Inventory of mineral resources in northeastern Norrbotten County, Sweden

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Changes implemented April 23, 2021

Section The Pajala area, page 98

Figure 69 has been replaced. The figure previously showed the same map as figure 68.

Cover photo: Trial pits at the Outavaara prospect.
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INNEHÅLL

SAMMANFATTNING

Den här rapporten beskriver resultaten inom projektet ”Nordöstra Norrbottens malm och mineral”, vars syfte var att sammanställa och förbättra den geologiska informationen och kunskapen om områdets mineral- och bergartsförekomster.

Informationen är tänkt att kunna användas inom mineralprospektering, samhällsplanering och vid miljöfrågor. Studien har ökat kunskapen om mineralfyndigheterna och deras relation till berggrunden i området, information som kan användas vidare inom forskning, undervisning, geoturism, kulturhistoria etc.

Projektet innefattade sammanställning av befintlig geologisk information och fältbesök för att bättre kunna beskriva och karakterisera fyndigheterna. Fältbesök genomfördes under åren 2014 och 2015 och resultaten finns redovisade, förutom i föreliggande rapport, också i SGUs mineralresursdatabas som finns tillgänglig via SGUs hemsida (https://apps.sgu.se/kartvisare/kartvisare-malm-mineral.html). Många av de besökta förekomsterna har också provtagits och analyserats och resultaten finns redovisat i Appendix II och på SGUs hemsida (https://apps.sgu.se/kartvisare/kartvisare-bergartskemi.html).

Mineral- och bergartsförekomsterna inom det undersökta området varierar mycket vad gäller typ och storlek och innefattar allt från små järn-, basmetall-, guld- och industrimineralförekomster till aktiva gruvor och bergtäkter.

I det undersökta området förekommer följande fyndighetstyper:

- Koppar-zink-bly, molybden och guld
- Järnmalmsförekomster av typen ”kvartsbandad järnmalm” och ”skarnjärnmalm”
- Grafit
- Marmor
- Magnesium- och aluminiumsilikatförekomster (talk och sillimanit)
- Kvarts- och fältspat
- Krossberg- och blocksten

I rapporten presenteras också en sammanfattning av områdets berggrundsgeologi och mineralförekomsternas relation till de geologiska enheterna. Beskrivningen av förekomsterna görs områdesvis och är inom varje delområde redovisade under olika rubriker beroende på typ av förekomst.

INTRODUCTION AND BACKGROUND INFORMATION

This inventory of mineral and bedrock resources in the northeastern part of Norrbotten county was carried out in 2014 and 2015, and is a continuation of the ongoing county-wise inventory programme on mineral and bedrock resources performed by the Swedish Geological Survey since the early 1990s. The latest published report in this series is the report on mineral and bedrock occurrences in Dalarna county, south-central Sweden (Ripa et al. 2016). This inventory was initially planned to cover all of Norrbotten county, but changes in priorities caused the inventory to be limited to the northeastern part, as presented in this report (fig. 1). The area investigated comprises some of the "key areas" of the Barents Project investigated in detail by SGU from 2012 to 2015. The Barents Project mainly focused on improving knowledge of the stratigraphy and the geological evolution of the region (see Bergman 2018 and references given there).

The main aim of the present study is to compile existing information on mineral and bedrock occurrences in northeastern Norrbotten county and also to update the information, where possible, with field investigations in order to better describe and characterise the deposits. The information in this report constitutes an important basis for updating the information in the SGU Mineral resources database (www.sgu.se). The information is intended to be used in mineral exploration, urban planning, and in examining environmental issues. This study also adds to our knowledge of mineral resources and the bedrock geology of northeastern Norrbotten, information that can be used in research, education, geotourism, etc. Additional information can be obtained from the SGU Mineral Resources Information Office in Malå. The Office is responsible for archiving and making material available for exploration as well as housing SGU's national drill core collection.

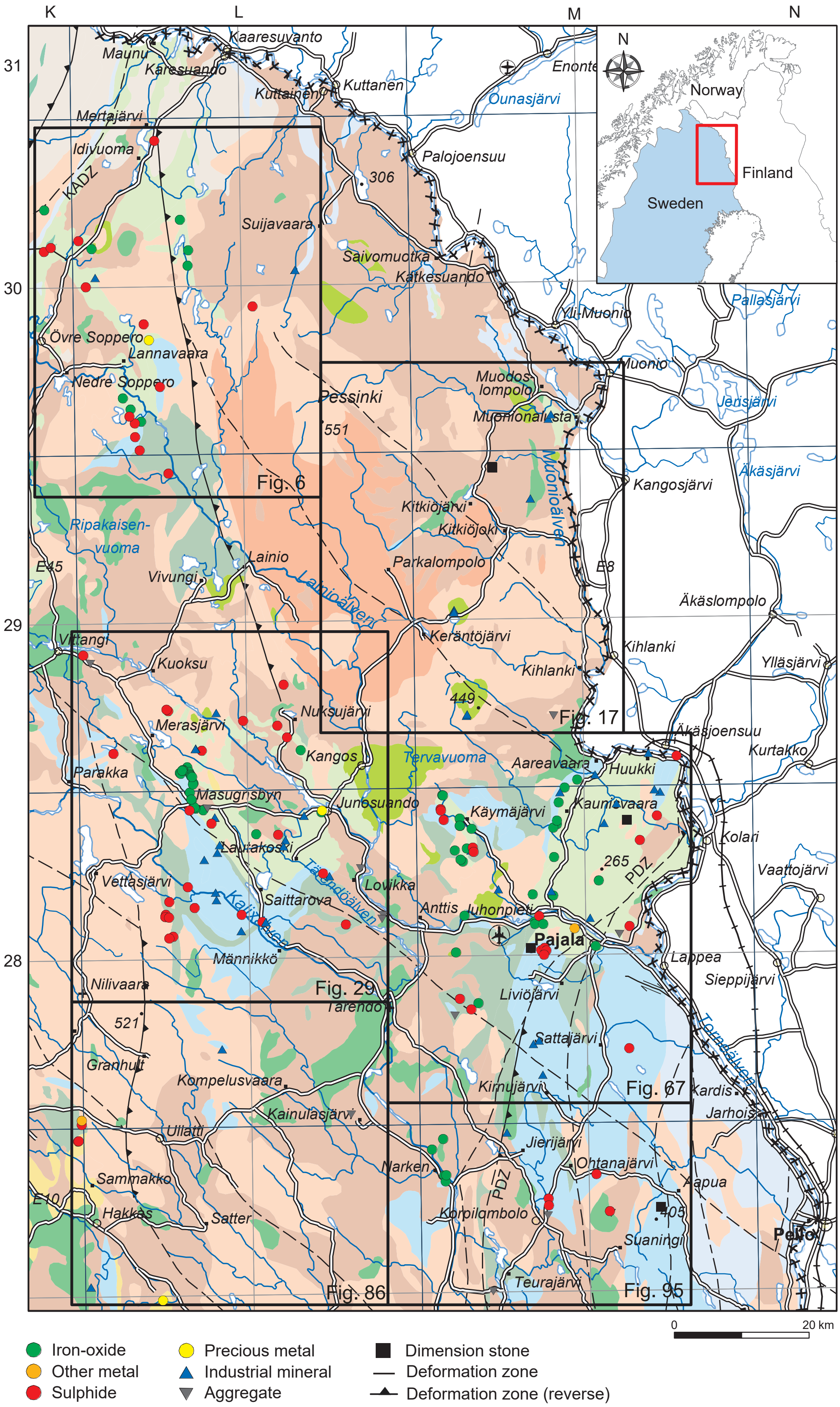
METHODOLOGY AND PRESENTATION

The present study compiles existing information on mineral and bedrock resources in northeastern Norrbotten. Where possible, occurrences were visited, described and sampled for chemical analyses. Before field work was carried out, a "target list" of potential sites to find and visit was prepared for the entire area. Strenuous efforts were also made to identify prospects or trial pits not previously described, using a LIDAR elevation model with a 2 m resolution. The elevation model clearly shows topographic depressions such as trial pits.

The mineral and bedrock resources of the target area (fig. 1) vary greatly, from small base metal and industrial mineral occurrences to large iron ores and active industrial mineral and rock quarries. Few of the iron ore and base metal occurrences have been mined, with the exception of the historical mines at Masugnsbyn and the major Tapuli iron deposit mined from 2012 to 2014, and reopened in 2018.

Mineral and bedrock occurrences are presented roughly from north to south and grouped into six geographical areas (fig. 1). The occurrences are described briefly using field observations and available information and grouped into chapters based on commodity types, with no economic valuation. The positions are given in the Swedish coordinate system SWEREF99TM, and the ID numbers are those used in the SGU Mineral resources database. Each occurrence is presented with a heading as follows:

Name of deposit	SGU database ID	SGU Field note ID (if available)
Commodity	Location coordinate SWEREF99TM, Easting	Location coordinate SWEREF99TM, Northing


K
L
M
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31
30
29
28
Kaaresuvanto
Maunu
Karesuando
Kuttainen
Kuttanen
Enonte
Ounasjärvi
Mertajärvi
Idivuoma
KADZ
Palojoensuu
306
Suijavaara
Saivomuotka
Katkesuando
Yli-Muonio
Pallasjärvi
Övre Soppero
Lannavaara
Nedre Soppero
Pessinki
551
Muodos-
lompolo
Muonionalusta
Muonio
Jerisjärvi
Muonioälven
Kangosjärvi
Äkäsjärvi
Fig. 6
Kitkiöjärvi
Kitkiöjoki
Ripakaisen-
vuoma
E45
Lainio
Vivungi
Parkalompolo
E8
Äkäslompolo
Lainioälven
Vittangi
Keräntöjärvi
Kihlanki
Kuoksu
Kihlanki
Ylläsjärvi
449
Nuksujärvi
Fig. 17
Merasjärvi
Äkäsjoensuu
Kurtakko
Kangos
Tervavuoma
Aareavaara
Huukki
Parakka
Masugnsbyn
Junosuando
Käymäjärvi
Kaunisvaara
Kolari
Lautakoski
265
PDZ
Vettasjärvi
Vaattojärvi
Lovikka
Saittarova
Tärendöälven
Anttis
Juhonpieti
Kalixälven
Pajala
Lappea
Männikkö
Sieppijärvi
Nilivaara
Fig. 29
Tärendö
Liviöjärvi
521
Sattajärvi
Granhult
Kompelusvaara
Kirnujärvi
Fig. 67
Kardis
Torneälven
Jarhois
Kainulasjärvi
Ullatti
Jierijärvi
Narken
Ohtanajärvi
Sammakko
Aapua
PDZ
E10
Hakkas
Satter
Korpilombolo
405
Pello
Suaningi
Teurajärvi
Fig. 86
Fig. 95
N
Norway
Finland
Sweden
0
20 km
Iron-oxide
Other metal
Sulphide
Precious metal
Industrial mineral
Aggregate
Dimension stone
Deformation zone
Deformation zone (reverse)

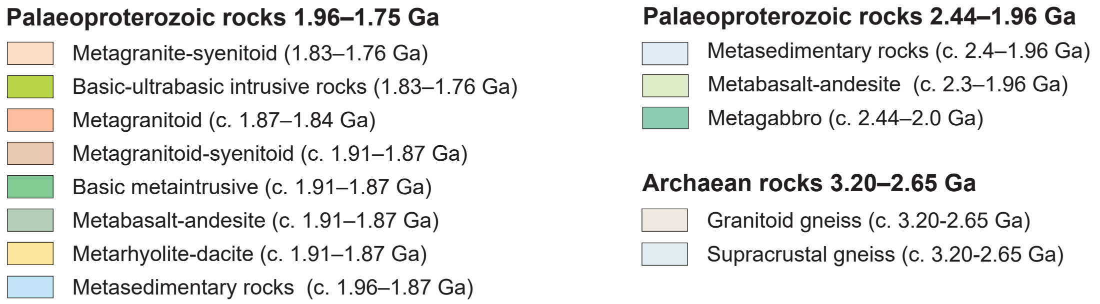


Figure 1. Bedrock geology map of northeastern Norrbotten showing the extent of the area investigated (modified from the SGU 1:1 million bedrock map database and the Mineral resources database).

GEOLOGICAL SETTING OF NORTHEASTERN NORRBOTTEN

Precambrian bedrock in northern Sweden includes a c. 3.2–2.6 Ga Archaean granitoid-gneiss basement, the Råstojaure complex, which is unconformally overlain by Paleoproterozoic meta-volcanic and metasedimentary successions (Figs. 2, 3, e.g. Ödman 1957, Witschard 1984, Bergman et al. 2001, Martinsson 2004, Kathol & Weihed 2005, Weihed et al. 2005, Martinsson & Wanhainen 2013, Martinsson et al. 2016, Lauri et al. 2016, Bergman 2018). To the west, the Precambrian rocks are overlain by Ediacaran–Cambrian platformal metasedimentary cover rocks and nappes of the Caledonian orogen. Sm-Nd isotopic analyses of 1.9–1.8 Ga rocks approximately delineates the Archaean paleoboundary zone between the reworked Archaean craton in the north and more juvenile Paleoproterozoic domains to the south, along the Luleå–Jokkmokk zone in Sweden and along the Raahe–Ladoga zone in Finland (fig. 2; e.g. Huhma 1986, Vaasjoki & Sakko 1988, Nironen 1997, Öhlander et al. 1993, Mellqvist et al. 1999). This approximate boundary zone defines the border between the Norrbotten lithotectonic provinces to the north and the Bothnia–Skellefteå lithotectonic provinces to the south (Stephens & Bergman Weihed 2020). The Pajala deformation belt (PDB, Luth et al. 2018) is a major shear zone trending north–south in the easternmost part of Norrbotten county. The zone can be clearly seen in the magnetic anomaly map (fig. 4). The eastern boundary of the Norrbotten lithotectonic unit has been placed along the western border of the Pajala deformation belt (Bergman et al. 2006). Rocks inside and east of this zone are assigned to the Överkalix lithotectonic unit (Stephens & Bergman Weihed 2020).

The Pajala deformation zone has been interpreted as a continental rift basin (Nironen 1997) or a possible suture zone between the two continents Norrbotten and Karelia (Lahtinen et al. 2015). The Karesuando–Arjeplog deformation zone (KADZ) is another important deformation belt occurring in the central area of Norrbotten county and intersecting the northwest of the study area (fig. 2). The KADZ is a belt of steeply dipping, ductile shear zones with a north-northeasterly strike and a length of at least 150 km (Bergman et al. 2001). Just south of the study area, in the southern part of the Norrbotten lithotectonic unit, the Nautanen deformation zone (Witschard 1996, Bergman et al. 2001) is one of several regional ductile shear zones with a northwesterly strike.

In northeastern Norrbotten, rift-related 2.5–2.0 Ga Karelian basic metavolcanic, intrusive rocks and associated metasedimentary rocks of the Kovo and Greenstone groups occur at the lowest stratigraphic level (figs. 1–3; e.g. Martinsson 1997, Lynch et al. 2018a). The Greenstone group is locally referred to as the Veikkavaara greenstone group and as the Kiruna greenstone group (Padget 1970, Ambros 1980). Volcaniclastic metabasalts are

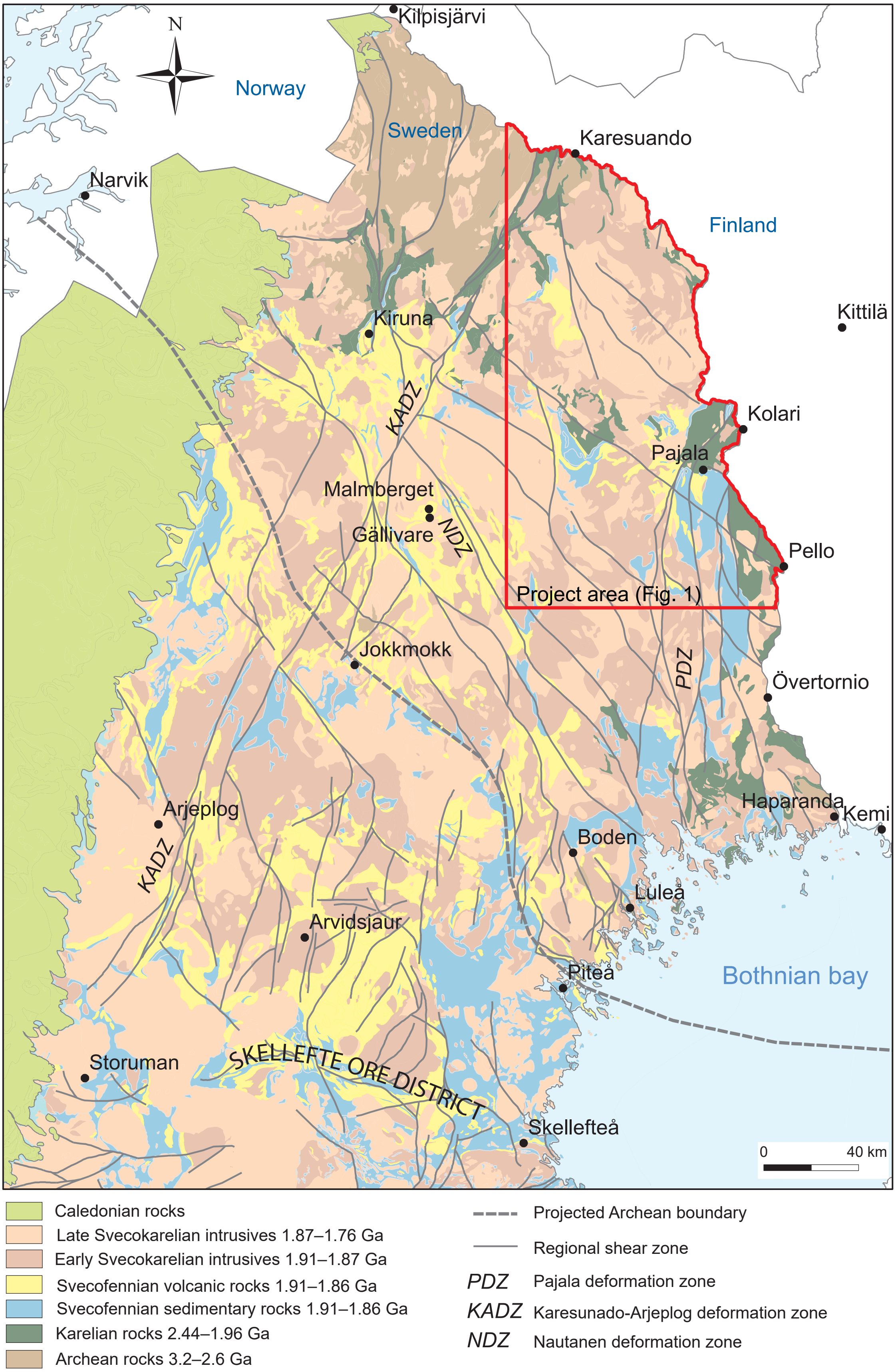


Figure 2. Geological outline of northern Sweden, showing selected lithological units (from the SGU 1:1 million bedrock map database).

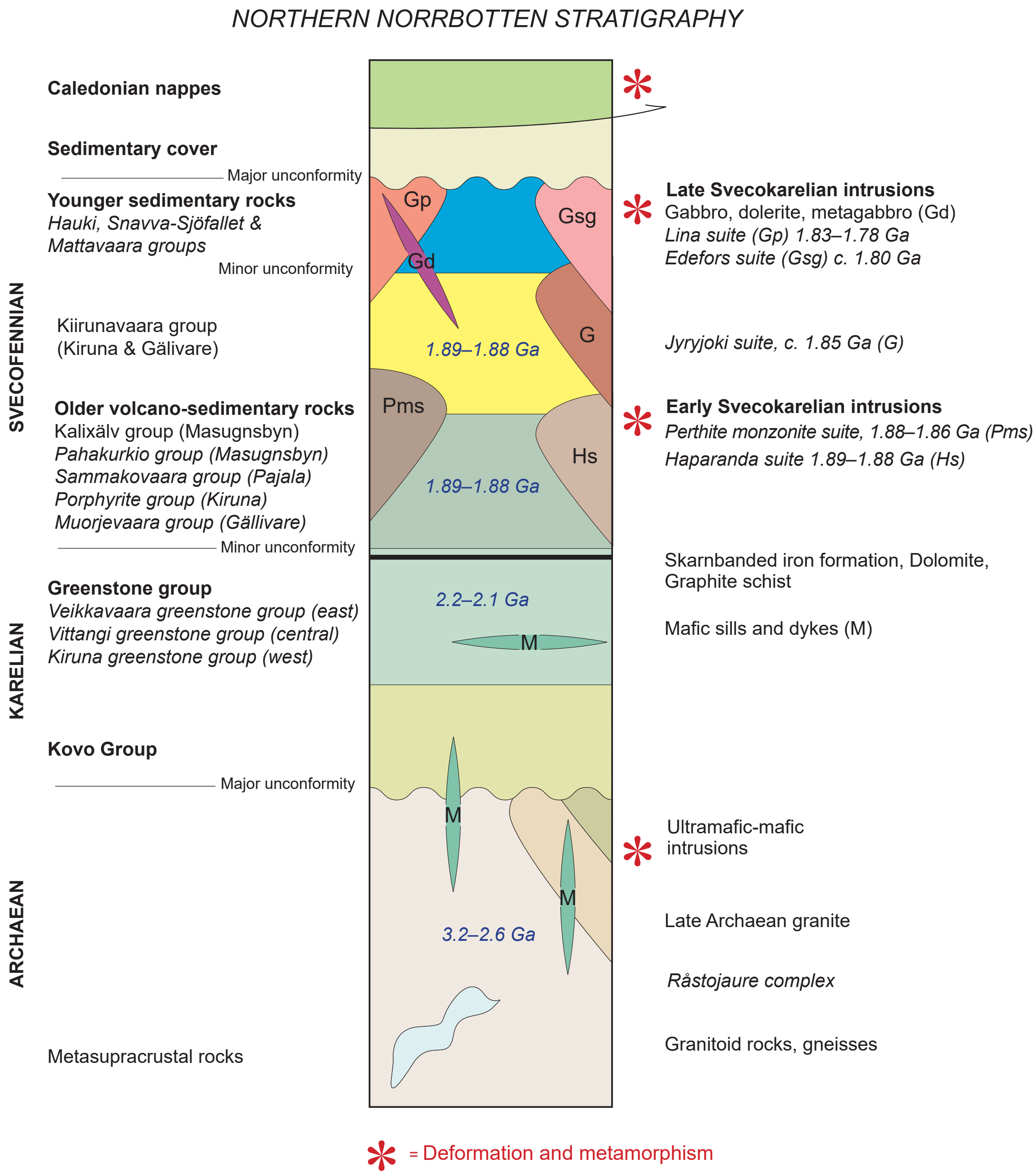


Figure 3. Schematic stratigraphic column showing the main rock units and events in northern Norrbotten. Not to scale (modified from Bergman et al. 2001).

typical of the greenstones in eastern Norrbotten. Amygdaloidal basaltic lava occurs in the stratigraphically lowermost unit, whereas the upper parts consist of graphitic schists, iron formations and dolomite. These are overlain by terrestrial to shallow water, c. 1.90–1.87 Ga Svecofennian successions, represented by clastic metasedimentary rocks of the Pahakurkio, Sammakkovaara and Kalixälv groups, the calc-alkaline, andesite-dominated, Porphyrite group, and the mildly alkaline volcanic rocks of the Kiirunavaara group, and in the uppermost stratigraphic level, younger clastic sedimentary rocks (e.g. Padget 1970, Bergman et al. 2001, Martinsson et al. 2018b, Hellström et al. 2018).

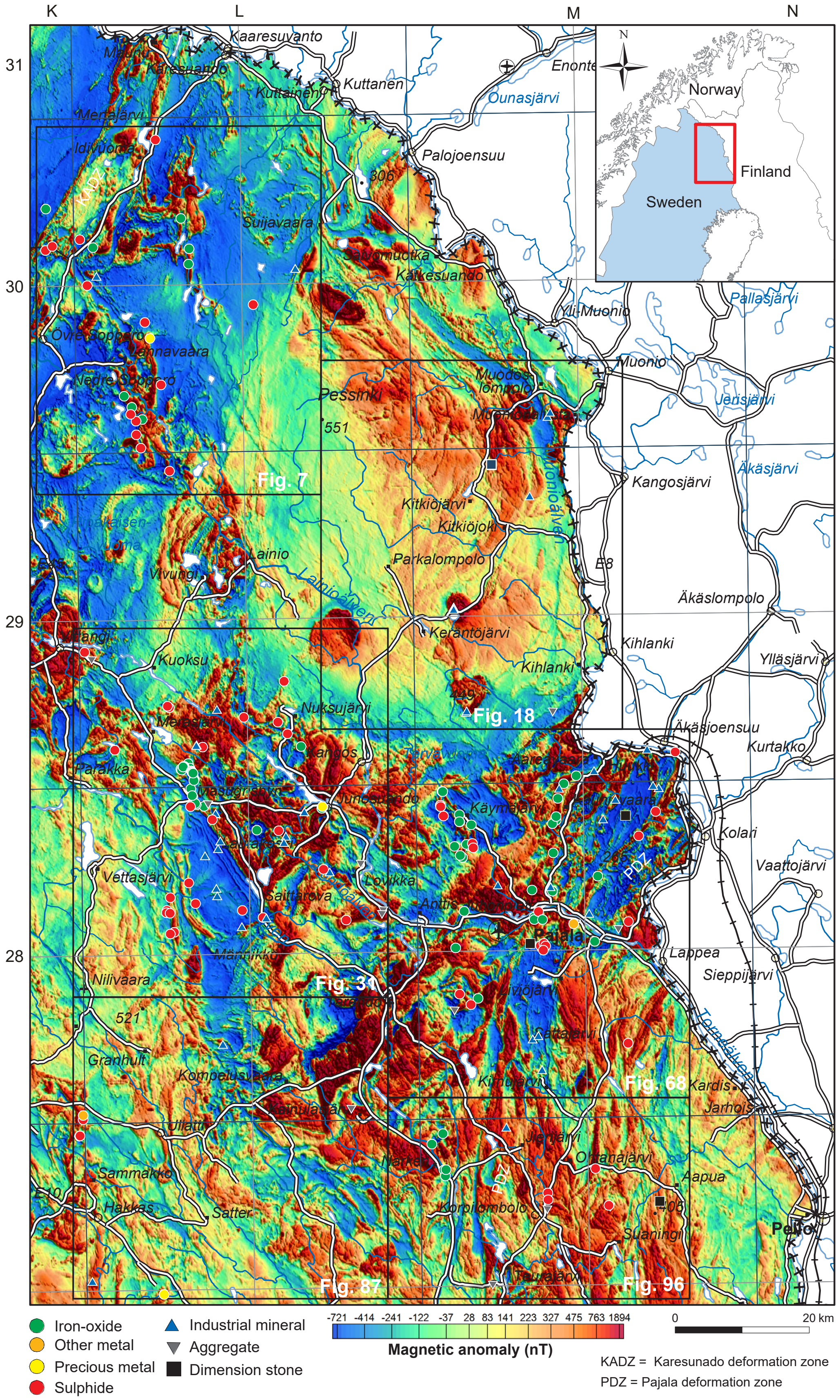


Figure 4. Magnetic anomaly map of northeastern Norrbotten (SGU data). The magnetic data were gridded by Johan Jönberger (SGU). Points show locations of mineral and bedrock resources (SGU mineral resources database).

Paleoproterozoic supracrustal rocks are intruded by the calc-alkaline 1.89–1.88 Ga Haparanda suite and the alkali-calcic 1.88–1.86 Ga Perthite Monzonite suite, considered to be comagmatic with the Svecofennian volcanic rocks of the Porphyrite and Kiirunavaara groups respectively (Witschard 1984, Bergman et al. 2001). The 1.85 Ga Jyryjoki granite occurs in northeastern Norrbotten and is mainly of granitic (sensu strict) composition (Bergman et al. 2006; Hellström & Bergman 2016). The 1.80–1.79 Ga eutectic (minimum-melt) granites and pegmatites, referred to as Lina granite, occupy large areas of Norrbotten county (Öhlander et al. 1987). Coeval with the mainly peraluminous rocks of the Lina suite, are c. 1.80 Ga GSDG-type (Granite-syenite-diorite-gabbro) magmatic intrusive rocks, generally referred to as rock of the Edefors suite. These rocks are related to the Transscandinavian Igneous Belt, which forms a 1,500 km-long, north–south trending belt along the western part of the Svecokarelian orogen (Högdahl et al. 2004). In northeastern Norrbotten, 1.8 Ga syenitoids with associated mafic intrusions occur (Martinsson et al. 2018a). A strong positive regional Bouguer anomaly, called the Merasjärvi or Muonionalusta gravity high (MGH, 40–50 mgal, fig. 5), suggests the presence of a major mafic complex at depth. It is suggested that mafic 1.8 Ga (?) ring gabbros within the MGH are genetically related to these deep-seated large mafic intrusions (Martinsson et al. 2018a). The MGH is located close to the Pajala deformation belt, interpreted as the Norrbotten and Karelian Craton margin (Lahtinen et al. 2015), and mantle-derived magmatic flux into the crust suggests that the area could offer potential for mineral exploration (Hannans Rewards Ltd, press release, 2 February 2015).

Archaean rocks were deformed during a first phase of deformation and metamorphism in Neoarchaean time (Bergman et al. 2001). Polyphase, 1.9–1.8 Ga Svecokarelian ductile deformation and metamorphism reworked the structures in the Archaean rocks as well as deforming the 2.5–2.0 Ga and the 2.0–1.8 Ga Paleoproterozoic, pre-orogenic and syn-orogenic rocks (Bergman et al. 2001, Bergman et al. 2006). The general structural grain is oriented northwest or north-northeast to north, largely controlled by major ductile shear zones with the same orientations (Bergman et al. 2001). Structural domains occur between the shear zones, with major fold structures and other geometries that preserve earlier parts of the polyphase structural evolution. Migmatisation, dated at 1.88 Ga, in such areas (Masugnsbyn) constrains the maximum age of folding of supracrustal rocks. It has been suggested that this is the result of heating by the large volumes of early Svecokarelian intrusions (Hellström 2018).

Metamorphic age determinations in the Pajala deformation belt confirm that deformation and high-grade metamorphism occurred between 1.83–1.78 Ga (Bergman et al. 2006, Hellström & Bergman 2016). In the central and southwestern parts of Norrbotten county, 1.88–1.87 Ga metagranitoid-metasyenitoid intrusions of the Perthite–Monzonite suite show variable low to high degrees of deformation and metamorphic recrystallisation, suggesting a heterogeneous, post-1.87 Ga age of deformation and metamorphism in large areas west of the Pajala deformation belt (e.g. Hellström et al. 2012, 2015, Sarlus et al. 2017).

Several types of hydrothermal alteration of the bedrock are observed in the area, some spatially related to mineralisations, others being of a more regional nature (Bergman et al. 2001). The most characteristic regional types are scapolite and albite alteration (Frietsch et al. 1997). Other alteration products include skarn, albite-carbonate, K-feldspar, sericite, tourmaline, epidote, and chlorite (Bergman et al. 2001). Albite-carbonate alteration, scapolitisation and sericitisation show a spatial relationship with major shear zones (Frietsch 1966, Offerberg 1967, Eriksson & Hallgren 1975, Romer et al. 1996, Frietsch et al. 1997).

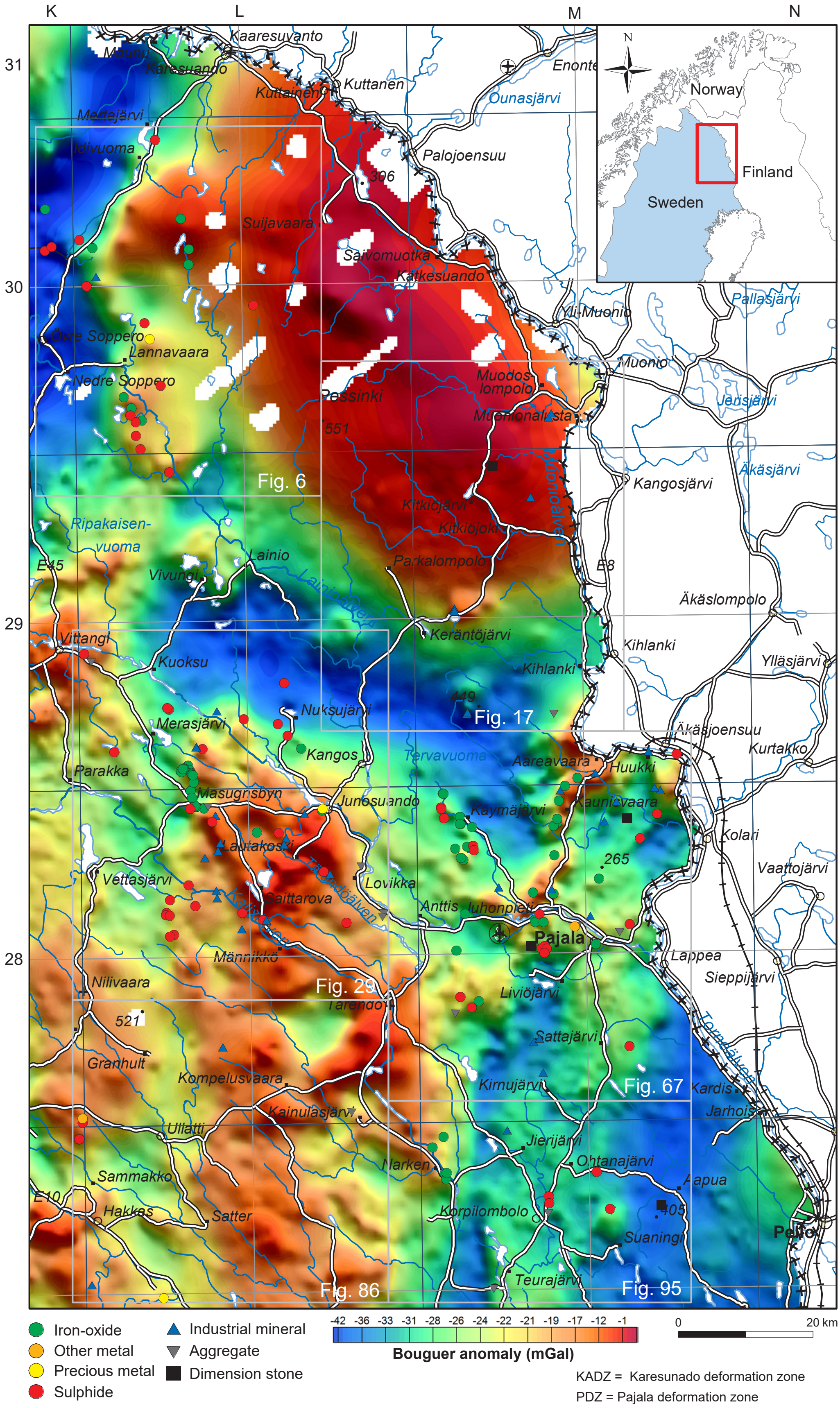


Figure 5. Bouguer anomaly map of northeastern Norrbotten (SGU data). The gravity data were gridded by Johan Jönberger (SGU). Points show locations of mineral and bedrock resources (SGU mineral resources database).

Reviews of mineral and bedrock occurrences in northern Norrbotten have been carried out by e.g. Bergman et al. 2001, Weihed et al. 2005, Martinsson & Wanhainen 2013, Martinsson et al. 2016. Mineral and bedrock occurrences in Norrbotten have been divided into the following main groups:

1. Stratiform Cu ± Zn ± Pb deposits (e.g. Viscaria, Huornaisenvuoma)
2. Iron deposits, including typical banded iron formations (BIF) and skarn-rich iron mineralisations (e.g. iron mineralisations in Pajala and Masugnsbyn)
3. Kiruna-type magnetite-apatite iron ores (not known in northeastern Norrbotten)
4. Epigenetic Cu ± Au mineralisations (e.g. Aitik, Nautanen)
5. Graphite mineralisations (e.g. Nunasvaara)
6. Carbonate rocks (e.g. Masugnsbyn dolomite)
7. Magnesium silicates (e.g. Lauttakoski)
8. Barite (Sattavaara manganiferous iron deposit, accessory minerals in Huornaisenvuoma)
9. Quartz (e.g. Nukutusvaara, Hopukka deposits)
10. Feldspar
11. Aluminium silicates
12. Apatite
13. Aggregate and dimension stone

The first two groups, the stratiform–stratabound base metal and iron deposits, occur in the middle and upper parts of the Karelian greenstones, whereas the Kiruna-type magnetite- apatite deposits occur in rocks of the Svecofennian Kiirunavaara group. Kiruna-type magnetite-apatite mineralisations are absent in northeastern Norrbotten. Epigenetic deposits include a variety of mineralisation styles and are hosted by rocks of both Karelian and Svecofennian age. Graphite and dolomite occurrences are mainly found in the uppermost part of the Greenstone group, but also occur in the overlying Svecofennian sedimentary rocks. Small amounts of barite are found at the Sattavaara manganiferous iron deposit south of Lannavaara (Ambros 1980). Barite also occurs as a disseminated accessory mineral in a few stratiform sulphide ores (Viscaria and Huornaisenvuoma, Bergman et al. 2001). Aluminium silicates, i.e. sillimanite and andalusite, mainly occur in Svecofennian mica schists and paragneisses in the Masugnsbyn and Pajala areas. Apatite iron ores (west of the study area) contain an average of 1–5% P, and are also a potential resource for REEs (Frietsch & Perdahl 1995, Bergman et al. 2001). Several gabbroic intrusions in northeastern Norrbotten are rich in apatite and contain between 1 and 3% phosphor (Bergman et al. 2001).

DESCRIPTION OF MINERAL AND BEDROCK RESOURCES

The Karesuando–Soppero–Lannavaara area

The Karesuando–Soppero–Lannavaara area is dominated by large volumes of Palaeoproterozoic granitoids and syenitoid, which generally host few mineral occurrences. Most of the known mineralisations are iron oxide or sulphide base metal-gold occurrences hosted by the Palaeoproterozoic meta-andesite to metabasalt and related metasediments (fig. 6). The known mineral occurrences are generally not exposed in outcrops; most were found by airborne geophysics and core drillings back in the 1970s (fig. 7). Some of the sulphide mineralisations are exposed in outcrop, and most were visited and documented during the current inventory.

Archaean rocks of the Råstojaure complex occur in the northwestern corner of the area (fig. 6) and are clearly outlined on the magnetic anomaly map as a low-magnetic area (fig. 7). The Karesuando–Arjeplog deformation zone (KADZ) strikes NE–SW east of and parallel with the Archaean boundary, transecting the Karelian rocks. To the east, the Archaean basement is overlain by a series of clastic sediments consisting of quartzite and conglomerate belonging to the Tjärro quartzite group, and further east, by Karelian greenstone group rocks, which generally have a high magnetic response (figs. 6, 7; Ödman 1939, Ambros 1980, Kumpulainen 2000, Luth & Berggren 2013, Luth et al. 2014). The greenstone rocks mainly consist of basaltic lavas and common dolerite sills, locally showing strong carbonate-albite alteration (fig. 7). Minor Cu ±Au sulphide mineralisations are associated with the greenstones, which are generally indicated by the elevated copper concentrations in till geochemistry (fig. 8). Till geochemical analyses of gold show only a few scattered anomalies, none directly related to known gold mineralisations, but one anomaly coincides with the Palovaara iron mineralisation in the Archaean–Proterozoic border zone (fig. 9). In the uppermost part of the Greenstone group, carbonate horizons and graphitic schists alternate with tuffitic layers. Skarn-bearing magnetite mineralisations are common in the uppermost unit, for example the Sattavaara and Sautusjärvi–Paljasjärvi iron prospects. The stratiform Huornaisenvuoma zinc-lead-silver-copper deposit is the largest sulphide deposit in northeastern Norrbotten, and is hosted by a thick dolomite in the upper part of the Greenstone group (Martinsson 1995). A positive Zn anomaly may be seen on the till geochemistry anomaly map (fig. 10), just north of the Huornaisenvuoma mineralisations.

The Greenstone group is preserved in the core of an anticline and is overlain by Svecofennian clastic metasedimentary rocks (quartzites and schists) of the Pahakurkkio group, and intermediate metavolcanic rocks of the Kiirunavaara group (Porphyry group, Ambros 1980, Frietsch 1985). Svecofennian supracrustal rocks occur in the south-central part of the map area (fig. 6). The Kevus and Teltaja iron mineralisations occur in trachytes and trachyandesite. Their lithostratigraphic position is uncertain, but they may belong to the younger Kiirunavaara group (Frietsch 1985).

Airborne Transient Electromagnetic measurements (TEM) were performed by SGU in 2013 within the scope of the Barents Project in an area from Kiruna to east of Soppero and included the central-western part of the Karesuando–Soppero area (fig. 11, Persson 2015). The TEM technique reveals electrical conductors in the ground, and most of the TEM anomalies shown in fig. 11, coincide well with old slingram measurements and known sulphide and iron mineralisations, and graphite schists in the area. However, a strong conductor is noted in the area south of the Paljasjärvi Fe prospect. The area is low-magnetic (fig. 7) and the TEM anomaly cannot therefore be caused by a continuation of the Palasjärvi iron ore horizon (fig. 11), but may be caused by graphite- and/or sulphide-rich rocks.

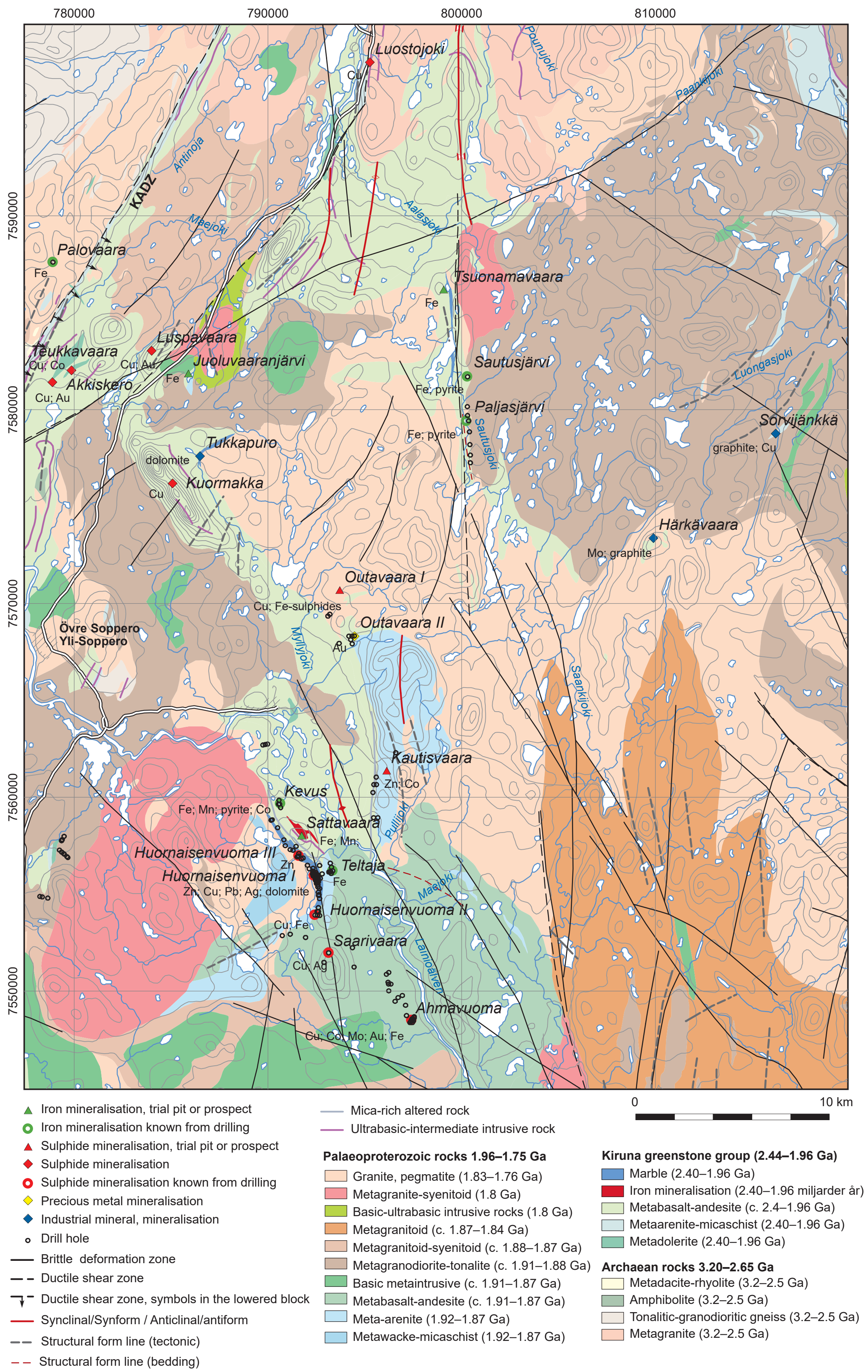


Figure 6. Bedrock geology map of the Karesuando–Soppero–Lannavaara area (modified from Bergman et al. 2001).

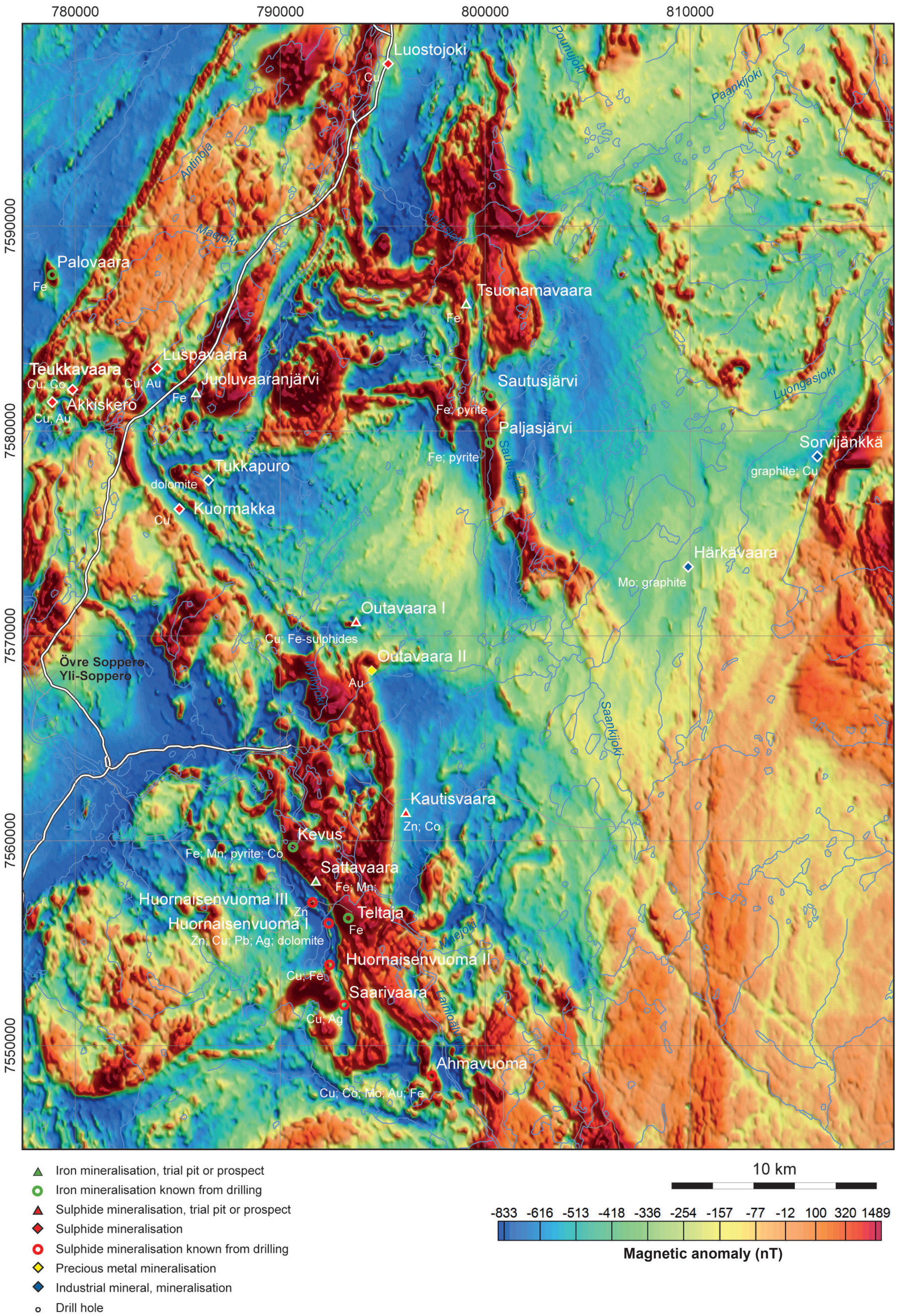


Figure 7. Magnetic anomaly map of the Karesuando–Soppero–Lannavaara area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU). Points show the locations of mineral and bedrock resources (SGU mineral resources database).

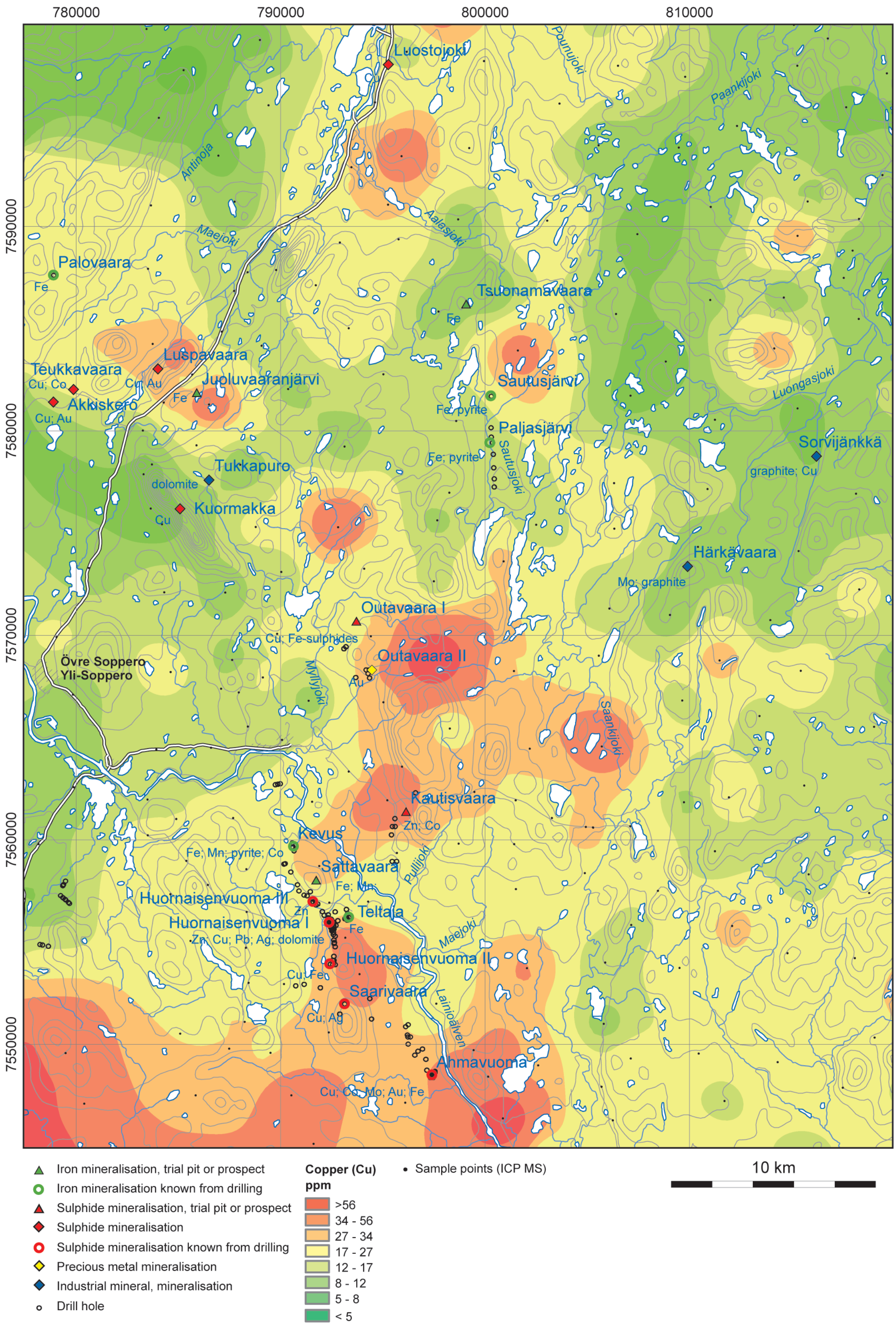


Figure 8. Copper concentrations in till (acid leach, ICP–MS data) for the Karesuando–Soppero–Lannavaara area.

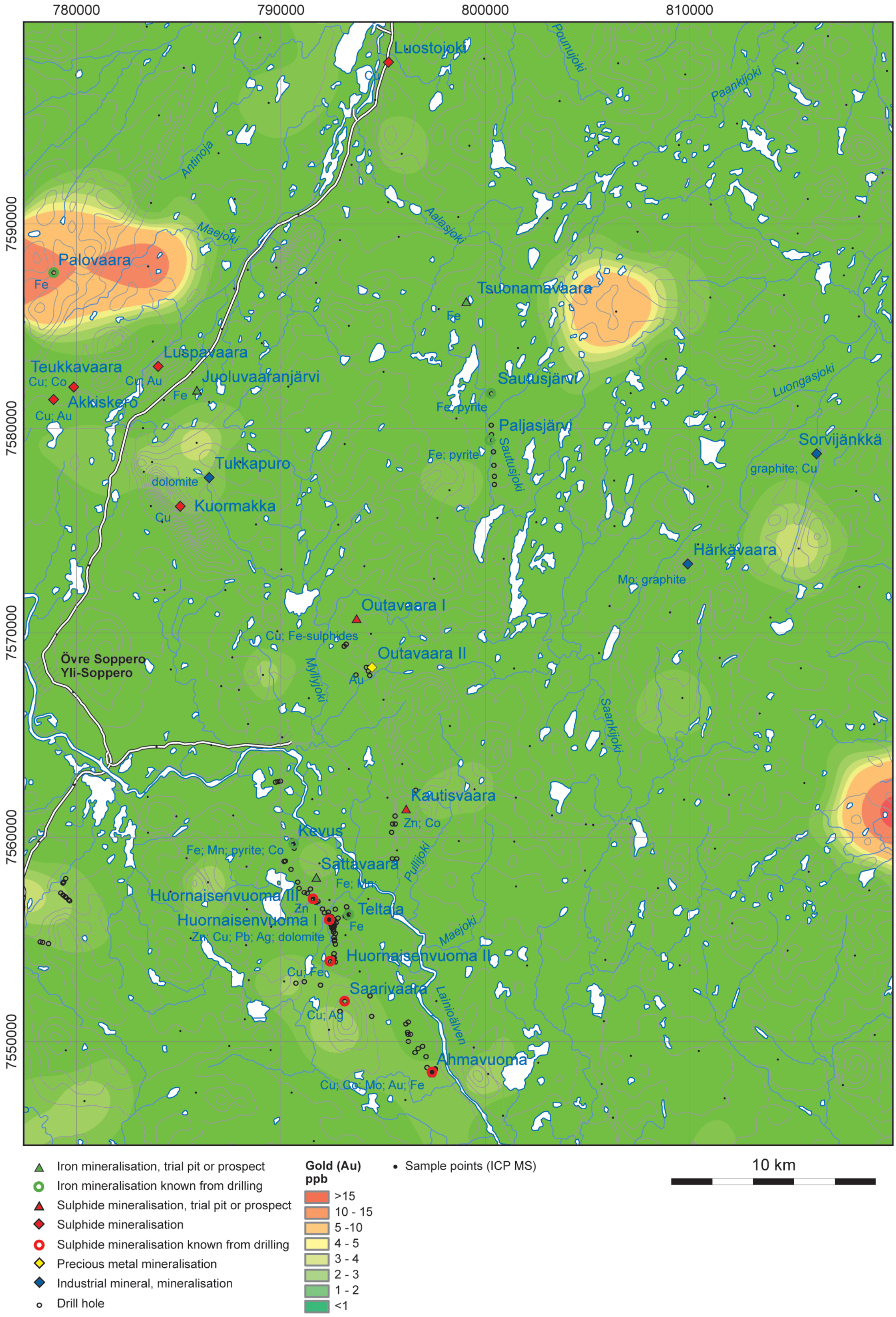


Figure 9. Gold concentrations in till (acid leach, ICP–MS data) for the Karesuando–Soppero–Lannavaara area.

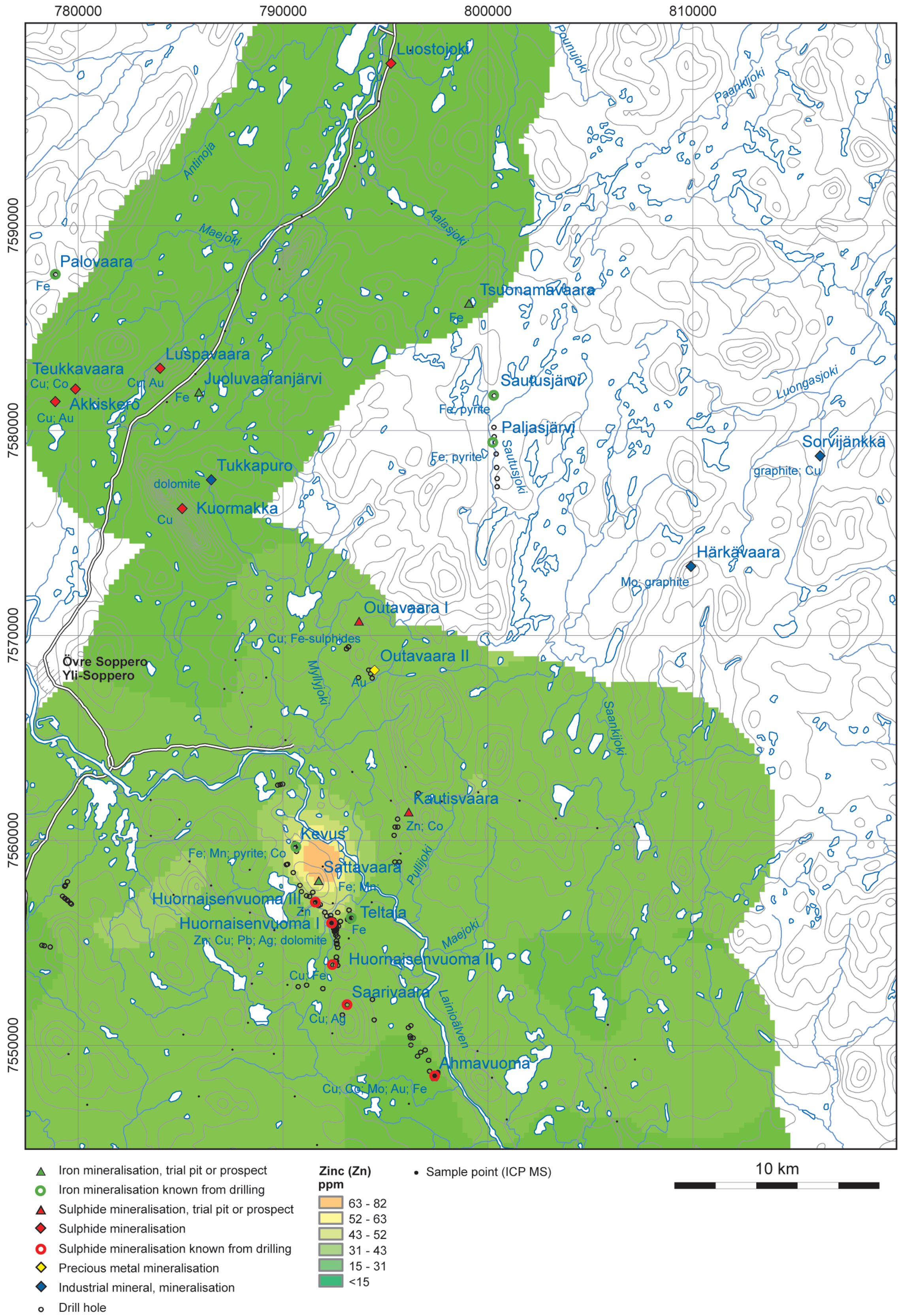


Figure 10. Zinc concentrations in till (acid leach, ICP–MS data) for the Karesuando–Soppero–Lannavaara area.

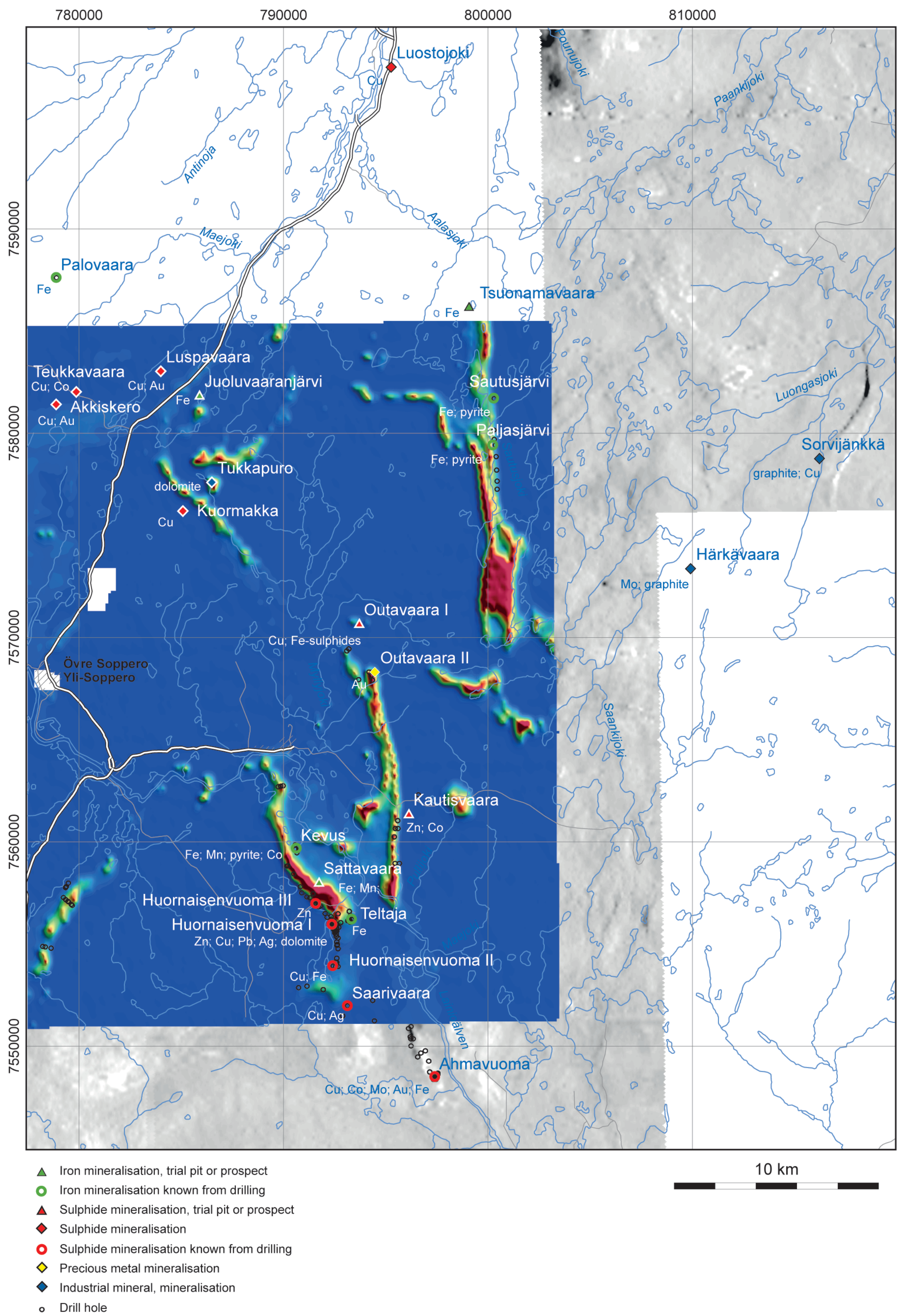


Figure 11. Electromagnetic maps of the Karesuando–Soppero–Lannavaara area (SGU–LKAB–NSG data). Transient electromagnetic map (in colour) and slingram anomaly map in grey scale. Red on the TEM map and dark grey on the slingram map show good conductors. The geophysical data were gridded by Johan Jönberger (SGU).

Iron oxide mineralisations

Palovaara	ORED00228	
Fe (drilling)	E 778887	N 7587614

The Palovaara iron ore prospect, 20 km north of Övre Soppero, was discovered by SGU in 1967 using airborne magnetic measurements. The mineralisation is located in an area covered by Archaean gneisses, about 2 km west of the Tjärro quartzite, which forms the contact with the Palaeoproterozic rocks to the east (fig. 6). The magnetic anomaly is an isolated magnetic high, 1 km long and trending north-northwest (Fig. 7). The Palovaara prospect was drilled in 1972 with one drill hole, graded 60 degrees eastwards and to a depth of 154 m. The mineralisation appears to be tectonically emplaced, and consists of magnetite in quartz veins in both granite and gabbro. Pyrite veins occur locally (Hallgren 1972, Frietsch 1997). The mineralisation is of a low grade. A 5-metre-long drill hole section contains 7.7% Fe, 0.055% P and 0.76% S (Frietsch 1997). Till geochemistry shows anomalous gold values at the location, but no whole-rock gold analyses are known from the mineralisation. Anglo American Exploration had an exploration permit (Saarijärvi no. 3) for the Palovaara prospect between 2004 and 2010, and performed electromagnetic and magnetic measurements.

Juoluvaaranjärvi	ORED00335	SLH150116
Fe (outcrops)	E 785899	N 7581876

Outcrops with exposed iron skarn occur northwest of Lake Juoluvaaranjärvi, 15.5 km north-northeast of Övre Soppero. The outcrops were found during SGU bedrock mapping of the area in 1966 and were revisited by SGU in 2015 (field note SLH150116). Anglo American Exploration had an exploration permit (Saarijärvi no. 4) for the Juoluvaaranjärvi prospect between 2004 and 2010, and performed air and ground electromagnetic and magnetic measurements in the area. The exposed ore zone is described by Frietsch (1967) as being approximately 10 m wide, with a length of 100 m along strike towards the north-northeast. The ore zone is a magnetite skarn-banded sequence consisting of diopside, tremolite-actinolite and small amounts of garnet and epidote (Frietsch 1967). The zone is partly banded with bands of pure magnetite up to 10 cm thick (SLH150116). The magnetite skarn is hosted by metasediments and metabasic volcanic rocks belonging to the upper part of the Greenstone group (2.4–1.96 Ga, fig. 6). The magnetite-bearing skarn and host rock is folded and locally cut by 0.5-m-wide veins of isotropic quartz-diorite that are suggested to belong to the Haparanda suite (Frietsch 1967). Xenoliths of magnetite skarn, up to 1 m in size, are also found in the quartz-diorite. Frietsch (1967) stated that the skarn iron ore cannot have formed from this intrusive source. In fact, he assigned a sedimentary origin to these skarn-banded iron ores. In addition, metasedimentary rocks occur east of the ore zone, including quartzite and a dark metasedimentary rock (Frietsch 1967).

