite Massif, Northern Finland: Geological Survey of Finland. Bull. 313, 126 p.

Williams, H., Turner, F.J., and Gilbert, C.M., 1954, Petrography: W. H. Freeman and Co., 406 p.

APPENDIX - A

DRILL HOLE NO. 81-1: WRITTEN DESCRIPTION AND SUMMARY, ALL NOTES BY S. D. OLMORE

0 - 12 m

Mixed rock unit. Mainly apatite-biotite rocks with marbled segregations of apatite, few søvite inclusions; grades to a greenish gray biotite-apatite rock that appears to be intrusive in origin. Loaded with fine grained, disseminated columbite (?) and pyrochlore. The columbite and pyrochlore tends to be distributed around phlogopite phenocrysts and occurs as streaks. Samples 1-3.95, 1-4.4, 1-6.35, 1-8.35, 1-9.6.

12 - 100 m

Dominantly coarse grained biotite-rich, magnetite-bearing søvite. Magnetite content is on the average of 1% throughout. Magnetite appears to occur as graphic intergrowths. The origin of the graphic intergrowths is entirely uncertain. The søvite is extensively banded with a consistent orientation of about 45° to the core axis. Whether this is primary layering or flow banding is uncertain. The mineral zoning of the søvite implies that the banding is primary and related to magmatic segregation.

100 - 114 m

Seems to be a border phase of the søvite intrusion. Definitely finer grained, contains disseminated pyrochlore.

114 - 140 m

Mixture of søvite and later rauhaugite dikes with locally well developed pink alteration haloes. This is the same relationship as observed in the Tuftestollen.

140 - 160 m

Mixed rock units - søvite Ds, dolomitic or raugaugitic dikes Gt, similar to Tuftestollen occurrence, fenite or fenitized precambrian Bsy,with syenitic textures. Rock unit that dominates is søvite with inclusions of basic silicate rocks (Ch) hollaite. Adjacent contacts with the basic silicate local carbonate flooding is observed. Dikes of Gt cut all rock units. Peripheral to Gt are pink søvite zones that appear to have developed from metasomatism.

K-feldspar flooding occurs marginal to dolomite (beforesite?) dikes. No question that syenite formed. Always medium grained, is metasomatic syenite at 196-197. Dolomite dikes are hard, gray on fresh surface and can contain appreciable amounts of apatite. Occasional fenite patches are found in basic silicate rocks.

200 - 220 m

Rock units are extremely mixed in this interval. Gt is apparently the more abundant of the rock types present. Gt is yellow-gray and has a fine-grained granular texture. The average grain size is less than 1mm and banding is evident. Cb grains are believed present and occur as small dark specks less than .5mm in diameter. Gt is later than søvite.

Søvite (Ds) is altered to a fine-grained, dense, rose- to violet- coloured rock.

Mineralization with pyrochlore/columbite appears best at 202-203m. Sample taken at 1-218.2 has been confirmed as columbite by microprobe analysis.

Fenitized Precambrian gneiss, k-f flooded, occurrs as relict patches in basic silicate rocks. Basic silicate rocks are typified by transecting calcite veins and veinlets with biotite haloes. Uncertain whether biotite results from magmatic crystallization or alteration.

Note that kf, or albite flooding of basic-silicate rocks (here called Hollaite-Ch) is well documented. The feldspar flooding is apparently related to dolomite or rauhaugite dikes cutting through basic silicate rocks.

220 - 240 m

A transition zone from dominantly carbonate rocks to dominantly silicate rocks, Gneissic fenite is altered to basic silicate rocks.

There are a number of white dolomitic dikes, dense, bluish gray, fine grained. These dikes have biotite haloes on them. Positive evidence for the brecciation of fenite with later metasomatic alteration to a mass of biotite, sphene and chlorite.

Late, coarse apatite dikes are brownish gray. They cut both Gt (Tuftestollen type rauhaugite) and Ds (søvite).

Pyrochlore mineralization in well-defined bands from 223-224m.

240 - 260 m

Zone consists mainly of basic silicate rocks (Ch, Hollaite) and feldspar-flooded fenite. Several types of carbonatite dikes present in this interval. Søvite (Ds) dikes barren of

Near-massive magnetite zone occurs at 146.5m. Columbite may occur together with pyrochlore as 0.3-0.7mm black crystals that are disseminated throughout Gt. Columbite-pyrochlore mineralization appears to be spatially related to Gt dikes. Interval from 145-146m is similar to the mineralization observed in the tufte area. Best mineralized zone for columbite and pyrochlore appears to be between 155 and 160m. Apatite is locally common and the green variety appears to be associated with gray dolomite dikes. Pyrrhotite and pyrite occur in streaks and bands and are commonly intermixed with magnetite.

Basic silicate rocks, common to abundant sphene is present, perhaps as much as 5 percent. The basic silicates are commonly altered to massive chlorite rock with disseminated pyrite. The basic silicate rocks contain no magnetite. They are apparently metasomatized by infiltrating søvite dikes to carbonate-rich rock. They also contain K-feldspar segregation zones or dikes. In one spot at 152.3m basic silicate grades into fenite. Where the basic silicates are most altered chlorite, black biotite, sulfides and sphene are present.

The søvite locally contains abundant amphibole lending a blue-green colour to the unit.

