

Generative project
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GENERATIVE PROJECT

Exploration potential for copper, gold
and lead - zinc in northern Troms and
Finnmark with a review of the geology

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SUMMARY AND CONCLUSION.

The report gives an outline as well of the general geology of northern Norway as of the Cu, Au and Pb-mineralisations occurring within this area.

As a resume there are recommended two areas in which ore mineralisation of economic enrichment can be expected.

Special interest is drawn to the different greenstone belts, in which the Cu and Au-mineralisations occur. From new data available the Karasjok greenstone belt (belongs to the West Inari Schist Zone) is part of the archaean formations, which cover the more eastern part of the area. It is therefore not longer comparable with the greenstone assemblage present on the western side of the Central Finnmark Gneisdome, which is clear proterozoic in age. The belt of the West Vidda finds its northern extension in the precambrian basement rocks of the two tectonic windows at Alta and Repparfjord. The greenstones, metasediments and acidic volcanics of the Western Granitic Belt of the Finnmarksvidda are at the present time difficult to assign. Their extension to the east is further obscure but there might be a connection to the rocks exposed in the Bidjovagge region.

The senprecambrian/eocambrian rockgroup is described in detail. The numerous Pb-impregnations are bound to arkosic sandstones of the Dividal-Group.

This autochthon sedimentgroup shows in places a very similar lithostratigraphy to the Laisvall-district in Sweden.

The Cu-deposits within the area can roughly be divided in three groups: Disseminated stratabound, ^{occurrences} vein type occurrences and brecciated vein type occurrences. No massive sulfide bodies are reported. The first group includes as well the far the most very low grade pyrrhotite, chalcopyrite disseminations in greenstones and black schists as the copper-enriched impregnations in albite-felsites, which are normally high in Au. The latter ones are expected to be the only occurrences of probable economic Cu and Au concentrations. Both vein type deposits carry in comparisons to the first mineralisations significant higher copper (about 5 %), but they should be uneconomic with regards to modern mining methods. Nevertheless they show in places Au-values of higher than 1 ppm.

The reported Au is bound to Au-quartz veins. It accompanies too, certainly in varying amounts, the different Cu-mineralisation.

The Pb-deposits are not restricted to any of the geological sequences. There is reported one occurrence from the Granulite-Belt of Finland. Low-grade impregnations are found all over the Dividal-Group. Here are they bound mostly to arkosic sandstone units occurring further upsection. Several Pb-mineralisations are distinguishable in the Nappe complexes, which are thrust over the Dividal Group. These deposits are engaged to tectonic features and are interpreted as being remobilisations from deeper seated Pb-concentrations.

RECOMMENDATIONS.

There are at least two areas in which ore mineralisations of economic enrichment can be expected. These are the Cierte area and the upper Reisa valley district.

The Cierte area is characterized by a deeply eroded volcanic rock assemblage of precambrian age. The occurring ring-structure leads to the assumption that one is dealing with an old volcano complex. The higher amounts of acidic volcanic rocks joining the outer ring together with basic volcanics and further metasedimentary rocks are a typical environment for massive sulfide bodies or at least disseminated sulfide mineralisations of higher tonnages. They may carry in analogy to the Bidjovagge Cu-mine and the Bergmark disseminated ores Au-values in the nearea of 1 ppm or even higher. The host rock will supposedly be the acidic volcanic or leucodiabas (texture). For special interest are the agglomerates and the brecciated rock types in which already the nowadays reported Cu-rich mineralisations occur.

A future exploration programme should be based on previously detailed studies of any information which is available from this area. The former exploration works from the NGU can for the first be completed and in places enlarged.

In this connection it should be drawn the attention to the practical knowledge by the use of geophysical methods for the discovery of sulfide mineralisations bound to albite-felsites. The interpretation of the results were in all cases. (Bergmark area, Bidjovagge) difficult to establish. For the first it is to respect that the disseminated ore always is poor in pyrrhotite, what results in a very soft Mag. These indications can often be covered by the much higher Mag of the surrounding basic rocks (metagabbros and metabasalts). A strong EM is effected by the always present graphite schist. This might in places coincide with the more weak occurring EM from the sulfide mineralisation. 2

The upper Reisavalley district is specially known for its numerous lead-occurrences. They are present as impregnations in the Dividal Group or as crackfillings in the overlying Nappe complexes. The latter are of special interest while they may represent indications for deeper seated Pb-enrichments. By several authors there are reported basement heights located at Bulljovagge (Caskias) and Carajavri, both in the nearea of the Reisa-valley.

A stratigraphical profile of the Avasjåkka region (sidevalley from the Reisa-valley) given by SKERLIE a. TAN(1960) shows significant analogies to the mineralized section at Laisvall in Sweden (BJØRLYKKE, 1981). Furthermore there are reported several sulfide impregnations from this region.

1.-----INTRODUCTION.

This report summarizes and analyses the Au, Cu and Pb - Zn occurrences of northern Norway, in order to find out new exploration targets in this area. The studies are based on all kinds of informations about the mines, prospects and mineralisations, mostly available in "Bergarkivrapports"(NGU) and further on the activities in geophysics and on alluvial examinations of the Geological Survey of Norway (NGU), present in several "NGU-rapports".

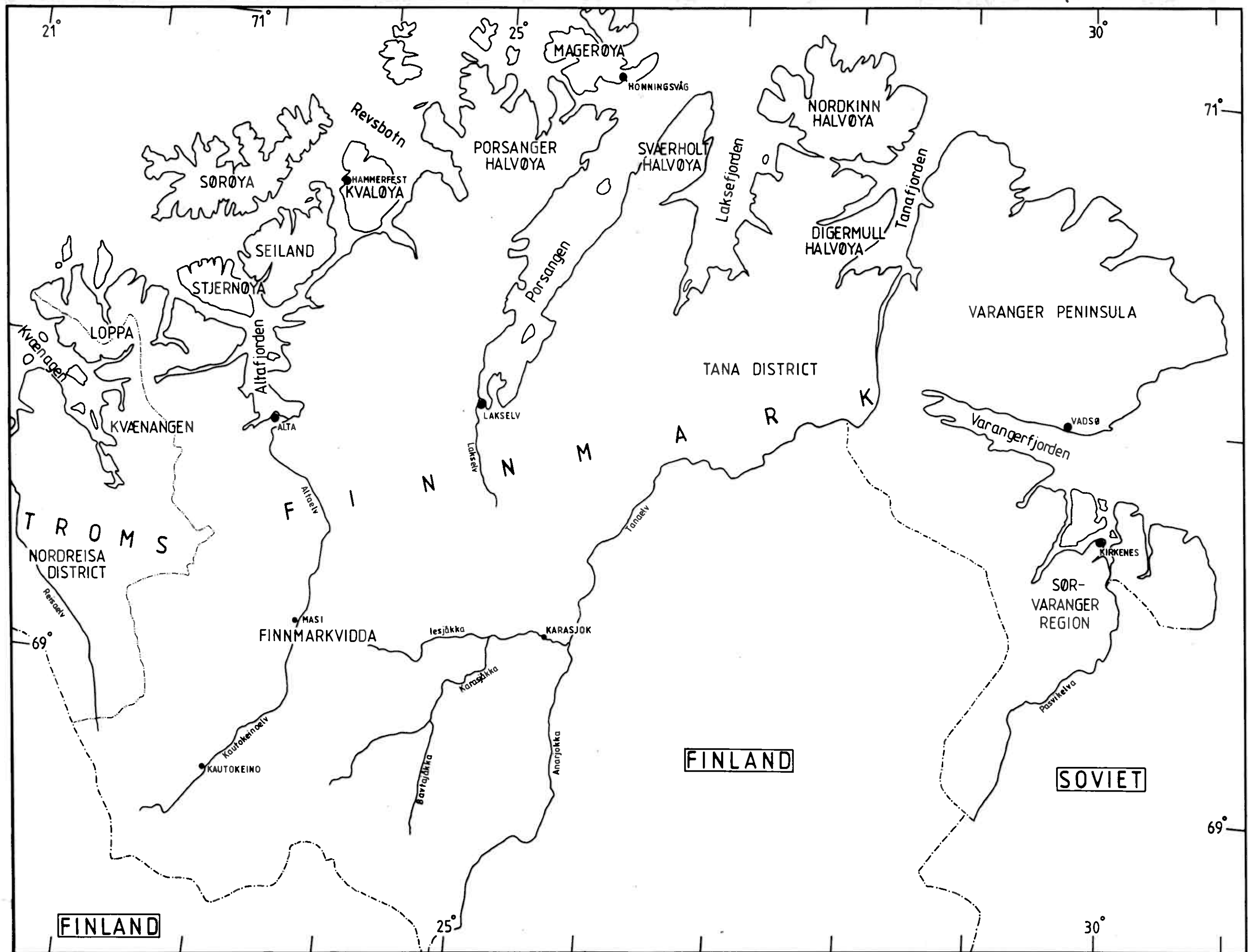
Special attention is drawn to the geology and geochronology, because of the stratigraphical controll of as well the Cu as the Au- mineralisations.

1.1-----Location and access.

