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Malmleting i Pasvik:
1990 to 1991 Exploration in Pasvik Finnmark

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Malm/metall	Ni Cu	

Sammendrag

Selskapets canadiske geolog Karen A Hudson har laget en rapport som oppsummerer det arbeidet som er gjort i Oksfjellområdet i 1991. En kopi er vedlagt for Bergvesenets informasjon.

1990 to 1991 EXPLORATION

IN PASVIK, FINNMARK

Karen A. Hudson

A/S Sulfidmalm

December, 1991

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INTRODUCTION

This report summarizes the exploration work completed by A/S Sulfidmalm from 1990 to 1991 in Pasvik, Finnmark. The A/S Sulfidmalm explored Pasvik from 1971 to 1982, and returned in 1990 due to the high nickel exploration potential in Finnmark for equivalents to the Proterozoic Pechenga nickel deposits. Geophysical, geological, structural, lithogeochemical and petrological data collected in 1991, along with a detailed model for Pechenga nickel and copper deposits led to the definition of several favourable targets which will be tested by drilling in 1992.

AREA OF INTEREST	Pasvik, Sør-Varanger, Finnmark, Norge Latitude 69°N, Longitude 30°E
PROPERTY	54 claims (1350 hectares) in the Oksfjell area on the Skogfoss Arch, Pasvik.
COMPANY	A/S Sulfidmalm Falconbridge Nikkelverk A/S Postboks 457 4601 Kristiansand S., Norge
MINERALIZATION OF INTEREST	Nickel, Copper

PECHENGA, RUSSIA - MODEL AREA FOR THE PASVIK EXPLORATION

The Pechenga nickel and copper deposits are situated in Russia at the extreme northwestern corner of the Kola Peninsula. Over twenty nickel and copper deposits and prospects are concentrated in the central part of the Pechenga syncline. Approximately 34.400 tonnes of contained nickel from ore grading an average of 1,18% Ni is mined annually and smelted on location at Nikel, only three kilometres from the Russian-Norwegian border. Differentiated ultramafic rocks were intruded into the Productive Formation, the shale-rich sedimentary formation of the fourth sedimentary-volcanic cycle of the Pechenga Group (Figure 1). Economic deposits are confined to synclinal fold hinges in ultramafic bodies.

The depositional environment for the Pechenga Group is envisioned as intracontinental sedimentary basins separated by syn-sedimentary faults within a one-sided rift system analogous to the Red Sea. Four sedimentary-volcanic cycles were deposited 2,4 to 1,9 billion years ago on consolidated Archean basement and layered mafic-ultramafic complexes. Ultramafic magmas migrated upwards along deep-seated syn-sedimentary faults and upon reaching the surface or near-surface, crystallized, precipitating nickel and copper sulphides which coalesced at the bases of ultramafic bodies hosted within the Productive Formation. Highest grade nickel deposits are located next to major syn-sedimentary faults.

Primary deformation was associated with basin closure and is represented by northward-verging thrusts, cleavage development, boudinage and northerly-verging asymmetrical folds with southerly-dipping, 35° to 60° axial planes. Breccia ores with shale and round serpentinite fragments occur in a nickel-copper sulphide matrix formed from the massive ores which migrated into pressure shadows at the ends of ultramafic boudins. Secondary deformation, characterized by open folding with steep northeast trending axial planes, produced doubly plunging ultramafic and orebody configurations.