Samples: 1-150.7 basic silicate - carbonate flooded, check alteration also composition of sphene, any niobium?

1-158.6 søvite at contact with basic silicate. Appears to contain disseminated columbite with pyrochlore cores. Check,could be from high-grade zone.

180 - 184.5

The interval is dominantly søvite with primary mineralogy and structure obliterated by alteration that formed during emplacement of Gt (dolomitic) dikes. Pale-reddish purple staining is pervasive. Question: What is the mineralogical and/or trace-element difference that contributes to the formation of reddish-purple carbonate? Is it Mn-bearing? Columbite mineralization is strong in this zone and is definitely related to emplacement of dolomitic dikes. Columbite grains may be very fine, .3mm and are abundant on the borders of dolomite dikes and within them. 182-184m could be and ore zone.

184.5 - 200 m

Basic silicate, greenish black, varies from fine grained to coarse grained. Altered to a mass of chlorite and sulfides. Sphene is common. Possibly some zones with nepheline - (equant gray grains) cut by numerous søvite and Gt (beforsite) dikes. Søvite dikes invariably have biotite margins and may cause some local carbonate flooding of the basic silicate. Bitotite occurs as an alteration halo on basic silicate dikes. Chloritization may result from hydrothermal solutions off of søvite magma.

mineralization, along with thin, 1-4mm-wide søivte dikelets with Ch haloes developed on them. Barren, white dikes of dolomite bearing pyrrhotite (Gw) also a few bonafide dikes of rauhaugite Gt are present. The white dikes have well-developed biotitic haloes marginal to them. They could be a dolomite distal phase of late søvite.

Appears to be no mineralization of economic interest within this interval.

One zone with coarse magnetite is present - Rock type (?) at 253.1.

The Hollaite (Ch) clearly developes in brecciated zones of syenitic character. Non-brecciated zones are not converted to Hollaite, only alteration selvages on a few søvite veins are present. Alteration of fenite is as follows: Bqf to Bsy to Ch to possible rheomorphic Hollaite or Dsc-silico-carbonatite in very thin dikes.

Note that at 259.5 gray dolomitic dike definitely cuts søvite.

260 - 280 m

Dominantly fenitized and syenitized granitic gneiss in variable stages of development. Syenitic fenite (Bsy) medium gray colour and coarse K-feldspar. Ordinary fenite (Bqf) observed in places, not recrystallized with trace amounts of quartz present.

Some of the Syenitic fenite may be termed pulaskitic, totally recrystallized K-feldspar-chlorite rock. Well developed zone from 272 to 280. Sample 1-276.3 check petrography. Bladed crystals of pink, perthitic K-feldspar, also pyrite. The pulaskitic phase of syenite development is definitely cut by Hollaite development.

Ds dikes are commonly yellow gray, may contain green apatite and are generally barren. They have reaction rims of Hollaite when in contact with Bqf and Bsy.

280 - 300 m

Syenitic fenite with pulaskitic textures. This rock unit appears to have formed in place by total recrystallization. Silico-carbonatite dikes could result from the intimate mixing of Hollaite in søvitic magma. The syenitic zones definitely formed by recrystallization before Hollaite developed.

At 286m a søvite dike has unusual relations with a dolomite phase. Is there possibly a composite relationship between these two phases?

Also at 299-300m coarse crystalline dolomitic carbonatite is columbite bearing. The dolomitic phase is later and cuts søvite.

Hollaite streaks in søvite result from inclusions of Hollaite caught up in the magma stream.

300 - 320 m

Mixed rock units. Dominantly Hollaite (Ch) with thin yellowish-gray dolomite or ankerite dikes (Gy) cutting through. The ankerite dikes have zones of K-feldspar flooding on either side of them. The ankerite dikes may correlate with the Gt dikes cutting søvite, but this is as yet unproved. The søvite ankerite dike at 300m may show a composite relationship between the two phases.

320 - 340 m

Dominantly Hollaite patches altered to Syenite - an event apparently related to dolomite or rauhaugite dikes. Also Hollaite contains patches of syenitic granitic gneiss. Hollaite contains mainly biotite, is black, and contains patches of epidote-Chlorite-sphene rock. These are probably alteration zones after Bsy and Bqf - (fenitic granitic gneiss bearing quartz).

Hollaite is transected by numerous hair-line søvite veinlets, it is also cut be Gy dikes "yellow dolomitic dikes" - source unknown. Hollaite has relict intrusive breccia structure preserved from 324 to 328 meters.

There is a local dike of silico carbonatite (Dsc) at 330m that is most definitely intrusive. At 331m true fenite begins. 331-340 mixed zone with Bqf (quartz fenite) syenitic fenite, and there is difficulty in differentiating between these two units.

One yellowish-gray dolomitic dike at 330.5m may contain columbite.

The edge of the intrusive breccia zone allowing the formation of Hollaite is at 331m.

340 - 360 m

Dominantly fenitic granitic gneiss. Quartz is present. Primary foliation is obliterated. This is a "crackle" zone outward from the Hollaite zone. Green alteration assemblage is chlorite plus sphene and aegirine, which is developed throughout and marginal to the Hollaite zone. Fine, randomly-oriented Hollaite selvages on søvite veinlets occur throughout. The rock has a jumbled appearance in many places, here it is altered to either Hollaite or chlorite-sphene-aegirine rock.