The examination area lies in the farest north of Norway, centered at lat. 70 degr., long. 25 degr.. It encloses the northeastern parts of the province Troms and the province Finnmark as a whole. The area borders in the far northeast against the U.S.S.R. and is in the south surrounded by Finland. The northern bounds are represented by the arctic sea. To the west it is limited by the 21st degr. of latitude. This tract of land covers more accurate the Sør-Varanger Region (centerpoint: Lat. 69° 35', long. 29° 40'), the Sør-Varanger Peninsula (lat. 70° 25', long. 29° 30'), the Nordkinn Halyøya (lat. 70° 55', long. 27° 45'), the Tana District (lat. 70° 15', long. 27° 30'), the Værholt Peninsula (lat. 70° 45', long. 26° 25'), the Porsanger Peninsula (lat. 70° 35', long. 25° 00'), the Finnmarksvidda (lat. 69° 22', long. 23° 50'), the Loppa - Kvenangen area (lat. 70° 00', long. 22° 10') and the Reisa District (lat. 69° 30', long. 21° 40'). The greater islands enclosed are: Magerøya (lat. 71° 05', long. 25° 45'), Kvaløya (lat. 70° 37', long. 23° 50'), Sørøya (lat. 70° 37', long. 22° 55'), Seiland (lat. 70° 20', long. 23° 15') and Stjernøya (lat. 70° 18', long. 22° 40').

The area is represented by a very mountainous coast belt and a further inland occurring peneplain. While the first shows a very good outcrop situation, the latter is characterized by a big alluvial cover. Singel outcrops are here more or less restricted to the rivervalleys.

There exists a typical climate of the higher latitudes. Low summer/ winter temperature changes are typical for the coast line, this is caused by the warm gulfstream, while further inland a real continental climate with warm and stable summers and extreme winters predominates. The whole year precipitation is for the latter around 430 mm.



The vegetation consists mostly of birch trees (crippel growth), different kinds of berries, grass, mosses and lichen.

The main cities are Alta, Hammerfest, Honningsvåg, Vadsø and Kirkenes.

There are existing two Nationalparks, the Stabbursdalen Nationalpark, which is located west of Lakselv and the Øvre Anarjåkka Nationalpark, which covers the most southeastern part of the Finnmarksvidda. Furthermore there should exist a Reisa-Valley Nationalpark, which runs along the Reisa river. At the present time this information is not proofed. There are found no indications for that on either road - (Cappelen, 1 : 400.000, 1978) or on topographic maps (NGO, 1 : 50.000).

The area is easy of access on either a paved or good gravel road, which is the extension of the further south named E-6 or by plane to Alta, Lakselv or Kirkenes. These cities are serviced by daily jet flights from Oslo and Trondheim.

The main road of the tract runs for the most along the coast. The inland is cut by only single gravel roads, which combine the small towns with each other. The areas in between can often be reached by jeep or tractor on muddy dirt roads or only by helicopter. The helicopter stations are Lakselv and Bardufoss, which is further south of the examination area.

2. GENERAL GEOLOGY OF THE FINNMARK - AND NORTH-EASTERN TROMS DISTRICT.

The Finnmark- and north eastern Troms district consists of precambrian (archean) to cambrosilurian rocks (Fig.) . They are combined to few main more or less characteristic units, the

1. Precambrian "basement"
2. Lateprecambrian to lower cambrian series.
3. Cambro - silurian rockunit (Caledonides).
4. Plutonic igneous rocks of the Seiland, Sørøy, Stjernøy area.

There exists a very complex geology, what complicate, both a clear general stratigraphy and an exact lithostratigraphy of the single units themselves.

The main precambrian areas are the Sør-Varanger region and the Finnmark-vidda. They are lying south of a SW-NE trending line running from the north-west corner of the Finnmarksvidda (Nordreisa district, Troms) up to the Varangerfjord in the E (Fig.) . This line marks the border between the precambrian series and the unconform overlying autochthon ("Dividalgruppe or Hyolithuszone") and allochthon (Porsangersandstone ("Gaissadecket")) rocks of eocambrian respectively lateprecambrian age.

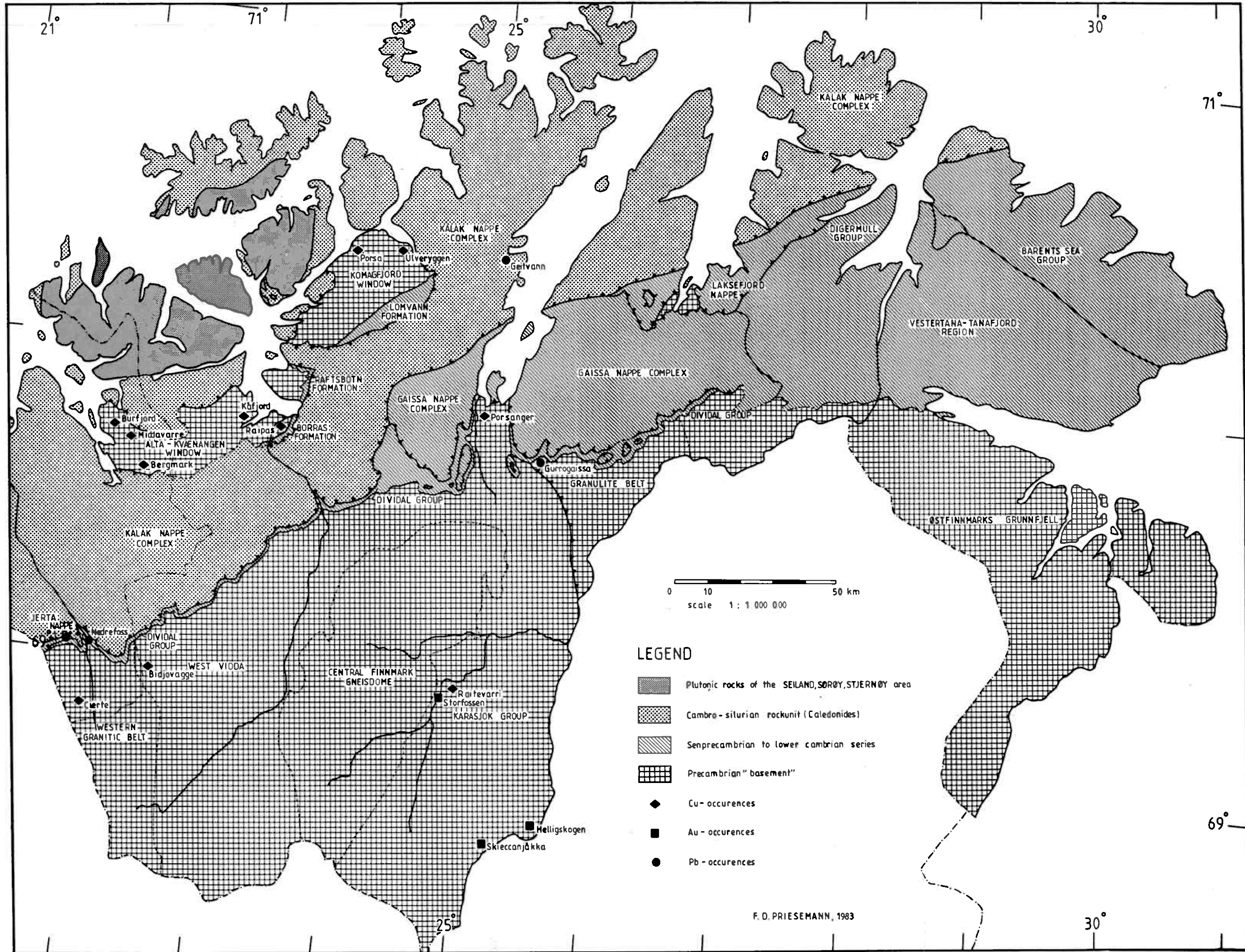
Furthermore there are existing two tectonic windows of precambrian - basement in the caledonian mountain-chain, known as the Komagfjord- and the Alta-Kvanangen tectonic window.

The lateprecambrian/lower cambrian series covers the main parts of the Varanger peninsula and the Digermul peninsula as a whole. As an approximately 40 km wide tongue it continues from here in a westerly direction to Stabburselva, which is located right between Lakselv and Alta. The further westerly extension of this rockgroup is represented by a narrow (1 to 20 km) characteristic seam, cropping out between the precambrian-basement and the caledonian nappe. It can be followed all along the border over Carajavrri, Cascejas to the Reisa-valley and further down to Galgo-jåkka, Troms (out of the examination area) and the precambrian window of the Dividalen - Altevatnet area (GUSTAVSON, 1966). The same sequence appears coronalike round the above mentioned precambrian tectonic windows.

The caledonian nappe complex extends as a NE-SW going coast belt from the Nordkinn peninsula into Troms and further down Norway. It includes (after OFTEDAHL, 1981), too the plutonic rock group of the Seiland, Sørøy, Stjernøy area.

The precambrian "basement".

No basic stratigraphy of the precambrian "basement", valid for the whole lapprovinse of northern Scandinavia, can be made. As a consequence the precambrian "basement" complex is divided into different rock provinces - each of them with a more or less own lithostratigraphy - whose genetic or geochronologic relations are not really cleared up yet. For the norwegian part these precambrian rock provinces are:



1. Øst Finnmarks grunnfjell (OFTEDAHL, 1981).
2. Granulite Belt or Granulite Complex of Lapland (GAAL, 1982).
3. Central Finnmark Gneisdome with surrounded Supracrustal Belts or Central Finnmark Nucleus (BARBEY et al. 1980).
4. Western Granitic Belt of the Finnmarksvidda.
5. Tectonic Windows.

Depending on their subjective economic importance there is given either a brief or a more accurate geological explanation of the single provinces in the following.