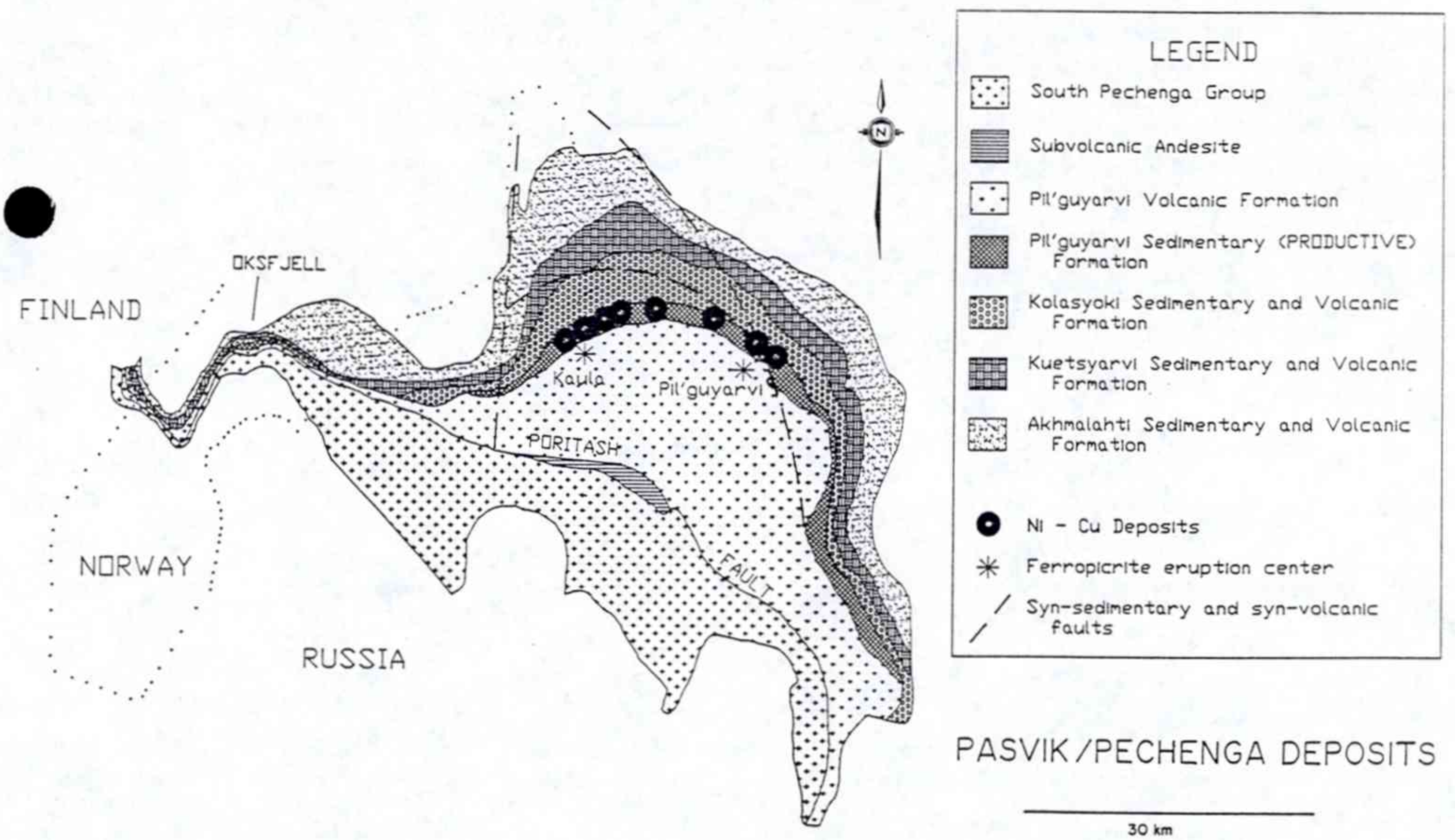


FIGURE 1

PASVIK, NORWAY

PREVIOUS WORK IN THE PASVIK AREA

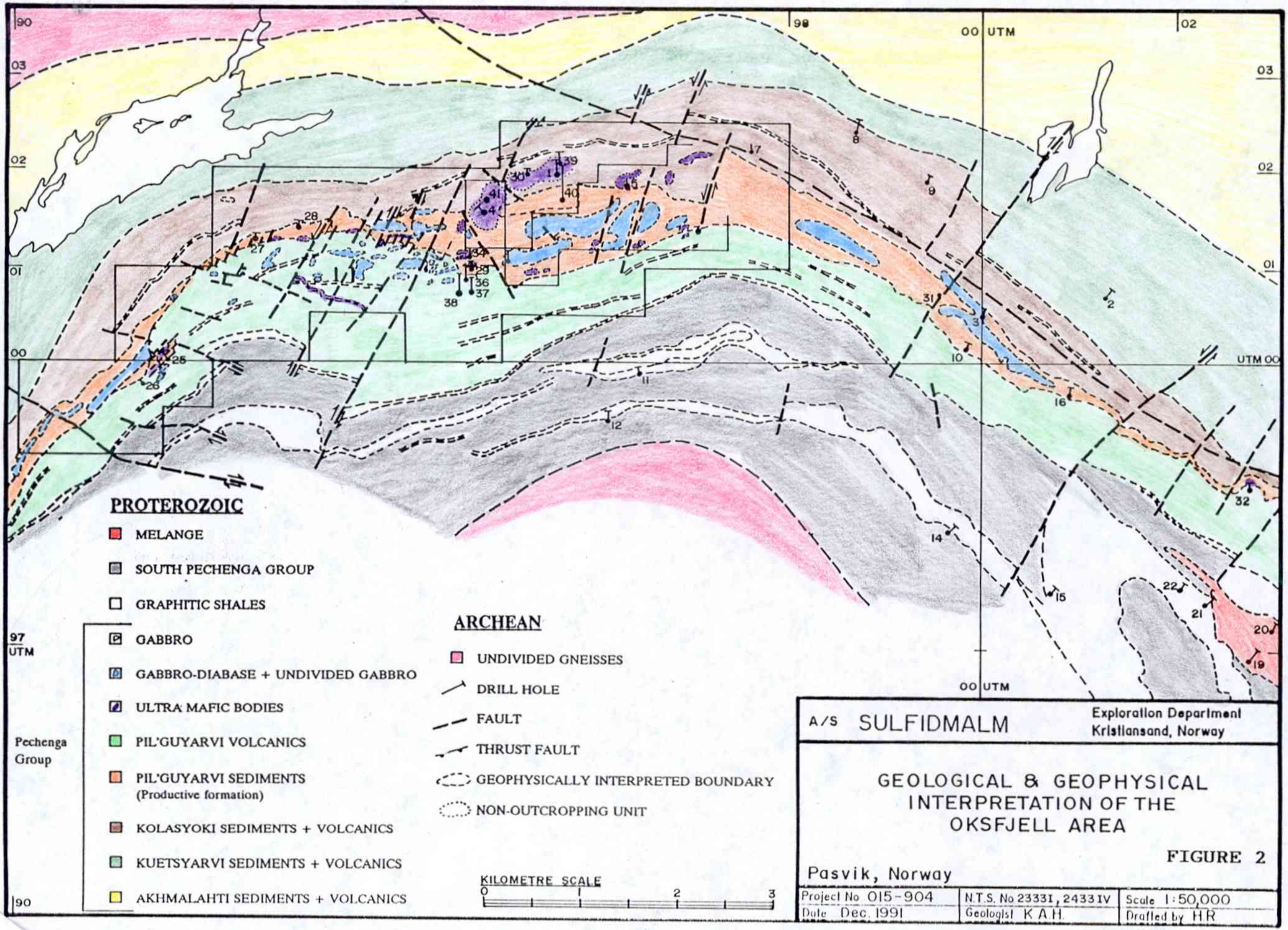
Mapping in the Pasvik area in 1957 by A/S Sydvaranger revealed that the Pechenga Group extended into Norway along the Skogfoss Arch. The Pechenga Group equivalent extends for 34 kilometres across Norway, where it is 5,5 kilometres wide at the Russian border and 1,2 kilometres wide at the Finnish border (Figure 1). Between 1971 and 1982 A/S Sulfidmalm, at times together with A/S Sydvaranger, conducted helicopter EM surveys over the belt, as well as 1:10.000 mapping, Quaternary geology, till geochemistry and 5079 metres of diamond drilling in 40 holes. Several ultramafic bodies were found, and the most interesting intersection was 0,33% Ni and 0,15% Cu over 1,7 m.

1990 to 1991 EXPLORATION WORK

The A/S Sulfidmalm Pasvik exploration program was reactivated in 1990 due to the high nickel exploration potential in Finnmark for equivalents to the Proterozoic Pechenga nickel deposits. Fifty-four 25 hectare claims were staked in the Oksfjell area on December 18, 1990. In April 1991, a 1409,5 line kilometre helicopter EM survey was flown over the entire length of the Pechenga Group in Norway. The 1971 to 1982 Sulfidmalm drill core was moved to the government core storage facility at Løkken in March and was re-logged in April, in cooperation with Victor Melezhik, a Russian scientist who had worked for several years in the Pechenga area and was on leave with the Geological Survey of Norway (NGU). From June to August, a field mapping program was carried out by A/S Sulfidmalm in cooperation with the NGU. The mapping focused on the Oksfjell to correlate its geology with well documented Pechenga units. A 41,93 line kilometre ground EM and magnetometer survey was carried out in July and August over the poorly exposed and virtually undrilled eastern portion of the Oksfjell claim block. Geological, structural, lithogeochemical, petrological and geophysical data was compiled in the autumn to plan the 1992 program.

