Dolomite hosted copper mineralisations in the Paleoproterozoic Alta – Kvænangen tectonic window, Finnmark County, Norway

Submitted by Rune Wilberg
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For Scandinavian Resources AB

Contents

1. Introduction

Chapters 2-7 were submitted pre field season 2011 as a summary with recommendations for follow-up work in the eastern part of the Paleoproterozoic Alta-Kvænangen tectonic window. Scandinavian Resources AB then held claim blocks covering the abandoned Kåfjord Mine and various dolomite hosted copper mineralisations west of Kåfjord, and also the Raipas and Borras occurrences SE of Alta.
The rest of this report describes field work conducted during the summer of 2011.
It was soon obvious that the area bear evidence of under-exploration, and a main part of the work was directed towards reconnaissance and prospecting within the interior of the tectonic window, west of the claims.

Several promising copper mineralisations have been discovered and claimed during this summer. The most prominent is Fiskarfjellet, with several kilometres long copper mineralised dolomites grading 1-2 % Cu. Exceptionally high copper and silver grades were obtained from a boulder finding at Flintfjellet, > 40 % Cu and 450 g/t Ag.

2. Working area

The Alta-Kvænangen window Paleoproterozoic rocks cover an area of approximately 700 m2 between Alta in the east and Kvænangen in the west. Bedrock is generally well exposed, however significant areas are covered by till and boulder fields.
The eastern and western parts (where all the historic copper workings are located) are easily accessible from the fjords and the main road (E6), while the interior is remote with no road access and altitudes up to 1150 m above sea level. Scandinavian Resources` licenses are concentrated in the eastern part of the window (fig. 1). The area is covered by the geological maps in scale 1:50 000 Alta and Gargia (Zwaan & Gautier 1980), and Flintfjell (Gautier et al. 1986).

3. Geological setting

The Raipas Group, exposed in the Alta-Kvænangen tectonic window, is divided in four formations: the Kvenvik-, Storviknes-, Skoadduvarri- and Luovusvarri formations (fig. 2). Discordantly above lie the Vendian to Cambrian Bossekop and Borras Groups, and the older, Caledonian Kalak Nappe Complex (Zwaan & Gautier 1980).
The Kvenvik Formation is the lowermost formation in the Raipas Group and is at least 2000 m thick. The main rock types are tholeiitic metabasalts and volcaniclastic tuffs and tuffites, some carbonate beds especially in the lower parts, and metagabbros and metadiabase sills. The low-grade metamorphic lavas are both subaerial and subaqueous and locally contain well-preserved primary structures. Minor copper deposits of different types occur within this formation (Bjørlykke et al. 1985, Vik 1985).
The greenstones are overlain by the Storviknes Formation, which is a more than 600 m thick sequence of siltstones and dolomites, which is frequently copper mineralised. Conformably above this lies the Skoadduvarri Formation. The relatively homogeneous, fine-grained sandstone is classified as a lithic wacke and has minor thin slaty and conglomeratic interbeds (Zwaan & Gautier 1980). This formation is at least 1000 m thick and is considered being deposited in a near-shore, fan-delta environment (Sandstad 1986). A thin dolomite

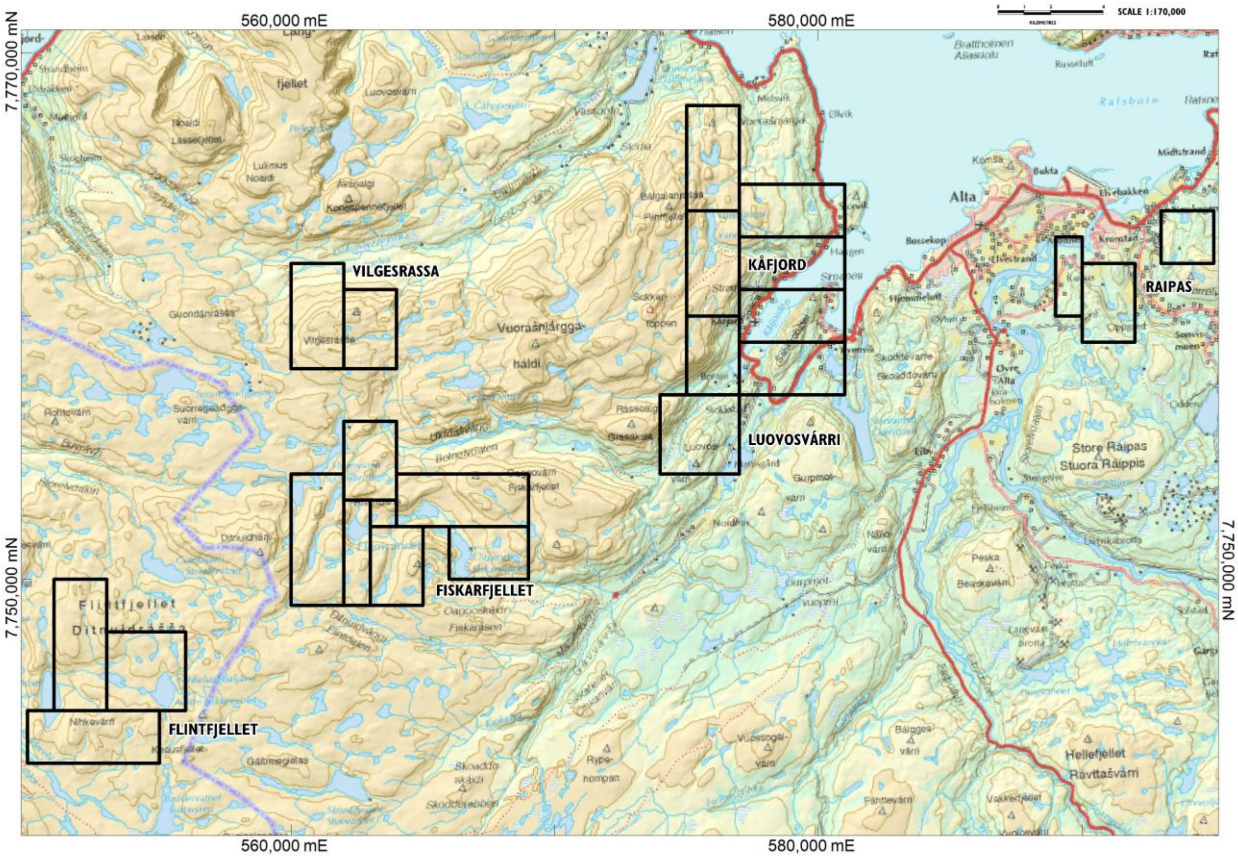

Fig. 1 Scandinavian Resources` exploration permits in the Alta-Kvænangen window.

interbedded with sandstone, termed the Luovusvarri Formation, forms the uppermost unit of the Raipas Group. No copper prospects are known in these two upper formations.
The Paleoproterozoic formations were deposited in shallow-marine environment. The lithostratigraphy suggests that sedimentation and volcanism occurred in a subsiding basin with limited supply of clastic material (Kvenvik and Storviknes formations), followed by sedimentation of more distal terrigenous material (Skoadduvarri and Luovusvarri formations). The geotectonic setting is debatable. Torske (1978) suggested deposition in an aulacogen, while Pharaoh et al. (1984) assumed that the volcanites were erupted in an early stage of opening of an ocean or back-arc basin.

The Storviknes Formation consists of a lower red siltstone, a dolomite unit and an upper grey siltstone with thin beds of dolomite. In the Raipas area the lower siltstone is approximately 50 m thick and is overlain by 200 m of dolomite. The dolomite unit is divided into a lower interlaminated dolomite and slate, and an upper massive dolomite. The upper siltstone can be several hundred metres thick and includes a few beds of dolomite, up to 4 m thick (Vik 1985). The interlaminated dolomite and slate is a reddish-brown rock with alternating one-centimetre thick dolomite- and more resistant silica-rich laminae. Intraformational breccias with tabular fragments and cross-cutting channels occur locally. The upper 50 m of the dolomite unit is a massive dolomite, usually without lamination. Laminated parts may have a higher content of organic material and commonly show stromatolitic structures. Chert is found as replacement of the stromatolite laminations, as small angular lumps and as layers. Locally, rocks with

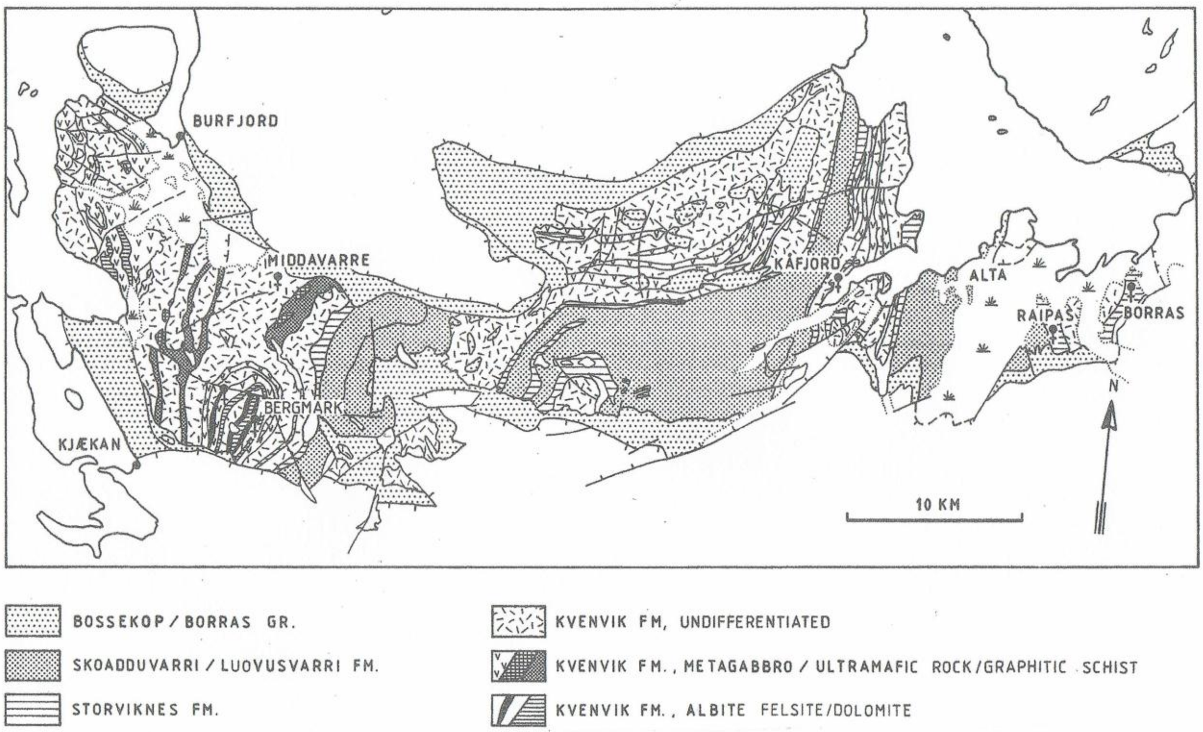

Fig. 2 Geological map of the Alta-Kvænangen tectonic window. From Sandstad (1986).

fragments of chert and slate in a matrix of red hematite-bearing claystone are present. Karst breccia with angular fragments of dolomite, chert and slate hosts copper mineralisation at the Raipas deposit (Vik 1985).

The primary structures of the dolomite indicate that the rocks were formed in a tidal-flat environment (Sandstad 1986). Some of the occurrences of chert can be interpreted as pseudomorphs after anhydrite, and suggest presence of a hypersaline solution, possibly in a sabkha-environment. The red claystones are assumed to have been deposited in karst depressions on the surface of the dolomite and as more extensive mud flows. The breccias of the Raipas mine probably originated as collapsed karst caves.

The siltstone above the dolomite is mineralogically similar to the siltstone below. The thin interbeds of dolomite in the upper siltstone can be traced along strike over several hundred metres, and usually consist of a massive basal part and an upper laminated part. Immediately beneath the dolomite, the siltstone has a paler colour and locally carries disseminated pyrite. The siltstones were probably deposited in a shallow-marine environment, with the interbedded dolomites representing intertidal sediments. Pyrite-disseminated layers indicate reducing conditions in a predominantly oxidizing environment (Vik 1985).

The dominant folding and metamorphism of the Raipas Group is probably of Svecokarelian age. The deformation is a parallel-type folding with open folds in the east and isoclinal folds

with thrusts in the core in the north-west (map sheet Alta). Fold amplitudes are up to several kilometres. Metamorphism varies from mostly lower greenschist facies to middle greenschist facies with the formation of biotite and blue-green hornblende in some of the greenstones (Zwaan & Gautier 1980).
A major feature of the Caledonian deformation within the area was the thrusting of basement rocks of different types together with cover rocks (mainly arkosic) from the north-west over the autochtonous units. Typical for the area is comparatively weak deformation and metamorphism of the autochtonous rocks. The allochtonous rocks on the other hand have been deformed in at least three tectono-metamorphic phases (Zwaan & Gautier 1980).

4. Exploration history

The first findings of copper in Kåfjord occurred around 1690 and the first, insignificant attempts to exploit the ore were done in the 18th century (Moberg 1968). Mining was carried out during the periods 1827-1878 and 1895-1906. About 5-6000 t of metallic copper has been produced from ore containing approximately 5-6 % Cu.
Subsequent to initiation of mining in Kåfjord additional deposits were found and ore transported to Kåfjord, which was the largest centre in Finnmark at that time. Raipas was mined from 1837, and a number of deposits were found and small-scale mined in Kåfjord and Kvænangen. The small workings at Anna, Lundstrøm and Gryteng (north-west and south of Kåfjord) probably took place during the last mining period of the Kåfjord Mine.

More recent exploration was carried out in the period 1960-75, mainly in Kvænangen. The Geological Survey of Norway (NGU) conducted geological mapping and geophysical measurements covering the Bergmark anticline in 1960-61 (Trøften 1962). During the 70th Sulitjelma Gruber A/S (owner of the Kåfjord Mine from 1903) in cooperation with Orkla Industrier A/S conducted comprehensive exploration in the same area (Kvænangen), including diamond drilling at Kisgangen and Cedar (Kruse 1975, Sen & Mukherjee 1975).
In the same period A/S Bleikvassli Gruber were active in the area (Strand 1972).
NGU drilled 5 holes at Middavarre (Kvænangen, fig. 2) in 1978 (Vik 1980) and 2 in Raipas (Vik 1979).
The Alta-Kvænangen window is covered by airborne geophysics (Håbrekke 1978, 1979) and stream sediment sampling (Næss & Staw 1979, Staw 1981), both conducted by NGU in 1978 and 1979.