2.1.1 The Øst-Finnmarks grunnfjell.

Only very little information are available about the geology and lithostratigraphy of the precambrian basement south of Varangerfjord. That is why most of the works are carried out by geologists of A/S Sydvaranger, here under the leadership of J.A.W. Bugge (BJØRLYKKE, 1982). However some notes and within that a general stratigraphy is found in OFTEDAHL (1981). More detailed descriptions about this rockgroup certainly from the continuation of it into Finland exist in several other papers. In addition geochronological data are given by MERILÄINEN (1976) and by GAAL (1978).

The series ("Inarijärvi nucleus" (BARBEY, 1980)) represents a classical archaean basement with a gneiss - greenstone duality and displays a two stage evolution (primary and secondary greenstone belt). The basis forms the "Jarffjord - komplekset", which consists of migmatitic grey gneisses of tonalitic to granitic composition. The U/Pb ages are distributed around 2.860 Ma. The primary greenstone-assemblage is represented by the "Bjørnevannsgroupe", about 2.600 Ma in age. It is composed of metavolcanics and metasediments, like mica schists, amphibolites (metamorphous dacitic to andesitic volcanics), calc-silicate rocks and quartzites. Of economic importance is the exhalative-sedimentary quartz-banded iron ore (Sydvaranger type deposit), which shows a clear connection to meta-rhyolites. With a clear discordance follows the "Petsamogruppe" (1800 Ma ?). This group starts with a basal-conglomerate ("Neverskrugg-conglomeratet"), what is mixed with arkosic sandstones. Upon that rests a sequence of basic volcanics ("Skogsforssgrønnstein"), made up out of submarine - pillowed - basic volcanics, now metamorphosed to greenstones and or amphibolites and not further differentiated ultrabasic volcanics with interbedded graphite slates and - schists. Further up section there are following more felsic volcanics and, in a greater amount, metasediments like mica schists and carbonates.

Various intrusives, some (gabbros, diorites, granodiorites and granites) connected to the emplacement of the early greenstones and others, which are later (granodiorites, granites) are obvious.

2.1.2 The Granulite Belt.

Only a very minor part of the Granulite Complex of Lapland is obvious in Norway. It covers the tract north of the Tana river, where it soon escapes under the lateprecambrian nappe (Gaissadecket). The western border of this complex is marked by a significant nearly N-S going uplift.

The complex can be followed by an approximately width of 50 km for about 400 km from Norway, over Finland into the U.S.S.R. It forms an arc-shaped belt of high-grade metamorphic rocks, which mainly are of volcano-sedimentary origin. An age of more than 2500 Ma was assumed by MERILAINEN (1976).

The belt consists predominantly of three assemblages (BARBEY et al, 1980, BJØRLYKKE, 1982):

1. a dominant metasedimentary sequence which is made up mainly by quartzo-feldspatic garnet gneisses and garnet-sillimanite gneisses. These are associated with small amounts of felsic metavolcanics, graphite bearing gneisses, quartzites and calc-silicate gneisses (acid granulites (BJØRLYKKE, 1982)).
2. a unit of orthogneisses (intermediate granulites (BJØRLYKKE, 1982)).
3. a minor unit of banded pyroxene and hornblende bearing gneisses and amphibolites. These are restricted to the south-western part of the belt (basic granulites (BJØRLYKKE, 1982)).

Both the acid and intermediate granulites are interpreted as metamorphosed volcanics and sediments. The basic granulites seem to be stressed and metamorphosed norites and gabbros (BJØRLYKKE, 1982).

2.1.3 Central Finnmark Gneisdome with surrounded supracrustal belts.

The Gneisdome/Supracrustal Belt assemblage of the Finnmarksvidda shows for the first point of view a very simple geology. In a central position lies a tongue-shaped gneisdome, which is elongated mainly in a N-S direction. While it's northern hinge is located in the nearea of Skoganvarre though it's southern extension nearly reaches the Killilä area of Finland. This gneiscomplex is doubtless archaean (2800 Ma) in age and represents the basis for the surrounded supracrustal belts. It shows a very uniform felsic petrology by a granitic to dioritic composition (BJØRLYKKE, 1982) - granodioritic to quartz-dioritic (SKÅLVOLL, 1972).

The surrounded volcanic-sedimentary serieses are typical greenstone - belts of lower greenschist to amphibolite-facies. Their horizons are running more or less N-S and by that parallel to the gneis borders. The unit shows clear lithological differences between it's eastern and western part, what efforts a discrimination in the Karasjok-group (Eastern Supracrustals) and the Vest-Vidda (Western Supracrustals).

The Karasjok-group is mainly described by WENNERVIRTA (1968) and by SKÅLVOLL (1972). The latter rests with a marked unconformity on the gneiscomplex. It consists out of two, supposedly three units: the arenaceous basis, the volcanic-sedimentary pile and a more sedimentary completion part. The last two ones are described as the Karasjok greenstone group. It belongs to the "West Inari Schists Zone" (RAITH et al., 1982), a mainly N-S trending formation, which runs from Porsangerfjorden in the north to the southern corner of the Finnmarksvidda and from here further into Finland, where it forms the Kittilä greenstone complex (WENNERVIRTA, 1968, BARBEY et al., 1980). It includes too the Tana River belt, a rock unit supposedly equivalent with the uppermost parts of the Karasjok greenstone Group.

RAITH et al. (1982) denote a possible archaean age of the schist zone as a whole. The same interpretation is found by BARBEY et al. (1980). Age determinations carried out by MERILAINEN (1976) on Zirkons of cross-cutting albite diabbases gave a U/Pb age of 2720 Ma (GAAL et al., 1978).

The Vest-Vidda is mainly described by HOLMES et al. (1957). The results of present works, carried out by A. SOLLI are at the moment not really available. However, the nowadays valid stratigraphy for the Vest-Vidda originates from OFTEDAHL (1981).

The supracrustale rock-assemblage, metamorphosed in either very low greenschist- (Caravarre region) or in amphibolite-facies, comprises out of three main groups. The bottompart builds the 'MASIGRUPPEN', which mainly is composed out of arenaceous sediments (Masi-conglomerate, Masi-quartzite). Right beyond this horizon there is found the "lowest" greenstone-series, which is called the Gåldenvarrifformation (BJØRLYKKE, 1982). The following "Caskias-group" consists of masses of metabasalts (amphibolites), beds of tuffites, graphite rich pelitic sediments and the often described and discussed "Albite-felsite" ("Albite-carbonate rocks" (HOLMSEN et al., 1957), "Quartz-Albite rocks" (BRUINSMA, 1964), "Albittrike-bergarter" (GJERSVIK, 1957)). The latter represents after HOLLANDER (1979) supposedly a felsic volcanic tuff (leptite). To the same result came FARETH et al. (1974). - The "albite-felsite" at Njallaavzi (belongs to the western granitic belt of the Finnmarksvidda), which was connected by HOLMSEN et.al (1957) to the "albite-carbonate rock" of the Vest-Vidda, is nowadays described as an acid volcanic to leucodiabas (texture). The "Caskias-group" is capped by the "Caravarre-group" a more arenaceous and argillaceous unit, which carries minor amounts of tuffaceous pelites.

The rock group of the Vest-Vidda continues further to the north under the caledonian cover and appearse as two textonic windows (se below) at the norwegian coast (PHARAOH, et al. 1982). It's southern extension runs through north west Finland and into north Sweden, where it possibly finds it's pendant in the Kiruna greenstones.

The lithology and several age determinations led to a possible svecokarelian age, what means about 1900 to 2000 Ma (GAUTIER et.al (1979), PHARAOH, et al. (1982)).

2.1.4 The Western Granitic Belt of The Finnmarksvidda.

The assemblage of the Western Granitic Belt is briefly described by HOLMSEN et.al (1957). More detailed examinations, certainly from the most north-western part, can be found in the description to the geological map Cierte (1733 II) of FARETH et.al (1977). However the main geology as a whole and furthermore the important question about the genetical relations especially to the Western Supracrustals are not solved yet. Even no idea about the mode of the formation exists.

The Western Granitic Belt has in general a NNW - SSE extension and is at a maximum 20 - 25 km broad. His eastern limb runs west of Caskias and Agjet. It represents a high-grade granitic gneiss terraine with interbedded metasediments and - volcanics. The most northwestern part shows a genetical obscure but significant ringstructure with a clear granite/granitic gneis-

metasediment/ - volcanic duality. However, the rock suite is divided into two complexes (FARETH et.al., 1977). The older series, called the "Raisaedno complex", is composed mainly of granitic rocks with bands and lenses of quartzite and amphibolite (metagabbros). The Njallajåkka complex consists of sedimentary, volcanic and intrusive rocks, occurring as amphibolites, marbles, micaschists, minor quartzites and different "albite-carbonate" rocks.

The group as a whole seems to be svekokarelish (1800 Ma.). No age determination are at the present time available.

2.1.5 The Tectonic Windows.

There are existing two tectonic windows of precambrian basement in the Caledonian Nappe Complex of West-Finmark. The more easterly one, what is located in the nearea of Hammerfest, is called the Komagfjord Tectonic Window. It covers by a slight NE-SW extension an area of about 900 km². The westerly window, the Alta-Kvamangen Tectonic window, runs from the Altenes Peninsula to the Kvamangsfjord, what means a linear distance of about 60 km.

Both windows are arranged on a large NE-SW trending basement culmination. They show a very near lithology, with mostly basaltic lavas, tuffs and sediments metamorphosed to lower greenschists facies. Their age is assumed to be svekokarelish (1900 - 2000 Ma.).

The Komagfjord Tectonic Window.

