BARENTS PROJECT 2014

Summary of geological and geophysical information of the Masugnsbyn key area

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Cover image: The lime kiln at Masugnsbyn dolomite quarry was built in 1952. Foto: Fredrik Hellström.

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INTRODUCTION

SGU's Barents mapping project (2012–2015) targets 14 geological key areas in northern Norrbotten for detailed studies with the aim to increase the knowledge about stratigraphy, mineralisations and the geological evolution of the region (Figs. 1–2). Increasing knowledge of the geology in the area is of fundamental importance for further mineral exploration. This report briefly summarises the existing geological and geophysical data of the Masugnsbyn key area, which is located c. 90 km south-east of Kiruna (Fig. 1). References to summary and field reports of the other key areas are given in Table 1.

The supracrustal sequence in the Masugnsbyn area consists of Karelian greenstones overlain by Svecofennian metasedimentary rocks and minor intermediate metavolcaniclastic units (Niiniskorpi 1986a, Padget 1970). Of economic interest are layers of iron mineralisations and dolomite between the greenstones and metasedimentary rocks, but also graphite layers within the volcaniclastic greenstones and base-metal, sulphide mineralisations in the sedimentary and volcaniclastic rocks (Geijer 1929, Padget 1970, Witschard et al. 1972, Grip & Frietsch 1973, Niiniskorpi 1986a, Frietsch 1997, Martinsson & Wanhainen 2013). The supracrustal sequence forms a large scale fold structure, including the Kalixälv dome, the Masugnsbyn syncline, the Saittajärvi anticline and the Oriasvaara syncline with the associated Kalixälv fault (Padget 1970), herein collectively referred to as the Masugnsbyn fold complex. A c. 400 km^2 large area was selected in this study to cover the supracrustal sequence and mineralisations of the Masugnsbyn fold complex.

Northern Sweden is one of the most important mining districts in Europe with world class mineral deposits, such as the Kiruna and Malmberget iron ores and the Aitik copper ore (Fig. 3). Apart from these major deposits, there are a large number of sub-economic to economic depos-