5. Known copper mineralisations in the Alta-Kvænangen tectonic window

The Paleoproterozoic supracrustal rocks in the tectonic windows Alta-Kvænangen, Altenes and Repparfjord-Komagfjord can be followed on magnetic maps below the Caledonian nappe cover proving these to be connected to the Kautokeino Greenstone Belt. This implies that we have an idea what to look for in the Alta-Kvænangen window, which is a copper metallogenetic province: Bidjovagge-type Cu-Au and Nussir-type Cu mineralisations, both stratabound, even the structurally controlled Bidjovagge deposit.
Bidjovagge is hosted by albite felsite and graphitic felsite, and occur as several mineralised lenses in tectonically deformed rocks. At Nussir disseminated copper mineralisation (1.5 % Cu) is hosted in a 2-3.5 m (0.5-7 m) thick dolomite layer over a length of 9 km. Both Bidjovagge and Nussir are at the moment at a pre-mining stage, and in-fill drilling is ongoing.

Within the Alta-Kvænangen window both the Kvenvik Formation (correlated to Caskijas Formation in Kautokeino) and the Storviknes Formation (correlated to Bihkkacohkka Formation in Kautokeino), belonging to the Lower Raipas Group, host copper mineralisations. No mineralisation is known to occur in the Upper Raipas Group sandstones of the Skoadduvarri Formation (correlated to the Caravarri Formation in Kautokeino) or the Luovusvarri Formation.

The small stratabound Cedar deposit (and Kisgangen) in Kvænangen, the western part of the window, is regarded a smaller, less deformed version of the Bidjovagge deposit, with chalcopyrite dissemination in albite felsite (Vik 1982)

In the Alta-Kvænangen window mineralisations with similarities to Nussir occur in the Storviknes Formation, where copper mineralisations are found in four stratigraphic positions:

- In the basal layers of thin beds of dolomite in the upper siltstone.
- In a thin conglomerate at the top of the massive dolomite.
- In matrix of karst breccias in the massive dolomite.
- In massive dolomite beds with a high content of organic material in the interlaminated dolomite and slate.

The mineralisation NW of Kåfjord, between Anna and Holmvatnet prospects, is stratabound and more or less continuously mineralised over a strike length of > 6 km, along the west flank of a large synclinal structure. Vein network of bornite-digenite-chalcopyrite (with minor and accessoric other sulphide minerals) mineralisation is hosted in 3 adjacent dolomite layers, each of 2-4 m thickness, in silt- and mudstone (occasionally sulphide veining is observed in the siltstone adjacent to the dolomite). Mineralisation is assumed to be diagenetic, with sulphide replacement of dolomite along a tectonic zone parallel to strike.

Also the east flank of the syncline is mineralised: At Melsvik mineralisation was found in 1979 by follow-up by NGU of a stream sediment survey (Næss & Staw 1979, Staw 1980) and no excavations are conducted. A 100 m thick siltstone unit contains 5 thin, 0.3-5 m thick, dolomite layers with bornite, digenite and chalcopyrite as dissemination and in quartz vein network over a strike length of at least 3 km.
The same dolomite sequence hosts mineralisation 8 km to the south, at Gryteng.

Also the small Raipas and Borras deposits (fig. 2) are hosted in the Storviknes Formation, at the west- and east flanks respectively of a SSE-plunging anticline. The exhausted Raipas deposit produced between 1845-1870 c. 12 500 t grading 6.3 % Cu. Also contained are baryte and linnaeite group minerals (Co-Ni), up to 21 g/t Ag in samples and weak enhancement of uranium (5-11 ppm). It is a karst-collapse breccia mineralisation regarded having small potential for significant deposits in the surrounding area.
More economically interesting than the Raipas-type is regionally occurring stratabound mineralisations, in the Raipas area bound to conglomerate (0.2-1m thick) along the massive dolomite-siltstone contact. According to Vik (1979) this is weak dissemination; drill-tested by two drill holes close to outcrop (NGU in 1978). It is indicated by an IP survey (Eidsvig 1979) which concluded with possibly graphite-related anomaly. The siltstone unit contains thin dolomite layers which are mineralised over several hundred metres length.
In the south, below the overlying Bossekop-quartzite, a `larger`, deep-seated IP-SP anomaly is not yet explained (Vik 1979, Eidsvig 1979). The Raipas mineralisations were not indicated by heliborne geophysics in 1977.

Similar to the above mentioned Cedar deposit in Kvænangen, the Kåfjord deposit (fig. 2) is hosted in the Kvenvik Formation, as the only representative in the claim areas beside the small Kvenvik occurrence and Simanes Fe-Cu occurrence (the latter is probably a volcanic-exhalative mineralisation). However, Kåfjord is a hydrothermal vein deposit, with frequent analogues in the western part of the window, and hence genetically different from the stratabound Cedar.

The Kåfjord deposit consists of several veins located in brecciated greenstones, and usually near the contact to metasediments comprising carbonates, mica schists and graphitic schists. The greenstones in the mining area have been assumed to represent intrusive rocks (Mørk 1970).

The rocks are folded into an anticline and metamorphosed in greenschist facies. A near flat-lying shear-zone, assumed to be a local thrust, has been recognised and this truncates the brecciated rocks (Mørk 1970). This shear-zone always occurs less than 100 m above the mineralised veins and partly follows the boundary between the metasediments and greenstones. The veins are mainly subparallel to the strike of the greenstone, although some branching occurs. The main veins have a strike length of up to 350 m and are commonly 1-3 m thick, although local thickness up to 8-10 m do occur. Within the veins the sulphide minerals chalcopyrite and pyrite are found as clusters and disseminations, and hematite and magnetite are occasionally present. The gangue minerals are mainly calcite and quartz, with minor amounts of ankerite, chlorite and actinolite (Mørk 1970).

The reason for abandoning the Kåfjord Mine was the steady decrease in grade and that the known ore reserves were very small (Lindahl, in Zwaan & Gautier 1980).

Mineralisations within the Kåfjord claims:

- Kåfjord
- Anna
- Lundstrøm
- Lundstrømvatnet
- Stampa
- Melsvik
- Holmvatnet
- Henning
- Kvenvik
- Simanes
- Sak`kubanja
- Gryteng

Mineralisations within the Raipas claims:

- Raipas
- Raipas I
- Raipas II
- Raipas III
- Raipas IV
- Raipas V
- Borras
- Raigorivatnet

A few comments on the Ore Database (NGU) assays: The manganese content is generally between 0.2-0.7 %. The Raipas and Borras deposits are known to carry significant amounts of barite, the assays show up to 0.17 % Ba in Borras, and up to 300-500 ppm in Lundstrøm and

Stompa. The mineralisations contain trace amounts of Zn (up to 0.1 % in Raipas and Holmvatnet), As (up to 0.2-0.3 % in Raipas and Anna) and Pb (up to 330 ppm in Anna).
Lundstrøm assay as high as 0.1 % Mo. Cobalt is enhanced in some of the deposits, e.g. Borras.
While the mineralisations in the western part of the window show scattered gold assays above 1 g/t, the mineralisations in the Storviknes Formation in the eastern part are low. Only the Simanes (volcex in the Kvenvik Formation) points out with 0.5-1 g/t. In Kåfjord (high in Co and Ni) one assay returned 0.8 g/t Au.
Silver content is often in the range 10-22 g/t (Gryteng, Anna, Raipas, Borras). Some mineralisations are slightly enhanced in uranium, 5-11 ppm U. U-enrichments are known to occur in some of the copper mineralisations in the Repparfjord-Komagfjord window (Krause 1980).

6. Stored historic drill cores

According to information from the NGU, Løkken storage, no drill cores from Alta-Kvænangen window are stored. This should be re-checked as `recent` holes from the NGU drilling at Raipas in 1977 and Middavarre in 1978, and Bleikvassli at Cedar, are expected to be stored.

7. Recommendations

In the Alta-Kvænangen window it is regarded potential for copper deposits analogue to Nussir (regarded viable), concerning grade (1.5 % Cu), thickness (2-3.5 m) and length (9 km), and Bidjovagge-type mineralisations are known to occur in the Bergmark anticline.

The dolomite horizon which hosts 6 km length mineralisation at Anna continues 20 km south-westwards, and in the area west of Fiskarfjellet it is repeated by a syncline and crops out at the hinge of an anticline, then as wide as 1500 m. I have explored (for the Ore Database, NGU) all the known mineralisations in the western part of the window, and deposits in the eastern, Alta part, but not in the central area west of Fiskarfjellet. It is not registered any mineralisations in this area (except Vilgesrassa, see below), but due to geological favourability - it almost looks like a replica of the Bergmark anticline, except that the latter belongs to the Kvenvik Formation and contains albite felsites (which might not be the case with Fiskarfjellet?); the Fiskarfjellet anticline is also faulted - this area should definitely be surveyed. It seems remote, but a drivable road actually extends quite far into Matthisdalen, to Ongajoksetra, from where it is 5-6 km into the Fiskarfjellet area.

It is known only one occurrence centrally in the Alta-Kvænangen window, Vilgesrassa, located 7 km NNW of the above mentioned Fiskarfjellet anticline and 4 km north of the very extensive dolomite layer running SW from Anna. Small Cu-mineralisations bound to peridotite and metabasalt of the Kvenvik Formation is reported to occur at Vilgesrassa (Hysingjord 1959). Assays have returned up to 6 g/t Au and 5 % Cu and could be worth looking at.

As well as a geological reconnaissance along the Anna-Holmvatnet horizon should be conducted, with the purpose of collecting average samples over the dolomite layers, the

Melsvik mineralisation at the eastern flank of the anticline should be investigated. Channel sampling will probably require some excavation.

A reconnaissance survey should be conducted in the Raipas area, focused at the extensive (but thin and weak?) stratabound mineralisations, also having in mind the deep-seated IP-anomaly in the south (Eidsvig 1979).

8. Results of first stage field work 2011

Focus was to explore dolomite beds of the Storviknes and Luovusvarri formations for copper mineralisations, which led to interesting discoveries in both formations. A few additional sulphide occurrences were found in the Kvenvik Formation, associated with both albite felsite and dolomite.
91 rock samples (appendix 1) were collected in the Alta region and analysed at ALS Laboratory in Piteå.
For assaying, ALS multi-element (33) ME-ICP61, trace level, four acid digestion method using ICP-AES was applied to all samples. 39 samples were assayed for Au by fire assay and ICP-AES, 30 g nominal sample weight, method Au-AA25. 52 samples were assayed for Au, Pt and Pd by fire assay and ICP-AES finish, 30 g nominal sample weight, method PGM-ICP23. Assay results are given in appendix 2.

8.1 Fiskarfjellet (map sheet 1834 IV Flintfjellet)

This area was objected to a reconnaissance due to geological favourability and potential copper mineralisation hosted in dolomite. The interior of the Alta – Kvænangen basement window, between the copper provinces in Alta and Kvænangen, do not (for some reason) contain any known mineralisations (except Vilgesrassa, see 8.9).

The dolomite layers, belonging to the Storviknes Formation, which host 7.5 km length of copper mineralisation between Holmvatnet and Anna (see 8.2) continues 20 km south-westwards from Anna through Kvartpååttevannet (see 8.3), and in the area west of Fiskarfjellet the Storviknes Formation is repeated by a syncline and crops out in an anticline, then as wide as up to 1500 m with siltstone, limestone, dolomite and argillite (not differentiated by Gautier et al. 1986).

The second part of the mission was to check a NGU stream sediment Cu-anomaly (510 ppm Cu) (Staw 1981) south of Fiskartind.

Access: Through Matthisdalen it is drivable road all the way to Ongajoksetra (where accommodation can be hired). From here it is a two hour walk along the Sami`s ATV track to the southern end of Fiskarvatnet. The ATV track extends further north through the area

8.1.1 Results

At the geological map sheet Flintfjellet (Gautier et al. 1986) the lithologies within the up to 1500 m wide crescent surrounding Fiskartind, designated `limestone and dolomite with siltstone layers` of the Storviknes Formation, are not differentiated.

The dominating carbonate within the formation is a fine-grained, pinkish-grey limestone or marble, often with repeated intercalations (banding in few-cm scale) of argillitic layers (fig. 3). Grey siltstone and dark grey argillite also occur in thicker units. Dolomite appears as kilometre-long and few-metre thick layers (fig. 4) at various levels, and is probably repeated by folding.

Successful exploration in the Fiskarfjellet area this summer led to discovery of stratabound copper mineralisations hosted in extensive dolomite horizons of the Storviknes Formation. 32 rock samples, including 4 from the Fiskartind Fault, have been collected for chemical analysis, and mapping of the various dolomite layers have been carried out in scale 1:25 000 (fig.5 and 6).

Even if no historical reports points to copper mineralisation in the area it is a fact that the early prospectors* have noticed it, proven by a small digging (1 m3 dump) north of Rundvatnet. They probably dismissed it as too low-grade, as no appropriate ore processing technique existed, and it was forgotten.

Fig.3 Intermixed limestone and argillite, south of Rundvatnet.

* Among others, the Lindeberg family was eager prospectors and miners in Kåfjord and Kvænangen in the 1800th. In 1898 Jafet Lindeberg was one of three Scandinavians to find and claim the rich gold deposits in Nome, Alaska (and he was the co-founder of the city), which initiated the legendary gold rush (Andersen 2011).

Fig.4 Two dolomite layers (light-coloured) north of Rundvatnet. Looking north.

As a large percentage of the bedrock in the Fiskarfjellet area is covered, it prevails confusion about the connection between the various dolomite horizons, and concerning the structural geology in general – no doubt that some of the horizons represent refolded counterparts, which a geophysical survey (e.g. IP) could be an aid in solving.

So far another important aspect is enigmatic, the thickness of mineralisation. Even if the copper mineralisation is laterally very extensive, and seems to follow more or less continuously along dolomite horizons over several kilometres, it is obvious that not all of the dolomite thickness (which in places can exceed 10 m) is mineralised. In well exposed areas mineralisation of good quality (estimated 1-2 % Cu) can be observed to be in the range up to 60-70 cm thick – distal, weaker disseminations not included. The Sæterfjellet mineralisations are thicker.

A general impression is that the copper mineralisations, at least the richer parts, are restricted to the dolomite contacts, often along the footwall, and usually hosted in massive dolomite. The typical host dolomite is almost white to light grey or yellowish, massive dolomite with creamy to yellow weathering surface, more seldom brown. Reddish (hematite-bearing) and dark grey dolomite (possibly increased level of organic material) (A characteristic feature in redbed copper deposits is deposition of copper from ascending fluids in a transitional zone between oxidised and reduced rocks.), silt-laminated and stromatolitic dolomites, and dolomite breccia are not favourable hosts. Chert-laminated dolomite is mineralised at Sæterfjellet. Occasionally the dolomite is quartz veined.