Silico-carbonatite dikes (Dsc) contain fine biotite. Yellow dolomitic dikes (Gy) definitely cut søvite dikes and have no alteration haloes.

Fenitic granitic gneiss comes in at 343m.

360 - 385.4 m

Typical quartz fenite with abundant aegirine veinlets and dikes. Also Hollaite haloes developed on søvite dikes. The gneiss has been thoroughly cracked and broken but rotation and transport has not occurred.

APPENDIX B

LIST OF ABBREVIATIONS USED ON DRILL LOGS AND MAPS OF S. D. OLMORE

@	=	at	dev	=	developed
adj	=	adjacent	diss	=	disseminated
&	=	and	dol	=	dolomitic
AA	=	as above	dom	=	dominant
abd	=	abundant			
Ag	=	aegirine	exc	=	excellent
alt	=	altered	E.O.H.	=	end of hole
am	=	amphibole			
ap	=	apatite	f	=	fluorite
			f.g.	=	fine grained
biot	=	biotite	fol	=	foliation
blu	=	blue	fs	=	feldspar
brn	=	brown	flu	=	fluorite
bx	=	breccia	ft	=	fault
bxed	=	brecciated			
			g	=	goethite
CA	=	core axis	grn	=	green
cb	=	columbite	grnd	=	grained
carb	=	carbonate			
cl	=	chlorite	h	=	hematite
com	=	common	h'line	=	hair-line
cms	=	centimeters			
crse	=	coarse	incs	=	inclusions
CL	=	Cathodoluminesscence			
			kf	=	potassium feldspar

lge	=	large
loc	=	locally
lt	=	light
mag	=	magnetite
mass	=	massive
med	=	medium
M	=	mica
mix	=	mixed
neph	=	nepheline
p-	=	weak presence
p	=	present
p+	=	strong presence
pc	=	pyrochlore or columbite
pk	=	pink
Po	=	pyrrhotite
poss	=	possible
phenos	=	phenocrysts
py	=	pyrite
q	=	quartz
qtz	=	quartz
rau	=	rauhaugite
s	=	sulfides
sy	=	syenitic
segs	=	segregations
sp	=	sphene
sub ll	=	sub parallel
sø	=	sovite
tab	=	tabular
typ	=	typical
tr	=	trace
vns	=	veins
v.f.g.	=	very fine grained
w/	=	with
wh	=	white
x cut	=	cross-cutting
yel	=	yellow or yellowish

APPENDIX C

The following list of analytical results are for nine split samples of coarse rejects from drill hole 81-1. The samples were sent by Ivar Hultin of Sydvaranger to J.W. Keim of Molycorp, Inverness, Colorado for analysis. Samples for the Molycorp analysis, for example FN-3 means the interval 3-4 meters, were analyzed by the DC plazma method at the Louviers, Colorado laboratory by M.P. Moore. The Louviers results "corroborate" the initial, quantitative XRF results reported by Sigurd Melsom of S.I. Laboratories, Oslo, Norway on 8 March, 1982, The assay numbers for both laboratories are summarized below.

Fenco Sample No.	S.I. Lab %Nb_2O_5 (*4)	Louviers Lab No.	Louviers Lab % Nb_2O_5
81-1, 2.35-3	6.15	FN-2	6.93
81-1, 3-4	3.86	FN-3	2.95
81-1, 4-5	4.00	FN-4	3.07
81-1, 5-6	3.43	FN-5	2.92
81-1, 6-7	5.43	FN-6	5.61
81-1, 7-8	4.43	FN-7	3.82
81-1, 8-9	6.29	FN-8	7.96
81-1, 9-10	4.72	FN-9	4.67
81-1, 10-11	2.00	FN-10	1.47
AVE.	4.47%	AVE.	4.38%
81-1, 11-12	1.43		NA

(*4) Conversion of NB-Nb_2O_5 on S.I. samples was 1.43 x % Nb.

cc: JDO
ANM

RECEIVED
APR 1 1982
MOLYCORP, INC.
ENGLEWOOD, CO.

Memorandum
Molycorp, Inc.

UNION 76
MOLYCORP

March 31, 1982

Proj: #70-17
Ref.: #156-33

TO: T.E. Sisneros

FROM: M.P. Moore mpm

SUBJ: Ore Samples from Norway

Nine ore samples were submitted by Jim Keim for analysis of niobium, tantalum, thorium, yttrium, cerium, lanthanum, phosphate, vanadium and nickel. The samples were digested in aqua regia. The iron, rare earths and alkaline earths were separated from the earth acids and phosphate by fluoride precipitation. All analyses were performed by DC plasma emission spectroscopy. The analytical results (including iron, calcium, magnesium, titanium and neodymium) are listed in the table below.