The general geology of the Komagfjord window is described either by REITAN (1963) or by PHARAOH (1980) (see KRAUSE, 1981). Both workers established an own stratigraphy. The main difference between is in the stratigraphical position of the "Lommevann Formation" (sandstones, quartzites, pelites), which REITAN counts to the precambrian suite of rocks, PHARAOH in the opposite interprete as eocambrian, comparable with the Dividalgruppen (see below).

REITAN (1963) divides the supracrustal series into two main groups, the "Repparfjordgroup" and the "Saltvannsgroup". The first one comprises of basic volcanics and pelitic sediments, while the latter carries mostly arenaceous sediments, mixed with some conglomerates and agglomerates. PHARAOH (1980) postulates a threefold division in "Magerfjellgroup" (basical greenstones mixed with tuffs and minor carbonates), "Saltvannsgroup" (feldspar-rich sandstones plus conglomerates, greenstones, conglomerates with red volcanic pebbles) and "Porsavanngroup" (tuffs, carbonates, agglomerates, quartzites, dolomites, black schists, tuffs, sandstones, carbonates). The whole series is intruded by gabbros and related intrusives and granites.

2.1.5.2 The Alta-Kvamangen Tectonic Window.

There are several papers available about the geology and petrology of the Alta-Kvamangen Tectonic window. The most interesting and complete descriptions are found by MILNES and RITCHIE (1962) and by ZWAAN and GAUTIER (1980). From the last ones originates too the geological map (1 : 50.000) of Alta (1834 I) and Gargia (1934 IV), which cover the eastern part of the area.

The precambrian rocks of this area are combined to the Raipas-group, which consists, following the new subdivision, out of four sections, known as the "Kvenvik-", "Storviknes-", "Skoaddivarri" and the "Luovusvarri Formation".

This group is overlain by the lateprecambrian "Bossekop-" and the eocambrian "Borras Formation".

The Kvenvik Formation encloses a more or less volcanic sequence, mainly built up out of metagabbros and metabasalts. They are interlayered by tuffs and tuffites which gradually increase in amount up section. This pure volcanic pile is in his upper parts more and more intermixed by pelitic and carbonaceous sediments.

The following Storviknes Formation carries an alternating bedding of carbonates and pelites.

Massive to slightly bedded sandstone, which is interbedded by some horizons of pelitic material, predominates in the Skuaddivarri Formation.

The Luovusvarri Formation shows a significant alternation of dolomites and sandstones.

2.1.6 Evolution of the precambrian in northern Lapland.

The newest result of geological, petrographical, geochemical and geochronological investigations of the precambrian rocksuite in northern Lapland is the clear division of the prior correlated (especially in Norway) different greensone-belts. A possible model for the crustal evolution, regarding the Inarijarvi Nucleus, the Granulite Complex of Finland, the West Inari Schistzone and the Central Finnmark Gneisdome is newly introduced by RAITH et al. (1982). He proposes the existance of an old island arc system, whose old geotectonic structure is still reflected by the present day geological setting. BARBEY et al. (1980) introduce for the same tract of land an old continent - continent collision, e.g. the Inarijarvi Nucleus and the craton of Central Finnmark.

For the more westerly parts no geodynamic model exists at the present time.

2.2 The lateprecambrian to lower cambrian series.

The lateprecambrian/lower cambrian series of the area represents the northern extension of the southern Sparagmites and tillites, quartzites, blackschists and carbonates. That series, occurring between the precambrian basement and the Caledonian Nuppe (FØYN, 1967).

The northern suite is divided in either autochthonous or allochthonous rocks.

The autochthonous succession is mainly described as the Dividal-Group or Hyalithus-Zone. More local names for the same horizon are Lomvann Formation (Komagfjord window), or Rafsbotn Formation (Altenes halvøya) and Borras Formation (both Alta - Kvanangen tectoni window) (ROBERTS a. FARETH, 1974, FØYN, 1964). It is of eocambrian to lower cambrian age.

The rockgroup rests with a marked erosional discordance mainly on the precambrian basement, which was eroded in lateprecambrian times to a peneplain with regional heights (e.g. around Carajavrre and Bulljovagge/Caskias (SKERLIE a. TAN, 1961)). The series is about 100 to 200 m thick and shows a very uniform lithology. It predominates at the base areaceous sediments, which are followed further upsection by more argillaceous rocks, black schists and limestones.

The allochthous rockgroup is represented by the lateprecambrian, "older" sandstone formation ("older sandstone series"), what occurs around Porsanger as the Gaissa Nappe Complex (with Porsanger sandstone and Porsanger dolomite) and in the Varangerfjord-Tanafjord region as the Vadsø- and Tanafjord-Group. This series must be equal too with the Bossekop Formation of the Alta-Kvænangen window (FØYN, 1967) and with the quartzites and argillaceous sediments of the Jerta Nappe or Tjerta Nappe from the Reisa district (ZWAAN a. ROBERTS, 1978).

The "older" sandstone series comprises low-grade metamorphic foreland - facies sandstones and stromatolite-bearing dolomites.

Of possible same age or even older are the sedimentary sequences of the Barents Sea Group, which cover the northern part of the Sør-Varanger Peninsula. They are divided from the other, quite dissimilar sandstone series of the Tanafjord - Varangerfjord Region by a huge NW - SE trending thrustfold (Trollfjord - Komagfjord - Forkastning). (SIEDLECKA a SIEDLECKI, 1966).

To a stratigraphic higher position belong the sediments of the Vestertana- and Digermul - Group (northeastern Finnmark). They could be the eastern equivalent to the Dividal Group (FØYN, 1967). The Laksefjord - Nappe, with a meta-arkosic lithology, possibly represent analogous sediments (ZWAAN a. ROBERTS, 1978).

2.3 The cambro - silurian rock unit.

The cambro-silurian or caledonian rock unit, better known as the Kalak/Reisa - Nappe Complex, is characterized by a very complex tectonic, visible in several minor nappe complexes, which are thrust on each other from the northwest. The greater part of the nappe complex consists of high-grade metasediments, as psammites, pelites, limestones, graphitic schists and quartzites.

An important element is that of a suite of plutonic rocks, whose occurrence is centered in the Seiland - Stjernøy province. There exists a high variety of igneous rocks, presented by layered gabbros and basic dolerite dykes, by diorites, gabbros and peridotites of later intrusion and alkaline complexes, including carbonatites and nephelin syenites.

3. EXPLORATION POTENTIAL FOR CU.

Northern Norway is specially known for its abundance of Cu-mineralisations, which are restricted to the precambrian supracrustal rocks. The occurring deposits can roughly be divided in three types:

1. disseminated type
2. vein type
3. brecciated vein type

The disseminated stratiform mineralisations show a significant restriction to the more volcanic units of the different greenstone belts. They are occurring in greenstones, black schists, dioritic gneisses, further in arenaceous sediments and "albite-felsites". They are interpreted as syngenetic. Their average Cu-content is normally very low and varies between 0,4 and 0,5 %. Enrichments to 1 % Cu or even more are local exceptions to the rule.

A lot of exploration works, including pitting and drilling have been carried out on single locations. Two deposits (Bidjovagge, Repparfjord) have been mined for a shorter period.

The vein type deposits show a very inhomogeneous habit and develops as crosscutting features in the lower greenstone sequence. The gangue material consists mostly of quartz and carbonate. The ore occurs as chalcopyrite, which is accompanied sometimes by bornite and digenite, than pyrrhotite and pyrite and further magnetite or hematite. The Cu-values are considerable higher than from the first reported ones. There is favoured an exhalative origin. Mining activities have taken place on several locations mainly in the 19th century.

The brecciated vein type is present only in two mineralisations at Borrás and Raipas, which are located in the Alta-Kvanangen Tectonic Window. They had only a minor economic importance.

Porsanger Cu-district, Porsanger kommune, Finnmark.

The Porsanger Cu-district is located south of Porsangerfjord, right in the neighbourhood of the river Lakselv. It is covered by the top sheets Skoganvarre (2034 IV), Halkkavarre (2034 I) and Lakselv (2035 III).

The Cu-mineralisations are discovered in a 10 km. broad zone, which extends for about 25 km in a N - S direction from the head of Porsangerfjord (north) to Skoganvarre (south). About 24 occurrences are nearer described, while exploration works, as ground geophysical surveys, pitting and drilling were restricted to only some better looking ones. By now no economic mineralisation have been proved.

The predominating rocks in the ore-bearing district consist of basic volcanics (greenstones), hornblende schists and mica schists of supposedly sedimentary origin, than quartzites, some feldspar - bearing rocks and limestones. They belong to the Caskias - Porsanger group, which surely represents the northern lithological equivalence of the volcanic-sedimentary section of the Karasjok-group. The occurrences are divided in a stratiform type and vein type.

The stratabound sedimentary deposits are present as "rustzones", which can be traced sometimes over several kilometers along the strike. The thickness vary in normal between 0,5 to 2 m, but can reach sometimes 10 to 20 m. Their country rocks are greenstones or banded sequences of that with limestones and quartzites (carbonate facies of banded iron formation ?). The main sulfides present are pyrrhotite and pyrite which are accompanied by lesser amounts of chalcopyrite, digenite and spalterite (arsenopyrite BUGGE, 1978). The economic investing Cu-content ranges between 0,35 and nearly 5 %, while the average lies under 1 % Cu. In addition to that comes 0,2 to 0,4 % Zn and traces of gold. Locally enrichments can grade up to about 2 ppm Au.