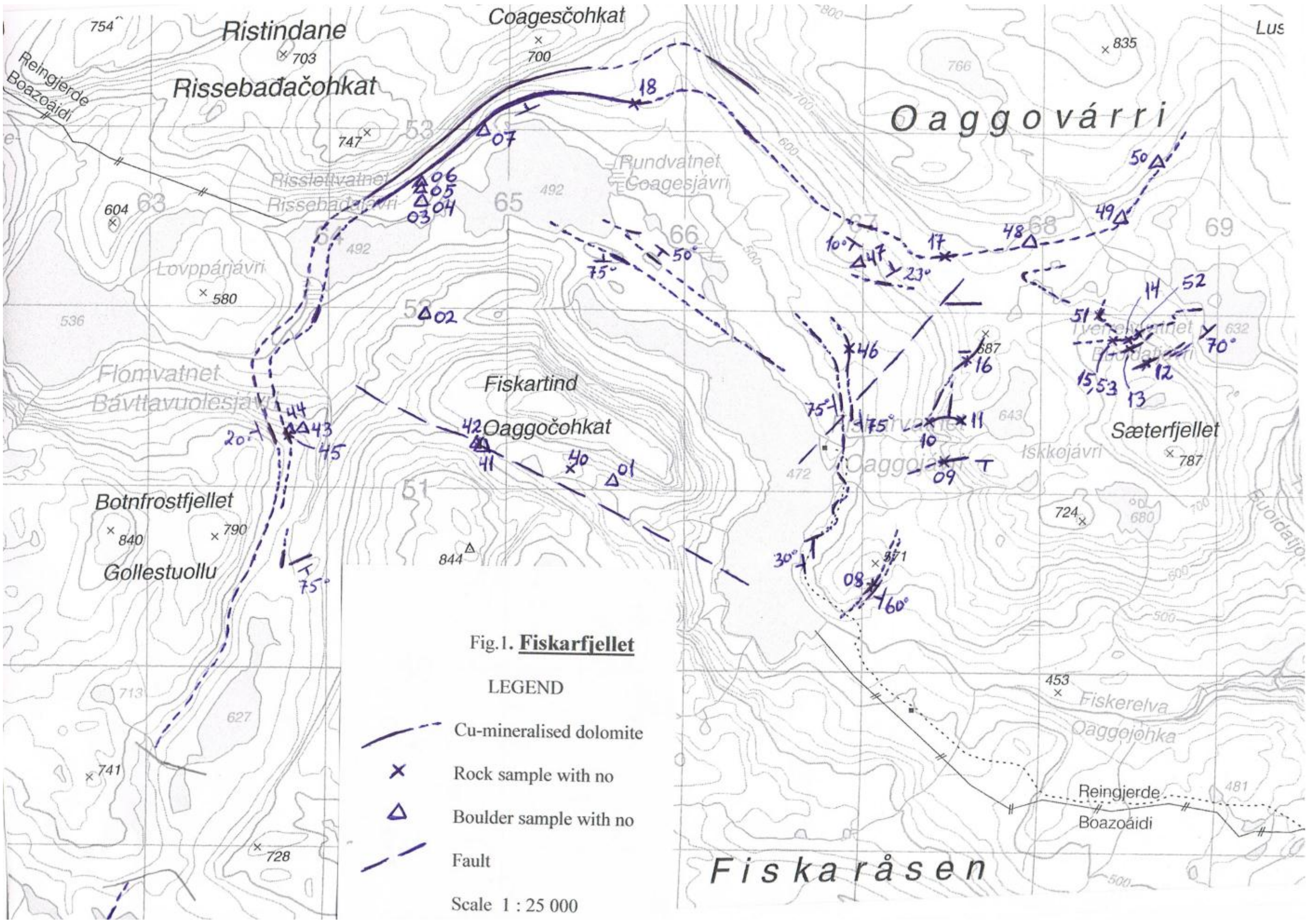

Fig.5 Copper mineralised dolomite beds at Fiskarfjellet. 1 km distance between UTM grid lines. The dolomite in the SW`ern corner is abrupted by a corridor of cover rocks.

Field observations suggest a link between development of structures and ore formation. Parts of the Fiskarfjellet mineralisations resemble the mineralisations in the Storviknes Formation west of Kåfjord (8.2) as well as Kvartpååttevannet (8.3), where copper deposition evidently has occurred along tectonic structures, supporting a late-stage epigenetic mode of sulphide emplacement. This feature is probably only a late event of redistribution of earlier-formed sulphides in a multistage stratabound mineralisation, where multiple fluid events ranging from initial diagenetic to late-stage epigenetic (syn- or post-orogenic) have occurred. Secondary enrichment in the form of remobilisation is important in the ore-forming process, demonstrated e.g. at Sæterfjellet, with high copper grades bound to hinge zones in the folded dolomite. The latter mechanism is also observed more locally, not restricted to hinge zones in macro-folds, but also in internal, rather chaotically folded dolomite, due to its plastic nature.

The copper mineralised dolomites in the Fiskarfjellet area occur within an approximately 5 x 5 km² sized area. This is divided in three subareas in the detailed description below: 1) two extensive dolomite beds north of Rundvatnet, 2) Sæterfjellet, and 3) east of Fiskarvatnet.
The two former seem to be more prospective than the latter.
1) The dolomites north of Rundvatnet can be traced in outcrops and boulders over 10 km strike length, from Flintdalen to Fiskarfjellet (Oaggovarri), and they are up to 10 m thick. At least 6.5 km of these are copper mineralised, if the boulder indication south of Fiskarfjellet is included, with the majority of assays between 0.9-1.9 % Cu and up to 12.9 g/t Ag (fig. 7).

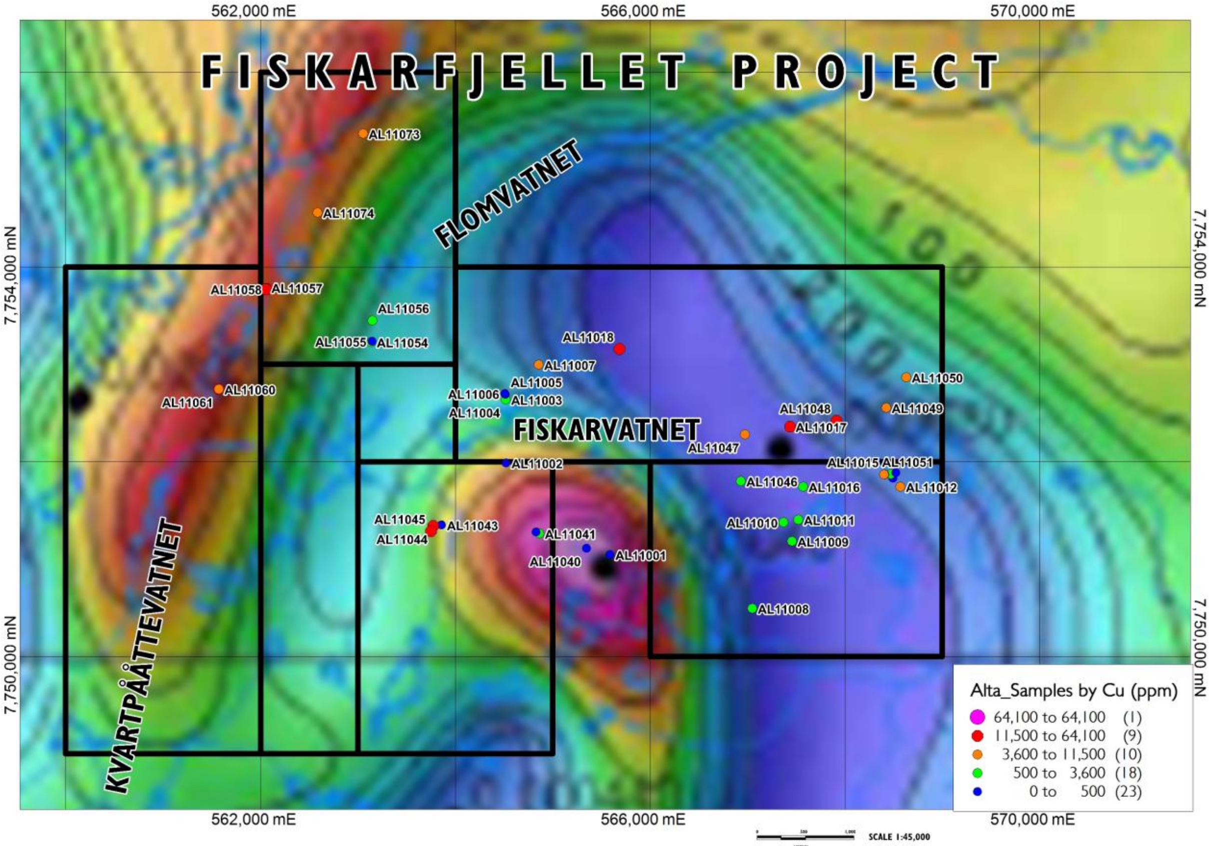

Fig. 6 Rock sample locations and airborne mag image.

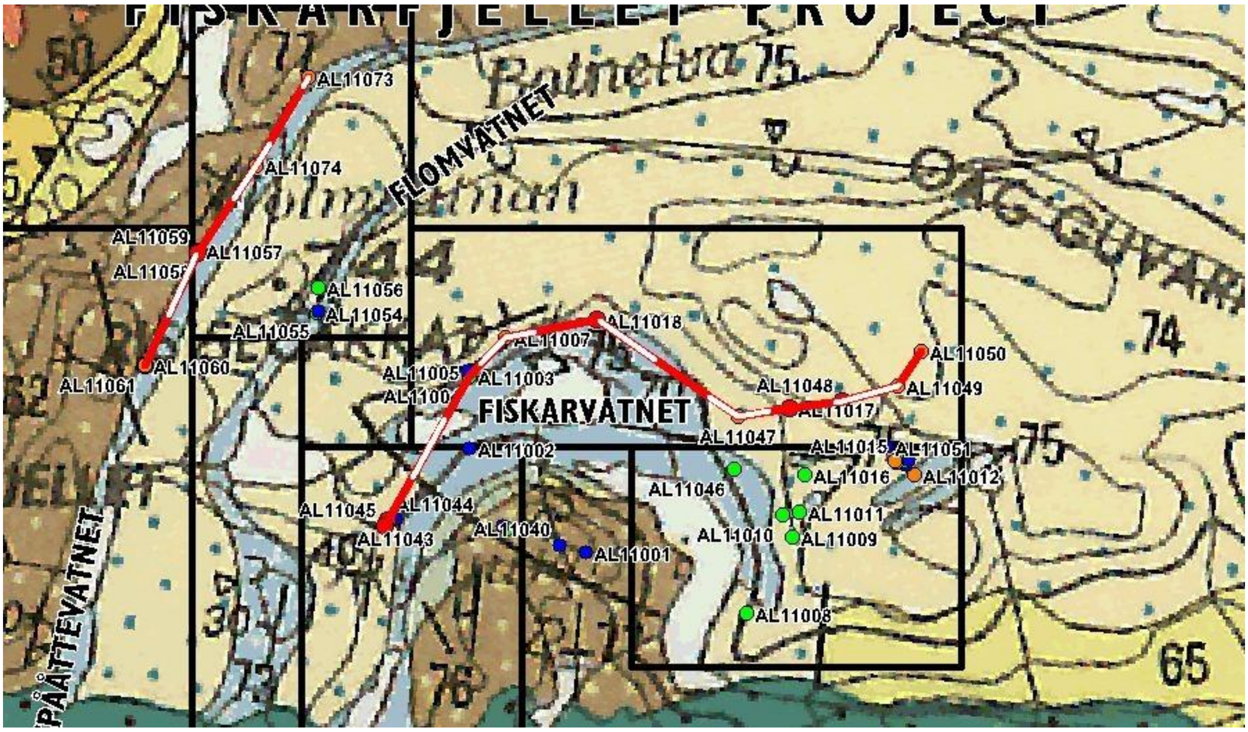

Fig. 7 Outline (red/white line) of the mineralised dolomite north of Rundvatnet. Numbers on the geological map (Zwaan 1988): 65-Bossekop Gr; 73-Luovusvarri Fm; 74-Skoaddovarri Fm; 75 and 76-Storviknes Fm; 77-Kvenvik Fm.

2) At Sæterfjellet bedrock is poorly exposed due to boulder fields. The dolomite is fairly resistant to erosion compared to the siltstone and crops out a few places. At Sæterfjellet 5 subcropping and outcropping dolomite beds within 200 m width can be traced over less than 1 km strike length. In addition, two folded dolomite beds occur in the valley between Sæterfjellet and Oaggovarri. Grab samples from the Sæterfjellet mineralisations assayed up to 1.89 % Cu and 11.3 g/t Ag.
3) The outcropping parts of the dolomites in the rather covered lowlands east of Fiskarvatnet seem to be more low-grade, and the copper content is mainly in the range 0.1-0.2 %. The distal character of ore formation in these beds is reflected in dominance of chalcopyrite over other copper sulphides.

The macroscopically identified sulphide mineralogy includes chalcocite, bornite, chalcopyrite, and subordinate pyrite and arsenopyrite. Secondary malachite is not particularly well developed at weathered surface, hence it is not the evident guide to mineralisation as could be expected. Malachite coating is frequently better developed along lamellar bedding within the copper-bearing dolostone. The sulphides often have a banded appearance (fig. 8), or occur as discrete dissemination, or within irregular veins.

Fig. 8 Chalcocite-banded dolomite. Height of picture is 8 cm. UTM 568631 7752867.

Silver is an economic element in the mineralisations and shows good to moderate correlation with copper. The higher-grade samples (> 0.7 % Cu) contain between 2 and 13 g/t Ag.
Antimony is enhanced within the sulphidic beds, up to 313 ppm Sb.
Arsenic content is up to 0.47 % and zinc up to 681 ppm. These two demonstrate good inter-element correlation.
The barium content in the dolomite, probably bound in barite, is up to 0.61 %.

Manganese content is typically in the range 0.3-0.7 % and is probably bound in ankerite. Mangano-dolomites also carry manganese as lattice-bound in the dolomite. A secondary expression of the manganese content is frequently encountered in the Fiskarfjellet dolomites, as dendritic pyrolucite.

The stream sediment anomaly at Fiskartind is considered explained by the presence of the Fiskartind Fault, which has associated brecciation and carbonate-quartz-sulphide alteration, but the copper content in rock samples is as low as below 0.1 %.