	FN-2	FN-3	FN-4	FN-5	FN-6	FN-7	FN-8	FN-9	FN-10
% Nb_2O_5	6.93	2.95	3.07	2.92	5.61	3.82	7.96	4.67	1.47
% Ta_2O_5	0.054	0.024	0.021	0.012	0.038	0.022	0.057	0.041	0.034
% TiO_2	0.409	0.196	0.234	0.214	0.371	0.315	0.493	0.290	0.089
% ThO_2	0.018	0.010	0.006	0.006	0.012	0.005	0.038	0.032	0.047
% Y_2O_3	0.008	0.009	0.006	0.007	0.007	0.006	0.009	0.007	0.009
% CeO_2	0.230	0.213	0.135	0.197	0.141	0.177	0.223	0.204	0.146
% La_2O_3	0.084	0.079	0.053	0.080	0.065	0.065	0.081	0.076	0.051
% Nd_2O_3	0.080	0.076	0.049	0.064	0.059	0.064	0.084	0.073	0.053
% Fe	1.85	1.32	1.62	1.43	2.78	2.00	1.34	1.70	1.36
% Mg	5.37	2.89	4.15	3.51	<.01	6.93	3.45	5.54	0.92
% Ca	20.8	29.4	26.2	26.0	35.9	18.1	25.8	20.6	34.0
% P_2O_5	18.3	17.8	10.6	13.7	14.2	15.6	15.6	23.9	12.0
% Ni	0.027	0.016	0.019	0.016	0.023	0.015	0.001	0.018	0.012
% V_2O_5	0.183	0.084	0.086	0.085	0.165	0.118	0.014	0.135	0.043

MPM/kc

cc: J.W. Keim
W.R. Moran
N.C. Dimick

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RAPPORT

A/S Sydvaranger
Prospekteringskontoret
Boks 83
1321 STABEKK

Deres ref.	*Deres henv. av*	*SI's saksbehandler*	*Dato*
		SME/gmy	8 mars 1982

Oppdragets tittel

ANALYSE AV PRØVER FRA HULL NR. 1

Oppdrag nr.

453 - 80 11 13 - 23

Analysene er utført ved hjelp av røntgenfluorescensspektrometri etter Trinn I som avtalt.

Resultater (%):

	Nb	Y	Th	Ce
2,35 - 3	4,3	0,011	0,022	0,16
3 - 4	2,7	0,012	0,012	0,13
4 - 5	2,8	0,008	-	0,090
5 - 6	2,4	0,009	-	0,10
6 - 7	3,8	0,009	0,006	0,13
7 - 8	3,1	0,009	-	0,13
8 - 9	4,4	0,008	0,030	0,14
9 - 10	3,3	0,013	0,036	0,14
10 - 11	1,4	0,012	0,048	0,082
11 - 12	1,0	0,016	0,025	0,11
12 - 13	0,11	0,010	0,014	0,063
13 - 14	0,13	0,011	0,020	0,064
14 - 15	0,28	0,012	0,033	0,060
15 - 16	-	0,009	-	0,055
16 - 17	0,032	0,013	0,022	0,088
17 - 18	0,01	0,010	0,006	0,060
18 - 19	0,023	0,009	-	0,055
19 - 20	0,016	0,009	0,005	0,047
20 - 21	-	0,010	0,008	0,052

453 - 80 11 13 - 23 2

	Nb	Y	Th	Ce
21 - 22	-	0,008	-	0,066
22 - 23	-	0,008	-	0,064
23 - 24	-	0,010	-	0,062
24 - 25	-	0,009	-	0,067
25 - 26	-	0,008	-	0,065
26 - 27	0,015	0,009	0,007	0,064
27 - 28	-	0,010	-	0,065
28 - 29	0,016	0,009	-	0,063
29 - 30	-	0,011	0,006	0,063
30 - 31	-	0,009	-	0,066
31 - 32	-	0,009	0,006	0,066
32 - 33	0,010	0,014	0,008	0,064
33 - 34	0,090	0,009	0,011	0,071
34 - 35	0,13	0,010	0,015	0,066
35 - 36	0,23	0,010	0,028	0,083
36 - 37	0,41	0,009	0,041	0,063
37 - 38	0,16	0,009	0,016	0,063
38 - 39	0,049	0,009	0,007	0,062
39 - 40	0,19	0,009	0,020	0,069
40 - 41	0,15	0,009	0,014	0,066
41 - 42	0,34	0,009	0,033	0,068
42 - 43	0,11	0,010	0,011	0,060
43 - 44	0,19	0,008	0,014	0,066
44 - 45	0,29	0,008	0,026	0,074
45 - 46	0,11	0,010	0,010	0,066
46 - 47	0,15	0,009	0,019	0,067
47 - 48	0,072	0,011	0,013	0,067
48 - 49	0,077	0,009	0,013	0,057
49 - 50	0,12	0,009	0,017	0,069
50 - 51	0,055	0,017	0,042	0,081
51 - 42	0,024	0,014	0,014	0,066
52 - 53	0,10	0,011	0,022	0,069
53 - 54	0,062	0,009	0,008	0,058
54 - 55	0,10	0,007	0,010	0,052
55 - 56	0,014	0,009	-	0,066
56 - 57	0,035	0,010	0,008	0,067
57 - 58	0,020	0,011	-	0,071
58 - 59	0,020	0,009	-	0,063