1991 PERSONNEL

Øyvind Hushovd	President	A/S Sulfidmalm
Jørn Jacobsen	Accountant	Falconbridge Nikkelverk
Tony Green	Regional Exploration Manager	Falconbridge Limited
Karen Hudson	Field Geologist	Falconbridge Limited-A/S Sulfidmalm
Geir Johannesen	Junior Assistant	A/S Sulfidmalm
Ine Gressetvold	Junior Assistant	A/S Sulfidmalm


PROTEROZOIC
MELANGE
SOUTH PECHENGA GROUP
GRAPHITIC SHALES
GABBRO
GABBRO-DIABASE + UNDIVIDED GABBRO
ULTRA MAFIC BODIES
PIL'GUYARVI VOLCANICS
PIL'GUYARVI SEDIMENTS (Productive formation)
KOLASYOKI SEDIMENTS + VOLCANICS
KUETSYARVI SEDIMENTS + VOLCANICS
AKHMALAHTI SEDIMENTS + VOLCANICS
Pechenga Group
ARCHEAN
UNDIVIDED GNEISSES
DRILL HOLE
FAULT
THRUST FAULT
GEOPHYSICALLY INTERPRETED BOUNDARY
NON-OUTCROPPING UNIT
KILOMETRE SCALE
0 1 2 3
00 UTM
UTM 00
97 UTM
A/S SULFIDMALM
Exploration Department
Kristiansand, Norway
GEOLOGICAL & GEOPHYSICAL INTERPRETATION OF THE OKSFJELL AREA
FIGURE 2
Pasvik, Norway
Project No 015-904
Date Dec. 1991
N.T.S. No 2333I, 2433 IV
Geologist K.A.H.
Scale 1:50,000
Drafted by H.R.

VOLCANIC AND SEDIMENTARY ROCKS

Equivalent units from the Kuetsyarvi, Kolasyoki, Pil'guyarvi Sedimentary and Volcanic Formations and South Pechenga Group were logged in the Pasvik drill holes (Table 1). During the 1991 mapping, efforts were concentrated on Productive Formation, Pil'guyarvi Volcanic and to a lesser extent, Kolasyoki Volcanic equivalents, although representative outcrops of the other equivalent Formations in Norway were briefly examined (Figure 2). For the sake of simplicity and to avoid confusion for the reader, the Russian stratigraphic names are used in this report. It should be noted that the NGU is compiling a revised set of stratigraphic names (Table 2) for the correlative Pechenga Group units in Norway, which will probably be the standard in future years.

A prominent outcrop of Akhmalahti Sediments occurs on highway 885 at Brattli. Here, closely packed, poorly sorted, framework-supported conglomerates with round to elliptical pink granite and gneiss pebbles, and rarer Bjørnevatn iron formation pebbles, ranging in size from 1 centimetre up to 0,5 metre unconformably overlie Archean gneiss. The contact is weathered and irregular. The conglomerate becomes more matrix-supported towards the top of the unit.

Basaltic flows analogous to the Akhmalahti Volcanics were observed along the Malbekkan road which cuts across the stratigraphy to the east of the Oksfjell claims. Several prominent outcrops of highly sheared, chloritic and vesicular basaltic flows occur adjacent to the road. The vesicles are infilled with white vitreous quartz and yellow carbonate.

Quartzites analogous to the Kuetsyarvi Sedimentary Formation white quartzites have been described by B. Lieungh (1988) as the Koievann Quartzite. They range in colour from white to greyish white and pale pink, and can be traced intermittently through the whole Skogfoss Arch. Carbonate rocks analogous to the 'red-coloured dolomites' in the Kuetsyarvi sediments (V. Melezhik, pers comm., 1991) were observed adjacent to the Malbekkan road, stratigraphically overlying the quartzites. Here, the unit is a white (probably due to a higher degree of metamorphism), well-bedded and recrystallized dolomitic calcarenite.

Volcanic rocks from the Kuetsyarvi Volcanic Formation were observed in drill hole PS73-08. These consist of fine-grained, greyish green, variably amygdaloidal basaltic and andesitic flows and tuffs, which are imhomogeneously altered to pink potassium feldspar and epidote in patches and veins. Rare lithophysae were observed, similar to those at Pechenga in the Kuetsyarvi Volcanic Formation described by V. Melezhik as 'leopard rock' and attributed to syn-volcanic hydrothermal alteration. In outcrop, the Kuetsyarvi Volcanics comprise a wide range of rhyolitic and rhyodacitic rocks occurring as thin lava flows, ignimbrites and banded tuffs. B. Lieungh (1988) internally subdivided the Kuetsyarvi Volcanics which he called Skogfoss Formation.

TABLE 1 - STRATIGRAPHIC UNITS IN PASVIK DRILL HOLES

Hole	Stratigraphic Unit
PS71-01	Kolasyoki Volcanic Formation
PS73-04	Lower Productive Formation
	Kolasyoki Volcanic Formation
PS73-05	Lower Productive Formation
PS73-06	Pil'guyarvi Volcanic Formation
	Upper Productive Formation
	Middle Productive Formation
PS73-08	Kolasyoki Sedimentary Formation
	Kuetsyarvi Volcanic Formation
PS73-10	Middle Productive Formation
PS73-11	South Pechenga Group
PS73-16	Upper Productive Formation
	Middle Productive Formation
	Lower Productive Formation
PS75-25	Pil'guyarvi Volcanic Formation
	Middle Productive Formation
PS75-26	Pil'guyarvi Volcanic Formation
	?Upper Productive Formation
PS75-27	Upper Productive Formation
	Middle Productive Formation
PS75-28	Middle Productive Formation
	Lower Productive Formation
	Kolasyoki Volcanic Formation
PS75-29	Pil'guyarvi Volcanic Formation
	Middle Productive Formation
PS75-30	Kolasyoki Volcanic Formation
PS77-32	Pil'guyarvi Volcanic Formation
	Middle Productive Formation
	?Lower Productive Formation
PS77-33	Middle Productive Formation
PS77-34	Middle Productive Formation
PS81-36	Pil'guyarvi Volcanic Formation
	Middle Productive Formation
PS81-37	Pil'guyarvi Volcanic Formation
	Middle Productive Formation
PS81-39	Kolasyoki Volcanic Formation
PS81-40	Lower Productive Formation
	Kolasyoki Volcanic Formation
PS82-41	Lower Productive Formation
	Kolasyoki Volcanic Formation

TABLE 2 - CORRELATION OF PECHENGA AND PASVIK STRATIGRAPHY

PECHENGA	PASVIK - 1991	PASVIK - 1985
Pil'guyarvi Volcanic Formation	Kiltjørnan Formation	Oksfjellet Formation
Pil'guyarvi Sedimentary Formation (Productive Formation)	Black Shale Productive Formation	Oksfjellet Formation
Kolasyoki Volcanic Formation	Skjelvatnet Formation	Oksfjellet Formation
Kolasyoki Sedimentary Formation	Bergvatnet Formation	Oksfjellet Formation
Kuetsyarvi Volcanic Formation	Skogfoss Formation	Oksfjellet and Skogfoss Formations
Kuetsyarvi Sedimentary Formation	Koievann Formation	Malbekken Formation
Akhmalahti Volcanic Formation	Båttjørna Formation	Malbekken Formation
Akhmalahti Sedimentary Formation	Neverskrukk Formation	Neverskrukk Formation

Note: The Pechenga stratigraphic names are modified by V. Melezhik from Zagorodny et al., 1989 and Predovsky et al., 1974. The Pasvik - 1991 stratigraphic names are from Melezhik and Nilsson, 1991. The Pasvik - 1985 stratigraphic names are taken from Siedlecka et al., 1985.