Detailed description of outcrops and sample locations, subdivided in three areas:

1) The extensive, parallel dolomite beds north of Rundvatnet:
The above mentioned digging (blasted out 1 m3) is located at the hinge of the open Fiskartind antiform, at 565684 7753158, in the lower of two extensive dolomite layers. The wide dolomite is banded and folded, with chalcocite and minor chalcopyrite and malachite (AL11018, 1.2 % Cu and 4.3 g/t Ag).
Eastwards it is covered until 566273 7753041, where the dolomite is at least 5 m thick (partly covered).
Frequent dolomite boulders SE-wards to 566866 7752440.
567028 7752491: Subcropping dolomite. Direction 100°.
567439 7752360: Subcropping dolomite with chalcocite(-malachite) dissemination (AL11017, 1.15 % Cu and 6 g/t Ag). Direction 80°.
This dolomite is not exposed further east, but the boulder field along the south slope of Oaggovarri contains many dolomite boulders indicating an extension of at least 1.5 km to the ENE. Samples collected from these boulders:
567915 7752423: Dolomite rich in chalcocite, bornite, chalcopyrite and malachite (AL11048, 1.38 % Cu and 12.9 g/t Ag)
568424 7752555: AL11049 from a 0.6x0.6x0.6 m³ boulder of dolomite rich in chalcocite-bornite(-chalcopyrite-malachite)-dissemination and –veins (0.90 % Cu, 2.8 g/t Ag).
568631 7752867: Chalcocite bound to mm-thin parallel bands in dolomite (fig. 8, AL11050, 0.89 % Cu and 4.7 g/t Ag). Malachite. Also dolomite boulders further NE, and scattered southwards towards the small lake.

A more southern dolomite is subcropping between 567573 7752053 and 567461 7752062, with chalcocite, bornite, chalcopyrite and pyrite (+ malachite and Mn-dendrites) concentrated along lamellae.
This bed is probably continuous with 567108 7752179 where it is exposed an at least 4 m thick dolomite over 10 m length, 280° direction. Hanging-wall argillite strikes 240°/23°.
566972 7752280: Many dolomite boulders along an apparent glacial lake beach line. AL11047 (0.84 % Cu, 7.2 g/t Ag) is sampled from a 0.5 m³ boulder of dolomite rich in chalcosite, bornite, chalcopyrite and malachite as dissemination and in veins/bands (fig. 9).
566928 7752410: Strike/dip of argillite 123°/10°.

Westwards from the digging the two dolomite layers crop out in the cliff along the south slope of Ristindane (fig. 4). The lower dolomite bed is 8-9 m thick. The upper dolomite seems to be 3-4 m thick and crops out approximately 20 m above the lower. This cliff exposure is not yet examined. The scree material below, consisting of both dolomite and argillite boulders, was the first encounter of copper mineralisation and 5 low-grade samples were collected from the boulders:

564855 7752998: 0.5 m³ boulder of thin-banded impure dolomite with dissemination-bands of chalcocite and malachite (AAL11007, 0.41 % Cu).

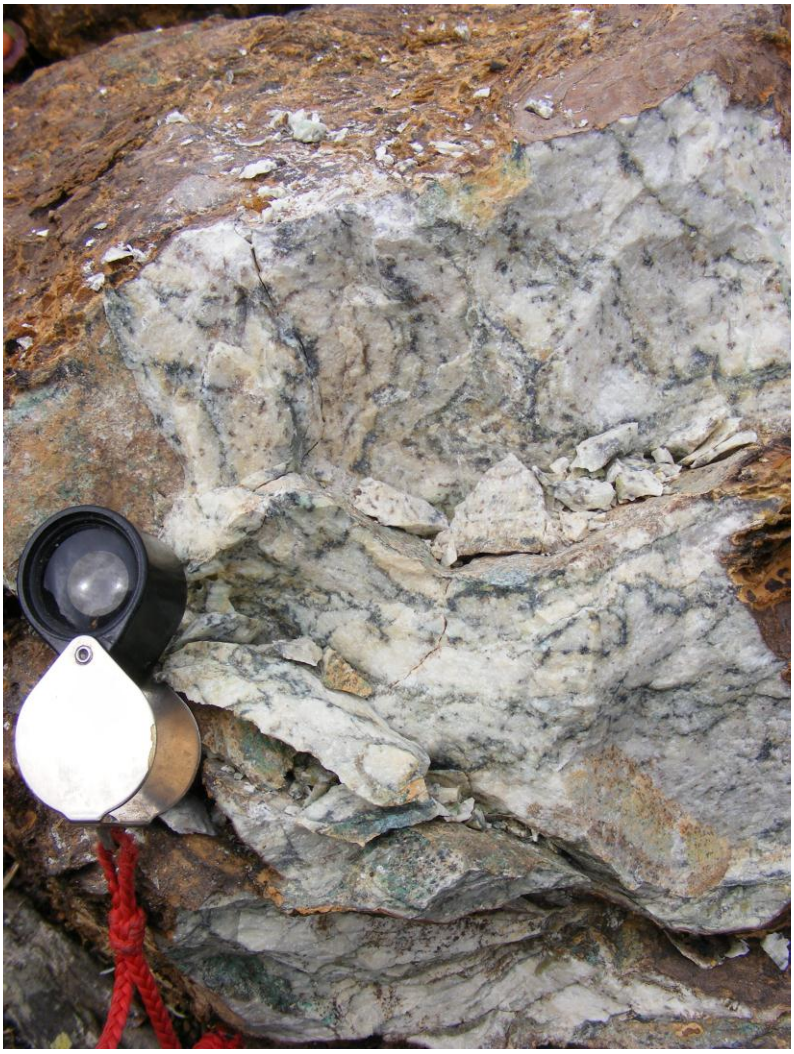

Fig. 9 Boulder of copper mineralised dolomite. UTM 566972 7752280.

564510 7752698: 0.5 m³ boulder of dolomite with disseminated chalcocite, chalcopyrite, pyrite, native copper and malachite (AL11006, 124 ppm Cu). The majority of boulders show banded, folded dolomite with silt layers, and some show dolomite breccia. Fig. 10 shows dolomite breccia with fragments of pink chert and dolomite.
564513 7752693: 50 kg scree boulder of dolomite with chalcopyrite dissemination (AL11005, 39 ppm Cu).
564518 7752640: 6 m³ sized boulder derived from one of the two dolomite layers in the cliff above, of fine-grained, banded (colour banding) in few-cm scale, dolomite with unknown opaque mineral dissemination (AL11003, 5 ppm Cu). Dolomite boulders show abundant quartz veining in up to 10 cm thick veins, and also some jasper layers. From same location, small boulder of irregularly mixed pink and green marble with chalcopyrite-chalcocite(?) dissemination (AL11004, 567 ppm Cu).

South of Risslettvatnet, at 563935 7751948, is subcropping a wide dolomite zone, probably the lower bed from the cliff. Dominating white weathering surface, eastern part is brown.

563856 7751351: Many quartz veined dolomite boulders, partly covered by snow. Some are weakly chalcopyrite-chalcocite-disseminated (AL11043, 42 ppm Cu).

Fig 10 Dolomite breccia boulder. Dolomite layers have absorbed stress due to competence contrast and are reworked. Fragments are broken up layers of microcrystalline quartz (chert) and dolomite. UTM 564510 7752698.

From 563775 7751339 and 100 m westwards: Many dolomite (and argillite) boulders. Some of them show rich chalcopyrite-chalcocite mineralisation and malachite (AL11044, 1.94 % Cu).
563673 7751335: Outcrop of ca 2 m thick dolomite with weak chalcopyrite-chalcocite-dissemination. Upper 1 m is laminated, with silt layers. Lower 1 m is more massive, with quartz veining. Green siltstone above and below. Strikes 155°/20°.
50 m SE-wards the dolomite thickness has increased to at least 3 m. Small dolomite exposures continue to 563706 7751274.
563749 7751285 is the northernmost outcrop in this area of the lower dolomite layer. It is approximately 7 m thick(?) and not well exposed. Estimated ca 10 m thick green siltstone between the two dolomite layers. The lower 60 cm of the lower dolomite bed is massive dolomite rich in chalcopyrite-chalcocite-dissemination and –veins, and malachite (AL11045, 1.61 % Cu). This dolomite layer can be followed just a few meters to the south, then it is buried. Boulders further south show dolomite breccia with up to 30x15 cm^2 sized rounded and edged dolomite fragments, plus chert- and jasper fragments.

The east slope of Botnfrostfjellet is covered by boulder field. Scattered dolomite boulders occur southwards, and indicate that the two dolomite layers extends at least 1 km southwards from the outcrop.

However, it is possible that a 30x20 m² subcropping dolomite at 563757 7750572 is part of the lower dolomite layer, here estimated to be ca 18 m thick: lower 6 m is red dolomite breccia with pink surface, mid 6 m has yellow weathering surface and frequent quartz veining, and the upper 6 m has white surface and quartz veining. N-S strike, dipping steeply to the west. Only traces of chalcopyrite observed.
From 563906 7750618 and 70 m towards the previous subcrop, a reddish-pink dolomite with traces of chalcopyrite is partly exposed. Along its southern contact is outcropping fine-grained, schisty, pink limestone – the one which is occupying a thick unit northwards. Here it strikes 60°/75°, while the adjacent dolomite has N-S banding with westerly dip. Their tectonic contact is not exposed.

Further south the extensive Fiskarfjellet dolomite was discovered in the Flintdalen valley, at 562819 7748588, continuing on the southern side of the 619-lake. Erosion through the Vendian cover sediments in the valley exposes a window of the Raipas Group, not earlier mapped by Gautier et al. (1986).

The copper mineralised dolomite layers outcropping north of Rundvatnet are traced over a total length of 10 km, from Flintdalen to the south slope of Fiskarfjellet.

2) Sæterfjellet:
This area is dominated by boulder field with subcrops and a few outcrops.
568569 7751745: Outcrop of dolomite with thin bands and dissemination of chalcocite, bornite, chalcopyrite and malachite (AL11012, 0.5 % Cu). Outcrop and subcrop shows 2.5-3 m thickness with direction 60°. This dolomite continues ENE-wards towards Tverrelvvatnet and is exposed at 568746 7751806. Strikes 35°/70° and is at least 3 m thick.
Parallel dolomite at 568752 7751771, at least 5 m thick, 50°/70°, wall-rock grey siltstone.
Yet another parallel dolomite 15 m to the south, > 2 m thick, few metres below the contact to Skoadduvarri Formation sandstone.
568470 7751874: Subcrop and small outcrops of a more northerly dolomite with bands and disseminations of chalcocite, bornite and chalcopyrite (AL11014, 885 ppm Cu). This layer extends westwards to 568405 7751867, where it is relatively rich mineralisation of chalcocite, bornite, chalcopyrite, native copper and malachite in thin (up to 1 mm) bands in the dolomite (fig. 11, AL11015, 0.70 % Cu and AL11053, 0.72 % Cu). This layer is abrupted few meters to the west, probably due to folding. It extends eastwards towards Tverrelvvatnet as a folded layer. At 568522 7751887 this folded dolomite is rich in chalcocite, bornite and chalcopyrite, + malachite (AL11052, 1.89 % Cu and 11.3 g/t Ag).
Between the two above mentioned layers is outcropping a possible fold hinge of a third dolomite layer with chalcocite, bornite and chalcopyrite (AL11013, 330 ppm Cu) at 568493 7751832.

568326 7752004: Limited area with exposures of folded dolomite. 70 cm thickness of the dolomite is relatively rich mineralised, with dissemination, veins and bands of chalcocite, bornite, chalcopyrite, malachite and azurite/chrysocolla (AL11051, 1.48 % Cu and 6.3 g/t Ag). It probably represents a fold hinge, with limbs to the north and east (indicated by dolomite boulders). Strike/dip just north of the dolomite hinge is 77°/75° and to the SW 210°/75°. Frequent dolomite boulders also SE-wards in the boulder field also indicate extension towards the above described Sæterfjellet mineralised dolomite layers.

In the valley bottom between Sæterfjellet and Fiskarfjellet (Oaggovarri), at 567897 7752231: Outcropping fold hinge(?) of at least 4.5 m thick dolomite with Cu-mineralisation. The layer probably bends off and extends to 567988 7752258, where it is large, local boulders/subcrop of dolomite. Indicated by boulders/subcrops, the other dolomite limb bends off 30 m south of the outcrop and runs SE-wards to a 60x30 m2 sized dolomite boulder field.

Fig. 11 Copper mineralised dolomite. Sample is 7x7 cm². UTM 568405 7751867.

3) East of Fiskarvatnet:
SE of Rundvatnet, 565806 7752315: 20 m long, at least 6 m thick NW-SE running outcrop of mainly darker, red dolomite with subordinate white layers. Strikes 127°/50°. Copper mineralisation not observed. Probably continuation to 565685 7752425, where it is small outcrops of densely quartz veined dolomite with traces of pyrite and chalcopyrite, but here the dolomite seems to branch off to 565728 7752414 (subcrops of yellow dolomite with weak Cu-dissemination).
Small dolomite outcrop at 565639 7752443.
Another parallel dolomite horizon to the south, 565674 7752278: Small outcrop of white dolomite with yellow surface and traces of Cu mineralisation.
Outcrop of argillite-banded limestone (267°/75°) from 565677 7752256 to 565581 7752288, which contains at least two horizons of dolomite breccia, one of them more than 3 m thick. Boulders indicate NW-ward extension into the lake.
Possibly continuous SE-wards to 566432 7751735 where dolomite is subcropping 5 m from Fiskarvatnet.

566928 7751462: Outcrop of 30 m long and at least 6 m thick dolomite, cut by a NE-SW fault.
(20 m to the SSE is two beds of white to red chert/jasper with 2 m interlayer of siltstone. Strike/dip of schistosity in siltstone to the east varies between 135°/35° and 170°/75°.)

This dolomite can be followed in scattered outcrops between 566922 7751681 and 566928 7751834 (possibly to 566888 7751894, but this seems to be a large (10 m^3) boulder). Mineralisation is bound to a thin(?) zone along the footwall where the dolomite carries thin veining of chalcopyrite, chalcocite and malachite (AL11046 from 566931 7751801, 856 ppm Cu) and quartz veins with sporadic sulphides.

A parallel dolomite layer to the west:
Dolomite (red-brown and massive) at 566714 7751837 to 566713 7751882, possibly continuous to 566840 7751721.
566878 7751498: Dolomite exposed over 30 m length. > 5 m thick. Direction 343°. Probably continuous to 566893 7751241 where dolomite subcrops in the creek. Outcrop 30 m to the north.
566918 7751079: Subcropping dolomite.
Outcropping dolomite, at least 6 m thick at 566717 7750741. Direction 235° towards the lake.
566718 7751699: Outcrop of dolomite, dipping westwards.

567049 7750492: Two dolomite layers: Upper is 5-6 m thick with 1 m thick intercalated siltstone. Hanging-wall is dark grey siltstone. Lower dolomite is c. 5 m thick and its upper contact is tectonic. The dolomite layers are separated by 6 m thick siltstone. AL11008 (0.14 % Cu) is sampled from banded and folded dolomite with chalcopyrite-chalcocite(?)-pyrite dissemination. A third dolomite layer crops out at a level 10-12 m below. It is 1 m thick and strikes 200°/60°. The outcrop can be followed 25 m to the NNE.
Axial plane cleavage indicates that this dolomite layer(s) occupies the east limb of an overturned anticline, while the above mentioned dolomite along the east shore of Fiskarvatnet is the same along the west limb.