Sautusjärvi	ORED00226	
Fe, Fe sulphide (drilling)	E 800284	N 7581704

The Sautusjärvi iron ore prospect, 25 km northeast of Övre Soppero (fig. 6), was drilled by SGU in 1972 (one drill core, 249 m). The ore body constitutes the northernmost part of the ore horizon and magnetic high defining the Paljasjärvi iron ore prospect described below (fig. 7). Iron mineralisations occur in a narrow band of supracrustal rocks between Lakes

Sautusjärvi och Paljasjärvi. These rocks probably belong to the upper part of the Greenstone group. SMOY performed ground magnetic measurements for Anglo American Exploration/ Northland Exploration Sweden AB in 2007, covering the area of the Sautusjärvi–Paljasjärvi mineralisations. Drilling of the Sautusjärv iron mineralisation showed a 10-m-thick magnetite skarn iron ore horizon 100 m below the surface in banded amphibolites (Ambros 1980, Frietsch 1997). The mineralisation includes some pyrrhotite, pyrite and small amounts of chalcopyrite. The grades reported are 30–40% Fe, 0.02–0.04% P, 0.02–0.09% S and 0.02–0.06% Mn (Frietsch 1997). The ore horizon dips to the east. No outcrops are present in the area and the site was not visited during the present inventory.

Paljasjärvi	ORED00087	
Fe, Fe sulphide (drilling)	E 800235	N 7579415

The Paljasjärvi iron ore prospect is situated 24 km northeast of Övre Soppero and constitutes a continuous magnetic high, 3.5 km long, and trending north–south (fig. 7) which also contains the Sautusjärvi iron ore prospect (see above). The Paljasjärvi iron ore prospect was drilled at seven sites in 1963 following ground magnetic measurements (Jonasson 1987). Specified coordinates represent the position of drill hole Bh6306 in the centre of the anomaly. West and stratigraphically below the iron mineralisation horizon, are sulphide-rich graphite schist, skarn, marble, and "jaspisquartzite". Banded amphibolite occurs east of the mineralisation (Ambros 1980). The ore horizon dips to the east and consists of a 10-m-thick, magnetite-diopside-actinolite-phlogopite skarn (Grip & Frietsch 1973). The richest parts hold an average of 46% Fe, 1.2% S and 0.09% P. A rough historical estimate suggests 45 million tonnes of ore with 40% Fe to a depth of 300 m (Jonasson 1987). Varying amounts of sulphides follow the magnetite ore, mainly pyrite and pyrrhotite, but traces of chalcopyrite have also been noted. Chemical analyses of sulphide-rich drill core sections and outcrops were presented by Jonasson (1987); only trace amounts of Cu, Mo and Au were detected, Cu < 0.15%, Mo < 160 ppm, and Au < 0.02 ppm. Hannans Reward Ltd evaluated the Paljasjärvi iron ore prospect in 2014, but it is unclear whether any further exploration work was done (Hannas Reward Ltd, 1 July 2014).

Tsuonamavaara	ORED25963	
Fe (outcrop)	E 799070	N 7586210

Magnetic anomalies north and southwest of Sautusjärvi and to the west under Lake Kallojärvi (30L 6c) probably reflect minor iron mineralisations (Ambros 1980). The area has been investigated by ground geophysical surveys, but none of the anomalies have been considered of interest for further investigations, and no drilling has so far been performed. An outcrop at Tsuonamavaara, north of Sautusjärvi (799070/7586210, obs. MA42/68), has a 0.5-m-wide skarn-bearing magnetite mineralisation hosted by banded, mafic sedimentary rocks and amphibolites. Layers of quartz and calcite run parallel with the magnetite layers. The mineralisation contains approximately 35% Fe, 0.08% P and 0.005% S (Ambros 1980, Frietsch 1997).

The Lannavaara ore district

The Lannavaara ore district forms a magnetic high, 6 km long, trending north–south to north–northwest, comprising the Kevus, Sattavaara and Teltaja iron prospects (figs. 7, 12). Kevus and Teltaja contain magnetite-hematite in massive bodies, veins or impregnations in trachyandesites and trachytes of uncertain lithostratigraphic position, belonging either to the

Kiirunavaara group or the Greenstone group. Sulphur isotopic compositions of the sulphides in the mineralisations (δ_{34S} = –1.8 to +31.2‰) show affinity to skarn iron ores and quartz-banded iron ores of the Greenstone group (Fritsch 1985, 1997, Fritsch et al. 1995). The Sattavaara ore is made up of a magnetite skarn-layered chert, and occurs in this uppermost unit of the Greenstone group (Fritsch 1985). The mineralisations were discovered in 1920–1921 by magnetic measurements performed by AB Nordsvenska malmfält Company (Högbom 1924, Frietsch 1997). The Lannavaara ores were investigated in more detail in 1967 using magnetometric and gravimetric methods (Ambros & Nylund 1976, Frietsch 1985). Drilling was carried out on Kevus and Teltaja in 1970–71, and exploration trenches were dug over the Sattavaara prospect. SMOY performed ground magnetic measurements for Anglo American Exploration/Northland Exploration Sweden AB in 2007, covering the area of the Kevus, Sattavaara and Teltaja prospects (Exploration data from Anglo American Exploration supplied to SGU) Hannans Reward Ltd evaluated the Lannavaara iron ore prospects in 2014, but it is unclear whether any further exploration work was done (Hannas Reward 1 July 2014). A brief description is given below for each prospect based on exploration reports and summaries presented.

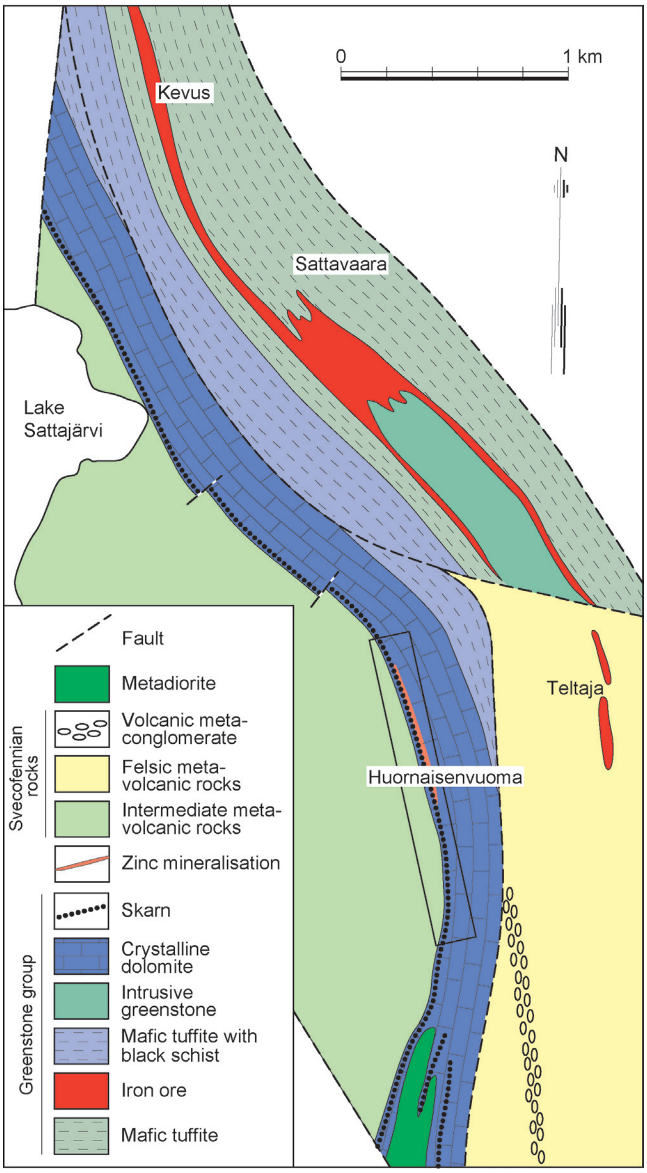


Figure 12. Geological map of the Lannavaara ore district (from Martinsson 1995 in Bergman et al. 2001).

Kevus	ORED00074	
Fe (drilling)	E 790632	N 7559677

The Kevus iron ore prospect is situated 5 km south of Lannavaara and is the northernmost prospect in the Lannavaara ore district (Ambros & Nylund 1976). It does not crop out, and is mainly situated under Lake Kurkkiojärvi and associated bog areas. Geophysics and drilling indicate that the mineralised zone is about 600 m long and 100 m wide, striking approximately north–south, and dipping 80–85 degrees to the west. The mineralisation is hosted by a layered metatrachyte, partly with strong scapolitisation (Ambros & Nylund 1976, Frietsch 1985). The main ore mineral is magnetite, which occurs in veins one millimetre to one centimetre wide, along with iron sulphides and skarn minerals, forming something resembling an "intrusive breccia" (Frietsch 1985). Magnetite also occurs as an even impregnation with skarn minerals like diopside, scapolite and hornblende. Small amounts of tourmaline, fluorite and analcime are present. The ore varies between 39 and 24% Fe and generally has a low content of manganese (< 0.5% Mn). In addition, in some of the magnetite-rich sections, small amounts of chalcopyrite have been noted. The copper content is up to 0.14% Cu (Ambros & Nylund 1976). Based on chemical analyses, the Kevus mineralisation is estimated to contain 38.8 million tonnes of ore with an average grade of 28% Fe (Frietsch 1985).

Sattavaara	ORED00223	
Fe, Mn (outcrops)	E 791743	N 7558025

The Sattavaara iron ore prospect is situated 6.5 km south of Lannavaara in the middle of the Lannavaara ore district (fig. 12). Like Kevus, Sattavaara was discovered in 1920–21 by AB Nordsvenska malmfält company and was further investigated by SGU by trenching and detailed geological mapping in 1971 (Ambros & Nylund 1976). A magnetite skarn zone hosted by chert, 100 to 300 m wide, was revealed in the central part of the prospect (Frietsch 1985). Skarn minerals and magnetite occur banded in 1 to 2-cm-wide layers. Narrow horizons of dolomitic marble, a few metres thick, also occur within the zone. The richest magnetite zone is 10 m wide and contains 33% Fe. The presence of manganese silicates is typical of the magnetite skarn zone, differentiating it from other skarn iron ores in northern Norrbotten (Frietsch 1997). Manganese content is generally 1–2%, but occasionally reaches 10% (Frietsch 1985). The silicates and skarn minerals clinopyroxene, biotite, garnet, microcline and hornblende have been noted, along with magnetite ore. The magnetite skarn zone contains iron sulphides and traces of chalcopyrite, locally with 0.2–0.3% Cu in metre-wide sections (Frietsch 1985). Marble horizons are all anomalous in zinc (Ambros & Nylund 1976). Characteristic of the whole zone is enrichment of barium, mostly exceeding 0.2% BaO, but there are sections with 1–10% BaO (Frietsch 1985). The presence of barium as a trace element is typical of the silicates at Sattavaara, the highest concentration being found in microcline (Frietsch 1997).

Teltaja	ORED00107	
Fe (drilling)	E 793332	N 7556200

The Teltaja iron prospect is situated 8.8 km south of Lannavaara, and is the southernmost prospect in the Lannavaara ore district (fig. 12). Like Kevus, the Teltaja prospect was drilled in 1971 with 7 drill holes totalling 1,703 m (Frietsch 1985). Three of the drill cores are still available at the SGU drill core archive at Malå. The Teltaja prospect is covered by glacial drift but, based on geophysics and drilling, the ore-bearing zone can be estimated to be 1 km long striking north–south and southeast. The mineralised zone is hosted by a felsic metavolcanic rock suggested as belonging to the Kiirunavaara group and divided into two parts dislocated by a fault trending east-northeast–west-southwest (Frietsch 1985). The ore minerals are magnetite and hematite, mainly present in quartz-rich breccia veins, along with microcline, albite, scapolite, tourmaline, fluorite, analcime and minor amounts of iron sulphides. The ore tonnage is estimated at 43 million tonnes, with an average grade of 41% Fe (Frietsch 1985, Frietsch 1997). The southern ore body contains 0.2–0.5% Mn, with short sections of 1–2% Mn bound to calcitic parts of the ore (Frietsch 1985).

Sulphide mineralisations

Luostojoki	ORED25658	STB961005
Cu (outcrop)	E 795252	N 7597936

Luostojoki is located 16 km southwest of Karesuando, and is a weak copper mineralisation found in outcrop during the mapping of the area in 1996 (Bergman et al. 2001). The mineralisation consists of visible malachite hosted by fine-grained andesitic metavolcanic rock. The andesite is strongly foliated N20°/78°, corresponding to the nearby Karesuando Arjeplog Deformation Zone (KADZ, fig. 6). The malachite is mainly observed on fracture planes and was most likely formed secondarily after disseminated chalcocite or chalcopyrite. The weak mineralisation has not given rise to any chemical Cu anomaly in the till chemistry from the area (fig. 8).

Luspavaara	ORED15390	
Cu, Au (outcrops)	E 783982	N 7583051

Outcrops of meta-andesite to metabasalt with quartz veins and quartz-filled vesicles with chalcopyrite and pyrite occur on Luspavaara hill, 16 km north-northeast of Övre Soppero (Carlson 1982a). Chemical analysis returned grades up to 0.5% Cu and 0.5 ppm Au (Carlson 1982a). The mineralised outcrop could not be found during the present inventory, and the above coordinates must be assumed to be highly uncertain.

Teukkavaara	ORED25964	SLH131092
Cu, Co	E 779848	N 7582045

SGU (S. Luth) noted a copper mineralisation in outcrop southwest of Teukkavaara, 13.5 km north of Övre Soppero during the Barents Project in 2013 (Luth & Berggren 2013). According to van der Stijl (2005), the mineralisation (chalcopyrite and bornite) occurs along a 60–80 m section along strike of the north-northeast-striking, regional Karesuando–Arjeplog shear zone in a tectonised, albite-carbonate-altered mafic volcanic rock with quartz veins (fig. 6). Chemical analysis of a sample from the mineralisation (SLH13092B) shows a Cu content of 5%, < 0.2 ppm Au and 875 ppm Co (SGU lithogeochemical database).

Akkiskero	ORED25652	TOB150025
Cu, Au	E 778862	N 7581428

Akkiskero is a Cu-Au mineralised outcrop 1.1 km north of Lake Anteruksenjärvi, 13 km north of Övre Soppero (fig. 6). The mineralisation was discovered in 2003 by Torbjörn Lindwall from Lannavaara, who was awarded first prize for the find in *Norrlands mineraljakt* ("Northern Sweden Mineral Hunt") 2003. Anglo American Exploration BV (AAE) had an exploration permit (Saarijärvi no 2) for the Juoluvaaranjärvi prospect between 2004 and 2009. An airborne magnetic and frequency domain EM survey was conducted by GTK for AAE over the Saarijärvi concession area in 2004, leading to several new geophysical targets. Areas of known Cu mineralisation could be recognised as anomalies on the AEM conductivity map, enhancing the prospectivity of the Saarijärvi concession (van der Stijl 2005). AAE completed some geological field reconnaissance work in the summer of 2004, confirming the reported Cu occurrences in outcrop. The Cu prospectivity of the Teukkavaara–Akkiskero area is confirmed by a strong (up to 0.8% Cu) peat bog anomaly (van der Stijl 2005, SGU data).

The mineralisation is related to a 0.5 × 0.5 m lens of milky quartz in a strongly foliated meta-andesite of the same type as the outcrops at Luostojoki, Luspavaara and Teukkavaara, described above (fig. 13A). As at Luostajoki, the only visible copper mineral is malachite, which is found on fracture planes in the milky quartz and in the metavolcanite (fig. 13B). Quartz lenses are found in several outcrops nearby, but no copper minerals were noted.

Figure 13A. Outcrop with a copper-mineralised quartz lens in meta-andesite north of Anteruksenjärvi. Photo: Torbjörn Bergman.

Figure 13B. Close-up of malachite on fracture planes in meta-andesite and quartz at Anteruksenjärvi. Photo: Torbjörn Bergman.

Chemical analysis of selected samples of the malachite mineralised metavolcanite showed 0.5% Cu and 0.005 ppm Au (Appendix 2). Grades of up to 5.1% Cu and 0.19 ppm Au can be detected in previously analysed samples (sample 032221-1, Arnbom et al. 2003). The presence of several vein quartz-related copper-gold mineralisations in Karelian meta-andesites in the Karesuando–Soppero area indicates exploration potential for the area (fig. 6). The spatial association to the Karesuando–Arjeplog Deformation Zone (KADZ) may imply a shear zone-related origin for the mineralisations. Copper concentrations in till samples are also somewhat elevated in the area (fig. 8).

Kuormakka	ORED15391	
Cu (outcrop)	E 785057	N 7576205

The copper mineralisation close to the top of Kuormakka hill was discovered in 1986 by Ove Pettersson from Lannavaara, who sent a sample to SGU as well as the ongoing *Norrlands mineraljakt* (Hansson 1986c). Chemical analysis of the sample revealed 1.35% Cu, 0.1 ppm Au, 5 ppm Ag and 1.78% S. The mineralisation is hosted by a silicified meta-andesite to metabasalt and is most likely of the same type as previously described Cu mineralisations in the area. An effort to find the mineralisation at Kuormakka was made during this inventory but the Cu-mineralised outcrop was not found (fig. 14). A copper-mineralised outcrop from the Kuormakka area, with 0.55% Cu, is also described by Virkkunen et al. (1984). However, no coordinates were presented in the report and this was not followed up in the present inventory.

Figure 14. View towards the southeast from the central part of Kuormakka hill, summer 2015. Photo: Torbjörn Bergman.

Outavaara I	ORED25654	TOB150031
Cu, Fe sulphide (trial pits)	E 793705	N 7570698

Two trial pits in a Fe sulphide-chalcopyrite disseminated felsic to intermediate metavolcanic rock have been dug on the hillside 2 km northwest of Outavaara hill and 6.8 km northeast of Lannavaara (fig. 6). The pits are approximately 6 × 2 m wide, with a maximum depth of 1 m (fig. 15). Excavated material is piled beside the pits and is iron oxide-weathered. The exposed wall rock reveals a strongly foliated and lineated felsic to intermediate metavolcanic rock. Foliation is approximately to the northwest and lineation to the southeast. Due to the high concentration of magnetic pyrrhotite, it is not possible to measure the structural orientation with a compass with confidence. The magnetic anomaly map suggests that the mineralisation is very localised (fig. 7). A sample from the excavated rock sent to Norrlands mineraljakt 2005 (sample 05-230 1), shows a Cu content of 3.3% and 0.17% Co (Bildström 2005). Samples analysed during the present inventory returned maximum values of 0.5% Cu, 0.05% Co and > 10% S (Appendix 2). A positive Cu anomaly can be seen in the till geochemistry southeast of the prospect (fig. 8).

Figure 15. The trial pits at the Outavaara prospect, looking towards the northwest. Photo: Torbjörn Bergman.

Outavaara-II	ORED15722	
Au-Cu (drilling)	E 794455	N 7568315

The Outavaara Au-Cu prospect is situated on the southwestern slope of Outavaara hill, 5.3 km northeast of Lannavaara. According to the SGU bedrock map, the prospect is in graphite schist of the upper part of the Kiruna greenstone group (Af 27, Ambros 1980). The prospect was drilled in 1986–87 with 8 drill holes totalling 1,397 m (SGU 1987). The drilling programme was mainly based on a strong positive magnetic anomaly identified by LKAB Prospektering (fig. 7; Lehto 1984). The most promising results were obtained in three drill holes penetrating a graphite-bearing metasedimentary sequence with a 3-m-thick massive pyrrhotite horizon. The mineralised horizon is clearly visible on the TEM anomaly map from 2015 (fig. 11). Chemical analyses of drill core samples show grades of up to 2.5 ppm Au, 0.5% Cu and 0.1% Zn (SGU 1987). The area of the Outavaara mineralisations was covered by exploration permit Lannavaara no 1001, issued to Boliden Mineral AB (2007–2013). The company performed electromagnetic ground measurements over an area covering 17.4 km^2.

Kautisvaara	ORED25955	
Zn, Co	E 796130	N 7561381

An excavated and blasted 2 × 1.5 m outcrop of graphite schist, rich in pyrite and pyrrhotite, occurs at Kautisvaara, 19 km east-southeast of Övre Soppero (upper Kiruna greenstone group, fig. 6). The outcrop was discovered by Torbjörn Lindvall, who was awarded a prize by SGU and *Norrlands Mineraljakt* for the find in 1999. A chemical analysis of a sample from the outcrop shows a content of 0.45% Zn, 0.09% Cu, 0.09% As and 986 ppm Co (SGU 1999, SGU protocol 99291:1).

Huornaisenvuoma

The Huornaisenvuoma Zn-Pb-Cu prospects are situated approximately 9 km south of Lannavaara, and were discovered in 1979 by LKAB Prospektering AB. The discovery was based on results obtained from exploration work that began in 1977, comprising geophysical ground measurements and boulder tracing (Virkkunen 1984). More than 50 cores were drilled on the prospect. These show that the mineralisation is stratiform and hosted by a skarn horizon in dolomite bounded by quartzite and an intermediate tuffite to the west, and marble to the east (Lehto 1979). A unit of graphitic schist east of the marble can be clearly seen in electromagnetic data (Fig. 11). The units occur in the uppermost part of the Greenstone group (Forsman 1988). The mineralised horizon trends mainly north–south, and can be followed for 4 km from east of Lake Rovajärvi in the south (Huornaisenvuoma II) to Lake Sattajärvi in the north (Huornaisenvuoma III, fig. 16; Lehto 1979). The richest Zn-Pb skarn mineralisation is identified in the central part, 1 km west of the Teltaja iron prospect (Huornaisenvuoma I). A thin stratiform sulphide horizon exists at the base of a 20–35-m-thick skarn zone in the upper part of the dolomite, and a further mineralised horizon exists in the upper part of the skarn. A short summary of each prospect is presented below. Two additional sulphide prospects, Saarivaara and Ahmavuoma, occur in the extension of the Huornaisenvuoma mineralised zone, and are also described here.

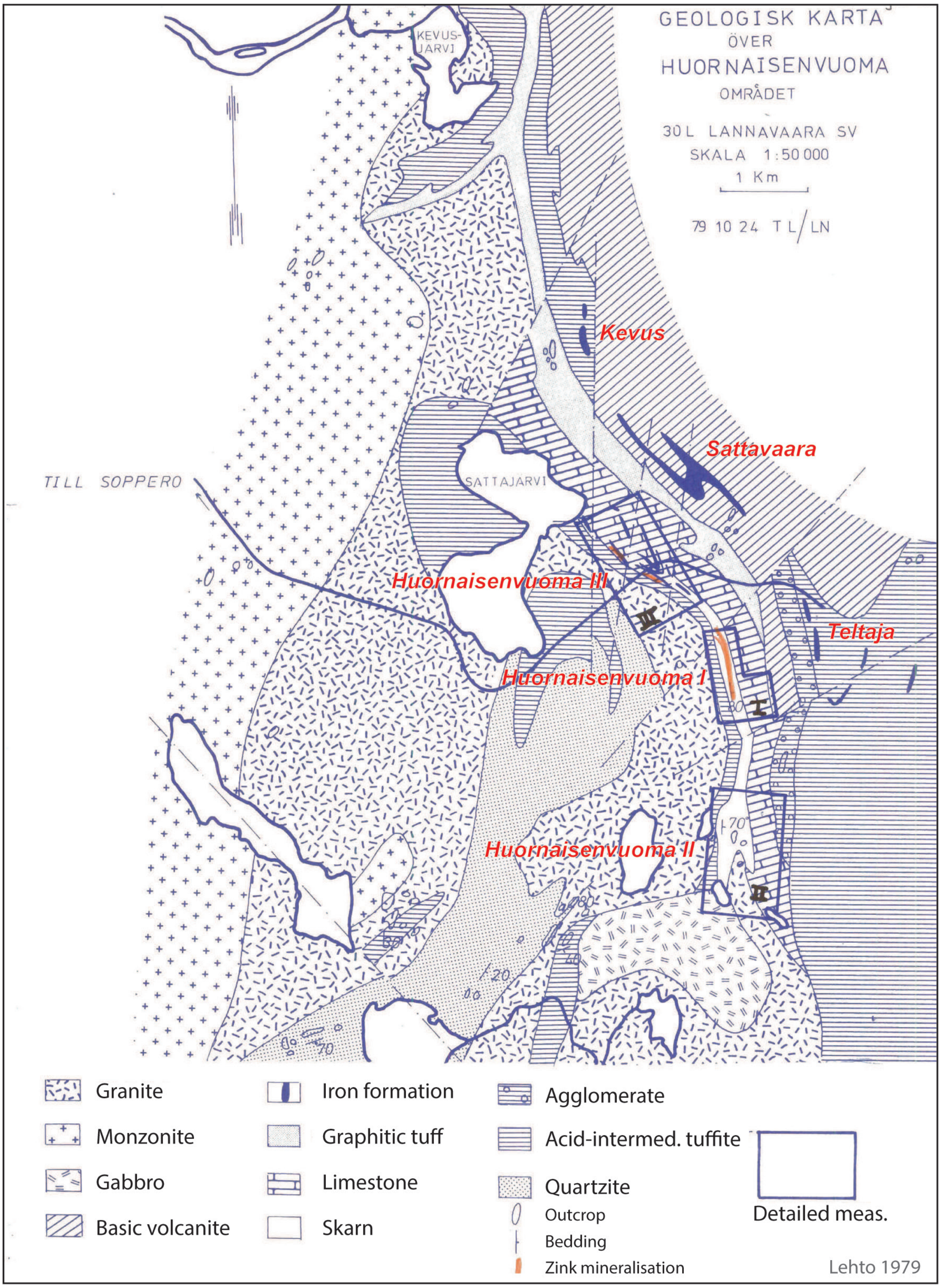


Figure 16. Huornaisenvuoma Zn-Pb sulphide prospects (from Lehto 1979).

Huornaisenvuoma I	ORED00835	
Zn, Pb, Ag, Cu (drilling)	E 792372	N 7555953

The Zn-Pb prospect Huornaisenvuoma I is situated 1 km west of the Teltaja iron prospect and is the most promising part of the Huornaisenvuoma zone. The mineralisation consists of a 600-m-long, sphalerite-galena skarn horizon, 0.5 to 20 m wide and dipping 70 degrees to the east (Lehto et al. 1987). Chemical analyses of drill cores give a tonnage estimate of 0.56 Mt, with 4.8% Zn, 1.7% Pb, 0.2% Cu and 12 ppm Ag (Lehto et al. 1987).

Huornaisenvuoma II	ORED15720	
Cu, Fe (drilling)	E 792413	N 7553921

The Huornaisenvuoma II prospect is situated 2 km south of Huornaisenvuoma I, and is the southern continuation of the skarn horizon. The mineralisation is indicated by a weak positive magnetic anomaly, which was drilled in 1979 with three holes (Lehto 1979). Zn is not present but Cu concentrations of up to 0.74% over a one-metre section in drill hole KHUO-4 were recorded. In addition, Mn content of up to 1.5% is seen in a magnetite-rich skarn (Lehto 1979).

Huornaisenvuoma III	ORED15717	
Zn (drilling)	E 791580	N 7556972

Huornaisenvuoma III, situated 1 km southeast of Lake Sattajärvi and 1.2 km southwest of the Sattavaara Fe prospect, is well defined by a circular positive magnetic anomaly. It is the northernmost prospect in the mineralised skarn horizon. The magnetic anomaly was drilled in 1979 (Lehto 1979), and Zn- and Cu-mineralised skarn and marble were identified within a fold structure. Zinc mineralisation is weak and occurs in magnetite-bearing skarn and skarn-altered marble. The copper mineralisation occurs in skarn-altered marble on the northwestern limb of the fold structure and returned up to 0.3% Cu (Lehto 1979).

Saarivaara	ORED00879	
Cu (drilling)	E 793126	N 7551960

Saarivaara is the presumed southern extension of the Zn-Cu-bearing skarn horizon identified in the Huornaisenvuoma prospects. Saarivaara was drilled in 1981 with two holes (Lehto 1981a). The drilling did not encounter the zinc-bearing skarn horizon, but an intermediate magnetite-chalcocite-bearing metatuffite was found. Chemical analyses show an average of 0.58% Cu and 5 ppm Ag over a 5-metre section of core (Lehto 1981b).

Ahmavuoma	ORED00879	
Cu, Co; Au, Fe (drilling)	E 797398	N 7548494

The Ahmavuoma prospect is situated 18 km southeast of Lannavaara, and was identified in the early 1980s by a positive magnetic anomaly with high electrical conductivity (Lehto 1983, 1987). The magnetic anomaly was assumed to be a southern continuation of the Kevus and Telja iron ore prospects. Drilling showed a fractured and biotite-microcline-scapolite-altered felsic to intermediate metavolcanic rock with veins and disseminations of magnetite, pyrite and chalcopyrite. The altered rocks belong to the 1.91–1.88 Ga Porphyrite group (Bergman et al. 2001). Chemical analyses of a 41-metre section, with near massive pyrite and some chalcopyrite, showed up to 0.76% Cu, 0.58% Co and 1.5 ppm Au. In addition, 2% Cu and 0.76% Co have been noted locally (Lehto 1987). According to Lehto (1987), the mineralisation is related to a north–south tectonic lineament, which was considered to have high potential for gold. The Ahmavuoma prospect was recently the subject of exploration work by Tertiary Minerals plc (exploration permit expired 2008) and Kiruna Iron AB (exploration permit expired 2013), including core drilling and electromagnetic measurements (TEM). Talga Battery Metals AB currently has the exploration permit (2017–2020).

Tertiary Minerals plc (2004), states that a survey of deep penetrating ground geophysics was conducted over the 3-km-long Ahmavuoma magnetic anomaly, and confirmed strong electrical conductors in the Northwest Zone (2 km long) and the Central Zone (1 km long), and a weak conductor in the Discovery Zone, where previous exploration drilling intersected promising levels of copper-cobalt and gold. Three drill holes were completed in winter 2004 at 50 m intervals along the strike of the Discovery Zone. In all three holes sulphide mineralisation is associated with albite alteration, magnetite veining and brecciation, and late-stage brittle fractures typical of "Iron ore-copper-gold" mineralisations. The core includes a 5-metre section with 1.37% Cu and 0.3 ppm Au in hole 04AH003, and a section 18.05 metres long, with 0.4% Co and 0.15% Cu in hole 04AH001. Both intersections occur in a broader zone of lower-grade copper mineralisation, 33–68 m wide, grading between 0.25 and 0.40% Cu. The Central Zone, a 1-km-long coincident magnetic and electromagnetic anomaly, was drilled (hole 04AH004) at its southern end, where base till samples show anomalously high copper. This 192-m-long hole intersected altered and pervasively fractured volcanic rocks with abundant magnetite veining and brecciation. Massive magnetite occurs in two intervals: a 2-metre section between 46–48 m, and a second, 7-metre section between 106–113 m. The Northwest Zone comprises an electrical conductor 2 km long, with a weak magnetic signature. Drill hole 04AH005 was drilled to test the conductor at its southern end and intersected a broad zone of IOCG-style rock alteration but nothing that would explain the electrical conductor (Tertiary Minerals plc 2004).

Broad zones of high-grade cobalt with copper at Ahmavuoma were confirmed through re-assaying of historical diamond drill core, which also revealed new intercepts that extend mineralised zones (Talga Resources Ltd 20171005). Key new intercept reported was 73.1 m at 0.16% Co and 0.24% Cu from 33.75 m (04AD001), including 22.8 m at 0.34% Co and 0.13% Cu from 54 m. The new assays validate significant high-grade historical intercepts of cobalt, copper and gold mineralisation over significant downhole widths including 52 m at 0.24% Co, 0.59% Cu, 0.17g/t Au, which contains 21 m at 0.38% Co, 1.12% Cu and 0.42g/t Au from 60 m (Talga Resources Ltd, 31 May 2017).

Industrial minerals

Sorvijänkkä	ORED15400	
Graphite, Cu, Mo (outcrops)	E 816197	N 7578773

In 1979 LKAB Prospektering AB noted outcrops and boulders with Cu-Mo-graphite-bearing schist in the Sorvijänkkä area, 30 km northeast of Lannavaara, by (Niiniskorpi 1979). Graphite-bearing schist was also noted in three outcrops. Chemical analyses of the richest part showed a carbon content of 26.2% over a one-metre section. A boulder with up to 2.15% Cu was also found in the area (Niiniskorpi 1979). Additional analyses of outcrops and boulders from the area did not exceed 0.3% Cu and 0.1% Mo. The prospect was not visited during the present inventory. The Sorvijänkkä prospect is situated in the southern extension of a northeast- to north-trending electrical conductor seen in slingram measurements (fig. 11).

Härkävaara	ORED00293	
Graphite, Mo (outcrop)	E 809892	N 7573380

According to Ambros (1980), graphite-bearing schist is noted in an outcrop at Härkävaara mountain, 21 km northeast of Lannavaara. The graphite is coarse-grained but the host rock has low carbon concentration: 5.2% C. The exposed outcrop is only 2.5 m wide, but geophysical ground measurements suggest a zone 20 m wide by 300 m long (Ambros 1980). An outcrop with a molybdenite-bearing skarn in granite was noted when the area was mapped in the 1950s (Ambros 1980). The location coordinates given above for these two observations must be regarded as approximate, however. The Härkävaara prospect was not visited during the present inventory.

Tukkapuro	ORED15714	
Dolomite (outcrop)	E 786480	N 7577608

The Tukkapuro dolomite prospect is situated 12 km northeast of Övre Soppero and 4.7 km east of the road between Vittangi and Karesuando (fig. 6). The prospect was investigated in detail by SGU and the results have been presented by Shaikh et al. (1989). Dolomite outcrops in a northeast- to north-striking area, 500 metres long and 300 metres wide, in contact with mafic metavolcanic rock to the west and Lina granite to the east (fig. 6). The dolomite is white to light grey or light brown. Microscopy analysis shows a grain size of 0.5 to 3 mm. Besides calcite and dolomite, less than 1% of other minerals such as muscovite, pyroxene, amphibole, apatite, titanite and opaque minerals occur (Shaikh et al. 1989). The dolomitic marble at Tukkapuro is regarded as very pure, with generally less than 1% SiO_2. An electrical conductor is seen in electromagnetic data at the prospect site (fig. 11). The outcrops were not visited during the present inventory.

The Muodoslompolo–Kihlanki area

The Muodoslompolo–Kihlanki area is characterised by large areas of Palaeoproterozoic syenitoids and granitoids, generally devoid of known iron and sulphide mineralisations (fig. 17). Some mafic to ultramafic intrusives occur (fig. 17, 18), of which a number have been the subject of prospecting for nickel and PGE. So far, no economic or sub-economic occurrences have been found, however. One of the strongest positive Bouguer anomalies in Sweden, referred to as the Merasjärvi or Muonionalusta gravity high (MGH, 40–50 mgal, fig. 5), occurs in the north of this sub-area, suggesting a major mafic complex at depth. Influx of mantle-derived magma into the crust in the vicinity of a major crustal break (the Pajala shear zone) suggests that the area offers potential for mineral exploration (Hannans Rewards Ltd, 2 February 2015). Copper and gold anomalies also occur in till geochemistry in the north of the sub-area (figs. 19, 20). The bedrock exposure of the area is very low, however. Several small quartz prospects occur, and the granitoids have been quarried at two places. All occurrences were visited and documented during the current inventory and are described briefly below.

As a curiosity, many iron meteorites have been found in the northeast of the Muodoslompolo–Kihlanki area, at Muonioalusta village by the Muonio River. The first one was found in 1906 (Högbom 1910). The meteorites occur in the upper soil layers and weigh between less than a kilogram and more than a tonne (Lagerbäck & Wickman 1997, Hättestrand 2009).

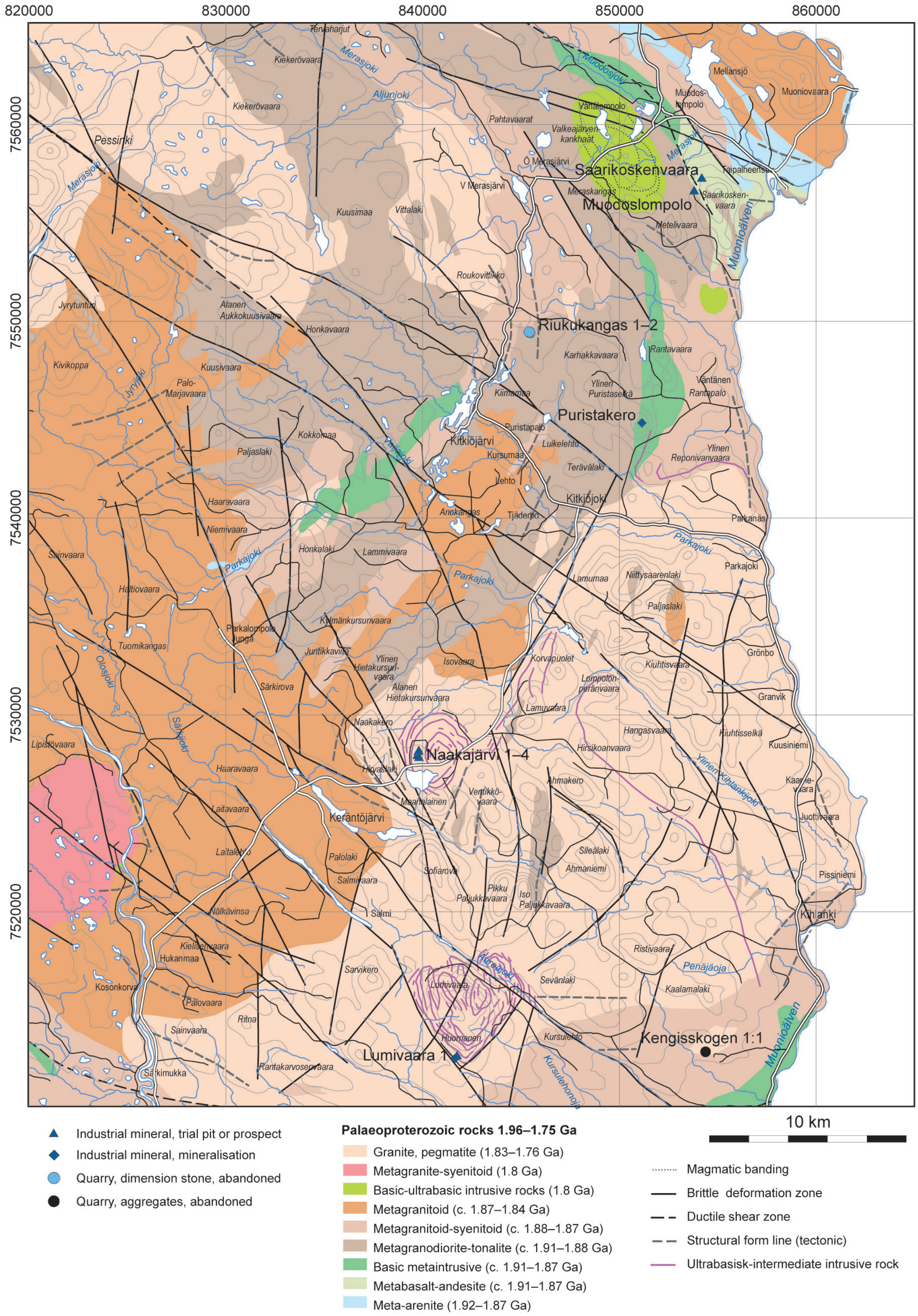


Figure 17. Bedrock geology map of the Muodoslompolo–Kihlanki area (modified from Bergman et al. 2001). Points show locations of mineral and bedrock resources (SGU Mineral resources database).

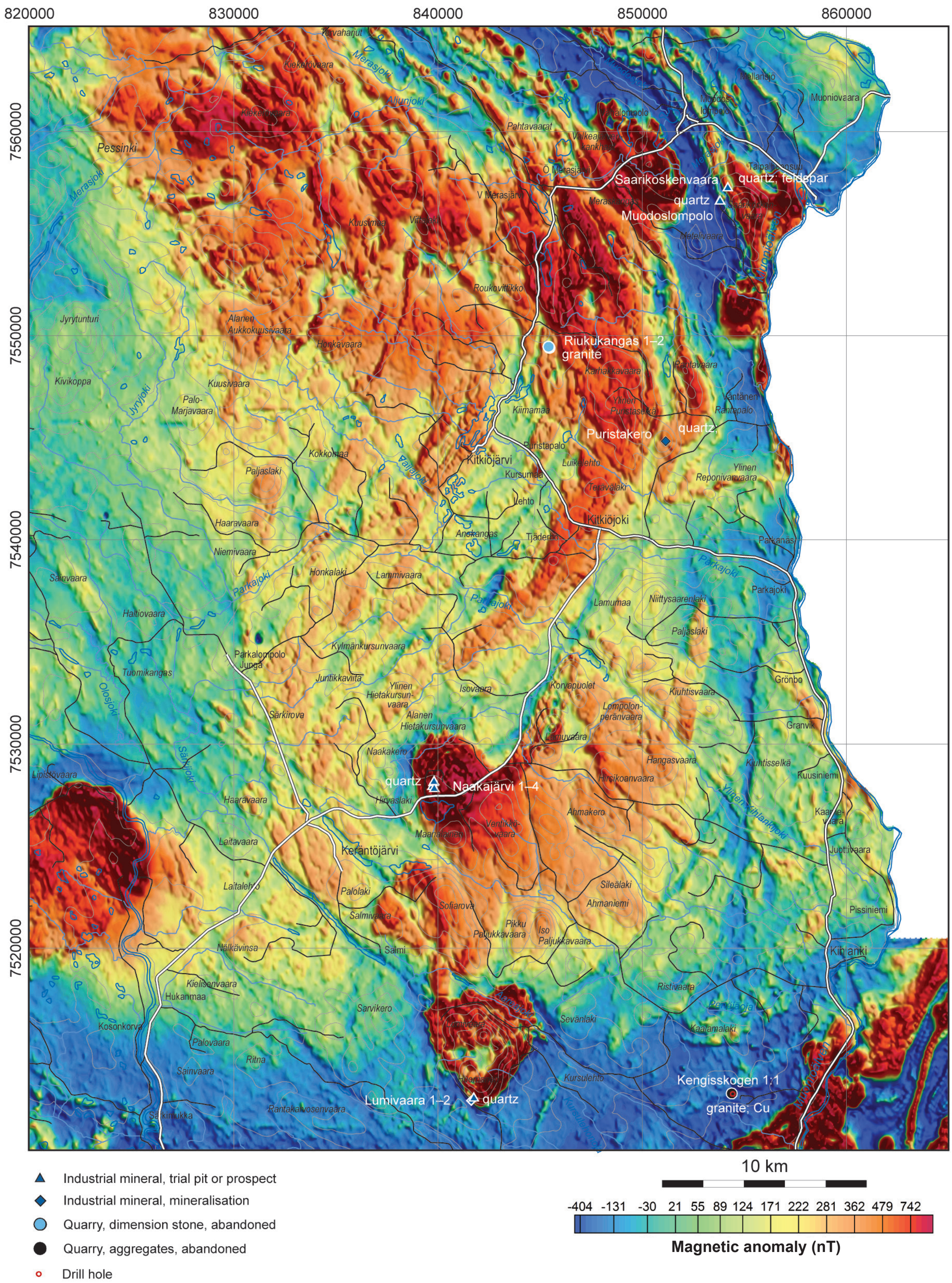


Figure 18. Magnetic anomaly map of the Muodoslompolo–Kihlanki area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU). Points show locations of mineral and bedrock resources (SGU mineral resources database).

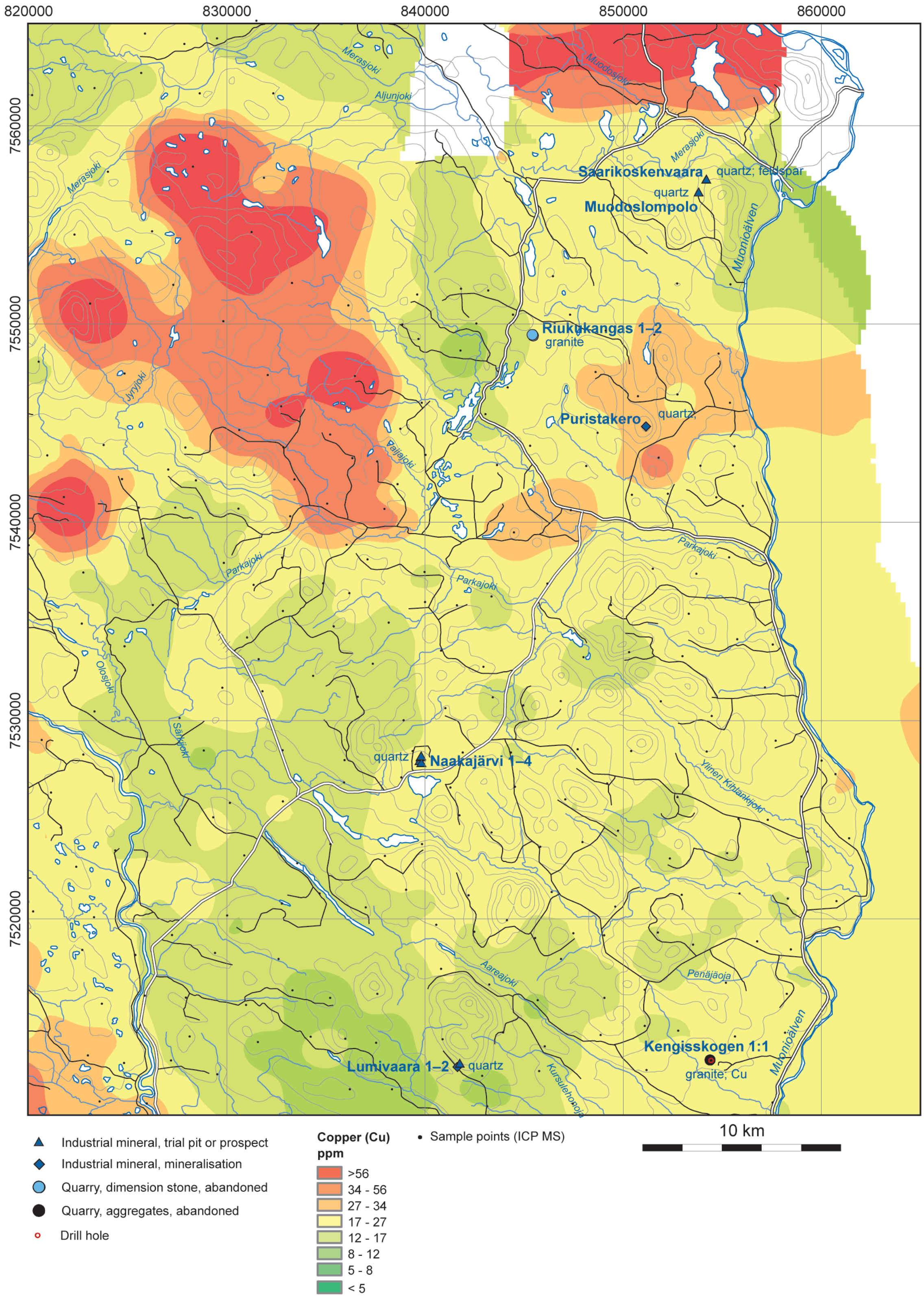


Figure 19. Copper concentrations in till (Nitric acid leach, ICP-MS data, SGU) for the Muodoslompolo–Kihlanki area.

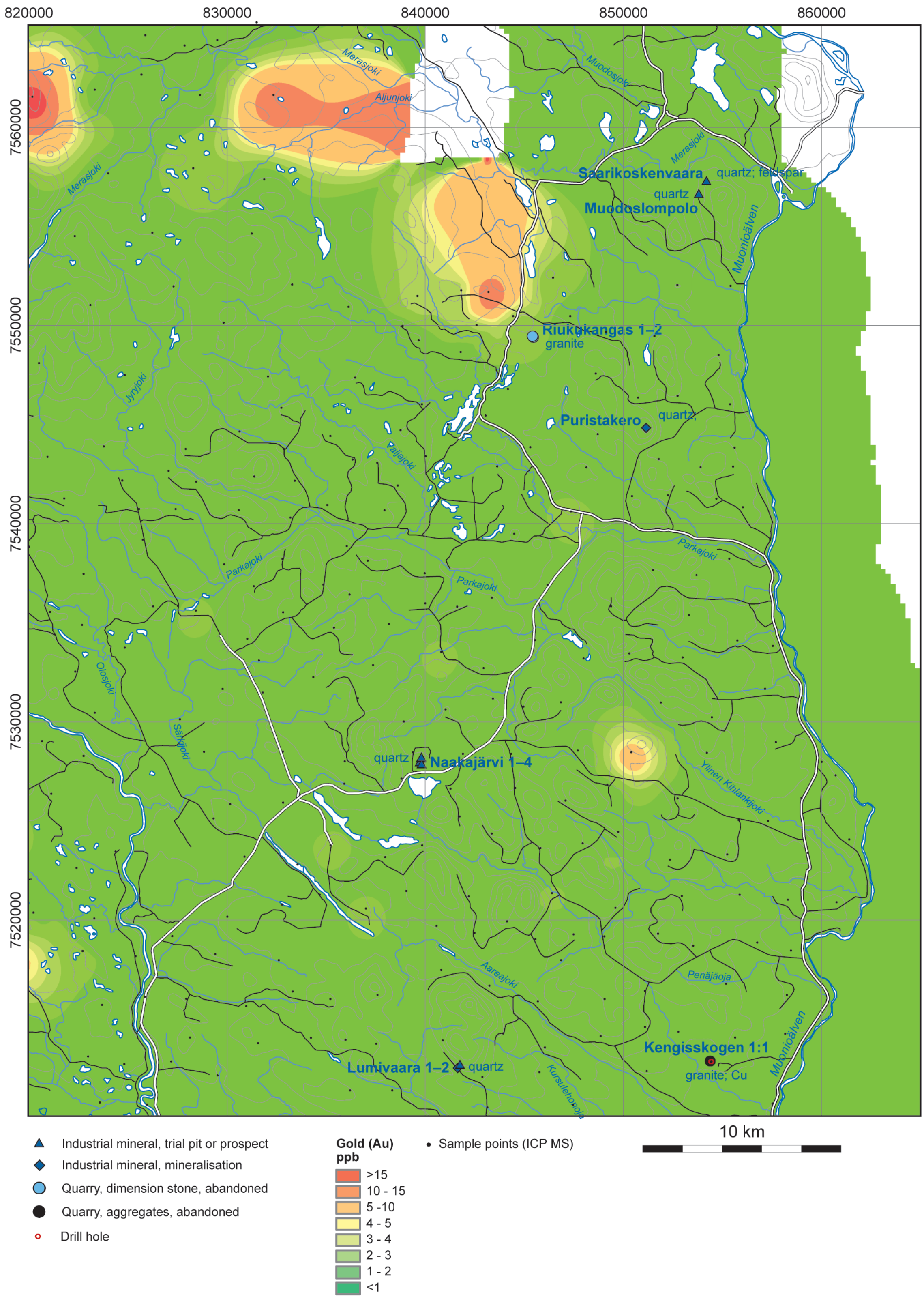


Figure 20. Gold concentrations in till (aqua regia acid leach, ICP-MS data, SGU) for the Muodoslompolo–Kihlanki area.

Industrial minerals

Muodoslompolo area

Saarikoskenvaara	ORED15756	TOB150030
Quartz (outcrops)	E 854204	N 7557309

The Saarikoskenvaara quartz prospect is situated on the northwestern slope of Saarikoskenvaara, 4 km southeast of Muodoslompolo (fig. 17). The occurrence was investigated by Sveriges geologiska AB (SGAB) during a survey in 1988 while looking for high-purity quartz (Holmqvist et al. 1988).

The quartz at Saarikoskenvaara is hosted by a pegmatite dyke, striking N130 degrees. The quartz is milky and occurs in lenses, 5–10 m across. Occasionally, microcline and biotite are relatively abundant, occurring as scattered enclaves in the quartz. The pegmatite is exposed in six trenches, now partly backfilled, however (fig. 21). The entire surface of quartz is estimated at 200 m^2 (Holmqvist et al. 1988). The depth of the deposit has not been investigated. Chemical analyses show that the quartz is relatively pure, with an average trace element content of 107 ppm (Holmqvist et al. 1988).

Figure 21. Exploration trench at Saarikoskenvaara quartz prospect, summer 2015. Photo: Torbjörn Bergman.

Muodoslompolo	ORED15755	TOB150029
Quartz (outcrops)	E 853824	N 7556667

The Muodoslompolo quartz prospect is situated on the western slope of Saarikoskenvaara, 4 km southeast of the small village of Muodoslompolo and 750 m southwest of the Saarikoskenvaara quartz prospect. The quartz at Muodoslompolo is also hosted by a pegmatite dyke, and occurs as quartz-dominated lenses in the pegmatite (fig. 22). The deposit was investigated by SGAB in 1988 (Holmqvist et al. 1988), and the pegmatite was stripped of overburden along seven trenches. The quartz is milky-white to greyish. Small amounts of smoky quartz occur locally (Holmqvist et el. 1988). The area of exposed quartz is estimated at 80 m^2. The depth of the deposit is not known. Chemical analyses show that the quartz is relatively pure, with a content of 100 ppm trace elements, of which 50% are aluminium (Holmqvist et al. 1988).

Puristakero	ORED15748	TOB150028
Quartz (outcrop)	E 851156	N 7544830

A quartz dyke, 20 metres long and 3 metres wide, hosted by a feldspar-rich pegmatite, occurs on top of Puristakero hill, 8.5 km east of Kitkiöjärvi, (fig. 23; Dahlman 1971a). Pegmatite-granite is the predominant rock type of Kitiöjärvi hill. The dyke strikes 285°/65°.

Figure 22. Outcrop with pure milky quartz at Muodoslompolo. Photo: Torbjörn Bergman.

Figure 23. Quartz dyke at Puristakero. Photo: Torbjörn Bergman.

Naakajärvi

High-purity quartz occurs on Naaka hill, 35 km north-northeast of Junosuando. The occurrence was found in 1972 by Karl Grönberg from Pajala (SGU *Norrlands mineraljakt* protocol 65/72). It was later investigated in detail by SGAB, including stripping of overburden, percussion drilling and chemical analyses (Falk & Einarsson 1988). Four of these stripped areas are still visible today. The chemical analyses from the stripped outcrops indicate high quality quartz, with less than 140 ppm trace elements (Hålenius & Einarsson 1989). The quartz occurs as lenses in pegmatite dykes cross-cutting gabbro and granite. The gabbro is part of a ring-shaped structure, named the Naakajärvi gabbro by Lindroos & Henkel (1981). An estimation of tonnage gives 8,400 tonnes of quartz (Falk & Einarsson 1988). The Naakajärvi occurrences have not yet been worked. A brief description of each stripped area is presented below. The areas are numbered from north to south.

Naakajärvi 1	ORED00407	TOB140039
Quartz (excavation)	E 839807	N 7528222

Close to the top of Naaka, on the northern side, a 5 × 10 m stripped area exposes a quartz-dominated pegmatite dyke oriented in an east–west direction (N75, fig. 24). The dyke is 5 m wide and appears vertical. The quartz is milky-white and very pure.

Figure 24. Milky quartz exposed in outcrops close to the summit of Naaka. Photo: Torbjörn Bergman.

Naakajärvi 2	ORED25522	TOB140040
Quartz (excavation)	E 839787	N 7528172

A stripped area occurs 50 m southwest of Naakajärvi 1. The area is 25 × 40 m and reveals several outcrops with pure milky quartz. Feldspar only occurs scattered within the quartz. No wall rock contacts are exposed, so the strike of the pegmatite cannot be determined. However, the elongation of the stripped area is predominantly northwest (N330).

Naakajärvi 3	ORED25523	TOB140041
Quartz (excavation)	E 839733	N 7527980

The third excavation on Naaka hill is an almost circular area with a radius of 25 m, in which several outcrops with pure milky quartz are exposed. Rose quartz is also present in a few places. Microcline was not noted in the outcrops.

Naakajärvi 4	ORED25524	TOB140041
Quartz (excavation)	E 839817	N 7527876

Two intersecting trenches occur on the south of Naaka hill, each approximately 20 m long. They form a cross, their limbs pointing toward the northeast and north-northwest. In the centre, a lens of pure milky quartz is exposed in contact with a strongly foliated mafic rock with a schistosity striking northeast (N35). Minor enveloped lenses of microcline have been noted in the schist in a few places. These are most likely the remnants of a strongly foliated pegmatite.

Lumivaara

Two quartz prospects, Lumivaara 1 and Lumivaara 2, are found on the southern slope of Lumivaara hill, 21 km northwest of Kaunisvaara. The Lumivaara occurrences were discovered in 1967 by Erik Lantto from Kaunisvaara, who was rewarded for the discovery by SGU in the *Norrlands mineraljakt* competition (Lindroos 1969). The quartz is pure and milky, and enclaved in pegmatite. The total tonnage of the two occurrences is estimated at 20,000 tonnes (Lindroos 1969). The two prospects are briefly described below.

Lumivaara 1	ORED25519	TOB140035
Quartz (trial pit)	E 841758	N 7512721

Lumivaara 1 is the more prominent of the two occurrences at Lumivaara and is well exposed due to stripping and excavation workings (fig. 25A). The date of excavation/digging of a trial pit is unknown to the authors. The excavated part is 20 × 5 m, and 2–3 m deep. The excavated quartz is divided into two piles, one 8 × 5 × 2 m, the other 4 × 3 × 2 m (fig. 25B). The quartz is pure and milky. Only small amounts of microcline are noted. The total area with quartz is estimated at 500 m^2 over an area of approximately 20 × 25 m. A chemical analysis by Holmqvist (1988) showed a trace element content of 159 ppm, of which 31 ppm consists of titanium.

Figure 25A. Trial pit excavation on milky quartz at Lumivaara.

Figure 25B. Pile of excavated quartz at Lumivaara. The rock pile is 8 × 5 × 2 m. Photo: Torbjörn Bergman.

Lumivaara 2	ORED15742	TOB140034
Quartz (outcrops))	E 841644	N 7512527

The Lumivaara 2 occurrence consists of a few small outcrops on the northern side of the unsurfaced road from Kaunisvaara, 21 km to the southeast. The quartz-dominated outcrops can be followed over a distance of 20 m and consist of pure white milky quartz with minor amounts of microcline. The width of the exposed quartz is 1–1.5 m. According to Lindroos (1969), the quartz is associated with a north–south-trending pegmatite with an estimated width of 22–25 m. It has not been possible to determine whether Lumivaara 2 is the same pegmatite as noted 200 m to the north in Lumivaara 1 due to lack of outcrop between the two.

Aggregate and dimension stone quarries

Riukukangas 1-2	ORED25653, ORED15744	TOB150026-27
Granite (quarry)	E 845413	N 7549464

Riukukangas is situated 5 km northeast of Kitkiöjärvi, and consists of two small abandoned dimension stone quarries in gneissic granite. The quarries are 50 m apart. The western quarry is approximately 20 × 10 m, with a 5-metre-high excavation wall. The eastern quarry (at 845455/ 7549418) is 35 × 15 m, with a 10 m high excavation wall. The granite is greyish-red, medium-grained and with a strong gneissic foliation (fig. 26). Scan Mining has carried out a till geochemical survey in the Riukukangas area (exploration permit Riukukangas no 1, expired 13 April 2000).

Figure 26. Gneissic granite in the Riukukangas 1 quarry, summer 2015. Photo: Torbjörn Bergman.

Kengisskogen (Kaalamarova)	ORED25520	TOB140036
Granite, Cu (quarry)	E 854392	N 7512879

The abandoned Kengisskogen aggregate quarry is situated at Kaalamarova, 4.4 km west of Kaalama village on the Muonio River. Fine- to medium-grained red granite was quarried here by Swerock between 2007–2014. In summer 2014 the quarry was 100 × 100 m wide and 15 m deep. The granite is regularly fractured with both vertical and sub-horizontal fractures with a spacing of 0.1–0.7 m (fig. 27). The granite is in some places cross-cut by pegmatitic dykes and veins. The pegmatites are generally pale pinkish-grey-green. Small amounts of magnetite, chalcopyrite and molybdenite occasionally occur in the pegmatite. Chemical analysis of a mineralised sample sent to SGU and *Norrlands mineraljakt 2008*, showed a content of 0.3% Cu and 0.3% Mo (Arnbom et al. 2008a).

In the late 1990s, before the aggregate quarry was established, the granite was quarried on a small scale by Heikki Markkula, a rock contractor, in the same area. The total amount of rock excavated was approximately 40–50 tonnes and the granite was used for purposes such as flooring at Pajala airport and as a plinth for the bronze bust in honour of a former county governor of Norrbotten, Ragnar Lassinantti. The statue is situated outside the county government office in Luleå (fig. 28), personal communication, Heikki Markkula 2015).

Figure 27. Regularly fractured, red granite in the abandoned quarry at Kaalamarova (854392 / 7512879). Photo: Torbjörn Bergman.

Figure 28. Granite from Kengisskogen (Kaalamarova), used as plinth for a bronze bust in honour of Ragnar Lassinantti, a former county governor of Norrbotten. The statue stands at the county government office in Luleå. Photo: Elisabeth Hedman, NSD.

The Vittangi–Masugnsbyn–Tärendö area

In the Vittangi–Masugnsbyn–Tärendö area Svecofennian c. 1.9 Ga supracrustal rocks of the Pahakurkio and Kalixälv groups occur stratigraphically above the Karelian 2.2–2.1 Ga Veikkavaara greenstone group (figs. 29, 30; Padget 1970, Niiniskorpi 1986a, Lynch et al. 2018a, Hellström et al. 2018). The supracrustal sequence is intruded by 1.89–1.87 Ga early- and c. 1.85–1.76 Ga late Svecokarelian intrusions (fig. 29). The supracrustal rocks host numerous mineralisations, including stratiform skarn-associated Fe oxide, dolomite and graphite deposits in the upper part of the Veikkavaara greenstone group, as well as epigenetic Zn-Pb-Cu- and Cu ±Au-sulphide mineralisations in both the Karelian and Svecofennian supracrustal rocks (e.g. Geijer 1929, Padget 1970, Witschard et al. 1972, Grip & Frietsch 1973, Niiniskorpi 1986a, Frietsch 1997, Martinsson et al. 2013a, 2016, Hellström & Jönsson 2014, 2015, Bergman et al. 2015, Lynch et al. 2018a, Hellström 2018, Hellström et al. 2018).

The Veikkavaara group predominantly consists of mafic volcaniclastic rocks, and forms a V-shaped area between Masugnsbyn, Saittarova and Junosuando, clearly outlined as a high-magnetic banded sequence on the aeromagnetic map (fig. 31; Padget 1970). Metadoleritic sills appear to be concordant with the basaltic tuffs, and are considered to have intruded shortly after the deposition of the basaltic volcanic sandstones, possibly representing near-surface intrusions related to the contemporary volcanism. A dolerite sill was dated by U-Pb in zircon at 2139±4 Ma, and is also suggested to constrain the age of the Veikkavaara greenstone group (Lynch et al. 2018a). Graphite-bearing horizons in the greenstones are well known from electromagnetic measurements. Layers of marble and iron formations occur at the top of the greenstones. *The Pahakurkio group* comprises arenitic to pelitic metasedimentary rocks overlying the Veikkavaara greenstone group. Sandstones are immature arkoses to sub-arkoses of predominantly upper continental crust provenance. The overlying *Kalixälv group* consists of similar metasedimentary rocks, i.e. originally shales and sandstone, now sillimanite-bearing mica schist, migmatitic paragneisses and quartzites. Both successions were deposited in a marine coastal environment with the presence of wave activity and vertical facies changes from shallow to deeper water where graphite-bearing shales partly represent deposition in stagnant waters beneath the storm wave base (see Hellström et al. 2018 and references given there).

The supracrustal sequence is deformed into large-scale fold structures and is cut by faults (figs. 29, 31). Structures have a northeast or northwest trend, thus intersecting at high angles (Padget 1970, Grigull et al. 2018). Metamorphic mineral associations in the metapelitic rocks, with andalusite, sillimanite and cordierite, and the absence of kyanite indicate amphibolite facies conditions of relatively high temperature and low to moderate pressures (Padget 1970). Partial melting in migmatitic paragneisses in the south of the area suggest that upper amphibolites facies grades of metamorphism have been reached. Migmatisation in the paragneiss is dated at 1878 ±3 Ma and is suggested to have been caused by heat from large volumes of contemporaneous early orogenic Svecokarelian intrusions (Hellström 2018). There are later metamorphic/hydrothermal events in this area, as previously recorded by U-Pb monazite age at c. 1.86 Ga and by U-Pb titanite ages at 1.80–1.76 Ga (Bergman et al. 2006, Martinsson et al. 2016).

Sandstones from the Pahakurkio and Kalixälv group record similar negative $\varepsilon_{Nd(1.89Ga)}$ values at -3.0 and -3.9 respectively, consistent with mixing of debris from predominantly 1.9–2.2 Ga and 2.6–3.0 Ga old rocks, a theory supported by U-Pb provenance zircon dating (Hellström et al. 2018). The Kalixälv group differs from the Pahakurkio group in that it contains a much greater abundance of volcanic and volcanogenic sedimentary rocks, which show as high-magnetic bands (fig. 31). U-Pb zircon dating of meta-andesite and metasandstone samples shows that deposition of the volcanoclastic sequence occurred at c. 1.89–1.88 Ga.

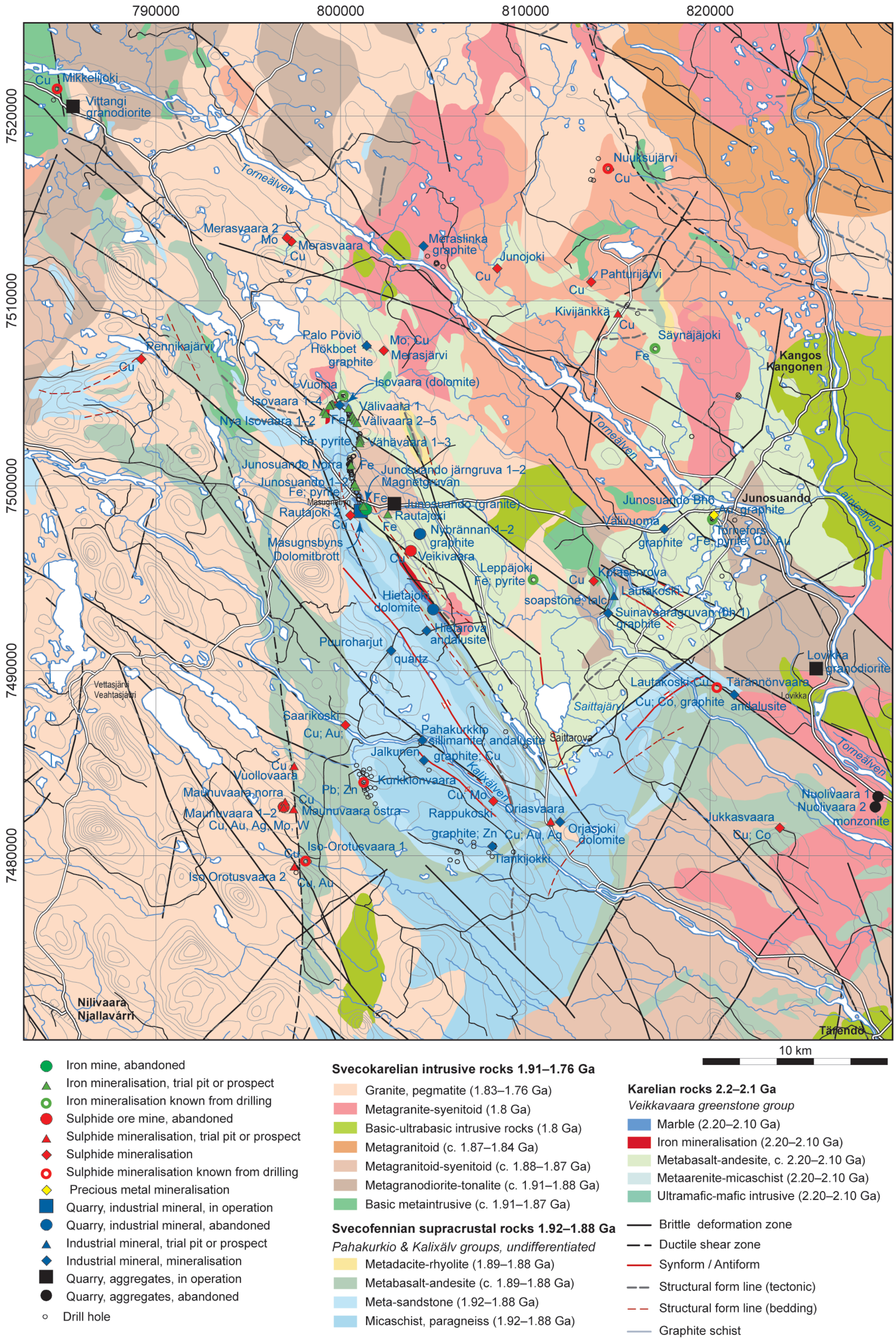


Figure 29. Bedrock geology map of the Vittangi–Masugnsbyn–Tärendö area (modified from Bergman et al. 2001).