453 - 80 11 13 - 23 3

	Nb	Y	Th	Ce
59 - 60	0,020	0,012	0,010	0,062
60 - 61	-	0,010	0,007	0,069
61 - 62	-	0,010	-	0,067
62 - 63	-	0,009	-	0,066
63 - 64	-	0,010	-	0,066
64 - 65	-	0,010	-	0,066
65 - 66	-	0,009	-	0,063
66 - 67	-	0,010	-	0,064
67 - 68	-	0,009	-	0,067
68 - 69	0,010	0,013	0,015	0,061
69 - 70	0,019	0,009	0,015	0,051
70 - 71	0,010	0,011	-	0,066
71 - 72	-	0,010	-	0,068
72 - 73	0,014	0,010	0,006	0,15
73 - 74	0,033	0,014	0,015	0,28
74 - 75	-	0,009	-	0,069
75 - 76	-	0,009	0,007	0,074
76 - 77	-	0,010	0,006	0,070
77 - 78	-	0,009	-	0,066
78 - 79	-	0,010	0,008	0,074
79 - 80	-	0,013	-	0,067
80 - 81	-	0,008	-	0,074
81 - 82	-	0,009	-	0,069
82 - 83	-	0,009	-	0,069
83 - 84	-	0,010	0,005	0,065
84 - 85	-	0,009	-	0,067
85 - 86	-	0,011	0,010	0,073
86 - 87	-	0,009	0,005	0,064
87 - 88	-	0,009	-	0,067
88 - 89	-	0,009	-	0,060
89 - 90	-	0,010	0,007	0,063
90 - 91	-	0,009	-	0,044
91 - 92	-	0,010	-	0,055
92 - 93	-	0,008	-	0,060
93 - 94	0,014	0,009	-	0,066
94 - 95	-	0,008	-	0,057
95 - 96	-	0,010	-	0,061

	Nb	Y	Th	Ce
96 - 97	-	0,008	-	0,056
97 - 98	0,012	0,010	0,006	0,052
98 - 99	0,010	0,010	-	0,056
99 - 100	0,010	0,010	-	0,043
F 00764	0,18	0,012	0,034	0,052

Påvisningsgrenser

Nb : 0,01 %

Y, Th : 0,005 %

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S. Melsom
S. Melsom
cand.real.

Betty Dirdal
B. Dirdal
ing.

Kopi: A/S Årdal og Sunndal Verk
v/cand.real. Viggo H. Wiik
Postboks 5177 Majorstua
Oslo 3

APPENDIX D - MICROPROBE ANALYSES OF COARSE, ZONED PHLOGOPITE MICAS FROM MICA-APATITE LAMPROPHYRE

DATA AFTER HENNING QVALE, 4/82, TØYEN, NORWAY

Sample No.	SiO_2	TiO_2	Al_2O	FeO	MnO	MgO	CaO	BaO	Na_2O	K_2O	F-	Sum	MgO/FeO	Point	Comments
F81-1,	40.3	0.5	12.5	4.9	Tr	25.0	0.0	nd	0.5	10.2	3.0	96.9	5.1	1A	Core
8.35m	40.3	0.5	12.8	4.7	0.0	25.2	0.0	nd	0.4	10.3	3.4	97.6	5.4	1B	
GRAIN I	41.2	0.6	11.5	7.5	Tr	23.0	0.0	nd	0.0	10.8	3.5	98.1	3.0	1C	
	41.4	0.4	11.8	5.5	0.0	25.4	0.0	nd	0.0	11.0	5.2	100.7	4.6	1D	
	41.7	0.8	11.3	7.0	0.0	23.3	0.0	nd	0.0	10.4	4.0	98.5	3.3	1E	
	42.5	0.5	11.8	6.8	Tr	23.9	Tr	nd	Tr	10.7	4.7	100.9	3.5	1F	RIM
F81-1,	40.0	0.5	12.5	4.9	Tr	25.3	0.0	nd	0.4	9.9	5.0	98.5	5.2	1G	CORE
3.35m	40.5	0.5	11.6	6.6	0.0	23.8	0.0	nd	Tr	10.6	5.0	98.6	3.6	1H	
GRAIN II	41.9	0.5	12.2	6.0	0.0	24.0	0.0	nd	Tr	10.7	3.8	99.1	4.0	1J	RIM
F81-1,	40.2	0.3	11.5	4.4	Tr	25.3	0.0	nd	0.3	10.2	2.4	94.6	5.8	1A	CORE
3.95m	40.7	0.5	10.8	6.0	0.0	24.6	0.0	nd	Tr	10.4	3.9	96.9	4.1	1B	
GRAIN I	40.7	0.6	11.7	6.6	0.0	23.4	Tr	nd	0.3	11.0	5.4	99.7	4.0	1C	RIM

Note, see Figure 3A for grain I and grain II of F81-1, 8.35m.

DIAMOND DRILL HOLE LOG HOLE NO. 81-1

PLATE I

EXPLANATION

- Eam apatite-mica rock (lamprophyre)
- Gw white dolomitic dikes
- Gy yellowish-green dolomitic dikes
- Gt Rauhaugite-Tufte type
- Ds Søvite
- Dsc Silico-Carbonatite dikes
- Ch Hollaite
- Bsy Syenitic Fenite
- Bqf Quartz-Aegirine Fenite

- K-feldspar dikes
- apatite rich zones
- flooded, pink zones adjacent dolomitic dikes, zones of alkali feldspar flooding
- faults
- foliation or banding showing approximate attitude
- breccia
- coarse feldspar
- orbicular structure
- pyrochlore or columbite mineralization
- inclusions
- graphic and dendritic textures