Kolasyoki Sedimentary Formation rocks were observed only in hole PS73-08. They comprise andesitic tuff, black shales, sandstones and siltstones. The black shales in this hole are graphitic and carry 1 to 3 millimetre pale pink garnet porphyroblasts. Dolomites (red lacustrine protoevaporites) observed at Pechenga at the base of the Kolasyoki Sedimentary Formation were not recorded in hole PS73-08.

Rocks of the Kolasyoki Volcanic Formation were observed in several drill holes (PS71-01, PS73-04, PS75-28, PS75-30, PS81-39, PS81-40, PS82-41). They ubiquitously consist of green fine-grained basaltic pillows, flow and tuff with 1 centimetre up to 1 metre scale graphitic black shale beds. These are characterized by white milky quartz veins and lenses, as well as grey-white chert lenses. Cherts at Pechenga contain silicified microfossils (V. Melezhik, pers comm., 1991). In outcrop, the basalts are medium to dark green, monotonous, and found as tear-shaped pillows (generally showing younging to the south, indicated by the tear-shape and vesicle concentrations) and pillow tubes.

The contact between the Kolasyoki Volcanic Formation and the overlying Productive Formation (Pil'guyarvi Sedimentary Formation) is either marked by a fault or is gradational and is judged by a sharp increase in the proportion of sedimentary lithologies (black shales, sandstones, siltstones) and the disappearance of mafic pillows and flows. Rocks of the Productive Formation are present in several holes. The lower Productive Formation rocks are represented by quartz-rich sandstones, siltstones and mafic tuff. The middle Productive Formation Pasvik rocks are very similar to those at Pechenga in that they dominantly consist of graphitic, sulphidic black shales with interbedded greywacke rhythmites, diagnostic grey diagenetic carbonate lenses and centimetre-scale bands of pyrrhotite with fine black shale fragments ('fossil black smokers'). The upper Productive Formation is faulted out in holes PS75-25 and PS75-29 (or may not be present originally), and is very thin in hole PS75-26 (2,63 metre intersection), but when present, consists of ultramafic and basaltic tuff.

Pil'guyarvi Volcanic Formation rocks in the Pasvik holes are green, fairly monotonous basaltic flows and tuffs with minor, centimetre-scale black shale horizons. In outcrop, they occur as flows, pillows (tubes and bulbs) and tuff. The flows are massive, light to medium green, inhomogeneously foliated, and contain trace specks of pyrrhotite. They are coarser-grained internally, attaining gabbroic to diabasic textures. Well defined pillow lavas are present at several localities all over the Oksfjell hill, and generally are flattened or rodded and vesicular, with rarely preserved cooling rims and related cracks. The mafic tuffs are well-bedded, generally moderately to well foliated, medium to dark green, laminated, with up to 2% pyrrhotite aligned along foliation planes.

Rocks assigned to the South Pechenga Group were logged in hole PS73-11. They consist of highly graphitic black shales, andesitic volcanoclastic rocks, picritic basalt and finely laminated epiclastic tuff.

ULTRAMAFIC AND GABBROIC ROCKS

Two types of gabbroic rock were detected in the Pasvik drill holes, and include (a) gabbro-diabase and (b) gabbro (gabbro-wehrlite association). These two types also are seen at Pechenga, where the gabbros represent the more differentiated portions of the ultramafic bodies, and the gabbro-diabases are distinct intrusions believed to be the subvolcanic equivalents of the Pil'guyarvi Volcanics (Hanski et al., 1990).

Gabbro-diabases were recorded in several of the Pasvik holes, with intersections ranging from 1 to 30 metres. The margins of these bodies are generally fine-grained and chloritic (chilled?), but the contacts are either diffuse and gradational or sharp (rarely crosscutting). The rocks are medium green, fine- to medium-grained actinolite-epidotized plagioclase-sphene-bearing rocks with sub-ophitic to granular textures. These bodies were observed in Pil'guyarvi Volcanics, in all levels of the Productive Formation, at the Lower Productive Formation / Kolasyoki Volcanic Formation interface and within the Kolasyoki Volcanic Formation.

Four medium-sized gabbro-diabase bodies crop out within the staked Oksfjell area. These occur at the Kolasyoki Volcanic Formation - Productive Formation contact and within the Productive Formation. Several gabbro-diabase bodies have been inferred through relatively high resistivity measurements within the Productive Formation in the eastern part of the Oksfjell claims. They are fine- to medium-grained (up to 5 millimetres crystals) and range texturally from stubby to elongate amphibole grains with interstitial white plagioclase (melanocratic type) to dark green, rectangular amphibole grains in white plagioclase (30 to 40% amphibole; 60 to 70% plagioclase).

Gabbro (gabbro-wehrlite) bodies were observed in holes PS71-01, PS75-29, PS75-30, PS77-34, PS81-39 and PS82-41. These tend to be more leucocratic and coarser-grained than the gabbro-diabases. They consist of actinolite and plagioclase with lesser ilmenite and apatite exhibiting gabbroic (intergrown) textures. In outcrop, they were observed only in the vicinity of hole PS75-29, where several outcrops show weakly serpentinized pyroxenite grading into melanocratic gabbro stratigraphically overlying serpentinized and carbonatized ultramafic units.

Ultramafic rocks were recorded in holes PS71-01, PS73-05, PS73-06, PS73-16, PS75-25, PS75-27, PS75-29, PS75-30, PS77-32, PS77-33, PS77-34, PS81-36, PS81-37, PS81-39 and PS82-41. They occur as both sills/dykes/flows(?) and as tuffs. The ultramafic bodies are dark grey, very fine- to coarse-grained, and exhibit xenomorphic, porphyroblastic and equigranular textures. Relict olivine grains, generally pseudomorphed by chlorite and carbonate, are present. Pyroxene relict grains as well as tear-dropped shaped carbonate porphyroblasts have been identified. The ultramafic rocks have been extremely metamorphosed and altered to mixtures of blue birefringent iron-rich chlorite, tremolite, talc, carbonate (magnesite?) and magnetite.