The next outcrop northwards in the otherwise covered terrain is at 567456 7751184: 5 m thick folded dolomite with steep contacts that seem to be faults – the plastic dolomite is moulded into a fault zone which strikes 85° and dips steeply to the south. The dolomite contains chalcocite-chalcopyrite dissemination (AL11009, 775 ppm Cu) and extends a few meters eastwards before it is covered. A dolomite outcrop at 567318 7751094 is probably a western continuation.

567371 7751379: 20 m long outcrop, direction 50°, of dolomite with chalcocite and chalcopyrite (AL11010, 0.13 % Cu).
567521 7751404: Outcrop of relatively flatlying (hence wide: approx 20 m), folded dolomite containing chalcocite, chalcopyrite and malachite (AL11011, 0.21 % Cu). It is probably continuous with the above mentioned.
567497 7751550: Outcropping few meter thick dolomite that extends southwards (190°) towards the above mentioned dolomite. Possibly it continues northwards below cover to 567515 7751681, from where the dolomite is exposed and subcrops towards NE. It is 10-12 m wide and internally folded. The layer seems to be incontinuos (folded?) but shows up again in a wide zone at 567570 7751743 within psammites and argillites. It is again mineralised with chalcocite and chalcopyrite (AL11016, 948 ppm Cu). It is more or less continuous to 567647 7751839.
567540 7751787: Outcropping dolomite.
From 567407 7751490 and 70 m NNE-wards: Outcropping dolomite.

4) The Fiskartind Fault:
4 rock samples were collected in the WNW-ESE directed valley south of Fiskartind aiming at explaining NGU`s stream sediment anomaly (510 ppm Cu) (Staw 1981).
The southern mountain side of Fiskartind consists of rusty, fine-grained, banded greenstone with weak magnetite-pyrite dissemination. Some of the scree boulders show greenstone with up to 20 cm thick carbonaceous, tectonic zones, often expressed as drag folds, with traces of chalcopyrite and pyrite (AL11001, 66 ppm Cu).
At 565347 7751112 is outcrop of fine-grained, banded, rusty greenstone with light weathering surface and weak pyrrhotite-chalcopyrite-dissemination, enriched along < 1 mm thin bands (AL11040, 175 ppm Cu).
Boulders along the fault show brecciation of the greenstone and carbonate-quartz-sulphide alteration, both pervasive and vein-bound:
564863 7751263: Boulders of brecciated greenstone with carbonate-pyrrhotite-chalcopyrite veins (AL11041, 891 ppm Cu).
564828 7751277: Frequent boulders of fine-grained, brecciated, pervasively carbonate-quartz altered greenstone with weak chalcopyrite-dissemination (AL11042, 185 ppm Cu).

8.1.2 Recommendations

Follow-up work should include a geophysical survey. IP will trace the disseminated sulphides within the dolomites, and mag could possibly prove useful in mapping the boundary between the Storviknes Formation siltstone and the Skoadduvarri Formation sandstone, especially in the eastern part of the area, which is assumed to be more structurally complex and covered by boulder field. Based on the geophysical anomaly map, additional geological detail mapping should be conducted, especially the well-exposed cliff north of Rundvatnet should be studied and channel samples transecting mineralisation collected. Hopefully this work will encourage a more appropriate sampling method as core drilling. A light-weight, portable drilling machine can provide first stage shallow level intersections of the mineralised dolomites, including potentially mineralised wall-rocks.

8.2 Anna – Holmvatnet (map sheet 1834 I Alta)

As the author has previously studied and described the Anna, Lundstrøm, Stampa and Holmvatnet mineralisations (the Ore Data Base, NGU), this investigation focused at some additional outcrops around the Anna workings and to track the dolomite extensions further SW-wards from Anna. This added 1.5 km strike length of copper mineralised dolomite SW of Anna to the previously known 6 km.
The best way to access the copper occurrences is by foot along a cart track from Kåfjord towards the old Northern Light Observatory at Haldi (Sukkertoppen). The walk up to Anna takes about one and a half hour.

8.2.1 Results

The copper mineralisation NW of Kåfjord, between Anna and Holmvatnet prospects (fig. 12), is stratabound and more or less continuously mineralised over a strike length of 7.5 km, along the west flank of a large synclinal structure. Vein network of bornite-digenite-chalcopyrite (with minor and accessoric other sulphide minerals) mineralisation is hosted in 4 adjacent

Fig. 12 Location of the copper occurrences west of Kåfjord.

dolomite layers, each of 2-5 m (locally 12 m) thickness, in silt- and mudstone (occasionally sulphide veining is observed in the siltstone adjacent to the dolomite). Mineralisation is assumed to be diagenetic, with sulphide replacement of dolomite along a tectonic zone parallel to strike. Fine-grained dolomite is replaced by coarse-grained quartz, calcite, dolomite, barite and sulphides. Another type of mineralisation occurs at Lundstrøm. That is deformed, few-cm thick quartz-carbonate veins with bornite and digenite hosted in the siltstone, subparallel to schistosity.

The dolomite hosted copper mineralisations are stratabound, with an epigenetic signature. It is evident from several localities that mineralisation of any significance is concentrated along tectonic contact zones between dolomite and siltstone, then as narrow zones, generally 20-40 cm thick. Fig 13, from one of the Anna diggings, demonstrates this; with a discordance between dolomite lamination and siltstone schistosity. Copper mineralisation occurs in the dolomite adjacent to this tectonic zone.

Where the cart track from Kåfjord crosscuts the dolomites at Anna: Within 40 m thickness occur from east to west 4 m thick dolomite, 3 m siltstone, 1 m dolomite, 28 m siltstone and 4 m dolomite with subvertical dip to the west.
Between Lundstrømvatnet and Annavatnet, at 575902 7762758, is the only outcrop of the westernmost dolomite layer, 10 m thick with intercalated few-cm thick argillite layers. Very weak copper mineralisation concentrated to some few-cm thick beds.
110 m to the east (576010 7762787): Eastern dolomite layer is 5 m thick, scarce mineralisation. A 20 cm thick dolomite bed some meters to the west. N-S strike/vertical.

575998 7762528: Approximately 5 m thick dolomite (incompletely exposed), middle layer. Within the dolomite, up to 40 cm thick concordant (vertical) hydrothermal quartz vein with weak copper mineralisation.
576049 7762385: Eastern dolomite (silt-banded in few-cm scale) is 4 m thick and extends into the Annavatnet in the south. Copper minerals as dissemination and in thin, irregular veins.

575842 7761905: Small working.
575834 7761759: 2x2 m² shallow digging in the 2.5 m thick middle dolomite bed. Mineralisation is bound to immediate footwall of the dolomite, which has a tectonic contact to the siltstone (fig. 13).
Separated by 4 m siltstone, the 4 m thick eastern dolomite outcrops. Again, the footwall contact is tectonic. The dolomite contains narrow quartz bands that are strongly folded/crumbled.

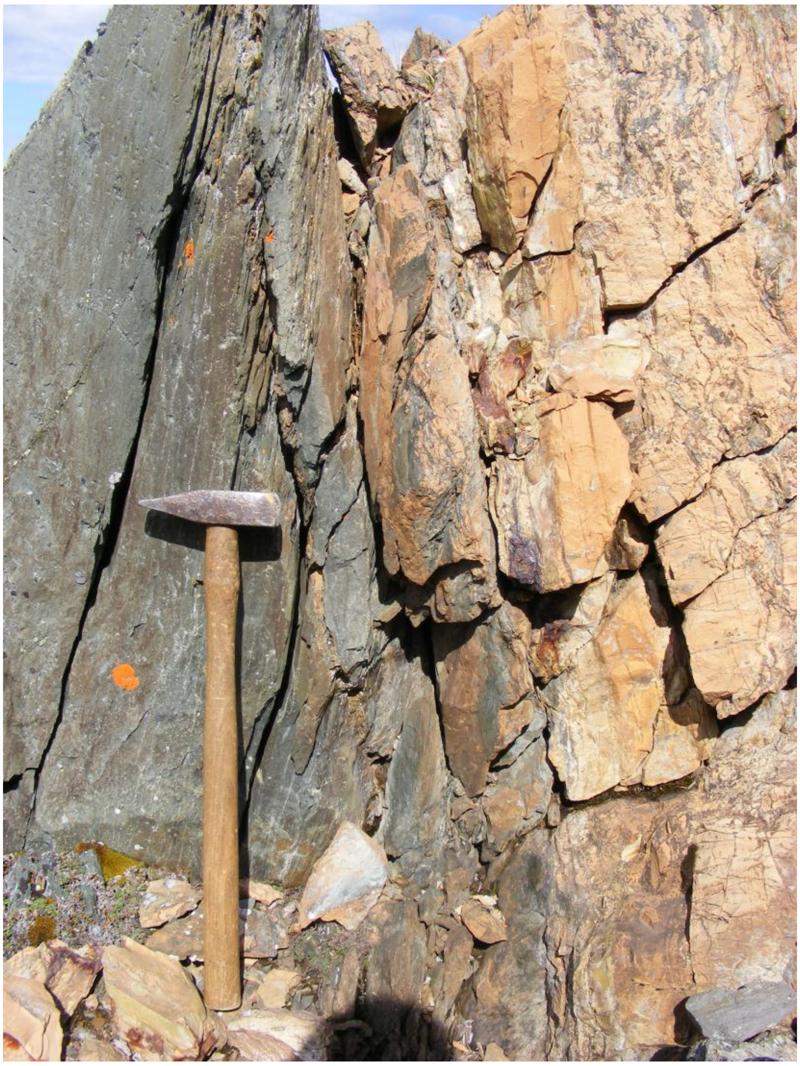

Fig. 13 Tectonic and copper mineralised contact between siltstone and dolomite at Anna digging. Looking north. UTM 575834 7761759.

SW of the Anna workings:
574899 7760580: 12 m thick dolomite. 225°/80-85°. Internal isoclinal folds plunging 205°/flat and 235°/75°. Quartz and silt lamellae. Crosscutting thin quartz veins. Chalcocite and subordinate chalcopyrite dissemination concentrated in 30-40 cm thick massive dolomite (elsewhere it is banded/lamellar) along hanging-wall (AL11019, 0.49 % Cu). It thins out SW-wards (boudinage).

574753 7760432: Small outcrop of a more SE-erly dolomite. Massive, with network of mm-thin quartz veins. Dendritic pyrolucite. Only traces of mineralisation.
Probably same dolomite at 574714 7760384, here 8 m thick: Chalcocite(-malachite) dissemination bound to a 30 cm thick massive-layer along the hanging-wall contact (AL11020, 0.67 % Cu). The rest of the dolomite is banded, and also minor dolomite breccia. Another dolomite bed can be seen higher up in the mountain side to the south.

The SW-ernmost outcrop of dolomite is at 574177 7759890. This is 5-6 m thick and carries weak chalcopyrite-chalcocite dissemination (AL11022, 485 ppm Cu), and consists of intermixed dolomite and siltstone in 10-50 cm scale.
In accordance with the geological map Alta (Zwaan & Gautier 1980), the dolomite wedges out here, and when this carbonate horizon shows up again at 570807 7758032 it consists of impure, barren limestone.

Outcropping in the cliff at 570820 7758270: 80 cm thick hydrothermal quartz zone in red siltstone consists of parallel veins and vein network of quartz. Dips towards NW. Vertical, extensional fractures cutting the veins are hematite-filled.
570803 7758178: Grab sample collected from hydrothermal quartz boulders in the scree (AL11021).

8.2.2 Recommendations

In spite of the significant strike extent, more or less continuous over 7.5 km, the narrow character of the mineralisations limits the potential. However, as the ore thicknesses are not established with confidence, trenching or shallow-level drill sampling should be considered.

8.3 Kvartpååttevannet (map sheet 1834 IV Flintfjellet)

This is the same dolomite horizon belonging to the Storviknes Formation which hosts copper mineralisation west of Kåfjord (8.2), and is outcropping over 25 km strike length along the west-flank of a synform.
The area is located rather remotely west of the Fiskarfjellet mineralisations (8.1) and by foot the best access is from Ongajoksetra in Matthisdalen.

8.3.1 Results

Rich chalcocite-chalcopyrite mineralised dolomite was detected at the SE shore of lake Kvartpååttevannet and followed 3 km NNE-wards (fig.7), from where the mineralisation weakens ENE-wards. South of Kvartpååttevannet has potential for 3 more kilometres length

of mineralisation. The Kvartpååttevannet dolomite bed is poorly exposed and mineralised width is unknown.
The present ore-bearing minerals and their distribution are attributed to late-stage epigenetic processes, probably remobilised from early- to late-diagenetic sulphide formation – a massive, copper mineralised dolomite is seen to discordantly cut through a folded, silt-laminated, schisty dolomite, suggesting injection of sulphide-bearing massive-dolomite remobilised from a precursor laminated dolomite.
As demonstrated in fig. 14, apart from impregnation, sulphides are also hosted in a network of small veinlets that suggest a significant role for deformation in the development of the mineralisation. The crosscutting texture of the veinlets suggests that mineralisation occurred after lithification of the original carbonate.

At the SE shore of Kvartpååttevannet, at 561570 7752745, it is a small outcrop of mineralised dolomite in a slope. Massive dolomite contains relatively rich network- and impregnation of chalcocite and chalcopyrite plus malachite (fig. 14, AL11060, 1.47 % Cu and 6.0 g/t Ag, and AL11061, 1.03 % Cu and 6.3 g/t Ag). It is not much more than a bedding surface (196°/70°) that is exposed, consequently thickness of mineralisation is unknown. Floats show that also the dark grey dolomite is mineralised here, it is rich in dusty cpy-diss.
Scattered yellow dolomite boulders continue southwards, at least to 561454 7752329, where a stromatolite boulder is located. To the west a wide zone of reddish limestone with chert layers is exposed.

Fig. 14 Vein network of chalcocite and chalcopyrite in dolomite. Picture height is 6 cm. UTM 561570 7752745.

North of Kvartpååttevannet subcrops of dolomite with vein-bound chalcocite and chalcopyrite plus malachite were found (fig. 15). Sample AL11058 (562070 7753775) assayed 2.09 % Cu, 7.6 g/t Ag, 0.13 % Zn and 0.48 g/t Au, and AL11059 (562051 7753768) assayed 1.61 % Cu, 7.4 g/t Ag, 0.10 % Zn and 0.15 g/t Au). They are enhanced in gold and zinc. Possibly mineralisation occurs along the footwall of the dolomite. Abundant large, barren dolomite boulders are located above.
562055 7753788: Boulders of ultramafic lava(?) with weak chalcopyrite dissemination (AL11057, 257 ppm Cu).