HOLE LENGTH - 385,4m
HOLE DIRECTION - S 70° W
INCLINATION - 45°
HOLE BEGAN - Sept. 26, 1981
HOLE COMPLETED - Oct. 21, 1981
COLLAR LOCATION x = 141534
y = 50974

NORWAY-FEN PROJECT
HOLLA AREA

DIAMOND DRILL HOLE LOG
HOLE NO. 81-1
S.D.OLMORE, 26/3/82
WITH SCINTILLOMETER AND MAGNETIC MEASUREMENTS BY J.E.WANVIK

UMN FEN REPORT NO.03

GAMMA RADIOACTIVITY (CPS) 0 100 200 300

%Mag. 1 2 3 4 5 6 7 8 9 10

SULFIDES, CHLORITE, HEMATITE, FLUORITE, FELDSPAR, AMPHIBOLE, MICA, SPHENE, APATITE, PYROCHLORE, NIOBIUM, TANTALUM

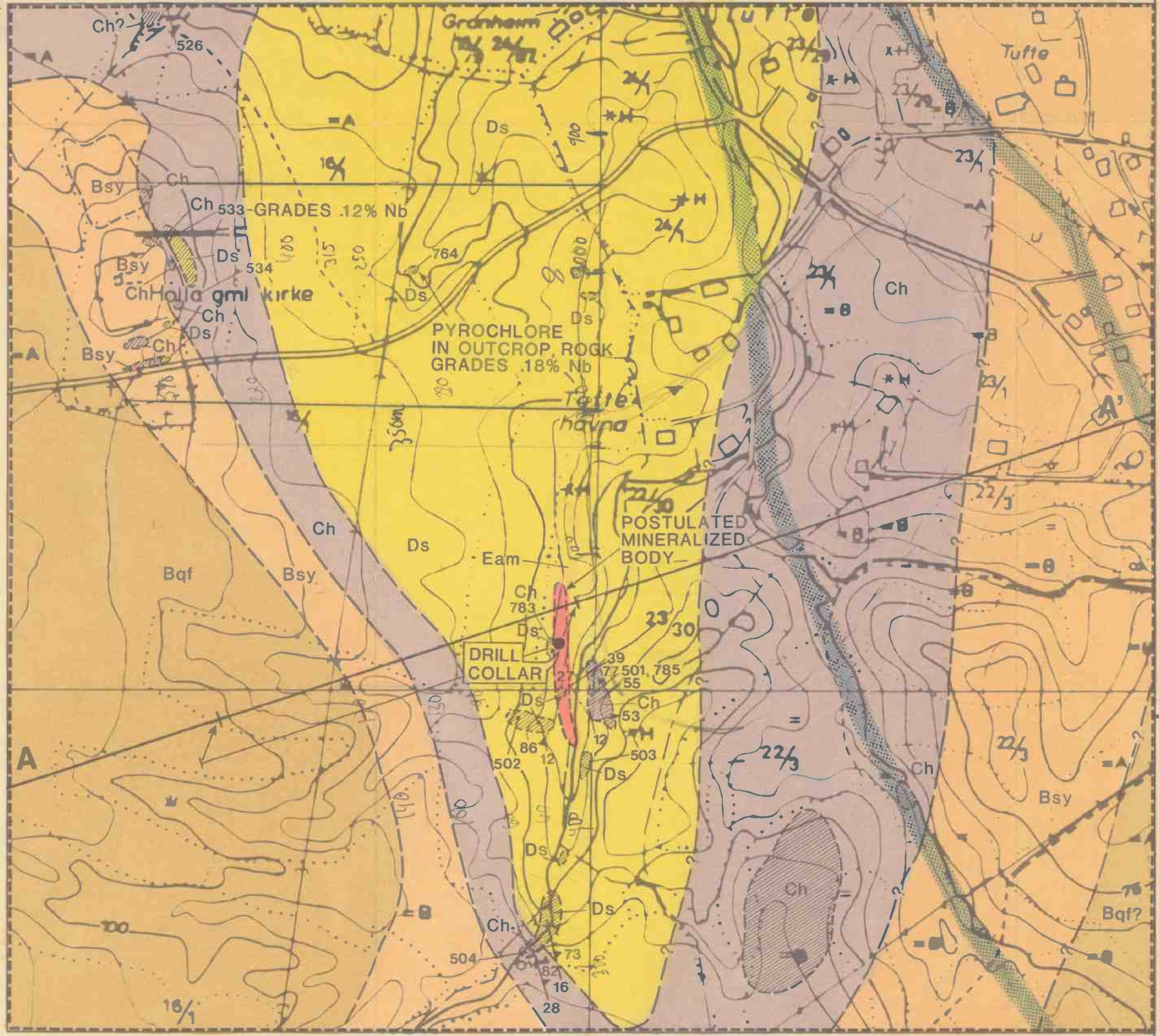
Depth	ROCK UNITS & PERCENTAGES	DESCRIPTION	MINERALIZATION STRUCTURE	S	Cl	H	flu	fs	am	m	sp	ap	pc	%Nb	%Ta
0	—	0-2.38 No core Recovery													
1															
2	Eam 35-100	Silicate rich 5-2mm biot flakes	cut by gray dikes							A		A	A	4.3	
3	Eam 100	AA may contain marbled apatite stringers	AA							A		A	A	2.7	
4	Eam w/Ds incs	AA w/white to pink seines, they contain flakes of brn biot	AA							A		A	A	2.8	
5	AA	AA w/marbled ap stringers	AA							A		A	A	2.4	
6	AA	AA, segregations are apatite rich.	30° veins							A		A	A	3.8	
7	AA	AA								A		A	A	3.1	
8	AA	Coarse biotite-apatite rock with segregations of columbite								A		A	A	4.4	
9	AA	coarse grading to fine-grained green rock								A		A	A	3.3	
10	Ds dominant apatite rich phase	dominant pink søvite with gray green rock cutting through last 25 cms.	fol@ 30°							P		C	C	1.4	
11		greenish gray, apatite rich dike cuts søvite								P		C	C	1.0	
12	Ds	med grained gray-white søvite	fol @ 30°	P						P		P	P	0.11	
13	AA	AA	AA	P						P		P		0.13	
14	AA	AA, loc abd mag blades, metamict haloes on PC grains	gray dike w/PC	P						P		P	P	0.28	
15	AA	AA, w/graphic mag zones	crse mag	P						P		P			
16	AA	AA, w/patchy gray alt zones.	graphic mag	P						P		P		0.032	
17	AA	AA		P						P		P		0.01	
18	AA	AA, w/lt yelgray dol dikes		P						P		P		0.023	
19	AA	AA		P						P		P		0.016	
20	AA	AA w/clusters of graphic mag thruout, Ap, tr biot, trpy	brn mineral not PC	P						P		P	2	—	
21	AA	AA	graphic mag	P						P		P		—	
22	AA	AA w/slightly less mag more biot	graphic mag	P						P		P		—	
23	AA	AA		P						P		P		—	
24	AA	AA							P	P		P		—	
25	AA	loaded w/ap ry mag @ blue am abd biot. blue → gray patches thruout.												—	
26	AA	AA												0.15	
27	AA	barren, lt gray w/patches of blu fibrous amphibole, some brn biot												—	
28	AA	AA												0.6	
29	AA	AA	seg sands of mag @ 50°						Pt					—	
30	AA	AA Crse mag zone @ 30cm	AA						Pt						