Super-unit	Unit	Sub-unit	Rock units	(m)
Svecofennian supracrustal rocks	Rissavaara quartzite	4	Quartz sandstone (quartzite)	
	Kalixälv grp	3b	Semipelitic,-pelitic-, basic schists, migmatitic paragneiss	
		3a	Conglomerate, meta-sandstone, intermediate metavolcanic rocks	
	Sakarinpalo suite		Intermediate-felsic metavolcanic rocks	
	Pahakurkio grp	upper sandstone (2d)	Subarkosic metasandstone	1800
		upper shale (2c)	Pelitic micaschist, graphite schist, marble	1000
		lower sandstone (2b)	Subarkosic-arkosic metasandstone, greenshist	430
		lower shale (2a)	Pelitic micaschist	600
Karelian supracrustal rocks	Veikkavaara greenstone grp	Masugnsbyn fm (1c)	Graphite schist, skarnbanded chert (BIF), marble	370
		Tuorevaara greenstone fm (1c)	Metabasaltic tuff, graphite schist, metadolerite sills	1000
		Suinavaara fm (1b)	Pelitic schist and quartzite (Suinavaara quartzite)	100
		Nokkokorvanrova greenstone fm (1a)	Basaltic greenstone	2000

Figure 30. Schematic stratigraphy of the supracrustal rocks in the Vittangi–Masugnsbyn–Tärendö area, from Padget (1970), Wischard (1970), Lynch et al. 2018a, Hellström et al. 2018. The alphanumeric names of the sub-units used by Padget (1970) are in brackets. grp = group, fm = formation.

Extensive volcanism is a potentially important heat source driving hydrothermal alteration, leading to the generation of the minor Zn-Pb-Cu and Cu ±Au sulphide mineralisations that occur along the border zone between the Pahakurkio and Kalixälv groups. However, the partly vein-hosted character of the ore deposits suggests a later, epigenetic, hydrothermal origin, with mineralisations formed from boron-rich fluids (Niiniskorpi 1986a, Hellström 2018).

Exploration activities, including geophysical and geochemical surveys, bedrock mapping and drilling, are summarised below alongside the description of the mineral occurrences. A summary of geological and geophysical information on the Masugnsbyn area itself is given by Hellström & Jönsson (2014, 2015, Barents Project). Sulphide and graphite mineralisations are seen in electromagnetic data as conductive zones (fig. 32), while magnetite-bearing iron mineralisations are clearly outlined in magnetic anomaly maps (fig. 31). Examples of soil geochemistry maps are given in figs. 33–35. A clear zinc anomaly is associated with the Kurkkionvaara Zn-Pb-Cu mineralisation (fig. 33). Copper concentrations in soil above greenstone areas are elevated, suggesting that potential Cu sulphide mineralisations occur in these poorly exposed areas (fig. 34). Intrepid Minerals Cooperation has carried out till geochemical sampling in the eastern part of the Veikkavaara greenstones, between Junosuando and Saittarova (exploration permit Junosuando nr 100, 74 km^2, expired 5 August 2006; data supplied to SGU). Minor sulphide mineralisations associated with greenstones are also known in the border zones between mafic volcaniclastic rocks and intercalated mafic sills. Several isolated gold anomalies are seen in the soil geochemistry, but none is clearly related to known mineralisations (fig. 35). However, several studies show that the till stratigraphy of northern Norrbotten is complex, with two or more generations of till. This complicates the interpretation of till geochemical surveys (Fagerlind 1981, Lagerbäck 1982). There are two separate ice movement directions, an older one from the northwest and a younger one from the south-southwest. The older ice movement has left well-developed drumlins, and appears to be the more important in terms of material transported.

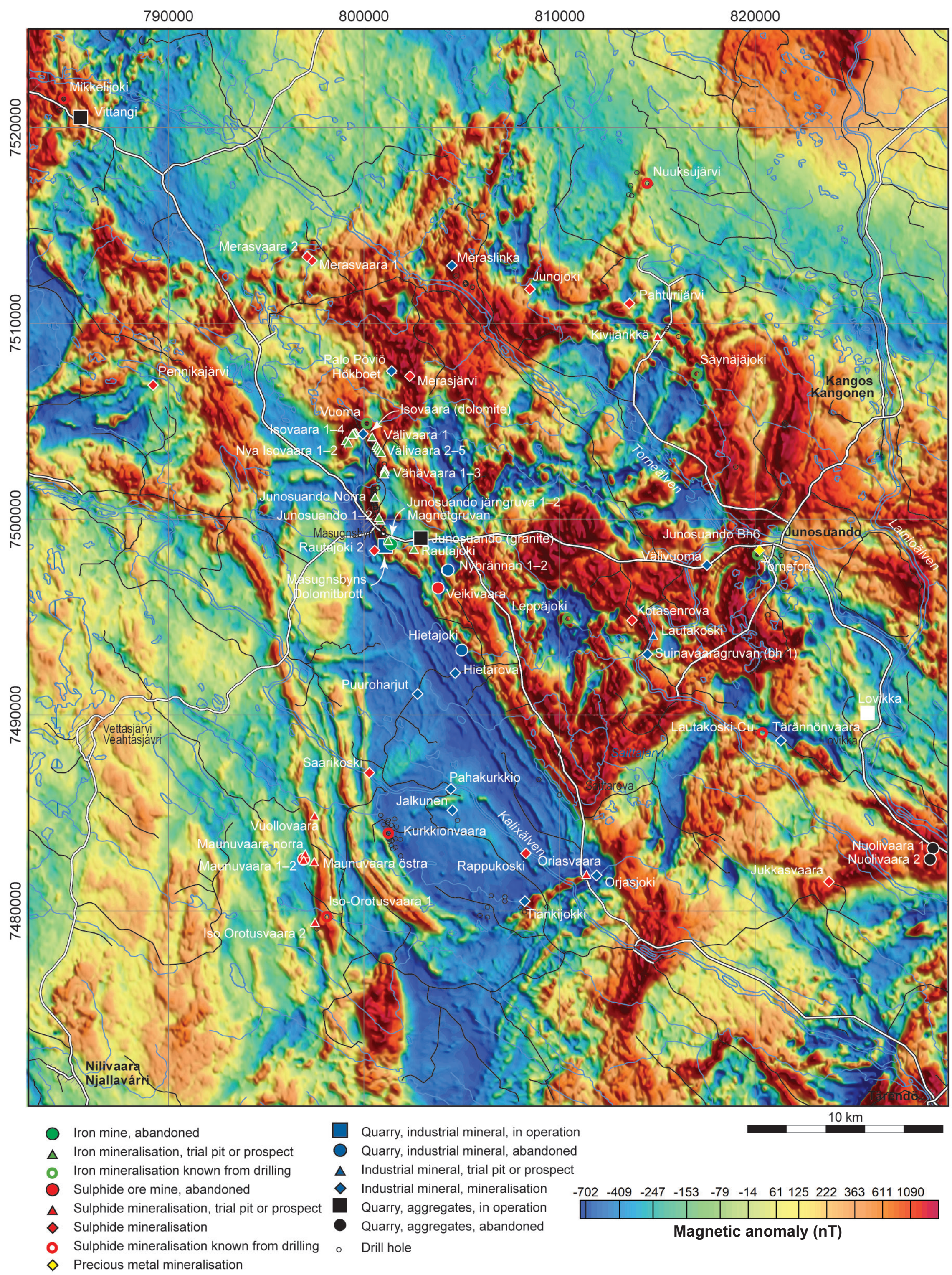


Figure 31. Magnetic anomaly map of the Vittangi–Masugnsbyn–Tärendö area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU). Points show location of mineral and bedrock resources (SGU mineral resources database).

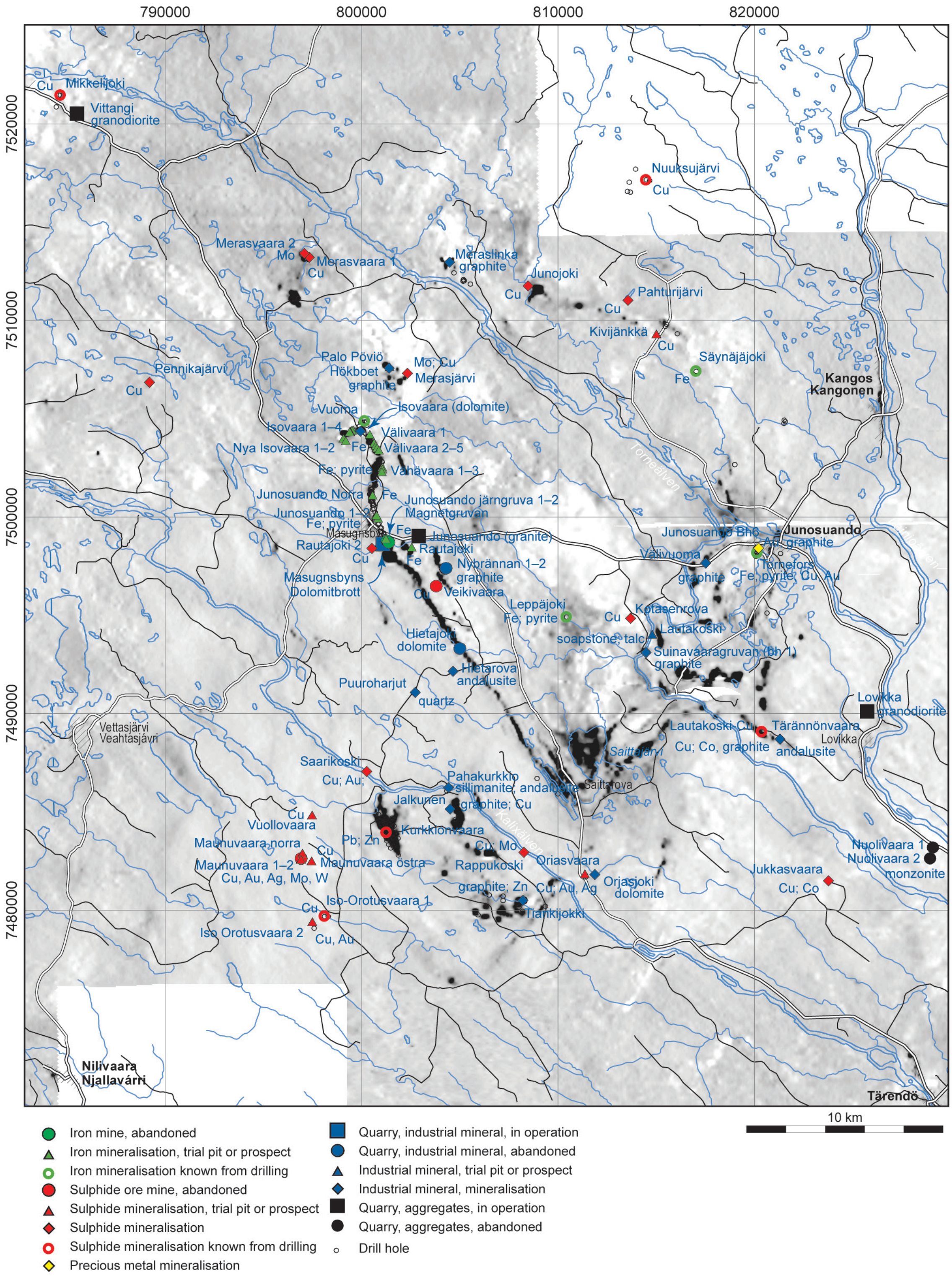


Figure 32. Electromagnetic map (slingram, real) of the Vittangi–Masugnsbyn–Tärendö area. Dark colours show good electrical conductors. The geophysical data were gridded by Johan Jönberger (SGU).

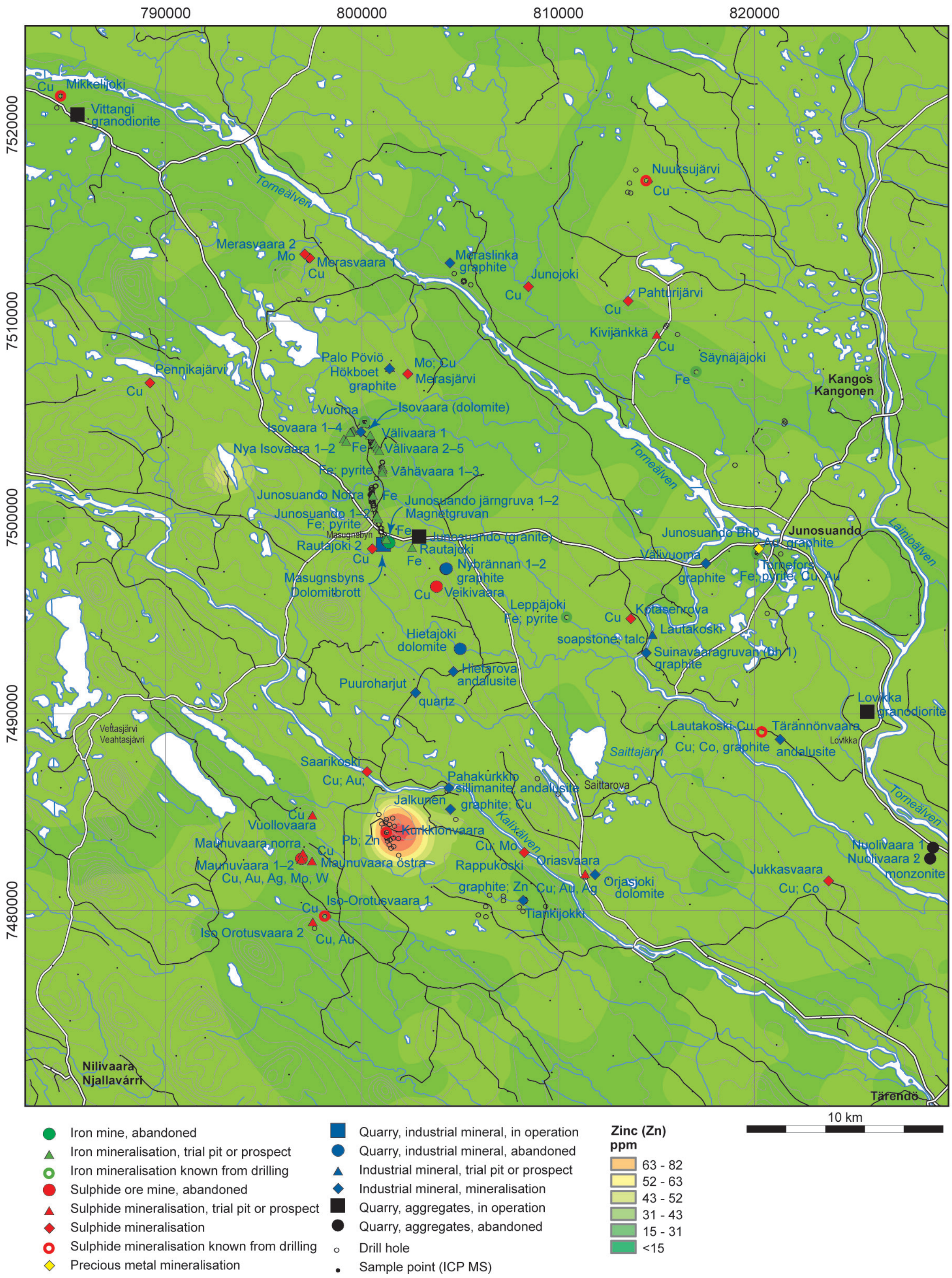


Figure 33. Zinc concentrations in till (nitric acid leach, ICP-MS data, SGU) for the Vittangi–Masugnsbyn –Tärendö area.

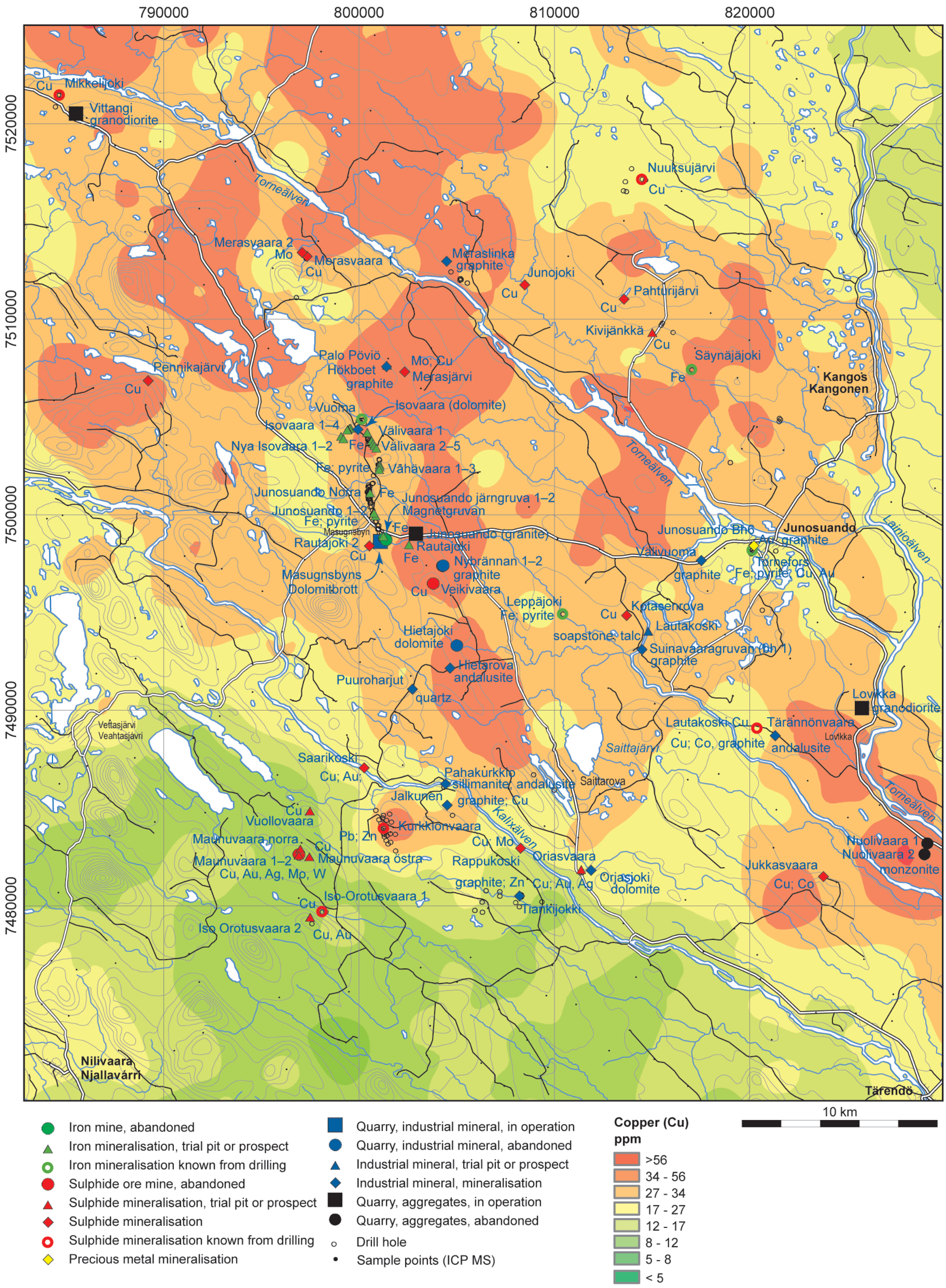


Figure 34. Copper concentrations in till (nitric acid leach, ICP-MS data, SGU) for the Vittangi–Masugnsbyn–Tärendö area.

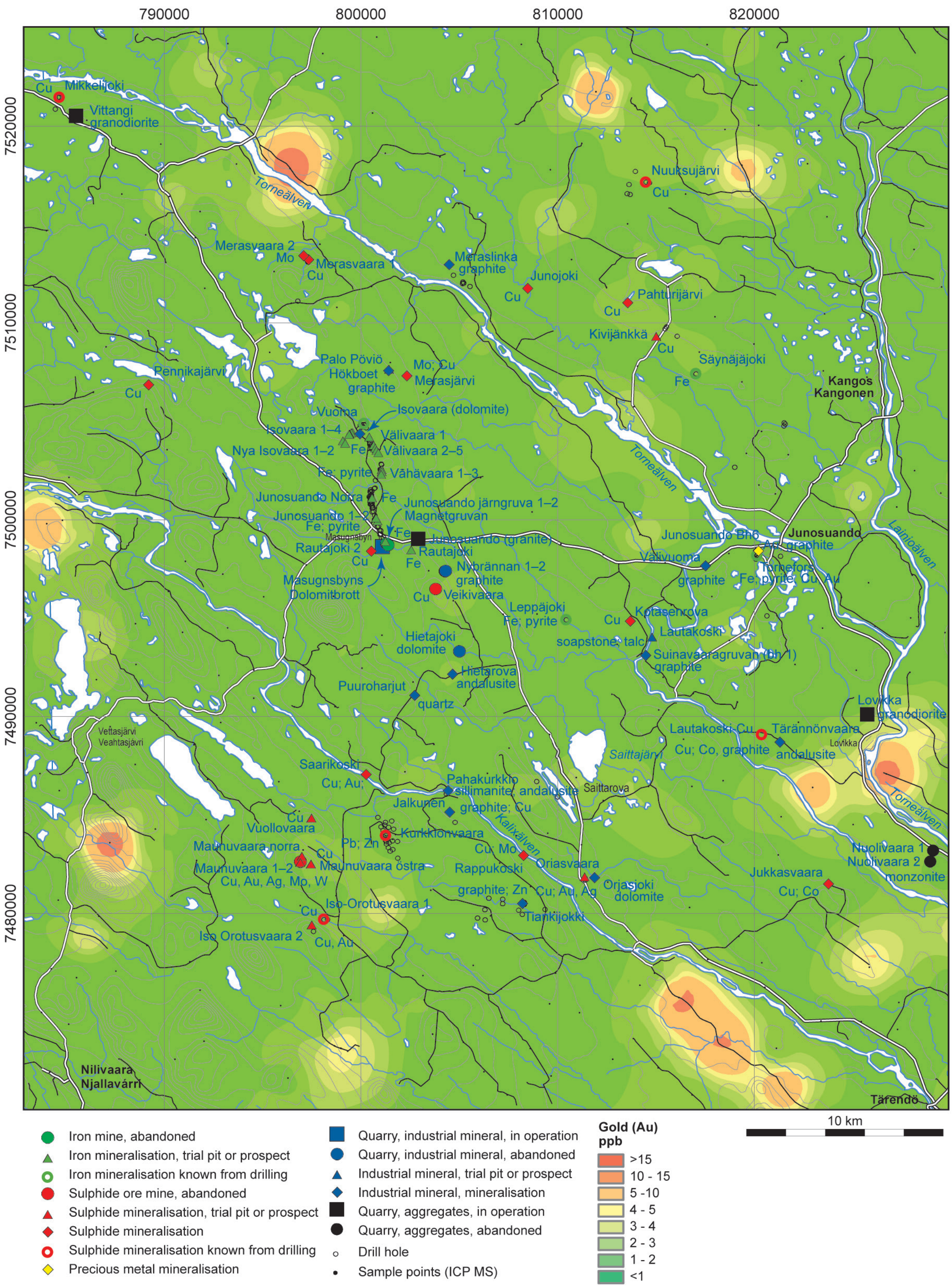


Figure 35. Gold concentrations in till (nitric acid leach, ICP-MS data, SGU) for the Vittangi–Masugnsbyn–Tärendö area.

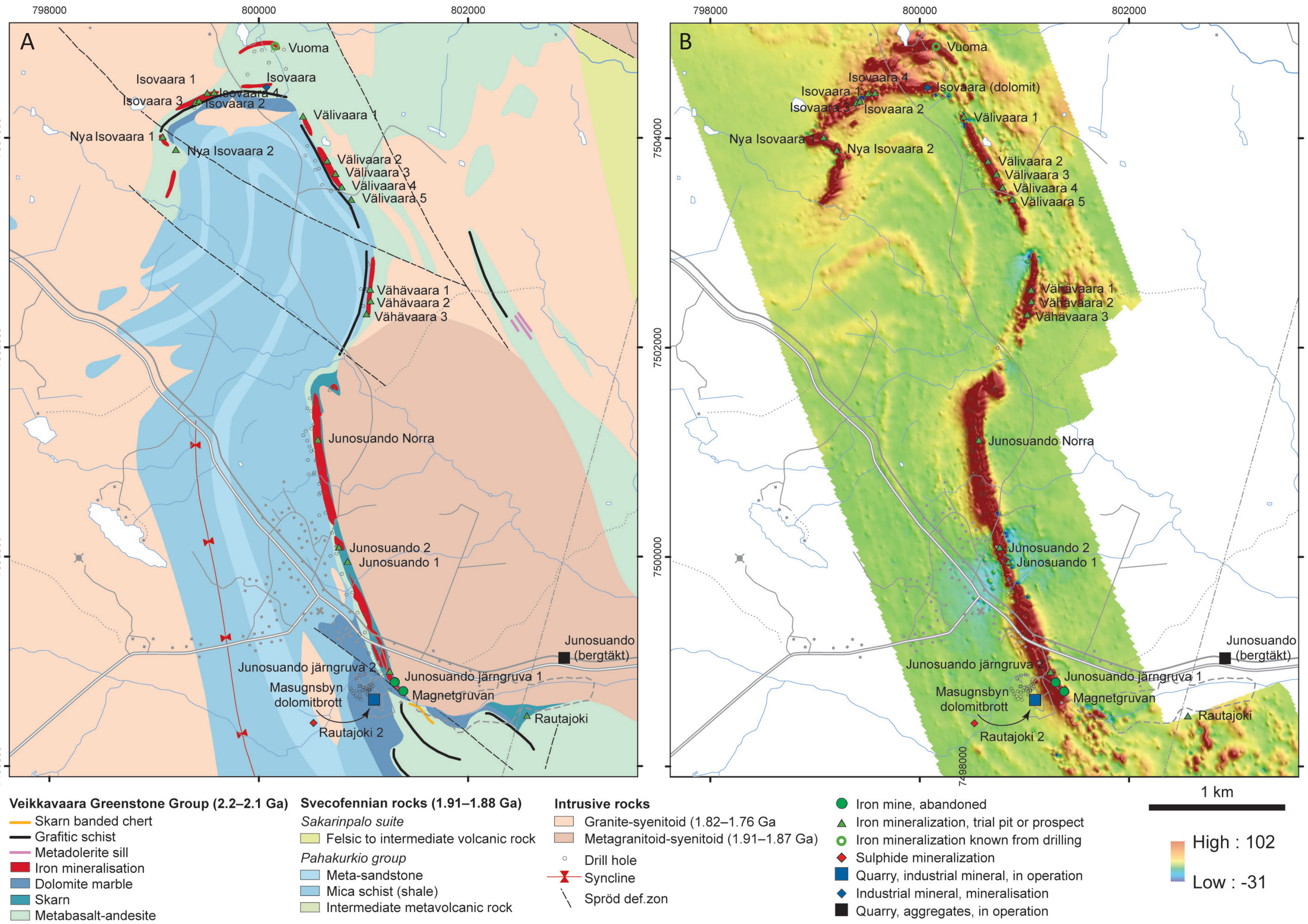
Iron oxide mineralisations

The Masugnsbyn iron ores

The Masugnsbyn iron mineralisations form a regular, 8-km sheet concordantly between the Veikkavaara greenstones and the overlying Pahakurkio metasedimentary rocks, constituting the eastern limb of a syncline structure (fig. 36; Frietsch 1997, Geijer 1929, Witschard et al. 1972). The iron mineralisations occur in the eastern limb of a narrow north–south trending syncline with a steep westerly dip. The strike turns westwards as the syncline closes to the north, apparent on the magnetic maps (fig. 36). The Masugnsbyn ore district has been divided into six sub-areas or "fields", from the south: Junosuando, Vähävaara, Välivaara, Vuoma, Isovaara and Nya Isovaara. Only the two southern sub-areas (Junosuando and Vähävaara) contain concentrations of economic interest, with resulting systematic drilling and ore calculation (Witschard et al. 1972, Talga Resources 20130801, Martinsson et al. 2013a).

The southern deposits are classified as skarn iron ores, whereas the mineralisations to the north partly have the character of sedimentary, millimetre- to centimetre-wide, quartz-calc-silicate + magnetite, banded iron ore, suggesting an exhalative origin. But skarn iron ores also occur together with these, and it is difficult to distinguish the two types locally (Geijer 1929). The southern iron ores are bordered by a perthite-granite to the east. The close spatial connection between the skarn iron ores and the granite suggests that heat from the intrusion is responsible for the skarn formation and remobilisation of iron, with higher grade and coarser grain size of the magnetite ore in the footwall next to the granite (cf. Geijer 1929, Witschard et al. 1972, Frietsch 1997). The presence of the rather thick dolomitic marble in the southwestern part of the Junosuando deposit is probably also important for skarn iron ore formation. Hellström (2018) dated migmatisation in the south of the Masugnsbyn area at 1878±3 Ma, suggesting that metamorphic alterations at c. 1.88 Ga were contemporaneous with large volumes of early orogenic intrusions, including the Masugnsbyn perthite granite, redated at c. 1.88 Ga (Hellström 2018.). Skarn minerals are intimately associated with magnetite in a steeply dipping zone, 70–100 metres wide, with diopside, tremolite-actinolite and phlogopite, and more rarely serpentine and chondrodite. Chalcopyrite is a minor constituent in the ore, which generally contains abundant iron sulphides. Uranium mineralised fractures are found locally (Padget 1970, Witschard et al. 1972).

▶ **Figure 36. A.** Bedrock geological map of the Masugnsbyn iron ore district. **B.** Magnetic anomaly map based on ground measurements (same extent as in A). The magnetic data were gridded by Cecilia Jönsson (SGU).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798000
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7504000
7502000
7500000
7498000
Vuoma
Isovaara
Isovaara 1
Isovaara 2
Isovaara 3
Isovaara 4
Isovaara (dolomit)
Nya Isovaara 1
Nya Isovaara 2
Välivaara 1
Välivaara 2
Välivaara 3
Välivaara 4
Välivaara 5
Vähävaara 1
Vähävaara 2
Vähävaara 3
Junosuando Norra
Junosuando 2
Junosuando 1
Junosuando (bergtäkt)
Junosuando järngruva 2
Junosuando järngruva 1
Magnetgruvan
Masugnsbyn dolomitbrott
Rautajoki 2
Rautajoki
1 km
High : 102
Low : -31
Veikkavaara Greenstone Group (2.2–2.1 Ga)
Skarn banded chert
Grafitic schist
Metadolerite sill
Iron mineralisation
Dolomite marble
Skarn
Metabasalt-andesite
Svecofennian rocks (1.91–1.88 Ga)
Sakarinpalo suite
Felsic to intermediate volcanic rock
Pahakurkio group
Meta-sandstone
Mica schist (shale)
Intermediate metavolcanic rock
Intrusive rocks
Granite-syenitoid (1.82–1.76 Ga
Metagranitoid-syenitoid (1.91–1.87 Ga)
Drill hole
Syncline
Spröd def.zon
Iron mine, abandoned
Iron mineralization, trial pit or prospect
Iron mineralization known from drilling
Sulphide mineralization
Quarry, industrial mineral, in operation
Industrial mineral, mineralisation
Quarry, aggregates, in operation

The Junosuando field

The skarn iron ore at Magnetgruvan in the southernmost part of the Masugnsbyn iron ores was discovered before 1644 as the first iron deposit in Norrbotten (Geijer 1929). The blast furnace closed down in 1805, but the ore at Magnetgruvan and at the Junosuando järngruvor was mined intermittently on a small scale until at least 1870 (Geijer 1929). Exploration resumed in 1914, and was conducted by AB Nordsvenska Malmfält. Several new iron occurrences were discovered using diamond core drilling in the 1920s (Högbom 1919, Asplund 1920, Geijer 1929).

Magnetgruvan is part of the Junosuando deposit, which was investigated by magnetic and gravimetric ground measurements, diamond core drilling, and detailed geological mapping of the ore zone by the SGU in the 1960s. Aeromagnetic maps of 28L Tärendö and 29L Laino also became available at that time. SGU carried out a drilling programme on the Masugnsbyn iron mineralisations between 1967–1970, with 33 holes with a total length of 5,488 m (fig. 37). Based on the drilling, the ore tonnage of the Junosuando deposit was estimated at 60 million tonnes of iron ore, with an average grade of 30% Fe (1.9% S, 0.024% P, 1.3% F and 0.08% Cu). The ore contains relatively high fluorine concentrations (0.29–3.2%, average 1.3%), but is poor in other trace elements (Witschard 1972). Recent investigations, including new drillings by Talga Resources Ltd, resulted in new estimates of 112 million tonnes of ore at 28.6% Fe JORC Indicated and Inferred resources (Talga Resources 20130521; 201308, Martinsson et al. 2013a).

The mineralisation occurs within a sulphide-bearing skarn zone, 65–140 metres thick, sub-vertical or dipping steeply to the west, defined by drilling (fig. 37). It consists of medium- to coarse-grained magnetite developed within two parallel zones. The footwall zone contains

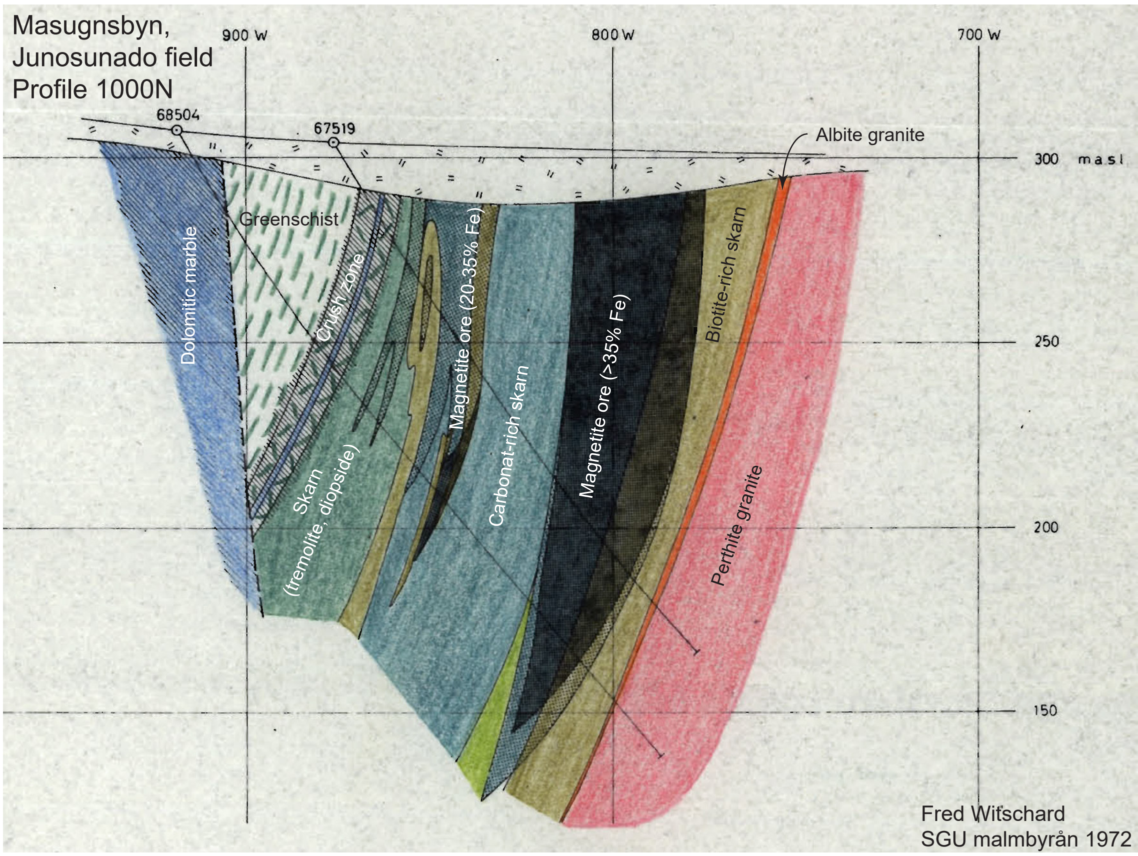

Figure 37. Vertical geological section in the southern part of the Junosuando field (modified from Witschard et al. 1972)

consistently higher iron grades, averaging 35.2% (Martinsson et al. 2013a). The eastern wall rock is a perthitic granite, with a marginal phase of albite alteration 1–2 metres wide along the contact to the ore-bearing skarn. The hanging wall consists of dolomitic marble and skarn in the south, and metasediments, greenschist or skarn in the north. The ore is limited to the south by a fault zone (Geijer 1929, Witschard et al. 1972).

In detail, the skarn zone is very complex, but different skarn types are usually interbanded more or less concordantly with stratigraphy. Magnetite is irregularly distributed, but tends to concentrate in bands (Geijer 1929, Witschard et al. 1972). Four main skarn types have been recognised: tremolite-actinolite-diopside-(augite) skarn, biotite (phlogopite)-rich skarn, serpentine-rich skarn and carbonate-rich skarn. Tremolite-actinolite-diopside-(augite) skarn is the most common; biotite-rich skarn is directly associated with the ore zone, and serpentine skarn is late, replacing chondrodite or pyroxene. Normally, there is fairly regular zoning of the ore zone, with increasing amounts of magnetite towards the footwall, accompanied by a change from tremolite skarn to serpentine skarn (Witschard et al. 1972, Martinsson et al. 2013a). Sulphide minerals are generally subordinate and usually occur as late fracture fillings within the skarn. Sulphides are primarily pyrite and pyrrhotite, although small amounts of chalcopyrite occur (Witschard et al. 1972).

Magnetgruvan	ORED25657	FHM140035
Fe (closed mine)	E 801378	N 7498718

A small pit/mine shaft is found in the southernmost end of the Junosuando iron deposit at Masugnsbyn (fig. 36), referred to as Magnetgruvan on a map from 1736 (Mining Inspectorate of Sweden). The pit measures 18 × 5 m and is open to the south, but has an irregular wall, 1–2 metres high, on the northern edge, where granite outcrops border the pit. The pit is shallow and water-filled in the eastern part; the western part is partly covered with timber and is of unknown depth. A large quantity of rusty waste material is found south of the pit, a pile approximately 25 × 5 m across and 0.5–2 m high (fig. 38A). A further pile of waste 15 × 5 m across and 0.5 m high is found northeast of the pit. Large amounts of waste rock are also found between this pit and Junosuando järngruva 1 to the northwest (see below). The rusty waste rock contains abundant sulphides as disseminations in actinolite-tremolite skarn (fig. 38B), mostly iron sulphides, but traces of chalcopyrite can be found. Magnetite is disseminated or massive in a fine- to coarse-grained actinolite-tremolite skarn. A massive magnetite sample

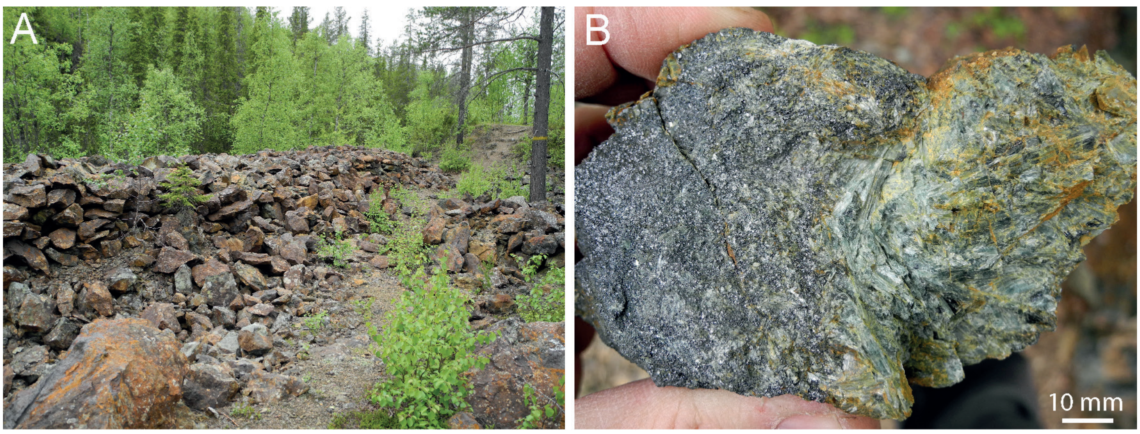

Figure 38. A. Piles of waste rock containing rusty, sulphide-rich skarn iron ore at Magnetgruvan. **B.** Magnetite in actinolite-tremolite skarn.

from the waste dump contains 66% Fe, with low titanium (0.1%) and phosphor (<0.004%), but with an elevated sulphur content of 3.1% S, weakly anomalous in copper (0.1%) and with trace amounts of gold (0.005 ppm, FHM140035A, Appendix 2). An actinolite-tremolite sample with rich sulphide dissemination containing 5.3% S has an elevated copper content of 0.7%, but with only trace amounts of gold (0.049 ppm, FHM140035B, Appendix 2).

Junosuando järngruva 1	ORED15726	FHM140034
Fe (closed mine)	E 801297	N 7498804

In the southernmost part of the Junosuando deposit is a water-filled open pit, about 40 × 10–15 metres across, with an estimated 60–70-metre-long, shallow to dry extension to the northwest (fig. 39A). Sounding in the centre gave a water depth of 13 m. Albite-altered granite makes up the eastern contact to the ore (fig. 39B), which is a magnetite-actinolite-tremolite-diopside skarn with minor disseminations of pyrite. Large amounts of waste rock are found east and southeast of the pit, clearly seen in the 2 m elevation lidar data. On a map from 1736 (Steinholtz 1736, Mining Inspectorate of Sweden), the mine is referred to as "Junosuando jerngruvor".

Junosuando järngruva 2	ORED25879	FHM140036
Fe (closed mine)	E 801251	N 7498906

In the north-northwest continuation of Junosuando järngruva 1 there is a water-filled open pit, 25 × 7 m across, the result of small-scale mining of a skarn iron ore. The pit is only 1 m deep and the wall rock is exposed to the south.

Junosuando 1	ORED00070	FHM140038
Fe (trial pit)	E 800847	N 7499955

About 500 m northeast of the church in Masugnsbyn village is a trial pit 7 × 7 m across and 1–2 m deep, with some bedrock exposed in the northern and southern walls. An additional trial pit, 7 × 2 metres across and 1 metre deep, is found 20 m to the south. Small amounts of waste rock with fine-grained magnetite-diopside skarn occur. The trial pits are situated in the central part of what is denoted the "Junosuando field".

Figure 39. A. Junosuando järngruva 1. **B.** Albite-altered wall rock of perthite granite.

Junosuando 2	ORED25953	FHM150012
Fe (trial pit)	E 800764	N 7500094

About 600 m north-northeast of the church in Masugnsbyn, in the central part of the Junosuando field (fig. 36), there is a trial pit 10 × 2 m across, water-filled to a depth of about 1 m. Excavated material is found along the sides of the pit, and forms 0.5 m high banks. The small amount of excavated material is a fine-grained magnetite-serpentine skarn.

Junosuando Norra	ORED15725	FHM140040
Fe (excavation)	E 800564	N 7501119

Approximately 1,500 m north of Masugnsbyn village, in the northern part of the Junosuando field (fig. 36), an excavation approximately 13 × 3 m across and 2 m deep is found but without exposed bedrock or waste rock.

Vähävaara ore field

Based on core drillings, the total tonnage of the Vähävaara iron deposit, down to 150 m below surface, is estimated to be 3.1 million tonnes, with an average grade of 28.8% Fe, 2.7% S and 0.048% P (Frietsch 1997). The magnetite ore forms a 400-m-long, stratiform north-northeast-trending sub-vertical or steep west-dipping sheet in sulphide-bearing skarn (fig. 40). The wall rock consists of different schists, in part graphite-bearing, generally with 5–10% carbon (Witschard et al. 1972, Frietsch 1997).

Vähävaara 1	ORED00116	
Fe (excavation)	E 801064	N 7502553

In the northern part of the Vähävaara ore field there is a water-filled pit 5 × 1–2 m wide and 1–2 m deep (fig. 36). Around the pit are banks with excavated earth, but no visible ore or waste rock.

Vähävaara 2	ORED25608	FHM140048
Fe (trial pit)	E 801067	N 7502444

In the central part of the Vähävaara ore field there is a rectangular exploration/trial pit measuring 12 × 5 metres. The pit is filled with water to 1 m below ground level, with a depth of 0.5 m. Banks around the edges of the pit contain overgrown excavated material with a few angular boulders of quartz skarn-banded magnetite ore with traces of pyrite. Magnetite occurs disseminated in amphibole-diopside skarn or occasionally as fine-grained massive iron ore.

Vähävaara 3	ORED25609	FHM140047
Fe (trial pit)	E 801029	N 7502320

In the southern part of the Vähävaara ore field there is a rectangular exploration/trial pit measuring 3 × 3 m. The pit is water-filled to 1 m below ground level, with a water depth of 1.5 m. The embankment around the pit contains overgrown excavated material with some angular boulders of actinolite-tremolite skarn incorporating 0.5-cm-thick layers of fine-grained magnetite and accessory amounts of pyrite (fig. 41).

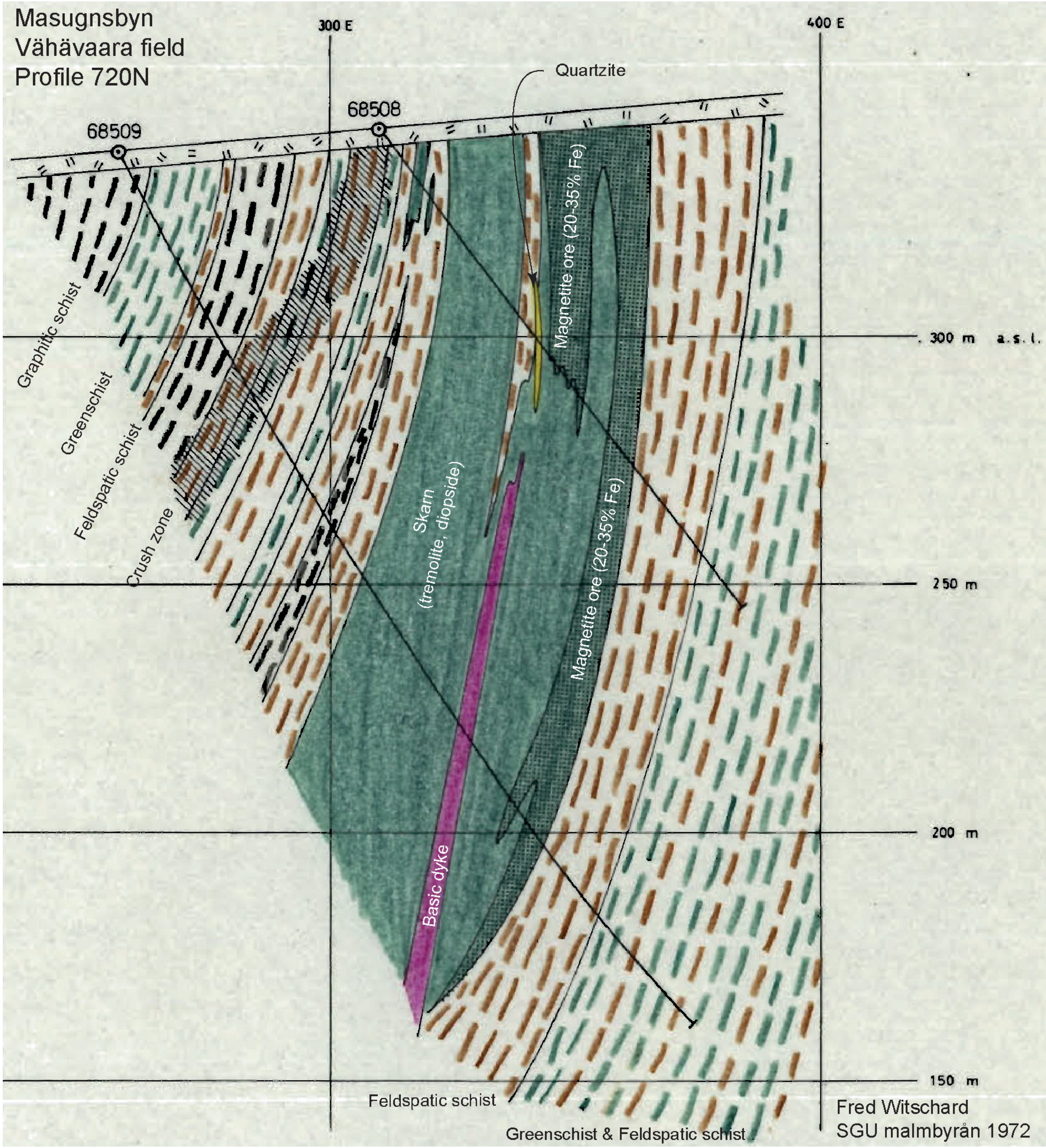

Figure 40. Vertical geological section at the Vähävaara field (modified from Witschard et al. 1972).

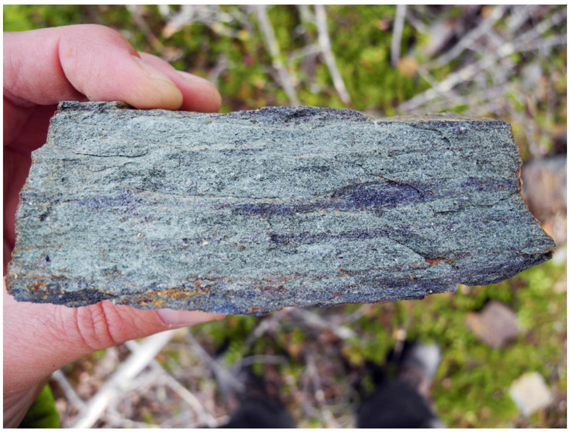

Figure 41. Magnetite bands in tremolite-actinolite skarn at Vähävaara 3. Photo: Fredrik Hellström.

Välivaara ore field

Magnetite-bearing skarn occurs in the Välivaara ore field (fig. 36), and is hosted by metasediments and minor greenschists (fig. 42; Witschard et al. 1972). The magnetite concentrations are mainly in skarn but occasionally occur concordantly in well-banded, fine-grained and quartz-rich metasediments. Graphite schists west of the skarn zone generally contain 7–18% carbon and are sulphide-rich (pyrrhotite, pyrite and minor chalcopyrite), with sections containing more than 20% S. Small marble horizons within feldspathic schists occur, and occasional granite and pegmatite dykes are observed. A few boreholes have been drilled in this field. Asplund (1920) reported a 5-metre drill core section, averaging 59.8% Fe, 0.015% P and 2.1% S.

Välivaara 1	ORED00167	FHM140050
Fe (trial pit)	E 800423	N 7504207

Approximately 4.6 km north of Masugnsbyn, in the northern part of the Välivaara ore field, is an exploration/trial pit measuring 30 × 5 m. It is filled with shallow water up to about 1–2 m below ground level. The banks around the edges of the pit contain overgrown excavated material. Remnants of timber occur in the centre of the pit, possibly covering a deeper part. Remains of barbed wire are seen in the southern part. The overgrown waste material in the southwestern part consists of a quartz skarn-banded iron ore with a rich dissemination of magnetite (magnetic susceptibility = 20,000 × 10^{-5} Si units, fig. 43). Thin veins with pyrite and minor amounts of chalcopyrite are noted.

Välivaara 2	ORED25610	FHM140045
Fe (trial pit)	E 800653	N 7503783

Approximately 4.2 km north of Masugnsbyn, in the central part of the Välivaara ore field, there is a water-filled excavation without exposed bedrock, measuring 10 × 2 metres. The banks around the pit contain overgrown excavated material. Most of the boulders are granite, but a few boulders of relatively magnetite-rich amphibole-diopside skarn were also noted during the present inventory.

Välivaara 3	ORED25612	FHM140044
Fe (trial pit)	E 800733	N 7503660

Approximately 4.0 km north of Masugnsbyn, in the southern part of the Välivaara ore field, is a shallow water-filled exploration/trial pit 8 × 2 metres wide. Banks around the edges of the pit contain overgrown excavated material, including angular boulders with poorly disseminated magnetite, as well as granite boulders.

Välivaara 4	ORED25613	FHM140043
Fe (trial pit)	E 800791	N 7503533

Approximately 3.9 km north of Masugnsbyn, in the southern part of the Välivaara ore field, there is a northeast-trending exploration trench 20 × 3 m wide and 1–2 m deep. The trench is open towards the northeast. Banks around the trench contain overgrown, excavated material. There are a few angular boulders with quartz-banded, poor magnetite ore.

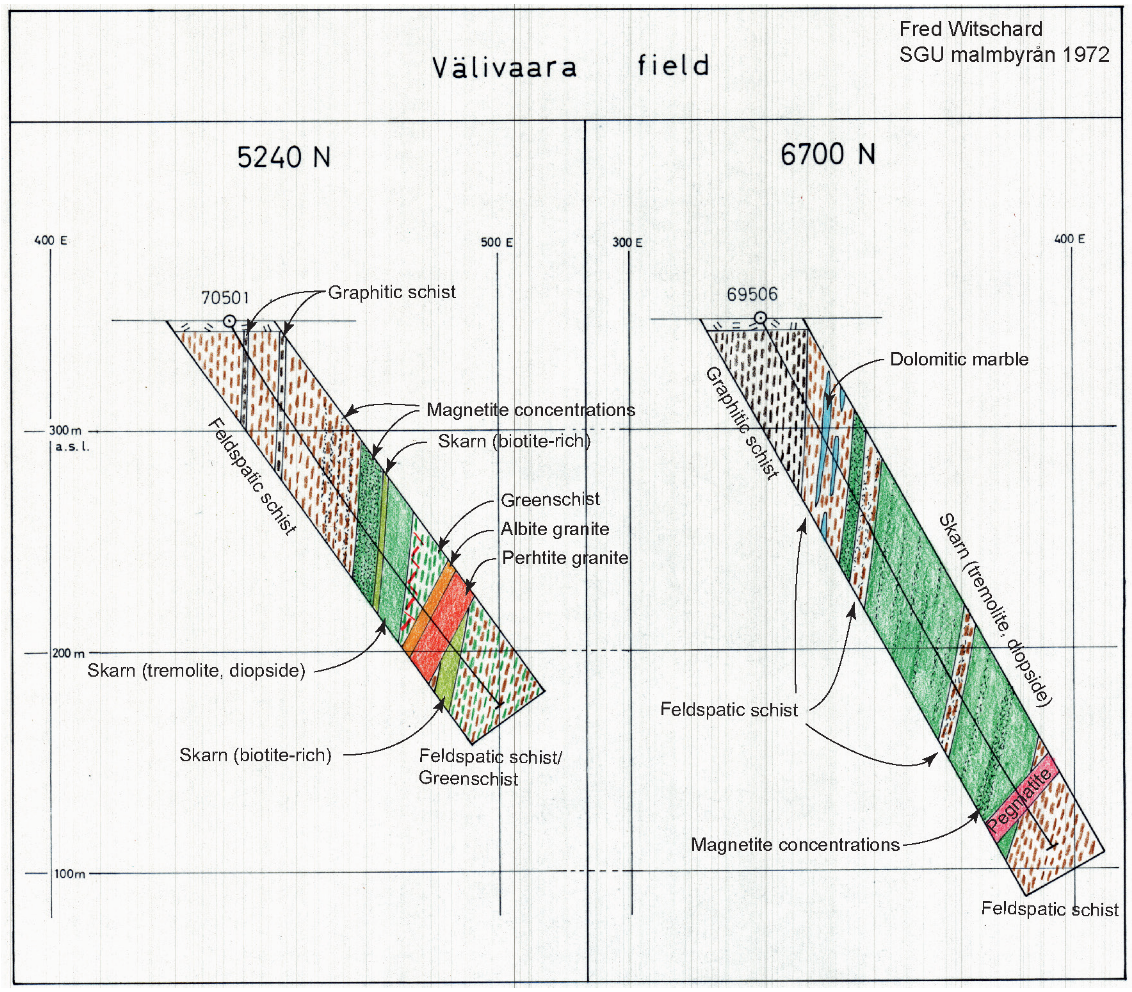

Figure 42. Vertical geological section at the Välivaara field (modified from Witschard et al. 1972).

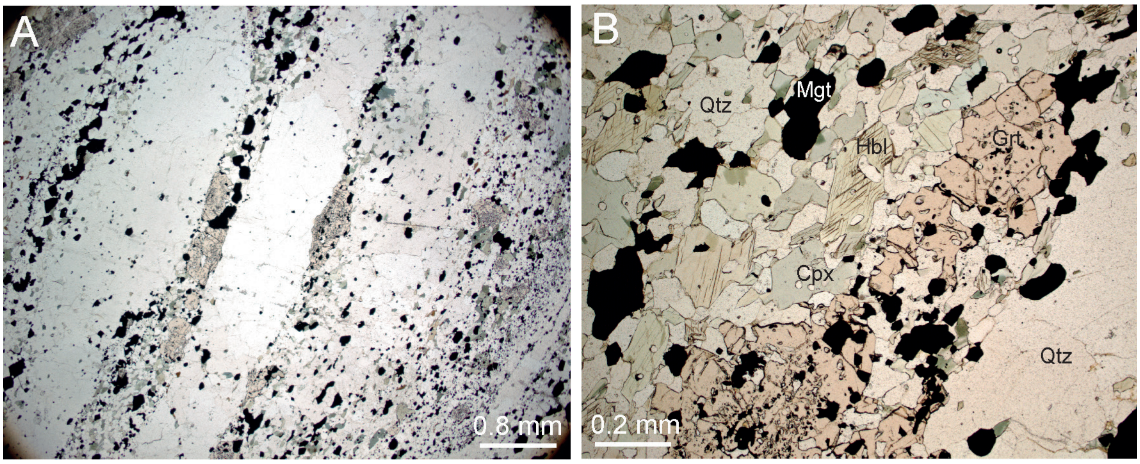

Figure 43. A. Quartz-calc-silicate-banded rock with a disseminated magnetite. Micrograph in plane polarised light. **B.** Detail of photo A, showing a quartz band (right) and calc-silicate band, with garnet, diopside, amphibole including grains of magnetite (left). Micrograph in plane polarised light. Photo: Fredrik Hellström.

Välivaara 5	ORED25614	FHM140046
Fe (excavation)	E 800883	N 7503412

Approximately 3.8 km north-northeast of Masugnsbyn, in the southern part of the Välivaara ore field, is an excavated pit, 13 × 4 m wide and filled with shallow water up to 0.5 m below ground level. Banks around the pit contain overgrown, excavated soil material without ore-bearing rock fragments. The pit is probably an exploratory attempt to find iron ore.

The Vuoma field

The Vuoma field, situated in the northernmost part of the Masugnsbyn iron ore district (fig. 36), is characterised by the absence of skarn minerals (Witschard et al. 1972). Magnetite concentrations generally occur in well-banded, fine-grained metasediments (fig. 44). A few metres of compact magnetite occasionally occur within biotite schists. Granite-pegmatite dykes, up to 40 m wide, sharply cut the supracrustal rocks. The mineralisation is known from core drillings from five drill holes. Asplund (1920) estimated the total mineralised area to be 2,036 m^2, divided between two ore bodies, measuring 470 × 2.8–3.8 m and 50 × 10 m. Four analyses of iron ore from the drill cores returned 47.9–57.4% Fe, 0.048–0.130% P and 0.039–0.113% S; they are thus relatively rich in phosphor. The Vuoma mineralisation has a roughly east–west orientation with a steep southerly dip, occurs approximately 350 m north of the Isovaara field, and lies parallel to it (Högbom 1919, Geijer 1929, Witschard et al. 1972).

Vuoma	ORED00165	
Fe (drilling)	E 800158	N 7504875

This is an unexposed Fe mineralisation as described above. The given coordinates represent a "to-the-surface" projected and estimated average point for the mineralisation based on the magnetic anomaly map shown in fig. 36B.

The Isovaara field

The Isovaara field lies in the northern part of the Masugnsbyn iron ore field (fig. 36, 45). Magnetite concentrations are found in skarn, and concordantly within alternating quartzite, schist and skarn bands, with abundant iron sulphides (Wischard et al. 1972). Only two drill holes have been drilled, penetrating Lina granite north of the ore zone. Stratified iron ore with quartz layers alternating with iron silicates, occur immediately south of the skarn iron ores (Geijer 1929). According to Högbom (1919), there are nine exploration trenches transecting the magnetic anomaly. Asplund (1920) estimated the total mineralised area to be 1,150 m^2, and presented six analyses of iron ore, with 50–69% Fe, 0.010–0.072% P and 0.002–0.024% S. The Isovaara mineralisation has a westerly to west-southwesterly orientation and is about 1 km long (Frietsch 1997).

Isovaara 1	ORED00164	FHM140054
Fe (trial pit)	E 799574	N 7504435

Approximately 4.9 km north-northwest of Masugnsbyn, in the central part of the Isovaara field, is an exploration pit 6 × 2–3 m wide and 2–3 m deep. Banks around the pit contain overgrown excavated material. Some mineralised waste rock is seen in the southern part and consists of

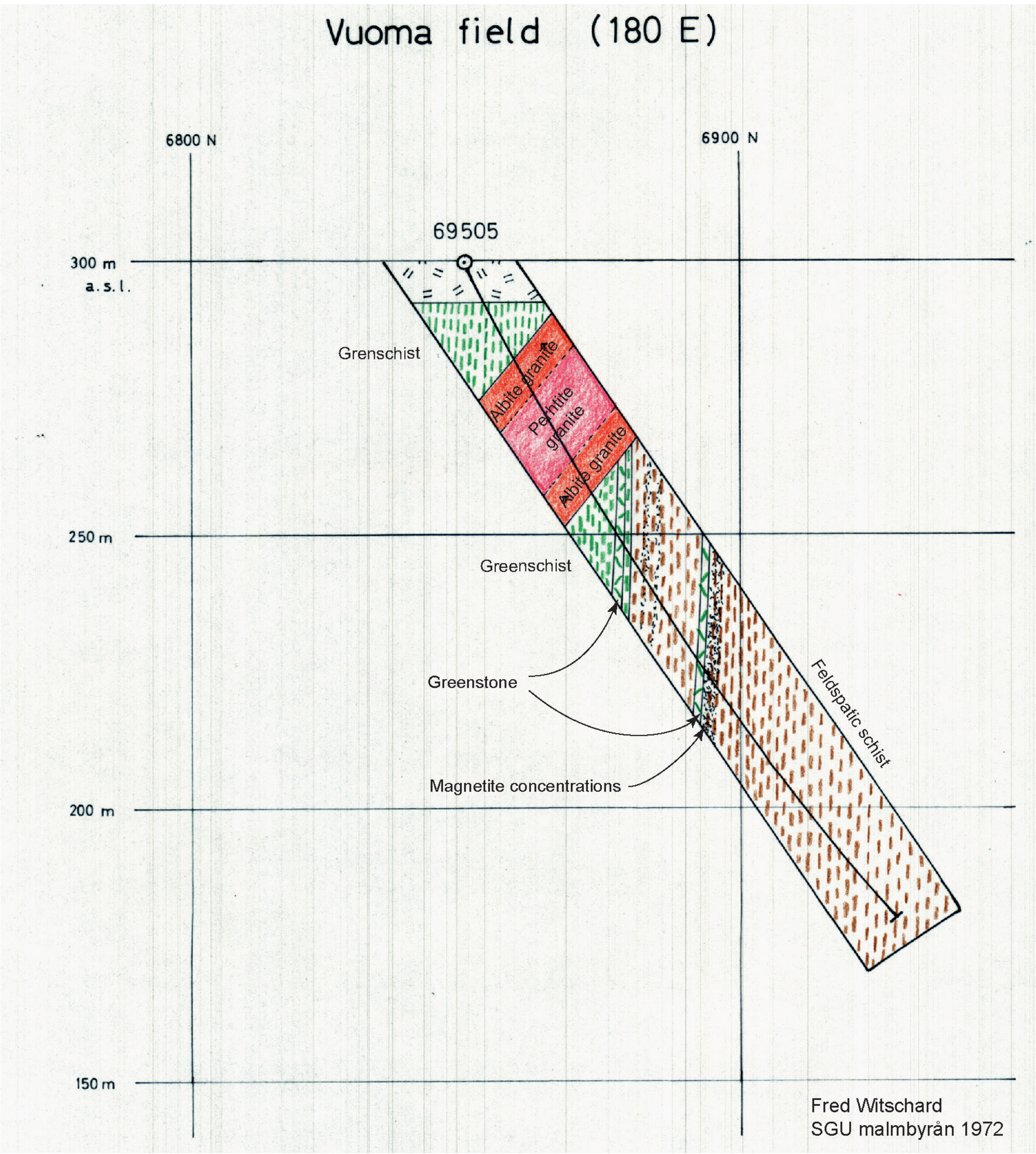

Figure 44. Vertical geological section at the Vuoma field (modified from Witschard et al.1972).

fine-grained magnetite ore (magnetic susceptibility >100,000 × 10^{-5}) with bands of white mica. Rusty boulders with rich sulphide dissemination in pyroxene-amphibole skarn and quartz veins are also observed. The sulphides generally consist of pyrite and pyrrhotite, but traces of chalcopyrite occur. There is an additional shallow excavation east of this pit. A Fe sulphide-rich skarn sample, analysed during the present inventory, contains 10.5% S, low concentrations of Cu (420 ppm), and a gold content below the detection limit (<0.001 ppm; Appendix 2).