Original olivine and pyroxene phenocrysts have been pseudomorphed by blue chlorite and by carbonate which subsequently was altered, giving a ragged, irregular appearance.

There is some evidence that the ultramafic and gabbroic bodies in the Pasvik area may be extrusive flows rather than intrusives (based mainly on drill core evidence). No xenoliths were observed. Contact metamorphism of adjacent sedimentary rocks was only seen in the underlying sedimentary rocks, and over lengths only up to 50 centimetres (short intersection if this were an intrusion). Margins of the bodies are chilled (rarely on both the top and bottom margins), sheared and brecciated. There is evidence of multiple pulses of gabbro and ultramafic within single, larger units. The gabbro often is chilled against adjacent ultramafic rocks, but also shows gradational contacts. Only one contact was observed in outcrop on the Oksfjell, in the vicinity of hole PS75-29. Here, graphitic black shale shares a strongly sheared contact with a highly magnetic, dense, serpentinized ultramafic body. The shale is weakly metamorphosed near the contact and the ultramafic contains a greater proportion of disseminated pyrrhotite (3 to 4%) than most observed in the Oksfjell area. The primary nature of the contact has obviously been obliterated.

A large, segmented and differentiated mafic-ultramafic body was intersected in holes PS71-01, PS75-30, PS81-39 and PS82-41 (Figure 2). The body consists of 8 to 17 metres (drill hole thickness) of medium- to coarse-grained gabbro which is underlain by 27,2 to 92,82 metres of highly serpentinized, magnetic ultramafic rocks. This body lies completely within the Kolasyoki Volcanic Formation and does not outcrop.

Ultramafic tuffs occur in several holes. They generally are less than 5 metres in intersection length, are light to medium grey, very fine-grained, bedded and finely laminated units with interlaminae of black shale and biotite-rich siltstone. They display gradational contacts with overlying and underlying sedimentary rocks. They also occur in outcrop, as thin, very weakly to non-magnetic, less than 5 metre bedded units interbedded with black shales (UTM 593900E, 7701350N) and as small, less than 40 metre by 100 metre outcropping bodies (boudins) along the northern edge of the Oksfjell hill. The origin of the latter actually is in question; the rocks texturally are tuff-like and appear to be bedded, especially when in contact with overlying mafic tuffs of the Pil'guyarvi Volcanic Formation (e.g. UTM 592700E, 7701300N), but two of the five bodies display a close relationship with coarse-grained gabbro bodies. Also, the highly foliated nature of the rocks may be a structural one only, suggesting that the 'tuffs' may actually be deformed flows. Alternately, they may have been laminated tuffs which deformed more easily and took up a great deal of strain.

Ultramafic (ferropicritic) flows were observed at several locations within the Pil'guyarvi Volcanic Formation. At UTM 592350E, 7700950N three boudins of ultramafic flow are separated by thrust planes within Pil'guyarvi pillow basalts. Other scattered flow outcrops occur along strike of this outcrop (e.g. UTM 594120E, 7701008N) as isolated, weakly soapy, pale green flows within the Pil'guyarvi Volcanic Formation. At UTM 592900E, 7700900N a spectacular outcrop of pillowed ultramafics, with pillows up to 1 metre long and displaying fine-grained rims and medium-grained internal structures, occur beside a small pond on the eastern side of a large regional fault. About 12 metres north of the pillowed outcrop, a differentiated pyroxenite-serpentinized ultramafic flow crops out, and is overlain by a rhyolitic tuff analogous to the ferropicritic rhyolitic tuffs representing the last ferropicritic magmatism in the Pechenga area. Only one outcrop of rhyolitic tuff was exposed in the Oksfjell area, and it appears to be an ash tuff with partially to completely weathered out carbonate concretions, and internal erosional surfaces. No further ferropicritic-rhyolitic horizons were discovered further south (up section) than this outcrop, and the unit appears to have a limited lateral extent (800 metres), sandwiched between two major NE-striking regional faults, as shown by magnetic geophysical measurements.

MINERALIZATION

The most intensely mineralized rocks are the carbon-rich black shales of the middle Productive Formation. Pyrrhotite is the dominant sulphide mineral in these rocks (5 to 30%), occurring as fine, irregular and ragged patches or aggregates, disseminated grains, bands and stripes, and threads and bands parallel to and lining foliation surfaces. Pyrrhotite-rich breccias with fine black shale fragments are relatively common. Chalcopyrite also occurs as rare disseminated grains (about 1%). Sulfidmalm assayed most of the sulphide-rich black shales, but results were disappointing (generally less than 0.01% Ni, less than 0.05% Cu). A few samples were taken during the 1991 re-logging which confirm these results.

Most of the other sedimentary rocks, and the Pil'guyarvi and Kolasyoki Volcanic Formations are poorly mineralized, with generally less than 2% sulphide. Previous assays of these rocks were negligible for nickel and copper.

Mineralization in the ultramafic/gabbroic rocks in the Pasvik cores is negligible to absent (0 to 5%). It occurs as very fine scattered grains and matrix disseminations of pyrrhotite and lesser chalcopyrite, but no veinlets or stringers are present. Background Ni contents for the ultramafics are 0.17 to 0.20 %. The best intersection obtained by Sulfidmalm was 0,33% Ni, 0,15% Cu (hole PS75-29, 64.5-65.00 metres), in a talcose ultramafic tuff containing 1-2% pyrrhotite.

Twenty-nine (29) surface samples were collected for geochemical analysis during the 1991 field work. These included samples of serpentinized ultramafic bodies with minor disseminated sulphide, gabbro-diabases with trace to 4 to 5% sulphide (mainly pyrrhotite), rusty shear zones in Pil'guyarvi Volcanic Formation rocks and graphitic, sulphidic Productive Formation black shales. All of the samples returned only background values for their respective lithologies for Ni, Cu and Co, and negligible Au, Pd and Pt.

STRUCTURAL GEOLOGY

Structural data collected during the 1991 field season, combined to some extent with that collected by J. James (1981), is plotted on the 1:10,000 geological maps. Statistical structural analysis of planar structures, minor folding and rodding, and conjugate shear zone sets was carried out using a Schmidt equal area net and a Kalsbeek counting net to contour the data. Results are presented in Figures 3a and 3b.

Primary bedding (S_0) structures are rarely seen due to the strong primary schistosity (S_1) onto which the S_0 is transposed. Where seen, bedding contacts tend to be highly sheared. They are best preserved in the shales, ultramafic tuffs and sandstones, and are less well defined by primary stacking in pillow lavas.