The most important occurrence of this type is that at Karinhaugen, what lies at the northeastern corner of the Porsanger field. The better mineralized zone is about 500 to 600 m long and between 3 and 5 m thick. It dips about 45° to SW. The sulfide disseminations consists of digenite "broget kopper" (native Cu ?) and some chalcopyrite. The country rocks are medium grained hornblendites, which are locally accompanied by chlorite - to talkrich aktinolitites than, quartzites and veins and bands of carbonates (limestones, dolomites).

Magnetite is specially enriched at the hanging wall of the greenstones and is found too as impregnations in both, the quartzites and the carbonates.

On this property a lot of exploration works have been carried out since the discovery in 1904. Pitting activities took place at 45 locations. Drilling operations, including 8 drill holes with together 630 m were carried out in 1940. In the past followed ground geophysical surveys undertaken by NGU (EM/GM-rapport 137 B, 1954), IP and Mag. (NGU-rapport 1750/63 A, 1980)). Certainly there were pointed out some better looking areas, but they were interpreted as being too small, that they require further exploration.

The average Cu-content from handspecimen from Karinhaugen of about 1,7 % Cu (richer parts 2,6 % Cu) is considerable higher than that from core material, what range between 0,5 - 0,6 % Cu. The highest detected copper was 2,7 % over a 1,60 m thick zone. In addition there are coming only traces of Au, but 2 ppm Ag.

The vein type deposits are very inhomogeneous in habit and develops mostly as crosscutting features in greenstones. The veins range from 0,1 to 1,5 m in thickness and can sometimes be followed over a distance of about 900 m. The only occurring gangue material is quartz. The sulfide mineralisation mostly consisting of chalcopyrite, bornite or digenite, with small quantities of molybdenite, are present either in heavy irregular formed lumps or as seams on the walls to the greenstone. Furthermore significant sulfide impregnations are accompanying these features in the surrounding greenstones.

The veins and veinletts carry considerable more ore than the disseminated deposits, but show too a much more irregular mineralisation. The Cu-values range from 0,4 to 15 % or may grade even to 30 % or more. In addition to that there are reported from some veins some higher amounts of Au:

Joh's Perssons gång ("guldsynken")	1,6 - 4,4 ppm
Consul Perssons gång	0,9 - 2,4 ppm
Lappetomterna	1,3 - 2,6 ppm
Gomhangerne	1,7 - 2,4 ppm

(Carlson, Bergarkiv 588).

The genesis of these deposits are not definitely established. There might be a connection to the metamorphic event. Remobilisation took place by increasing temperature. Precipitation from the solutions was effected by pressure decrease in the fissures and cracks.

Porsa - Kvalsund Cu-veins, Kvalsund kommune, Finnmark.

The Porsa - Kvalsund area is situated in the Komagfjord Tectonic Window of precambrian rocks. It covers here the more northeastern part which is surrounded to the east by the Repparfjord and to the north by the Vargsund. The district encloses the northern parts of the top sheets Repparfjord (1935 I) and Vargsund (1935 IV) and the most southern cuts of Hammerfest (1936 III) and Reisbotn (1936 II).

The Cu-mineralisations occur as crosscutting veins or veinlets in greenschists (metamorphosed basalt flows) or on the junctions of these with metasediments (quartzites and dolomites of the Repparfjord-group (REITAN, 1963)), or can be found stratabound in black schists. Their position can be related to the main geological structures. They represent therefore crack-filling deposits consisting of iron sulfides and - oxides, copper sulfides and quartz with calcite as gangue minerals. Some of the mineralisations bear uranium and Au.

Their genesis is related to the metamorphic event. The ore minerals were remobilized from the surrounding greenstones or other formations by tempered solutions and precipitated again in the tectonic feature.

The main mining in the area has been carried out near the coast between Beritsfjord and Grubevann. It was concentrated round two mines "Bachkes gruva" og "Porsa gruva". The largest of them was the Porsa Mine at Grubevann, which was driven on two parallel veins, the so - called "Grenville" vein (Greville - Gruve) and "Parallel" vein (Michelsens gruve). These were exploited from 1890 to 1910 and from 1924 to 1931. During the last working period the grade was not higher than about 1 % Cu.

Mine maps and reports indicate an outthinning of the veins with depth. The "Grenville" vein thinned for example from 10 m near the surface to 3 m at 75 m below. The "Parallel" vein in analogy thinned from 11 m to about 2 m at 96 m below. This fact is due to the occurrence of curving faults, which become flatter with depth.

Both veins can be followed for more than 100 m along the strike.

The veins show often very sharp boundaries to the surrounding rocks. Seldom are brecciation zones with irregular limitation (back veining).

The lodes consist of a quartz and carbonate core with some magnetite, idiomorphic amphiboles and minor amounts of sulfides. The ore shoots occur as seams normally at the walls. They consist of chalcopyrite and pyrite accompanied by magnetite and the typical weathering products malacite and azurite.

The Bachkes Mine was worked from 1900 to 1906. It showed a somewhat higher Cu-content, which was calculated to an average of about 3 %. The mined vein was about 1,5 m thick and could be followed about 90 m along the strike. Under operations a depth of 40 m was reached. Later diamond drilling pointed to a good mineralisation (3 % Cu) definitely continuing to 90 m depth.

In addition to these mines there are numerous small prospects from which a few tons of hand-sorted ore have been produced. These were the:

Langvann-skjerp (Kvalsunddalen)
 Angeline Paulsens Gruve (shaft west of Langvann, Vesterdalen).
 Hamborg skjerp (200 m northwest of Langvann, on the contact between greenstones and dolomite).
 Ingebriktens skjerp (3 shafts, 700 m northeast of Langvann)
 Middagstind Gruve, Puntervolds gruve, Schütz-gruve, Lunds malmgang,
 Halligstads skjerp, Hans gruve, Kirhus gruve (all in the nearea of Middagstindfjell)
 Bahrs gruve (between Middagstindfjell and Segelnesfjell)
 Kvalsunddalen skjerp (east of Storvann)
 Kvitherget gruve (2 shafts northside of Segelnesfjell),
 Høgfjell gruverne (600 m north of Nedre Neverfjordvann)
 Malakitskjerpene (200 m northeast of Langvann, in dolomites)
 Gruvedalen skjerp (west of Kvalsund)
 Saltvann gruve (shaft east of Saltvann)
 Korsfossen gruve (Korsfossen, contact vein on the junction of a slate and dolomite), Bratthammeren-gruve.

In the middle 60th of this century Elkem A/S explored the Porsa-district for Cu again. Their activities were mainly restricted to the Porsa Mine and Bachkes Mine and further to the Malakitt-skjerp. No economic Cu-concentration had been proved. From that activities originates too an outline of production and final reserves of the two biggest mines.

Greville gruve:

Production:		
Year:	Tonnes:	% Cu:
1905	230,0	3,85
1906	238,8	5,48
1923-1930	28000,0	ca. 0,8
reserves		
30000 tonnes with ca. 0,8 % Cu		

Parallelen gruve:

Production:		
Year:	Tonnes:	% Cu:
1905	100	6,7
	90	6,8
1906	24,1	14,8
	94	6,75
1920-1924	2000	ca. 0,8
1925-1930	28000	ca. 0,8
reserves:		
36000 tonnes with ca. 0,8 % Cu		

Bachkes gruve:

Production:		
Year:	Tonnes:	% Cu:
1901	330	12
1902-1903	260	20
	2400	10
1929-1930	7800	1,65
reserves:		
19000 tonnes with ca. 1,65 % Cu		

The Malakitt-skjerp showed very low Cu-values ranging between 0,013 and 0,2 %.

Without respect were some single assays for Au available in only a few older Bergarkiv-rapports. One sample from Bachkes Mine with 11,8 % Cu contained 0,38 ppm Au. Cu-concentrates from the Porsa Mine with 20 to 25 % Cu showed an Au content of 2,7 ppm (Bergarkiv 302). Samples from either the Saltvann grube or the Korsfossen grube carried by 7,79 % Cu 2,5 ppm Au (Bergarkiv 211). The last year collected sample from the Gruvedalen skjerp gave Au-values between 0,2 (KVA-82-1) and 0,48 ppm (KVA-82-2) (report 16469, Nov. 82). In this connection it should be drawn the attention to the occurrence of talk-chlorite schists, which carry significant amounts of disseminated sulfides. They are normally known for some Au. Some horizons were intersected by drilling activities of Folldal Verk A/S in the Repparfjord field

Ulveryggen Cu-occurrence, Kvalsund kommune, Finnmark.

The Ulveryggen Cu-occurrence is situated in the precambrian Komagfjord window and lies on the western side of the Repparfjord. This area is covered by the to sheet Repparfjord (1935 I).

The Cu-mineralisation occurs as disseminations or as small veinlets in the arkosic sandstone of the Saltvann group (REITAN, 1963). It appears to be related here to an area of particularly intense faulting and shearing. The ore is enriched in diffuse zones, which occur within a 400 m broad belt with a strike length of about 2 km. The individual lenses varies from a few meters up to 10 m.

The main ore minerals are bornite, chalcopyrite and digenite. In addition comes chalcocite, covellite and iron oxides. Malakite fills often the small but numerous veins and veinlets.

There are heavily discussed either a syngenetic (red bed typus) or epigenetic (circulating solutions) origin of the ores. However the mikro-textures favour a syngenetic mineralisation. The deposit is cut by younger quartz-veins carrying significant amounts of bornite and digenite. Some hematite is also present. Furthermore there are described various fissure veins with large amounts of carbonate and chalcopyrite (Bergarkiv 2276).