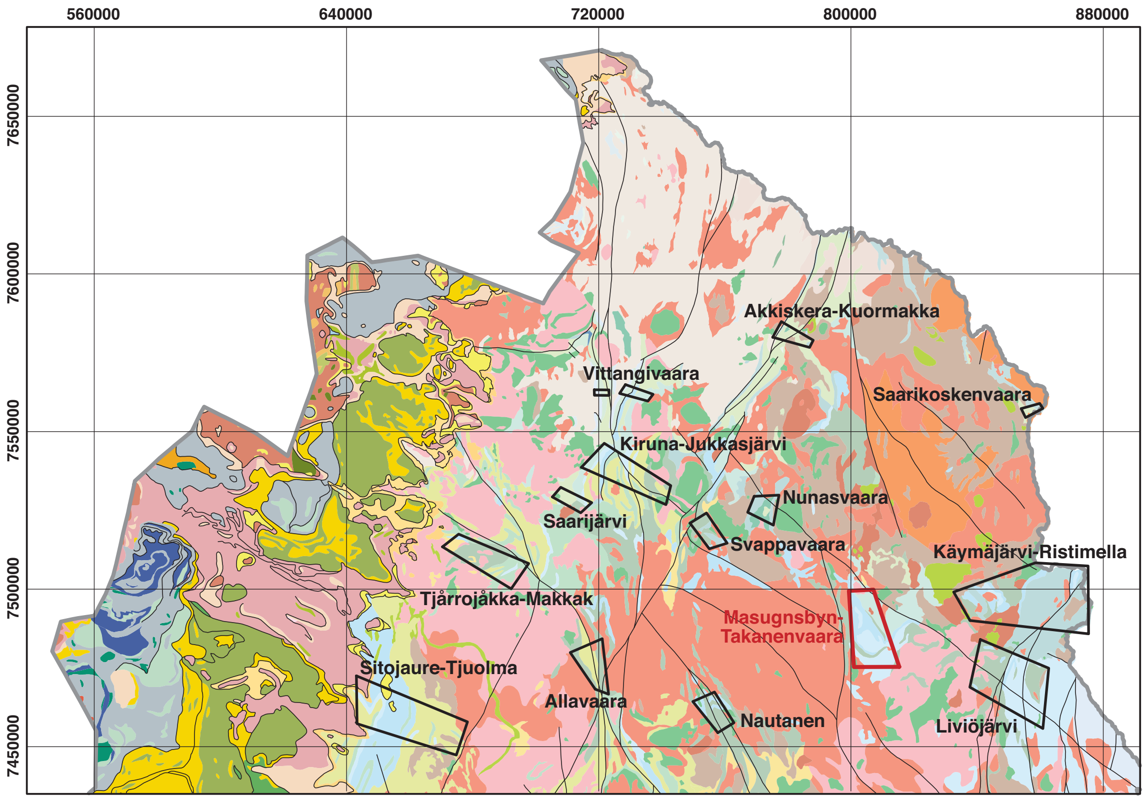


Figure 1. Geological map of northern Norrbotten showing the location of the Barents project key areas.

its containing Fe and Cu±Au (Figs. 3–5, Martinsson & Wanhainen 2013, Weihed et al. 2008). Nearly all known mineralisations are hosted by supracrustal rocks, and the Barents project key areas were selected to cover the complete stratigraphy of these (Fig. 2). Detailed work in solving questions specific to each key area will also answer regional-scale issues, including the correla-