[illegible]

Y 50 000
Y 50 100
Y 50 200
Y 50 300
Y 50 400
Y 50 500
Y 50 600
Y 50 700
Y 50 800
X 140 700
X 140 600
X 140 500
X 140 400
X 140 300
X 140 200
X 140 100
INDEX MAP
NORSJØ
72km
OUTLINE OF FEN COMPLEX
HOLLA
69km
59°15'00"
9°13'10"
15km
18km
1km
APPROXIMATE OUTLINE OF MELTEIG/BRISKEMYR AREA
MAP SYMBOLS
Contour interval 1 m
GEOLOGY UNMAPPED
S W PORTION OF AREA
INFERRED N.W. STRIKING
FAULT ZONE
POSSIBLE EXPLOSION VENT
FOLIATION UNMEASURABLE DUE TO BRECCIATION
AEGIRINE DEVELOPMENT
ZONE OF DEUTERIC ALTERATION
MELTEIG FARM HOUSE
RED HOUSE MELTEIG FARM
EXPLANATION
OUTCROP | INFERRED
Nb Bostonite dikes, transect breccia.
Id Damkjernite.
bx Explosion breccia, possibly related to Damkjernite intrusion.
Dsc Silicosøvite (one small 1m² outcrop).
Cu Urtite and ijolite, undivided.
Ct Tinguaite dike.
Cm Melteigite.
Bsy Syenitic fenite.
Bqf Quartz-aegirine fenite.
Ag Granite, medium grained, apparently unfenitized.
Zones of strong deuteric alteration in Melteigite.
Coarse breccia zones.
Aegirine in measured veinlets, random veinlets, and disseminated.
Inferred or approximate contact.
Foliation in quartz aegirine fenite, measured and approximate.
Sample locality.
Hypothetical large fault zones.
SCALE=1:1000
0 10 20 30 40 50m
N
NORWAY-FEN PROJECT
MELTEIG/BRISKEMYR AREA
GEOLOGIC SKETCH MAP
BY S.D.OLMORE
FENCO-UNION MINERALS NORGE
JOINT VENTURE
UMN FEN REPORT NO.03
SEPT.1981 REVISED APRIL: 22,1982
PLATE II
NOTE: GEOLOGIC MAPPING OUTSIDE OF CONTOURED AREA OF BASE MAP ACCOMPLISHED BY BRUNTON COMPASS AND TAPE METHODS; ALL ANGLES WITH 90° SCALE.