Records of copper-production in this area go back to the eighteenth century. The mining operations started with the Olles-, Johns-, Eriks- and Hans Mine, which were established in the very near area of heavy mineralized localities. Reports from these activities point already to a very irregular mineralisation, which can grade in single places up to 5 % but mostly remain under 1 % Cu. A period of extensive exploration began in the late 50th and continued into the middle 60th of this century. The exploration works were either carried out by the canadian company Invex Corporation, Toronto, by the NGU or by A/S National Industries, Drammen, which authorized too the NGU with the forthcoming exploration. These works included geochemical surveys on stream sediments, extensive diamond drilling, geophysical surveys (selvpotential, resistivity, IP, Mag), geological detail mapping and mikroskopical investigations. A proposal study from 1966 pointed out reserves of 3,7 mill.t. by 1 % Cu or 6,8 mill.t. by 0,7 to 0,75 % Cu. The Repparfjord mine started production in 1972, after the property was bought by Folldal Verk A/S. Copper mineralisation was proved to a depth of about 250 m. The total reserves were calculated to be 12 mill.t. by a copper content of 0,5 - 0,7 % Cu. The production was closes down already in 1978.

An important attribution to the Cu output were some amounts of Ag, which were estimated to about 8 ppm (average). Au was not reported (Bergarkiv 4633). This stands in contrary to Au-assays reported in a "Bergarkiv-rapport" from 1913. By that there were proved 2,9 ppm Au from fissure veins (see down), 1,8 ppm Au from contact veins (uncertain veins) and 0,9 ppm Au from the quartz-sandstone lode (Cu-mineralisation Ulveryggen), 1,95 % Cu (Bergarkiv 2276).

Raipas Cu-occurrence, Alta kommune, Finnmark.

The Raipas Cu-occurrence lies in the near south of Alta (top sheet Alta, 1834 I).

The mineralisation is bound to brecciation zones, which occur as cross-cutting features in massive dolomites of the precambrian Storviknes Formation of the Alta - Kvanangen Tectonic Window. There are described two different types of deposits.

The vein-like ones are restricted to the lower dolomite. They exhibit as more regular, plate - ruler shaped boddies of 1 to 5 m thickness and a 30 m dimension. The most important ones of this type are the "Laboucheres Lode" and the "Old No. 11 Lode".

The other type is represented by irregular bodies occurring in the upper dolomite. They exhibit no regular system and do not appear to form continuations of the veins in the lower dolomite. More likely they seem to be the result of the through-going failure of the dolomite. Their horizontal dimensions range between 10 m and 2 or 3 m, while their downward extension reaches 5 m.

Both types consists of zones of breccia and crush. These are made up of unsorted masses of fragments of dolomite and mudstone (of all sizes, cemented by sulfides (partly replacing the carbonate), ironcarbonates (siderite), baryte and normal carbonate.

The ore minerals, in order of decreasing importance, are chalcopyrite, bornite, tennantite, siegnite (Co, Ni sulfide), digenite and covellite.

The Raipas paragenesis shows considerable similarities to the Cu-occurrences of the Northern-Zimbabwe Copper belt (VOKES, 1956).

The Raipas deposit was found in 1830 and came in production in 1837. The main mining period was from 1845 to 1858, smaller quantities were produced up to 1870. The works were carried out by the Alta Copper Works Ltd.. The total production amounted 12.500 t. of ore with an average of 6,3 % Cu (VOKES, 1954). From 1900 to 1906 there followed investigations by diamond drilling, which proved no further economic Cu-concentrations. In the middle 70th of this century the Raipas deposit was extensively explored again by the NGU. These surveys included detail-mapping, stream sediment geochemistry (NGU rapport 1657), helicopter geophysics and diamond drilling. There were found a lot of smaller low grade mineralisations mostly occurring at the junction of the massive dolomite with the overlying siltstone. No indication was found for a greater Cu-occurrence in this area.

Borras Cu-occurence, Alta kommune, Finnmark.

The Borras Cu-showings lie southeast of Alta in the nearea of the Raipas Cu Mine. They occur in the far northwestern corner of the top sheet Gargia (1934 IV).

The Cu-mineralisations are situated on the eastern - to Raipas opposite - slope of a N - S trending anticline which combines Borras and Raipas with each other. The deposits are from the same type like those found at Raipas. No Cu-production is reported from this area, but tunnels and several showings are documents of an extreme prospecting.

The area is covered by helicopter geophysics and is further explored by stream sediment (NGU rapport 1657) and humus (GM rapport 204 G) geochemistry. There were found no indications of heavy Cu-mineralisations.

Kåfjord Cu-occurrences, Alta kommune.

The Kåfjord copper-occurrences are distributed along the northwestern side of the Kåfjord (an appendix of the Altafjord) mostly bordering the little village of Kåfjord, what is located in the nearer west of Alta. The area is covered by the topographic map Alta (1934 I).

The Cu-mineralisations are bound to veins which are interpreted as crack-fillings. They are situated in the heavily deformed volcanic pile of the Kvenvik Formation of the precambrian Alta - Kvanangen Tectonic Window. There are describe 15 to 20 Cu-bearing veins, with thicknesses from cm to 10 m - average 1 to 3 m - and a strike length with up to 300 m. Their gangue minerals are quartz and carbonate, which are often accompanied by dolomite, ankerite and asbestiform actionolite. The ore minerals are chalcopyrite and pyrite with some magnetite or hematite.

Mining activities in the Kåfjord area go back to 1927. The main operations took place in two periodes, from 1827 to 1878 and from 1896 to 1909. The works were carried out by the Alta Copper Works Ltd.. The total production of metallic copper amounted to 13000 t.. The ore contained at the beginning an average of about 5,8 % Cu, but was of a much lower grade in the later period.

The producing mines were "Gamle Gruve" (largest), "Karl Johan Gruve", "St. Petrus", "Consulns gångkomplex", Michels gruve", "Woodfalls Gruve", "Wards Gruve", "Ryers Gruve", "Mancurs Gruve" and several others more.

Beside these, there are existing some more mineralisations of the same type, occurring outside from Kåfjord mining field. They are concentrated at two locations round Kvenviknes at the heads of the Kåfjord and the Altenes peninsula, situated at the Altafjord northeast of Alta. But only small quantities of ore were put out here.

The whole area was covered in the last 70th by exploration programmes' of the NGU. There were carried out airborne (helicopter) geophysics and stream sediment geochemistry, applying Cu, Pb, Zn, Ni and Co. By the latter method there was not covered the old Cu-mining area of Kåfjord. This complicated, in fact the normal high Cu-back-ground in the all occurring' greenstone, the interpretation of the results. Anyways there were outlined some single areas right north of the old mines with good corresponding high Cu-values and EM - Mag. anomalies.

Middavarre Cu-occurences, Kvanangen kommune, Troms

The Middavarre Cu-occurences are situated in the western part of the precambrian Alta-Kvanangen Window several km east of the Kvanangfjorden. The area is covered by the topographic sheest Kvanangen (1734 I) and Flintfjell (1834 IV).

The Cu-mineralisations occure in a number of steep dipping quartz-carbonate veins, supposely of the same type like those of the Kåfjord Cu-veins. They are situated too in the Kvenvik-formation. The thickness of the veins and veinletts vary between 20 cm and neraly 2 m. The ore minerals are mostly chalcopyrite, accompanied by some amounts of pyrite and bornite and very rarely magnetite. As reported before (Porsa) it is obvious that the best mineralisations (compact ore) occure on the contact to the country rock.

The mining activities took place at several locations. There are "Nordre Spalte", "Kalkspatgangen", "Langgangen", "Store Kwartsgangen", "Søndre Spalte", "Hansgangen", "Jensens Gruve", "Georgs Gruve", "Sieverts Gruve", "Øst-Vest-Gangen", and "Malmkula". Relicts of the works are obvious today as tunnels (135 m long "Sieverts Gruve"), testpits and prospects. The operations were between 1910 and 1920. In this time about 80 to 100 tonnes of ore were produced. Most of them came from "Sieverts Gruve". The average Cu-content was around 6 % Cu. In addition to that came an average content of 0,5 ppm Au (NGU-rapport 1650/46 A).

The Cu-occurences are covered by airborne EM - Mag. and γ -surveys. Furthermore A/S Sulitjelma Gruver carried out a geopchemistry programme on stream sediments, while NGU undertook diamond drilling. There were found no indications for economic Cu- or Au enrichments.

Burfjord Cu-occurences, Kvanangen kommune, Troms.

The Burfjord Cu-veins occure in the western part of the Alta-Kvanangen Window northeast of the Middavarre area.

The Cu-veins are of the same character like those found at Middavarre.

Mining operations as tunneling and pitting were undertaken around 1910. These activities had only test character.

Bergmark (periodically called Badderren) Cu-occurences, Kvanangen kommune, Troms.

The Bergmark Cu-occurences are situated in the western part of the Alta-Kvanangen Window in the nearer east of the head of Kvanangsfjorden. The area is covered by the topographic sheets Kvanangen (1734 I) and Flintfjell (1834 IV).

The Cu-mineralisations are bound to the lower and upper sections of the Kvenvik Formation, together a ca. 2200 m thick volcanic-sedimentary pile

which consists of dolomites, cherts, albite-felsites, black-schists, dolomitic-feldspar rocks, tuffs and tuffites, metamorphosed basaltic lavas and sills of Mt-bearing gabbros. The Formation contains in comparison to most of the other precambrian Cu-areas high amounts of intermediate to felsic volcanics.