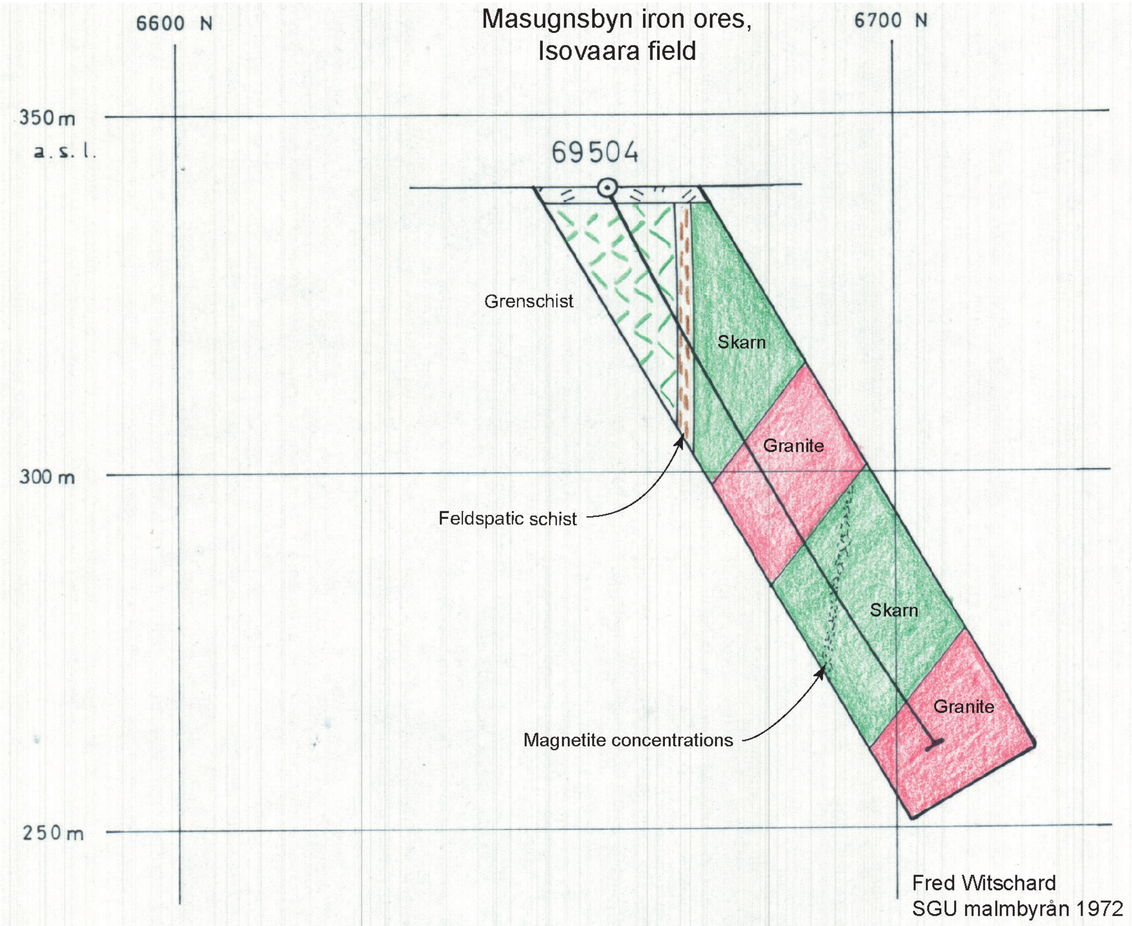

Figure 45. Vertical section at the Isovaara field (from Witschard et al. 1972).

Isovaara 2	ORED25605	FHM140055
Fe (trial pit)	E 799508	N 7504428

Isovaara 2, located about 65 m west-southwest of Isovaara 1, is an irregularly shaped exploration pit, approximately 27 × 13 m across and 1–3 m deep. Banks around the edges of the trench contain overgrown excavated rock and till material. In the centre of the pit is a pile of rich iron ore, with fine-grained magnetite. Skarn-banded magnetite ore with centimetre-thick bands of magnetite alternating with fine-grained diopside and some amphibole is also observed (fig. 46). Traces of pyrite, disseminated or as thin veins cross-cutting the banding occur. A selected sample of skarn iron ore, analysed during the present inventory, contains 51.7% Fe, 0.1% Ti, 0.01% P, 0.03% S (Appendix 2).

Isovaara 3	ORED 25606	FHM140056
Fe (trial pit)	E 799430	N 7504354

Isovaara 3 is a trial pit 10 × 9 m wide and 3 m deep. The edges are inclined inwards down to a 4 × 5 m water-filled base with a water depth of 0.5 m. The pit is surrounded by a bank that is 1 m high and 1–2 m wide, with overgrown excavated material. Piles of waste rock south and east of the pit consist of fine-grained magnetite ore (magnetic susceptibility 50,000–100,000 × 10^{-5} SI units) with pale mica or serpentine. Diopside-amphibole skarn with disseminated pyrrhotite is also found. According to Asplund (1920), 50 tonnes of ore was mined at Isovaara 3.

Figure 46. Skarn-banded magnetite ore at Isovaara 2. Photo: Fredrik Hellström.

Isovaara 4	ORED25607	FHM140057
Fe (trial pit)	E 799396	N 7504341

Isovaara 4 is an exploration/trial pit about 20 × 4 m across and 3 m deep. It is fringed by banks of overgrown excavation material 0.5–1 m high and 1–2 m wide. The pit edges are inclined inwards ending in a trench. Some waste material occurs in the bottom of the pit, consisting of fine- to coarse-grained diopside skarn with disseminated magnetite.

Nya Isovaara

Nya Isovaara is the westernmost sub-area of the Masugnsbyn ore field, approximately 4.5 km north-northwest of Masugnsbyn village (fig. 36), and is only known from five exploration pits (Högbom 1919, Geijer 1929). A fairly rich but somewhat weathered skarn iron ore is found in the exploration pits. Poorer varieties show irregular magnetite dissemination in a quartz-rich chert-like rock. Three iron ore analyses from the pits show 54–69% Fe, 0.005–0.031% P and 0.002–0.006% S (Asplund 1920). The iron mineralisations seem to have a southeasterly to southwesterly strike, evident from the magnetic map (fig. 36B).

Nya Isovaara 1	ORED25602	FHM140060
Fe (trial pit)	E 799083	N 7504011

Nya Isovaara 1 is an exploration trench 20 m long and 1 m wide, with <0.5 m water depth in the southern part. A few waste rock pieces contain massive magnetite ore with veins of drusy quartz.

Nya Isovaara 2	ORED 25604	FHM140062
Fe (trial pit)	E 799208	N 7503888

Nya Isovaara 2 is a shallow water-filled exploration pit (?) 14 × 5 m across and 0.5 m deep, with some piles of excavated material along the edges. There are a few boulders of cherty/rhyolitic rock with disseminated magnetite (fig. 47, magnetic susceptibility 30,000 × 10^{-5} SI units).

Figure 47. Very fine-grained chert/rhyolite with disseminated magnetite. Photo: Fredrik Hellström.

Mineralisations and iron ore drillings east of Masugnsbyn

Rautajoki	ORED15728	FHM150003
Fe (outcrop)	E 802561	N 7498484

Approximately 2.2 km east-southeast of Masugnsbyn, just south of the border with the perthite granite, there are outcrops with a magnetite-quartz skarn-banded rock, possibly originally a banded iron formation (fig. 48). A rich dissemination of magnetite occurs locally or in patches, in an isotropic fine- to coarse-grained skarn assemblage consisting of amphibole, clinopyroxene and garnet. A chemical analysis of an outcrop sample, taken during the present inventory, shows a rather low iron content of 13.8% Fe. Traces of iron sulphides result in an S concentration of 0.25%.

Säynäjäjoki	ORED00488	
Fe (drilling)	E 817020	N 7507409

One bore hole (150.2 m) was drilled in 1972 by SGU 18 km east-northeast of Masugnsbyn village (fig. 29). Chemical analyses of sections between a depth of 80 and 140 m indicate an iron content of 25–54% Fe (chemical data available from the SGU archive). No information on ore type or host rock was found. The drill core is stored at SGU Malå.

Figure 48. Quartz skarn-banded rock with disseminated magnetite at Rautajoki. Photo: Fredrik Hellström.

Tornefors	ORED00113	
Fe, Cu, Au (drilling)	E 820126	N 7498168

The Tornefors iron prospect is situated at Junosuando village (fig. 29), and was discovered by SGU in 1949 by magnetic measurements. Six drill holes were drilled at the prospect the same year, and two further ones were added in 1970 (Damberg et al. 1974). The mineralisation forms a layer 700 m long and up to 120 m wide, extending in a north–south direction, and consists of magnetite bands alternating with skarn and quartzite (fig. 49). According to Martinsson et al. (2016), the Tornefors iron formation is a "transitional BIF", in which a magnesium-rich iron-formation grades into BIF towards the hanging wall and/or laterally. The skarn minerals are actinolite-tremolite, diopside and, locally, small amounts of calcite. Serpentine occurs frequently in the western part of the ore zone (Frietsch 1997). Locally, pyrite, pyrrhotite and small amounts of chalcopyrite are present in the iron ore. Chemical analyses of drill cores show an average of 20% Fe and, in some sections, up to > 50% Fe, with less than 0.03% P and 1–3% S. The magnetite-bearing ore zone occurs between marble to the west and greenstone toward the east. The marble also carries small amounts of magnetite (Damberg et al. 1974). Ore reserves are estimated at 2.6 million tonnes, with 20% Fe (Frietsch 1997).

In 1987–88, Viscaria AB started exploration work in the Junosuando area, and sections from the old drill cores were analysed (Godin & Rönkkö 1989). Some of the drill core sections analysed showed anomalous amounts of Cu (up to 0.46% Cu), Au (up to 1.14 ppm) and Ag (up to 53.3 ppm). The richest gold section, with 1.14 ppm Au, was noted in drill core Bh 6 (Junosuando Bh6 at 820210/7498428 north of the road to Lautakoski; see fig. 50. The results were considered interesting but not good enough for further work (Godin & Rönkkö 1989).

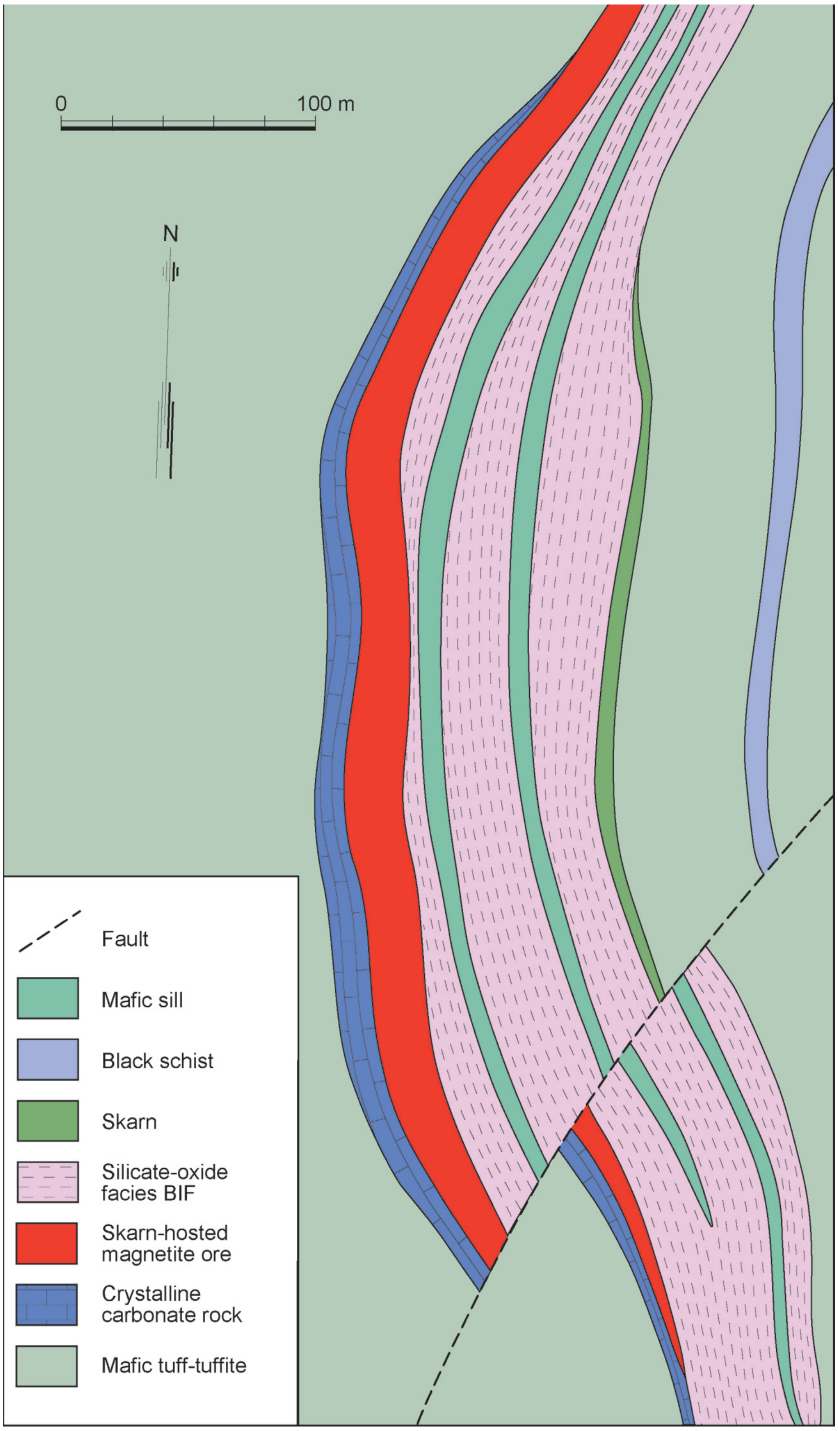

Figure 49. The Tornefors deposit (from Bergman et al. 2001).

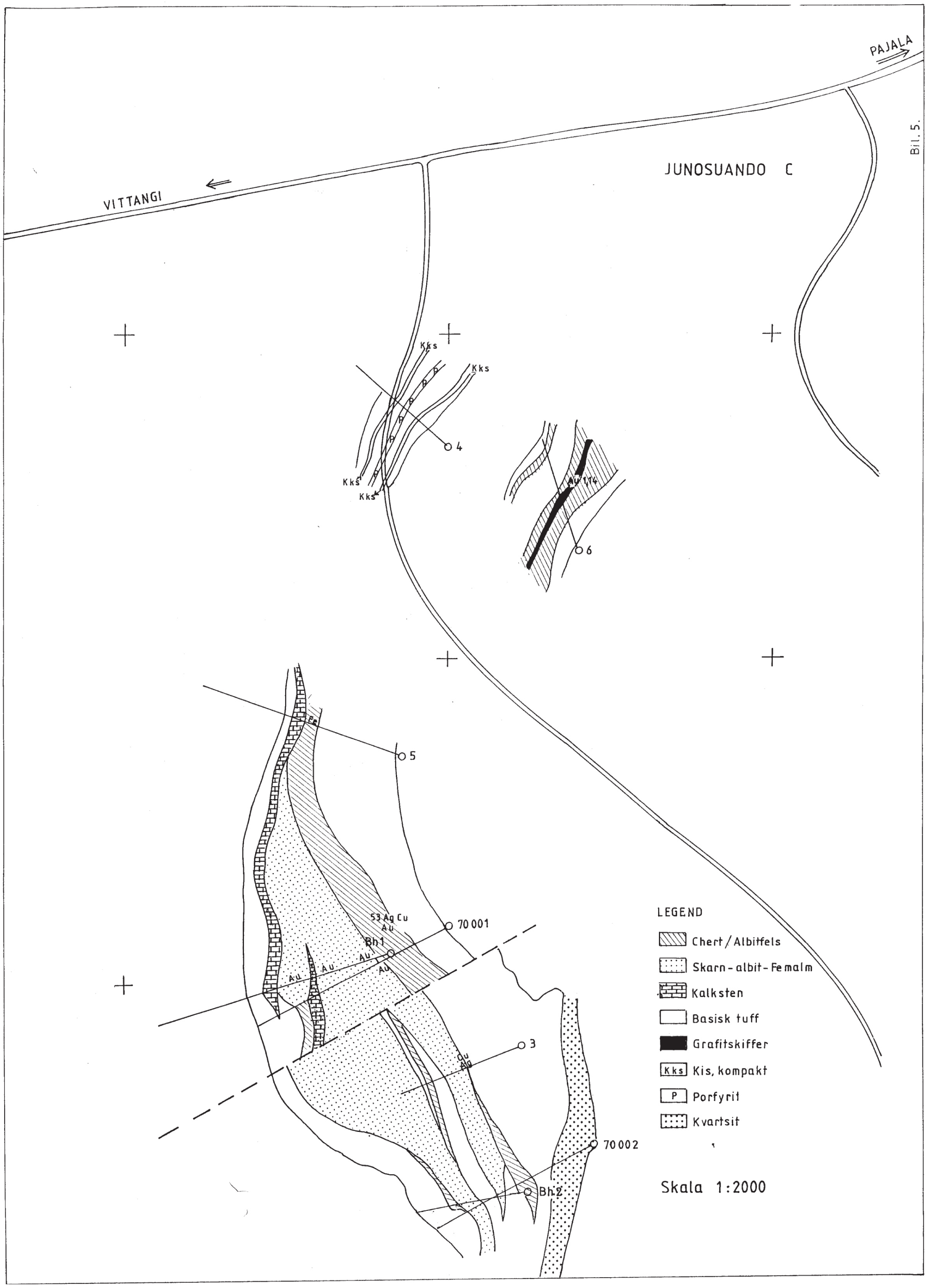

Figure 50. Geological map and drill holes in the Junosuando area (from Godin & Rönkkö 1989).

Leppäjoki	ORED00154	
Fe, Fe sulphides (drilling)	E 810426	N 7494908

The Leppäjoki iron prospect is located in the Maunuvuoma bog area, 10 km west-southwest of Junosuando (fig. 29), and was discovered by SGU using airborne magnetic measurements in 1962. Magnetic and gravimetric measurements were made in 1964–1965 and 1968, followed by drilling of one borehole of 221.14 m (Lindroos 1979; Frietsch 1997). The mineralisation is covered by soil to a depth of 12 m. The drill core penetrates two east–west-trending magnetite skarn ore horizons, which dip steeply to the north. The ore zones are hosted by a small outlier of mafic metavolcanic rock enclosed by granite (fig. 29). The southern ore zone is about 35 m wide, and the northern zone 5–8 m wide. The skarn consists of amphibole, chlorite, quartz and calcite. Pyrrhotite and pyrite also occur as impregnations and vein fillings within the magnetite ores (Lindroos 1979). Chemical analyses from the northern ore zone returned 41% Fe with 0.08% S, and from the southern ore zone 32% Fe, 0.9% S and 0.4% Cu. The phosphorus content is less than 0.4% in both horizons. The estimated total tonnage is 6 million tonnes at 32% Fe (Lindroos 1979).

Sulphide mineralisations

Mikkelijoki	ORED25952	
Cu (drilling)	E784673	N7521455

Electromagnetic and magnetic anomalies occur along the eastern margin of the Vittangi gabbro, 27 km northwest of Masugnsbyn, and have been investigated by IP ground measurements and core drilling by LKAB Prospektering (figs. 29, 31, 32). The strongest anomalies in the southern part contain dykes and veins of massive magnetite up to 3 m wide, together with amphibole, feldspar, and some pyrite, pyrrhotite and chalcopyrite (Lehto 1978). One sample contains 0.11% Cu, 0.02% Co, 0.03% Ni, 0.24% V, 1.67% Ti, 46.7% Fe and 3.21% S (1.15 m, drill hole 78056). Another IP magnetic anomaly occurs 4.4 km to the north-northwest. This has been drilled with two holes (78057, 78058). The cores show a weak pyrite-chalcopyrite impregnation in gabbro.

Nuuksujärvi	ORED25804	
Cu (drilling)	E 814477	N 7517134

The Nuuksujärvi copper prospect, 5 km north of the village of Nuuksujärvi (fig. 29), was found in the early 1970s during a geochemical till survey of Pajala municipality (GeoVista AB 1998). In the Nuukutus area, a promising geochemical anomaly was drilled with six drill holes in 1985 after ground geophysical measurements (Niva 1984a, Fredriksson 1985, Petersson 1986). In total, 550 m was drilled and 15 sections were analysed. The richest part contained 0.4% Cu over a 1.5-metre section (Fredriksson 1985). The results were not good enough and the prospect was abandoned. No further exploration has been carried out on the prospect. The predominant rock type is Parojoki diorite, which occurs in contact with rocks of the Greenstone group. Poor sulphide mineralisation occurs, mainly in the greenstone. In general, the bedrock is strongly tectonised, with hematite-bearing crush zones. These give rise to electrical conductors. ScanMining has carried out detailed till geochemical sampling some 4–5 km east of the Nuuksujärvi prospect (Tuorerova no 1, 17.5 km^2, expired 22 December 2001; data supplied to SGU).

Merasvaara 1	ORED25950	FW112/66
Cu (outcrop)	E 797329	N 7513221

14 km north-northwest of Masugnsbyn is an outcrop with pyroxenite (90% augite, 10% biotite) in contact with graphite-bearing schist (fig. 29). A little pyrite and chalcopyrite is present in the pyroxenite (no 30-29L in table, Carlson et al. 1984c, field notes of Fred Witschard, FW66-112). The locality coincides with a slingram anomaly; one bore hole was drilled (Merasvaara_dbh_73802) in 1973 by SGU. No core logging protocol is available. The locality was not visited during the present inventory.

Merasvaara 2	ORED25951	FW113/66
Mo (outcrop)	E 797076	N 7513418

An outcrop with pegmatite disseminated with small crystals of molybdenite and crystals of tourmaline a few centimetres across occurs 14.3 km north-northwest of Masugnsbyn (fig. 29). Mo-mineralised boulders of pegmatite and skarn also occur close to the locality (no 31-29L in table, Carlson et al. 1984c, field notes of Fred Witschard, FW113/66). The locality was not visited during the present inventory.

Junojoki	ORED25947	AN1/49
Cu (outcrop)	E 808484	N 7511768

In Junojoki stream, 14 km north-northeast of Masugnsbyn (fig. 29), there is a small outcrop area of sheared greenstone containing a 10-cm-wide zone with partly rich impregnations of chalcopyrite (No 6 (29L) in table, Carlson et al. 1984c, field notes AN1/49, FW758/67, SGU archive). The outcrop was not visited during the present inventory. Intrepid Minerals Corporation carried out till geochemical sampling around the Junojoki prospect under its limited (1.77 km^2) exploration permit (Purnuvuoma no 100, expired 4 July 2006; data supplied to SGU).

Pahturijärvi	ORED25948	83K PTL33
Cu (outcrop)	E 813556	N 7511033

South of Lake Pahturijärvi, approximately 17 km northeast of Masugnsbyn (fig. 29), is an outcrop of acid to intermediate volcanic rock containing impregnations and pods of pyrite and chalcopyrite (0.65% Cu, No 63 (29L) in table of Fredriksson & Bergström 1984). The locality was not visited during the present inventory.

Kivijänkkä (Pahturi)	ORED00484	PAC950528
Cu (trial pit)	E 815006	N 7509327

The Kivijänkkä prospect, situated 2 km south-southeast of Pahturi hill, 12 km northwest of Junosuando (fig. 29), was discovered in 1949 when boulders of chalcopyrite-rich greenstone were found in the area (Petersson 1986). Geophysical ground measurements were carried out, and drilling was performed by SGU in 1974. In 1985 two of the geophysical anomalies were investigated with another three drill holes (Fredriksson 1985, Petersson 1986). The southern electrical anomaly is caused by graphite-rich metasediments; the northern anomaly is explained by a 100-m-wide poor mineralisation of pyrite and chalcopyrite in the skarn-altered, effusive greenstones (dh 85101). However, the richest parts only contain 0.1–0.3% Cu over a 2-metre drill core section (Petersson 1986). Gold concentrations are below the detection limit (<0.01 ppm). Two small overgrown trial pits were noted during bedrock mapping (PAC950528: 815008/7509322), one with actinolite skarn and syenitoid material, and one with magnetite-rich metabasalt-andesite.

Merasjärvi	ORED15397	
Mo, Cu (outcrop)	E 802323	N 7507319

The Merasjärvi prospect, located 8 km north of Masugnsbyn (fig. 29), was discovered by a find in *Norrlands mineraljakt 1979*. The prospect is described as an east–west-trending rusty zone, 200 m long and 15–20 m wide, with patches of molybdenite, pyrite and scattered chalcopyrite hosted by a granitised greenstone. Chemical analyses show a grade of 0.2–0.3% Mo (Lehto 1981b). Exploration work in the area has also revealed boulders with Cu-Mo-bearing skarn with an average content of 100–200 ppm Mo and 0.2% Cu (Lehto 1981b).

Pennikajärvi	ORED25945	ÖN 221/41
Cu (outcrop)	E 789213	N 7506866

On the northern slope of Kuusivaara, south of Lake Pennikajärvi, 14 km west-northwest of Masugnsbyn (fig. 29), there are outcrops of gabbro with weak disseminations of pyrrhotite, pyrite and chalcopyrite (No 2 (29L) in table of Carlson et al. 1984a, 0.26–0.44% Cu). A find from *Norrlands mineraljakt 1988* (88049, 88213, 88214), at roughly the same place (789161/7506965), describes 11 small rusty outcrops and some exploration pits in the area. Pods and impregnation of pyrrhotite, pyrite and chalcopyrite occur in coarse-grained, gabbroid dykes, which are up to 1 m wide, and strike concordantly with the hosting paragneiss. The gneiss contains a weak sulphide mineralisation adjacent to the gabbroid dykes. In addition, molybdenite was noted in one of the pits (Carlson et al 1984a). Chemical analyses show up to 3.96% Cu. The prospect was not visited during the present inventory.

Rautajoki 2	ORED25946	
Cu (outcrop)	E 800522	N 7498414

Approximately 1.2 km south of Masugnsbyn, close to the Rautajoki River (fig. 29), is an outcrop with chalcopyrite impregnation in metasediment (0.37% Cu, <0.1 ppm Au and Ag according to Fredriksson & Bergström (1984, no 86 in table). The outcrop was not visited during this inventory.

Veikkavaara	ORED25621	FHM140017
Cu (closed mine)	E 803790	N 7496493

The Veikkavaara Cu mineralisation is located about 4.4 km southeast of Masugnsbyn (fig. 29), and occurs along the western boundary of a mafic sill 30 to 40 m thick, which intrudes a laminated basaltic tuff of the upper part of the Veikkavaara greenstone group (Martinsson 1994). The 20 × 6 m, north–south-oriented trial pit is dug directly into bedrock and contains shallow water 2–3 m below ground level (fig. 51). Sulphides are dominated by pyrrhotite occurring together with some chalcopyrite as irregular disseminations and patches in predominantly pyroxene and amphibole-bearing skarn, with subordinate biotite and scapolite (Martinsson et al. 2016). A bulk sample of rich sulphide mineralisation, analysed during the present inventory, contains 1.02% Cu, and is weakly enriched in Co (219 ppm), but has a gold content below the detection limit (<0.001 ppm Au, Appendix 2). Large piles (approximately 300 m^3) of rusty waste material occur west of the pit. U-Pb analysis of one fraction of titanite from the mineralisation is

Figure 51. The Veikkavaara Cu prospect. Photo: Fredrik Hellström.

dated at 1.8 Ga (Martinsson et al. 2016). In 2004, Tertiary minerals Ltd carried out base-of-till/bedrock percussion drill hole geochemical sampling on two traverses in the area (Exploration permit Vehkavaara no 1, valid 2003–2007; exploration data supplied to SGU). They also took grab samples for geochemical analyses from outcrops, boulders and waste dump material at Veikkavaara (geochemical data supplied to SGU, Tertiary Minerals Ltd 2004).

Kotasenroa	ORED15399	TOB150039
Cu (outcrop)	E 813688	N 7494850

A rewarded find from *Norrlands mineraljakt 1984* (Id-code 84382) consists of several small outcrops of skarn-altered felsic metavolcanite or metasediment with visible amounts of chalcopyrite, malachite and pyrite (fig. 29). But chemical analysis of a sample taken during the present inventory showed a copper content of less than 0.1% (Appendix 2).

Saarikoski	ORED15724	
Cu, Au (outcrop)	E 800245	N 7487063

A mineralisation less than 10 cm wide occurs in an outcrop at Saarikoski near Kalixälven, some 12 km south of Masugnsbyn (fig. 29). The mineralisation is hosted by the basal conglomerate of the Kalixälv group. Chemical analysis of a sample from the mineralisation showed a content of 0.65% Cu and 0.6 ppm Au (Niiniskorpi & Hansson 1984).

Kurkkionvaara	ORED00834	
Zn, Pb, Cu (drilling)	E 801266	N 7483954

The Kurkkionvaara Zn-Pb-Cu mineralisation is located about 15 km south of Masugnsbyn at the contact between metasedimentary rocks of the Pahakurkkio group and the metasedimentary and intermediate metavolcanic rocks of the Kalixälv group (fig. 52). The Kurkkiovaara prospect has been described in several exploration reports (Niiniskorpi 1982, 1985a, 1986a, b, 1987a, Hansson 1985a). It was discovered as a result of boulder tracing in 1981, when boulders with up to 2% Zn, 1.1% Pb and 0.15% Cu were found. The same year the area was covered by airborne geophysical measurements (magnetic, electromagnetic and VLF), a geochemical survey of peat bogs, and a drilling campaign of 11 drill holes. During 1982–1985 a geochemical survey of basal till, trenching and continued drilling (a further 11 drill holes) was performed, and several minor Zn, Pb, Cu mineralisations were identified. Despite extensive exploration efforts in the area, no mineralisation of economic significance has been found.

The mineralisations occur as scattered sulphide veins or fracture fillings with sphalerite and galena, mainly in the metasedimentary rocks of the Pahakurkio groups, but also in the overlying basal conglomerate of the Kalixälv group. Locally, in fracture zones, 0.4–2.0-metre sections displaying richer mineralisation occur, with Zn-Pb content of up to a few per cent. Pyrrhotite, pyrite and, locally, chalcopyrite occur as impregnations in metre-wide zones in the sedimentary rocks. The highest concentrations of iron sulphides occur in the 10–20-m-wide conglomerate horizon above the Pahakurkio group as an impregnation within the matrix. Veins of pyrrhotite generally occur parallel to bedding in the sediments, whereas the Pb-Zn filled fractures are usually steeply dipping and cross-cut bedding. There is a positive correlation between B and Zn + Pb content in lithochemical analyses, suggesting a hydrothermal system with boron-rich fluids containing base metals (Niiniskorpi 1986a). At Kurkkionvaara, tourmalinites occur in the pelitic sediments, but tourmaline-rich pegmatites are also seen. Boron-rich fluids probably had a source in the metapelites, originally deposited as marine sediments.

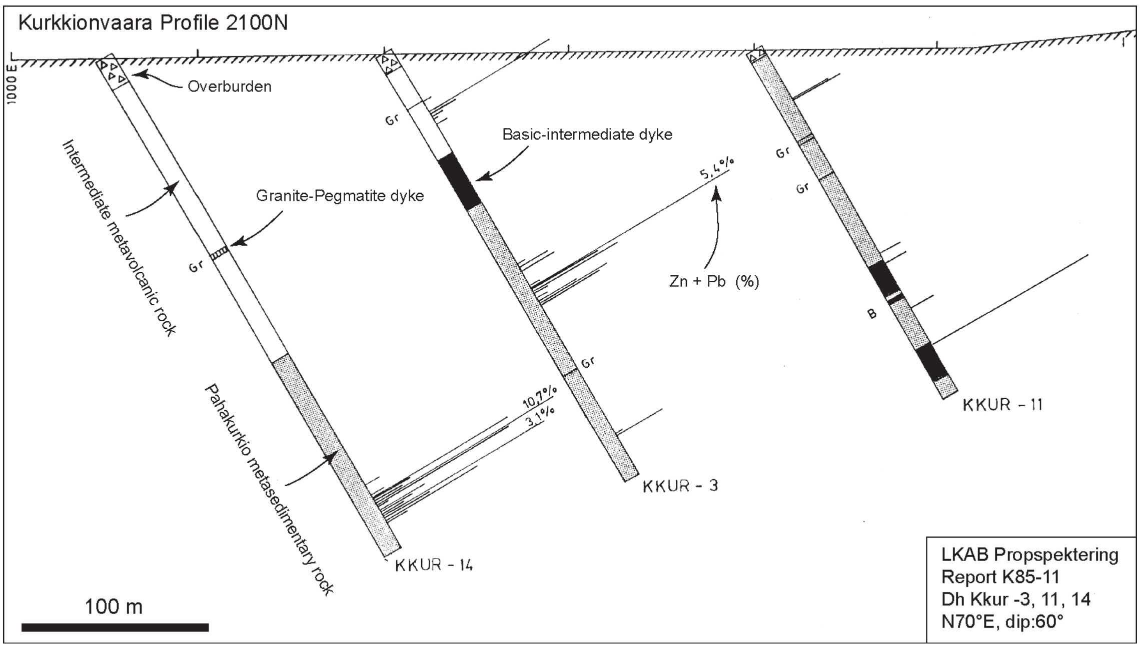

Figure 52. Vertical section at the Kurkkionvaara Zn-Pb-Cu mineralisation (from Niiniskorpi 1985a).

Rappukoski	ORED15732	
Cu, Mo (outcrop)	E 808267	N 7482952

A copper mineralisation occurs at Rappukoski, about 18 km south-southeast of Masugnsbyn (fig. 29; Grip & Frietsch 1973). The mineralisation occurs in a layer of calcareous skarn in outcrops on both sides of the Kalixälven River. A system of tension fractures created during folding is filled with quartz, calcite, hornblende, chalcopyrite, bornite and molybdenite. Chalcopyrite is also disseminated within the wall rock to some extent. The width of the mineralised zones is usually 0.1–0.3 m, but locally up to 2 m wide in the folded parts. The mineralisation contains 1–2% copper and traces of molybdenum (Grip & Frietsch 1973). The bedrock of the area predominantly comprises metasedimentary rocks of the Pahakurkio group, mainly quartzitic mica schist, but also layers of conglomerate and concordant greenstones, all cut by granite and pegmatite (Padget 1970, Ödman 1939). The mineralisation was searched for but not found during the present inventory.

Oriasvaara	ORED00311	TOB140048, TOB140049
Cu, Au (drilling)	E 811366	N 7481871

The Oriasvaara copper-gold prospect is situated 20 km south-southeast of Masugnsbyn, east of the road between Tärendö and Masugnsbyn and 1 km north of Oriasvaara hill (fig. 29). The Oriasvaara prospect was found by SGU in 1965 using electromagnetic measurements, and was further investigated in the 1970s and 80s by SGAB, LKAB and Studsvik Analytica AB, using geological mapping, boulder tracing, trenching, core drillings and additional geophysical measurements (Quezada 1976, Carlson 1982b, Petersson 1986, Fredriksson 1986a, b, Jonasson 1986). The Oriasvaara Cu-Au mineralisation is spatially associated with the Kalixälv fault.

According to the above references, two zones of mineralisation have been identified in supracrustal rocks that have been assigned to the lower part of the Kalixälv group, just south of the southwest-striking Kalixälv fault. In the western part, the mineralisation is associated with greenstones; in the east, the mineralisation is situated in a limestone horizon. The eastern mineralisation contains an irregular and fine-grained impregnation of pyrrhotite, chalcopyrite and pyrite in dolomitic limestone. The mineralisation is locally richer in skarn-altered parts, occurring as impregnations or in bands. The western mineralisation has an impregnation of sulphides, including pyrrhotite, pyrite, chalcopyrite and trace amounts of bornite, in greenstones and in "quartzites", which probably represent zones of strong silicification. The scapolite-altered rocks form a unit about 180 m thick, which generally strikes southwest–northeast. The mineralised zone is bound by mica schist to the north and east, and by pegmatite to the south. The ore zone appears to continue westwards, as indicated by geophysical maps.

Analyses of mineralised rocks returned up to 1.3% Cu, and a few analyses of gold returned up to 0.5 ppm Au (Carlson 1982a, Carlson 1982b, Quezada 1976). Whole-rock geochemical sampling was carried out in 1985 in two trenches with a total length of 286 m (fig. 53; Petersson 1986). The rock in the trenches predominantly comprises greenstone with zones of silicification. The eastern trench contained a weak Cu-Au mineralisation, but the western trench is more interesting, with two richer sections. The northern mineralised section is 40 m wide, with a 4-metre section containing 0.5% Cu and 0.64 ppm Au. The southern mineralised section contains 0.95% Cu and 0.016 ppm Au over 4.8 m. These mineralised sections coincide with the eastern extension of two strong slingram anomalies, 200 m and 175 m long, which were later investigated with two drill core holes with a total length of 300 m (Jonasson 1986). However, assaying of 55 drill core sections showed only low copper and gold values, the best sections being 0.36% Cu and 0.15 ppm Au over 2 m.

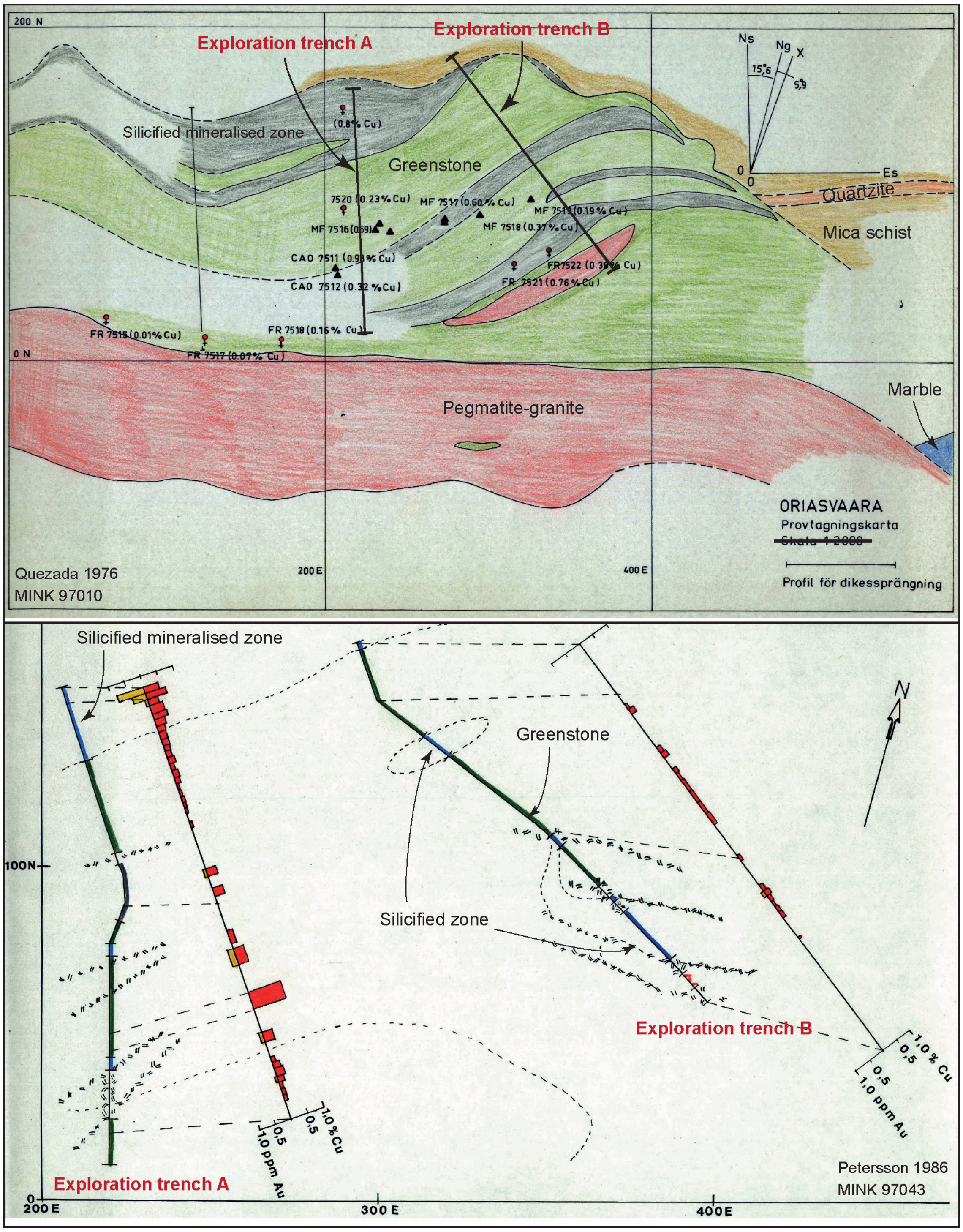

Figure 53. Geological map of the Oriasvaara Cu-Au mineralisation, showing exploration trenches and results from geochemical analyses (modified from Quezada 1976, Petersson 1986).

During a visit in summer 2014 as part of the present inventory, traces of the trenching were still visible in the area as a shallow, 40-metre-long trench in a northwest–southeast direction. Rusty boulders and dump material can be found along the trench (fig. 54). The rusty rock is quartz-rich, fine-grained and was interpreted as felsic metavolcanic rock or metasandstone with a strong dissemination of pyrrhotite and pyrite. This may, however, be silicified green-

Figure 54. Exploration trench A (see fig. 53) at Oriasvaara summer 2014. View towards the south. Photo: Torbjörn Bergman.

stone, as described above by previous authors. Chalcopyrite is only noted as scattered grains, less than 1 mm across. Chemical analysis of a sample taken from an outcrop in the trench shows a Cu content of 0.25% and 0.02 ppm Au (Appendix 2). Scan Mining carried out till geochemical sampling approximately 4 km southeast of the Oriasvaara prospect (Mustamaa no 1, 3.3 km^2, expired 14 October 2001; data supplied to SGU). Lake Resources also carried out till and whole-rock sampling south of the Oriasvaara prospect in their 96 km^2 exploration Palolaki no 1 (expired 18 May 2001; data supplied to SGU).

Jukkasvaara	ORED25949	BOM950313
Cu, Co (outcrop)	E 823753	N 7481502

At the end of the gravel road in the northern part of Jukkasvaara, 12 km north-northwest of Tärendö (fig. 29), is a find from *Norrlands mineraljakt* (SGU 2005) by Vesa Hiltunen, awarded first prize in *Norrlands mineraljakt* in 2005 for best find in Norrbotten. The find consists of an outcrop with a rusty exposure of gneissic, mafic metavolcanic rock some 2.5 m long and 1.5 m wide, with semi-massive sulphide veins dominated by pyrite with chalcopyrite-rich parts. Excavation by machine was carried out to better expose the mineralisation. The rusty zone continues northwards under the road. The mineralisation consists of two types: 1. Rich impregnation to semi-massive pods of pyrite and magnetite in a brecciated and somewhat microcline-altered and gneissic mafic metavolcanic rock. 2. Network/stockwork of semi-massive veins of pyrite and chalcopyrite in amphibole-rich, chlorite-altered mafic rock. The surrounding rocks are an unaltered mafic metavolcanic rock, and a somewhat migmatitic, granitic rock occurs approximately 10–20 m to the southeast (SGU 2005, Field note protocol, 05165-7). An analysed rock sample contained 1.37% Cu, 0.15 ppm Au, 0.8 ppm Ag and 502 ppm Co, according to the *Norrlands mineraljakt* report (05165-7). Bothnia exploration collected four 210-metre lines of magnetic ground measurements of the mineralisation (Bergsstaten & SGU 2009). Scan Mining carried out till geochemical sampling a few kilometres to the northwest of the Jukkasvaara prospect (Isovinsa 2, 16 km^2, expired 21 December 2000; data supplied to SGU).

The Vuollovaara–Maunuvaara–Iso–Orotusvaara Cu-Au-Ag mineralisations

Cu-Au-Ag mineralisations including Vuollovaara, Maunuvaara and Iso–Orotusvaara occur in a more than 7-km-long north–south trending zone located in the west of the Masugnsbyn area (fig. 29; Hermelin 1804, Geijer 1918, Tegengren 1924, Niiniskorpi 1982, 1983, 1984, 1986c, Niiniskorpi & Hansson 1984, Hansson 1985b). The small, scattered mineralisations occur in quartz-amphibole veins or as impregnations in lenses of gneissic andesite of the Kalixälv group, surrounded by Lina granite. The north–south-trending zone, with intermediate metavolcanites, continues north, and the chances of finding similar copper-gold mineralisations in its extension are considered good. According to the regional bedrock map of northern Norrbotten (Bergman et al. 2000), the mineralisations coincide with a regional ductile deformation zone. Ore minerals are chalcocite with small amounts bornite and chalcopyrite. Malachite and azurite are present, as well as zeolites, including aggregates of stilbite (desmin) and chabazite.

Niiniskorpi (1982, 1983, 1984) has described exploration work in the Maunuvaara area from the early 1980s, including geological mapping, boulder tracing, geochemical sampling of deep till, bog peat, heavy minerals and stream sediment, and magnetic and electromagnetic measurements (VLF, IP). Copper concentrations in mineralised rocks are generally low, but locally can reach a few per cent, while the gold content is generally below 2 ppm, with one sample containing 6.5 ppm (300 ppm Bi, 135 ppm Te, Niiniskorpi 1981). The silver content generally varies between 10 and 27 ppm. Some rock samples show anomalous molybdenum (200 ppm) and tungsten (2,900 ppm). Bog peat samples show Cu, Mo and Sn anomalies, but mineralisations are hard to trace with geophysics. Scan Mining has carried out till geochemical sampling about 3 km west of the Maunuvaara area (exploration permit Kivivaara no 1, 19.7 km^2, expired 8 January 2002; data supplied to SGU).

Vuollovaara	ORED25620	FHM140032
Cu, Au (trial pit)	E 797496	N 7484847

There are three minor trial pits, approximately 1 × 1 m wide and 0.5 m deep, over a distance of 20 m in a north–south direction. Immediately to the east there is a large outcrop area of Lina granite. The host rock to the mineralisation is a hornblende porphyric, veined, gneissic andesite-basalt with cm-wide alteration zones of albite and skarn (amphibole, diopside, epidote). There are traces of chalcocite and secondary copper sulphides such as malachite. Hermelin (1804) described the Maunuvaara mineralisation and copper mineralisation at the mountains Vuolovaara and Rovavaara, 2 km to the northeast, and 10 km northwest of Maunuvaara respectively. Chemical analysis of a selected rock sample from the waste rock at Vuollovaara revealed 0.1% Cu, with low amounts of sulphur (0.02%), and traces of gold (0.09 ppm Au; Appendix 2).

Maunuvaara norra	ORED15395	FHM140031
Cu, Au (trial pit)	E 797005	N 7482920

In the northern part of the mountain Maunuvaara is a trial pit 12 × 1–2 m wide and 1 m deep. A pile of waste rock about 12 × 4 m across and 0.5–2 m high is found on the northern side of the pit. Two smaller trial pits occur to the south. The predominant rock is a relatively dark, foliated andesite-basalt (amphibolites), partly silicified with quartz veins. There are traces of chalcocite, disseminated or with quartz. A waste rock sample contained 0.48% Cu, with traces of gold (0.03 ppm) and silver (3.4 ppm, Appendix 2). According to the compilation by Fredriksson (1984), one analysis of an outcrop sample contained 2.08% Cu, 17 ppm Ag and 0.4 ppm Au.

Maunuvaara 1	ORED00264	FHM140030
Cu, Au (closed mine)	E 796922	N 7482641

In the northwestern area of the summit of Maunuvaara, 17 km south-southwest of Masugnsbyn, is an old copper mine known from the 17th century, at which time the ore was processed at the Svappavaara kopparverk (also named Magnovaara, Hermelin 1804, Geijer 1918, Tegengren 1924; see also additional references above). The bedrock at the deposit is described as fine-grained, grey, plagioclase-hornblende-bearing gneiss, intruded by a light red to white, isotropic granite and some pegmatite. The granite is noted in outcrops on the northwestern slope of the mountain and the fine-grained gneiss is abundant in the waste rock. Typical mineralisation consists of chalcocite with small amounts of bornite and chalcopyrite in veins, together with quartz and hornblende in the wider dykes. Thin fracture fillings consist mostly of chalcocite. Malachite and azurite are also present, as well as zeolites, including aggregates of stilbite (desmin) and chabasite.

The pit is 18 × 8–10 m wide and contains water 1–2 m below ground level to a depth of 1–2.5 m (fig. 55). Medium-grained granite and some pegmatite are exposed in the northern and southern walls. A few hundred tonnes of partly overgrown waste rock is found south of the pit. The predominant rock type in the waste is grey, foliated or lineated meta-andesite with quartz veins. Chalcocite is mainly disseminated in the meta-andesite, but is also associated with the quartz veins or as fracture fillings. Secondary copper minerals, malachite and azurite,

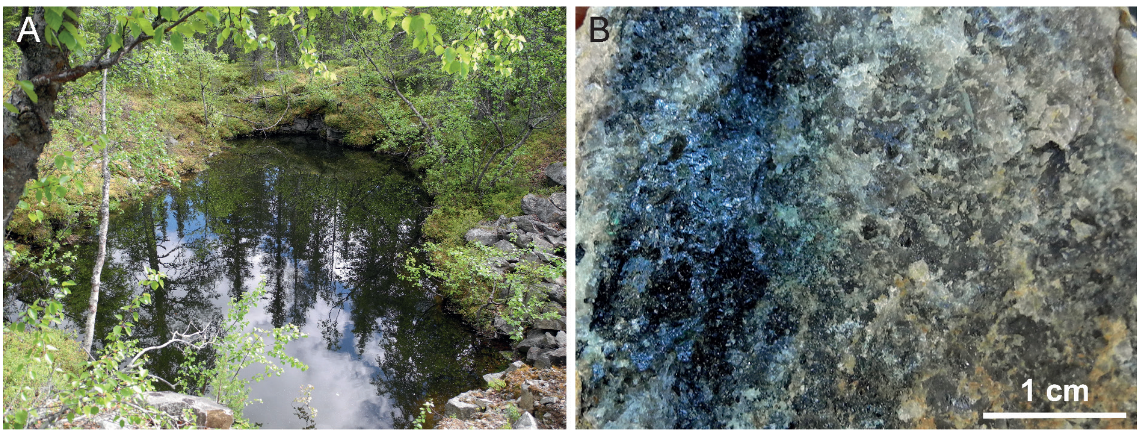

Figure 55. The Maunuvaara copper prospect (Maunuvaara 1). **A.** The mine pit measure 18 × 8–10 m. **B.** Chalcocite in quartz vein.

are common. Chemical analysis of two samples of meta-andesitic rock with quartz veins and visible amounts of chalcocite revealed 0.88 and 1.98% Cu, trace amounts of gold (0.08 and 0.12 ppm), silver (13.2 and 6.0 ppm), bismuth (8.4 and 4.0 ppm) and tellurium (1.35 and 0.31 ppm). The sulphur content is low (0.22 and 0.52%, Appendix 2).

Maunuvaara 2	ORED25617	FHM140029
Cu, Au (shaft)	E 796920	N 7482591

Approximately 50 m to the south of the main pit is a shaft, about 1–1.5 m in diameter, with the remnants of a wooden hoisting device. The hole is 3.5 m deep, with snow at the bottom when visited. Rock is exposed in the lower part. There is no fence around the shaft. Some waste material occurs around the hole, but large piles of waste rock are found to the west (common with Manuvaara 1).

Maunuvaara östra	ORED25618	FHM140028
Cu (trial pit)	E 797463	N 7482509

Maunuvaara östra is a poor Cu mineralisation in the eastern part of the mountain Maunuvaara. Two small trial pits are oriented in an east–west direction. The western pit is 4 × 5 m across and 1–2 m deep, with bedrock partly exposed along the edges, but is otherwise overgrown. The eastern pit is 9 × 2 m wide and 1 m deep. East of the pits is a high, irregular pile of waste rock 14 × 9 m across and 0.5–1.5 m high; a 1 × 1 × 0.5 m pile is found on the northeastern side. The mined rock is a fine-grained, laminated meta-andesitic tuff with slightly sheared quartz veins less than 1 cm wide, as well as pegmatite dykes (fig. 56). Malachite is noted on fracture surfaces and in drusy cavities within the quartz-pegmatite dykes. Local bleaching occurs adjacent to the quartz veins. Surrounding outcrops consist of granite-pegmatite of the Lina type. A sample from the waste rock contained 0.36% Cu and was weakly anomalous in gold (0.02 ppm), silver (1.9 ppm) and bismuth (4.0 ppm; Appendix 2). According to Fredriksson (1984), two analyses show 1.88% and 4.14% Cu, 16 and 26 ppm Ag, 0.3 and <0.1 ppm Au (outcrop and boulder).

Figure 56. Volcanoclastic, metadacitic tuff constitutes the host rock to the Maunuvaara eastern prospect. The quartz vein contains trace of chalcocite and secondary copper sulphides.

Iso-Orotusvaara 1	ORED15723	
Cu (drilling)	E 798113	N 7479687

A weak Cu sulphide mineralisation (<0.12% Cu) in intermediate tuffs or tuffites of the Kalixälv group is found at Iso-Orotusvaara, some 20 km south of Masugnsbyn (Niiniskorpi 1985b, 1986c). The mineralisation was discovered using soil geochemistry and diamond core drilling (3 holes). Pyrite and pyrrhotite, with or without chalcopyrite, occur as a weak dissemination or locally as fracture fillings. Small amounts of bornite and chalcocite are also found in quartz-amphibole-filled veins in one of the three drill cores. Granite dykes cutting the tuffs contain small amounts of sulphides such as chalcopyrite and molybdenite (Niiniskorpi 1986c)

Iso-Orotusvaara 2	ORED25619	FHM140033
Cu, Au (trial pit)	E 797511	N 7479418

On the summit of Iso Ortusvaara hill is a small, T-shaped trial pit, 10 × 1–5 m wide and 1–2 m deep. Piles of waste material (approx. 10 m^3) occur south and east of the pit. Mineralisation is poor, with small amounts of chalcocite and bornite in quartz veins less than 2 cm wide, and partly in bleached and silicified, slightly foliated meta-andesite/amphibolite. Secondary copper minerals are malachite and azurite (fig. 57). Chemical analysis of a whole-rock sample, taken during the present inventory, revealed 0.85% Cu, 0.82 ppm Au, 2.9 ppm Ag, 15.6 ppm Bi and 0.87 ppm Te and 0.27% S (Appendix 2).

Figure 57. Cu sulphide-mineralised meta-andesite with quartz-veins from the Iso Ortusvaara Cu prospect. Photo: Fredrik Hellström.

Industrial minerals

Dolomite

A unit of carbonate rocks 150–250 m thick constitutes the top of the Veikkavaara greenstone group. It is suggested that this unit forms a more or less continuous layer from the Hietajoki deposit, 6.5 km southeast of Masugnsbyn dolomite quarry, continuing to Isovaara, in the northern parts of the Masugnsbyn iron ores (figs. 29, 36; Stacey 1965, Padget 1970, Kihlstedt et al. 1973, Bida 1979, Shaikh et al. 1989, Zaki 2015). At the Masugnsbyn quarry, the dolomite is thicker, approximately 300 m, possibly due to folding (Stacey 1965, Padget 1970).

Isovaara	ORED00386	FHM150011, PAC95505
Dolomite (prospect)	E 799937	N 7504368

At *Isovaara*, approximately 4.8 km north of Masugnsbyn village (fig. 36), a 140 × 70 m area of dolomite has been documented by drilling to a depth of 20 m, and is estimated to contain 400,000 tonnes of dolomite (Shaikh 1974a, Shaikh et al. 1989). The marble is of lower quality than that at Masugnsbyn, however, and has not yet been quarried. Outcrops in the area show dolomitic marble with some pyroxene, amphibole, white mica, scapolite and iron sulphides.

Approximately 850 m west-southwest of the Isovaara dolomite prospect is a boulder several metres across, comprising fine- to medium-grained white dolomite, with small amounts of pyrrhotite. According to the map of Geijer (1929), a band of dolomite occurs in the bedrock at this place. An unpublished memorandum by Mullern (1965, SGU archives) reports that percussion drilling confirmed that the dolomite occurrence is a boulder and not an outcrop. A chemical analysis of a sample taken in this study showed 28.5% CaO, 23.1% MgO, 1.09% Fe_2O_3 and 2.5% SiO_2 (FHM140059, 7 799168/504125, Appendix 2).

Masugnsbyn	ORED00404	TOB140047, FHM150010
Dolomite (quarry)	E 801101	N 7498637

The Masugnsbyn dolomite quarry is located in the southernmost part of the Junosuando iron ore field (figs. 36, 58). The dolomite was originally quarried by Norrbottens Järnverk AB from 1952 to 1972. The quarry is now operated by LKAB. The dolomite is mainly used as an additive in the production of iron ore pellets. The dolomite is relatively pure, with a SiO_2 content of 1.5%, essential for industrial use. The dolomite sequence at the quarry is more than 300 m wide and is currently quarried to a depth of 50 m in an open pit, 250 × 250 m across (fig. 58A). Total dolomite production from the late 1970s to 2015 was about 4 million tonnes, with an annual production of about 200,000 tonnes (Zaki 2015). According to Zaki (2015), dolomite resources are estimated at 28.3 Mtonnes of first quality ($SiO_2 \leq 3\%$) and 3.4 Mtonnes of secondary quality (SiO_2 3–10%). The major components of the dolomite are constant, with 21% MgO and 30% CaO, and variable amounts of impurities resulting in elevated SiO_2 and Fe_2O_3. Mineralogically speaking, the impurities predominantly consist of quartz, tremolite, pyrite, and limonite (formed after pyrite). Variable trace amounts of olivine, diopside, sericite, chlorite, bornite, chalcopyrite, covellite, serpentine, talc, and scapolite have been reported. The dolomite has a polygonal, medium-grained recrystallised texture and is white to light yellowish (fig. 58B). Some layers are dark grey, attributed to disseminated graphite. A chemical analysis of a sample taken during the present inventory is presented in Appendix 2 (FHM150010A).

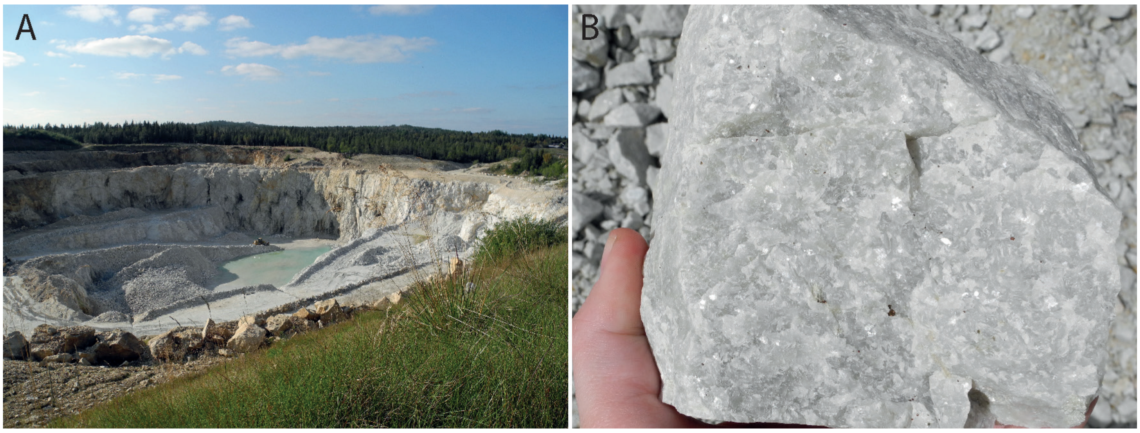

Figure 58. A. Masugnsbyn dolomite quarry in summer 2015. **B.** Rock sample of fine to medium-grained dolomite marble. Photo: Fredrik Hellström.

Hietajoki	ORED00382	FHM140025
Dolomite (prospect)	E 805002	N 7493320

Hietajoki is an unworked dolomite prospect situated about 6.5 km southeast of the Masugnsbyn quarry (fig. 29). It is located at the same stratigraphic position as the Masugnsbyn dolomite, in the border between the Veikkavaara greenstone group and sedimentary rocks of the Pahakkurkio group (Bida 1979, Shaikh 1974a, Shaikh et al. 1989, Hansson 1990). From east to west, the carbonate unit consists of (1) a lowermost unit of fine- to medium-grained calcitic marble 20–25 metres thick, with intercalations of fine-grained schist and skarn bands; (2) a dolomitic marble 150–200 metres thick; and (3) an uppermost skarn-altered rock with tremolite and calcite, approximately 30–40 m wide. To the west, above the carbonate rocks, andalusite-bearing mica schist of the Pahakurkio group occurs and appears to be concordant with the carbonate rocks. Bedding generally strikes northwest (N30–50°), and dips steeply to the east (approximately 80–85°). Bedrock mapping suggests a fairly constant thickness of about 200 m over a distance of 1 km (Bida 1979). However, the carbonate horizon is thought to form a more or less continuous layer from Hietajoki to the Masugnsbyn dolomite quarry (Hellström et al. 2018).

The dolomitic marble is pinkish or yellowish to greyish-white. Some layers are dark grey, caused by fine-grained disseminated graphite. Mineralogically, the dolomitic marble consists of medium- to coarse-grained, polygonal to granular dolomite, with minor amounts of quartz, tremolite, pyrite and limonite (after pyrite). Small amounts of diopside, sericite, chlorite, serpentine and scapolite occur in addition (Bida 1979). Late-stage calcite–filled fractures are also found. The composition of the dolomite is fairly constant, with 21% MgO, 30% CaO and variable amounts of impurities giving 0.5–3.0% SiO_2 and 0.5–1.5% Fe_2O_3 (Bida 1979). The occurrence has been investigated by diamond core and percussion drilling by SGU and LKAB, is calculated to contain 4.6 million tonnes of dolomite down to 50 m, divided between three blocks with SiO_2 content of 1.23%, 0.99% and 0.68% (Hansson 1990). Shaikh et al. (1989) estimated the reserves to be approximately 9 million tonnes of dolomite down to 55 m (5.9 million tonnes of low-silica dolomite, and 2.8 million tonnes of high-silica dolomite). LKAB has carried out test mining, but the area has now mostly been restored (fig. 59).

Figure 59. The Hietajoki dolomite prospect. Photo: Fredrik Hellström.

Orjasjoki	ORED04682	FHM140102
Dolomite (prospect)	E 811882	N 7481830

Orjasjoki is an unworked marble prospect situated 850 m northwest of Orjasvaara hill, 20 km southeast of Masugnsbyn (fig. 29). The prospect is well documented and analysed by Shaikh et al. (1989). The marble was sampled in several outcrops from the Orjasjoki River in the southwest and along strike for 650 m to the northeast. The marble is relatively pure, white to yellowish-white and compositionally calcitic-dolomite to dolomite (Shaikh et al. 1989). The areal distribution is estimated at 40,000 m^2. Thin-section studies show the presence of up to 10 vol. % quartz, serpentine, pyroxene, amphibole and mica alongside calcite and dolomite.

Graphite

Graphitic schists are important members of the upper part of the Veikkavaara greenstone group, but graphite also occurs in metapelitic rocks of the Pahakurkio and Kalixälv groups (Padget 1970). Though rarely exposed, their presence can easily be detected by electromagnetic methods (Fig. 32). Known occurrences include Jalkunen, 28L 6e (Niiniskorpi 1987a, Gerdin et al. 1990, 1991), Junosuando, 28L 9g (Padget 1970), Nybrännan, 28L 9e (Gerdin et al. 1990), Palo Pöyviö, 29L 1d (Geijer 1918, Gerdin et al. 1990), Tiankkijokki, 28L 5e (Niiniskorpi 1983, Gerdin et al. 1990, 1991), Meraslinka, 29L (Lundqvist 1952, Gerdin et al. 1990) and Suinavaaragruvan, 28L 7g (Padget 1970, Gerdin et al. 1990).

Meraslinka	ORED00179	
Graphite (drilling)	E 804482	N 7512964

The Meraslinka graphite prospect is situated 13.9 km north-northeast of Masugnsbyn (fig. 29). It was found by SGU in 1949 using magnetic and electrical methods, and was drilled with 5 drill holes in 1951 (Lundqvist 1952). The graphite-bearing schist occurs on both sides of the Torneå River. However, the richest parts occur 0.7 km northeast of the rapids at Ojustankoski, where a 3-metre section with up to 36% C and a 15.5-metre section with an average of 27% C were penetrated (Lundqvist 1952, Gerdin et al. 1990). However, outcrops are absent in the area. Based on the drillings, the distribution of the graphite-bearing schist is estimated at 34,000 m^2. The graphite is generally fine-grained. The Meraslinka deposit has not been worked, but Intrepid Minerals Corporation has carried out geochemical sampling of till around the Meraslinka prospect within their limited (2.2 km^2) exploration permit (Meraslinkka no 100, expired 4 July 2006; data supplied to SGU).

Palo Pöviö	ORED15727	PAC950518
Graphite (outcrop)	E 801432	N 7507645

The Palo Pöviö graphite deposit was found in the early 1900s and, according to Geijer (1918), "a few barrels of graphite have been delivered to Stockholm" from the deposit. The mineralisation is exposed in an outcrop on the eastern side of a small ravine, 8 km north of Masugnsbyn (fig. 29). The graphite mainly occurs with a strongly foliated, biotite-rich, felsic metavolcanite with calc-silicate layers with diopside, labradorite and small amounts of titanite (Geijer 1918). The thickest graphite-bearing layer is 2 m wide and occurs in contact with a calc-silicate rock with several thin graphite-bearing layers. According to Gerdin (1990), the electrical conductor coincides with the border between greenstone and younger granite. Analyses of graphite-bearing greenstone taken from two trial pits returned approximately 33.5% of fine-grained (<0.1 mm) graphite. The Palo Pöviö deposit has not been further worked or evaluated by drilling.

Hökboet	ORED25760	PAC950520
Graphite (outcrop)	E 801388	N 7507583

The Hökboet prospect is situated on the southwestern side of the ravine, 50 m southwest of the Palo Pöviö deposit (fig. 29). A graphite-bearing calc-silicate layer is traced in outcrops for 40 m. The layer is 3.5 m wide and dips gently to the west. The graphite-bearing rock is cut by granite and dolerite (Geijer 1918).

Välivuoma	ORED15735	
Graphite (drilling)	E 817521	N 7497664

The Välivuoma prospect, situated 3 kilometer west of Junosuando (fig 29), is an electrical conductor that has been drilled with one hole and most likely represents graphite-bearing schist, according to Gerdin et al. (1990). Although the drill core is stored at the SGU drill core archive in Malå, no drill core protocol or other information has been found to verify this statement.

Nybrännan 1, 2	ORED00180, ORED25616	FHM140001, FHM140002
Graphite (abandoned quarry)	E 804271, E 804304	N 7497394, N 7497399

A layer of graphite schist with a northwest–southeast strike occurs in the Veikkavaara greenstones and is exposed in the Nybrännan graphite quarry (fig 29), which is approximately

45 × 10 m across and up to 2.5 m deep (Nybrännan 1; fig. 60). To the east is an additional excavation (exploration trench?) with a southwesterly strike, about 22 × 5 m wide and up to 5 m deep (Nybrännan 2). The graphitic schist unit is bordered to the west by a dolerite sill about 20 m thick; to the east there are no known outcrops. Locally, the schist is inter-layered with plagioclase-rich, light grey tuffite containing subordinate biotite, pale green actinolite and accessory titanite and pyrrhotite. Gerdin et al. (1990) describes the graphite-rich horizon at Nybrännan as a northwest-trending and sub-vertical layer approximately 20 metres thick, with up to about 40% graphite. The graphite schist extends at least 50 m along strike, but electromagnetic data suggest it extends much further. The graphite at Nybrännan is typically very fine-grained (approximately 0.005 mm, amorphous) and disseminated within a groundmass of microcline, quartz, plagioclase, biotite, titanite and rutile. Locally, graphite occurs in aggregates and veins with more variable grain size. Amphibole porphyroblasts (approximately 0.5–2 mm) also occur. The schist also contains iron sulphides, resulting in rusty outcrop surfaces. A graphitic schist sample taken during this inventory contained 33% C and 6.0% S (Appendix 2).

Talga Resources Ltd has recently conducted exploration work at Nybrännan (Talga Resources Ltd, 16 September 2014, 20 October 2016). Two preliminary exploration drill holes totalling 226 m were located approximately 100 m south of the historical graphite workings and were planned using slingram electromagnetic (EM) measurements completed by Talga in 2015. Both holes intercepted approximately 16 m (downhole) of visually high-grade graphite. In addition, drill hole NYB16002 intercepted at about 15 m (downhole depth) a strongly altered and sulphidic gabbro at the end of the hole with base metal (chalcopyrite) mineralisation (Talga Resources Ltd, 20 October 2016). Significant intercepts include 16.1 m with 15.5% Cg from in drill core NYB16001 and 17.1 m with 16.6% Cg from drill hole NYB16002 (Talga Resources Ltd, 6 December 2016).