Primary schistosity is developed consistently through the area as a finely spaced, moderately to well-developed schistosity in all lithological types. This schistosity is axial planar to north, northeast- and northwest-verging asymmetrical folds. Contoured data for S_1 and S_0 defines a great circle, suggesting that the schistosities are cylindrically folded during a second folding event (D_2). The secondary fold axis (F_2) is defined by the pole to the schistosity/bedding 'best fit' great circle, which in this case is 45 towards an azimuth of 166°.

The F_2 fold axis defined above and the macroscopic arch shape of the Pechenga Group in Pasvik are the main evidence of the second folding event. Only gentle buckling and warp folding is observed and there is no associated development of penetrative schistosity.

Minor folding is very poorly developed in this area, but where seen it is represented by open warp folds with moderate to steep plunges and minor asymmetrical folds. A stereonet plot of minor open folds reveals that their plunge and trend coincide with the determined F_2 fold axis.

Elongate, lozenge-shaped boudins are extremely common throughout the field area, composed of ultramafic (serpentinite), quartz veins, gabbros and pillow basalts. These boudins formed due to the strong flattening perpendicular to S_1 schistosity plane, as they lie within this plane and are warp folded during D_2. They are parallel to the intermediate tectonic axis (i.e., the fold axis) of F_1.

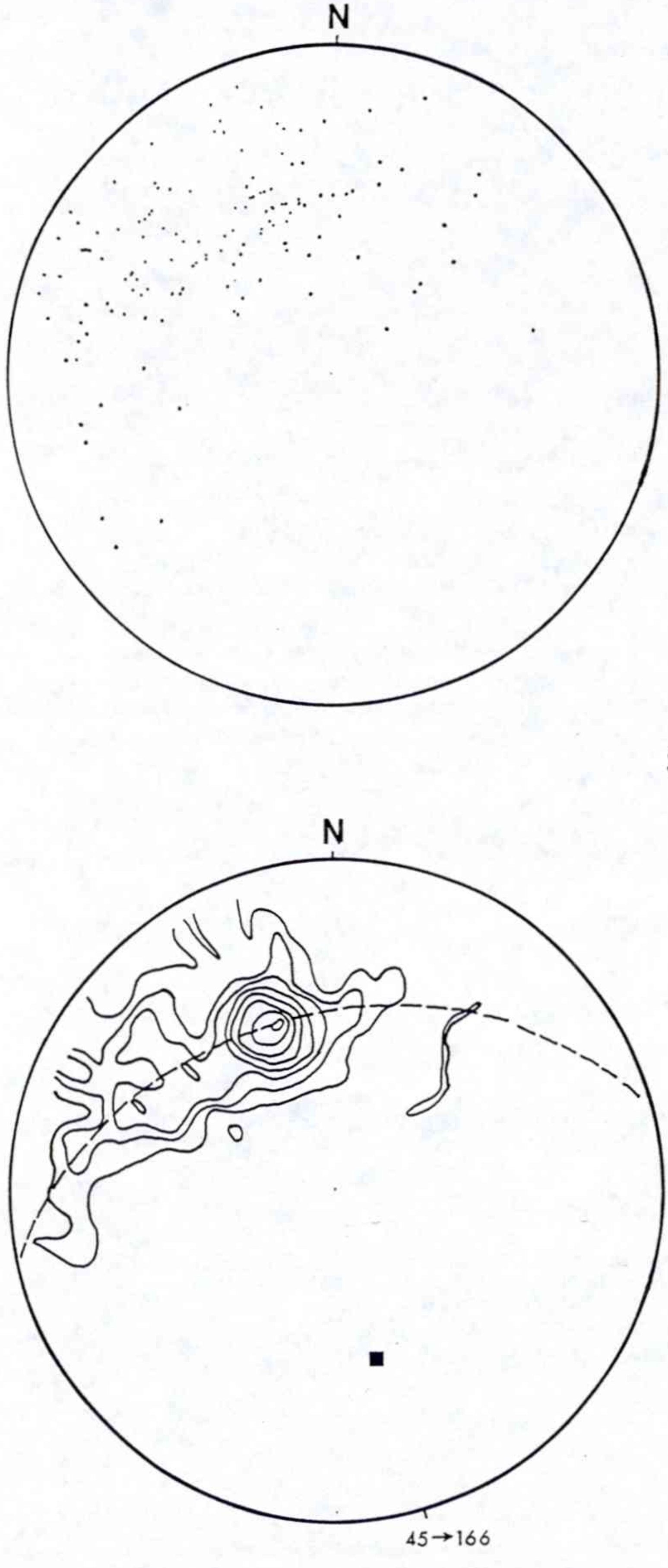
Shear zones are well-developed over most of the area. They occur in two conjugate sets (Figure 3a,b). The first dominant set (SZI) (024/70SE) is characterized by localized, intense to mylonitic schistosity and the development of en echelon vein arrays, on outcrop scale, and of larger regional fault systems, visible on air photographs and geophysical maps (especially the vertical gradient EM). Most of the SZIs record a dextral sense of shear, recorded in tension gashes and offsets of lithological units.

The second shear zone set (SZII) (286/60N) is expressed by a 1 to 5 millimetre spaced fracture cleavage which intersects the S_1 cleavage and has the appearance of a crenulation cleavage. Strongly schistose zones associated with SZII are less well developed than the SZI's, but where present, a pencil cleavage lineation tends to be developed (e.g. at UTM 592380E / 7700970 N).

The larger fault systems outlined Figure 2 were plotted from air photograph lineaments, topographical features, geophysical maps, and extrapolation from outcrop-scale shear zones. There is good evidence that these faults were early syn-sedimentary rift-basin bounding faults, which subsequently were activated and re-activated as large-scale shear zones, throughout the deformational history of the Pechenga Group. One of the major NE-trending faults cuts and offsets interpreted South Pechenga Group rocks in the south-central portion of the area, and thus is interpreted to have been active after this time (post 1,9 billion years). Strike-slip displacement along these major shear zones/faults ranges from a few to 250 metres.