The rock sequence is tectonically deformed to a N - S trending anticline, which crops out in a horseshoe formed structure of about 5 km length.

The associated Cu-deposits are present either as stratabound disseminations in albite-felsites or are bound to quartz-carbonate or iron-carbonate veins.

The dissemination type is described by impregnations or small veinlets of chalcopyrite and pyrite with minor amounts of magnetite or hematite restricted to albite-felsites. The Cu-ore appears often in the very near area of a black schist, but rarely continues into it. This type of mineralisation can only be found in the western part of the anticline and is represented here by the "Cedars Gruve", "Kisgangen Gruve" and some minor deposits. Furthermore it is correlated with the Cu - Au occurrence at Bidjovagge, Kautokeino kommune, Finnmark (s.b.)

These deposits are very well known as Au-bearing. Two samples from Cedars Gruve contained as much as 0,38 ppm (quartz-carbonate with sulfides) and 1,0 ppm Au (chalcopyrite ore with carbonate). In 6 from 40 samples from the Cedars and Kisgangen Gruve there were detected minor Au-amounts, ranging between 0,05 (detecting limit) and 0,4 ppm Au. The highest value plotted out came from a black schist of the Kisgangen Gruve, which contained about 5,9 % As.

- Cedars Gruve:

The mineralisation occurs in a 50 m thick unit consisting of an albite-felsite and black schist, which is bordered on each side by a metagabbro layer (metabasalt ?). The albite-felsite extends out to the depth and also on the east side of the mine. Its western continuation in the direction to Kisgangen is clearly proved by geophysical methods. The sulfide ore is found in the albite-felsite and occurs either as disseminations or as shots in small veinlets. There are further described sulfide-magnetite mineralisations connected to chlorite-rich rocks.

The highest Cu-values were classified to 7 or 8 % Cu. The average content was around 1,6 % copper. In addition came some Au.

The estimated reserves are surely minor than 100.000 tonnes by 2 % Cu (NGU-rapport 188/46 C).

- Kisgangen Gruve:

The mineralisation occurs too in an unit of an albite-felsite and a black schist, enclosed by a metagabbro. The Cu-ore is present either as disseminations as well in the albite-felsite as locally in the black schist and as shots in a number of smallest veinlets crosscutting the albite-felsite.

The main sulfide mineral is chalcopyrite, which is accompanied by some pyrite and arsenopyrite.

The average Cu-content of the ore is about 0,5% Cu.

Besides these two mines there are known a number of smaller prospects placed on the same lithological types of rocks. They are the "Strix Gruve", "Japan Gruve" and "Nye Kisgangen".

The quartz-carbonate vein type deposits are present as 1 - 2 m thick veins occurring in metagabbros or metabasalts. The country rocks are often highly altered to chlorite, quartz and carbonate assemblages, which can be indentified in outcrops by their typical knot-shaped weathering surface.

The gangue material is carbonate and quartz accompanied locally by dolomite and ironcarbonates. The ore minerals are chalcopyrite and pyrite obvious mostly as smaller or bigger clusters and some magnetite and hematite.

The veins are discovered by test pits, tunnels and prospects at "Bergmark Gruve", "Kalkspatgangen", "Magnus Gruve" and "Gamle Gruve IV". They show clear analogies to the vein type deposits at Middavarre and the Kåfjord area.

The iron-carbonat veins restricted to a 2 km long area what extends from the "Gamle Gruve" northwards to the Baddernelva. The veins are bound to zones of altered-carbonated- metagabbros. They consists of ironcarbonates and quartz and carry varying amounts of iron-oxides, sulfides (chalcopyrite bornite, digenite) and iron silicates.

They occur in two different types:

1. network type (cm-thick dendritic veinlets)
2. Normal vein type (m-thick).

They are not as much examined as the above described deposits.

The Bergmark area contains in addition to the outlined Cu-mineralisations some Co-indications bound to metagabbros and metabasalts, than stratabound heavy As-mineralisations in albite-felsites (possibly high in Au) and at least pyrrhotite/pentlandite impregnations in tuffs.

These occurrences seem to be no further touched by any exploration work.

In the opposite, the Bergmark area must be well explored in order to the occurring Cu-mineralisations. Former prospecting was undertaken by A/S Bleikvassli gruver in a joint venture with Orkla Industrier A/S, than by A/S Sulitjelma Gruver and by the NGU (USB). These works included a geochemical programme on stream sediments (not all assayed for Au), diamond drilling (only some Au, As assays), airborne (helicopter) geophysics and detail mapping.

As a conclusion, the area is characterized by numerous minor Cu-deposits, which carry locally high Cu-content. Economic concentrations have not been proved yet by any of the prospecting methods. The former mining operations were compared with those from the Kåfjord area very small. The total output is estimated to 6800 tonnes of ore with an average content of 7,4 % Cu.

Bidjovagge Cu-occurrence, Kautokeino kommune, Finnmark.

The Bidjovagge Cu-occurrence is situated on the Caskias mountain what lies in the northwestern part of the Finnmarksvidda, just at the border to Troms. This region is covered by the topographic sheet Ravsjavrre (1833 III).

The mineralisations occur in the Caskias Group, which belongs to the supracrustale rocksequence of the Vest-Vidda. The group consists at this location of either greenstones or greenschists, than carbonaceous schists, albite-felsites and of intrusive amphibolites and metadiabases. The sequence forms a steep dipping, N - S striking anticline, which is cut by numerous later faults.

The mineralisations are mostly bounded to the eastern limb of this structure and occur either as low-grade disseminations or as veins or veinlets first in the albite-felsite, but also in the carbonaceous schists. The most important sulfide enrichment areas are found in faulted and brecciated areas. They form now the A, B, C and D ore bodies.

The main ore minerals are chalcopyrite, pyrite and pyrrhotite. Magnetite, ilmenite, rutile, sphalerite, galena and pentlandite occur in accessory amounts. The reported Au is mostly connected with chalcopyrite and pyrite, or, by lesser amounts of sulfides, to Bi-, Ni-, Fe-tellurides.

The copper content varies between 1,8 and 2,1 %. The Au-content shows a great variation both between the different ore bodies and within each of them. The average grade is about 1,2 ppm. The Au-richest deposits are the A and B body, which show a Au-range of 2 and 7 ppm.

The Bidjovagge deposit is clearly stratabound but the ore bodies appear to be structurally controlled. Thus folding, faulting and fissuring have been the very important factors for the localization and concentration of the sulfides. A syngenetic exhalative origin has been proposed on the primary deposition of the sulfide ore.

The Bidjovagge Cu-occurrence was mined from 1970 to 1975 by A/S Bleikvassli Mining Company, which was overtaken in 1972 by A/S Sydvaranger. There were produced 400.000 metric tonnes of ore from the A and C ore bodies. The proved reserves today are:

100.000 tonnes of 2,1 % Cu A-body
50.000 tonnes of 1,83 % Cu B-body
250.000 tonnes of 1,83 % Cu C-body
200.000 tonnes of 1,84 % Cu D-body

The indicated Au-content is 0,5 % ppm.

Raitevarre Cu-occurrence, Karasjok kommune, Finnmark.

The Raitevarre Cu-occurrence is situated within the running Karasjok project. It lies ca. 30 km west of Karasjok in the nearea of the E-W trending Karasjokka. The deposit is seated in the southern part of the topographic sheet Iesjokka (2033 IV).

The mineralized dioritic gneiss belongs to the middle part of the Karasjok group. It is enclosed in a flat lying section consisting of a barren dioritic gneiss, a graphite schist and an amphibolite gneiss, which contains locally

garnets. This sequence is about 10 to 50 m thick and can be traced along the strike for more than 4 km.. It is marked by a killing zone.

Chalcopyrite and pyrite are the dominant ore minerals. They occur only as fine impregnations.

The Cu-content varies greatly and is estimated to an average of about 0,4 %. In addition comes some Au.

The area is well explored by A/S Sydvarnger by mapping and diamond drilling. At the present no attractive Cu - Au concentration has been found.

Cierte Cu-occurrence, Nordreise kommune, Troms.

The Cierte area lies at the southern end of the Reisa valley. It encloses the most northwestern part of the Finnmarksvidda and is covered by the top sheet 1733 II.

The area is made up of precambrian supracrustal rocks, which belong to the Western Granulite Belt. The rocks exposed are granites or granitic gneisses, amphibolites (metagabbros) and quartzites, then further metabasalts, marbles, micaschists and masses of acidic volcanics. The latter occur often with agglomerate structures and shows significant brecciation. The rock assemblage forms a well visible nearly ring shaped structure of 10 to 15 km. extend. This is represented by a clear granitic gneis/metavolcanic, - sediment duality. While the internal gneis is barren with regard to any mineralisation of interest, occur several deposits in the outer metavolcanic - sedimentary assemblage, called the "Njallajokka complex". These consists of either sulfide or uranium occurrences.

The sulfide mineralisations are of a Cu-rich and a pyrrhotite-rich type. The first one is present in lumps and veins or veinlets either in amphibolites or greenstones or in brecciated acidic volcanics, which were in places correlated with the albite - felsites, rocks, which are the dominant Cu and Au barriers in the Bidjovagge mine (s.) and the Bergmark mineralizations (s.) The reported Cu-minerals are chalcopyrite, bornite, digenite and covellite. They are accompanied by some magnetite and hematite (martitisation). The most present gangue material is carbonate, quartz and feldspar.