In 2004 Tertiary Minerals Ltd performed base-of-till geochemical sampling in a 780-metre-long profile perpendicularly across the electromagnetic anomaly, some 230 m south of the Nybrännan quarry (Exploration permit Vehkavaara no 1, valid 2003–2007; exploration data supplied to SGU). Fifty base-of-till/bedrock percussion drill holes were completed, in two traverses, to follow up surface copper-geochemical anomalies. Three zones of bedrock anomalies were noted, and a programme of follow-up trenching was carried out in November 2004 (Tertiary Minerals Ltd 2004). Only weak bedrock mineralisation was exposed. Grab samples for geochemical analyses from outcrops, boulders and waste dump material at Veikkavaara were also taken (geochemical data supplied to SGU).

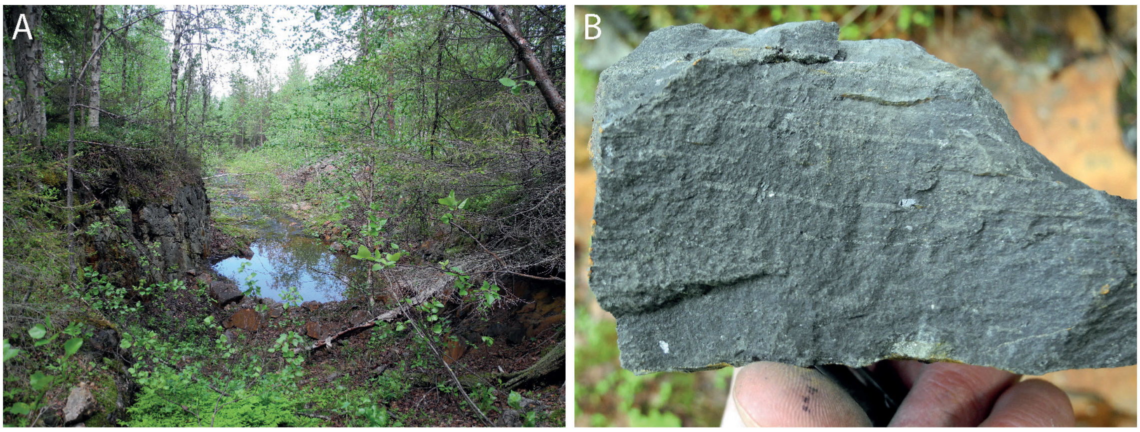

Figure 60. A. The Nybrännan graphite prospect. **B.** Sample of graphitic schist from Nybrännan. Photo: Fredrik Hellström.

Suinavaaragruvan	ORED15734	
Graphite (drilling)	E 814477	N 7493118

Suinavaaragruvan, 2 km northwest of Lautakoski village (fig 29), is a graphite prospect, drilled with a 98-metre hole in 1958 by Rederi AB Nordstjernan. The drilling penetrated several graphite-bearing sections to a depth of 90 m. The richest section, with up to 35% carbon, was found at a depth of between 78.2 and 87.6 m (Gerdin et al. 1990). An estimate of about 125,000 tonnes of graphite at 29% C and 1.9% S is given in Gerdin et al. (1990). An electrical anomaly occurs 1 km northeast of Suinavaaragruvan. Talga Resources Ltd has carried out a ground-based EM survey of Suinavaara, which confirmed the airborne EM survey results and outlined a conductor of approximately 900 m in strike length (Talga Resources Ltd, 26 February 2015).

Lautakoski Cu	ORED25962	
Cu, graphite, Co, Au (drilling)	E 820366	N 7489071

Talga Resources Ltd has drilled one exploration hole (101 m) at its Lautakoski prospect, approximately 4.8 km east-southeast of Lautakoski village (fig. 29), to investigate an EM conductor identified from historical airborne surveys and ground EM surveys completed by the company in 2015. The drill hole (LAU16001) intercepted a strongly altered sequence of predominantly mafic volcanosedimentary rocks, including a zone of visibly high-grade, variably altered and brecciated graphite in a sulphide-rich matrix (pyrrhotite-pyrite±chalcopyrite). Assays returned 9.2 m with 5.4% Cg from 14.2 m downhole depth (Talga Resources Ltd, 20 October 2016, 6 December 2016).

Below the graphite unit in the drill core, the mafic volcanosedimentary rocks are strongly altered and variably but pervasively mineralised with disseminated pyrite-pyrrhotite-chalcopyrite (Talga Resources Ltd, 20 October 2016). Assays revealed a broad zone of copper mineralisation with coincident cobalt and weak gold mineralisation (Talga Resources Ltd, 6 December 2016). The LAU16001 borehole was re-entered in July 2017 and extended to a depth of 210 m, broadening the zone of low-grade copper-cobalt mineralisation, resulting in an intercept of 91.8 m at 0.18% Cu and 147 ppm Co from 14.20 m, including a higher-grade zone of 21 m at 0.34% Cu and 182 ppm Co from 85 m (Talga Resources Ltd, 11 October 2018). The highest-grade individual samples include a 0.7-metre drill core section with 1.5% Cu, and 0.27 ppm Au from 89.3 m and a 1.15-metre section with 565 ppm Co from 95.5 m (Talga Resources Ltd, 6 December 2016). Two additional 50-metre step-out holes were also made to test "Conductor 1". A single 130.7-metre-long bore hole (LAU17003; 820575/7490500) tested an EM anomaly 2.5 km to the north, referred to as "Conductor 2". The drill hole intercepted graphite breccia units with narrow zones of lead-zinc mineralisation interbedded with weakly skarn-altered intermediate-mafic volcanoclastic rocks, before passing into a calcarenite unit (Talga Resources Ltd, 11 October 2018).

The unexpectedly high levels of sulphides at Lautakoski may be the source of the EM anomalies, suggesting further potential for base metals in addition to the graphite. Stronger untested EM anomalies are located approximately 1.4–3 km to the north. This area was investigated by Geoforum Scandinavia AB (exploration permit Lautakoski no 101, 7.4 km^2, expired 25 August 2003). According to data and unpublished reports provided by Geoforum to SGU (Mining Inspectorate), geophysical data comprise airborne EM and magnetic data acquired during a GEOTEM survey flown in October 1997 by Geoterrex (now part of Fugro) for Orvana Minerals Corp (Canada). Data were interpreted and a number of good EM targets worth following up, either with geochemistry or by shallow drilling, were noted.

Jalkunen	ORED15729	
Graphite (drilling)	E 804517	N 7485162

The Jalkunen graphite-Cu prospect was discovered in 1981 by airborne geophysical measurements during investigations of the Kurkkionvaara Zn-Pb sulphide mineralisation 3.5 km to the southwest (fig. 29; Niiniskorpi 1987b). The measurements showed strong slingram anomalies in the Jalkunen area, for example, and were followed by ground magnetic and slingram measurements, as well as geochemical sampling of deep till, showing Cu, Zn, Pb and Mo anomalies (Hansson 1984, Niiniskorpi 1986d). The graphitic schist belongs to sedimentary rocks of the Pahakurkio group and, in the Jalkunen area, dips gently to the west (5–30°). Graphite schist is also exposed in outcrops at Jalkunen (Ödman 1939). The geophysical and geochemical anomalies at Jalkunen were drilled with three holes in 1986 (Niiniskorpi 1987b). Drilling revealed the presence of a graphite-bearing schist 50 m wide, with anomalous pyrrhotite and subordinate pyrite, sphalerite, galena and chalcopyrite. Chemical analysis of a 2-metre drill core section (K-JAL 1, 162–164 m) showed a content of 17.6% C, but the graphite is generally fine-grained (<0.1 mm, Niiniskorpi 1987b, Gerdin et al. 1990). The Jalkunen prospect was investigated by Talga Resources, with 8 drill holes in 2015, totalling 1,082 m, distributed approximately 1,000 m along strike of the mineralisation (Talga Resources Ltd, 4 June 2015). Six holes intersected the targeted gently-dipping (18°) graphite unit, which averaged 50–60 m true thickness (Fig. 61). Graphite grades average approximately 16% Cg and reach up to 31.8% Cg. A maiden 2012 JORC-compliant inferred resource was estimated to total 31.5 Mt at 14.9% graphitic carbon (Cg) for Jalkunen, using a 10% Cg cut-off grade (Talga Resources Ltd, 27 August 2015).

Tiankijoki (Tiankijokki)	ORED15731	
Graphite (drilling)	E 808220	N 7480516

The Tiankijoki (Tiankijokki) graphite prospect is situated some 20 km south-southeast of Masugnsbyn (fig. 29), hosted by mica schists occurring in the same stratigraphic position as the Kurkkionvaara Zn-Pb-Cu sulphide mineralisation, i.e. in the border zone between the Pahakurkio and Kalixälv group (Niiniskorpi 1983, 1987c, d, Hansson 1986a, Gerdin et al. 1990, 1991). Tiankijoki was discovered in 1981 by LKAB using airborne magnetic and slin-

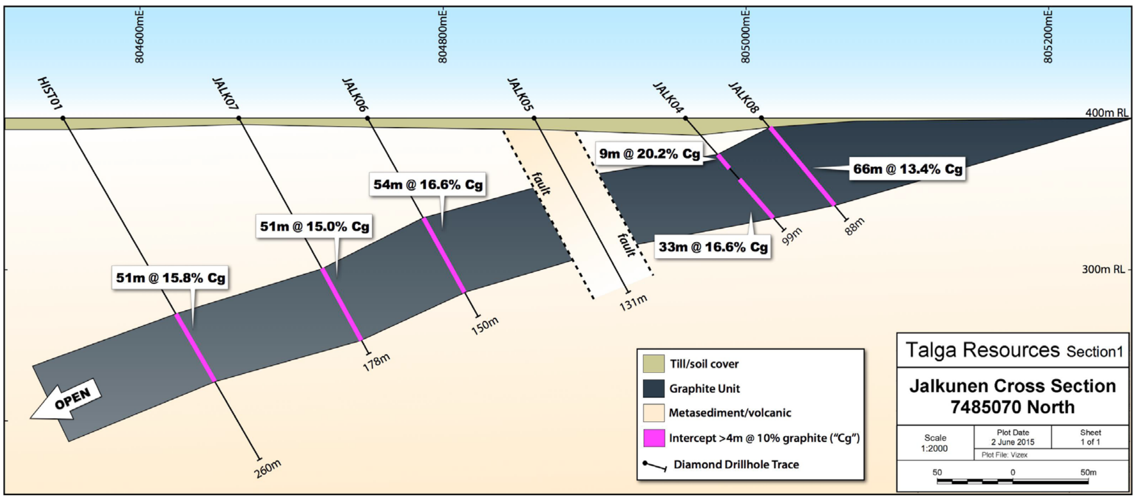

Figure 61. Geological section at the Jalkunen graphite prospect (from Talga Resources Ltd ASX:TLG Announcement, 4 June 2015, http://www.talgaresources.com).

gram geophysical measurement, followed by geophysical ground measurements (magnetic and electromagnetic) in 1982 and geochemical base-of-till sampling in 1983. Altogether, 14 diamond cored holes (totalling 2,118 m) were drilled to investigate the electrical conductors. Five of these (640 m) transect graphitic schist. One of the graphite-rich zones has an indicated tonnage of 600,000 tonnes, with an average grade of 27.7% C. The other four bodies have a combined tonnage of 0.38 million tonnes, with an average grade between 10.1 and 15.7% C (Gerdin et al. 1991). The grain size of the graphite varies between <0.005 mm and 0.4 mm, but most of the graphite grains are less than 0.1 mm. Anomalous values of base metals were detected by assays of drill cores, but were considered to be of no economic interest.

Quartz

Puuroharjut	ORED25954	
Quartz (outcrop)	E 802717	N 7491094

According to a find in *Norrlands mineraljakt 1979*, there is an outcrop with a quartz dyke 10 m wide and 40 m long approximately 9 km south-southeast of Masugnsbyn (fig. 29). The main part is clean and homogenous quartz, but with some contamination of microcline and iron sulphides (SGU 1979). The locality was not visited during this inventory.

Andalusite and Sillimanite

Tärännönvaara	ORED00384	BOM950145
Andalusite (outcrop)	E 821295	N 7488710

The Terrännönvaara andalusite prospect is situated 4 km west of Lovikka (fig. 29). Andalusite-bearing mica schist is noted in outcrops in an area 1 km long and 200 m wide (Shaikh et al. 1986). The andalusite occurs as porphyroblasts in zones 6–8 m wide, with porphyroblasts generally 0.5–2 cm across. The concentration of andalusite was determined by XRD analyses at 7% by volume (Shaikh et al. 1986).

Hietarova	ORED00394	STB951079
Andalusite (outcrop)	E 804654	N 7492168

The Hietarova andalusite prospect is situated 8.3 km southeast of Masugnsbyn (fig. 29), and consists of outcrops with anomalously high amounts of andalusite in mica schist (fig. 62). The andalusite is noted in outcrops 120 m along strike to the northwest (Shaikh et al. 1986). The distribution of andalusite is highly variable, and the richest zones, 10–15 m wide, contain an average of 8 vol.% andalusite (Shaikh et al. 1986).

Pahakurkkio	ORED00414	STB951056
Sillimanite (outcrop)	E 804430	N 7486240

The Pahakurkkio sillimanite prospect is situated some 13 km south-southeast of Masugnsbyn at the Kalixälven River, where mica schist of the Pahakurkio group is found in outcrop (fig. 29; Shaikh et al. 1986). XRD analysis of a selected rock sample revealed 8 ± 2 vol.% sillimanite. A thin section shows fibrolitic aggregates of sillimanite in bands 1–4 mm wide.

Figure 62. Andalusite porphyroblast in mica schist of the Pahakurkio group. And = Andalusite. Photo: Fredrik Hellström.

Soapstone

Lautakoski	ORED00401	TOB140045
Soapstone, talc (drilling)	E 814794	N 7494041

The Lautakoski soapstone-talc prospect, situated 15 km east-southeast of Masugnsbyn (fig. 29), was known as long ago as the late 1880s (Fredholm 1886) and was later described by Svenonius (1915). The soapstone at Lautakoski occurs along a 1-km-long tectonic zone, and is interpreted to have been formed from the alteration of the local ultramafic metagabbro (Shaikh 1972). Metagabbro intrusives are the predominant rock type in the area (fig. 63), and in unaltered parts is medium-grained and dark green. According to Shaikh (1972), mineralogical composition varies within the massif; the most common types consist of hornblende-chlorite-albite, augite-hornblende-oligoclase or hornblende-biotite-albite.

The soapstone only crops out along the eastern bank of the Tärendö River. To obtain more information on the soapstone, SGU performed trenching and drilling in the area from 1967 to 1969 (Shaikh 1972). The northern part of the occurrence was also investigated by trenching in 1996, and 30 tonnes was quarried for tests (GeoVista AB 1998). The total tonnage of soapstone is estimated at 2 million tonnes, based on the assumption that it continues to a depth of 50 m (Shaikh 1972).

The soapstone is grey or greenish-grey, fine-grained and consists of talc, chlorite and carbonates, dolomite, magnesite and calcite (Shaikh 1972). Talc is the predominant mineral and constitutes 45–55% of the rock, while chlorite makes up approximately 20%. The proportion of carbonate minerals is highly variable, and predominantly comprises dolomite and magnesite

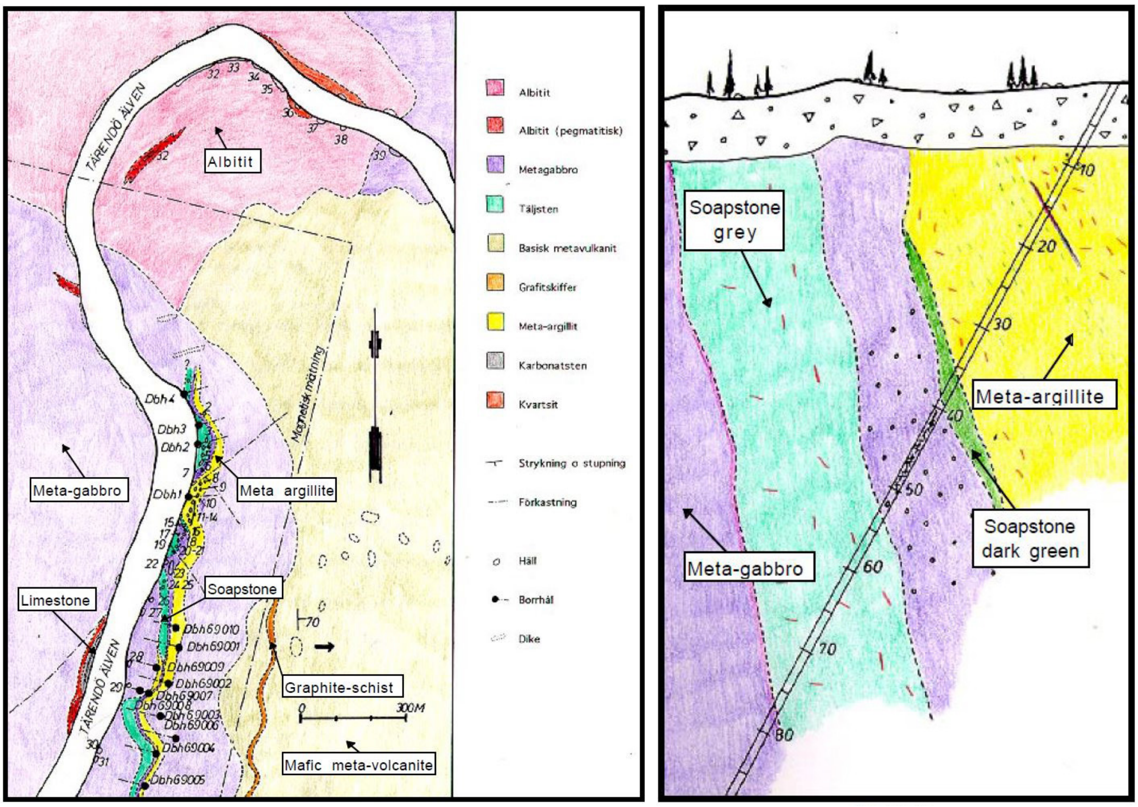

Figure 63. Bedrock maps of the Lauttakoski soapstone deposit (from GeoVista AB 1998).

in the northern part of the occurrence, whereas calcite is the main carbonate in the southern part. Occurrences of megacrystic amphibole and serpentinised olivine locally give the rock a spotted appearance. Fine-grained magnetite is also present in significant amounts and can constitute up to 10–15% of the rock (Shaikh 1972). Microprobe analysis of magnetite shows it to be nickel and chromium-bearing, with up to 0.5% nickel and 2.2% chromium (Shaikh 1974b).

Aggregate quarries

Vittangi	ORED25656	TOB150036
Granodiorite (active aggregate quarry)	E 785524	N 7520525

A medium- to coarse-grained granodiorite has been quarried by Svevia 3 km southeast of Vittangi since 2014 (fig. 29). In summer 2015 the quarry was 150 × 50 m wide and 10–15 m deep. The rock is crushed in the quarry and is mainly used in local road construction.

Junosuando	ORED25525	TOB140043, FHM140012
Granite (active aggregate quarry)	E 802917	N 7499036

A medium-grained, equigranular red granite has been quarried north of the main road between Masugnsbyn and Pajala, 2 km east of Masugnsbyn (fig. 29), since 2014. In summer 2015 the quarry was 40 × 50 × 10 m and partly filled with detached blocks for crushing and use in ongoing improvements to the roads in the area (fig. 64).

Figure 64. Junosuando granite quarry, summer 2015. Photo: Torbjörn Bergman.

Lovikka	ORED 25761	
Granodiorite (active aggregate quarry)	E 825757	N 7490121

On the southern side of Krakanvaara, 1 km north of Lovikka (fig. 29), Swerock AB has quarried a medium-grained metaquartzdiorite since 2014 (petrographic analysis by MRM Luleå). The material is mainly used for road construction in the region (personal communication, A. Göransson, Swerock Luleå). In summer 2015 the quarry was approximately 50 × 70 m across and 10–20 m deep (fig. 65).

Nuolivaara 1	ORED15737	TOB150038
Monzonite (abandoned aggregate quarry)	E 829084	N 7483194

A abandoned aggregate quarry is found on the northwestern slope of Nuolivaara hill, 6.5 km southeast of Lovikka (fig. 29). The rock is dark, equigranular, medium-grained monzonite. The quarry is 25 × 25 m in area, with a 10-metre-high face wall.

Nuolivaara 2	ORED25526	TOB140046
Monzonite (abandoned aggregate quarry)	E 828935	N 7482640

An abandoned aggregate quarry is located on the western slope of Nuolivaara hill, 6.9 km southeast of Lovikka (fig. 29). The quarry is 80 × 60 m across, with a face wall up to 10 m high. The quarried rock is dark, equigranular, medium-grained monzonite to monzodiorite.

Figure 65. The Lovikka quarry, September 2014. Photo: Göran Andersson, Swerock AB.

The Pajala area

The bedrock of the Pajala area is poorly exposed, but is briefly described in Eriksson (1954), Padget (1977), Gustafsson (1993), Martinsson (1995), Bergman et al. (2001), Bergman et al. (2006), Martinsson et al. (2013b), Grigull et al. (2014), Luth & Jönsson 2014, Martinsson et al. 2016, Grigull et al. 2018, Luth et al. 2018, Martinsson et al. 2018b. The oldest rocks belong to the Karelian greenstone group, and comprise ultramafic–mafic metavolcanic rocks, as well as epiclastic and chemical metasedimentary rocks. This group, including similar rocks in the Masugnsbyn area further west, is referred to as the Veikkavaara greenstone group, and is probably stratigraphically equivalent to the Kiruna greenstone group in northwestern Norrbotten (fig. 66). The overlying 1.9 Ga Svecofennian Sammakkovaara group consists of metavolcanic and epiclastic metasedimentary rocks. Stratigraphically equivalent units are the Pahakurkio and Kalixälv group in the Masugnsbyn–Tärendö area (e.g. Padget 1970, Hellström et al. 2018), the Porphyrite group and the Kurravaara conglomerate in the Kiruna area (Offerberg 1967, Bergman et al. 2001), and the Muorjevaara group in the Gällivare area (e.g. Lynch et al. 2018b). The Karelian and Svecofennian supracrustal rocks in the Pajala area are intruded by large volumes of early and late Svecokarelian intrusive rocks (fig. 67).

The area is divided into two separate structural domains, separated roughly along a north–south-trending structural boundary defined by the western margin of the Pajala deformation belt (see Bergman et al. 2006, Luth et al. 2018). The eastern domain, within the Pajala deformation belt, is characterised by north-northeast–south-southwest to north-northwest–south-southeast high-strain zones with high-grade metamorphic alterations. This structural pattern

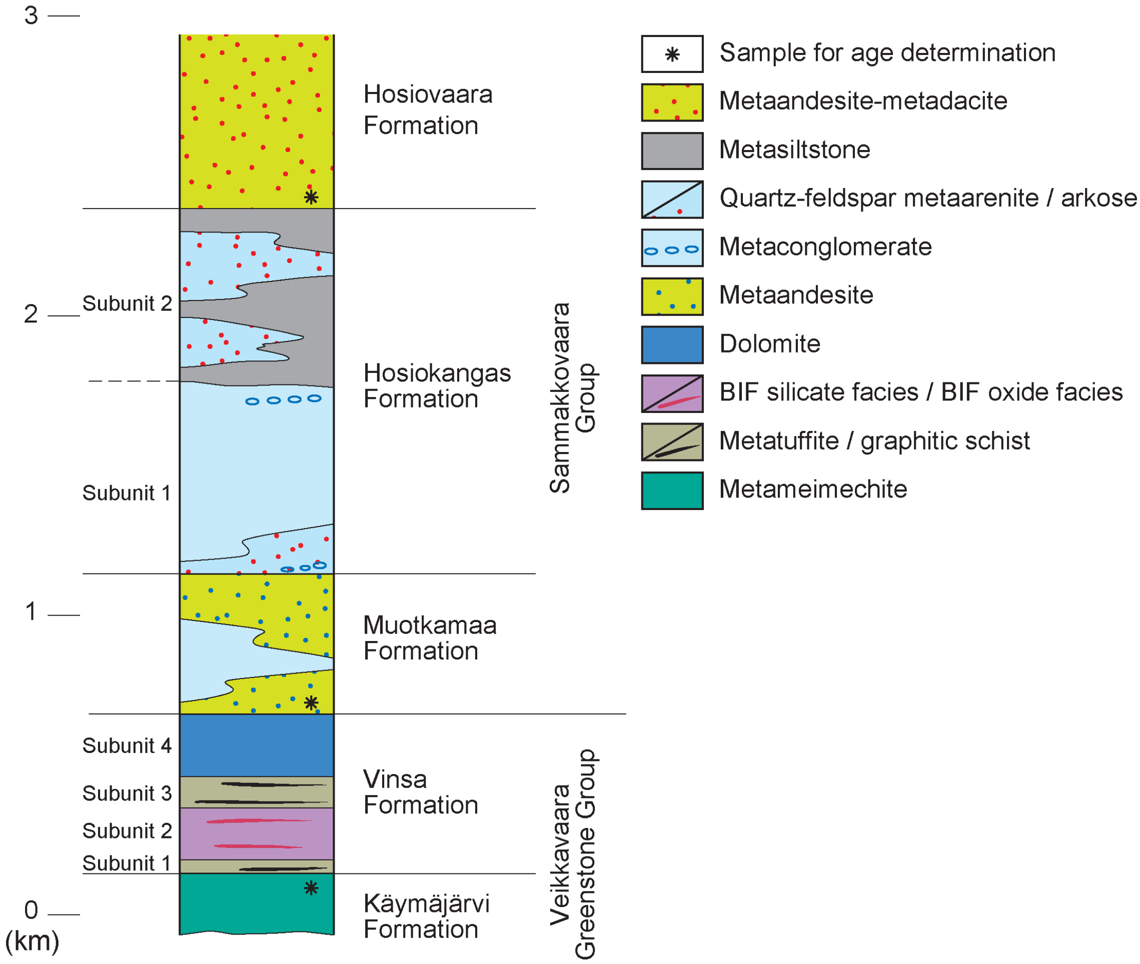

Figure 66. Lithostratigraphy of the Pajala area, as outlined from relatively well-preserved and exposed rocks in the Käymäjärvi area in the western part (from Martinsson et al. 2018b).

is clearly seen as a banded pattern on the magnetic anomaly map (fig. 68). The area west of the Pajala deformation belt is structurally heterogeneous, but is generally of a lower metamorphic grade. Deformation and high-grade metamorphism in the Pajala deformation belt is dated in the 1.83–1.78 Ga range (Bergman et al. 2006, Hellström & Bergman 2016).

The northeastern part of the area, roughly between the Torneå and Muonio rivers, predominantly comprises rocks of the Karelian Veikkavaara greenstone group. These also form the core of an anticline at Käymäjärvi, further west. Karelian meta-arenitic rocks occur in the easternmost part at the border with Finland (fig. 67). In the Pajala area, the rocks of the Veikkavaara greenstone group are subdivided into two formations, with a lower unit (Käymäjärvi Formation) consisting of ultramafic and basaltic metavolcanic rocks, and an upper unit (Vinsa Formation) made up of mafic tuffites, graphite schists, banded iron formations (BIF), with dolomite as the uppermost unit (Martinsson et al. 2018b and references given there). In the Kaunisvaara belt, north of Pajala, skarn iron ores (e.g. Stora Sahavaara, Tapuli) occur at the position of the BIF unit.

South of Pajala is a large area of Svecofennian, mainly metasedimentary rocks, transformed to quartzites, mica schists and migmatites by high-grade alterations within the Pajala deformation belt (fig. 67). Better preserved Svecofennian volcanic and epiclastic sedimentary rocks occur in the Käymäjärvi area (northwestern part) and in the Soursa area (southwestern part), named the Sammakkovaara group. It includes the Svecofennian supracrustal rocks and has been sub-divided into three formations (Martinsson et al. 2018b): (i) *the Muotkamaa formation*, comprising a lower andesitic metavolcanic unit together with minor intercalated clastic metasedimentary rocks; (ii) *the Hosiokangas formation*, predominantly comprising arenitic to clay-rich metasedimentary rocks; and an upper meta-andesite-dominated unit that constitutes (iii) *the Hosiovaara formation* (fig. 66). Meta-andesites in the Muotkamaa and Hosiovaara formations have been dated using the U-Pb zircon method at 1882±2 Ma and 1874±11 Ma respectively (Martinsson et al. 2018b). Mafic and intermediate metavolcanic rocks in the southwest (the Soursa area) are also included in the Sammakkovaara group.

Several occurrences of skarn iron mineralisation occur in the Kaunisvaara area north of Pajala, including the Palotieva, Tapuli and Sahavaara deposits. These occur in the upper part of the Veikkavaara greenstone group at the contact between mafic volcaniclastic rocks in the footwall and Svecofennian epiclastic to volcaniclastic rocks in the hanging wall. The "skarn iron ores" may be metamorphosed banded iron formations or a similar type of syngenetic iron formation (e.g. Frietsch 1997). The geological formation hosting the Kaunisvaara ores continues into Finland, and the historical Mannakorpi Fe skarn deposit is situated 12 km northeast of Tapuli (Hiltunen 1982, Eilu 2012). Under contract to Northland, the Geological Survey of Finland (GTK) performed a detailed airborne geophysical survey of the Pajala area in August 2006. The GTK survey was conducted using a four-frequency EM system, a total field magnetometer, and a gamma ray spectrometer (Lindholm 2009b and references given there). The magnetite deposits at Tapuli, Sahavaara, and Palotieva were shown to be reasonably good electrical conductors but were not nearly as good as the abundant graphite-bearing rocks of the area (fig. 69). The graphitic rocks were found to be both low- and high-magnetic formations. Potentially economic mineralisations are known to occur within or adjacent to the graphite-bearing formations, and local variations in the geophysical character of these rocks were part of the study (Lindholm 2009b). Aside from the iron ores in the Käymäjärvi and Kaunisvaara areas, some scattered minor unworked iron ore bodies are also known west and southwest of Pajala (fig. 67).

Examples of soil geochemistry maps are given in figs. 70–72. Copper concentrations in till are elevated in large areas west of Pajala (fig. 70), suggesting potential for finding Cu-sulphide mineralisations in these poorly exposed areas. Some small scattered Cu ± Au prospects are also known in this area. Scattered gold anomalies are seen in the soil geochemistry (fig. 71). Anglo American Exploration targeted the Pajala ironstone belt because its geophysical signature and tectonic setting were generally comparable to other known iron-oxide-copper-gold (IOCG) occurrences in the world (Lindholm 2009a). Basal till sampling during mineral exploration has also revealed significant copper-gold geochemical anomalies, for example in the Liviovaara area west of Pajala (Lindholm 2009b), and at Palotieva in the north of the Kaunisvaara ore field (Lindholm & Mukhopadhyay 2008). In the Käymäjärvi area, northwest of Pajala, in addition to BIFs and the skarn iron ores, there are numerous geological and geochemical indications of Cu and Au mineralisation, including pyrrhotite-rich zones with Cu mineralisation and up to 3.5 ppm Au (Eriksson 1953, Baker & Lepley 2010b). Zinc concentrations in soil seem to be less elevated, although a small single anomaly occurs in the far southeast of the area (fig. 72).

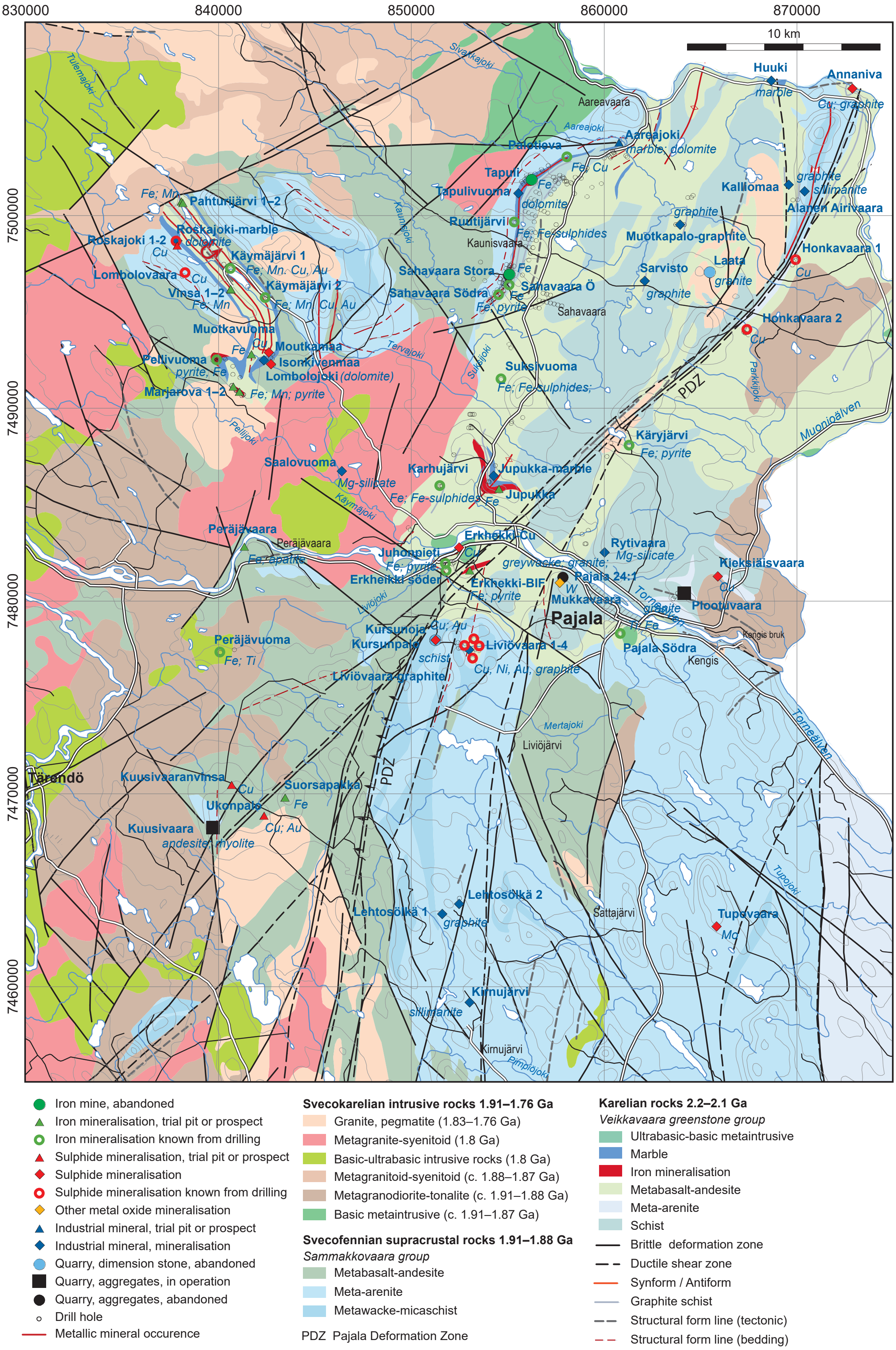

Figure 67. Bedrock geology map of the Kaunisvaara–Pajala–Liviöjärvi area (modified from Bergman et al. 2001).

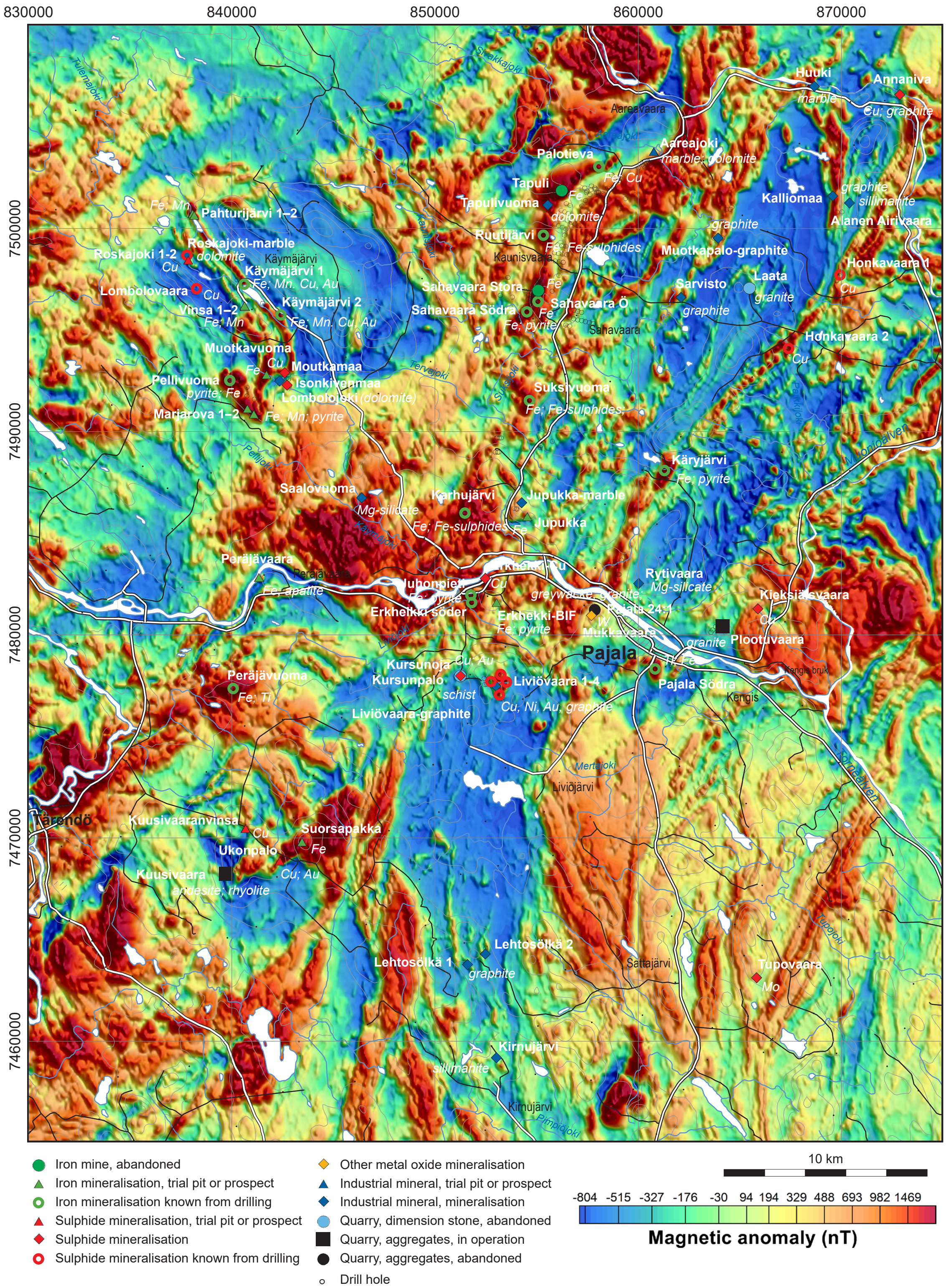

Figure 68. Magnetic anomaly map of the Kaunisvaara–Pajala–Liviöjärvi area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU). Points show location of mineral and bedrock resources (SGU mineral resources database).

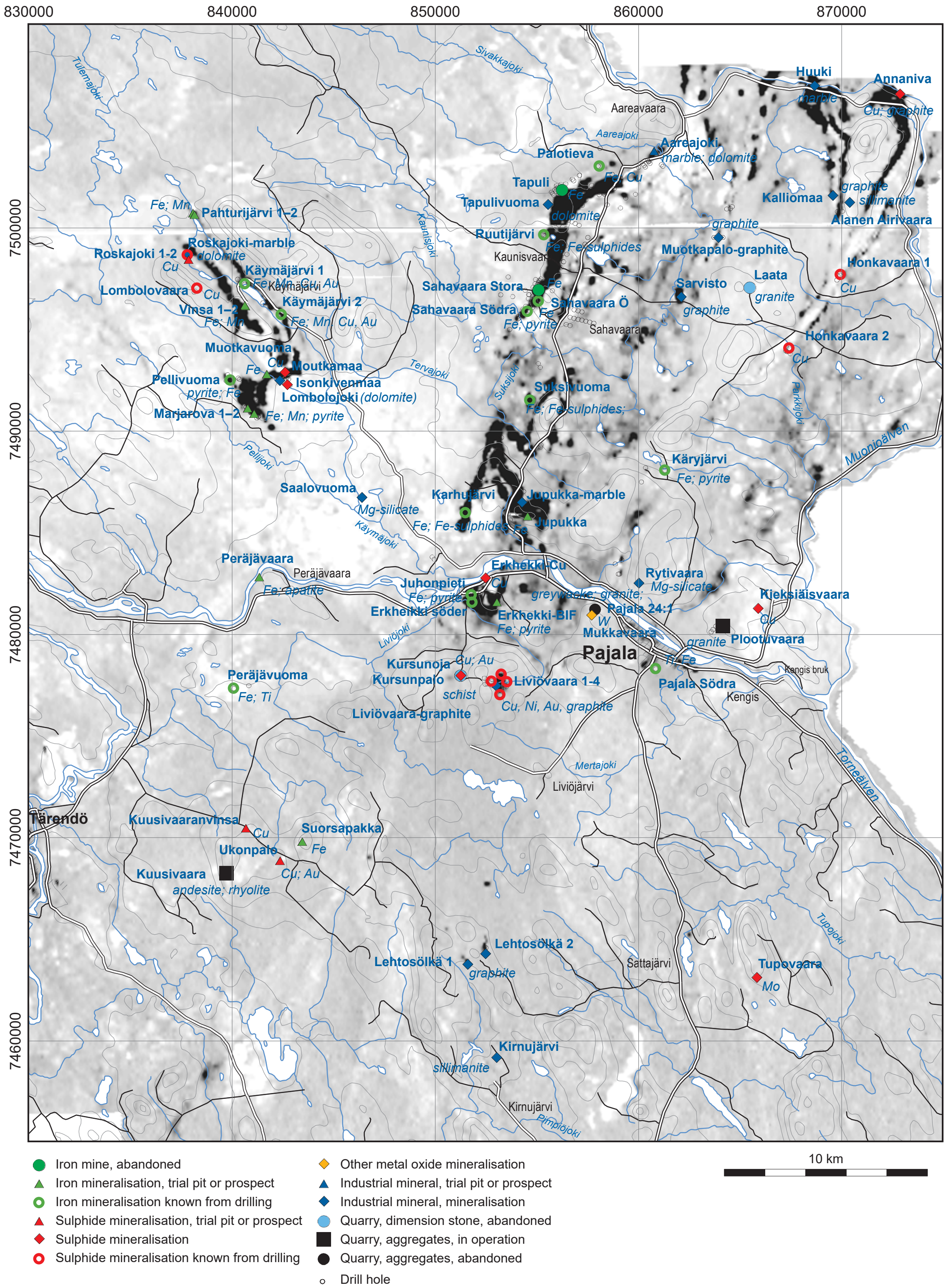

Figure 69. Electromagnetic maps of the Kaunisvaara–Pajala–Liviöjärvi area. Dark colours show good electrical conductors. The geophysical data were gridded by Johan Jönberger (SGU).

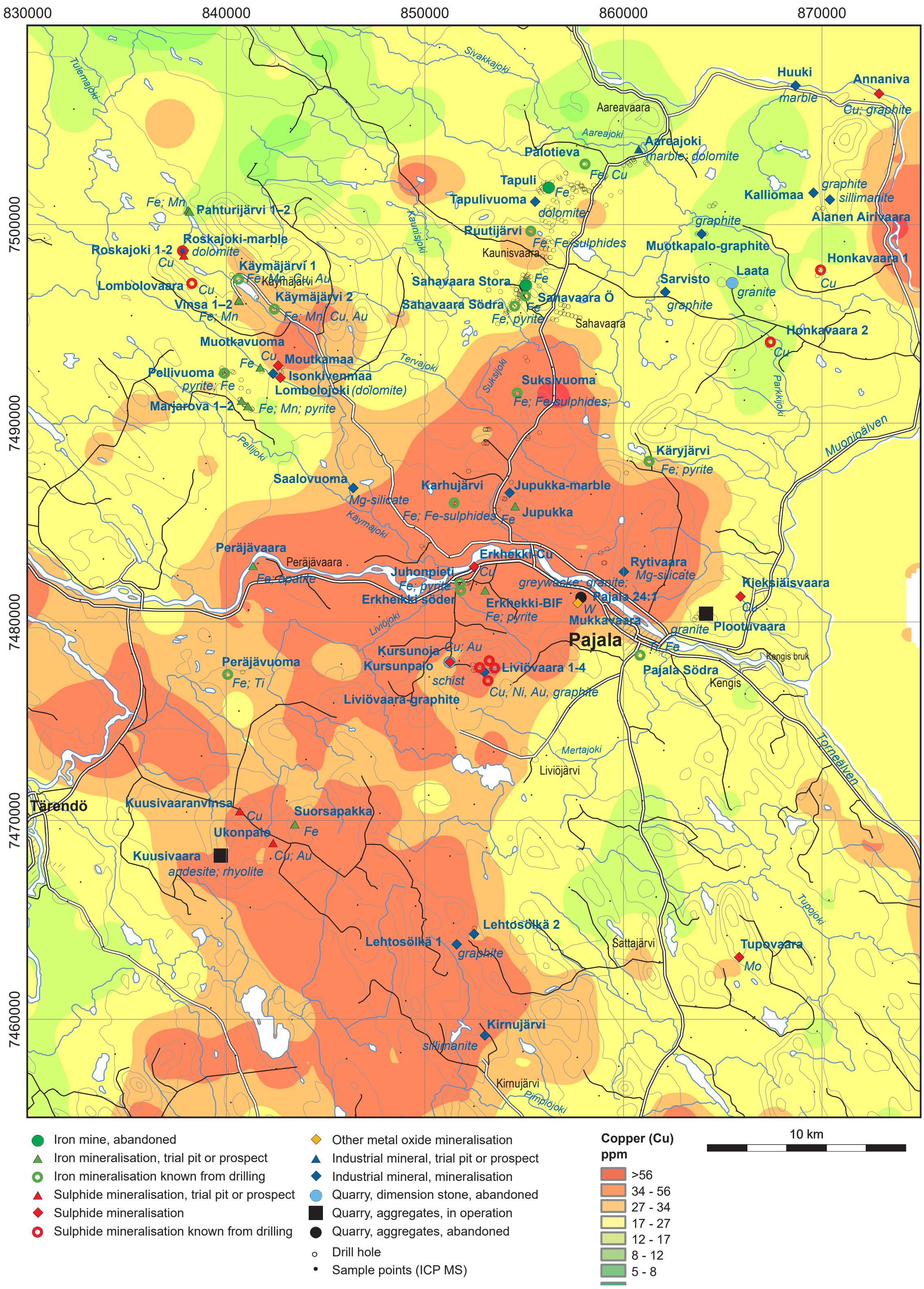

Figure 70. Copper concentrations in till (acid leach, ICP-MS data, SGU) for the Kaunisvaara–Pajala–Liviöjärvi area.

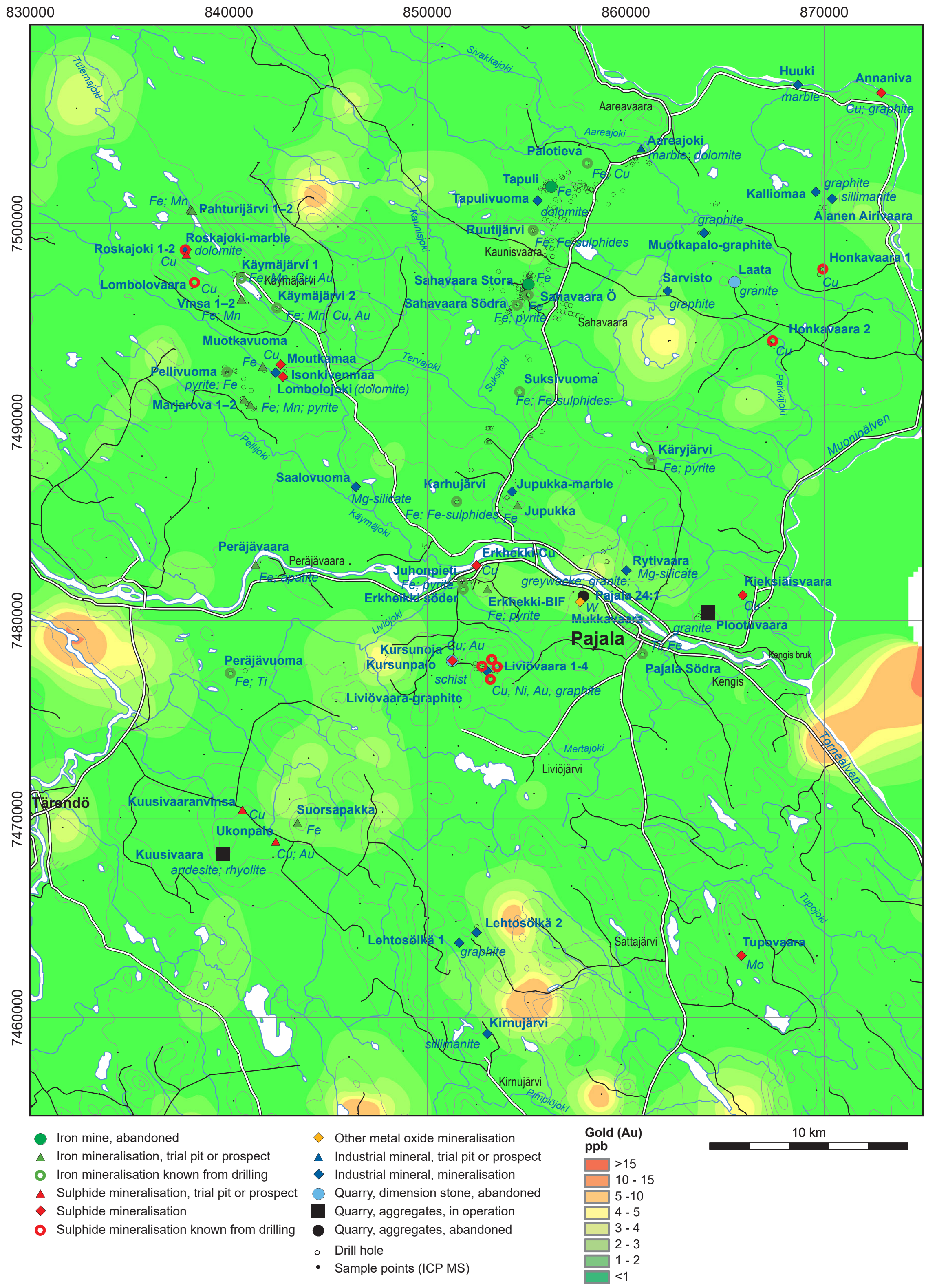

Figure 71. Gold concentrations in till (acid leach, ICP-MS data, SGU) for the Kaunisvaara–Pajala–Liviöjärvi area.

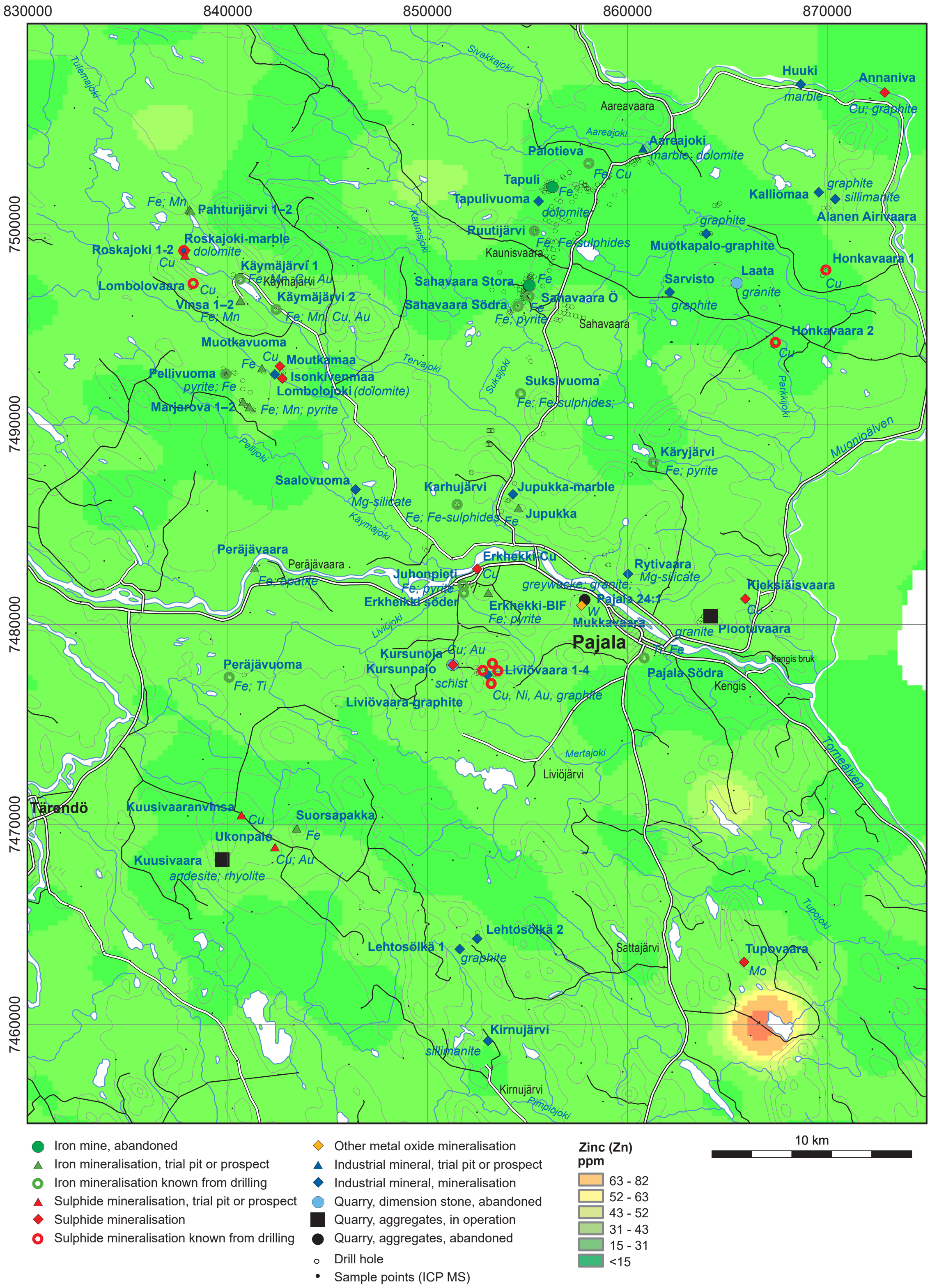

Figure 72. Zinc concentrations in till (acid leach, ICP-MS data, SGU) for the Kaunisvaara–Pajala–Liviöjärvi area.

Iron oxide mineralisations

The Kaunisvaara ore field

The Kaunisvaara ore field, 22 km northwest of Pajala (figs. 67, 73), hosts the most important iron ores in northeastern Norrbotten. The field was discovered in 1918 by the geologist V. Tanner, who identified five ore bodies over a distance of 10 km using a magnetometer (Tanner 1919). The ore bodies were named from north to south: Palotieva, Norra Tapuli, Stora Tapuli, Stora Sahavaara and Södra Sahavaara. Later, in 1940, the Ruutijärvi ore body was identified by Boliden AB in the area between Tapuli and Sahavaara. In 1958 prospectors from the Johnson Company discovered the Karhujärvi and Suksivuoma deposits, located in the southernmost part of the Kaunisvaara ore field (fig. 73). SGU started investigations in the area in 1960, including magnetic and gravity-based surveys carried out from 1963 to 1965 over the Tapuli, Palotieva, Suksivuoma, and Ruutijärvi prospects. Core drilling in the Sahavaara area, and later in the Tapuli and Ruutijärvi areas continued until 1971 (Lindroos et al. 1972, Lindroos 1974).

In 2004 a new era of exploration started in the Kaunisvaara ore field performed by Northland Resources AB (Northland), which concluded an agreement with, and later (2008) purchased the exploration permits from, Anglo American Exploration B.V. (Anglo), to acquire a 100 per cent interest in the "Swedish Pajala Properties", also referred to as the "Pajala Project", which included the Tapuli and Sahavaara iron deposits (Baker & Lepley 2010a, b). Northland continued drilling in the area, and in 2007 test mining of the Stora Sahavaara ore was also performed. The Chief Mining Inspector granted an exploitation concession for the Tapuli deposit to Northland in November 2008. In November 2012 the Tapuli mine was opened and mined in an open pit for two years. The company experienced financial difficulties, and in October 2014 Northland went bankrupt and mining ceased. In July 2018 the company Kaunis Iron resumed mining at Tapuli, and is still in operation (March 2020). The Tapuli ore is the only ore body in the Kaunisvaara ore field that has been mined so far.

The iron ores of the Kaunisvaara ore field are situated in the upper part of the 2.06–1.96 Ga old Karelian Veikkavaara greenstone group, close to the contact with Svecofennian clastic metasedimentary rocks of the Sammakovaara group (fig. 73). The ore-bearing sequence is northeast-trending, northwesterly-dipping, and can be followed across the border into Finland, where similar rocks and iron occurrences are found, e.g. the Mannakorpi deposit (Lindroos 1974, Hiltunen 1982, Bergman et al. 2001). The foot wall of the iron ore horizon consists of graphitic phyllite and dolomitic marble (Vinsa formation), and the hanging wall of quartzite and mica schist of the Sammakkovaara Group (Martinsson et al. 2013). All the ore bodies are associated with calc-silicate mineral assemblages and classified as "skarn iron ores" (Frietsch 1997). Serpentine- and clinopyroxene-amphibole skarn are the most abundant types, although occasional scapolite skarn occurs (Baker & Lepley 2010a, b). Small amounts of chalcopyrite and iron sulphides are also present.

The iron ore bodies in the Kaunisvaara ore field are briefly described below, from north to south.

Palotieva	ORED00030	
Fe, (Cu) (drilling)	E 858082	N 7503033

The Palotieva iron ore prospect is the northernmost ore body of the Kaunivaara ore field, and is the northeastern continuation of the Tapuli ore body (fig. 73). The ore type is characterised as a magnetite skarn with some pyrite, pyrrhotite and chalcopyrite. The skarn minerals are mainly diopside and tremolite (Lindroos et al. 1972).

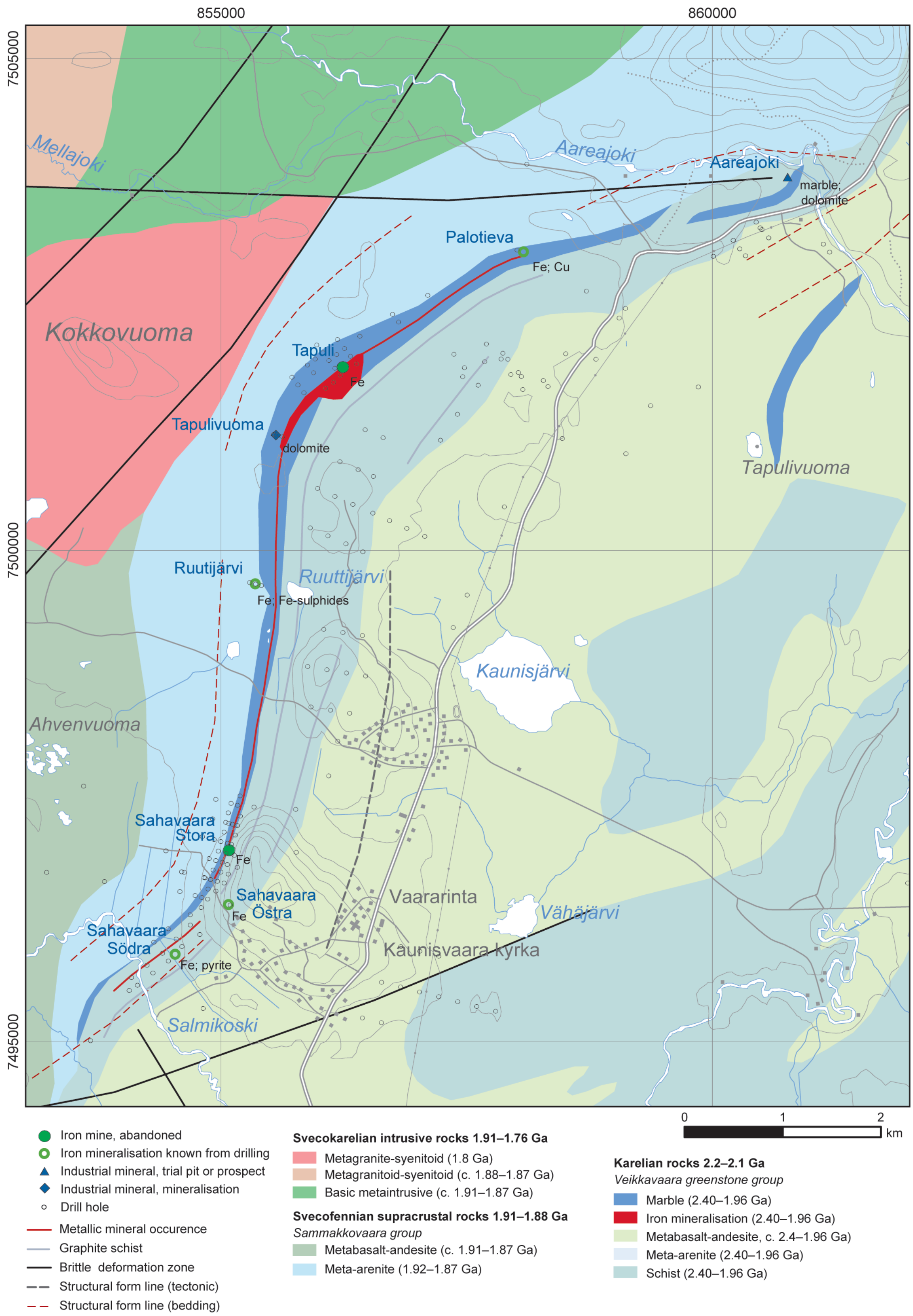

Figure 73. The Kaunisvaara ore field (modified from Bergman et al. 2001). The southernmost part, including the Karhujärvi and Suksivuoma magnetite deposits, is not shown, but can be found on the geological overview map in fig. 67.

The Palotieva prospect was discovered in 1918 using magnetic measurements, and was later investigated by SGU, which performed magnetic and gravimetric surveys in 1963–1965, and core drilling in 1969 (Lindroos et al. 1972). The ore horizon is approximately 300 m long and 60 m wide, striking east-northeast and dipping 65 degrees to the northwest. The historical resource estimate at Palotieva is quoted at 8.1 Mt to a depth of 200 m, with 27.4% Fe, 2.39% S and 0.06% P, based upon magnetics and limited drilling (Lindroos et al. 1972). However, more recent investigations by Anglo American Exploration and Northland Resources, based on extensive core drilling of the Tapuli-Palotieva ore prospect in 2007–2008, indicate that the Palotieva ore body measures 360 m along strike (on a 70° azimuth), and 10–30 m across strike (Baker et al. 2011). It was modelled to a depth of 300 m (dipping 60° to the northwest). The Palotieva deposit was also divided into low- and high-sulphur ore bodies. For the low-S ore, the indicated resources are 1.6 Mt with 22.52% Fe (tot), 0.12% S, 0.03% P and 0.08% Mn, and inferred resources are 1.3 Mt with 22.45% Fe (tot), 0.10% S, 0.03% P and 0.08% Mn. For the high-S ore, the indicated resources are 4.3 Mt with 25.11% Fe (tot), 1.42% S, 0.03% P and 0.06% Mn, and inferred resources are 1.5 Mt with 24.61% Fe (tot), 1.49% S, 0.04% P, and 0.06% Mn (Baker et al. 2011).

Copper content is generally less than 0.1%, but 5.3% Cu was recorded in a 1-metre drill core section from the 1960s (Lindroos et al. 1972). In addition, according to Mihalop et al. (2008), detailed base-of-till sampling (383 samples) at Palotieva by Anglo American Exploration identified a linear Cu anomaly of moderate intensity (up to 0.54% Cu and 176 ppb Au) over approximately 2,000 m of strike length. A single line, 140 m in length, of detailed samples (2.5 m spacing) was later assayed by Northland and found to contain a 20-metre section averaging 4.6% Cu and 0.9 ppm Au in bedrock from below the base-of-till samples (Lindholm & Mukhopadhyay 2008).

Tapuli	ORED00046	
Fe (open pit, active mine)	E 856238	N 7501865

The Tapuli iron ore body was investigated by SGU in 1963–65 using magnetic and gravimetric measurements. Drilling was performed during 1965–69 with 25 drill holes (Frietsch 1997). Northland Resources continued the drilling in 2007–2008 with 105 diamond core holes, and the ore body was outlined down to 300 m below the surface, and remains open down dip (Baker & Lepley 2010a). According to Baker & Lepley (2010a), the Tapuli deposit was estimated to have a combined resource of 107.4 Mt grading 26.01% Fe (total) and 0.23% S. Of this, 52.8 Mt grading 27.02% Fe (total) and 0.23% S is in the Measured category, and 54.6 Mt grading 25.04% Fe (total) and 0.24% S is in the Indicated category. In addition, 24.7 Mt grading 24.58% Fe (total) and 0.23% S is in the Inferred category. Northland Resources started open-pit mining at the Tapuli prospect in October 2012. Mining there was discontinued in December 2014 due to falling world market prices (fig. 74). In total, 8.1 Mt iron ore was mined between 2012 and 2014 (SGU 2015). In July 2018 Kaunis Iron resumed mining at Tapuli, and mining continued as of December 2019.

The typical Tapuli ore type is a magnetite skarn with scattered chalcopyrite, pyrite and pyrrhotite. The ore is slightly banded and is zoned from hanging wall to footwall in the sequence: actinolite magnetite skarn, clinopyroxene-tremolite-magnetite skarn and serpentine-magnetite skarn (Lindholm & Mukhopadhyay 2008, Martinsson et al. 2013b). The bands of magnetite ore vary between 10 and 200 m in width and the Fe-richest parts are a serpentine skarn with magnetite (Lindholm & Mukhopadhyay 2008).

The ore zone appears as stratabound lenses concordantly with the metasedimentary sequences, dipping 45–60 degrees to the northwest or west-northwest. The ore is situated in

Figure 74. The open pit mine at Tapuli in June 2014. Photo: Torbjörn Bergman.

the upper part of the Karelian greenstones at the contact between dolomitic marble, tuffite and graphitic tuffites belonging to the Vinsa formation in the foot wall, and Svecofennian metasedimentary rocks of the Sammakkovaara group in the hanging wall (Martinsson et al. 2013b). The hanging wall rock is a layered sedimentary unit of phyllite, quartzitic phyllite and quartzite or their metamorphic equivalents (mica schist and biotite gneiss). This unit is well-bedded and exhibits sedimentary structures in the unmetamorphosed parts. The thickest part of the ore zone (up to 200 m wide) is located along a significant northeast-trending S-fold, with a fold axis dipping 60 degrees to the northwest. The ore zone is occasionally moderately displaced by cross-cutting, sub-vertical faults (Baker & Lepley 2010a).

Ruutijärvi	ORED00097	
Fe (drilling)	E 855350	N 7499656

The Ruutijärvi iron prospect is situated 2.3 km northwest of the village of Kaunisvaara between the Tapuli and Stora Sahavaara deposits (fig. 73), and was discovered by Boliden in 1949 (Lindroos & Johansson 1972). SGU discovered a faulted extension to the Ruutijärvi occurrence known as the "Blind Ruutijärvi" 20 years later, located 300 m from the outcropping "Northern Ruutijärvi" occurrence discovered by Boliden. The northern Ruutijärvi prospect was drilled with one hole following geophysical ground measurements, and consists of a 10-metre-wide, near-surface magnetite skarn lens with approximately 40% Fe, bordered by dolomitic marble (Lindroos & Johansson 1972).