Fig. 15 Chalcocite-chalcopyrite-malachite mineralised dolomite. Picture width 6 cm. UTM 562051 7753768.

Further NNE-wards, between 562561 7754508 and 562661 7754715, parts of the dolomite are in places outcropping. At 562586 7754557 chalcocite-bornite-chalcopyrite-malachite mineralisation is bound to massive dolomite with brown weathering surface (AL11074, 0.71 % Cu and 3.4 g/t Ag). The mineralisation is possibly no more than 10 cm thick, the hanging-wall is not exposed. The mineralisation is evidently epigenetic, or at least remobilised – the massive, mineralised dolomite cuts through a folded, silt-laminated, schisty dolomite.

563055 7755368: Local boulder of dolomite with dissemination and veining of chalcopyrite, chalcocite and malachite (AL11073, 0.36 % Cu and 0.6 g/t Ag) which contains breccia fragments of dolomite and chert. The dolomite horizon runs few metres above but is not exposed.
563094 7755424: Here the outcropping dolomite is bent to N-S strike with easterly dip. Few metres to the south it turns to the SW with SE dip. Northwards it bends off and follows the river.
563320 7755594: Yellow-white dolomite outcropping at both sides of the river (if it is continuous it is at least 8 m thick). Dips to the north. Only weak chalcopyrite-pyrite-dissemination within the exposed part.
To the east, two dolomite horizons are outcropping in Botnelva.

564909 7755962: 30-40 m thick dolomite horizon, consisting of both grey dolomite with prominent banding (with incorporated large lenses of brown-surfaced dolomite), red-brown dolomite, yellow-white dolomite, and dolomite breccia (fragments of dolomite, argillite and chert). Foot-wall is 10 cm argillite and 1.5 m thick tectonised chert. Mineralisation not observed.
This dolomite horizon extends ENE-wards, towards the Anna-Holmvatnet mineralisations (8.2).

4 samples from the southern part assayed between 1.03-2.09 % Cu and 6.0-7.6 g/t Ag.
As content is up to 0.72 %, Zn up to 0.13 % and Sb up to 444 ppm. Two Au assays returned 0.48 g/t and 0.15 g/t respectively. The samples are lower in Ba and about the same in Mn compared to Fiskarfjellet.

8.3.2 Recommendations

This dolomite-hosted copper mineralisation is copper-rich, including by-product Ag, Au and Zn, but might have very limited thickness from what can be observed at the few outcrops. It is, however, not properly exposed – consequently significant dimensions can not be ruled out. The 3 km long southern extension of the dolomite, towards the nappe contact, should be explored. An IP survey and possibly trenching is recommended.

8.4 Flomvatnet (map sheet 1834 IV Flintfjellet)

Discoveries of copper mineralisation in the Storviknes Formation both at Fiskarfjellet and Kvartpååttevannet prompted exploration also along the dolomites of the Luovusvarri Formation. This formation is the youngest member, and forms the upper part of the Paleoproterozoic Raipas Group. It consists of dolomite intermixed with greywacke, siltstone and conglomerate, and occupies the core of an overturned (to the east) synform outcropping over 6 km length between the Storviknes dolomites at Fiskarfjellet and Kvartpååttevannet (fig. 7).

8.4.1 Results

This potentially copper-hosting lithology was explored by one profile north of Flomvatnet:

Among the abundant dolomite boulders in the scree south of the westernmost mountain of Ristindane, a few contain weak dissemination of finely dispersed chalcopyrite (AL11054, 0.13 % Cu and 2.0 g/t Ag).
The dolomite overlies siltstone/argillite with tectonic, discordant contact at 563211 7753409. The footwall schist strikes 205°/45°.
The Luovusvarri Formation synform is here approximately 60-70 m thick, and dominated by dolomite (subordinate dolomite breccia) with few-metre thick interlayers of argillic schist and quartzite. The hanging-wall contact is exposed at 563148 7753448. Copper mineralisation similar to the sampled boulder occurs within approximately 2 m dolomite thickness along the hanging-wall contact (AL11056, 0.16 % Cu and 1.7 g/t Ag). The mineralised dolostone contains minor clastic quartz grains. The hanging-wall consists of quartzite/greywacke, which is also weakly chalcopyrite-pyrite impregnated adjacent to the dolomite. Hydrothermal quartz veins intrude the quartzite but not the dolomite.

The overturned synform with dolomite and intercalated siltstone and quartzite widens out south of Flomvatnet (fig. 16).

Fig. 16 The east-vergent Flomvatnet syncline viewed southwards from Flomvatnet. Dolomite is brownish and intercalated siltstone and quartzite is light grey.

In September the 3 km long southern part, south of Flomvatnet was explored.
Dolomite layers intercalated with siltstone run along each fold limb. Observed copper mineralisation in outcrops are weak, while a few boulders show better grades.

At 562273 7750023 is exposed a 25 m thick succession of alternating dolomite and siltstone striking 196°/subvertical. The dolomite is massive, yellow-white and quartz-veined, with

subordinate thin layers of red dolomite. Weak chalcopyrite dissemination is concentrated along narrow bands (AL11088, 142 ppm Cu). Also outcropping 300 m to the SSW.
A more westerly dolomite with weak and scarce chalcopyrite-pyrite dissemination outcrops at 562222 7750101.

In a boulder field to the east, at 562491 7750115, a 150 kg boulder of rusty-yellow surfaced dolomite with chalcocite (+ malachite and dendritic pyrolucite) dissemination (AL11087, 0.23 % Cu and 2.5 g/t Ag) was found.

Northwards, a western limb dolomite with well developed stromatolites is exposed in the boulder field at 562432 7750402. The dolostone hosts weak chalcopyrite dissemination within a 40 cm thick dolomite-quartzite layer.
562464 7750655: Outcropping dolomite with weak, finely dispersed chalcopyrite dissemination. Also outcropping dolomite to the east and 50 m to the west.
562424 7750896: Exposed dolomite with pyrite-chalcopyrite dissemination (AL11089, 22 ppm Cu). Also dolomite further east.
From here the dolomite layers extends NNW-wards down to Flomvatnet and further.

The east flank dolomite-siltstone intercalations, with only traces of mineralisation, outcrop sporadically from Flomvatnet and SE-wards through 562646 7751103, 562956 7750859 and 563008 7750794. Boulders indicate its continuation SSW-wards to the 713-lake, towards the contact to the Vendian Borras Group.

It was detected that the dolomites extend 1 km further south than earlier mapped by Gautier et al. (1986). Erosion through the Vendian cover sediments in the Flintdalen valley exposes a window of the Raipas Group. Thereby the western limb of the Flomvatnet dolomite zone is outcropping at 561231 7749016, here more than 50 m thick (202°/65°). Scattered dolomite outcrops are found in the boulder field 150 m southwards (195°).
The eastern limb dolomite is also exposed in Flintdalen, at 561794 7748890, over 100 m length (outcrops and boulders), as an at least 30 m thick succession of dolomite and schisty siltstone layers (193°/36°). Weak chalcopyrite dissemination is found in thin bands.

The Luovusvarri Formation mineralisations (Flomvatnet and Luovusvarri) are significantly lower in grade, both copper and silver, than corresponding mineralisations in the Storviknes Formation. Chalcopyrite (often finely dispersed, with affinity to dolomite with clastic quartz) is the dominating sulphide, while the Storviknes mineralisations contain major amounts of chalcocite and bornite.

8.4.2 Recommendations

The next step would be an IP survey to reveal potential hidden mineralisations covered by the boulder fields, which is indicated by a few mineralised boulders, but as outcrops demonstrate very low grades, further work on this target has low priority.

8.5 Flintfjellet (map sheet 1834 IV Flintfjellet), located in Kvænangen, Troms County

The aim for reconnaissance in this area was to check potentially copper mineralised dolomites, which is intercalated with siltstone and greywacke within the Luovusvarri

Formation syncline between Nihkeluobbalat and Buvravzzegiera. Only the southern and eastern parts were investigated during the one day reconnaissance in this remote area, but nowhere sulphides were seen. However, boulders with high-grade Cu-Ag mineralisation were discovered to the east.
Accessible through a more than 20 km walk from Ongajoksetra through Flintdalen. Helicopter transport is appropriate for further work in this area.

8.5.1 Results

Barren dolomite is frequently exposed along the southern hinge, from 553873 7747082 and more than 1 km westwards, and at 553683 7747729 a N-S running dolomite is exposed and can be followed northwards in outcrop and boulders.

A more interesting discovery appeared at 554597 7747025. Within a large boulder field of Skoadduvarri Formation greywacke boulders, some large copper mineralised dolomite boulders occurred within a restricted area. AL11090 was sampled from a 1.5 m^3 sized dolomite boulder with bornite-chalcocite-hematite veining (2-3 cm thick veins) and significant amounts of malachite. Along one side of the boulder hematite-chert breccia was attached.
At 554583 7747036, adjacent to another large mineralised dolomite boulder, fist sized (up to 16x10x6 cm^3) massive bornite-chalcocite-hematite-malachite (AL11091) were found.
Assays returned exceptionally high copper and silver grades: > 40 % Cu and 435-484 g/t Ag, and anomalous Bi (106-133 ppm), Th (30 ppm) and W (20-30 ppm), while Ni (< 1 ppm) and P (40-50 ppm) are low.
The mineralised boulders are located in the vicinity of an extensive east-west fault. A possibility is vein-type Cu-Ag mineralisation associated to this structure.

900 m eastwards, at 555471 7747074, a 50 kg boulder of massive magnetite with disseminated pyrite were found in a boulder field.

The Cu-Ag mineralised boulders are possibly derived from vein type mineralisation as they resemble such occurrences located further to the west (Vik 1985), which are characterised by copper sulphides and magnetite/hematite within calcite-quartz-dolomite veins.
However, their chemistry is distinctly different. The high silver content is not reflected in the earlier known occurrences. They assay generally < 1 g/t, highest single assay is 8.8 g/t Ag from Edvards Gruve (the Ore Data Base, NGU). The Flintfjellet boulder samples are also distinctly higher in Bi, W and Th (although this is correlated to, and explained by the high copper contents), while they are lower in gold. The Kvænangen hydrothermal vein occurrences typically show gold contents in the range 0.2-0.8 g/t, highest single assays being 4.6 g/t Au from Kalkspatgangen and 1.8 g/t Au from Edvards Gruve.

8.5.2 Recommendations

The boulder finding should be followed-up and the source traced. The source is expected to be found very close to the mineralised boulders. While in this remote area, some Storviknes Formation dolomites to the SSW should be checked, as well as additional reconnaissance within the Luovusvarri Formation synform.

8.6 Luovusvarri (map sheet 1834 I Alta)

A reconnaissance was conducted at the Luovusvarri mountain which is underlain by alternating layers of dolomite, siltstone and quartzite belonging to the Luovusvarri Formation, the same formation that is mineralised at Flomvatnet. Dolomites of the Luovusvarri Formation tends to be distinctly weaker mineralised than dolomites belonging to the Storviknes Formation, but both at Luovusvarri and Flomvatnet adjacent siltstone and quartzite are copper mineralised. Opposed to the Storviknes mineralisations, Luovusvarri Formation mineralisations seem to have affinity to quartz-grained sections of the dolomites and chalcopyrite is the dominating copper sulphide.

The area can be accessed from either Matthisdalen or Botnelvdalen, 1-2 km walks.

8.6.1 Results

This is yet another discovery of copper mineralisation not previously reported. The grades are however low, 0.1-0.3 % Cu, and the mineralisations are thin.
The best mineralisations were found at Stokkstadfjellet where repeated dolomite layers of 0.5-1 m thickness and adjacent siltstone are mineralised:
575798 7755609: Approximately 0.5 m thick dolomite layer with quartz veining and chalcopyrite(-chalcocite)-dissemination (AL11084, 0.16 % Cu).
575812 7755584: Few metres below, a 0.5 m thick dolomite bed with chalcopyrite(-chalcocite)-dissemination (AL11085, 0.16 % Cu).
575825 7755568: Further below, a 1 m thick dolomite layer with green silt lamellae and quartz veins. Narrow chalcopyrite enrichment is bound to the contact of quartz-dolomite and schisty siltstone (AL11086, 0.37 % Cu).
575835 7755478: Further below, 1 m thick quartz veined dolomite with weak chalcopyrite-dissemination.
575807 7755441: 0.7 m thick dolomite with chalcopyrite-dissemination. Strikes 203°/30°.
These mineralised dolomite layers can be followed southwards.

576051 7756119: 1 m thick quartz-dolomite with chalcopyrite(-chalcocite)-dissemination (AL11083, 370 ppm Cu), in carbonaceous, schisty siltstone. Strikes 194°/30°.
576143 7756296: Two dolomite layers, 1 and 2 m thick respectively, separated by 2 m quartzite/siltstone. Minor chalcopyrite-dissemination in all 3 layers, and pyrite in the quartzite.

576189 7756694: Within dolomite, a 20 cm thick layer of white quartzite with finely dispersed chalcopyrite.
576137 7756729: Scree boulder of quartz-dolomite with finely dispersed chalcopyrite (AL11082, 0.21 % Cu).

Dolomite layers were not found within the upper levels of the formation, which is exposed at the NW top, but they show up again at the bottom of the NW slope, in Botnelvdalen (575686 7756562).

8.6.2 Recommendations

One more day of prospecting is needed to cover the east side of Stokkstadfjellet.

8.7 Melsvik (map sheets 1834 I Alta and 1835 II Talvik)

A short visit was paid to the Melsvik occurrence, which is located 2.5 km west of the main road (E6) and the Altafjord. It is currently claimed by REE Mining and TEØK AS.

The Melsvik mineralisation was found in 1979 by NGU`s follow-up of a stream sediment survey (Staw 1981) and no excavations are conducted. It is an analogue to the Anna-Holmvatnet mineralisation (8.2), and is hosted in dolomite layers of the Storviknes Formation at the east flank of the syncline.

8.7.1 Results

A siltstone unit contains 5 thin, 0.3-5.5 m, dolomite layers with bornite, digenite and chalcopyrite as dissemination and in quartz vein network over a strike length of at least 3 km.
The same dolomite sequence hosts mineralisation 8 km to the south, at Gryteng.
Cu-mineralisation of any significance (0.3-0.6 % Cu) seems to be restricted to the upper and lower contacts of the dolomite beds, with weak disseminations in the central parts, and it does not look very encouraging.

577231 7765690: 3.5 m thick dolomite layer with silt lamellae and thin, irregular quartz veins. Cu-minerals are finelly disseminated in the whole thickness but seem to be somewhat enriched along the foot-wall (AL11025, 0.33 % Cu) and the brecciated hanging-wall (AL11026, 102 ppm Cu).
Above this, at 577218 7765692, within ca 20 m thickness of green siltstone, are 4 more dolomite layers (up to 3 m thick), striking 175°/30°. Copper minerals occur in lamellar veins, irregular veins and disseminated in the dolomite (AL11027, 0.63 % Cu). The dolomite layers can be seen to continue southwards.