142000x

51000y



141500x

51000y

MAP SYMBOLS

- A — Easily worked soil
- B — Less easily worked soil
- H — Soil suitable for afforestation
- Coniferous woodland
- Deciduous woodland
- Fertilized pasture
- Cultivated land
- Cemetery
- Boundary between different land types
- Path
- Road
- Projected road
- Telegraph line
- Power line
- 22/3 — Property number

Contour interval 5 m

SCALE-1:2500

0 50 100m

N

EXPLANATION

Eam	APATITE-MICA DIKE, LAMPROPHYRE, WELL MINERALIZED
Ds	SØVITE
Ch	HOLLAITE
Bsy	SYENITIC FENITE
Bqf	QUARTZ-AEGIRINE FENITE
	OUTCROP
502	SAMPLE LOCATION
	FAULT ZONES (POSTULATED)
-?—?-	SPECULATIVE CONTACT
	COLLAR OF DRILL HOLE 81-1
A A'	CROSS SECTION - SEE PLATE IV

PLATE III

NORWAY - FEN PROJECT GEOLOGIC SKETCH MAP OF THE HOLLA ANOMALY AND VICINITY

BY S.D.OLMORE
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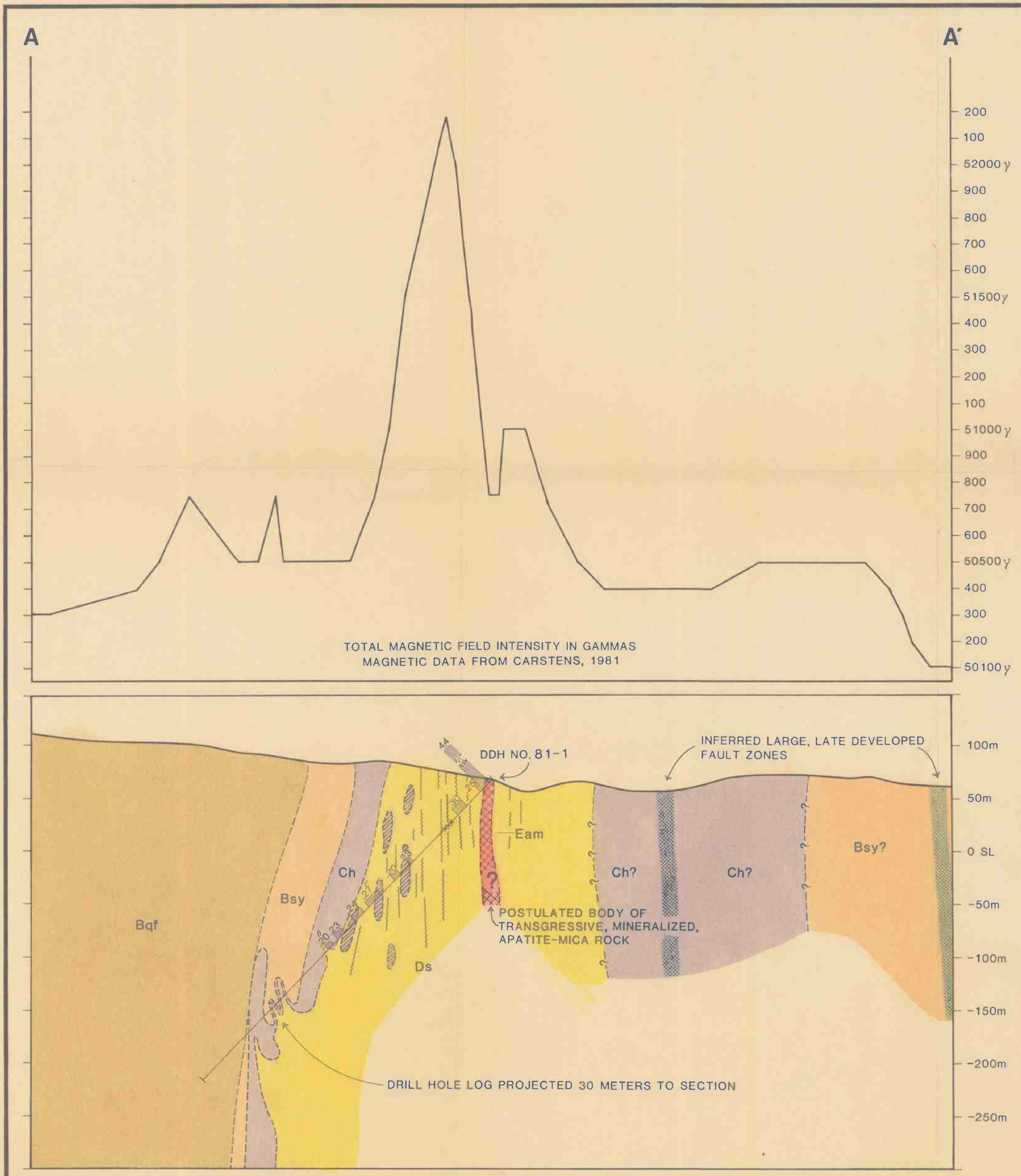
JULY 17, 1981, REVISED: MARCH 24, APRIL 22, 1982



EXPLANATION

- Eam — APATITE-MICA DIKE, LAMPROPHYRE, RICH NIOBIUM MINERALIZATION
- Ds — SØVITE AND RAUHAUGITE, UNDIVIDED
- Ch — HOLLAITE
- Bsy — SYENITIC FENITE
- Bqf — QUARTZ-AEGIRINE FENITE
- MEASURED FOLIATION DIRECTIONS
- POSTULATED FAULT ZONE
- xxx — MAGNETITE-RICH ZONE
- .20 — ZONES OF Nb_2O_5 MINERALIZATION SHOWING GRADE
- -?--?- — SPECULATIVE CONTACT

PLATE IV

NORWAY - FEN PROJECT GEOLOGIC SKETCH SECTION AND MAGNETIC PROFILE NEAR LINE OF DRILL HOLE NO.81-1

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