SGU performed a ground geophysical survey of the area, and in 1969 three holes totalling 426 m were drilled to test the magnetic anomaly caused by the Blind Ruutijärvi mineralisation (Frietsch 1997). The ore horizon of Blind Ruutijärvi is estimated to be a north–south-striking magnetite lens, 200 metres long and 100 metres wide, dipping 40–45 degrees to the west. The top of the ore is cut by a gently dipping fault at a depth of 190 m (Fig. 75). The historical resource was estimated to be 8.3 Mt, averaging 41% Fe, <0.10% Cu, 2.2% S and 0.08% P, at a depth of 190 to 320 m (Lindroos & Jonasson 1972). The ore zone of Ruutijärvi consists of dolomitic marble and magnetite skarn, and generally resembles Stora Sahavaara, being relatively rich in iron sulphides (Lindroos & Jonasson 1972). The hanging wall consists of phyllitic and quartzitic sedimentary rocks. Graphite phyllite occurs in the footwall.

Stora Sahavaara	ORED00101	
Fe (open pit, trial pit)	E 855080	N 7496950

Stora Sahavaara is the second-largest ore body in the Kaunisvaara ore field after Tapuli, and was drilled with 39 drill holes by SGU in 1961–1964. Recent investigations and additional drilling by Northland Resources indicate that the Stora Sahavaara and Södra Sahavaara have a combined

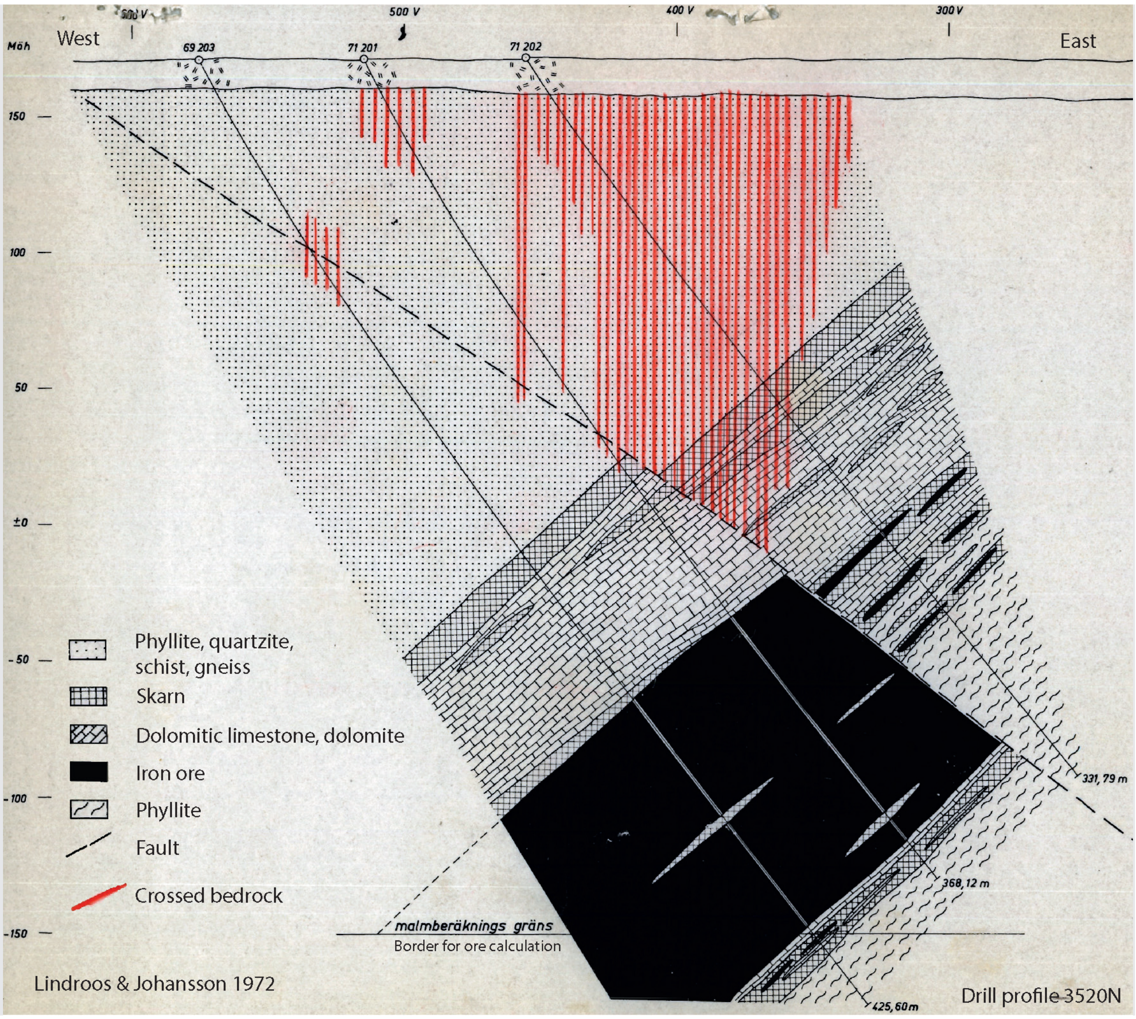

Figure 75. Geological profile in an east–west vertical section showing the "Blind Ruutijärvi" iron ore (modified from Lindroos & Johansson 1972)

Measured and Indicated Resource of 86.8 Mt grading 39.82% Fe (total) and 1.93% S. In addition, 34.7 Mt grading 37.28% Fe (total) and 1.44% S is in the Inferred category (Baker & Lepley 2010b). The ore body was test pitted by Northland Resources in 2007 for refining tests. The test pit is now water-filled, and measures approximately 40 × 50 m across (fig. 76). Northland planned to mine Stora Sahavaara as the second ore after Tapuli (Baker & Lepley 2010b).

The Sahavaara ore body is a magnetite skarn and, like Tapuli, is situated at the contact between Karelian graphitic black schist in the footwall, and Svecofennian siltstones and andesitic volcaniclastic rocks in the hanging wall (fig. 77). Remnants of skarn-altered dolomite occur in the skarn ore, reflecting the likely protolith. The magnetite ore horizon strikes northeast, dipping gently to the west, and can be followed over a distance of 1.3 km along strike on the surface. The average true width of the ore zone is 50 m at the surface, and at a down-dip distance of 550 m the ore zone has been traced for 600 m along strike with an average width of 43 m (Lundberg 1967).

The ore-hosting skarn mineral assemblage is predominantly serpentine skarn and clinopyroxene-amphibole skarn. Subordinate scapolite skarn also occurs. The clinopyroxene-amphibole skarn is composed of equal proportions of tremolite and diopside, with minor amounts of scapolite and garnet (Lundberg 1967). Development of clinopyroxene-amphibole skarn is mostly confined to the hanging wall of the magnetite body and is observed locally as intercalations within the core of the magnetite mineralisation. Serpentine skarn is common in both the hanging wall and the footwall, predominantly consisting of very fine-grained serpentine, with varying amounts of magnetite, chlorite, talc and calcite. The scapolite skarn mainly occurs on the footwall side of the magnetite body, but can be observed locally in the hanging wall, where it predominantly consists of fine- to medium-grained scapolite, with varying amounts of diopside and tremolite. Pyrrhotite and pyrite occur disseminated in the ore, along with small amounts of chalcopyrite.

Sahavaara Södra	ORED00100	
Fe (drilling)	E 854534	N 7495890

Sahavaara Södra was discovered in 1918 using magnetic survey methods. The magnetic anomaly was core drilled at 13 sites by SGU in 1964–65. The ore type is similar to Stora Sahavaara, consisting of magnetite skarn with a relatively high content of iron sulphides (Lundberg 1967). The ore horizon is at a stratigraphically lower position, however, and is mainly hosted by phyllite (fig. 77). The skarn is of two types: serpentine-phlogopite skarn in the magnetite-rich parts, and tremolite-diopside skarn in the iron-poorer parts. The tonnage is estimated at 19.6 million tonnes, with 32% Fe and 0.05% Cu (Frietsch 1997). According to Baker & Lepley (2010b), the Södra Sahavaara deposit has Measured and Indicated Resources of 20.6 Mt grading 30.65% Fe (total), 0.55% S, 0.14% Mn and 0.03% P. In addition, there is a 12.6 Mt Inferred Resource grading 30.12% Fe (total), 0.65% S, 0.14% Mn and 0.03% P.

Sahavaara Östra	ORED00099	
Fe (drilling)	E 855078	N 7496395

Sahavaara Östra is an ore body 200 m east of the main ore zone in the Kaunisvaara ore field, stratigraphically on the same level as Sahavaara Södra (fig. 77). Sahavaara Östra was discovered by SGU using gravimetric measurements and drilling in 1964. The mineralisation is a magnetite skarn with a relatively high content of pyrite and pyrrhotite. The skarn consists of serpentine, phlogopite, diopside and tremolite-actinolite (Fritsch 1997). An estimate of tonnage down to 100 m indicates at least 2 million tonnes of ore, with an average content of 40.5% Fe, 0.014% P and 0.03% Cu (Frietsch 1993).

Figure 76. Test pit at Stora Sahavaara, summer 2014. Photo: Torbjörn Bergman.

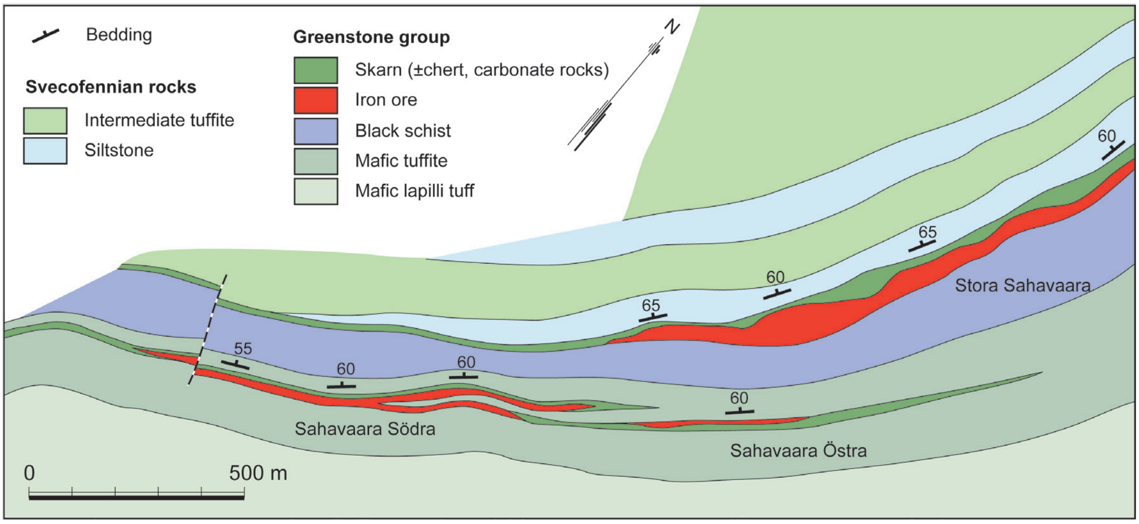

Figure 77. Geological map of the Sahavaara deposits (modified from Lundberg 1967, Bergman et al. 2001).

Suksivuoma	ORED00105	
Fe, Fe sulphides (drilling)	E 854658	N 7491519

The Suksivuoma prospect was discovered in 1958 by Rederi AB Nordstjernan (Axel Johnson Co) using airborne magnetometer surveying. It is situated 5.5 km south of Stora Sahavaara (fig. 67) in the southern extension of the Kaunisvaara ore field (Lindroos 1974), and is defined by a magnetic anomaly that is around 800 metres long. Suksivuoma was drilled with two holes, and mining rights were granted in 1963 (Frietsch 1997).

In 2001 Anglo American Exploration drilled one hole away from the magnetic anomaly but did intersect short intervals between 6 and 14 metres, with 20–25% estimated magnetite content (Baker & Lepley 2010b). In 2008 Northland contracted GeoVista and Astrock Oy to model the airborne geophysical data on the Suksivuoma property. Both models support the potential for small to mid-size (+25 Mt) iron resources, mineable using an open pit (Baker & Lepley 2010b).

During 2000–2004 Anglo American Exploration conducted geophysical surveys at Suksivuoma, a 6.25-km^2 grid with ground magnetometer (12.5-metre stations) and TEM surveys (Lindholm 2009b). 510 base-of-till samples were collected at Suksivuoma by Anglo at intervals of 50 to 100 m, and geochemical results indicated a number of significant but dispersed copper-gold anomalies, with up to 0.5% Cu and 1.6 ppm Au (Lindholm 2009b).

Karhujärvi	ORED00072	
Fe, Cu(drilling)	E 851484	N 7485980

The Karhujärvi prospect is situated 2 km west of Jupukka, in the southern part of the Kaunisvaara ore field (fig. 67). The iron ore body was discovered in 1958 by the Axel Johnson Co (Lindroos 1974). The magnetic anomaly was drilled in 1961 with 5 drill holes, and an ore zone with 42% Fe, 2–3% S and 0.1–0.8% P was intersected (Frietsch 1963). The tonnage is estimated at 2 million tonnes (Kautsky & Frietsch 1971).

According to Baker & Lepley (2010b), Northland Resources investigated the possibility of including minor magnetite deposits in a cluster of deposits in the resource base of the Kaunisvaara mining complex. The Karhujärvi iron oxide-copper mineralisation was one such target, defined by a magnetic anomaly as having a total length of about 1600 m. Previously, in 1996, Outokumpu had drilled three holes for gold in the Karhujärvi area, away from the magnetic anomaly but did intersect short intervals, 1–10 m thick, with 20–25% estimated magnetite content. In 2008 Northland contracted GeoVista and Astrock Oy to model the airborne geophysical data on the site. GeoVista and Astrock Oy suggested there was potential for a mid-size (+50 Mt) iron resource mineable using an open pit. In 2009 Northland tested the Karhujärvi airborne magnetic anomaly with two drill holes totalling 338.1 m, which included a 30- to 60-metre-long section with >30% Fe and approximately 1,000 ppm Cu, supporting an exploration model for IOCG mineralisation in the area and warranting further exploration.

Scattered iron mineralisations in the Pajala area

Käryjärvi	ORED00222	
Fe (drilling)	E 861300	N 7488078

The Käryjärvi iron prospect is situated 8.8 km north of Pajala and 600 m southeast of Lake Käryjärvi (fig. 67). The mineralisation was discovered by SGU in 1960 using airborne measurements, identifying a distinct positive magnetic anomaly 1 km long, striking north-northeast. Ground magnetic surveys were carried out in 1969 covering an area of 2.4 km^2; detailed gravity measurements in 1968 covered an area of 12 km^2 (1,400 points, Grigull et al. 2014). Drilling at the site was performed in 1971 by SGU (Padget & Lindroos 1971, Frietsch 1997). In 2001 Anglo American Exploration drilled two holes about 1 km west of the Käryjärvi iron prospect. The drill cores are stored at SGU, Mineral Resources Information Office in Malå. In addition, Anglo American (in a joint project with Rio Tinto Mining and Exploration Ltd) also performed ground magnetic and TEM measurements under exploration permit Käryjärvi no 1 (Bergsstaten & SGU 2003; geophysical data supplied to SGU).

Drilling confirmed a poor magnetite-hematite mineralisation hosted by a fractured and partly metasomatically-altered, scapolite-bearing greenstone. Besides magnetite and hematite, the mineralisation consists of epidote, calcite, quartz and iron sulphides (Padget & Lindroos 1971). The ore grade is only 10% Fe, with low phosphor content (< 0.08% P). Some Anglo drill core sections are weakly anomalous in Cu, up to 0.3% (data supplied to SGU Malå).

Jupukka	ORED00339	SGL140080
Fe (outcrop)	E 854545	N 7485823

There are several outcrops of fine-grained, quartz-rich, laminated, magnetite-amphibole skarn on the summit of Jupukka, 8.5 km northwest of Pajala (fig. 67). The quartz-rich type of mineralisation has been compared to that noted at Erkheikki and in the Käymäjärvi area (Tanner 1919, Geijer 1925, Eriksson 1954). This mineralisation has not been drilled. According to Lindholm (2009b), Anglo American Exploration carried out detailed basal till sampling in the Pajala area between 2000 and 2004. 506 samples were collected at Jupukka, outlining a geochemical anomaly of high copper and gold values within the basal till samples (up to 0.4% Cu and 105 ppb Au). During the same period, Anglo American conducted ground magnetometer (12.5-metre stations) and TEM surveys at Jupukka, over a 6-km^2 grid (Lindholm 2009b).

Juhonpieti (Erkheikki söder)	ORED00064, ORED15405	
Fe, Fe sulphides (drilling)	E 851777	N 7481937

Iron ore was discovered in the early 1920s by Nordsvenska malmfält AB at Erkheikki, 9 km west-northwest of Pajala (Frietsch 1997; fig. 67). SGU drilled the prospect in 1969–70, and identified a zone of magnetite mineralisation 600–700 m long and up to 30 m wide, with up to 35% Fe. A similar parallel zone with up to 50% Fe was also seen in one drill core (ERK70002) 350 m to the south (Erkheikki söder at 851819 / 7481572). The magnetite in both mineralisations is associated with serpentine, phlogopite, chlorite and some pyrite and pyrrhotite. Skarn zones with tremolite and diopside also occur along with the ore horizon. The mineralisation is hosted by a greenstone sequence similar to that in the Kaunivaara ore field, i.e. mafic volcanics, phyllite, graphite-bearing schist and quartzite. The total tonnage at Juhonpieti is estimated to be 3.4 million tonnes of ore, with an average of 32.5% Fe, 2.1% S, 0.08% P and 0.07% Cu (Frietsch 1997).

In addition, Northland Resources tested a geophysical anomaly in their Juhonpieti no 1 exploration permit area, some 2 km southwest of the Juhonpieti iron prospect. The one drill hole contained graphite-bearing phyllite with amphibole-pyroxene skarn horizons (Bergsstaten & SGU 2011).

Erkheikki-BIF	ORED15750	SLH150056
Fe (outcrop)	E 853029	N 7481670

According to Geijer (1925), outcrops of banded quartzite with amphibole and magnetite occur at the top of the hill in the village of Erkheikki (fig. 67). Field visits during the Barents Project in 2014 and 2015 could not verify the presence of magnetite, but did confirm a rusty outcrop with fine-grained skarn-banded metasedimentary rock with a weak hematite mineralisation (SGU Field note BAA14006). A similar hematite mineralisation is also noted in a road cut 150 m to the southwest at 852954/741555 (SGU Field note SLH150056). Chemical analyses from the outcrops showed 17% Fe, 0.13% Mn, 0.06% Ti, 0.14% P and 0.26% S, and 23.5% Fe, 0.12% Mn, 0.09% Ti, 0.3% P and 1.4% S. Geijer (1925) compared the style of mineralisation to the Jupukka mineralisation 4.5 km northeast of Erkheikki. These two mineralisations form distinct spot-like positive magnetic anomalies on the magnetic anomaly map, in contrast to the Juhonpieti mineralisation, described above, which is part of a positive magnetic anomaly that can be followed for at least 20 km north-northeast. The Erkheikki anomaly has never been drilled.

Pajala Södra	ORED00482	
Fe (drilling)	E 860845	N 7478306

Drilling performed by SGU in 1967 on a positive magnetic and gravimetric anomaly, 0.8 km south of Pajala town centre (fig. 67), revealed the presence of a magnetite-bearing gabbro. The iron content is at most 12% Fe, and no further work has been performed on the prospect (Frietsch 1997).

Peräjävaara	ORED15740	TOB140021
Fe apatite (outcrop)	E 841347	N 7482823

A small outcrop with magnetite-hematite mineralisation occurs on the eastern bank of the Torneälven River at Päräjävaara, some 20 km west of Pajala (fig. 67). The outcrop was observed in 1948 (Eriksson 1954). It was also visited in 2014 during the present inventory, and a hydrothermally-altered, red-stained and fine-grained metagranite or metavolcanic rock with veins of magnetite and hematite was noted (fig. 78). Eriksson (1954) reported the presence of apatite and suggested this mineralisation is comparable to, and a miniature equivalent of, apatite iron ore of the Kiruna type. The restricted spot-like positive magnetic anomaly suggests that the mineralisation is small (fig. 68). A chemical analysis of a sample from the outcrop showed 30.6% Fe, 0.16% Mn, 0.53% Ti and 0.28% P (Appendix 2, TOB140021A).

Figure 78. Outcrop on the river bank west of Päräjävaara, with red-stained and altered fine-grained granite or metavolcanite, with veins of magnetite and hematite. Photo: Torbjörn Bergman.

Peräjävuoma	ORED00229	
Fe-Ti-V (drilling)	E 840079	N 7477341

The Peräjävuoma Fe-Ti prospect is situated in a large bog area, 20 km west-southwest of Pajala, and was discovered in 1961 by SGU using airborne magnetic and gravimetric measurements. The area lacks outcrops, and 2 drill holes were drilled in 1970 (Frietsch 1997). The mineralisation is hosted by a scapolitised metagabbro and consists of magnetite, ilmenite and small amounts of pyrite and hematite (Frietsch 1997). Chemical analyses show an average of 10% Fe, 1.8% Ti and 0.23% V.

Suorsapakka	ORED00317	TOB140012, SLH140044
Fe (outcrop)	E 843453	N 7469806

At the top of Suorsapakka hill, 20 km southwest of Pajala, are several well-exposed outcrops with metabasalt. A 1-metre-wide zone with magnetite in quartz-amphibole-epidote skarn occurs at the above coordinates. More felsic and probably hydrothermally-altered veins and layers occur in the same outcrop. The rock is strongly foliated (20°/90°), and the felsic, quartz-rich veins are very similar to the host rock of the Ukonpalo copper-gold mineralisation noted 1,500 m to the southwest. A strong positive magnetic anomaly connects the two mineralisations. No sulphide minerals are noted at Suorsapakka. A chemical analysis of a sample taken during the present inventory is presented in Appendix 2 (TOB140012A).

Scan mining AB carried out a detailed geochemical sampling survey of till immediately north of Suorsapakka (exploration permit Hukta no. 1, 36 km^2, expired 22 December 2001; data supplied to SGU). A few samples are weakly anomalous in gold (<86 ppb).

The Käymäjärvi–Marjarova area

The Käymäjärvi area, 25 km northwest of Pajala, has been the subject of ore prospecting since 1919, when the first iron mineralisation was found at Pellivuoma and Marjajärvi, to the southeast (fig. 67, Carlson et al. 1984b). The area exhibits a complex metallogeny, including the presence of both BIFs and skarn iron ores, together with numerous geological and geochemical indications of Cu and Au mineralisation, including pyrrhotite-rich zones with Cu mineralisation and up to 3.5 ppm Au, found in boulders and outcrops (Eriksson 1953, Baker & Lepley 2010b).

In the Käymäjärvi–Marjarova area, the upper part of the Veikkavaara greenstone group occupies the central part of a northwest–southeast-trending anticline that is surrounded by younger Svecofennian volcanic and sedimentary rocks of the Sammakkovaara group (fig. 79; Geijer 1931, Eriksson 1953, Padget 1977, Martinsson et al. 2018, Grigull et al. 2018). The fold axes of the anticline generally plunge approximately 45 to 60° to the southeast, where the western limb dips 30–60° towards the southwest. The eastern limb is tectonically more complex due to intersection with a shear zone. Two phases of folding have resulted in a dome and basin pattern. The core of the anticline includes the upper parts of the Veikkavaara greenstone group, and consists of ultramafic lapilli tuff (the Käymäjärvi formation), overlain by metatuffite, graphite schist, banded iron formation (BIF), and dolomite (the Vinsa formation, Martinsson et al. 2018b; fig. 66). Lying conformably on top of the Veikkavaara greenstone group are metamorphosed Svecofennian volcaniclastic and clastic sedimentary rocks constituting the Sammakkovaara group. These can be further divided into three formations: (i) the Muotkamaa formation, comprising a lower andesitic metavolcanic unit together with minor intercalated clastic metasedimentary rocks; (ii) the Hosiokangas formation, which predominantly consists of arenitic to clay-rich metasedimentary rocks; and (iii) an upper unit predominantly made up of andesitic metavolcanic rocks, representing the Hosiovaara formation (Martinsson et al. 2018b).

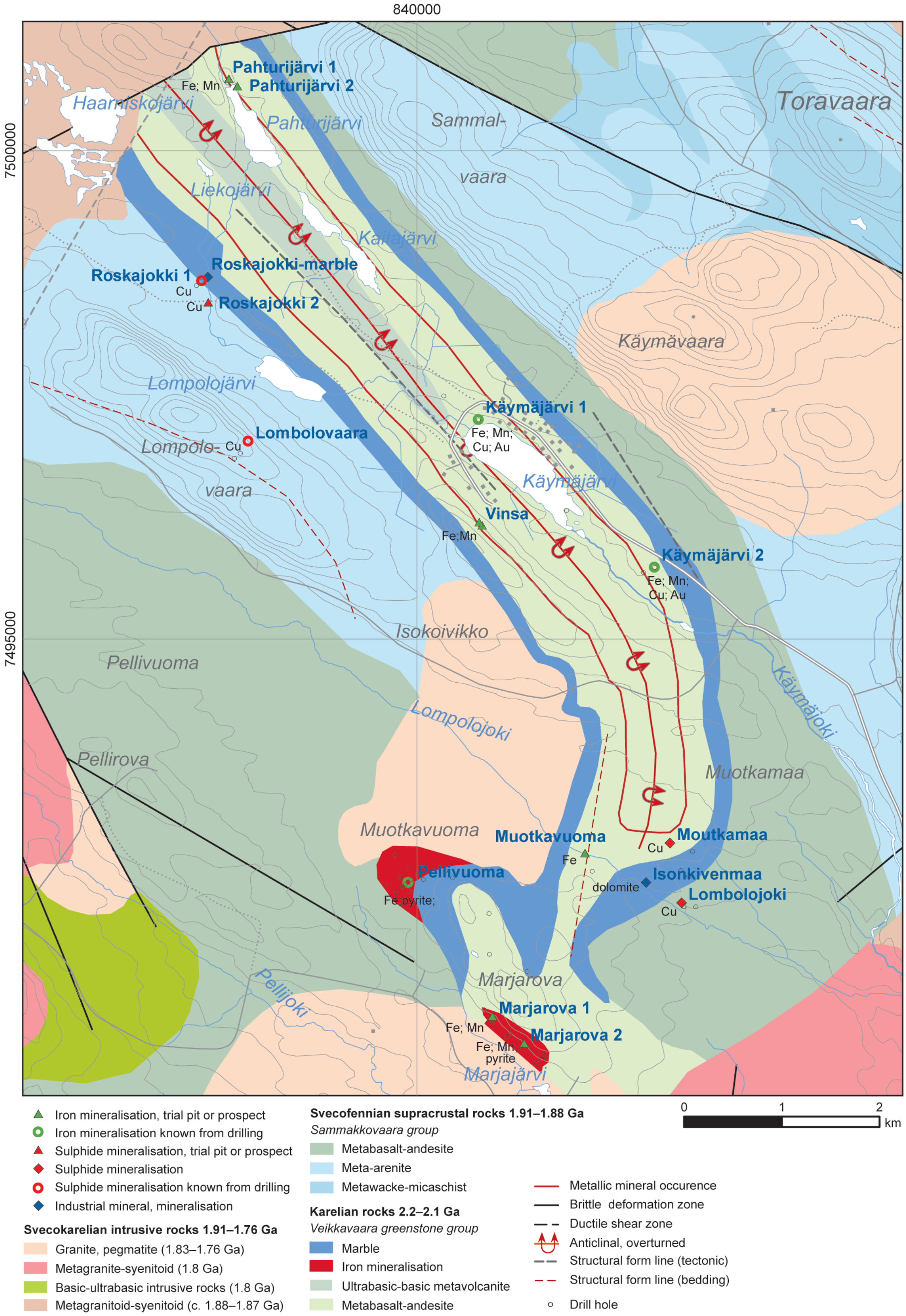

Figure 79. Bedrock geology of the Käymäjärvi area (modified from Bergman et al. 2001).

Most of the prospects in the area are known from drilling, and are not generally exposed in outcrop. The following description of the prospects is based on information summarised from exploration reports and field observations during the current inventory.

Pahturijärvi 1–2	ORED25516, ORED25517	TOB140024, TOB140025
Fe, Mn (outcrops)	E 838081, 838166	N 7500738, 7500663

Two outcrops with magnetite-bearing metabasalt occur northeast of Lake Pahturijärvi, 4.3 km northwest of Käymäjärvi (figs. 79, 80). Chemical analyses of samples from the outcrops showed an average of 39% Fe, 1.9% Mn and 0.1% P (Appendix 2).

Käymäjärvi 1	ORED00282	
Fe, Mn, Cu, Au (drilling)	E 840630	N 7497245

The Käymäjärvi iron mineralisation horizon is a skarn-banded iron formation in the upper part of the Veikkavaara greenstone group (fig. 79). It was drilled with six holes in 1960 by Stora Kopparberg AB. The target of the drilling was the northwest–southeast-trending positive magnetic anomaly under Lake Käymäjärvi (fig. 68; Grip & Frietsch 1973). According to drill core logs, a magnetite-bearing skarn-layered quartzite, 16–18 metres wide, was intersected in two of the drill holes (Hellgren 1961). Chemical analyses show that the iron content is low and does not exceed 20% Fe. The phosphor content is generally less than 0.1%, and the manganese content varies between 1.5–2.5%. Skarn minerals are predominantly grunerite and hyperstene. Less common are fayalite, mica and garnet (Grip & Frietsch 1973).

Figure 80. Outcrop with magnetite-bearing metabasalt at Pahturijärvi, 4 km northwest of Käymäjärvi. Photo: Torbjörn Bergman.

Käymäjärvi 2	ORED25977	
Fe, Mn, Cu, Au (drilling, outcrop)	E 842431	N 7495732

Based on the discovery of sulphide mineralised boulders and outcrops in the area, the same magnetic anomaly as observed at Käymäjärvi 1 was later drilled by SGAB southeast of Lake Käymäjärvi (Niva 1983, Lundmark 1985). The mineralised boulders and outcrops consist of albitised greenstone and graphite schist, with some chalcopyrite, pyrite and pyrrhotite. Chemical analyses of samples from the boulders show grades varying between 0.1–2.0% Cu and 0.1–3.5 ppm Au (Carlson et al. 1984b). The two western drill holes in the profile were disrupted due to technical issues, and did not intersect the magnetic anomaly caused by the skarn-banded iron formation. However, the eastern drill hole (N-KÄY-3) intersected a 10-metre-wide zone with graphite schist containing 0.13% Cu, but no gold (Lundmark 1985). Some of the zones with graphite and chemical sedimentary rocks contain 1–4% Ba.

Approximately 1.1 km east-southeast of Käymäjärvi 2, a considerable number of small gold and chalcopyrite grains, as well as zeolite minerals, were seen in deep till samples taken in trenches several metres deep dug during sampling of a banded iron formation (Carlson et al. 1984b).

Vinsa 1	ORED25514	TOB140022
Fe, Mn (trial pit and outcrop)	E 840668	N 7496166

On the northeastern slope of Vinsa, southwest of Lake Käymäjärvi, a trial pit measuring 5 × 5 × 3 m is dug in fine-grained, quartz-rich, magnetite-amphibole-pyroxene skarn at the same stratigraphic position as the Käymäjärvi iron mineralisation. Chemical analysis of a sample taken from the pit showed 15% Fe and 2.4% Mn (Appendix 2). A small magnetite-laminated, fine-grained skarn-quartzite outcrop occurs thirty or forty metres northwest along strike. This is most likely the same type of mineralisation as seen in the pit (Vinsa 2, fig. 81). Geijer (1925) describes the steeply inclined banding as very fine-grained, siliceous magnetite, brownish-gray, grunerite amphibole skarn, with fine-grained grey quartz. A boulder of albite-altered, iron sulphide-bearing greenstone is anomalous in barium (0.9% Ba, Carlson et al. 1984b). Approximately 250 m south of the Vinsa prospect, Intrepid Minerals Corporation sampled a 1.6-km-long, northeast–southwest-trending till geochemical profile (Exploration permit Käymäjärvi no 100, expired 4 July 2006; data supplied to SGU, Bergsstaten & SGU 2007).

Muotkavuoma	ORED15741	TOB140032, BOM950158
Fe (outcrop)	E 841721	N 7492808

A small outcrop with magnetite-layered pyroxene skarn occurs on the northern side of the Lompolojoki River, 4.4 km south-southeast of Käymäjärvi. The outcrop was found during bedrock mapping of the area by SGU in 1995 (Bergman et al. 2001). Chemical analysis of a sample taken during the present inventory showed an Fe content of 20% and 0.4% Mn (Appendix 2). The outcrop is right on the southern continuation of the same positive magnetic anomaly as at the Käymäjärvi iron sulphide prospect described above. Phelps Dodge Exploration Sweden AB has carried out core drilling in the area, with a single hole (PdKay04, 841794/7492622) located 200 m southeast of the Muotkavuoma mineralisation. A few core sections were weakly anomalous in copper (exploration permit Käymäjärvi no 2, expired 4 December 2006; data supplied to SGU).

Figure 81. Fine-grained, laminated magnetite skarn rock at the Vinsa prospect. Photo: Torbjörn Bergman.

Pellivuoma	ORED00090	
Fe (drilling)	E 839913	N 7492507

The Pellivuoma iron prospect is located 4.8 km south-southwest of Käymäjärvi village (fig. 79), and was one of the first iron ores found in the Käymäjärvi area by Nordsvenska Malmfält Company in 1919. The prospect was drilled by SGU in the late 1960s and early 70s, with 13 holes totalling about 2,500 m (Ros et al. 1980, Frietsch 1997). The area is covered by detailed gravimetric and ground magnetic measurements obtained during 1963–1966 (Ros et al. 1980). Glacial till and peat moss cover the entire Pellivuoma deposit area, and there are no bedrock exposures. Much of the geological interpretation therefore relies on drill core data coupled with local geophysical data. Based on the SGU drilling, ore reserves were calculated to a depth of 200 m, with an estimated 43.5 million tonnes of ore with 32.7% Fe, 0.04% P and 0.58% S (Ros et al. 1980, Frietsch 1997). Six drill cores from Pellivuoma prospect are stored at the SGU drill core archive in Malå. Two of these were scanned using hyperspectral IR analysis; the data are available via the SGU map viewer (www.sgu.se).

Northland Resources drilled 12 holes totalling 1,813 m in 2008, with an additional 46 holes totalling 9,817 m the following year. Based on a 20% Fe cut-off grade model, the Pellivuoma deposit has indicated mineral resources totalling 33.81 Mt at a grade of 30.15% Fe and 0.56% S (Lindholm 2009a, b; as of April 20, 2009). Inferred mineral resources total 57.01 Mt at a grade of 29.75% Fe and 0.99% S. Drilling continued at the site during resource evaluation, and a total of 24 new holes were added. Modelling identifies relatively sulphur-rich zones (>2% S) at the western edge, as well as on the southeastern extreme of the package of mineralisation. The large central zone, which contains more than two-thirds of the total tonnage, has a considerably lower sulphur grade of 0.43% (Lindholm 2009b).

GeoVista AB performed a ground survey covering an area measuring 3 km^2 from Pellivuoma in the northwest to Marjarova in the southeast using magnetometry and slingram (Horizontal loop EM). In 2009 Astrock Oy was contracted to conduct a downhole geophysical programme encompassing magnetic susceptibility, resistivity, IP and density (Lindholm 2009a).

The Pellivuoma iron mineralisation is a magnetite-dominated, calcium-magnesium and magnesium silicate skarn-hosted deposit occurring in the upper part of the Veikkavaara greenstone group. It is probably a metamorphosed banded iron formation or similar type of syngenetic iron formation (e.g. Frietsch, 1997). The skarn minerals associated with the magnetite are mainly actinolite, diopside, serpentine and subordinate phlogopite (Ros et al. 1980, Frietsch 1997). Clinopyroxene-tremolite skarns appear to predate a magnetite-actinolite stage, while the serpentinisation stage is the youngest, post-dating the mineralisation event. Serpentine is the predominant gangue mineral in the Fe-richest part of the deposit, and the magnetite ore is here locally semi-massive. A common feature is breccia-style mineralisation, in which magnetite with actinolite ± biotite brecciates the host rock. The host rock is typically clinopyroxene-tremolite skarn, but locally dolomite is the host (Lindholm 2009b). Pyrrhotite, pyrite and small amounts of chalcopyrite occur along with the skarn.

According to Lindholm (2009a), the Pellivuoma Fe ore deposit covers an area of approximately 700 × 600 m, and consists of several southwest-dipping, winding ore lenses that are 20 to 100 m thick and dip approximately 50 degrees. They are generally conformable with the footwall granite contact. Magnetite-rich skarn rocks are irregularly intercalated with non-mineralised clinopyroxene-actinolite-serpentine skarns. The iron mineralisation is cut by several low-angle and sub-vertical fault zones. A low-angle north-northwest-running displacement roughly sub-divides the deposit into more sulphur-rich shallow ore and a deeper low-sulphur ore. Towards the southwest the mineralisation plunges to a depth of 250 m, and remains open to that direction (Lindholm 2009a). In addition to iron, shallow levels of the southwestern part of the deposit show pronounced Cu enrichment, with chemical analyses yielding 0.1–1.0% Cu (Lindholm 2009a).

Marjarova 1 and 2 (Marjajärvi)	ORED25518, ORED00081	TOB140029 and TOB140026
Fe, Mn, pyrite (drilling)	E 841099, 841099	N 7490863, 7490863

The Marjarova iron prospect, 6 km south of Käymäjärvi (fig. 79), was discovered in 1919 by Nordsvenska Malmfält AB. Magnetic and gravimetric measurements were carried out by SGU in 1964 and were followed up by drilling between 1968 and 1970, with 9 holes totalling 1,710 m (Frietsch 1997). The Marjarova iron prospect was covered by a ground geophysical survey (magnetometry and slingram) by GeoVista AB for Northland Resources in 2008 (Pitkänen 2008 cited in Lindholm 2009a). The mineralisation is of skarn type with magnetite layers alternating with layers of fine-grained quartzite. It occurs in the southwestern limb of an antiform dome structure southwest of the Käymäjärvi anticline (Carlson et al. 1984b). The rocks belong to the upper part of the Veikkavaara greenstone group, i.e. at the same stratigraphic position as the Pellivuoma mineralisation, some 2 km to the northwest. The skarn minerals are cummingtonite-grunerite, hornblende, biotite, hedenbergite and fayalite (Geijer 1925, Frietsch 1997). Besides magnetite, minor amounts of pyrrhotite, pyrite and accessory amounts of chalcopyrite also occur. The iron content is up to 45%, with an average of 32% Fe in a layer 1 km long and 10–20 m thick. Phosphor content is less than 0.05%; sulphur content is 1–5%. Copper content is less than 0.1%. The ore reserve is estimated at 3 million tonnes

(Frietsch 1997). According to Carlson (1984b), dissemination of copper sulphides occurs throughout the length of the mineralisation. The best section is found in dh70603 with 1.3% Cu in a 1-metre core section.

A row of water-filled trial pits, without any exposed rocks, was found in summer 2014 during a field visit to the area. The location of the trial pits follows the magnetic anomaly and a small shaft, about 2 × 2 m, was found at 841099/7490863 (Marjarova 2, fig. 82), but no ore-bearing waste rock was observed. However, a small amount of waste rock was found at one of the trial pits, 425 m to the northwest (Marjarova 1 at 840776/7491138). The waste rock consists of a banded magnetite-(hematite)-quartz-rich ore type without any visible sulphide minerals. The ore type is richer in quartz than the ore type at Vinsa in the Käymäjärvi area. The presence of hematite along with magnetite is also different from the typical ore type at Käymäjärvi. Chemical analysis of a sample taken from the dump showed a content of 37%, Fe and 1.5% Mn (Appendix 2, TOB140029A).

Figure 82. Wood reinforced trial pit at Marjarova, summer 2014. Photo: Torbjörn Bergman.

Sulphide mineralisations

Scattered sulphide occurrences in the northern and central part of the Pajala area

Honkavaara 1	ORED25965	
Cu (drilling)	E 869936	N 7497699

The Honkavaara 1 prospect is located 20 km northeast of Pajala in metabasalts of the Greenstone group within the Pajala deformation zone. The prospect was discovered by Anglo American Exploration in 2002. Base-of-till geochemical sampling, and ground magnetic and TEM surveys were followed by three drill holes. The prospect is seen as a weak, discontinuous, north–northwest-striking slingram anomaly and a positive magnetic anomaly (figs. 68–69). One of the drill holes (Dh 02HON001, 152.20 m) intersected a sulphide-rich fault zone within a mafic schist, with 0.14–0.33% Cu over 9.25 m. The last 1.40 m section of this interval is weakly anomalous in gold (0.78 ppm; data supplied to SGU).

Honkavaara 2	ORED25966	
Cu (drilling)	E 867419	N 7494084

The Honkavaara 2 prospect is located 4.5 km south-southwest of Honkavaara 1 (fig. 67) in strongly altered amphibolite, metagabbro-syenitoid and marble. Four drill holes by LKAB Exploration in winter 1985/1986 targeted a weak magnetic and electromagnetic anomaly, which also coincides with Cu anomalies in deep till samples (Hansson & Martinsson 1986). Dissemination of pyrite and pyrrhotite is common but the content of copper and gold is only weakly anomalous. A three-metre section contained 0.16% Cu; a short section (0.15 m) contained 3.7% Cu and 0.25 ppm Au. In 2002 Anglo American carried out additional exploration work including base-of-till geochemical sampling, ground magnetic and TEM surveys, and two drill holes, albeit with disappointing results. The best core section contained 0.46% Cu over 1.65 m in metagabbroic rocks (exploration data supplied to SGU).

Roskajoki 1	ORED15738	
Cu (drilling)	E 837802	N 7498664

The Roskajoki 1 prospect, 3.5 km west-northwest of Käymäjärvi (fig. 79), was core drilled with two holes in 1984 (Lundmark 1985). The mineralisation consists of chalcopyrite, pyrite and small amounts of molybdenite, and was found to be related to hydrothermally-altered zones in the host quartzite and intermediate metavolcanic rocks (Lundmark 1985). These rocks occur above a 90-metre-thick unit of marble, which shows skarn alteration in the contact zone. The mineralisation seems to be discordant to the bedding, instead appearing to be located in a tectonic zone. Mineralisation also occurs outside the tectonic zone, west of the slingram north–south-trending anomaly described below (Roskajoki 2). Chemical analyses of sulphide-rich sections showed a maximum content of 0.6% Cu over a 1.8 m section. Along with the drilling for copper, a 90-metre-thick section of dolomite belonging to the Käymäjärvi group was intersected (ORED04680, Roskajoki marble, described below).

Roskajoki 2	ORED25967	
Cu (outcrop)	E 837869	N 7498450

The Roskajoki 2 copper mineralisation consists of chalcopyrite and pyrite in skarn-altered marble, and occurs between units of banded iron formation and graphite schist to the west, and basaltic metasedimentary rocks to the east (fig. 79, Carlson 1982b). The mineralisation was mapped and sampled by excavations, drilling and blasting in 1973. 25 samples were analysed; the richest contained 2.04% Cu, with trace of zinc in some samples. The prospect was sampled again by SGAB in 1982, with up to 1.3% Cu and 0.2 ppm Au being recorded in the richest part of the Cu mineralisation, a 30 × 15 m area (Carlson 1982b). The mineralisation is indicated by a strong slingram anomaly, which continues to the north giving a total length of 400 m (Niva 1984b; see Roskajoki 1 above).

Lombolovaara	ORED25968	
Cu, Au (drilling)	E 838275	N 7497025

A weak copper-gold mineralisation in conglomerate, with bornite and secondary Cu sulphide minerals, azurite and malachite, disseminated in the quartz-rich matrix, occurs at Lombolovaara, about 3 km west of the village of Käymäjärvi (fig. 79; Eriksson 1954, Carlson 1982b). The conglomerate pebbles consist of quartzite or quartz. Iron oxides (magnetite and hematite) occur in the matrix as heavy mineral concentrations, with up to a few per cent magnetite, seen as a weak but sustained anomaly in magnetic surveys (Carlsson et al. 1984b). It is suggested that the conglomerate unit has a lateral extent of about 2 km. Outcrops of quartzites at the top of the hill suggest a steep dip to the bedding (Eriksson 1954). The rocks at Lombolovaara belong to the Sammakovaara group, and similar conglomerates occur on the eastern side of the Käymäjärvi anticline. Analyses of nine local conglomerate boulders showed an average of 0.4% Cu and 0.25 ppm Au, with maximum concentrations of 1.0% Cu and 0.6 ppm Au (Carlson 1982b).

The conglomerate was investigated by boring two drill holes in 1984 (Lundmark 1985). A conglomerate 0.6 m wide was encountered in the eastern drill core (N-LOM2) at a depth of 137.75–138.35 m. A biotite-bearing quartzite, with local heavy mineral concentrations is noted below and above the conglomerate. Cross-bedding in the quartzite indicates a stratigraphic origin up to the west. Analyses of the conglomerate showed only weakly elevated concentrations of copper (0.1%) and gold (45 ppb, Lundmark 1985). According to Eriksson (1954), outcrops of conglomerates occur at the foot of Lombolovaara hill, and it is possible that the main conglomerate unit was never reached in the drill hole (N-LOM2).

Muotkamaa	ORED25969	
Cu (outcrop)	E 842591	N 7492912

Outcrop samples in the Muotkamaa area, 4.4 km south-southeast of the village of Kärmäjärvi (fig. 79), contain 0.1–1.3% Cu and trace amounts of gold (Carlson et al., 1984b). Sulphide mineralisation is noted in skarn-altered greenstone, in grey, epidote-altered volcanic rock and in BIF and consists of disseminated pyrrhotite, chalcopyrite, chalcocite, bornite and malachite. Frietsch (1956) describes strong EM anomalies in the Lombolojoki area (see below), which was drilled in 1956. The anomalies were shown to be caused by graphite-bearing phyllite and iron sulphides in breccia (Carlson 1982b). One section, in drill hole 5, 250 m east of the mineralised outcrops at Muotkamaa, contained 0.12% Cu and 33.4% Fe (Frietsch 1956, Carlson 1982b).

Lombolojoki	ORED25970	
Cu (outcrop, drilling)	E 842710	N 7492300

Exploration work in 1945 by SGU located copper-mineralised outcrops in the Lombolojoki–Muotkamaa area (Eriksson 1953). The mineralisation is weak, can be followed 150 m, and is less than 20 m wide. It consists of disseminated bornite and chalcopyrite hosted by a grey quartzite, which is seen as weak slingram anomalies. Drilled with 5 holes, only a weak dissemination of pyrite and chalcopyrite was noted in the cores (Frietsch 1956). Chemical analyses of drill core samples showed 0.7–1.7% Cu in 0.4–1.0-metre sections, but no gold was detected (Carlson 1982b).

Kieksiäisvaara	ORED15764	
Cu (outcrop)	E 865891	N 7481291

According to Hansson et al. (1984), small amounts of bornite and malachite occur on fracture and schistosity planes in a fine-grained meta-arkose cropping out on the southern side of hill Marjavaara, 5 km east-northeast of Pajala (fig. 67). Chemical analysis showed 0.12% Cu (Hansson et al. 1984b). An unsuccessful attempt to find the mineralised outcrops was made during the present inventory.

Erkhekki-Cu	ORED15749	TOB140033
Cu (outcrop)	E 852472	N 7482791

A small outcrop occurs on the southern bank of the Torneälven River at Erkheikki (fig. 67). The outcrop consists of a mafic metavolcanic rock, brittly deformed and sealed with millimetre- to centimetre-wide veins of quartz and feldspar. The rock gives a general impression of strong alteration; small amounts of pyrite and chalcopyrite are noted in both the veins and disseminated within the volcanite. Chemical analyses of samples from the outcrop showed copper concentrations of up to 0.6% (Hansson et al. 1984b, Appendix 2).

Kursunoja	ORED 15404	TOB14003
Cu, Au (outcrop)	E 851259	N 7477991

A quartz vein sample, taken in the Kursunpalo schist quarry south of Erkheikki (fig. 67), was sent to SGU and *Norrlands mineraljakt* in 1985 (sample 85498:01). It contained visible amounts of chalcopyrite and pyrite, Chemical analysis of the sample showed 0.3% Cu, 0.2% Pb and 0.1 ppm Au. Chemical analysis of a quartz-rich sample taken in the quarry during the present inventory confirmed the previously reported anomalous copper and gold content, returning 0.1% Cu and 0.09 ppm Au (Appendix 2). In addition, a small gold anomaly is seen in the till geochemistry 4 km west of Kursunoja quarry (fig. 71).

Liviövaara prospects

In the area southeast of Liviövaara, 7 km west-southwest of Pajala (fig. 67), copper-gold and graphite mineralisations have been identified by drilling on positive magnetic and electrical anomalies in the area. The Liviövaara area was first investigated in detail in 1985 by LKAB using ground measurements, electrical and magnetic methods (Johansson 1985). The geophysical investigations were followed by core drilling in 1986, which revealed graphite mineralisations, as well as zones anomalous in copper and gold (Hansson 1986b). The area has been claimed several times since then, e.g. by ProGold HB (1990–1993), Viscaria AB (1995–1997), Anglo American Exploration (2000–2002), and Northland Resources AB (2003–2010). In 2000 Anglo American Exploration drilled 9 drill holes and obtained promising results, with anomalous copper and gold in several of the drill cores. Talga Resources performed chemical analyses of graphite-rich sections of the Anglo American drill cores in 2012. According to Lindholm (2009b), geochemical results from 270 basal till samples taken at the top of Liviövaara (approximately 852300/7478300) by Anglo American show a significant basal till copper-gold-uranium anomaly, nearly 500 × 200 m wide, with up to 0.14% Cu, 92 ppb Au, and 83 ppm U. In 2000–2004 Anglo American carried out geophysical surveys with ground magnetometer and transient electromagnetic (TEM) measurements on a 3 km^2 grid at Liviövaara. Five lines 100 m apart were surveyed by IP with 25-metre dipole spacing (Lindholm 2009b). The company's original exploration data sets, including drill core section analyses, are currently stored at SGU Malå office and are open access.

Liviövaara 1	ORED25972	
Cu, graphite, (drilling)	E 853256	N 7478030

A drill hole (dh 00LIV004, 208.7 m) bored at Liviövaara 1 by Anglo American Exploration shows sections with anomalous copper, a 49-metre section with 0.15% Cu, and a 47-metre section with 0.19% Cu (Talga Resources Ltd, 21 August 2012). Minor concentrations of the sulphides pyrrhotite, pyrite and chalcopyrite occur throughout the drill core, hosted in biotite-graphite schist and actinolite-biotite-albite rock with varying degrees of silicification (Anglo American drill core log). Talga resources analysed carbon from the Anglo American drill core and reported graphite-rich sections containing 21.1% C over a 1.8-metre section, 20.7% C over a 4.0-metre section, and 13.7% C over a 12.2-metre section (Talga Resources Ltd, 21 August 2012).

Liviövaara 2	ORED25971	
Cu, Au (drilling)	E 852763	N 7477682

A drill hole (dh 00LIV001, 199.7 m) bored at Liviövaara 2 by Anglo American Exploration penetrated an 11-metre section with 0.63% Cu, and a 10-metre section with 0.15% Cu (Talga Resources Ltd, 21 August 2012). The richest part includes a 2.4-metre section with 2.4% Cu and 2.3 ppm Au (exploration data supplied to SGU). The host rock is a biotite-bearing, quartz-feldspathic rock showing varying degrees of silicification, scapolite alteration and late-stage epidote-carbonate alteration. Zones of sulphide breccias contain pyrite, chalcopyrite, bornite (drill core log, Anglo American Exploration).

Liviövaara 3	ORED25973	
Cu (drilling)	E 853529	N 7477652

A drill hole (dh 00LIV009, 288.3 m) drilled at Liviövaara 3 by Anglo American shows a 45-metre section with 0.27% Cu (Talga Resources Ltd, 21 August 2012). Minor sulphides, pyrrhotite, pyrite and chalcopyrite occur as disseminations, as vein fillings or as sulphide breccias throughout the drill core. The host rock is mainly a quartzo-feldspathic schist (Anglo drill core log, SGU Malå).

Liviövaara 4	ORED25974	
Cu, Au (drilling)	E 853193	N 7477019

A drill hole (dh 00LIV003, 212.8 m) drilled at Liviövaara 4 by Anglo American Exploration shows a 39-metre section with 0.16% Cu (Talga Resources Ltd, 21 August 2012). Talga resources analysed carbon from the Anglo drill core and reported a graphite-rich section with 16.7% C over 3.0 m.

Scattered sulphide occurrences in the southern part of the Pajala area

Kuusivaaranvinsa	ORED15739	TOB140010
Cu (rock rubble)	E 840688	N 7470464

A pile of rock rubble measuring 20 × 10 × 4 m is found on the southern side of the gravel road to Suorsapakka Nature Reserve, 10 km east-northeast of Tärendö (fig. 67). The pieces are 0.1–0.5 m in diameter, and consist of fine-grained meta-andesite to metagabbro. Some of the rock samples are rich in pyrite, and small amounts of chalcopyrite are also seen. It has not been possible to identify the source of the rubble, but it is most likely the result of local blasting. Chemical analyses of selected samples from the rubble showed up to 0.4% Cu and 0.1 ppm Au (Appendix 2).

Ukonpalo	ORED20241	TOB140011
Cu, Au (outcrop)	E 842366	N 7468870

The copper-gold-mineralised outcrop at Ukonpalo,12.5 km east of Tärendö (fig. 67), was discovered in 2007 by Vesa Hiltunen and Per Krekula who were awarded first prize in *Norrlands mineraljakt 2007* for the find (Arnbom et al. 2008b). The mineralisation consists of disseminated chalcopyrite, bornite and magnetite in felsic metavolcanite. Chemical analyses of samples sent to SGU and *Norrlands mineraljakt* showed up to 2.4% Cu, 0.5 ppm Au, 2 ppm Ag (Arnbom et al. 2008b). Analysis of a sample taken from outcrop as part of the present inventory returned only 0.8% Cu, 0.13 ppm Au and 0.6 ppm Ag (Appendix 2). The area was claimed in 2008 by Blackstone Nickel AB, which continued exploration in the area with trenching (fig. 83) and seven short drill holes (personal communication, Vesa Hiltunen Junosuando 2016). The style of mineralisation is comparable to Aitik and is suggested to be IOCG-type. The exploration permit expired in 2012 and, promising results notwithstanding, the area has not been subject of exploration since.

Tupovaara	ORED15763	
Mo (trial pit)	E 865821	N 7463129

The presence of molybdenite, pyrite and chalcopyrite in a small trial pit in migmatite granite on the southern slope of Hautalaki, 3.7 km east of Sattajärvi was reported by Carlson et al. (1984a) (fig. 67). An unsuccessful attempt to find the pit was made during the present inventory. The coordinates given above are therefore uncertain and have not been verified.

Figure 83. Exploration excavation at Ukonpalo Cu, Au prospect. Photo: Torbjörn Bergman.

Tungsten

Mukkavaara	ORED25956	
W (outcrop)	E 857696	N 7480959

Two north–northeast-striking vertical quartz dykes in gneiss, 30–50 cm and 60 cm wide, occur at Mukkavaara, 2 km west of Pajala (fig. 67). They contain unevenly dispersed crystals of yellow scheelite. The outcrop was discovered by Roland Snell during Norrlands Mineraljakt 1994 (SGU 1994, protocol 94087:01-02).

Industrial minerals

Marble

Huuki	ORED04678	
Marble (outcrop)	E 868664	N 7507006

Outcrops of calcite-marble occur on the banks of the Muonio River at Huuki (Lundberg 1963, Lindroos & Henkel 1981; fig. 67). The marble is impure, with high quantities of skarn minerals and graphite (Shaikh et al. 1989). The marble has not been quarried in Huuki itself, but 400 m to the northeast in Äkäsjoensuu on the other side of the Muonio River in Finland. The quarry is 400 × 300 m and was abandoned several years ago. 4.5 million tonnes have been quarried at Äkäsjoensuu, mainly for agricultural use and production of raw mix for Portland cement (Nurmi 1989, Maier et al. 2015).

Aareajoki	ORED04677	TOB140017
Dolomite (abandoned quarry)	E 860768	N 7503799

A small abandoned dolomite quarry occurs at Aareajoki, 2 km southwest of Aareavaara on the Muonio River (fig. 67). The quarry is 5 × 4 m across and 3 m deep. The marble quality was investigated in 1973, and the results presented in Shaikh et al. (1989). The width of the marble horizon was then estimated to be at least 60 m, and was followed along strike for at least 1 km. The marble is slightly banded, medium-grained and white-yellow to greyish-green, strikes 230–240 degrees and dips 40–60 degrees. The marble is situated at the same stratigraphic level as the marble associated with the iron ores in the Kaunisvaara ore field (Shaikh et al. 1989). Detailed microscopic work on samples from the Aareajoki area shows that the marble is an impure dolomitic type with a relatively high content of quartz, amphibole and muscovite in addition to calcite and dolomite (Shaikh et al. 1989).

Tapulivuoma	ORED04679	
Dolomite (drilling)	E 855555	N 7501174

Although the Tapulivuoma dolomite is not exposed in outcrop, it was found and investigated during the iron ore inventory in Norrbotten in the 1960s (fig. 67). The marble horizon is at least a hundred metres wide, dipping to the west, and situated in the footwall position below the Kaunisvaara iron ores (Shaikh et al. 1989). The dolomite is relatively pure, with approximately 5 vol.% of accessory minerals such as quartz, biotite, apatite, amphibole, pyroxene and muscovite. The dolomite content varies between 50–90%, according to the mineralogical analyses of drill core samples (Shaikh et al. 1989). The Tapulivuoma marble prospect has not been worked.

Roskajoki	ORED04680	
Dolomite (drilling)	E 837860	N 7498707

Along with the drilling for copper at Roskajoki, described earlier in this report (fig. 79), a 90-metre-thick section of dolomite belonging to the Käymäjärvi group was penetrated. The dolomite was analysed and investigated microscopically, and was found to be relatively pure, consisting of up to 96% dolomite (Shaikh et al. 1989). The dolomite is not exposed in outcrop.

Isonkivenmaa	ORED00499	
Dolomite (outcrop)	E 842346	N 7492509

The outcrops of dolomitic marble at Isonkivenmaa, 5 km south-southeast of Käymäjärvi, were investigated by SGU in 1985 (fig. 79; Shaikh et al. 1989). The dolomite is medium-grained, light grey, with small amounts of tremolite, pyrrhotite and chalcopyrite. Mineralogical analyses show a dolomite content of 90–96%. The prospect has not been worked.

Jupukka-marble	ORED04681	
Marble (outcrop)	E 854273	N 7486515

On the northern slope of Jupukka, 9 km northwest of Pajala (fig. 67), a marble horizon 1 km long and 100 m wide was identified and investigated in detail by SGU in 1985 (Shaikh et al. 1989). Chemical and mineralogical analyses show that the marble is an impure calcitic dolomite, with a high content of silicates such as plagioclase, mica and quartz. The prospect was not visited during the present inventory.

Graphite

Annaniva	ORED15767	TOB140037
Graphite, Cu, (outcrop)	E 872861	N 7506607

Small amounts of chalcopyrite, graphite and pyrite are noted in metagreywacke in an outcrop by the banks of the Muonio River, 3.5 km east of Huuki (fig. 67). Chemical analyses of sample from the outcrop, performed by LKAB (Hansson 1984), showed an average of 0.4% Cu and 5% C.

Kalliomaa	ORED15766	
Graphite, Cu, Au (drilling)	E 869561	N 7501613

LKAB Prospektering AB performed drilling on a Cu-Au graphite-bearing rock sequence belonging to the Greenstone group at Kalliomaa, 5.2 km south of Huuki (fig. 67; Hansson & Martinsson 1986). Three drill cores (N-KAL 1-3) show a complex sequence of rock types, including basaltic tuffs, metasediments, marble and intrusive rocks. The most promising results were obtained in drill hole N-KAL 3, cutting a graphite-bearing schist intercalated in a mafic metatuffite. The C content is up to 40%, and averages 36% over a 6-metre section (Hansson & Martinsson 1986). In drill holes N-KAL 1 and 2, the C content is only up to 5%. However, anomalous amounts of Cu and Au were detected, with up to 0.18% Cu (N-KAL 1) and 0.2 ppm Au in a graphite schist section in drill hole N-KAL 2, (Hansson & Martinsson 1986).

Muotkapalo	ORED15761	
Graphite (drilling)	E 863928	N 7499540

Six exploratory drillings were performed in 1985 by LKAB to investigate a positive magnetic anomaly west and southwest of Muotkapalo, a small hill (fig. 67), 8.5 km west of Kolari, (Hansson & Martinsson 1986). The most promising result was obtained in drill hole 2,300 m northwest of the Hanhijänkkä bog (coordinates above), in which a greenstone sequence with graphite schist was penetrated to a depth of 85 m. The graphite-bearing section totals 5 m, and chemical analyses showed a carbon content of up to 20%.

Liviövaara graphite	ORED 15752	
Graphite, Cu, Ni, Au (drilling)	E 852993	N 7477477

The first find in the Liviövaara area, 7 km west-southwest of Pajala (fig. 67), was discovered in 1985 by LKAB. Four drill holes (N-LIV01-04), totalling 602 m, were drilled on geophysical anomalies in 1986. The most promising result was obtained in a 4.6-metre core section with graphite schist containing up to 40% C (Hansson 1986b). Drill core sections with anomalous Cu-Au values occur in altered metarhyolites and metasedimentary rocks, in marble, and in intrusive rocks (Hansson 1986b).

Sarvisto (Kaunisjoki)	ORED15759	
Graphite (drilling)	E 862110	N 7496617

Two exploratory drillings were carried out in 1984 by LKAB Prospektering at Sarvisto, 5 km east of Kaunisvaara (fig. 67; Hansson et al. 1984a). A total of 175 m was drilled, and mafic metavolcanites and metasediments, with occasional high content of pyrrhotite and graphite, were penetrated. The richest part was found in drill core N-SAR-2, comprising a 9-metre section with an average of 30% carbon (Hansson et al. 1984a).

Lehtosölkä 1, 2	ORED15746, ORED25975	
Graphite, Cu, Co, Au, Zn, Pb (drilling)	E 851599, 852476	N 7463781, 7464291

Graphite-bearing schists were identified by LKAB Prospektering in 1986 by drilling at Lehtosölkä, 22 km east-southeast of Tärendö (5 holes totalling 329.8 m, Hansson 1986b). A ground magnetic and slingram survey were carried out, and two relatively short electrical conductors were detected (Hansson 1986a, Gerdin et al. 1991). The graphite mineralisation consists of three bodies; two occur in the southwestern part (Lehtosölkä 1) and one about 1 km to the northeast (Lehtosölkä 2). The total tonnage for the Lehtosölkä graphite mineralisations was estimated at roughly 1.5 million tonnes, with a carbon content varying between 7.8–13.8%. The grain size of graphite is bimodal, mainly about 0.1 mm and 0.3–0.4 mm. About 20% of the graphite grains are larger than 0.4 mm (Gerdin et al. 1991). Weak copper sulphide dissemination occurs in the drilled sections, with irregular zones rich in pyrrhotite. Varying anomalous gold concentrations (<0.2 ppm) are also associated with the sulphides. The best section contains 0.35% Cu and 0.23 ppm Au over 4.9 m (Lehtosölkä 1). A zinc- and lead-rich horizon was noted in one of the drill cores, with 2% Zn and 1% Pb over 2.1 m (N-LEH3, Hansson 1986b).

Two drill holes are located approximately 1 km to the northeast (Lehtosölkä 2). One of these (N-LEH-4) has a 0.9-metre core section, with 0.95% Cu and 0.11% Co hosted in paragneiss at the contact with a granite (Hansson 1986b).

Sillimanite

Alanen Airivaara	ORED00426	
Sillimanite (outcrop)	E 870390	N 7501275

An outcrop area of sillimanite-bearing metasedimentary rock, 1.5 × 0.5 km wide, and containing up to 5% sillimanite, occurs at Alanen Airivaara, 5.6 km south-southeast of Huuki (fig. 67, Shaikh et al. 1986). The metasediment is banded and the sillimanite occurs in centimetre-sized quartz-muscovite-porphyroblasts in biotite-schist layers. The outcrops were not visited during this inventory, and the coordinates given are approximate.

Kirnujärvi	ORED00413	
Sillimanite (outcrop)	E 853026	N 7459185

Outcrops with sillimanite-bearing biotite-rich gneiss occur on the western side of Männikö hill, 2.2 km north of Kirnujärvi and 22 km south-southwest of Pajala (fig. 67). The prospect was investigated by SGU in 1986 and sillimanite-bearing outcrops were found in a zone 1 km long and 100–200 m wide (Shaikh et al. 1986). The sillimanite occurs sporadically in layers 10–20 cm wide within the gneiss. The sillimanite-bearing outcrops were sampled and analysed by XRD, and an average content of 6% sillimanite was found (Shaikh et al. 1986). Sillimanite-bearing outcrops were also found on the hills Karhulehto and Kaljuniemi, 4 km to the northeast, during bedrock mapping performed by SGU in 1995 (Bergman et al. 2001).

Mg silicates

Saalovuoma	ORED15745	
Mg silicate (outcrop)	E 846586	N 7486746

LKAB expended a great deal of effort in the mid-1980s to find Mg-rich rocks for use in production of iron pellets (Martinsson 1986). One of the prospects, the Saalovuoma gabbro, 12 km west-northwest of Pajala, was sampled from outcrops, and analyses showed, among other things, an olivine-rich gabbro with up to 25% MgO (Martinsson 1986). The Saalovuoma prospect has not been worked or further investigated.

Rytivaara (Pahtasenvaara)	ORED00846	
Mg silicate (outcrop)	E 860020	N 7482530

Outcrops of ultrabasite are observed at Pahtasenvaara, 2.5 km north of Pajala. The outcrops were sampled and analysed by LKAB during an exploration campaign searching for Mg-rich rocks for use in production of iron pellets (Martinsson 1986). Chemical analysis of the rock showed an Mg content of 30%.

Aggregate and rock quarries

Laata	ORED25521	SGL140036, TOB140038
Granite (dimension stone)	E 865472	N 7497064

On the eastern slope of Laata hill, 8 km east of Kaunisvaara (fig. 67), is a backfilled abandoned quarry, approximately 40 × 30 m wide and 1–2 m deep. Judging from small outcrops and the boulders of waste rock in the pit, a fine-grained, whitish-grey alkali feldspar-granite has been quarried. The quarry was active in 1996, operated by BD Stenindustri AB (owner Heikki Markkula). The rock was processed into paving stone and was used for purposes such as the paving around the sundial monument in central Pajala (Markkula, personal communication 2015).

Plootuvaara (Pajala 14:1)	ORED25512	TOB140014
Migmatite (active aggregate quarry)	E 864164	N 7480419

On the western side of Plootuvaara, about 4 km east of Pajala town centre (fig. 67), is a working quarry, where fine-grained, light red, migmatitic arkose has been quarried since 1997. The quarry is operated by Snell Entreprenad AB, and in summer 2014 the size of the pit was approximately 180 × 100 m, with a total bench height of 20–25 m (fig. 84).

Pajala 24:1	ORED25513	
Metagreywacke/granite (aggregate quarry)	E 857858	N 7481227

There is an abandoned aggregate quarry 3 km west of Pajala town centre (fig. 67). The quarry was operated by Snells Entreprenad during 2007–2009. The predominant rock type quarried was a fairly biotite-rich metagreywacke. Feldspar and granite predominate in some parts, however. The quarry is bow-shaped, with two excavation fronts. Each limb is approximately 100 m long, 25 m wide and excavated to a depth of 15 m.