A 5.5 m thick dolomite layer is outcropping at 577273 7766041. It seems like copper is enriched close to the dolomite contacts. Also mineralised thin quartz veins. AL11028 (633 ppm Cu) is an attempted average sample collected over 5.5 m thickness of dolomite. 2 or 3 overlying dolomite beds outcrop in the mountainside.
577378 7766323: Dolomite that underlie the previous by 25-30 m. Ca 20 m thick carbonates are dominated by barren, dark grey limestone with white weathering surface, with intercalations of a few brown-weathered dolomite layers with only traces of sulphides.
577471 7767193: Dolomite boulder with copper mineralisation (AL11029, 0.53 % Cu), derived from the mountainside to the west.

At a lower level and east of the above described, at 577376 7765870, is exposed 3 m thick banded limestone with a few, up to 20 cm thick, dolomite layers with weak and finelly dispersed pyrite and chalcopyrite bound to a few <1 cm thick bands (AL11024, 19 ppm Cu). Banding/foliation strikes 178°/57°. Foot-wall is graphite-bearing blackschist. Hanging-wall: 6 m siltstone overlain by dark grey, massive limestone with traces of sulphides and quartz vein network.

8.8 Møllevatna (map sheet 1834 I Alta)

Discoveries of dolomite-hosted copper mineralisations in the Storviknes and Luovusvarri formations prompted reconnaissance of Kvenvik Formation dolomites.
At least 3 extensive, up to 4 km long, dolomite layers occur in the gabbro-intruded mafic metavolcanics of the Kvenvik Formation west of Møllevatna.
The area can be reached by a couple of hours walk along the cart road from Kåfjord to Haldi (Sukkertoppen).

8.8.1 Results

The reconnaissance established that the dolomites are copper-mineralised but grades are very low.

The southern part of the eastern dolomite is outcropping between 573445 7760549 and 573539 7760836 (strikes 187°/60°). At 573523 7760760 this dolomite is at least 12 m thick and silt-laminated. Weak chalcopyrite-chalcocite(-malachite)-dissemination is limited to an up to 40 cm thick, boudinated massive-dolomite layer (AL11078, 347 ppm Cu).
At 573590 7760931 an apparently even more easterly silt-laminated dolomite is outcropping. Very weak chalcopyrite dissemination is hosted along the upper and lower contacts, especially within a 20-40 cm thick massive-dolomite bed close to the footwall.
Northwards the eastern dolomite is outcropping at 573641 7761222, 573681 7761408 and 573673 7761808. It shows up again at 574067 7762667 over 10-12 m thickness. Only traces of sulphides occur. It is underlain by rusty blackschist, and continues north of the lake as a thin, barren dolomite layer within limestone.

A more westerly dolomite has scattered outcrops (due to folding) between 573422 7760948 and 573509 7761764. It is more massive, reddish-pink and white varieties, contains dendritic pyrolucite and only traces of pyrite and chalcopyrite. The northern part is densely quartz veined.
Northwards this dolomite is squeezed into a mylonitic thrust fault, where only thin (up to 20 cm), boudinated dolostone beds are observed along the cliff. Boulders derived from these are sampled at 573677 7762387: AL11079 (333 ppm Cu) of quartz-dolomite with pyrite-chalcopyrite-dissemination, and AL11080 (345 ppm Cu) of quartz-carbonate rock with chalcopyrite-(chalcocite?)-hematite-dissemination; and at 573682 7762456: AL11081 (46 ppm Cu and 124 ppb Au) of dolomite with chalcocite(?) dissemination.

An even more westerly dolomite is outcropping over 7 m thickness in a boulder field at 573522 7762970. Striking 157°/20°. Only traces of sulphides seen.

South of Møllevatna an interesting succession was detected: sulphide-mineralised albite felsite, graphite schist and dolomite within basaltic tuffite and adjacent metagabbro.
At 573855 7761415 is a small outcrop of banded, and in places carbonate-rich albite felsite with pyrite dissemination (AL11075, 175 ppm Cu)). Locally derived gossanous and rusty floats are scattered around this outcrop, dominated by albite felsite with few-cm thick layers of semimassive pyrite and minor chalcopyrite, and traces of graphite (AL11076, 216 ppm Cu and AL11077, 0.15 % Cu). It is also floats of chlorite-amphibole schist with pyrite dissemination.

Below the albite felsite is subcropping graphite schist with outcropping dolomite below. At 573885 7761467 the north-south striking and west-dipping dolomite (dark grey, fine-grained with rusty-brown surface, with traces of chalcopyrite) turns eastwards to 573939 7761448, where at least 4, up to 30 cm thick dolomite layers/lenses occur in green siltstone. Strike/dip is 114°/45°. The dolomite carries weak pyrrhotite-pyrite-chalcopyrite dissemination/-veins.
The outcropping albite felsite also has overlying graphite schist, 100 m to the SW (separated by boulder field).

8.8.2 Recommendations

These dolomites are only weakly copper-mineralised and do not encourage further work. Neither does the mineralised albite felsite which does not carry gold. Further to the west, at the east-slope of Talviktoppen, a dolomite horizon with a layer-parallel fault along it should be inspected. However, the northern part of this extends into a protected area.

8.9 Vilgesrassa (map sheet 1834 IV Flintfjellet)

The area is located 15 km west of Kåfjord at an elevation of 900 m.a.s.l., and appropriate transportation is by means of helicopter from Alta.
A reported copper mineralisation at Vilgesrassa (Kviturfjellet) was visited by a NGU geologist in 1959 (Hysingjord 1959). According to his description it is two subvertical hydrothermal-breccia veins/lenses of insignificant dimensions (5m x 1m) with 500 m separation, hosted in `a basic rock, probably peridotite`. The veins consist of calcite with peridotite fragments and chalcopyrite.
NGU failed to relocate this mineralisation in 1991. However, it was found a 40 m long and 20-50 cm thick vein of calcite and quartz, with pyrite, chalcopyrite and magnetite, along the contact between metabasalt and overlying dolomite (Kvenvik Formation). NGU sampled the mineralisation in 1991, and two assays returned 1 and 6 g/t Au respectively, the latter with 5 % Cu and 28 % S.
A more thorough investigation was conducted in 1992 by Finnmarksforskning (a scientific organisation). 12 samples were assayed. The high gold values were not reproduced.

This survey was not able to relocate any of these mineralisations. However, such vein type mineralisations have limited potential. I have previously investigated similar veins with similar paragenesis within the Kvenvik Formation in Kvænangen, and some of them came out with single assays of 1 g/t Au (the Ore Data Base, NGU), but with average grades significantly lower.
I was sure to be on the right location for the NGU-sampled mineralisation, but what I found was copper mineralised albite felsite outcropping along the described contact. No less promising for gold as it has a greater extent.

The second part of the two days survey at Vilgesrassa intended to follow-up anomalous stream sediments from NGU sampling in 1980 (Staw 1980), and to access the northern part of the Kvartpååttevannet dolomite (described in 8.3).

8.9.1 Results

A 3.5 km long by up to 200 m wide dolomite is outcropping south of the Vilgesrassa peak, 900 m.a.s.l. It is generally light-coloured with brown weathering surface, massive and regularly banded, not internally folded. Sulphides are generally only found in trace amounts, except along the weakly brecciated contacts, where hematite, pyrite and chalcopyrite occur.
561939 7759359: Albite felsite runs slightly discordantly along the dolomite foot-wall. The felsite is from flesh-red to grey-yellow and greenish. It is dolomite-veined, and in places contains laminar and irregular dissemination of pyrite (AL11065, 561958 7759356, 133 ppm Cu), and pyrite-chalcopyrite-sphalerite-galena dissemination (AL11066, 561963 7759357, 0.14 % Cu, 934 ppm Zn and 708 ppm Pb).
The foot-wall of the albite felsite is poorly exposed in the boulder field, but its thickness is seen to be at least 3.5 m. One outcrop shows a thin(?) dolomite horizon below it. The overlying dolomite contains a 1 m thick carbonate altered diabase sill 2 m above the albite felsite (fig.17).

Fig.17 Albite felsite with overlying dolomite and diabase.

Within a narrow band, less than 0.5 m thick, just above the albite felsite contact, the dolomite contains hematite and minor chalcopyrite (AL11063, 0.11 % Cu), and chalcopyrite dissemination in dark grey, impure carbonate layers (AL11064, 0.20 % Cu).
Local boulders show dolomite with up to 6 cm thick quartz-carbonate veins with pyrite(-chalcopyrite) dissemination (AL11067, 561963 7759357, 0.14 % Cu).
1.5 km to the east along the same contact 4 adjacent albite felsite layers with dissemination of pyrite and traces of chalcopyrite are outcropping (AL11070, 36 ppm Cu).

The albite felsite/dolomite contact is not exposed west of the former outcrop, but at the approximate location for the NGU sample site, 561061 7759286, ca 1.5 m thick(?) albite felsite is outcropping along the dolomite contact to overlying chlorite-carbonate altered greenstone with traces of chalcopyrite dissemination. Local floats of the poorly exposed carbonaceous albite felsite show pyrite-chalcopyrite(-hematite) dissemination (AL11068, 90 ppm Cu, and AL11069, 0.14 % Cu from 561048 7759278).

The approximately 20 km² stream sediment anomalous (up to 500 ppm Cu) area between Vilgesrassa and Vuorasnjarggahaldi is underlain by an east-west trending series of mafic flows and tuffites, intruded by diabase sills. The succession is folded with east-west trending axis, and faults are directed north-south. Sediments are more abundant than indicated on the geological map (none) by Gaultier et al. (1986), probably due to their affinity to covered east-west topographic lows. Weakly graphite-bearing argillites are often bound to zones of weakness, upon where the rigid diabases have moved, e.g. at 564165 7758209, where 5 m thick banded, carbonaceous and rusty (pyrite dissemination) argillite is mylonitic below the diabase contact. Carbonate beds are observed occasionally.

The anomalous copper in stream sediments can be reasoned in a weak chalcopyrite dissemination which is widespread in the Kvenvik greenstone and metadiabase, hence these rocks often have a rusty surface. Occasionally the greenstone and diabase are carbonate altered, with few-cm thick carbonate layers, and boulders of pervasive carbonate alteration are observed.
At 561974 7759002 the fine-grained greenstone carries irregular dissemination of pyrite, pyrrhotite, galena, sphalerite and chalcopyrite over a narrow and 20 m long, more or less stratabound horizon (AL11062, 260 ppm Cu, 0.79 % Zn and 2.46 % Pb). This is a small outcrop in a boulder field and strike extension is unknown.

564648 7758280: 0.5 m thick alteration lens within diabase of coarse-grained calcite and asbestous tremolite with weak pyrrhotite-chalcopyrite-dissemination and malachite. Also weak pyrrhotite-chalcopyrite-dissemination in the adjacent diabase, which is weakly altered. The foot-wall of the lens is tectonic, with a carbonate enriched layer and a dark grey schist.

564604 7757184: NE-SW running and ca 130 m wide dark grey to black carbonate rock, probably a carbon-bearing albite felsite (black-felsite), which was traced from a more than 1 km long boulder fan to the north. The rock is banded, with a cavy and rusty surface, and contains pyrite dissemination (AL11072, 137 ppm Cu).
Within this unit, at 564621 7757263, is abundant local floats in a `large` area of hydrothermal quartz with thin carbonate veins, and abundant chalcopyrite and pyrite (plus malachite) in irregular veins and dissemination (AL11071, 0.26 % Cu). Floats indicate a rather extensive quartz-carbonate-sulphide vein running SW-wards.

8.9.2 Recommendations

As the gold and copper contents were discouraging in potentially favourable hosts as albite- and black felsites, no further exploration work is recommended in this area.

8.10 Langfjordhamn (map sheet 1735 II Øksfjordjøkelen)

A short visit to Langfjordhamn in Loppa kommune was motivated by a distinct Cu-Ni anomaly (595 ppm Ni) in till sample (Reimann et al. 2011) collected at the pass between Langfjordhamn and Tverrfjorden in the Øksfjord gabbro/ultramafic massif.
Access by boat from Øksfjord to Langfjordhamn, from where it is a couple of kilometres to walk southwards.

8.10.1 Results

The area of interest is located adjacent to the contact between olivine gabbro in the west and pyroxene gabbro in the east, both of Caledonian age. Banded, rusty (pyrrhotite-chalcopyrite disseminated) gneisses occur along this contact and also along the valley bottom north of Tredjevatnet.
6 samples were collected (appendix 2), 3 from gabbro with pyrrhotite-chalcopyrite dissemination, and 3 from ultramafic boulders with pyrrhotite dissemination. Ultramafics are not found outcropping but frequent, large boulders occur in the valley between Storfjellet and Stuoravuoncahca, and in the valley west of Andrevatnet (where Viscaria Alpina grows within a restricted area).
The ultramafic boulders assayed low in Cu (< 300 ppm), and up to 0.18 % Ni and 0.19 % Cr.

At the side of the road (E6) along Langfjorden, at 558831 7773713, is a lot of rusty boulders derived from the mountainside to the south where a large rusty outcrop of gabbro can be seen between the compass directions 117° and 131°. Sample AL11034 is gabbro with semimassive pyrrhotite and subordinate chalcopyrite. The assay returned 830 ppm Cu and 554 ppm Ni, and showed the sulphide-mineralised gabbro to be atypically anomalous in Zn, Pb, Mo and U.

8.10.2 Recommendations

No further work recommended except a short field check at the source for the Langfjorden boulders, which is seen outcropping as strong rust staining in the mountain side to the south.

8.11 Raipas – Borras (map sheets 1834 II Alta and 1934 IV Gargia)

The Raipas – Borras area has so far not received attention beyond a short visit, and the known copper-disseminations in the dolomite should be explored, having in mind NGU`s deep IP indication. Also copper dissemination in tuffite layers in the Raipas – Borras area, reported by Vik (1985), should be explored.
If the cores from NGU`s drilling at Raipas in 1977 are stored at Løkken, these should be inspected. They intersected copper dissemination.

9. Summary

Significant discoveries of not previously known copper mineralised dolomite beds within both the Storviknes, Luovusvarri and Kvenvik formations were done this summer. Highest priority should be laid on Fiskarfjellet and Kvartpååttevannet, where geophysical IP surveys and further geological mapping are proposed. Exceptionally Cu-Ag-rich dolomite boulders were found at Flintfjellet.