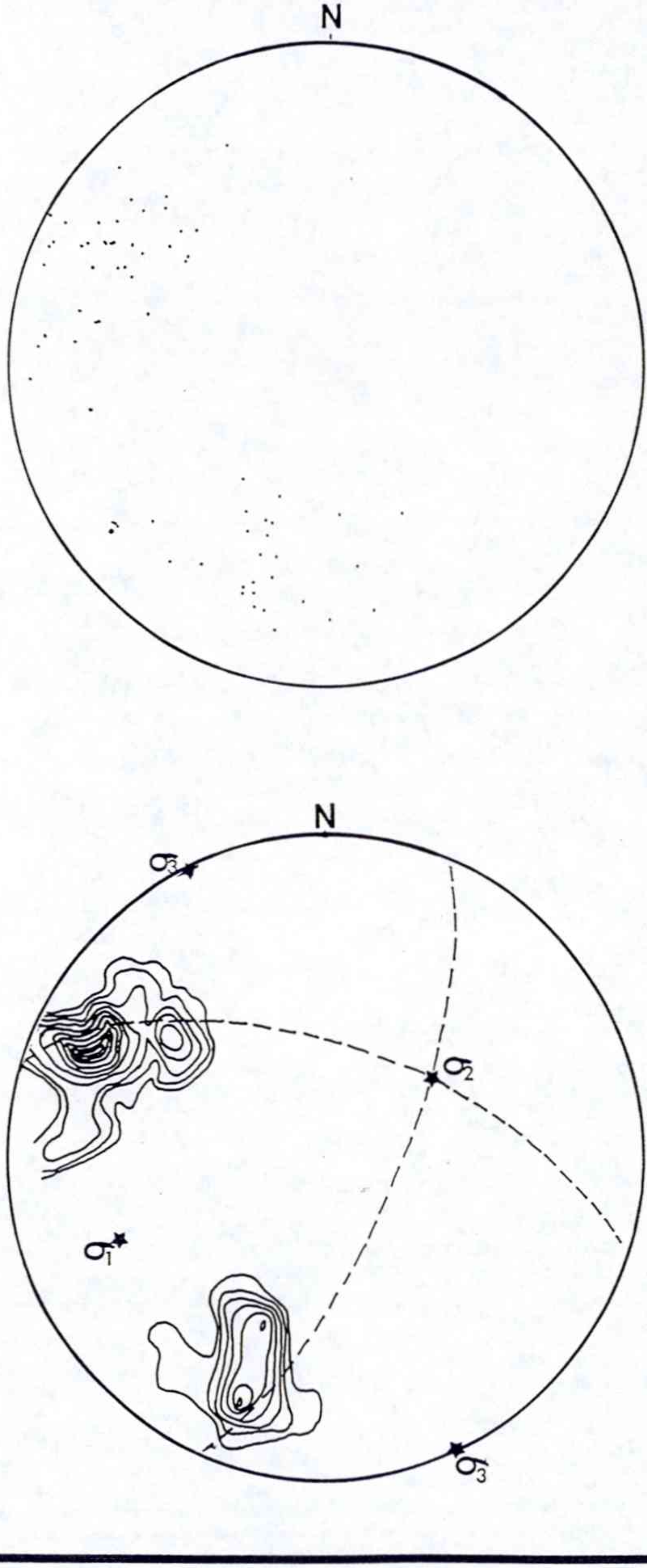
There is also evidence in the area that thrusting occurred during the primary deformation event. In the area of drill holes PS81-37, PS81-36, PS75-29 and PS77-34 (Figure 2), strong rodding and slickensides in pillow lavas of the Pil'guyarvi Volcanic Formation, strongly sheared, localized zones in outcrop, milky quartz-filled breccia zones in drill core, and the absence of the upper Productive Formation attests to the thrusting of the Pil'guyarvi Volcanic Formation over the middle Productive Formation in this area. This accounts for the absence of ultramafic bodies in holes PS81-37 and PS81-38. It is possible that there was no upper Productive Formation deposited in this area, but the evidence for thrusting still is strong. The thrust planes generally parallel S_1 schistosity planes and are interpreted to be related to the D_1 event which probably was associated with the one-sided rift basin closure.

Another good example of thrusting occurs in the Pil'guyarvi Volcanic Formation at UTM 592350E / 7700950N (Figure 2). Here, south-dipping, north-verging thrust planes, indicated by strong EW schistosity and slickenside development in Pil'guyarvi pillow lava have offset serpentinized ultramafic boudins.



S_1 / S_0

FIGURE 3a



Shear
Zones

FIGURE 3b

GEOPHYSICS

Two major geophysical surveys were carried out during 1991: a 1409,5 line kilometre helicopter-borne AEM survey (April-May) and a 47,71 kilometre (37,88 kilometre surveyed) ground mag and Slingram EM survey (August). The results of the AEM survey are on file at the geophysical department of the NGU, and will remain confidential until 1998. The ground survey results are on file with A/S Sulfidmalm.

The AEM survey was designed to cover the Kuetsyarvi, Kolasyoki and Pil'guyarvi Sedimentary and Volcanic Formations, and part of the South Pechenga Group throughout the Skogfoss Arch between the Russian and Finnish borders. On the magnetic maps, the magnetite-bearing Kuetsyarvi trachyandesites dominate the map as two to four separate zones with magnetic amplitudes in the order of 500 to 2.000 nanoTesla (nT) above a background of approximately 53.500 nT. In the southwestern part of the horizon, amplitudes are considerably attenuated to a few hundred nanotesla and only one horizon is present.

Ultramafic bodies within the Productive Formation are well-portrayed in the magnetic, especially the vertical gradient magnetic, maps as round to elliptical high-amplitude shapes within and bordering the highly conductive graphitic shales. The shapes of these bodies attests to the modelled boudin shape of the bodies due to deformation.

The EM results outline several strong conductors, most of which are interpreted to be graphitic shales. The Productive Formation is interpreted to occur continuously throughout the Skogfoss Arch, based on geophysical interpretation and outcrop exposures mainly in the Oksfjell area. It is in the Oksfjell area that the Productive Formation is the thickest, but is also the area of the greatest concentration of non-magnetic, resistive (based on resistivity maps 935Hz Coaxial, 4.600 Hz Coaxial, 4.175 Hz Coplanar, 32.000 Hz Coplanar) gabbro-diabase bodies. Several other continuous conductive horizons are evident on the airborne EM maps. They are interpreted to represent graphitic shale horizons within the Kolasyoki and Pil'guyarvi Volcanic Formations and the South Pechenga Group.

Resistivity measurements determined from the four frequencies outline the non-magnetic gabbro-diabases (discussed above) which are the subvolcanic facies of the Pil'guyarvi Volcanics. The Productive Formation and other highly conductive interpreted graphitic shales stand out as prominent resistivity lows, especially on the 4.600 Hz (Coaxial) map.

The VLF results were severely distorted due to Russian radar interference, but filtering and correction of the data highlighted conductors with north to northeast and east-west strike directions which gave the highest amplitude conductive results. These correspond well with the conjugate shear zone/mega shear zone array.