Figure 84A. The Plootuvaara quarry in summer 2014. Photo: Torbjörn Bergman.

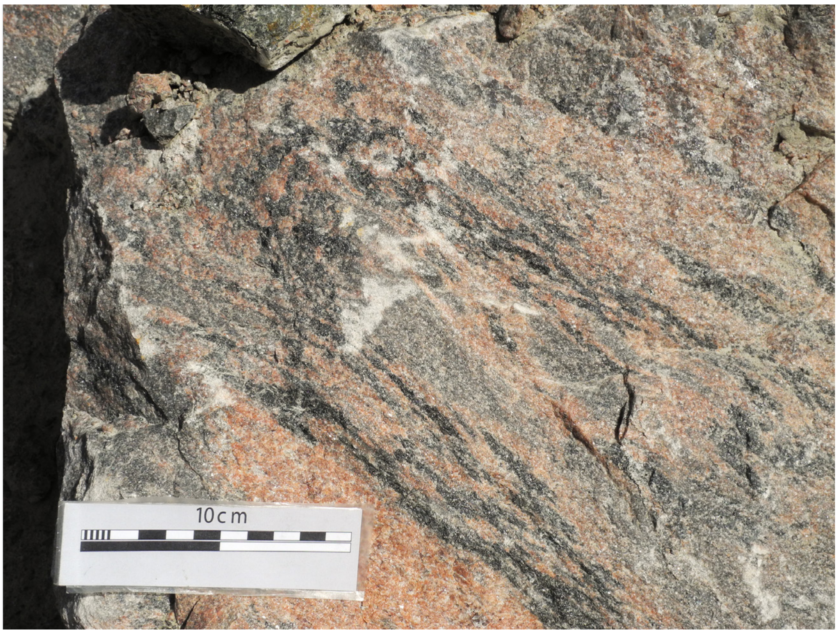

Figure 84B. Close-up of the quarried migmatitic granite/ migmatitic meta-arkose. Photo: Torbjörn Bergman.

Kursunpalo	ORED 25506	TOB14003
Schist (abandoned quarry)	E 851250	N 7477974

There is an abandoned schist quarry (fig. 85) southwest of Liviövaara, 4 km southwest of Erkheikki (fig. 67). The schist has developed in a shear zone forming part of the major "Pajala shear zone" (Luth et al. 2018). The schist is grey, formed by ductile deformation of metagreywacke, and is rich in both muscovite and biotite. The quarry is 40 m long, 4 m wide, with a maximum depth of 4 metres. According to local resident K V Palo at Kursunpalo, the rock has been used locally, mainly as paving stones and in stone fireplaces, and also as garden paving. The quarry was probably already in use in the 17th century, and was last active in the 1980s.

Figure 85. The Kursunpalo schist quarry in summer 2014, looking north. Photo: Torbjörn Bergman.

Kuusivaara	ORED25511	TOB140013
Quartzite (aggregate)	E 839738	N 7468242

On the southern slope of Kuusivaara, 9.4 km east of Tärendö, there is a small aggregate quarry in fine-grained, quartzo-feldspathic supracrustal rock, classified on the local bedrock map as a quartzite (Padget 1977). The quarry is 50 × 30 m wide and in summer 2014 had a front wall 5 m high. The quarry is owned by Sveaskog, and is currently operated by Bertil Oja Entreprenad AB in Pajala. Quartz veins with lumps of pyrite also occur in the eastern part of the quarry. Chemical analysis of pyrite-rich quartz samples during the present inventory did not show any elevated levels of base metals or precious metals (less than 0.05 ppm Au, Appendix 2).

The Ullatti–Hakkas area

The Ullatti–Hakkas area predominantly consists of Palaeoproterozoic intrusive rocks, mainly Early Svecokarelian metagranite and subordinate metasyenitoids and metagabbro belonging to the 1.88–1.86 Ga Perthite monzonite, and the Late Svecokarelian granite-pegmatite belonging to the 1.83–1.76 Ga Lina suite (figs. 86–87, Padget 1970, Witschard 1996, Hellström et al. 2012, Claeson & Antal Lundin 2012). Svecofennian 1.96–1.87 Ga supracrustals occur in the westernmost part. These are mainly metavolcanic rocks, but also metagreywackes and paragneiss. Only a few mineral and bedrock occurrences are known from the area, and comprise quartzite at Rissavaara in the north, two minor sulphide mineral occurrences in the west, a granite quarry in the east, and quartz and copper-gold occurrences in the south. Till geochemistry shows some scattered, small gold anomalies, and there are some weak copper anomalies (figs. 88–89). Very little exploration work has been carried out in the area, however. North Atlantic Natural Resources has done some exploration in the Hakkas–Hammanen area, in the far southwest of the study area (Solberget nr. 101, 1001, expired 27 May 2000), including magnetic and electromagnetic measurements, till geochemical sampling and lithogeochemistry. Core drilling at two localities (Arrojoki East & Arrojoki North) did not identify any significant mineralisations.

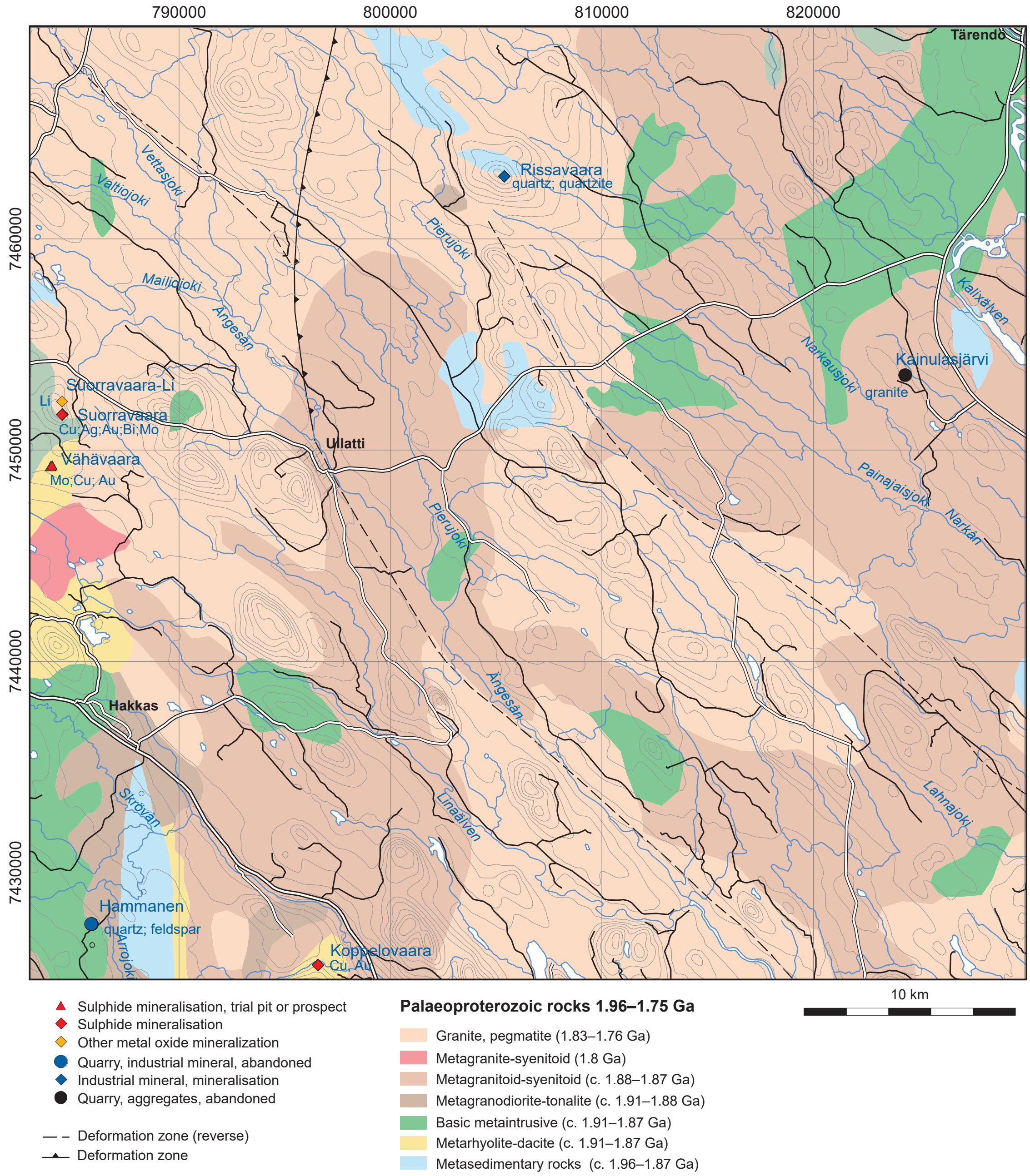

Figure 86. Bedrock geology map of the Ullatti–Hakkas area (modified from the SGU 1:1 million bedrock map database).

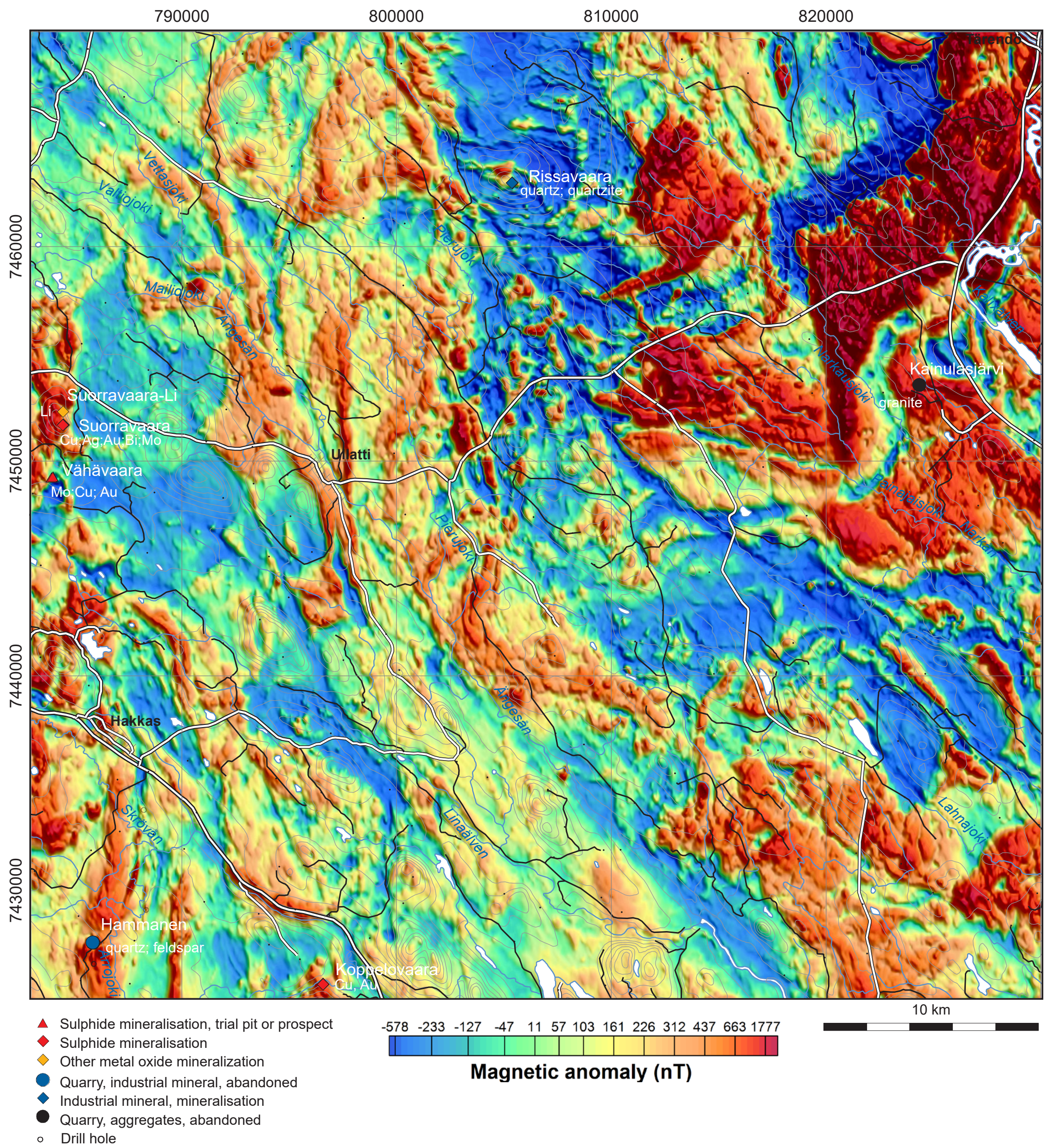

Figure 87. Magnetic anomaly map of the Ullatti–Hakkas area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU).

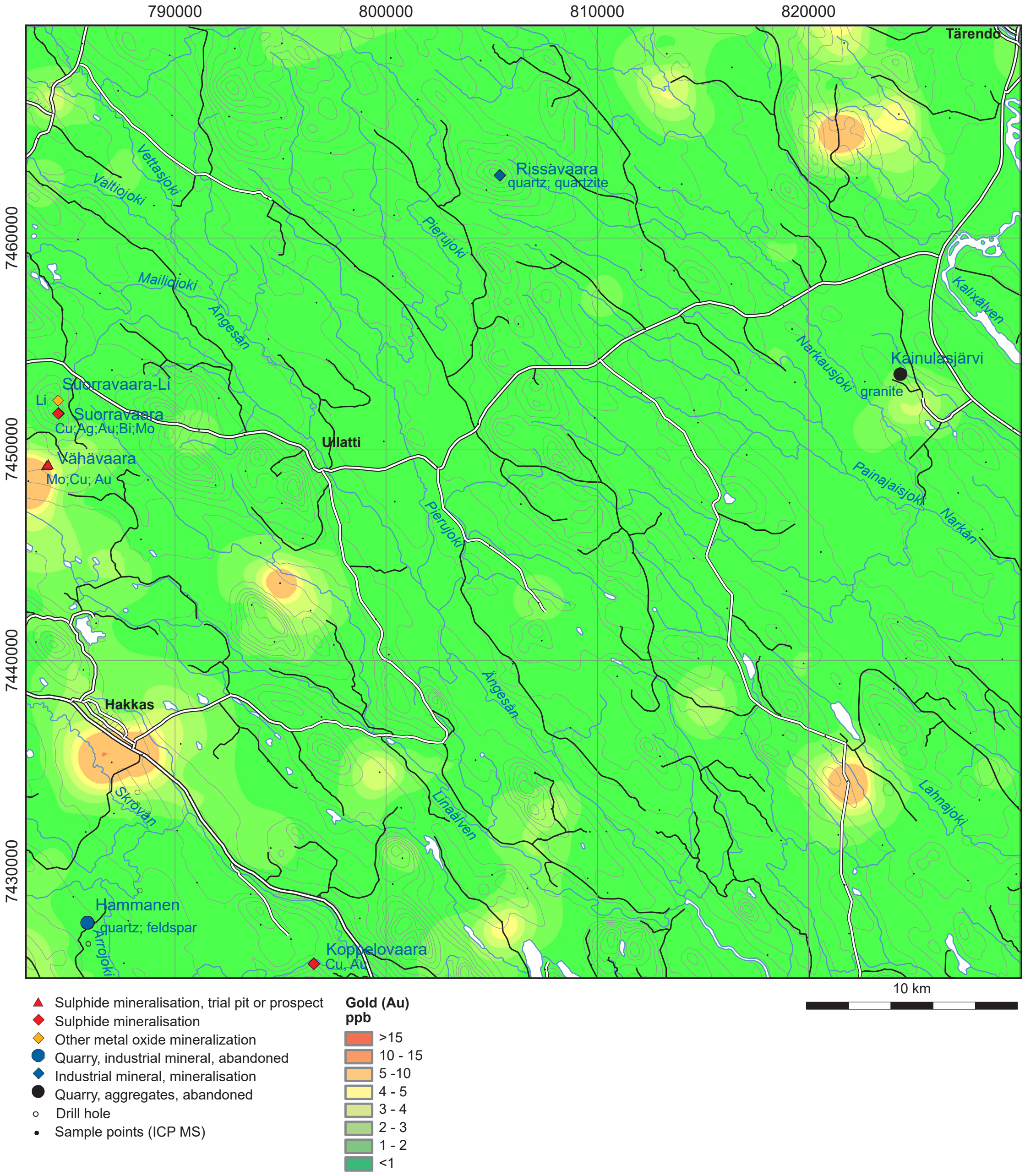

Figure 88. Gold concentrations in till (acid leach, ICP-MS data) for the Ullatti–Hakkas area.

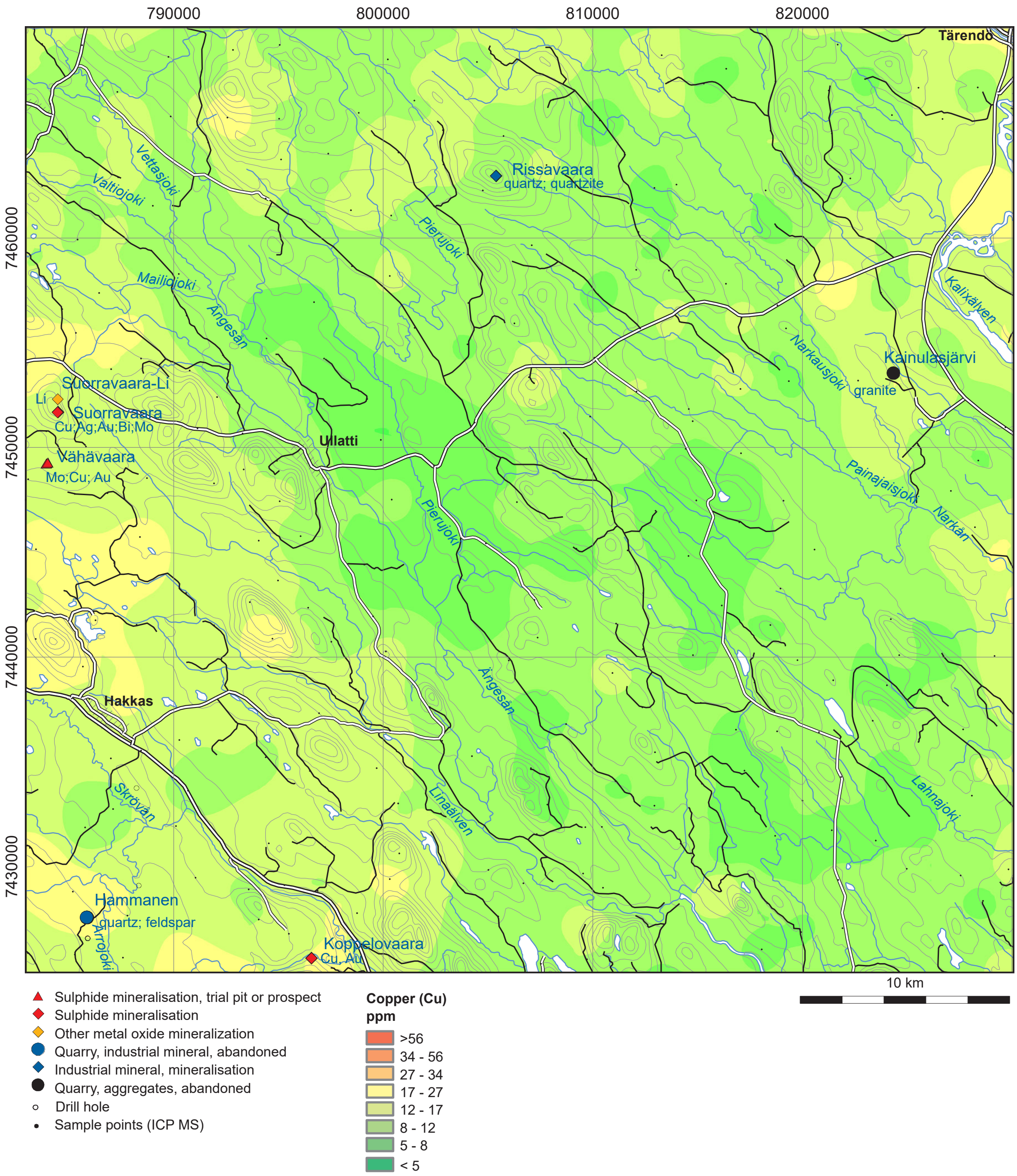

Figure 89. Copper concentrations in till (acid leach, ICP-MS data) for the Ullatti–Hakkas area.

Sulphide/gold mineralisations

Suorravaara	ORED00343	TOB150033
Cu (outcrop)	E 784467	N 7451692

The Suorravaara copper prospect is situated 12 km west-northwest of Ullatti on the southeastern slope of Suorravaara hill. Most of the outcrops on Suorravaara consist of pegmatite, but a few outcrops of fine-grained, grey, intermediate metavolcanic rock or volcanic sandstone, are exposed on the southeastern slopes of the hill at the given coordinate. Malachite and azurite occur on fractures as secondary minerals, formed after fine-grained disseminations of bornite and, most likely, chalcocite (fig. 90). Chemical analysis of selected samples from the outcrop taken during the present inventory showed a copper content of 0.1% Cu (Appendix 2). Older analyses presented in Carlson (1982b) reported grades varying between 0.24–1.84% Cu. According to Gustavsson (1984), there are also a few small but rich Cu-Mo-U mineralisations in pegmatites at the top of the hill.

Phelps Dodge Exploration Sweden AB has made a profile of soil geochemical sampling at Suorravaara (exploration permit Suorravaara no 1, 4 km^2, expired 29 April 2007; data supplied to SGU). Talga Resources Ltd (11 October 2018) reported assay results from two rock chip samples from the copper mineralisation described as hosted in a quartz-biotite gneissic directly underneath an overlying flat pegmatite sheet. The richest sample (A24345) returned assay results of 0.57% Cu, 0.38 ppm Au and 12.25 ppm Ag.

Suorravaara Li	ORED25978	
Li (outcrop)	E 784304	N 7451964

Lithium minerals in pegmatite have been noted at six localities in the northeastern part of Suorravaara hill, where large areas of pegmatite and graphitic granite occur. Lepidolite, red and green tourmaline, as well as brown and black tourmaline, together with clevelandite, rose quartz, and light green microcline have been noted (Ödman 1957, Dahlman 1971b, Augsten 2008). The localities were not visited during this inventory, and the coordinates given are those according to Per and Christina Nysten, who visited one of the outcrops in summer 2018 (personal communication, Per Nysten 2018). Talga Resources Ltd (11 October 2018) reported assay results from 13 grab rock samples of the outcropping, flat-lying pegmatite at Suorravaara, with peak assay returns of 1150 ppm Li, 350 ppm Cs, 48 ppm Ta and 790 ppm Rb (Samples A24344; 784298/7451925). Two other samples (A24372, A24373) from the same locality, returned anomalous tantalum and lithium grades (>100 ppm and 84.4 ppm Ta respectively 412 ppm and 470 ppm Li; 784295/7451921).

Vähävaara	ORED00255	TOB150034, ABD060129
Mo, Cu, (Au) (closed mine)	E 783931	N 7449246

In the central area of Kantinkultavaara, a small hill 12 km west of Ullatti, a pegmatite dyke was mined for molybdenum for a short period during World War I (Näslund et al. 1963). The pegmatite was mined in small pits along its 100-metre length across the hill. At the given coordinates, there is a partly backfilled pit, 5 × 5 m wide and 4 m deep (fig. 91A). The pegmatite is a few metres wide, strikes towards the northeast, and cross-cuts a mafic metavolcanite (amphibolite). Judging from the waste material, the mineralisation is mainly hosted by the pegmatite, and consists of molybdenite, bornite and chalcocite. Malachite and

Figure 90. Fine-grained intermediate metavolcanic rock at Suorravaara with visible malachite. Photo: Torbjörn Bergman.

azurite are also common (fig. 91B). Small amounts of copper minerals are also noted in the amphibolitic wall rock in the pit. The mineralisation was known in 1922, and is described by Geijer (1924). Chemical analysis of a sample taken from the dump in the present inventory show grades of 1.2% Mo, 3.1% Cu, 1.4 ppm Au, 7.5 ppm Te and >250 ppm Bi (Appendix 2).

There is an additional pit on the northeastern side of the hill (ORED25655). The pit is 5 m wide, 20 m long and 1–3 m deep. As in the other pit, a molybdenite and bornite-bearing pegmatite has been mined. Tourmaline and magnetite are also noted in small amounts in the pegmatite.

Phelps Dodge Exploration Sweden AB collected profiles for soil geochemical sampling at Vähävaara in 2005 (exploration permit Vahavaara no 1, 4.3 km^2, expired 8 May 2006; geochemical data supplied to SGU).

Talga Resources Ltd (11 October 2018) reported assay results from six rock chip samples collected from outcrop across the copper prospect. Four of the samples returned 2.2–4.8% Cu, 0.3–0.6% Mo, 0.7–1.2 ppm Au, 42–66 ppm Ag, 6.0–9.3 ppm Te and 253–462 ppm Bi.

Koppelovaara	ORED21724	SSG060097
Cu, Au (outcrop)	E 796571	N 7425632

In blasted outcrops along a gravel road at Koppelovaara, 15 km southeast of Hakkas, there are centimetre-wide veins of quartz and magnetite with small amounts of bornite occurring in a metadacite (fig. 92). An analysis shows weakly elevated content of copper and precious metals, 0.15% Cu, 0.28 ppm Au and 1.6 ppm Ag (Hellström et al. 2012). Dozens of sulphide-rich boulders are found further south along the road (796469/ 7424903). However, chemical analysis of a sample from one of the boulders showed only low base metal concentrations. The Koppelovaara metadacite is part of a metavolcanic sequence of acid–intermediate composition. These rocks generally have high magnetic susceptibility and, judging from the magnetic anomaly map, can be interpreted to be fairly extensive, forming a large-scale, antiform fold structure. If this interpretation is correct, the metavolcanic rocks are in contact with metapelitic rocks to the west, a contact zone which could be a prospective area for sulphide mineralisations.

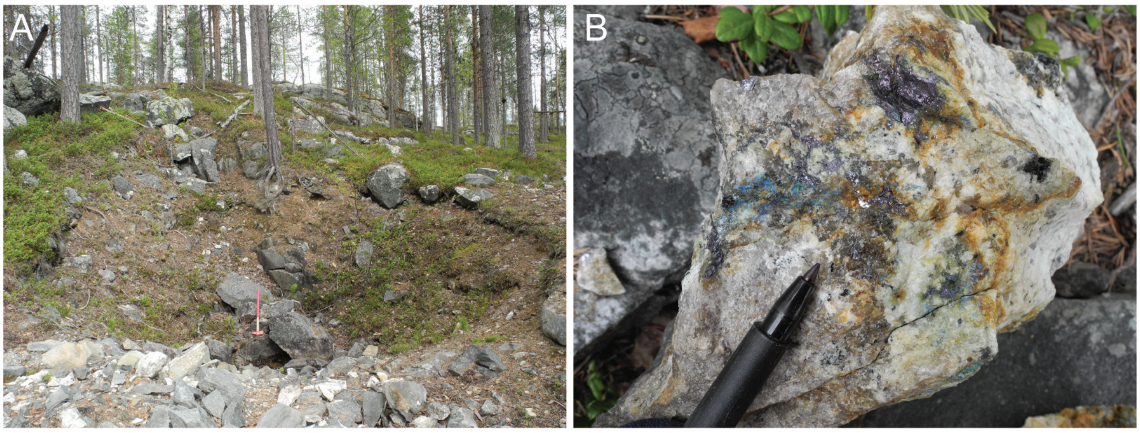

Figure 91. A. The southwestern pit of Vähävaara at Kantinkultavaara. **B.** Hand specimen of molybdenite-bornite-bearing pegmatite from the dump. Photo: Torbjörn Bergman.

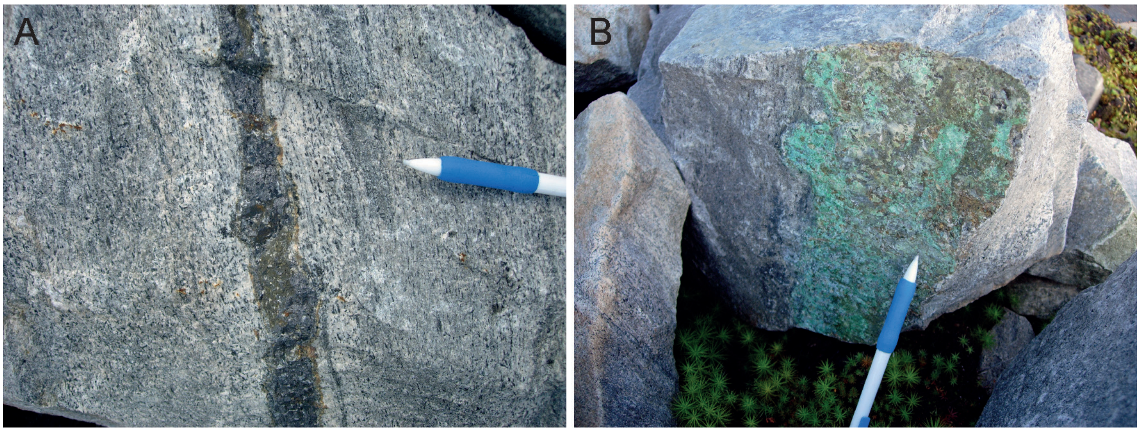

Figure 92. A. Veins of magnetite and quartz, and with traces of bornite in metadacite at Koppelovaara. **B.** Secondary copper sulphide mineral, malachite, is seen in blasted rock boulders from the road cuts at Koppelovaara. Photo: Fredrik Hellström.

Industrial minerals

Rissavaara	ORED15730	
Quartzite/Quartz (outcrop)	E 805382	N 7462980

The Rissavaara quartz prospect is situated 25 km west-southwest of Tärendö on the hills Stora and Lilla Rissavaara, and consists of quartzite intercalations in a metasedimentary rock sequence enclave in the Lina granite (1.8 Ga). The quartzite was investigated by SGU by trenching and sampling in 1965–1966, and in 1976 (Shaikh 1967, Persson 1978). The purity of the quartzite is highly variable, and the quartzite layers occur along with quartz and mica-rich metasediments. Analysis of selected samples of quartzite from the trenches showed a SiO_2 content of 95–97% (Persson 1978). The Rissavaara deposit was assessed as uneconomic and no further exploration was recommended at that time (Persson 1978).

Hammanen	ORED20261	FHM060092
Pegmatite (quarry)	E 785853	N 7427583

At Hammanen, some 10 km south of Hakkas, there is a pegmatite dyke 100 m long and 20 m wide cross-cutting gabbro (Lundmark 1987, Lundmark et al. 1988, Westfal 1988, Holmqvist et al. 1989, 1990, Sabelfeld 2004). Ground magnetic measurements were carried out to locate the pegmatite which, in contrast to the surrounding gabbro, is non-magnetic (Lundmark et al. 1988). Four diamond drill cores were drilled to investigate the shape of the zoned pegmatite body, which has a core of pure K-feldspar (fig. 93; Lundmark 1987). The feldspar body was divided into an area of 385 m^2 with pure K-feldspar and an area of 115 m^2 with some quartz and tourmaline contamination. The K-feldspar resources were estimated at 3,000–4,000 tonnes (Lundmark 1987). Additionally, in 1988 trenching east of the quarry exposed 18 m of pure quartz along the trench (Holmqvist et al. 1989). The zoned pegmatite has been mined in a quarry approximately 40 × 15–20 m across, orientated in a west-northwest direction (figs. 93, 94). According to Sabelfeld et al. (2004), 1,000 tonnes of K-feldspar and 600 tonnes of quartz have been mined, and the resources are estimated at 75,800 tonnes of K-feldspar and 45,500 tonnes of quartz. Rose quartz was noted in the waste rock east of the quarry.

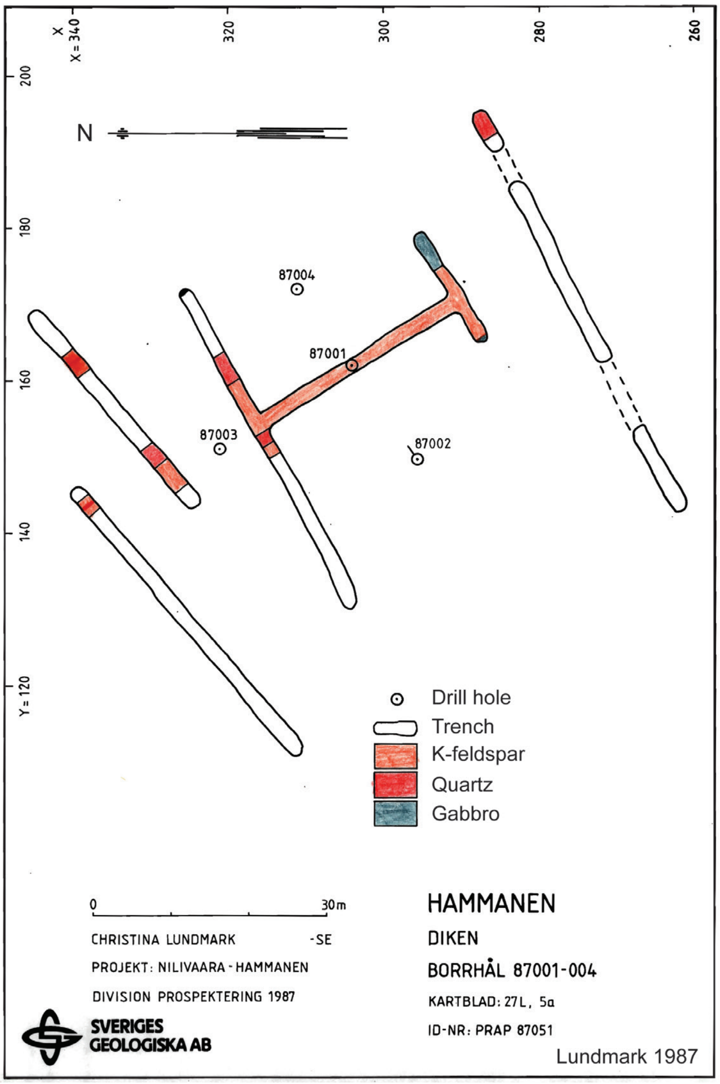

Figure 93. Sketch of exploration trenches and location of drill holes at the Hammanen pegmatite (from Lundmark 1987).

Figure 94A. The Hammanen pegmatite quarry in 2006. Photo: Fredrik Hellström.

Figure 94B. Coarse-grained pegmatite with K-feldspar, quartz and biotite. Photo: Fredrik Hellström.

Aggregate quarry

Kainulasjärvi	ORED25528	TOB140050
Granite (abandoned aggregate quarries)	E 824352	N 7453552

Kainulasjärvi comprises two abandoned aggregate quarries, situated 2 km northwest of Kainulasjärvi, south of Tärendö. Swerock AB quarried coarse-grained, porphyritic granite from 2004 to 2008. The granite was excavated in two quarries 50 m apart, the larger being 60 × 60 m and the smaller 30 × 20 m. Both quarries have a depth of approximately 15 m.

The Narken–Korpilombolo area

The bedrock geology of the Narken–Korpilombolo area has been described by Jonsson & Kero (2013) and predominantly comprises Early Svecokarelian 1.91–1.88 Ga meta-intrusive rocks of the Haparanda and Perthite monzonite suite, as well as Late Svecokarelian 1.83–1.76 Ga granite-pegmatite of the Lina suite (fig. 95). Mafic meta-intrusive rocks of the Tärendö gabbro complex are noted as a large positive Bouguer anomaly in the northwest of the area (fig. 5). The eastern part of the area constitutes part of the Pajala deformation belt (Luth et al. 2018), and is dominated by strongly deformed, amphibolite facies, sedimentary gneisses of uncertain age (Karelian or Svecofennian). The magnetic anomaly map shows a banded pattern trending north–south, revealing the structural grain of the bedrock (fig. 96). Metasedimentary rocks also occur west of the Pajala deformation belt, where fuchsite-bearing meta-arenites in part form a core of an antiformal, domal structure overlain in the east by biotite-rich, andalusite-bearing Svecofennian (?) metasedimentary rocks with interlayers of intermediate metavolcanic rocks (Hellström et al. 2012, Jonsson & Kero 2013). Strongly negative $\varepsilon_{Nd1.9\ Ga}$ (-10) of the fuchsite-bearing meta-arenite suggests they mainly consist of Archaean material (Lahtinen et al. 2015).

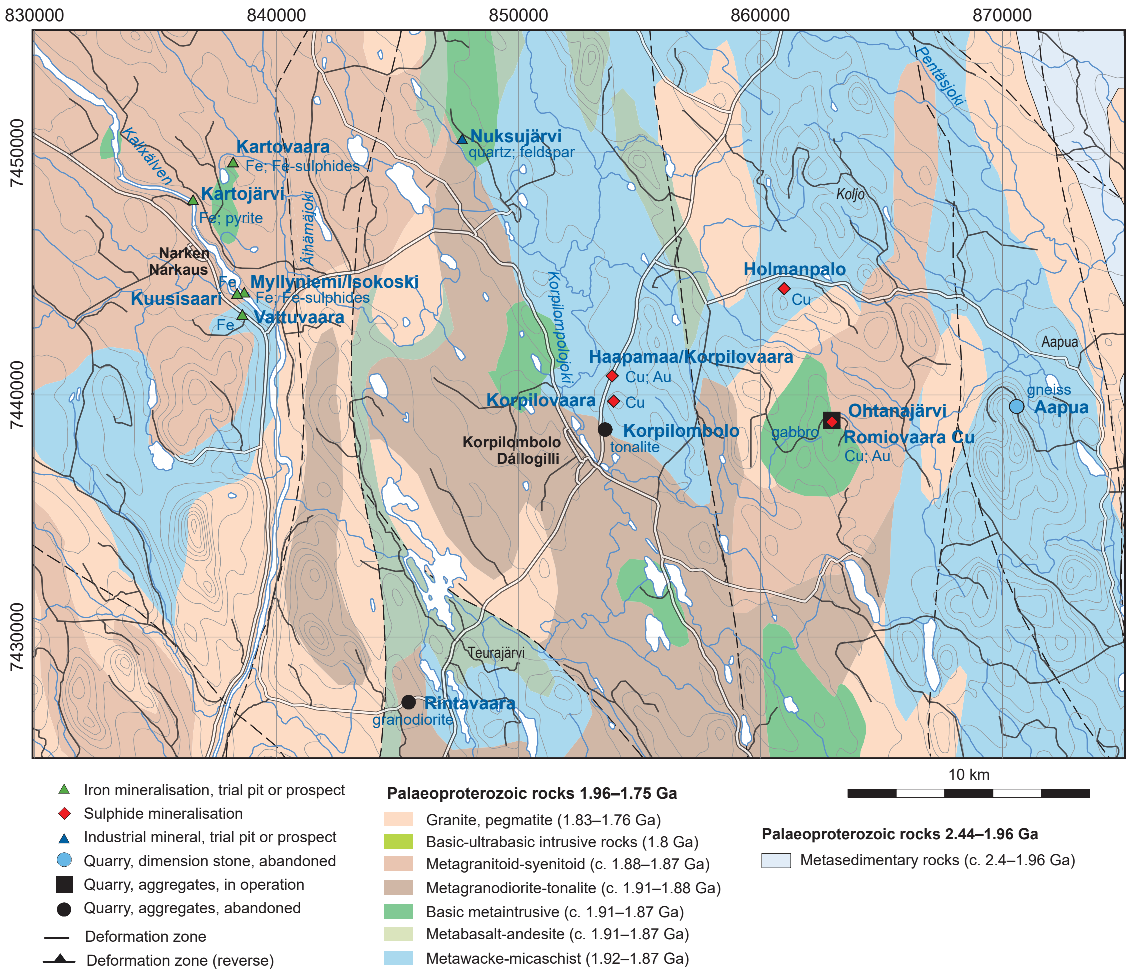

Figure 95. Bedrock geology map of the Narken–Korpilombolo area (modified from the SGU 1:1 million bedrock map database).

The known mineralisations in the area consist of minor vein-type Cu-Au-(Pd) mineralisations in the Korpilombolo area, and minor iron-magnetite-hematite breccia-style mineralisation in the Narken area. Till geochemical data show large areas with elevated copper concentrations (fig. 97). There are also a few small and weak gold anomalies (fig. 98).

Iron mineralisations

The Narken area

Several small apatite-rich iron mineralisations occur in the Narken area, 15 km northwest of Korpilombolo (fig. 95). The mineralisations are generally of a "breccia infilling" character in strongly hydrothermally-altered metasedimentary rocks and are all small, varying from a few square metres to 200 m^2 in exposed outcrop. The iron oxide mineralisations are enriched in REE and contain up to 0.5% Cu, but are low in Au (Martinsson 2009). None of the mineralisations has so far been proved to be of any economic significance. The largest is the Vaatuvaara occurrence, 1.5 km southeast of Narken village (fig. 95). The mineralisations in the Narken area

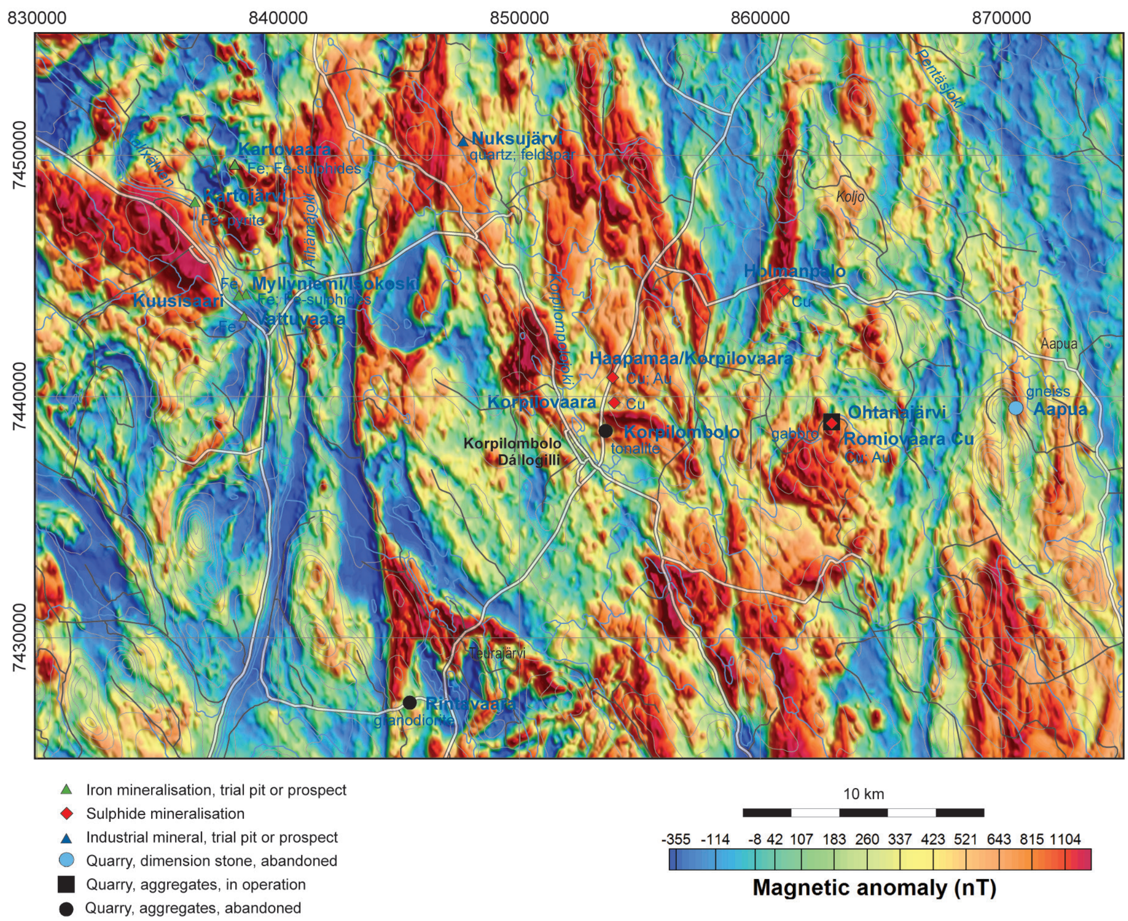

Figure 96. Magnetic anomaly map of the Narken–Korpilombolo area (SGU data). The magnetic data were gridded by Johan Jönberger (SGU).

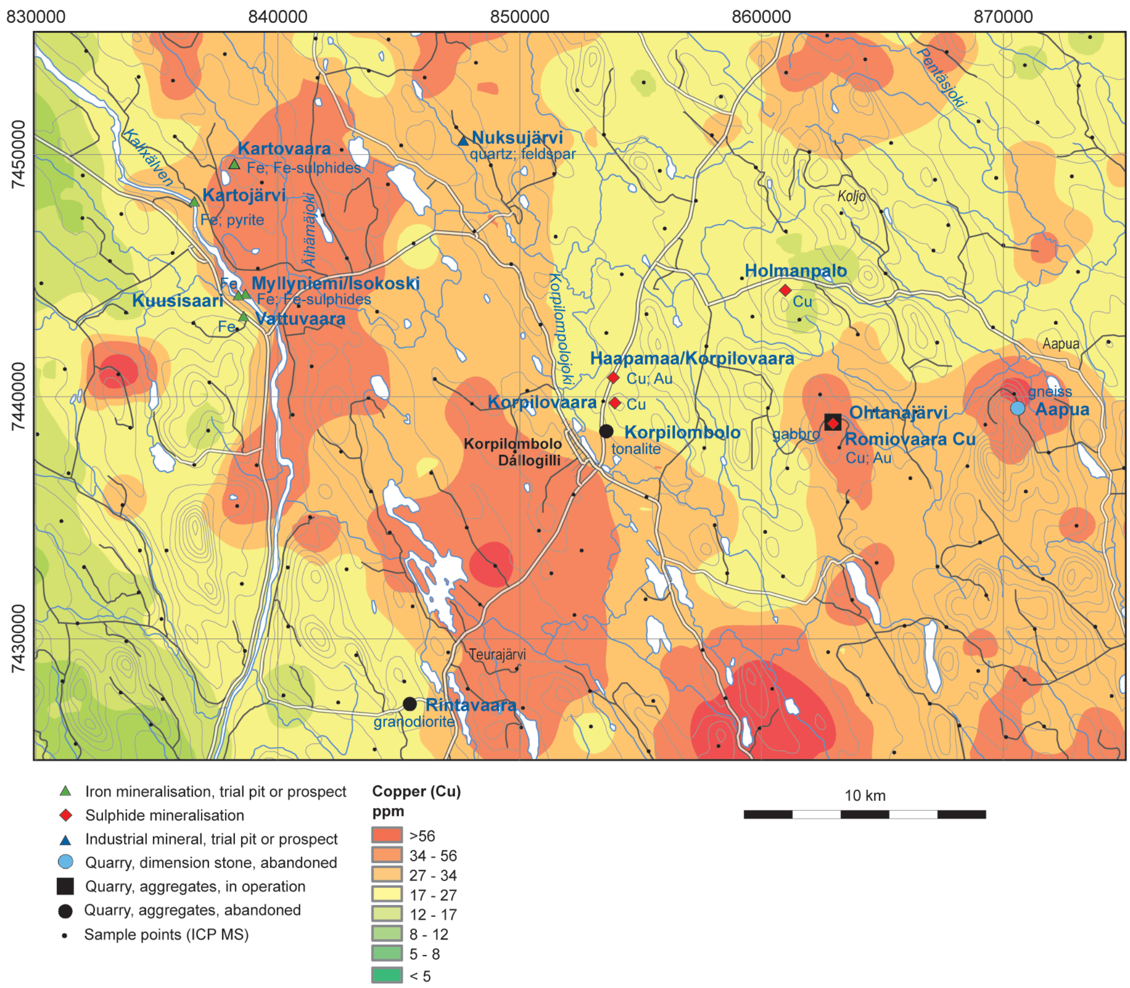

Figure 97. Copper concentrations in till (acid leach, SGU ICP-MS data) for the Narken–Korpilombolo area.

were discovered in 1946 during regional geological mapping of Norrbotten county by SGU (Ödman 1957). The area was remapped in 1970, and the mineralisations have been described by Frietsch (1972) and Martinsson (2009). Frietsch (1972) concluded that the mineralisations are of late origin, formed by the action of metasomatic solutions in a tectonic zone. A syngenetic, sedimentary origin is excluded. Martinsson (2009) suggested that the Narken deposits are transitional in character, between apatite iron ores and IOCG-style mineralisation.

Rio Tinto Mining and Exploration Limited has carried out some exploration work in the Narken area (exploration permits Narken nos 1 & 2, Vattuvaara no 1, expired 27 July 2000), including gravity and IP measurements, and some whole lithochemistry of boulders and outcrops (data supplied to SGU).

Some of the mineralised outcrops in the Narken area were visited during the present inventory, and a short summary is presented below for each of the mineralisations, from north to south.

Kartovaara	ORED00351	TOB140019, KES070143
Fe, Cu, pyrite, REE (trial pit)	E 838210	N 7449628

A small excavation on a hematite-magnetite-pyrite-bearing calc-silicate rock is found on the northwestern side of Kartovaara hill, 4.5 km north-northeast of Narken village (fig. 95).

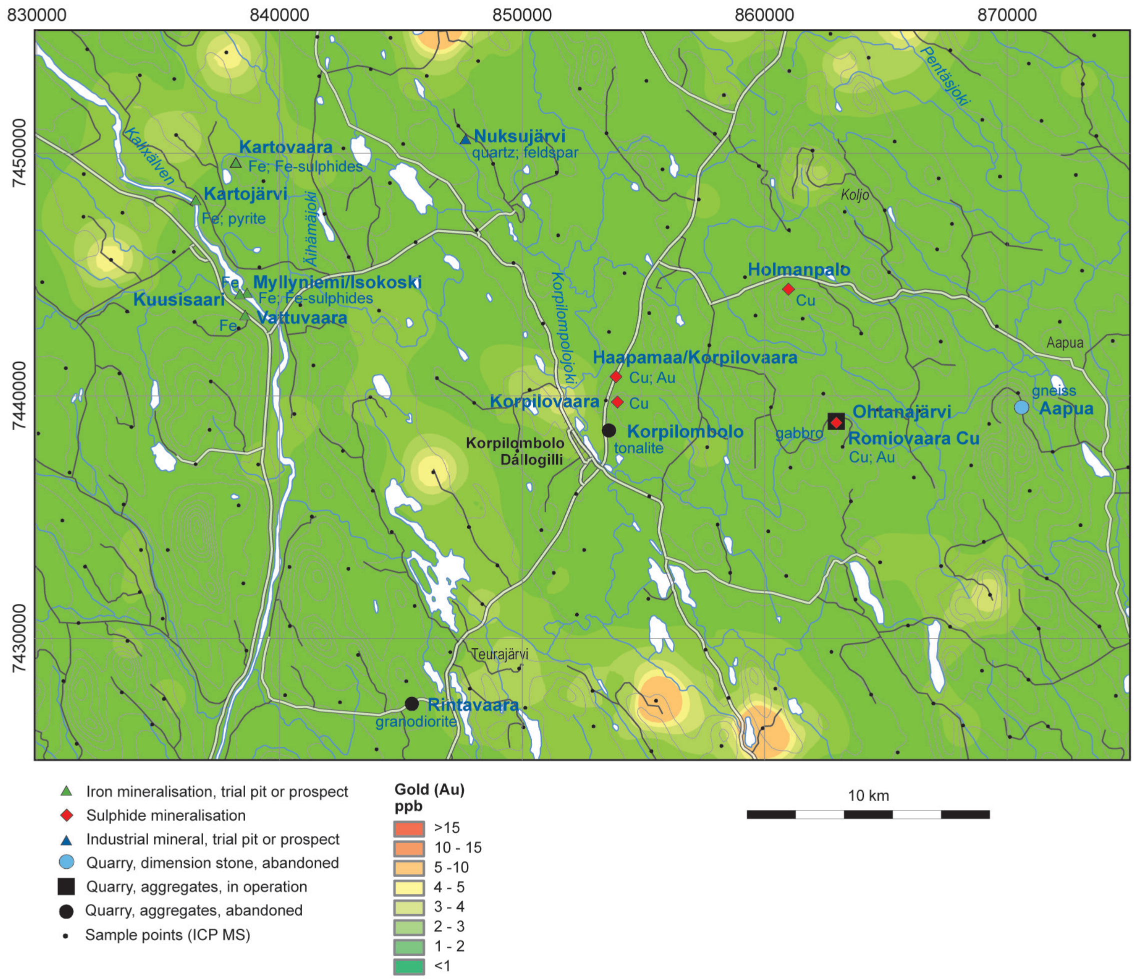

Figure 98. Gold concentrations in till (acid leach, SGU ICP-MS data) for the Narken–Korpilombolo area.

The excavation is 4 × 3 m wide, and has an excavation front 2 to 3 metres high. Most of the excavated material appears to be piled up in a small dump in front of the excavation (fig. 99). The mineralisation predominantly consists of hematite and magnetite in a fine-grained matrix of epidote and biotite. Pyrite occurs as millimetre-sized, idiomorphic crystals in the hematite-magnetite skarn matrix. The same type of mineralisation is also noted in an outcrop 30 m to the southeast (KES070144, Jonsson & Kero 2013). According to petrographic studies by Frietsch (1972), accessory quartz, chlorite, apatite and allanite also occur with the mineralisation. The mineralisation is surrounded by albite-rich alteration rocks (Frietsch 1972). The most common type is a red or brown, fine-grained, non-schistose, syenitic feldspar rock that is generally rich in epidote. Chemical analysis of a sample taken from the dump during the present inventory showed 45% Fe, 0.44% Cu and 0.03 ppm Au (Appendix 2). Anomalous concentrations of REE were also detected, with total REEs at 1,350 ppm, of which Ce constitutes 690 ppm. Similar results were reported by Jonsson (2008) from samples during bedrock mapping of the area (Jonsson & Kero 2013). The magnetic susceptibility measured in the trial pit shows values up to 20,000 × 10^{-5} SI units. The Kartovaara mineralisation is most likely very small, given the weak positive magnetic anomaly visible on the magnetic anomaly map.

Figure 99. Trial pit on hematite-magnetite-pyrite-bearing calc-silicate rock at Kartovaara, north-north-east of Narken village. Photo: Torbjörn Bergman.

Kartojärvi	ORED15144	
Fe, pyrite (outcrop)	E 836550	N 7448075

Southwest of Lake Kartojärvi, on the northern bank of the Kalixälven River (fig. 95), an outcrop of green, fine-grained, none-schistose epidote rock contains small angular to sub-angular fragments of hematite and some pyrite. The rock is most likely a product of hydrothermal alteration, and its origin is not known (Frietsch 1972). The rock is also intersected by narrow quartz veins, 2–5 mm wide.

Myllyniemi/Isokoski	ORED15402	TOB140020
Fe, pyrite (outcrop)	E 838662	N 7444254

Several well-exposed outcrops of metasediment and amphibolite occur on the eastern bank of the Kalixälven River, 150 m southeast of Myllyniemi (fig. 95). The outcrops are brecciated and sealed by a network of quartz veins in several places. The veins occasionally contain rock fragments consisting of fine-grained intergrowths of hematite and magnetite. Epidote is common, as is idiomorphic pyrite. The style of mineralisation has much in common with that noted at Kartovaara and Vattuvaara. According to Frietsch (1972), the metasedimentary rocks near the brecciated rocks are somewhat epidotised and rich in hematite and magnetite, implying a genetic link with the mineralisations at Kartovaara and Vattuvaara. Similar types of mineralised rocks are also described from the southern part of the small island of Kuusisaari, 300 m to the west at 838374/7444210 (Frietsch 1972).

Vattuvaara	ORED00353	TOB140018, KES061001
Fe (outcrop)	E 838593	N 7443336

The Vattuvaara mineralisation is found 1.5 km southeast of Narken village, and is the largest of the known iron mineralisations in the Narken area (fig. 95). The mineralisation is well exposed in natural outcrops and in a stripped and excavated area 35 × 20 m (fig. 100A). Like the other Fe mineralisations in the area, the Vatuvaara mineralisation is of a breccia

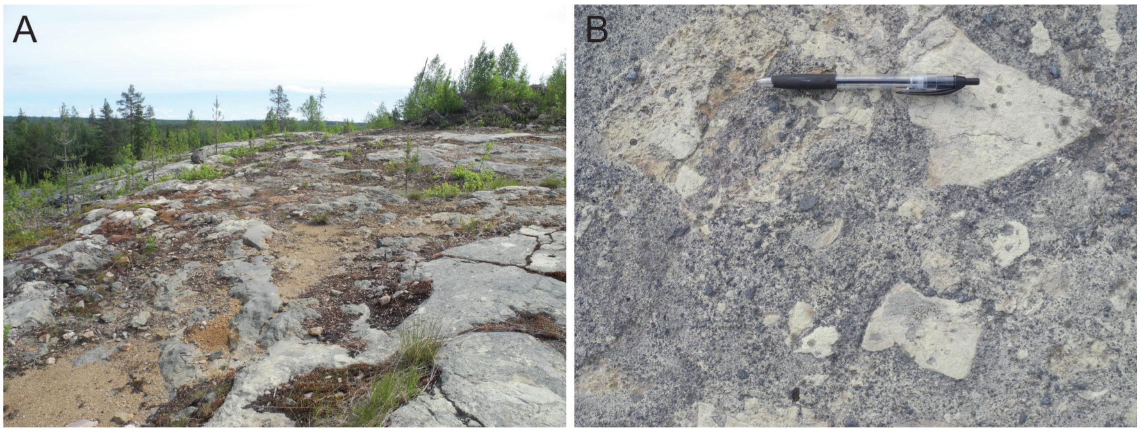

Figure 100. A. The stripped outcrop area at the Vattuvaara mineralisation, summer 2014. **B.** Breccia with fine-grained epidote-dominated rock fragments enclosed in a matrix predominantly comprising magnetite, hematite, epidote and chlorite. Photo: Torbjörn Bergman.

type, which appears to have been formed during brittle deformation and extensive hydrothermal alteration (Frietsch 1972; Jonsson 2008). Magnetite and hematite are the main ore minerals and occur in a fine-grained matrix of hematite, epidote and chlorite. Rock fragments of a fine-grained epidote-dominated rock between one and 10 centimetres across occur in the matrix (fig. 100B). Magnetite occurs mainly as isolated octahedral megacrysts 0.5–10 mm across in the fine-grained hematite-epidote-chlorite matrix and is mostly partly or totally altered to hematite. Hematite in the matrix is fine-grained and flaky, varying in size from 0.2 to 3 mm. Apatite is noted in small amounts as reddish to white prisms up to 1 mm long in the matrix. Allanite occurs as an accessory mineral in the matrix and forms euhedral crystals (Frietsch 1972). The wall rock to the ore breccia is a meta-andesite, with intercalations of metasedimentary rocks. Quartz and feldspar occur as breccia infills in the hanging wall in the area and are most abundant in the immediate vicinity of the ore breccia (Martinsson 2013).

Sulphide-and precious metal mineralisations

Haapamaa/Korpilovaara	ORED20287	TOB140004, KES070116
Cu, Au, Pd (outcrop)	E 853849	N 7440797

In a small outcrop on the eastern side of the road between Övertorneå and Pajala, 3 km nortnortheast of Korpilombolo (fig. 95), a quartz vein containing visible bornite, chalcopyrite, malachite and magnetite was identified in 1997 by Peter Lantto from Aapua (fig. 101). A sample sent to SGU and *Norrlands mineraljakt* was analysed and found to contain 5.4 ppm Au. The quartz vein was further investigated and analysed during the bedrock mapping performed by SGU in the Korpilombolo area in 2007 (Jonsson & Kero 2013). The vein is 0.5 m wide, hosted by a metatexitic greywacke and strikes 80°/85°. Microscopic work and microprobe analyses on thin sections identified the presence of native gold and several Pd-Te-Bi minerals (Jonsson 2010). Chemical analyses of samples taken during the present inventory could only detect low concentrations of these elements, however (Appendix 2, TOB140004).

Figure 101. Cu-Au-(Te-Bi-Pd)-bearing quartz vein in a road cut 3 km northeast of Korpilombolo. Photo: Torbjörn Bergman.

Korpilovaara and Holmanpalo	ORED20290 and 20291	TOB140005, VSL080146 and VSL070227
Cu (outcrop)	E 853915	N 7439752

A small pegmatite dyke with visible bornite and malachite was noted during bedrock mapping performed by SGU in 2008 on the western side of Korpilovaara, 2 km nort-northeast of Korpilombolo (fig. 95; Jonsson & Kero 2013). The dyke is hosted by metagreywacke, and strikes 110°/74°, which is parallel with the gneissosity of the metagreywacke. A similar outcrop with malachite is reported from the northern slope of Holmanpalo, 8.5 km to the northeast (SGU field observation VSL070227, Holmanpalo at 860978/7444399).

Industrial minerals

Nuksujärvi	ORED25509	KES070025, TOB140008
Quartz, feldspar (trial pit)	E 847671	N 7450592

Northeast of Nuksujärvi (fig. 95), a minor trial excavation on a pegmatite dyke was noted by SGU during bedrock mapping of the area in 2007 (fig. 102, Jonsson & Kero 2013). The pit is only 1 × 1 m wide and 0.5 m deep. The pegmatite dyke cross-cuts quartz diorite and is almost vertical, 5 m wide and strikes 60°.

Figure 102. Jierivaara, a minor trial pit on pegmatite, northeast of Nuksujärvi. Photo: Torbjörn Bergman.

Dimension stone and aggregate quarries

Aapua	ORED20288	TOB140007, KES061109
Granitic gneiss (abandoned quarry)	E 870587	N 7439525

On the eastern side of Etu-Aapua hill, 18 km east of Korpilombolo (fig. 95), there is an abandoned trial excavation in granitic orthogneiss (fig. 103). The pit is 15 × 10 m wide and 3 m deep, surrounded by a well-exposed stripped area, approximately 50 × 50 m. No information has been found on when or why the excavation was carried out.

Ohtanajärvi/Romiovaara	ORED25507, ORED25508	TOB140006, TOB150032
Gabbro, Cu, Au (aggregate quarry)	E 862954, 862947	N 7438952, 7438908

Gabbro has been quarried by Swerock AB on the northern slope of Romiovaara, 10 km east of Korpilombolo, since 2014. The quarried gabbro has mainly been used for road construction and foundations for wind turbines in the area. The quarry was 70 × 80 m and 20 m deep in the summer of 2015. The gabbro is occasionally cut by pegmatitic dykes 10 centimetres wide, striking approximately 130°/80°. Quartz-pyroxene-amphibole-rich veins, one to ten centimetres wide, with visible amounts of pyrite and chalcopyrite are associated with the pegmatite dykes. Chemical analyses of samples taken from veins in a quarried block show a metal concentration of up to 1.1% Cu, 2.6 ppm Au, 0.2 ppm Pd and 25 ppm Bi (Appendix 2).

Figure 103. An abandoned dimension stone quarry west of Aapua. Photo: Torbjörn Bergman.

Korpilombolo	ORED25505	TOB140002
Tonalite (abandoned quarry)	E 853591	N 7438574

Medium-grained foliated tonalite has been quarried in an abandoned quarry 1 km northeast of Korpilombolo (fig. 95). The quarry is 70 × 60 m wide, with a bench height of 20 m. It is not known when the quarry was active.

Rintavaara	ORED25504	TOB140001
Granodiorite (stripped outcrops)	E 845458	N 7427313

In the southern part of Rintavaara, 1.5 km west of Salmi, south of Korpilombolo (fig. 95), outcrops were stripped of overburden in summer 2014, most likely in preparation for an aggregate quarry. The rock type is a gneissic granodiorite, with frequent amphibolite enclaves and cross-cutting pegmatites.