Fiskarfjellet:
The dolomite layers, belonging to the Storviknes Formation, which host 7.5 km length of copper mineralisation between Holmvatnet and Anna continues 20 km south-westwards from Anna through Kvartpååttevannet, and in the area west of Fiskarfjellet the Storviknes Formation is repeated by a syncline and crops out in an anticline, then as wide as up to 1500 m with siltstone, limestone, dolomite and argillite.
The dominating carbonate within the formation is a fine-grained, pinkish-grey limestone or marble, often with repeated intercalations (banding in few-cm scale) of argillitic layers. Grey siltstone and dark grey argillite also occur in thicker units. Dolomite occurs as kilometre-long and few-metre thick layers at various levels, and is probably repeated by folding.

As a large percentage of the bedrock in the Fiskarfjellet area is covered, it prevails confusion about the connection between the various dolomite horizons, and concerning the structural geology in general – no doubt that some of the horizons represent refolded counterparts, which a geophysical survey (e.g. IP) could be an aid in solving.
So far another important aspect is enigmatic, the thickness of mineralisation. Even if the copper mineralisation is laterally very extensive, and seems to follow more or less continuously along dolomite horizons over several kilometres, it is obvious that not all of the dolomite thickness (which in places can exceed 10 m) is mineralised. In well exposed areas mineralisation of good quality (estimated 1-2 % Cu) can be observed to be in the range up to 60-70 cm thick – distal, weaker disseminations not included. The Sæterfjellet mineralisations are thicker.
A general impression is that the copper mineralisations, at least the richer parts, are restricted to the dolomite contacts, often along the footwall, and usually hosted in massive dolomite. The typical host dolomite is almost white to light grey or yellowish, massive dolomite with creamy to yellow weathering surface, more seldom brown. Reddish (hematite-bearing) and dark grey dolomite (possibly increased level of organic material) (A characteristic feature in redbed copper deposits is deposition of copper from ascending fluids in a transition zone between oxidised and reduced rocks), silt-laminated and stromatolitic dolomites, and dolomite breccia are not favourable hosts. Chert-laminated dolomite is mineralised at Sæterfjellet. Occasionally the dolomite is quartz veined.
Field observations suggest a link between development of structures and ore formation. Parts of the Fiskarfjellet mineralisations resemble the mineralisations in the Storviknes Formation west of Kåfjord as well as Kvartpååttevannet, where copper deposition evidently had occurred along tectonic structures, supporting a late-stage epigenetic mode of sulphide emplacement. This feature is probably only a late event of redistribution of earlier-formed sulphides in a multistage stratabound mineralisation, where multiple fluid events ranging from initial diagenetic to late-stage epigenetic (syn- or post-orogenic) have occurred. Secondary enrichment in the form of remobilisation is important in the ore-forming process, demonstrated e.g. at Sæterfjellet, with high copper grades bound to hinge zones in the folded dolomite. This mechanism is also observed more locally, not restricted to hinge zones in macro-folds, but also in internal, rather chaotically folded dolomite, due to its plastic nature.

The copper mineralised dolomites in the Fiskarfjellet area occur within an approximately 5 x 5 km2 sized area. The two dolomite layers north of Rundvatnet can be traced in outcrops and boulders over 10 km strike length, from Flintdalen to Oaggovarri, and they are up to 10 m thick. At least 6.5 km of these are copper mineralised, with the majority of assays between 0.9-1.9 % Cu and up to 12.9 g/t Ag.
At Sæterfjellet bedrock is poorly exposed due to boulder fields. The dolomite is fairly resistant to erosion compared to the siltstone and crops out a few places. At Sæterfjellet five subcropping and outcropping dolomite beds within 200 m width can be traced over less than 1 km strike length. In addition, two folded dolomite beds occur in the valley between Sæterfjellet and Oaggovarri. Grab samples from the Sæterfjellet mineralisations assayed up to 1.89 % Cu and 11.3 g/t Ag.
The outcropping parts of the dolomites in the rather covered lowlands east of Fiskarvatnet seem to be more low-grade, and the copper content is mainly in the range 0.1-0.2 %. The distal character of ore formation in these beds is reflected in dominance of chalcopyrite over other copper sulphides.

The macroscopically identified sulphide mineralogy includes chalcocite, bornite, chalcopyrite, and subordinate pyrite and aresenopyrite. Secondary malachite is not particularly well developed at weathered surface, hence it is not the evident guide to mineralisation as could be expected. Malachite coating is frequently better developed along lamellar bedding within the copper-bearing dolostone. The sulphides often have a banded appearance, or occur as discrete dissemination, or within irregular veins.

Silver is an economic element in the mineralisations and shows good to moderate correlation with copper. The higher-grade samples (> 0.7 % Cu) contain between 2 and 13 g/t Ag.
Antimony is enhanced within the sulphidic beds, up to 313 ppm Sb.
Arsenic content is up to 0.47 % and zinc up to 681 ppm. These two demonstrate good inter-element correlation.
The barium content in the dolomite, probably bound in barite, is up to 0.61 %.
Manganese content is typically in the range 0.3-0.7 % and is probably bound in ankerite. Mangano-dolomites also carry manganese as lattice-bound in the dolomite. A secondary expression of the manganese content is frequently observed in the Fiskarfjellet dolomites – that is dendritic pyrolucite.

Follow-up work at Fiskarfjellet should include a geophysical survey. IP will trace the disseminated sulphides within the dolomites, and mag could possibly prove useful in mapping the boundary between the Storviknes Formation siltstone and the Skoadduvarri Formation sandstone, especially in the eastern part of the area, which is assumed to be more structurally complex and covered by boulder field. Based on the geophysical anomaly map, additional geological detail mapping should be conducted, especially the well-exposed cliff north of Rundvatnet should be studied and channel samples transecting mineralisation collected.

Anna – Holmvatnet:
The copper mineralisation NW of Kåfjord, between Anna and Holmvatnet prospects, is stratabound and more or less continuously mineralised over a strike length of 7.5 km, along the west flank of a large synclinal structure. Vein network of bornite-digenite-chalcopyrite (with minor and accessoric other sulphide minerals) mineralisation is hosted in 4 adjacent dolomite layers, each of 2-5 m (locally 12 m) thickness, in silt- and mudstone (occasionally sulphide veining is observed in the siltstone adjacent to the dolomite). Mineralisation is

assumed to be diagenetic, with sulphide replacement of dolomite along a tectonic zone parallel to strike. Fine-grained dolomite is replaced by coarse-grained quartz, calcite, dolomite, barite and sulphides. Another type of mineralisation occurs at Lundstrøm. That is deformed, few-cm thick quartz-carbonate veins with bornite and digenite hosted in the siltstone, subparallel to schistosity.

The dolomite hosted copper mineralisations are stratabound, with an epigenetic signature. It is evident from several localities that mineralisation of any significance is concentrated along tectonic contact zones between dolomite and siltstone, then as narrow zones, generally 20-40 cm thick.
In spite of the significant strike extent, more or less continuous over 7.5 km, the narrow character of the mineralisations limits the potential. However, as the ore thicknesses are not established with confidence, trenching or shallow-level drill sampling should be considered.

Kvartpååttevannet:
Rich chalcocite-chalcopyrite mineralised dolomite was detected at the SE shore of lake Kvartpååttevannet and followed 3 km NNE-wards, from where the mineralisation weakens ENE-wards. South of Kvartpååttevannet has potential for 3 more kilometres length of mineralisation. The Kvartpååttevannet dolomite bed is poorly exposed and mineralised width is unknown.
The present ore-bearing minerals and their distribution are attributed to late-stage epigenetic processes, probably remobilised from early- to late-diagenetic sulphide formation – a massive, copper mineralised dolomite is seen to discordantly cut through a folded, silt-laminated, schisty dolomite, suggesting injection of sulphide-bearing massive-dolomite remobilised from a precursor laminated dolomite. Apart from impregnation, sulphides are also hosted in a network of small veinlets that suggest a significant role for deformation in the development of the mineralisation. The crosscutting texture of the veinlets suggests that mineralisation occurred after lithification of the original carbonate.
4 samples from the southern part assayed between 1.03-2.09 % Cu and 6.0-7.6 g/t Ag.
As content is up to 0.72 %, Zn up to 0.13 % and Sb up to 444 ppm. Two Au assays returned 0.48 g/t and 0.15 g/t respectively. The samples are lower in Ba and about the same in Mn compared to Fiskarfjellet.
This dolomite-hosted copper mineralisation is copper-rich, including by-product Ag, Au and Zn, but might have very limited thickness from what can be observed at the few outcrops. It is, however, not properly exposed – consequently significant dimensions can not be ruled out. The 3 km long southern extension of the dolomite, towards the nappe contact, should be explored. An IP survey and possibly trenching is recommended.

Flomvatnet:
Discoveries of copper mineralisation in the Storviknes Formation both at Fiskarfjellet and Kvartpååttevannet prompted exploration also along the dolomites of the Luovusvarri Formation. This formation is the youngest member, and forms the upper part of the Paleoproterozoic Raipas Group. It consists of dolomite intermixed with greywacke, siltstone and conglomerate, and occupies the core of an overturned (to the east) synform outcropping over 6 km length between the Storviknes dolomites at Fiskarfjellet and Kvartpååttevannet.
The discovered mineralisations are low-grade. The best section so far is 2 m thick containing about 0.15 % Cu, and adjacent quartzite being weakly mineralised.
The Luovusvarri Formation mineralisations (Flomvatnet and Luovusvarri) are significantly lower in grade, both copper and silver, than corresponding mineralisations in the Storviknes Formation. Chalcopyrite (often finely dispersed, with affinity to dolomite with clastic quartz)

is the dominating sulphide, while the Storviknes mineralisations contain major amounts of chalcocite and bornite.
The next step would be an IP survey to reveal potential hidden mineralisations covered by the boulder fields, which is indicated by a few mineralised boulders, but as outcrops demonstrate very low grades, further work on this target has low priority.

Flintfjellet:
Within a large boulder field of Skoadduvarri Formation greywacke boulders, some large copper mineralised dolomite boulders occurred within a restricted area. The dolomite boulders carry veins of massive chalcocite, bornite and hematite. Vein thickness up to 6 cm was observed.
Assays returned exceptionally high copper and silver grades: > 40 % Cu and 435-484 g/t Ag, and anomalous Bi (106-133 ppm), Th (30 ppm) and W (20-30 ppm), while Ni (< 1 ppm) and P (40-50 ppm) are low.

The Cu-Ag mineralised boulders are possibly derived from vein type mineralisation as they resemble such occurrences located further to the west (Vik 1985), which are characterised by copper sulphides and magnetite/hematite within calcite-quartz-dolomite veins.
However, their chemistry is distinctly different. The abnormal silver content is not reflected in the earlier known occurrences. They assay generally < 1 g/t, highest single assay is 8.8 g/t Ag from Edvards Gruve (the Ore Data Base, NGU). The boulder samples are also distinctly higher in Bi, W and Th, while they are lower in gold. The Kvænangen hydrothermal vein occurrences typically show gold contents in the range 0.2-0.8 g/t, highest single assays being 4.6 g/t Au from Kalkspatgangen and 1.8 g/t Au from Edvards Gruve.

Luovusvarri:
A reconnaissance was conducted at the Luovusvarri mountain which is underlain by alternating layers of dolomite, siltstone and quartzite belonging to the Luovusvarri Formation, the same formation that is mineralised at Flomvatnet. Dolomites of the Luovusvarri Formation tends to be distinctly weaker mineralised than dolomites belonging to the Storviknes Formation, but both at Luovusvarri and Flomvatnet adjacent siltstone and quartzite are copper mineralised. Opposed to the Storviknes mineralisations, Luovusvarri Formation mineralisations seem to have affinity to quartz-grained sections of the dolomites and chalcopyrite is the dominating copper sulphide.
This is yet another discovery of copper mineralisation not previously reported. The grades are however low, 0.1-0.3 % Cu, and the mineralisations are thin.

Melsvik:
The Melsvik mineralisation was found in 1979 by follow-up by NGU of a stream sediment survey and no excavations are conducted. It is an analogue to the Anna-Holmvatnet mineralisation, and is hosted in dolomite layers of the Storviknes Formation at the east flank of the syncline.
A siltstone unit contains 5 thin, 0.3-5.5 m, dolomite layers with bornite, digenite and chalcopyrite as dissemination and in quartz vein network over a strike length of at least 3 km.
The same dolomite sequence hosts mineralisation 8 km to the south, at Gryteng.
Cu-mineralisation of any significance (0.3-0.6 % Cu) seems to be restricted to the upper and lower contacts of the dolomite beds, with weak disseminations in the central parts, and it does not look very encouraging.

Møllevatna:
Findings of dolomite hosted copper mineralisations in the Storviknes and Luovusvarri formations prompted reconnaissance of Kvenvik Formation dolomites.
At least 3 extensive, up to 4 km long, dolomite layers occur in the gabbro-intruded mafic metavolcanics of the Kvenvik Formation west of Møllevatna.
The reconnaissance established that the dolomites are copper-mineralised but grades are very low.
East of the dolomite layers it was discovered an albite felsite with semimassive pyrite and minor chalcopyrite, containing no gold. The albite felsite is hosted in a sequence of dolomite, graphite schist and tuffite.

Vilgesrassa:
At Vilgesrassa, in Kvenvik Formation rocks, the contact zones of a wide dolomite are copper mineralised. Pyrite-chalcopyrite-hematite dissemination is hosted in albite felsite and the immediate dolomite. Assays of grab samples returned up to 0.2 % Cu and insignificant gold.
A few other sulphide occurrences were found within the area, e.g. a small Pb-Zn mineralisation, a metal association which is rare within the Raipas Group.
As the gold and copper contents were discouraging in potentially favourable hosts as albite and black felsites, no further exploration work is recommended in this area.

Langfjordhamn:
A short visit to Langfjordhamn in Loppa kommune was motivated by a distinct Cu-Ni anomaly (595 ppm Ni) in till sample (Reimann et al. 2011) collected at the pass between Langfjordhamn and Tverrfjorden in the Øksfjord gabbro/ultramafic massif.
The area is underlain by gabbro of Palaeozoic age.
Ultramafic boulders assayed low in Cu (< 300 ppm), and up to 0.18 % Ni and 0.19 % Cr.
At the side of the road (E6) along Langfjorden is a lot of rusty boulders of pyrrhotite-chalcopyrite mineralised gabbro, derived from the mountainside to the south where a large rusty outcrop of gabbro can be seen. The assay returned 830 ppm Cu and 554 ppm Ni, and showed the sulphide mineralised gabbro to be atypically anomalous in Zn, Pb, Mo and U.
No further work recommended except a short field check at the source for the Langfjorden boulders.

The *Raipas – Borras* area has so far not received attention beyond a short visit, and the known copper-disseminations in the dolomite should be explored, having in mind NGU`s deep IP indication. Also copper dissemination in tuffite layers in the Raipas – Borras area, reported by Vik (1985), should be explored.
If the cores from NGU`s drilling at Raipas in 1977 are stored at Løkken, these should be inspected. They intersected copper dissemination.

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