GEOCHEMISTRY

One hundred and ninety-nine (199) samples from surface and drill core in the Pasvik area were submitted to X-Ray Assay Laboratories (XRAL) in Don Mills, Ontario for whole-rock and trace element analysis by XRF. In addition, 11 samples of reference standard DS-A (16/11/83) were analyzed to test precision and accuracy. The results show the precision of most of the elements to be very good, except for S% and for those oxides and elements with low abundances (CaO, Na_2O, K_2O, P_2O_5, Rb, Zr, Nb). Accuracy is also good to 5%, except for the above mentioned elements with abundances less than 0.5% (oxides) and less than 50 ppm (elements).

Forty samples were submitted for Au, Pd, Pt (fire-assay-DCP) and Ni, Co, Cu (multi-acid extraction-DCP) to XRAL, along with two different standards. Although the precision of the method could not be tested with the limited samples, the accuracy is very good.

Pasvik ultramafic bodies defined by magnetic surveys, outcrop and drilling have a bulk chemistry similar to the Ni-bearing Pechenga ultramafic host rocks. They can be categorized as ferropicrites which are Fe/Ti-rich picrites with high MgO komatiitic affinities (Hanski and Smolkin, 1989). Examination of Ni and MgO data from Pasvik suggests that only those ultramafic bodies located within the Productive Formation were sulphur-saturated and of these sulphur-saturated ultramafics, several have a high enough MgO content to precipitate Pechenga-style nickel sulphides. These high MgO ultramafics at Pasvik are located near major shear zone/fault systems which may have acted as channels for upward-migrating ferropicritic magma to reach the surface or near-surface and precipitate Ni-Cu ores upon encountering sulphur-rich Productive Formation shales.

Comparison of Pasvik data for Akhmalahti, Kuetsyarvi, Kolasyoki and Pil'guyarvi Volcanic - equivalent Formations with correlative Pechenga data (Zagorodny et al., 1989) shows them to be very similar (Table 3).

TABLE 3 - AVERAGE WHOLE-ROCK ANALYSES OF PASVIK AND PECHENGA ROCKS

	Akhmalahti Basalt		Kuetsyarvi Basalt/Andesite		Kuetsyarvi Andesite		Kolasyoki Basalt	
	Pasvik	Pechenga	Pasvik	Pechenga	Pasvik	Pechenga	Pasvik	Pecheng
SiO_2	58.22	54.77	51.28	55.34	67.19	66.9	47.99	47.02
Al_2O_3	12.38	13.85	13.18	15.09	13.1	13.08	12.90	12.83
CaO	6.53	8.45	6.44	2.72	0.97	1.38	10.49	10.97
MgO	5.36	4.61	7.72	2.28	0.54	1.26	6.70	6.94
Na_2O	3.27	3.37	3.65	5.39	5.03	4.29	2.26	2.40
K_2O	1.25	1.02	1.06	3.27	3.25	3.49	0.17	0.20
Fe_2O_3	9.84	10.05	12.49	11.61	8.01	6.58	14.36	12.45
MnO	0.14	0.15	0.20	0.11	0.06	0.12	0.22	0.18
TiO_2	0.94	0.90	1.35	1.67	0.97	0.85	1.30	1.17
P_2O_5	0.16	0.02	0.16	0.38	0.17	0.24	0.10	0.00
LOI	0.88	2.59	1.33	2.08	0.22	1.64	2.16	4.62
SUM	99.00	99.78	98.92	99.94	99.51	99.83	98.68	98.78
S	<50	100	89	100	0	600	448	600
N	7.		10		1.		10.	

	Productive Fm Shale		Pil'guyarvi Basalt		Pil'guyarvi Rhyolite	
	Pasvik	Pechenga	Pasvik	Pechenga	Pasvik	Pechenga
SiO_2	54.66	57.53	48.43	47.02	73.60	70.80
Al_2O_3	14.64	13.67	13.36	12.83	10.90	10.13
CaO	1.62	0.42	9.74	10.97	1.20	4.26
MgO	3.24	2.22	6.52	6.94	0.85	0.57
Na_2O	2.15	1.02	2.36	2.40	2.41	0.74
K_2O	2.17	3.86	0.23	0.20	2.24	3.90
Fe_2O_3	12.92	11.74	13.80	12.45	6.42	4.19
MnO	0.09	0.11	0.21	0.18	0.09	0.06
TiO_2	1.81	1.46	1.37	1.17	0.60	0.40
P_2O_5	0.09	0.09	0.13	0.00	0.04	0.04
LOI	6.33	4.26	3.02	4.62	1.39	1.48
SUM	99.87	96.38	99.19	98.78	100.0	96.57
N	19.		24.			

PROPOSED EXPLORATION PROGRAM FOR 1992

The exploration program for 1992 is divided into three portions. From January to May there will be a continuation of the 1991 data evaluation and compilation, recommendation of up to 50 line kilometres of geophysical surveys and final preparation for the 1992 field season. The field season from June to August will include geophysical surveys, a drill program in the Oksfjell area (10 holes; 2000 metres) plus detailed field mapping in the Oksfjell area and regional mapping over the remainder of the Pechenga Series in Norway. The program from September to December will include compilation and analysis of the 1992 field work to plan for 1993.

SUMMARY AND CONCLUSIONS

The A/S Sulfidmalm Pasvik exploration program was reactivated in 1990 due to the high nickel exploration potential in Finnmark for equivalents to the Pechenga nickel deposits. The Pechenga deposits annually produce 34.400 tonnes of nickel from ore with an average grade of 1,18% nickel. The host rocks to the Pechenga deposits extend for 34 kilometres across Norway. Between 1971 and 1982 A/S Sulfidmalm conducted surveys and diamond drilling over most of this prospective belt. Proof of nickel mineralization occurring in the Pasvik area includes the observation of the nickel sulphide mineral pentlandite in Pasvik ultramafics in five drill holes and drill hole assays up to 0,33% Ni and 0,15% Cu over 1,7 metres.

Fifty-four 25 hectare claims were staked in the Oksfjell area on December 18, 1990. In April, 1991 a 1409,5 line kilometre helicopter EM survey was flown over the entire length of the Pechenga Group in Norway. Core logging and field mapping programs were carried out by A/S Sulfidmalm in cooperation with the Geological Survey of Norway. Ground geophysical surveys totalling 41,93 line kilometres were carried out over the poorly exposed and virtually undrilled eastern portion of the Oksfjell claim block. Geological, structural, lithogeochemical, petrological and geophysical data were compiled in the autumn to plan the 1992 program.

The proposed field exploration program planned for the summer of 1992 will include a drill program in the Oksfjell area (10 holes; 2000 metres), ground geophysical surveys (50 line kilometres), detailed geological mapping in the Oksfjell area and regional mapping over the remainder of the Pechenga Group in Norway.

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