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APPENDIX 1. LIST OF OCCURRENCES

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Aapua	ORED20288	870587	7439525	27M7h	Övertorneå	dimension stone	dimension stone, gneiss	147
Aareajoki	ORED04677	860768	7503799	29M0f	Pajala	industrial mineral	marble, dolomite	125
Ahmavuoma	ORED00856	797398	7548494	29L9c	Kiruna	precious metal, sulphide, Fe-oxide	Cu, Co, Au, Fe	31
Akkiskero	ORED25652	778862	7581428	30K6j	Kiruna	sulphide	Cu, Au	25
Alanen Airivaara	ORED00426	870390	7501275	28M9h	Pajala	industrial mineral	sillimanite	127
Annaniva	ORED15767	872861	7506607	29M0h	Pajala	sulphide, industrial mineral	Cu, graphite	126
Erkheikki söder	ORED15405	851819	7481572	28M5d	Pajala	Fe-oxide, sulphide	Fe, pyrite	110
Erkheikki-BIF	ORED15750	853029	7481670	28M5d	Pajala	Fe-oxide	Fe	110
Erkheikki-Cu	ORED15749	852472	7482791	28M6d	Pajala	sulphide	Cu	121
Haapamaa/Korpilovaara	ORED20287	853849	7440797	27M7d	Pajala	sulphide, precious metal	Cu, Au, PGE	145
Hammanen	ORED20261	785853	7427583	27L5a	Gällivare	industrial mineral	quartz, feldspar	138
Hietajoki	ORED00382	805002	7493320	28L8e	Pajala	industrial mineral	dolomite	83
Hietarova	ORED00394	804654	7492168	28L8e	Pajala	industrial mineral	andalusite	89
Holmanpalo	ORED20291	860978	7444399	27M8f	Pajala	sulphide	Cu	146
Honkavaara 1	ORED25965	869936	7497699	28M9h	Pajala	sulphide	Cu	119
Honkavaara 2	ORED25966	867419	7494084	28M8g	Pajala	sulphide	Cu	119
Huornaisenvuoma I	ORED00835	792372	7555953	30L0b	Kiruna	sulphide, industrial mineral	Zn, Cu, Pb, Ag, dolomite	31
Huornaisenvuoma II	ORED15720	792413	7553921	30L0b	Kiruna	sulphide, Fe-oxide	Cu, Fe	31
Huornaisenvuoma III	ORED15717	791580	7556972	30L1b	Kiruna	sulphide	Zn	31
Huuki	ORED04678	868664	7507006	29M0g	Pajala	industrial mineral	marble	124
Härkävaara	ORED00293	809892	7573380	30L4f	Kiruna	sulphide, industrial mineral	Mo, graphite	33
Hökboet	ORED25760	801388	7507583	29L1d	Kiruna	industrial mineral	graphite	85
Iso-Orotusvaara 1	ORED15723	798113	7479687	28L5c	Pajala	sulphide	Cu	81
Iso-Orotusvaara 2	ORED25619	797511	7479418	28L5c	Pajala	sulphide	Cu, Au	81
Isonkivenmaa	ORED00499	842346	7492509	28M8b	Pajala	industrial mineral	dolomite	125
Isovaara	ORED00386	799937	7504368	29L0d	Kiruna	industrial mineral	dolomite	82
Isovaara 1	ORED00164	799574	7504435	29L0d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	62

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Isovaara 2	ORED25605	799508	7504428	29L0d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	64
Isovaara 3	ORED25606	799430	7504354	29L0d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	64
Isovaara 4	ORED25607	799396	7504341	29L0d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	65
Jalkunen	ORED15729	804517	7485162	28L6e	Pajala	industrial mineral, sulphide	graphite, Cu	88
Juhonpieti	ORED00064	851777	7481937	28M5d	Pajala	Fe-oxide, sulphide	Fe, pyrite	110
Jukkasvaara	ORED25949	823753	7481502	28L5h	Pajala	sulphide	Cu, Co	77
Junojoki	ORED25947	808484	7511768	29L2e	Pajala	sulphide	Cu	71
Junosuando	ORED25525	802917	7499036	28L9d	Pajala	industrial rock	primary aggregate, granite	91
Junosuando 1	ORED00070	800847	7499955	28L9d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	57
Junosuando 2	ORED25953	800764	7500094	28L9d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	58
Junosuando Bh 6 (Tornefors)	ORED25900	820210	7498428	28L9h	Pajala	precious metal, industrial mineral	Au, graphite	67
Junosuando järngruva 1	ORED15726	801297	7498804	28L9d	Kiruna	Fe-oxide	Fe	57
Junosuando järngruva 2	ORED25879	801251	7498906	28L9d	Kiruna	Fe-oxide	Fe	57
Junosuando Norra	ORED15725	800564	7501119	28L9d	Kiruna	Fe-oxide	Fe	58
Juoluvaaranjärvi	ORED00335	785899	7581876	30L6a	Kiruna	Fe-oxide	Fe	21
Jupukka-marble	ORED04681	854273	7486515	28M6d	Pajala	industrial mineral	marble	125
Jupukka	ORED00339	854545	7485823	28M6e	Pajala	Fe-oxide	Fe	110
Kainulasjärvi	ORED25528	824352	7453552	28L0h	Pajala	industrial rock	primary aggregate, granite	139
Kalliomaa	ORED15766	869561	7501613	28M9h	Pajala	industrial mineral	graphite	126
Karhujärvi	ORED00072	851484	7485980	28M6d	Pajala	Fe-oxide, sulphide	Fe, Cu	109
Kartojärvi	ORED15144	836550	7448075	27M9a	Pajala	Fe-oxide, sulphide	Fe, pyrite	144
Kartovaara	ORED00351	838210	7449628	27M9a	Pajala	Fe-oxide, sulphide	Fe, Cu, pyrite	142
Kautisvaara	ORED25955	796130	7561381	30L2c	Kiruna	sulphide	Zn, Co	29
Kengisskogen (Kaalamarova)	ORED25520	854392	7512879	29M2e	Pajala	industrial rock, sulphide	primary aggregate, granite, Cu	44
Kevus	ORED00074	790632	7559677	30L1b	Kiruna	Fe-oxide	Fe	24
Kieksiäisvaara	ORED15764	865891	7481291	28M5g	Pajala	sulphide	Cu	121
Kirnujärvi	ORED00413	853026	7459185	28M1d	Pajala	industrial mineral	sillimanite	127
Kivijänkkä	ORED00484	815006	7509327	29L1g	Pajala	sulphide	Cu	71
Koppelovaara	ORED21724	796571	7425632	27L4c	Gällivare	precious metal	Cu, Au	136

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Korpilombolo	ORED25505	853591	7438574	27M7d	Pajala	industrial rock	primary aggregate, tonalite	148
Korpilovaara	ORED20290	853915	7439752	27M7d	Pajala	sulphide	Cu	146
Kotasenrova	ORED15399	813688	7494850	28L8f	Pajala	sulphide	Cu	73
Kuormakka	ORED15391	785057	7576205	30L5a	Kiruna	sulphide	Cu	27
Kurkkionvaara	ORED00834	801266	7483954	28L6d	Pajala	sulphide	Pb, Zn	74
Kursunoja	ORED15404	851259	7477991	28M5d	Pajala	precious metal, sulphide	Cu, Au	121
Kursunpalo	ORED25506	851250	7477974	28M5d	Pajala	dimension stone	dimension stone, schist	129
Kuusisaari	ORED00352	838374	7444210	27M8a	Pajala	Fe-oxide	Fe	144
Kuusivaara	ORED25511	839738	7468242	28M3b	Pajala	industrial rock, sulphide	primary aggregate, andecite, Fe-sulphides, quartzite	130
Kuusivaaranvinsa	ORED15739	840688	7470464	28M3b	Pajala	sulphide	Cu	123
Käryjärvi	ORED00222	861300	7488078	28M7f	Pajala	Fe-oxide, sulphide	Fe, pyrite	109
Käymäjärvi 1	ORED00282	840630	7497245	28M9b	Pajala	Fe-oxide, precious metal	Fe, Mn, Cu, Au	114
Käymäjärvi 2	ORED25977	842431	7495732	28M8b	Pajala	Fe-oxide, precious metal	Fe, Mn, Cu, Au	115
Laata	ORED25521	865472	7497064	28M8g	Pajala	dimension stone	dimension stone, granite	128
Lautakoski-Cu	ORED25962	820366	7489071	28L7h	Pajala	sulphide, industrial mineral	Cu, graphite, Co	87
Lautakoski	ORED00401	814794	7494041	28L8g	Pajala	industrial mineral	soapstone, talc	90
Lehtosölkä 1	ORED15746	851599	7463781	28M2d	Pajala	industrial mineral	graphite	127
Lehtosölkä 2	ORED25975	852476	7464291	28M2d	Pajala	industrial mineral, sulphide	graphite, Cu, Co, Zn, Pb, Au	127
Leppäjoki	ORED00154	810426	7494908	28L8f	Pajala	Fe-oxide, sulphide	Fe, Fe-sulphides	70
Liviövaara-graphite	ORED15752	852993	7477477	28M5d	Pajala	industrial mineral, sulphide	graphite, Cu, Ni, Au	126
Liviövaara 1	ORED25972	853256	7478030	28M5d	Pajala	sulphide, industrial mineral	Cu, graphite	122
Liviövaara 2	ORED25971	852763	7477682	28M5d	Pajala	sulphide, precious metal	Cu, Au	122
Liviövaara 3	ORED25973	853529	7477652	28M5d	Pajala	sulphide	Cu	122
Liviövaara 4	ORED25974	853193	7477019	28M5d	Pajala	sulphide, precious metal	Cu, Au	123
Lombolojoki	ORED25970	842710	7492300	28M8b	Pajala	sulphide	Cu	121
Lombolovaara	ORED25968	838275	7497025	28M9a	Pajala	sulphide	Cu	120
Lovikka	ORED25761	825757	7490121	28L7i	Pajala	industrial rock	primary aggregate, granodiorite	92
Lumivaara 1	ORED25519	841758	7512721	29M2b	Pajala	industrial mineral	quartz	42

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Lumivaara 2	ORED15742	841644	7512527	29M2b	Pajala	industrial mineral	quartz	43
Luostojoki	ORED25658	795252	7597936	30L9c	Kiruna	sulphide	Cu	25
Luspavaara	ORED15390	783982	7583051	30L6a	Kiruna	precious metal, sulphide	Cu, Au	25
Magnetgruvan	ORED25657	801378	7498718	28L9d	Kiruna	Fe-oxide	Fe	56
Marjarova 1 (Marjajärvi)	ORED25518	840776	7491138	28M7b	Pajala	Fe-oxide	Fe, Mn	117
Marjarova 2 (Marjajärvi)	ORED00081	841099	7490863	28M7b	Pajala	Fe-oxide, sulphide	Fe, Mn, pyrite	117
Masugnsbyn	ORED00404	801101	7498637	28L9d	Kiruna	industrial mineral	dolomite	82
Maunuvaara 1	ORED00264	796922	7482641	28L6c	Pajala	sulphide, precious metal	Cu, Au	79
Maunuvaara 2	ORED25617	796920	7482591	28L6c	Pajala	sulphide, precious metal	Cu, Au	80
Maunuvaara norra	ORED15395	797005	7482920	28L6c	Pajala	sulphide	Cu	79
Maunuvaara östra	ORED25618	797463	7482509	28L6c	Pajala	sulphide	Cu	80
Merasjärvi	ORED15397	802323	7507319	29L1d	Kiruna	sulphide	Mo, Cu	72
Meraslinka	ORED00179	804482	7512964	29L2e	Kiruna	industrial mineral	graphite	85
Merasvaara 1	ORED25950	797329	7513221	29L2c	Kiruna	sulphide	Cu	71
Merasvaara 2	ORED25951	797076	7513418	29L2c	Kiruna	sulphide	Mo	71
Mikkelijoki	ORED25952	784673	7521455	29L4a	Kiruna	sulphide	Cu	70
Mukkavaara	ORED25956	857696	7480959	28M5e	Pajala	other oxide	W	124
Muodoslompolo	ORED15755	853824	7556667	30M0e	Pajala	industrial mineral	quartz	39
Muotkamaa	ORED25969	842591	7492912	28M8b	Pajala	sulphide	Cu	120
Muotkapalo	ORED15761	863928	7499540	28M9f	Pajala	industrial mineral	graphite	126
Muotkavuoma	ORED15741	841721	7492808	28M8b	Pajala	Fe-oxide	Fe	115
Myllyniemi/Isokoski	ORED15402	838662	7444254	27M8a	Pajala	Fe-oxide, sulphide	Fe, Fe-sulphides	144
Naakajärvi 1	ORED00407	839807	7528222	29M5b	Pajala	industrial mineral	quartz	40
Naakajärvi 2	ORED25522	839787	7528172	29M5b	Pajala	industrial mineral	quartz	41
Naakajärvi 3	ORED25523	839733	7527980	29M5b	Pajala	industrial mineral	quartz	41
Naakajärvi 4	ORED25524	839817	7527876	29M5b	Pajala	industrial mineral	quartz	41
Nuksujärvi	ORED25509	847671	7450592	27M9c	Pajala	industrial mineral	quartz, feldspar	146
Nuolivaara 1	ORED15737	829084	7483194	28L6i	Pajala	industrial rock	primary aggregate, monzonite	92
Nuolivaara 2	ORED25526	828935	7482640	28L6i	Pajala	industrial rock	primary aggregate, monzonite	92

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Nuuksujärvi	ORED25804	814477	7517134	29L3g	Pajala	sulphide	Cu	70
Nya Isovaara 1	ORED25602	799083	7504011	29L0c	Kiruna	Fe-oxide	Fe	65
Nya Isovaara 2	ORED25604	799208	7503888	29L0d	Kiruna	Fe-oxide	Fe	65
Nybrännan 1	ORED00180	804271	7497394	28L9e	Pajala	industrial mineral	graphite	85
Nybrännan 2	ORED25616	804304	7497399	28L9e	Pajala	industrial mineral	graphite	85
Ohtanajärvi	ORED25507	862954	7438952	27M7f	Pajala	industrial rock	primary aggregate, gabbro	147
Oriasvaara	ORED00311	811366	7481871	28L6f	Pajala	sulphide, precious metal	Cu, Au	75
Orjasjoki	ORED04682	811882	7481830	28L6f	Pajala	industrial mineral	dolomite	84
Outavaara I	ORED25654	793705	7570698	30L3c	Kiruna	sulphide	Cu, Fe-sulphides	28
Outavaara II	ORED15722	794455	7568315	30L3c	Kiruna	precious metal	Au	29
Pahakurkkio	ORED00414	804430	7486240	28L6e	Pajala	industrial mineral	sillimanite, andalusite	89
Pahturijärvi	ORED25948	813556	7511033	29L1f	Pajala	sulphide	Cu	71
Pahturijärvi 1	ORED25516	838081	7500738	28M9a	Pajala	Fe-oxide	Fe, Mn	114
Pahturijärvi 2	ORED25517	838166	7500663	28M9a	Pajala	Fe-oxide	Fe, Mn	114
Pajala 24:1	ORED25513	857858	7481227	28M5e	Pajala	industrial rock	primary aggregate, metagrey-wacke, granite	128
Pajala Södra	ORED00482	860845	7478306	28M5f	Pajala	other oxide, Fe-oxide	Fe	111
Paljasjärvi	ORED00087	800235	7579415	30L5d	Kiruna	Fe-oxide, sulphide	Fe, Fe-sulphides	22
Palo Pöviö	ORED15727	801432	7507645	29L1d	Kiruna	industrial mineral	graphite	85
Palotieva	ORED00030	858082	7503033	29M0e	Pajala	Fe-oxide, sulphide	Fe, Cu	102
Palovaara	ORED00228	778887	7587614	30K7j	Kiruna	Fe-oxide	Fe	21
Pellivuoma	ORED00090	839913	7492507	28M8b	Pajala	Fe-oxide, sulphide	Fe	116
Pennikajärvi	ORED25945	789213	7506866	29L1b	Kiruna	sulphide	Cu	72
Peräjävaara	ORED15740	841347	7482823	28M6b	Pajala	Fe-oxide, industrial mineral	Fe, apatite	111
Peräjävuoma	ORED00229	840079	7477341	28M5b	Pajala	other oxide, Fe-oxide, industrial mineral	Fe, Ti, V	112
Plootuvaara	ORED25512	864164	7480419	28M5f	Pajala	industrial rock	primary aggregate, granite	128
Puristakero	ORED15748	851156	7544830	29M8d	Pajala	industrial mineral	quartz	39
Puuroharjut	ORED25954	802717	7491094	28L7d	Pajala	industrial mineral	quartz	89
Rappukoski	ORED15732	808267	7482952	28L6e	Pajala	sulphide	Cu, Mo	75

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Rautajoki	ORED15728	802561	7498484	28L9d	Pajala	Fe-oxide	Fe	66
Rautajoki 2	ORED25946	800522	7498414	28L9d	Kiruna	sulphide	Cu	72
Rintavaara	ORED25504	845458	7427313	27M5c	Pajala	industrial rock	primary aggregate, granodiorite	148
Rissavaara	ORED15730	805382	7462980	28L2e	Pajala	industrial mineral	quartz, quartzite	137
Riukukangas 1	ORED25653	845413	7549464	29M9c	Pajala	dimension stone	dimension stone, granite	43
Riukukangas 2	ORED15744	845455	7549418	29M9c	Pajala	dimension stone	dimension stone, granite	43
Romiovaara Cu	ORED25508	862947	7438908	27M7f	Pajala	sulphide	Cu, Au	147
Roskajoki-marble	ORED04680	837860	7498707	28M9a	Pajala	industrial mineral	dolomite	125
Roskajoki 1	ORED15738	837802	7498664	28M9a	Pajala	sulphide	Cu	119
Roskajoki 2	ORED25967	837869	7498450	28M9a	Pajala	sulphide	Cu	120
Ruutijärvi	ORED00097	855350	7499656	28M9e	Pajala	Fe-oxide	Fe	105
Rytivaara (Pahtasenvaara)	ORED00846	860020	7482530	28M6f	Pajala	industrial mineral	Mg-silicate	128
Saalovuoma	ORED15745	846386	7486746	28M6c	Pajala	industrial mineral	Mg-silicate	128
Saarikoskenvaara	ORED15756	854204	7557309	30M1e	Pajala	industrial mineral	quartz	38
Saarikoski	ORED15724	800245	7487063	28L7d	Pajala	precious metal, sulphide	Cu, Au	73
Saarivaara	ORED00879	793126	7551960	30L0b	Kiruna	sulphide	Cu	31
Sahavaara Södra	ORED00100	854534	7495890	28M8e	Pajala	Fe-oxide	Fe	107
Sahavaara Östra	ORED00099	855078	7496395	28M8e	Pajala	Fe-oxide	Fe	107
Sarvisto (Kaunisjoki)	ORED15759	862110	7496617	28M8f	Pajala	industrial mineral	graphite	126
Sattavaara	ORED00223	791743	7558025	30L1b	Kiruna	other oxide, Fe-oxide	Fe, Mn	24
Sautusjärvi	ORED00226	800284	7581704	30L6d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	21
Sorvijänkkä	ORED15400	816197	7578773	30L5g	Kiruna	industrial mineral, sulphide	graphite, Cu	32
Stora Sahavaara	ORED00101	855080	7496950	28M8e	Pajala	Fe-oxide, sulphide	Fe	106
Suinavaaragruvan	ORED15734	814477	7493118	28L8g	Pajala	industrial mineral	graphite	87
Suksivuoma	ORED00105	854658	7491519	28M7e	Pajala	Fe-oxide, sulphide	Fe, Fe-sulphides	108
Suorravaara-Li	ORED25978	784304	7451964	28K0j	Gällivare	other oxide	Li	135
Suorravaara	ORED00343	784467	7451692	28K0j	Gällivare	sulphide	Cu	135
Suorsapakka	ORED00317	843453	7469806	28M3b	Pajala	Fe-oxide	Fe	112
Säynäjäjoki	ORED00488	817020	7507409	29L1g	Pajala	Fe-oxide	Fe	66

Appendix 1. Continuation.

Name	Id-code	E (Sweref)	N (Sweref)	RT90 index	Municipality	Type	Commodity	Page
Tapuli	ORED00046	856238	7501865	28M9e	Pajala	Fe-oxide	Fe	104
Tapulivuoma	ORED04679	855555	7501174	28M9e	Pajala	industrial mineral	dolomite	125
Teltaja	ORED00107	793332	7556200	30L0b	Kiruna	Fe-oxide	Fe	24
Teukkavaara	ORED25964	779848	7582045	30K6j	Kiruna	sulphide	Cu, Co	25
Tiankijoki (Tiankijokki)	ORED15731	808220	7480516	28L5e	Pajala	industrial mineral	graphite	88
Tornefors	ORED00113	820126	7498168	28L9h	Pajala	Fe-oxide, sulphide	Fe, Cu, Au	67
Tsuonamavaara	ORED25963	799070	7586210	30L7d	Kiruna	Fe-oxide	Fe	22
Tukkapuro	ORED15714	786480	7577608	30L5a	Kiruna	industrial mineral	dolomite	33
Tupovaara	ORED15763	865821	7463129	28M2g	Pajala	sulphide	Mo	123
Tärännönvaara	ORED00384	821295	7488710	28L7h	Pajala	industrial mineral	andalusite	89
Ukonpalo	ORED20241	842366	7468870	28M3b	Pajala	sulphide, precious metal	Cu, Au	123
Vattuvaara	ORED00353	838593	7443336	27M8a	Pajala	Fe-oxide	Fe	144
Veikkavaara	ORED25621	803790	7496493	28L9d	Pajala	sulphide	Cu	72
Vinsa 1	ORED25514	840668	7496166	28M8b	Pajala	Fe-oxide	Fe, Mn	115
Vinsa 2	ORED25515	840639	7496199	28M8b	Pajala	Fe-oxide	Fe, Mn	115
Vittangi	ORED25656	785524	7520525	29L3a	Kiruna	industrial rock	primary aggregate, granodiorite	91
Vuollovaara	ORED25620	797496	7484847	28L6c	Pajala	sulphide	Cu	78
Vuoma	ORED00165	800158	7504875	29L0d	Kiruna	Fe-oxide	Fe	62
Vähävaara 1	ORED00255	783931	7449246	27K9j	Gällivare	sulphide, precious metal	Mo, Cu, Au	135
Vähävaara 2	ORED25655	783997	7449286	27K9j	Gällivare	sulphide, precious metal	Mo, Cu, Au	135
Vähävaara 1	ORED00116	801064	7502553	29L0d	Kiruna	Fe-oxide	Fe	58
Vähävaara 2	ORED25608	801067	7502444	29L0d	Kiruna	Fe-oxide, sulphide	Fe, pyrite	58
Vähävaara 3	ORED25609	801029	7502320	29L0d	Kiruna	Fe-oxide	Fe	58
Välivaara 1	ORED00167	800423	7504207	29L0d	Kiruna	Fe-oxide	Fe	60
Välivaara 2	ORED25610	800653	7503783	29L0d	Kiruna	Fe-oxide	Fe	60
Välivaara 3	ORED25612	800733	7503660	29L0d	Kiruna	Fe-oxide	Fe	60
Välivaara 4	ORED25613	800791	7503533	29L0d	Kiruna	Fe-oxide	Fe	60
Välivaara 5	ORED25614	800883	7503412	29L0d	Kiruna	Fe-oxide	Fe	62
Välivuoma	ORED15735	817521	7497664	28L9g	Pajala	industrial mineral	graphite	85

APPENDIX 2. LITHOGEOCHEMISTRY

Methods

Lithogeochemical analysis were conducted at ALS Minerals in 2014 & 2015 using analytical packages referred to as CCP-PKG01, PGM-ICP23, Cl-IC881. ALS method code refers to analytical method used for each element and is described in ALS methodology factsheets at http://www.alsglobal.com

Sample preparation was carried out by ALS Minerals in Piteå (Sweden) and subsequent analytical work performed at ALS Minerals lab. Preparation involved crushing of the sample and pulverising it to a powder using low-chrome steel grinding mills. The lithogeochemical analysis at ALS was conducted using the whole rock major and trace element package CCP-PKG01, which is a combination of different methods. Lithium metaborate fusion ICP-AES (ME-ICP06) was used for major elements. Total carbon and sulphur were analysed using a LECO sulphur analyser (ME-IR08). The sample (0.01 to 0.1 g) is heated to approximately 1 350°C in an induction furnace while passing a stream of oxygen through the sample. Total sulphur and carbon are measured by an IR detection system. Trace elements including the full rare earth element suites are reported from three digestions with either ICP-AES or ICP-MS finish: a lithium borate fusion for the resistive elements (ME-MS81), a four acid digestion for the base metals (ME-4ACD81), and an aqua regia digestion for the volatile gold related trace elements (ME-MS42). The chlorine content was determined by KOH fusion and ion chromatography using 0.2 g sample (Cl-IC881). Pt, Pd and Au were determined by fire assay and ICP-AES finish (PGM-ICP23).

Appendix 2. Lithogeochemistry

ID			FHM140001A	FHM140017A	FHM140028A	FHM140030A	FHM140030C	FHM140031A	FHM140032A	FHM140033A
N			7497394	7496490	7482513	7482641	7482641	7482920	7484847	7479414
E			804271	803773	797469	796922	796922	797005	797496	797509
ORED ID			180	25621	25618	264	264	25620	25620	25619
Prospect			Nybrännan 1	Veikkavaara	Maunuvaara Ö	Maunuvaara 1	Maunuvaara 1	Maunuvaara N	Vuollovaara	Iso-Orotusv. 2
Rock			Graphite schist	Sulphide rich skarn, po, cpy	Metadacite, cct, qz-vein	Metaandesite, cct, qz-vein	Metaandesite, cct, qz-vein	Metaandesite, cct, qz-vein	Metaandesite, cct, skarn	Metaandesite, cct, bn, qz-vein
SiO2	ME-ICP06	%	26,4	40,7	63,1	71	49,9	49,9	47,9	53,4
Al2O3	ME-ICP06	%	6,65	5,52	17,45	9,24	14,3	13,85	16,75	15,6
Fe2O3	ME-ICP06	%	13,35	21,9	4,82	6,09	17,05	15,4	8,93	11,6
CaO	ME-ICP06	%	7,39	17,15	6,05	4,23	7,29	10,95	12,35	11,1
MgO	ME-ICP06	%	4,43	6,27	2,4	2,74	4,9	5,25	8,06	4,34
Na2O	ME-ICP06	%	1,84	1,12	4,07	1,57	2,55	2,08	2,16	1,31
K2O	ME-ICP06	%	0,18	0,23	0,96	0,93	1,07	0,62	1,29	0,44
Cr2O3	ME-ICP06	%	0,03	0,01	0,02	0,01	0,01	0,01	0,03	0,01
TiO2	ME-ICP06	%	0,51	0,3	0,67	0,98	1,74	1,69	0,65	1,37
MnO	ME-ICP06	%	0,06	0,53	0,08	0,1	0,22	0,26	0,23	0,27
P2O5	ME-ICP06	%	2,49	0,05	0,19	0,21	0,29	0,28	0,26	0,25
SrO	ME-ICP06	%	< 0,01	< 0,01	0,04	0,01	0,02	0,03	0,05	0,03
BaO	ME-ICP06	%	< 0,01	< 0,01	0,05	0,05	0,03	0,02	0,07	0,01
C	C-IR07	%	33,3	0,16	0,02	0,02	0,03	0,04	0,03	0,05
S	S-IR08	%	6,02	5,76	0,06	0,52	0,22	0,11	0,02	0,27
LOI	OA-GRA05	%	36,4	6,19	0,52	0,77	0,77	0,37	1,53	0,83
Ba	ME-MS81	ppm	14,4	30	449	375	246	155,5	604	125
Ce	ME-MS81	ppm	44,3	9,4	34	16,4	36,6	42,3	30,3	43,7
Cr	ME-MS81	ppm	190	20	100	80	20	20	230	50
Cs	ME-MS81	ppm	0,1	0,4	1,18	2,46	2,63	0,56	2,45	2,1
Dy	ME-MS81	ppm	3,99	3,26	2,69	2,68	5,83	6,08	2,56	5,28
Er	ME-MS81	ppm	2,03	1,63	1,6	1,58	3,64	3,62	1,45	3,02
Eu	ME-MS81	ppm	1,02	0,67	1,35	0,96	1,68	1,78	1,13	1,49
Ga	ME-MS81	ppm	9,4	7,6	19,5	11,5	23,8	23,8	15,4	21,4
Gd	ME-MS81	ppm	3,87	2,32	3,21	2,59	5,39	6,07	2,96	4,91
Hf	ME-MS81	ppm	2	0,5	3	1,9	3,3	2,9	1,8	3,2
Ho	ME-MS81	ppm	0,72	0,62	0,59	0,57	1,25	1,33	0,48	1,11
La	ME-MS81	ppm	24,7	5	15,6	8	17,6	19,3	14	21,8
Lu	ME-MS81	ppm	0,29	0,29	0,19	0,25	0,46	0,53	0,21	0,43
Nb	ME-MS81	ppm	4,9	0,8	5,9	3,7	4,8	5	5,4	5,1
Nd	ME-MS81	ppm	18,7	5,4	19,3	9	20,3	23,4	15,7	21,8
Pr	ME-MS81	ppm	4,65	1,19	4,84	2,1	4,74	5,54	3,9	5,48
Rb	ME-MS81	ppm	11,1	13,7	25,5	55,5	70,9	13,7	37,9	18,7
Sm	ME-MS81	ppm	3,59	1,73	3,72	2,02	4,91	4,92	3,48	4,82
Sn	ME-MS81	ppm	< 1	2	1	< 1	1	1	1	< 1
Sr	ME-MS81	ppm	34,7	33,3	580	293	402	484	648	509
Ta	ME-MS81	ppm	0,6	< 0,1	0,3	0,3	0,3	0,3	0,2	0,2
Tb	ME-MS81	ppm	0,62	0,53	0,5	0,43	0,94	0,92	0,43	0,81
Th	ME-MS81	ppm	3,24	0,07	4,94	1,2	2,63	2,64	2,2	2,98
Tm	ME-MS81	ppm	0,3	0,24	0,18	0,25	0,49	0,56	0,15	0,46
U	ME-MS81	ppm	7,34	0,41	4,23	1,3	0,82	1,39	1,22	1,5
V	ME-MS81	ppm	222	154	134	160	411	402	162	318
W	ME-MS81	ppm	1	1	2	< 1	1	1	1	1
Y	ME-MS81	ppm	23,8	16,5	14,8	16,4	35,8	35,9	13,5	31
Yb	ME-MS81	ppm	2,18	1,82	1,58	1,65	3,37	3,76	1,36	3,01
Zr	ME-MS81	ppm	74	16	129	71	130	127	64	140
As	ME-MS42	ppm	8	1,1	1,1	0,5	1,5	1,9	0,7	1,1
Bi	ME-MS42	ppm	2,71	0,03	4,04	8,43	3,95	0,25	5,29	15,6
Hg	ME-MS42	ppm	0,006	< 0,005	< 0,005	0,009	< 0,005	< 0,005	< 0,005	< 0,005
Sb	ME-MS42	ppm	0,2	0,07	0,17	0,17	0,06	1	0,14	0,39
Se	ME-MS42	ppm	58,9	7,2	1,5	3,4	0,4	1,4	2,5	3,1
Te	ME-MS42	ppm	3,92	2,28	0,11	1,35	0,31	0,13	3,27	0,87
Ag	ME-4ACD81	ppm	< 0,5	< 0,5	1,9	13,2	6	3,4	< 0,5	2,9
Cd	ME-4ACD81	ppm	< 0,5	1	0,8	< 0,5	0,7	0,7	< 0,5	< 0,5
Co	ME-4ACD81	ppm	77	219	13	20	39	42	34	34
Cu	ME-4ACD81	ppm	372	> 10 000	3 600	> 10 000	8 810	4 780	1 040	8 530
Mo	ME-4ACD81	ppm	18	2	< 1	13	3	9	5	13
Ni	ME-4ACD81	ppm	487	106	16	15	15	14	39	24
Pb	ME-4ACD81	ppm	<2	< 2	3	<2	< 2	< 2	< 2	<2
Sc	ME-4ACD81	ppm	20	46	14	17	36	36	25	32
Zn	ME-4ACD81	ppm	13	69	31	56	107	121	72	39
Li	ME-4ACD81	ppm	< 10	10	20	20	30	10	20	10
Tl	ME-MS42	ppm	0,58	0,1	0,12	0,3	0,31	< 0,02	0,07	0,02
Cl	Cl-IC881	ppm	180	1 950	140	160	150	120	290	200
Cu	Cu-OG62	%		1,015		1,98				
Au	PGM-ICP23	ppm	0,002	< 0,001	0,023	0,115	0,077	0,031	0,092	0,816
Pt	PGM-ICP23	ppm	0,005	0,006	< 0,005	< 0,005	< 0,005	< 0,005	0,005	< 0,005
Pd	PGM-ICP23	ppm	0,006	0,009	0,001	< 0,001	< 0,001	0,001	0,01	< 0,001

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz

Appendix 2. Continuation.

ID			FHM140035A	FHM140035B	FHM140054B	FHM140055A	FHM140059A	FHM150010A	TOB140003A	TOB140004A
N			7498721	7498721	7504435	7504430	7504125	7498645	7477991	7440797
E			801373	801373	799574	799509	799168	801025	851259	853849
ORED ID			25657	25657	164	25605		404	25506	20287
Prospect			Magnetgruvan	Magnetgruvan	Isovaara 1	Isovaara 2		Masugnsbyn	Kursunpalo	Haapamaa
Rock			Skarn mgt ore, massive	Act skarn, po, cpy diss	Amf-px skarn, rich sulph diss	Skarn mt ore, massive	Dolomite, boulder	Dolomite	Qz-vein	Qz-vein
SiO2	ME-ICP06	%	2,04	45,3	64,4	13,05	2,54	0,63	76,1	62,9
Al2O3	ME-ICP06	%	0,63	1,19	0,13	4,12	0,18	0,07	7,19	14,45
Fe2O3	ME-ICP06	%	94,4	17,15	20,6	73,9	1,09	0,88	8,27	5,43
CaO	ME-ICP06	%	0,04	9,67	3,02	4,14	28,5	32,3	0,18	4,11
MgO	ME-ICP06	%	2,24	20	2,27	4,2	23,1	21,2	3,88	2,69
Na2O	ME-ICP06	%	0,05	0,9	0,09	0,53	0,01	0,01	0,08	3,75
K2O	ME-ICP06	%	0,34	0,47	0,05	0,42	0,08	< 0,01	2,98	3,82
Cr2O3	ME-ICP06	%	0,01	< 0,01	< 0,01	0,01	< 0,01	< 0,01	0,01	0,01
TiO2	ME-ICP06	%	0,16	0,02	< 0,01	0,21	0,01	0,01	0,29	0,51
MnO	ME-ICP06	%	0,08	0,1	0,15	0,22	0,1	0,08	0,09	0,07
P2O5	ME-ICP06	%	< 0,01	< 0,01	< 0,01	0,03	0,03	0,02	0,12	0,11
SrO	ME-ICP06	%	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	0,03
BaO	ME-ICP06	%	< 0,01	< 0,01	< 0,01	0,01	< 0,01	< 0,01	0,02	0,23
C	C-IR07	%	0,03	0,02	0,02	< 0,01	12,15	12,65	0,01	0,05
S	S-IR08	%	3,12	5,3	10,45	0,03	0,1	0,09	0,31	0,66
LOI	OA-GRA05	%	1,79	5,35	10,8	- 1,64	44,1	46,5	1,22	1,25
Ba	ME-MS81	ppm	12,5	6,5	2,5	90,4	28,9	9,5	157,5	2 210
Ce	ME-MS81	ppm	1,7	5,4	4,8	7,4	2,7	2,2	40,7	56,3
Cr	ME-MS81	ppm	10	10	10	40	10	10	50	30
Cs	ME-MS81	ppm	0,17	0,24	0,02	0,04	0,16	0,04	6,43	1,75
Dy	ME-MS81	ppm	0,21	1,76	0,47	0,89	0,15	0,16	3,12	3,71
Er	ME-MS81	ppm	0,14	0,86	0,27	0,74	0,08	0,05	1,61	2,21
Eu	ME-MS81	ppm	0,06	0,4	0,1	0,31	0,05	0,23	0,44	1,58
Ga	ME-MS81	ppm	11,5	2,3	1,5	12,6	0,5	0,3	12,5	13,7
Gd	ME-MS81	ppm	0,2	1,29	0,46	0,83	0,18	0,12	3,86	3,69
Hf	ME-MS81	ppm	0,6	0,9	< 0,2	0,2	< 0,2	< 0,2	1,3	5,9
Ho	ME-MS81	ppm	0,05	0,37	0,1	0,21	0,04	0,03	0,55	0,65
La	ME-MS81	ppm	0,8	1,6	2,2	7,7	1,8	1,6	20	23,1
Lu	ME-MS81	ppm	0,02	0,16	0,04	0,1	0,01	0,01	0,21	0,27
Nb	ME-MS81	ppm	1,1	2,8	0,3	1,2	0,2	0,8	7,9	6,1
Nd	ME-MS81	ppm	0,8	4,9	2,2	3,4	1,1	1,2	21,5	29,3
Pr	ME-MS81	ppm	0,22	1,06	0,54	0,93	0,26	0,24	4,5	6,85
Rb	ME-MS81	ppm	18,6	13,4	0,4	4,9	1,7	0,5	167	56,8
Sm	ME-MS81	ppm	0,33	1,42	0,26	0,81	0,22	0,21	4,31	4,99
Sn	ME-MS81	ppm	3	2	< 1	1	< 1	2	2	1
Sr	ME-MS81	ppm	2,2	5	2,3	9,9	37,7	22,9	4,6	420
Ta	ME-MS81	ppm	0,1	0,2	0,1	< 0,1	0,1	< 0,1	1	2,4
Tb	ME-MS81	ppm	0,04	0,25	0,07	0,15	0,04	0,03	0,58	0,51
Th	ME-MS81	ppm	4,78	0,13	0,06	< 0,05	< 0,05	0,24	6,61	32,4
Tm	ME-MS81	ppm	< 0,01	0,13	0,04	0,08	< 0,01	0,01	0,2	0,22
U	ME-MS81	ppm	39,3	0,34	0,11	0,41	0,08	1,26	1,75	6,18
V	ME-MS81	ppm	131	9	6	147	7	< 5	56	82
W	ME-MS81	ppm	1	< 1	1	< 1	< 1	1	1	2
Y	ME-MS81	ppm	1,1	9,3	3,4	7,2	1,3	1,2	14,3	17,5
Yb	ME-MS81	ppm	0,17	0,99	0,29	0,61	< 0,03	0,08	1,65	1,98
Zr	ME-MS81	ppm	23	17	5	7	2	3	50	243
As	ME-MS42	ppm	0,3	0,8	1,1	0,2	1,5	0,4	57,7	3,4
Bi	ME-MS42	ppm	0,08	0,05	0,25	0,05	0,01	0,01	7,73	0,33
Hg	ME-MS42	ppm	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005
Sb	ME-MS42	ppm	0,08	0,05	< 0,05	< 0,05	0,05	< 0,05	0,39	0,24
Se	ME-MS42	ppm	4,9	5,5	5,4	< 0,2	< 0,2	< 0,2	2,2	0,5
Te	ME-MS42	ppm	0,85	1,49	1,32	0,04	0,01	0,01	0,87	0,08
Ag	ME-4ACD81	ppm	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	0,8	< 0,5
Cd	ME-4ACD81	ppm	1,5	1	0,7	2	< 0,5	< 0,5	0,6	0,5
Co	ME-4ACD81	ppm	120	143	120	39	4	5	17	39
Cu	ME-4ACD81	ppm	996	7 040	420	15	15	7	1 110	329
Mo	ME-4ACD81	ppm	< 1	< 1	1	<1	< 1	< 1	7	3
Ni	ME-4ACD81	ppm	32	51	48	47	3	< 1	39	98
Pb	ME-4ACD81	ppm	3	< 2	< 2	< 2	< 2	2	220	33
Sc	ME-4ACD81	ppm	< 1	7	< 1	5	< 1	< 1	11	12
Zn	ME-4ACD81	ppm	25	14	19	43	4	5	68	53
Li	ME-4ACD81	ppm	< 10	< 10	< 10	< 10	< 10	< 10	30	10
Tl	ME-MS42	ppm	0,02	0,1	0,02	< 0,02	< 0,02	< 0,02	0,04	< 0,01
Cl	Cl-IC881	ppm	300	< 50	< 50	550	190	450	1 220	5 980
Cu	Cu-OG62	%								
Au	PGM-ICP23	ppm	0,005	0,049	< 0,001	0,001		< 0,001	0,096	0,003
Pt	PGM-ICP23	ppm	< 0,005	< 0,005	< 0,005	0,01		< 0,005	< 0,005	< 0,005
Pd	PGM-ICP23	ppm	0,005	0,003	0,005	0,016		< 0,001	0,004	< 0,001

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz

Appendix 2. Continuation.

ID			**TOB140006B**	**TOB140006C**	**TOB140006D**	**TOB140010A**	**TOB140010B**	**TOB140011A**	**TOB140012A**	**TOB140013A**
N			7438950	7438950	7438950	7470464	7470464	7468870	7469806	7468242
E			862960	862960	862960	840688	840688	842366	843453	839738
ORED ID			25508	25508	25508	15739	15739	20241	317	25511
Prospect			Romiovaara Cu	Romiovaara Cu	Romiovaara Cu	Kuusivaaranvinsa, rock rubble	Kuusivaaranvinsa, rock rubble	Ukonpalo	Suorsapakka	Kuusivaara
Rock			Qz-vein, py diss.	Qz-vein, px-skar, py	Massive py	Andesite, py, cpy diss	Andesite, py, cpy diss	Felsic volc. Py, cpy diss	Andesite, mt, py diss	Qz-vein, py
SiO2	ME-ICP06	%	89,1	52,1	5,59	54,5	51,9	68,1	38,8	62,8
Al2O3	ME-ICP06	%	5,17	10,45	0,63	14,65	14,4	11,65	8,33	11,4
Fe2O3	ME-ICP06	%	1,24	18,75	52	9,01	10,35	10,3	29	12,4
CaO	ME-ICP06	%	0,98	3,74	0,81	8,08	6,62	0,44	14,1	2,82
MgO	ME-ICP06	%	0,16	3,6	0,29	4,19	3,13	0,62	8,08	2,08
Na2O	ME-ICP06	%	1,59	2,06	0,06	3,8	3,36	3,21	0,76	2
K2O	ME-ICP06	%	0,38	0,35	0,06	2,28	3,2	3,12	0,58	1,75
Cr2O3	ME-ICP06	%	0,01	0,01	< 0,01	0,03	0,02	0,01	0,02	0,01
TiO2	ME-ICP06	%	0,04	0,38	0,7	0,99	0,94	0,46	0,44	0,49
MnO	ME-ICP06	%	0,01	0,1	0,01	0,14	0,12	0,02	0,54	0,05
P2O5	ME-ICP06	%	< 0,01	0,32	0,13	0,44	0,51	0,13	0,19	0,16
SrO	ME-ICP06	%	0,01	0,01	< 0,01	0,06	0,06	0,01	0,02	0,03
BaO	ME-ICP06	%	0,01	0,01	< 0,01	0,06	0,14	0,14	< 0,01	0,08
C	C-IR07	%	< 0,01	0,08	0,01	0,12	0,11	< 0,01	0,03	0,01
S	S-IR08	%	0,43	6,79	47,1	2,1	3,08	0,94	0,04	4,99
LOI	OA-GRA05	%	0,59	6,47	31,1	1,95	3,3	1,04	0,72	4,72
Ba	ME-MS81	ppm	110	60,4	6,1	583	1 335	1 315	43,8	649
Ce	ME-MS81	ppm	15,2	14,4	54,5	44,5	45	32	65,3	72,4
Cr	ME-MS81	ppm	30	20	10	220	170	80	130	60
Cs	ME-MS81	ppm	0,42	1,12	0,21	1,62	3,3	1,05	0,02	2,01
Dy	ME-MS81	ppm	0,82	1,37	3,02	4,55	4,79	2,26	2,8	3,07
Er	ME-MS81	ppm	0,51	0,96	1,58	2,39	2,19	1,57	1,44	1,36
Eu	ME-MS81	ppm	0,25	0,46	1,29	1,55	1,86	0,56	2,21	1,17
Ga	ME-MS81	ppm	5,5	11	1,8	17	16,9	10,3	10,9	16,5
Gd	ME-MS81	ppm	0,82	1,7	3,54	5,98	6,71	2,46	4,46	5,08
Hf	ME-MS81	ppm	0,5	1	0,3	3,8	4	5,7	1,9	3
Ho	ME-MS81	ppm	0,12	0,23	0,53	0,79	0,84	0,43	0,44	0,5
La	ME-MS81	ppm	9,1	8,3	22,4	19,7	19	15	35	58,5
Lu	ME-MS81	ppm	0,03	0,08	0,2	0,26	0,25	0,18	0,13	0,15
Nb	ME-MS81	ppm	1,5	1,9	5,7	11,6	12,7	8,2	4,4	9
Nd	ME-MS81	ppm	6,6	8,4	24,7	27,6	30,7	15,2	30,4	38,5
Pr	ME-MS81	ppm	1,6	1,82	6,06	5,97	6,4	3,71	7,31	9,94
Rb	ME-MS81	ppm	16,7	7,4	1,7	50	82,9	63,4	4,7	69,4
Sm	ME-MS81	ppm	1,28	1,53	4,39	6,52	7,19	3,08	5,62	6,58
Sn	ME-MS81	ppm	1	1	< 1	2	2	3	1	1
Sr	ME-MS81	ppm	172	148	7,6	437	467	100,5	194,5	324
Ta	ME-MS81	ppm	1,7	0,8	0,4	0,7	1	2,2	1,9	1,1
Tb	ME-MS81	ppm	0,12	0,19	0,49	0,75	0,87	0,32	0,52	0,57
Th	ME-MS81	ppm	3,76	0,49	3,66	8,01	9,22	13,35	3,65	4,97
Tm	ME-MS81	ppm	0,02	0,05	0,19	0,27	0,28	0,2	0,14	0,13
U	ME-MS81	ppm	1,8	0,75	2,72	1,73	3,16	3,18	3,06	4,41
V	ME-MS81	ppm	9	76	33	144	188	45	114	103
W	ME-MS81	ppm	< 1	1	1	1	1	12	1	2
Y	ME-MS81	ppm	3,6	7,3	14	21,8	20,6	11,4	13,7	13,6
Yb	ME-MS81	ppm	0,52	0,8	1,48	2,22	1,91	1,55	1,11	1,51
Zr	ME-MS81	ppm	19	38	6	154	151	233	76	120
As	ME-MS42	ppm	0,4	37	37,2	1,6	3,2	0,4	0,8	1,4
Bi	ME-MS42	ppm	25,4	0,3	0,3	0,16	0,87	0,07	0,11	0,53
Hg	ME-MS42	ppm	< 0,005	< 0,005	0,02	< 0,005	0,022	0,009	< 0,005	< 0,005
Sb	ME-MS42	ppm	0,05	0,14	6,91	0,14	0,22	< 0,05	0,2	0,08
Se	ME-MS42	ppm	11,1	6,1	21	4,2	6,6	1,1	< 0,2	6,6
Te	ME-MS42	ppm	2,34	0,54	4,74	0,23	0,74	0,3	< 0,01	0,61
Ag	ME-4ACD81	ppm	8,5	0,9	1,7	< 0,5	3,1	0,6	< 0,5	0,6
Cd	ME-4ACD81	ppm	0,6	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
Co	ME-4ACD81	ppm	2	294	3 650	46	152	27	44	255
Cu	ME-4ACD81	ppm	> 10 000	2 780	2 530	394	4 660	8 790	150	855
Mo	ME-4ACD81	ppm	< 1	< 1	5	< 1	12	< 1	< 1	2
Ni	ME-4ACD81	ppm	5	561	1 940	38	47	22	37	70
Pb	ME-4ACD81	ppm	17	10	86	4	5	< 2	< 2	6
Sc	ME-4ACD81	ppm	1	25	3	22	23	7	13	11
Zn	ME-4ACD81	ppm	12	68	< 2	79	109	9	96	36
Li	ME-4ACD81	ppm	< 10	30	< 10	10	20	10	10	10
Tl	ME-MS42	ppm	< 0,01	< 0,01	< 0,01	< 0,01	0,01	< 0,01	< 0,01	0,01
Cl	Cl-IC881	ppm	190	6 350	320	4 950	5 000	290	1 440	610
Cu	Cu-OG62	%	1,175							
Au	PGM-ICP23	ppm	2,59	0,047	0,039	0,003	0,112	0,132	< 0,001	0,033
Pt	PGM-ICP23	ppm	0,075	0,005	0,058	< 0,005	< 0,005	< 0,005	< 0,005	0,005
Pd	PGM-ICP23	ppm	0,202	< 0,001	0,036	< 0,001	0,001	< 0,001	< 0,001	0,001

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz

Appendix 2. Continuation.

ID			TOB140013B	TOB140019A	TOB140021A	TOB140022A	TOB140023A	TOB140024A	TOB140025A	TOB140029A
N			7468242	7449628	7482823	7496166	7496199	7500738	7500663	7491138
E			839738	838210	841347	840668	840639	838081	838166	840776
ORED ID			25511	351	15740	25514	25515	25516	25517	25518
Prospect			Kuusivaara	Kartovaara	Peräjävaara	Vinsa 1	Vinsa 2	Pahturijärvi 1	Pahturijärvi 2	Marjarova 1
Rock			Qz-vein, py	Epidote skarn, mt-ht-py	Rhyolite-mt-apatite	Skarn mt-Mn ore	Skarn mt-Mn ore	Skarn mt-Mn ore	Skarn mt-Mn ore	BIF, hem-mt-Mn ore
SiO2	ME-ICP06	%	75,7	18	33,4	54,2	37,7	27,1	27,3	42,6
Al2O3	ME-ICP06	%	8,54	6,4	5,99	0,25	2,55	0,14	0,97	0,25
Fe2O3	ME-ICP06	%	6,99	64,7	43,8	21	46	57,1	56,5	53,3
CaO	ME-ICP06	%	1,64	5,97	4,83	15,9	2,07	10,3	4,79	0,27
MgO	ME-ICP06	%	1,04	0,57	3,75	4,6	4,59	3,18	5,37	2,12
Na2O	ME-ICP06	%	1,99	0,05	1,8	0,18	0,1	0,25	0,09	0,02
K2O	ME-ICP06	%	0,99	0,2	2,54	0,07	0,55	0,04	0,06	0,05
Cr2O3	ME-ICP06	%	0,01	< 0,01	< 0,01	< 0,01	0,01	< 0,01	< 0,01	0,01
TiO2	ME-ICP06	%	0,25	0,09	0,89	0,01	0,25	0,02	0,05	0,01
MnO	ME-ICP06	%	0,03	0,03	0,21	3,15	5,23	1,43	3,51	1,98
P2O5	ME-ICP06	%	0,09	0,81	0,64	0,04	0,22	0,08	0,25	0,01
SrO	ME-ICP06	%	0,02	0,03	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01
BaO	ME-ICP06	%	0,04	< 0,01	0,12	0,02	1,48	< 0,01	0,01	< 0,01
C	C-IR07	%	< 0,01	0,01	0,04	0,17	0,02	0,01	0,09	0,02
S	S-IR08	%	3,36	1,92	0,05	0,01	0,09	0,16	0,03	0,06
LOI	OA-GRA05	%	2,92	2,45	1,12	0,11	- 0,8	- 1,32	- 0,07	- 1,22
Ba	ME-MS81	ppm	337	16,9	1 140	206	> 10 000	88	57	34,4
Ce	ME-MS81	ppm	42,3	690	301	10,8	13,6	13,4	18,6	6,3
Cr	ME-MS81	ppm	40	20	10	10	40	10	20	20
Cs	ME-MS81	ppm	1,41	0,22	0,04	0,12	2,04	0,03	< 0,01	< 0,01
Dy	ME-MS81	ppm	1,43	8,22	16,65	1,32	3,21	0,69	3,3	0,66
Er	ME-MS81	ppm	0,77	3,56	9,66	0,68	1,95	0,42	2,58	0,65
Eu	ME-MS81	ppm	0,67	5,02	2,74	0,26	0,36	0,16	0,62	0,07
Ga	ME-MS81	ppm	11,3	16,5	22	3,2	7,6	5,1	7,9	3,3
Gd	ME-MS81	ppm	2,62	14,55	19,25	1,16	2,65	0,68	2,95	0,4
Hf	ME-MS81	ppm	2,1	0,6	4,6	0,2	0,8	< 0,2	0,7	< 0,2
Ho	ME-MS81	ppm	0,22	1,23	3,08	0,23	0,62	0,14	0,73	0,17
La	ME-MS81	ppm	29,5	275	127	4,5	6,5	6	5,7	3,7
Lu	ME-MS81	ppm	0,05	0,27	1,79	0,02	0,18	< 0,01	0,17	0,07
Nb	ME-MS81	ppm	5	13,1	11,7	0,6	3,3	1	5,9	1
Nd	ME-MS81	ppm	21,9	229	135,5	5	6,3	4,4	8	2,4
Pr	ME-MS81	ppm	5,41	63,8	34,8	1,07	1,37	1,13	1,5	0,62
Rb	ME-MS81	ppm	45	5,6	32,9	0,8	17,5	0,6	0,6	0,4
Sm	ME-MS81	ppm	3,79	29	24,1	1	1,5	0,75	2,07	0,29
Sn	ME-MS81	ppm	1	2	7	< 1	1	< 1	< 1	3
Sr	ME-MS81	ppm	233	274	47,2	52,8	22,1	15,1	21,7	3,8
Ta	ME-MS81	ppm	0,6	0,2	0,7	0,4	0,2	0,1	0,2	0,3
Tb	ME-MS81	ppm	0,24	1,65	2,71	0,15	0,45	0,09	0,46	0,04
Th	ME-MS81	ppm	3,52	102,5	28,8	0,48	0,82	< 0,05	0,34	0,68
Tm	ME-MS81	ppm	0,07	0,35	1,37	0,05	0,23	0,02	0,26	0,06
U	ME-MS81	ppm	3,34	19,7	1,87	0,18	0,83	0,31	0,85	0,09
V	ME-MS81	ppm	46	99	532	16	67	41	107	17
W	ME-MS81	ppm	1	4	2	1	1	1	1	< 1
Y	ME-MS81	ppm	6,3	30,4	88,4	8,2	22,5	5,1	25,6	6,5
Yb	ME-MS81	ppm	0,61	2,5	10,7	0,64	1,56	0,3	1,77	0,6
Zr	ME-MS81	ppm	74	22	169	12	39	16	54	10
As	ME-MS42	ppm	1,7	0,6	0,9	2,6	2,2	2,6	2,6	0,2
Bi	ME-MS42	ppm	0,43	0,06	0,02	0,06	0,14	0,04	0,23	0,01
Hg	ME-MS42	ppm	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,005	< 0,005
Sb	ME-MS42	ppm	0,06	0,07	< 0,05	0,18	0,17	0,08	0,18	< 0,05
Se	ME-MS42	ppm	2,9	1,5	1,5	< 0,2	0,2	0,3	0,3	< 0,2
Te	ME-MS42	ppm	0,52	0,14	< 0,01	< 0,01	0,06	0,23	0,5	0,01
Ag	ME-4ACD81	ppm	0,6	1	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
Cd	ME-4ACD81	ppm	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
Co	ME-4ACD81	ppm	137	143	34	28	37	9	16	25
Cu	ME-4ACD81	ppm	861	4 440	21	21	3	45	41	4
Mo	ME-4ACD81	ppm	2	< 1	< 1	< 1	< 1	<1	< 1	< 1
Ni	ME-4ACD81	ppm	45	8	48	8	23	16	< 1	1
Pb	ME-4ACD81	ppm	14	12	5	5	4	4	3	< 2
Sc	ME-4ACD81	ppm	5	2	7	< 1	4	< 1	1	< 1
Zn	ME-4ACD81	ppm	26	8	68	121	207	58	176	56
Li	ME-4ACD81	ppm	10	< 10	10	20	20	< 10	< 10	< 10
Tl	ME-MS42	ppm	< 0,01	< 0,01	0,01	< 0,01	< 0,01	< 0,01	< 0,01	< 0,01
Cl	Cl-IC881	ppm	470	160	140	430	6 690	120	200	330
Cu	Cu-OG62	%								
Au	PGM-ICP23	ppm	0,016	0,028	< 0,001	< 0,001	0,005	0,013	0,012	< 0,001
Pt	PGM-ICP23	ppm	0,017	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005
Pd	PGM-ICP23	ppm	0,004	< 0,001	< 0,001	< 0,001	0,001	< 0,001	< 0,001	< 0,001

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz

Appendix 2. Continuation.

ID			TOB140032A	TOB140033A	TOB140048A	TOB140049A	TOB150025A	TOB150025B	TOB150031A
N			7492808	7482791	7481843	7481871	7581428	7581428	7570698
E			841721	852472	811390	811366	778862	778862	793705
ORED ID			15741	15749	311	311	25652	25652	25654
Prospect			Muotkavuoma	Erkhekki	Oriasvaara	Oriasvaara	Akkiskero	Akkiskero	Outavaara I
Rock			Skarn mt ore	Qz-vein, cpy, py	Qz-vein, cpy, py	Metaandesite, cpy, py	Metaandesite, cpy	Qz-vein, cpy	Metaandesite, mt-po
SiO2	ME-ICP06	%	39,5	48,2	87,9	49,1	45,4	97	38,7
Al2O3	ME-ICP06	%	1,05	13,05	3,43	7,4	15,25	0,15	8,92
Fe2O3	ME-ICP06	%	29,2	15,4	1,71	10,3	13,3	0,32	25,5
CaO	ME-ICP06	%	16,6	6,17	2,86	14,9	8,52	0,25	2,8
MgO	ME-ICP06	%	10,25	6,18	0,18	8,5	5,93	0,01	1,6
Na2O	ME-ICP06	%	0,34	4,11	0,27	0,57	3,84	0,04	4,12
K2O	ME-ICP06	%	0,23	2,76	1,72	3,87	0,15	0,02	0,19
Cr2O3	ME-ICP06	%	< 0,01	0,02	0,01	0,07	0,05	< 0,01	0,02
TiO2	ME-ICP06	%	0,24	0,79	0,02	1,19	1,32	0,01	0,6
MnO	ME-ICP06	%	0,51	0,09	0,04	0,35	0,24	0,01	0,03
P2O5	ME-ICP06	%	0,01	0,07	< 0,01	0,11	0,09	< 0,01	0,29
SrO	ME-ICP06	%	< 0,01	< 0,01	0,01	< 0,01	< 0,01	< 0,01	0,01
BaO	ME-ICP06	%	0,04	0,05	0,37	0,42	< 0,01	< 0,01	0,01
C	C-IR07	%	0,03	0,49	0,45	0,04	0,69	0,06	0,07
S	S-IR08	%	0,32	0,22	0,05	2,57	0,08	0,02	14,95
LOI	OA-GRA05	%	0,14	2,5	1,69	4,07	4,23	1	15,4
Ba	ME-MS81	ppm	365	466	3 480	3 920	13,3	1,6	47,1
Ce	ME-MS81	ppm	12,2	7	7,6	28,6	8,7	0,5	61,6
Cr	ME-MS81	ppm	10	110	40	540	370	20	160
Cs	ME-MS81	ppm	0,02	0,56	0,16	0,83	< 0,01	< 0,01	0,04
Dy	ME-MS81	ppm	1,93	3,57	0,35	3,52	5,21	< 0,05	8,16
Er	ME-MS81	ppm	1,3	2,55	0,19	1,74	3,75	< 0,03	5,07
Eu	ME-MS81	ppm	0,79	0,67	0,14	1,36	0,93	< 0,03	1,34
Ga	ME-MS81	ppm	7,5	20,1	3,4	10,8	21,7	0,5	12,6
Gd	ME-MS81	ppm	2,01	2,5	0,59	3,94	4,07	< 0,05	8,69
Hf	ME-MS81	ppm	0,4	1,4	0,7	2,6	2,4	< 0,2	2,3
Ho	ME-MS81	ppm	0,42	0,77	0,05	0,59	1,17	< 0,01	1,68
La	ME-MS81	ppm	5	3,9	4,6	12,1	3,7	0,5	21,8
Lu	ME-MS81	ppm	0,07	0,28	< 0,01	0,12	0,5	< 0,01	0,59
Nb	ME-MS81	ppm	1,2	0,4	0,2	7,4	3,5	< 0,2	6,7
Nd	ME-MS81	ppm	6,7	4,2	3,3	17,4	7,9	0,2	34,6
Pr	ME-MS81	ppm	1,37	0,87	0,81	3,9	1,43	0,05	8,8
Rb	ME-MS81	ppm	3,5	64,6	27,3	95,5	2	0,4	4,4
Sm	ME-MS81	ppm	1,7	1,38	0,65	4,25	2,74	0,04	8,14
Sn	ME-MS81	ppm	5	< 1	< 1	2	1	1	1
Sr	ME-MS81	ppm	17,3	81,4	85,7	61,9	89,8	2,6	152
Ta	ME-MS81	ppm	0,8	0,5	1,1	0,7	0,2	< 0,1	0,4
Tb	ME-MS81	ppm	0,28	0,48	0,04	0,57	0,77	< 0,01	1,3
Th	ME-MS81	ppm	0,53	0,08	0,73	3,6	0,51	0,1	10,4
Tm	ME-MS81	ppm	0,12	0,25	< 0,01	0,2	0,46	0,01	0,68
U	ME-MS81	ppm	0,67	0,19	0,44	2,5	0,23	0,06	137
V	ME-MS81	ppm	88	345	17	220	386	< 5	1 150
W	ME-MS81	ppm	< 1	1	1	2	< 1	< 1	3
Y	ME-MS81	ppm	13,2	19,5	1,7	15,6	30,3	< 0,5	59,2
Yb	ME-MS81	ppm	0,98	2,29	0,13	1,45	3,13	< 0,03	4,2
Zr	ME-MS81	ppm	20	40	26	102	76	2	90
As	ME-MS42	ppm	0,2	0,5	3,5	6,3	0,1	0,3	1,2
Bi	ME-MS42	ppm	0,01	0,02	0,05	0,43	0,05	< 0,01	2,56
Hg	ME-MS42	ppm	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005
Sb	ME-MS42	ppm	0,05	< 0,05	0,09	0,12	< 0,05	0,05	0,06
Se	ME-MS42	ppm	0,3	0,9	0,2	1,6	1,1	< 0,2	25,3
Te	ME-MS42	ppm	0,04	< 0,01	0,03	0,68	0,02	< 0,01	1,65
Ag	ME-4ACD81	ppm	< 0,5	< 0,5	< 0,5	0,7	< 0,5	< 0,5	0,9
Cd	ME-4ACD81	ppm	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5	< 0,5
Co	ME-4ACD81	ppm	8	68	5	64	68	3	466
Cu	ME-4ACD81	ppm	24	294	73	2 550	4 690	202	4 700
Mo	ME-4ACD81	ppm	< 1	< 1	7	4	< 1	1	1 630
Ni	ME-4ACD81	ppm	5	76	2	106	162	1	864
Pb	ME-4ACD81	ppm	< 2	< 2	< 2	2	< 2	< 2	36
Sc	ME-4ACD81	ppm	1	41	< 1	21	51	< 1	13
Zn	ME-4ACD81	ppm	34	27	13	54	117	9	30
Li	ME-4ACD81	ppm	10	< 10	< 10	20			
Tl	ME-MS42	ppm	< 0,01	< 0,01	< 0,01	0,01	< 0,02	< 0,02	0,12
Cl	Cl-IC881	ppm	260	7 790	440	210	830	< 50	< 50
Cu	Cu-OG62	%							
Au	PGM-ICP23	ppm	< 0,001	< 0,001	< 0,001	0,019	0,005	< 0,001	0,007
Pt	PGM-ICP23	ppm	< 0,005	0,022	< 0,005	0,017	0,017	< 0,005	< 0,005
Pd	PGM-ICP23	ppm	< 0,001	0,046	0,002	0,014	0,015	< 0,001	0,016

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz

Appendix 2. Continuation.

ID			TOB150031B	TOB150031C	TOB150032A	TOB150032B	TOB150033A	TOB150034A	TOB150039B
N			7570698	7570698	7438908	7438908	7451692	7449246	7494850
E			793705	793705	862947	862947	784467	783931	813688
ORED ID			25654	25654	25508	25508	343	255	15399
Prospect			Outavaara I	Outavaara I	Romiovaara Cu	Romiovaara Cu	Suorravaara	Vähävaara	Kotasenrova
Rock			Metaandesite, mt-po	Metaandesite, mt-po	Qz-fsp-vein	Qz-fsp-vein	Metaandesite, bn, cpy	Pegmatite, modn, cpy	Qz-cc-vein, cpy
SiO2	ME-ICP06	%	46	42	53,3	59,8	58,6	72,7	44,5
Al2O3	ME-ICP06	%	10,9	10,75	15,85	16,1	16,95	11,65	11,5
Fe2O3	ME-ICP06	%	21,3	26,7	10,3	7,41	8,03	3,1	6,09
CaO	ME-ICP06	%	4,87	4,46	6,75	5,59	5,8	2,85	12,55
MgO	ME-ICP06	%	2,08	1,77	3,82	1,63	0,93	0,41	6,05
Na2O	ME-ICP06	%	4,78	4,71	3,83	5,39	3,55	4,07	5,64
K2O	ME-ICP06	%	0,21	0,17	2,57	1,67	3,12	0,47	0,28
Cr2O3	ME-ICP06	%	0,02	0,02	0,01	< 0,01	< 0,01	< 0,01	0,02
TiO2	ME-ICP06	%	0,73	0,76	1,5	0,94	0,99	0,09	0,9
MnO	ME-ICP06	%	0,06	0,05	0,15	0,05	0,11	0,06	0,1
P2O5	ME-ICP06	%	0,07	0,17	0,46	0,48	0,63	0,47	0,07
SrO	ME-ICP06	%	0,01	0,01	0,05	0,04	0,06	0,04	< 0,01
BaO	ME-ICP06	%	0,01	0,01	0,18	0,06	0,12	0,01	< 0,01
C	C-IR07	%	0,05	0,03	0,06	0,23	0,02	0,03	3,36
S	S-IR08	%	9,72	12,4	0,33	1,48	0,04	1,95	0,07
LOI	OA-GRA05	%	7,54	9,55	1,1	2,52	0,51	1,53	11,05
Ba	ME-MS81	ppm	46	55,7	1 560	470	1 045	130,5	16,1
Ce	ME-MS81	ppm	54,1	47	72,7	38	81,9	13,4	1,8
Cr	ME-MS81	ppm	160	140	40	30	10	20	180
Cs	ME-MS81	ppm	0,07	0,03	0,95	2,41	2,76	14,95	0,08
Dy	ME-MS81	ppm	5,66	4,86	5,87	7,98	6,16	1,56	5,83
Er	ME-MS81	ppm	4,08	3,12	3,2	5,2	3,25	0,78	3,84
Eu	ME-MS81	ppm	1,57	1,46	2,18	1,51	1,91	0,33	0,66
Ga	ME-MS81	ppm	16,6	15,3	21,6	18,4	21,6	32,1	13,6
Gd	ME-MS81	ppm	5,64	5,17	6,86	6,01	7,65	1,71	3,2
Hf	ME-MS81	ppm	2,6	2,6	5,9	9,3	8,8	0,6	1,5
Ho	ME-MS81	ppm	1,16	0,99	1,06	1,57	1,16	0,23	1,18
La	ME-MS81	ppm	17,1	17,4	35,5	19,5	38,6	6,6	1
Lu	ME-MS81	ppm	0,6	0,52	0,39	0,63	0,44	0,14	0,39
Nb	ME-MS81	ppm	7,7	9	9,8	16,7	24,1	25,1	2
Nd	ME-MS81	ppm	28	24,2	40,2	18,3	44,1	6,9	1,8
Pr	ME-MS81	ppm	7,49	6,48	9,65	4,58	11,2	1,75	0,3
Rb	ME-MS81	ppm	3,3	1,9	55,5	61,2	85,2	114,5	7,7
Sm	ME-MS81	ppm	5,42	4,66	7,89	4,81	8,79	1,84	1,22
Sn	ME-MS81	ppm	1	1	1	1	3	3	1
Sr	ME-MS81	ppm	186,5	185	560	454	608	354	73,3
Ta	ME-MS81	ppm	0,6	0,6	0,6	2,9	1,5	6,1	0,2
Tb	ME-MS81	ppm	0,83	0,75	1	1,12	1,05	0,25	0,7
Th	ME-MS81	ppm	5,47	3,81	3,43	40,8	15,6	3,4	0,15
Tm	ME-MS81	ppm	0,52	0,45	0,39	0,76	0,42	0,11	0,49
U	ME-MS81	ppm	47,3	21,1	1,4	10,95	5,18	9,41	0,16
V	ME-MS81	ppm	1 090	938	211	96	80	43	226
W	ME-MS81	ppm	1	1	<1	2	1	2	< 1
Y	ME-MS81	ppm	43,8	35,3	29,2	45,9	31,3	10,4	32,1
Yb	ME-MS81	ppm	3,74	2,69	2,86	4,96	2,76	0,92	2,9
Zr	ME-MS81	ppm	96	90	262	297	360	11	47
As	ME-MS42	ppm	1,2	1,1	1,2	12,2	6,5	2,6	0,3
Bi	ME-MS42	ppm	2,13	2,9	0,03	0,53	0,84	> 250	0,14
Hg	ME-MS42	ppm	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005	< 0,005
Sb	ME-MS42	ppm	0,05	0,05	0,07	0,35	0,4	2,2	< 0,05
Se	ME-MS42	ppm	12,7	16,9	0,7	2	0,8	32,5	0,7
Te	ME-MS42	ppm	1,26	1,81	0,02	0,38	0,03	7,46	0,15
Ag	ME-4ACD81	ppm	0,6	< 0,5	< 0,5	< 0,5	1,3	47,1	< 0,5
Cd	ME-4ACD81	ppm	0,6	< 0,5	< 0,5	< 0,5	< 0,5	0,9	< 0,5
Co	ME-4ACD81	ppm	96	290	36	127	13	3	20
Cu	ME-4ACD81	ppm	1 280	1 150	160	1 480	1 110	> 10 000	536
Mo	ME-4ACD81	ppm	65	269	1	1	1	> 10 000	6
Ni	ME-4ACD81	ppm	654	736	37	82	< 1	2	35
Pb	ME-4ACD81	ppm	9	7	4	47	17	5	< 2
Sc	ME-4ACD81	ppm	16	16	25	3	11	4	40
Zn	ME-4ACD81	ppm	27	20	79	148	88	86	6
Li	ME-4ACD81	ppm							
Tl	ME-MS42	ppm	0,05	0,05	0,2	0,18	0,09	0,4	0,02
Cl	Cl-IC881	ppm	< 50	130	4 860	18 200	< 50	130	870
Cu	Cu-OG62	%						3,08	
Au	PGM-ICP23	ppm	< 0,001	0,001	< 0,001	0,003	0,038	1,425	0,019
Pt	PGM-ICP23	ppm	0,009	0,005	< 0,005	< 0,005	< 0,005	< 0,005	0,015
Pd	PGM-ICP23	ppm	0,017	0,02	0,001	< 0,001	0,001	< 0,001	0,024

po = pyrrhotite, cpy = chalcopyrite, cct = chalcocite, bn = bornite, mdn = molybdenite, mt = magnetite, amf = amphibole, act = actinolite, px = pyroxene, qz = quartz