Occurrence of this type are found around Mirkujákka - Jiettanasgårsa, at Ciertegårsa, in the Råggejavri district and at Njallaavzi. At some locations there can be found old prospects.

The pyrrhotite-rich type occurs as stratiform massive layers or impregnations, which are always marked by a significant rusty staining. The deposits are bound to greenschists and quartz- and graphite-rich mica schists. The main sulfides are pyrrhotite and pyrite, accompanied by accessory chalcopyrite. These mineralisations are present in the Råggejavri district and occur too at Nieidaskaidi.

The Cierte area is newly mapped by NGU (1976). It is partly covered by airborne (helicopter) EM - Mag - surveys and examined by stream sediment geochemistry. Some higher Au- was indicated.

At least it should be mentioned that equal rock assemblages with supposedly comparable Cu and uranium mineralisations are reported from the Rombak Window (Nordland). Here were discovered stratabound As - Au enrichments bound to metasedimentary - volcanic (?) rocks.

4. EXPLORATION POTENTIAL FOR AU.

Chances for finding gold are restricted in northern Norway to the archaean and proterozoic basement rocks. The one area of special interest, the Karasjok Greenstone Belt, is already covered by the present running Karasjok project. This is located in a geological setting of ultramafic - mafic volcanics (Komatiites), banded iron formations and metasediments.

From outside this area there are described one and another Au-occurrence, here, either from quartz veins or alluvial residues (placer). Furthermore there is reported gold from a great number of Cu-occurrences from the proterozoic supracrustal assemblages. It is here mostly enriched in quartz carbonate veins or in the deposits connected to intermediate or felsic volcanics (albite felsite). These are summarized before.

Helligskogen Au-occurrence, Karasjok kommune, Finnmark.

The Helligskogen Au-occurrences are lying at the Anarjokka about 100 km south of Karasjok (topographic sheet 2033 I).

The reported gold is either found in old alluvial terraces and further in several quartz-feldspar pegmatite veins and one lense.

The veins are present in two prospects. They are connected to highly pressed amphibolites and occur here as sills or crosscutting features. No indications are found either about their dimensions or about their Au-load. There is only mentioned, that there has been found some gold in it.

The occurring pegmatite lense is of 50 to 60 m length and 2 m thickness and consists of quartz, feldspar (red and glassy), biotite and muscovite, magnetite and accessory tourmaline, garnet and rutile. It carries 0,4 % Au.

Skieccanjokka Au-occurrence, Karasjok kommune, Finnmark.

The Skieccanjokka Au-occurrence is situated within the Øvre Anarjokka Nationalpark, which covers the most southern tract of the Finnmarkvidda (sheet 2032 I).

The "alluvial" Au-enrichment was discovered in 1924 by John Balto. His works lasted for a very short period and had only test character. The produced Au - about 32 g - was very unnormal in shape (specially mentioned). It was produced from a highly weathered schistose bedrock, where it filled as well the more upper as the further down occurring cracks. It wonders that the Au sometimes shows the attempt to go some distance down in the weathered rock (comment, Bergarkiv 1944). - In this connexion it should be drawn the attention to the Sargejok goldfield (just south of the Karasjok project area) where it occurs the same type of "alluvial" Au. It is open to question if these Au-occurrences are of alluvial or primary origin. There are at least several indications which favour the latter one.

Storfossen Au-veins, Karasjok kommune, Finnmark.

The Storfossen Au-deposit is covered by the present running Karasjok-project. It is here only mentioned why there are found some new informations about it:

By Bjørlykke (diary from 1937/38) there are reported several quartz-veins from the Storfossen area. The richest one carried 2 ppm Au. These veins are supposedly not combined with the here too occurring quartz-veins rich in pyrrhotite and pyrite, which were tested several times round 1900. They gave only negative results (see too assays for Au heavy pyrrhotite sample from Nicolaysen showing, report 16239, Oct. 1982).

5. Exploration potential for Pb.

Significant lead mineralisations are bound in western Scandinavia to the lateprecambrian, eocambrian rockgroup, which builds the autochthonous cover for the precambrian basement rocks. The noneconomic and economic (Laisvall, Vassbo (Sweden)) deposits are all of the sandstone type. At the present time there is running one lead-project, situated in the southern sparagmites of Norway.

From northern Norway there are reported several lead occurrences. Some of them are restricted to the "Dividal Group" (Hylithus zone) and their adjacent rock assemblages which show in places a comparable lithostratigraphy to the Laisvall-area (Reisa valley district). Furthermore there are found Galena and secondary Pb-mineralisations by the follow up of stream sediment anomalies. These are bound to tectonic features occurring in the different nappe complexes, which overly the autochthon Dividal Group. These remobilisations are typical pathfinders for deeper seated lead concentrations. In addition there is reported one further lead-mineralisation from the norwegian part of the Granulite Belt of Finland.

Gurrogaissa Pb-veins, Porsanger kommune, Finnmark.

The Gurrogaissa Pb-occurrence lies 26 km southeast of the head of Porsangerfjorden in the very nearea of the Graselv (topographic sheet Halkkavarre (2034 I)).

The Pb-mineralisation is bound to steep dipping fissures in precambrian garnet bearing quartzitic gneisses, which belong to the Granulite Belt of Finland. The individual fissures and cracks are of about 10 to 15 cm long and max. 5 cm thick and show a different orientation. In places are they very numerous and build up a very tight network. They are restricted to a 2 m broad zone of 180 m length. The fillings consists of quartz, carbonate and galena.

The average Pb-content of the zone is estimated to 10 %. The galena contains 30 ppm Ag and 0,35 ppm Au.

The deposit is known since 1905 and has got since that time through little exploration. However A/S Sydvaranger had a smaller programme in the beginning 70th of this century.

Geitvann Pb-veins, Porsanger kommune, Finnmark.

The Geitvann Pb-deposit occurs in the Kalak Nappe Complex and lies 2 km southwest from the Olderfjord, which is an appendix from the N - S going Porsangerfjord. The area is covered by the top sheet Billefjord (2035 IV).

The Pb-mineralisation is more exactly discovered in a swamp area west of Geitvann, where it is obvious in some smaller prospects and further in several blocks, which are thrown out over a greater region. The ore minerals as galena, chalcopyrite and sphalerite sometimes accessory pyrrhotite, occur in quartz and quartz-carbonate veins or stocklike forms which extension is not proved by now. A ground geophysical survey pointed out a ca. 200 m long anomaly. The thickness of the vein or veins is of 0,2 to 0,25 m. There were drilled 3 holes on this property by NGU. Only one of them showed up a lead mineralisation of 0,10 - 0,20 cm. The other two holes were either barren or carried only some negligible impregnations. In a later report it is admitted, that these holes might have been drilled from the wrong side.

The mineralisations are very inhomogeneous in habit. The lead load can range between 5 and 30 % Pb by 0,5 - 11 % Cu, 0,06 - 6,4 % Zn, 71 - 97 ppm Ag and 0,4 ppm Au.

The occurrence is thought to be a very restricted one with supposedly no economic importance. The exploration works have not cleared up the geological situation of the swamp area, what may represent a tectonic brecciation zone and might therefore be mineralized in a higher degree than it is expected.

Pb-impregnations in the Dividal Group and adjacent rocks.

There are described several locations with low grade Pb-mineralisations from the autochthon rockgroup covering the precambrian basement. These Pb-impregnations are mostly bound to a quartz sandstone unit occurring some distance above the lower tillite (conglomerate).

The locations are:

- | | |
|-------------------|---|
| Bojobaesk: | (between Altaelv and Lakselv):
0,5 m of a 1,5 m thick quartz-sandstone horizon
are mineralized with Pb. |
| Dakkujákka | (Reisadalen, 500 m south of Fossestua):
Pb-mineralisation (3,7 and 2,8 % Pb) in a fine
grained section 1 1/2 m above the precambrian
basement. The occurrence seems to be small. |
| Nedrefoss | (upper Reisadalen):
Pb as cementation together with quartz in askosic
beds. |
| Komagfjord Window | (Repparfjord):
Pb-impregnations in sandstones of the Lomvann
Formation. Drilled by Folldal Verk A/S. |

Reisavalley Pb-indications, Nordreise kommune, Troms.

The upper Reisa valley area is especially rich in Pb-indications. There are for the first the impregnations in the Dividal Group (see above) and than the several secondary Pb-anomalies, which were turned out by geochemical stream sediment programmes (NGU rapport 516 E). The latter ones are bound to tectonic features situated in the Nappe complexes, here the Jerta Nappe and the Reisa/Kalak Nappe, which cover the Dividal Group.

No further exploration work has been carried out on this indications.

6. Land status.

Referring the outlined occurrences claims are stacked only in the Cierte area, on the Bidjovagge Cu-occurrence and on the Geitvann Pb - Zn mineralisation. These information bases on the claim list for Troms and Finnmark, dated the 31st March 1982.

In the Cierte area there are hold 2 claimgroups of together 41 claims by USB (staten). They are located in the amphibolites and acidic volcanics at the southern part of the ringstructure. They cover only two of the mentioned Cu-occurrences (Mirkujákka, Nieidaskaidi). The claims were stacked in 1975, one 1976. They may be either running out in this year or be at the present time already available.

The two claims of the Bidjovagge area are hold by Bidjovagge Gruver A/S. They are dated to 1981.

The Geitvann claims are together 4. They are hold by USB (staten). They should be running out this year.

Furthermore there are stacked 4 claims by A/S Sydvaranger on a Pb-property called Luostegaissa which is located in the Porsanger kommune.

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