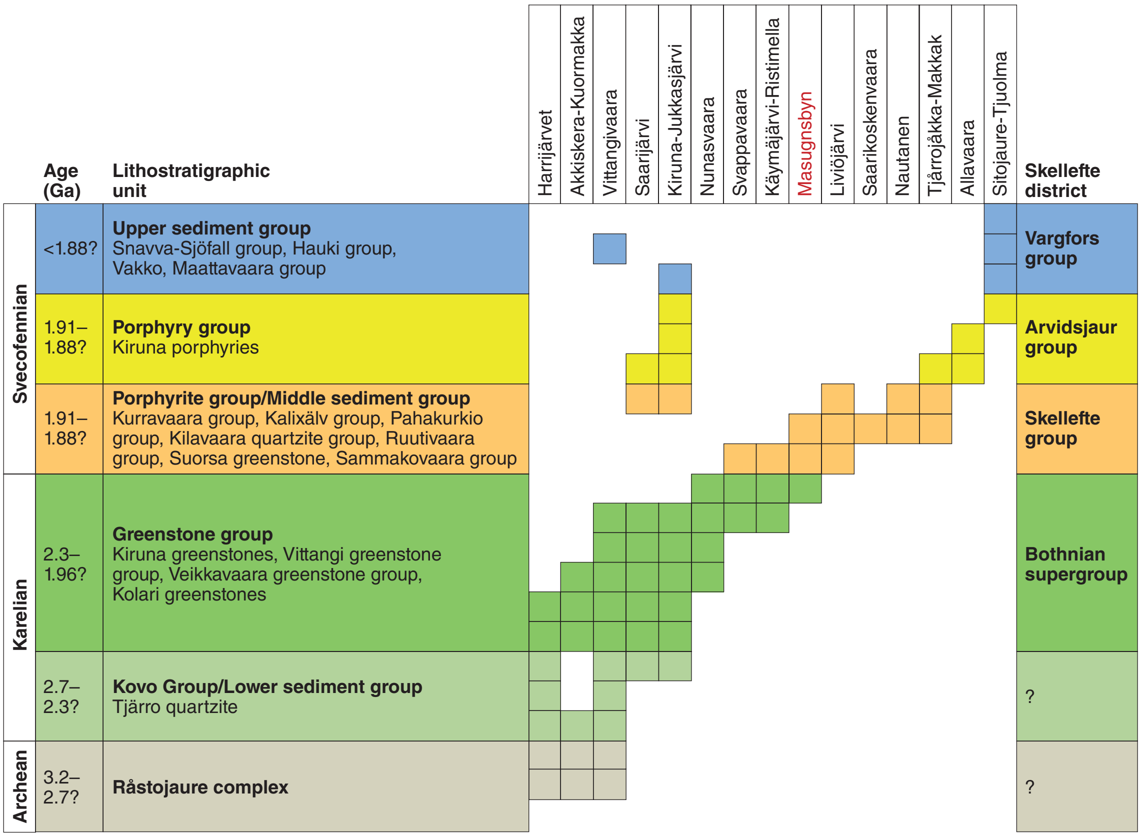


Figure 2. Tentative stratigraphic position of rocks in the Barents key areas. Ages of the stratigraphic groups are poorly constrained (modified after Bergman et al. 2001, Martinsson 2004 and Witschard 1984b).

Table 1. Summary and background reports of key areas in the Barents Project.

Key area	Report ID	Authors
Kiruna–Jukkasjärvi	SGU-rapport 2013:08; 2014:10	Grigull & Antal Lundin 2013; Grigull et al. 2014
Svappavaara	SGU-rapport 2013:09; 2014:10	Grigull & Jönberger 2013; Grigull et al. 2014
Nunasvaara	SGU-rapport 2013:10; 2014:04	Lynch & Jönberger 2013; Lynch et al. 2014
Saarijärvi	SGU-rapport 2013:11; 2014:04	Lynch & Jönberger 2013; Lynch et al. 2014
Akkiskera–Kuormakka	SGU-rapport 2013:12; 2014:09	Luth & Berggren 2013; Luth et al. 2014
Harrijärvet–Vittangivaara	SGU-rapport 2013:13; 2014:09	Luth & Antal Lundin 2013; Luth et al. 2014
Tjårrojåkka	SGU-rapport 2013:14; 2014:04	Lynch & Berggren 2013; Lynch et al. 2014
Masugnsbyn	This report	Hellström & Jönsson 2014
Käymäjärvi-Ristimella	In progress	Grigull & Berggren 2014
Sitojaure-Tjuolma		
Liviöjärvi	In progress	Luth & Jönsson 2014
Saarikoskenvaara	In progress	Luth & Jönsson 2014
Nautanen	In progress	Lynch & Jönberger 2014
Allavaara	In progress	Lynch & Jönberger 2014

Figure 3. Bedrock geological map of northern Sweden showing current mines. The map has been generated using the 1:1 million national bedrock database and the mineral and bedrock resources database (SGU). NLD = Norrbotten Lithotectonic domain. Modified from Martinsson & Wanhainen 2013.

tion of geological units between different areas across Norrbotten. General issues in the key areas are to characterise and improve the understanding of the following points:

- stratigraphy, geochemical signature and age of supracrustal rocks
- structural and metamorphic development of the bedrock
- mineralisations
- hydrothermal alterations.

OVERVIEW OF THE BEDROCK OF NORRBOTTEN

Regional reviews of the bedrock geology and metallogeny of northern Sweden are presented by e.g. Ödman (1957), Witschard (1984b) Bergman et al. (2001), Martinsson (2004), Weihed et al. (2005) and Martinsson & Wanhainen (2013). The Precambrian bedrock in northern Sweden includes a c. 3.2–2.6 Ga Archean granitoid-gneiss basement, the Råstojaure complex, which is unconformably overlain by Paleoproterozoic volcanic and sedimentary successions. Rift-related 2.5–2.0 Ga Karelian basic metavolcanic rocks and associated sedimentary rocks of the Kovo and Greenstone groups occur at the lowest stratigraphic level (Fig. 2). These are overlain by terrestrial to shallow-water, c. 1.9 Ga arc-related Svecofennian successions, represented by the calc-alkaline andesite-dominated Porphyrite group, the mildly alkaline volcanic rocks of the Porphyry group and, in the uppermost stratigraphic level, younger clastic sedimentary rocks (Fig. 2). The greenstones in the eastern part of Norrbotten differ from the Kiruna greenstones by the lack of

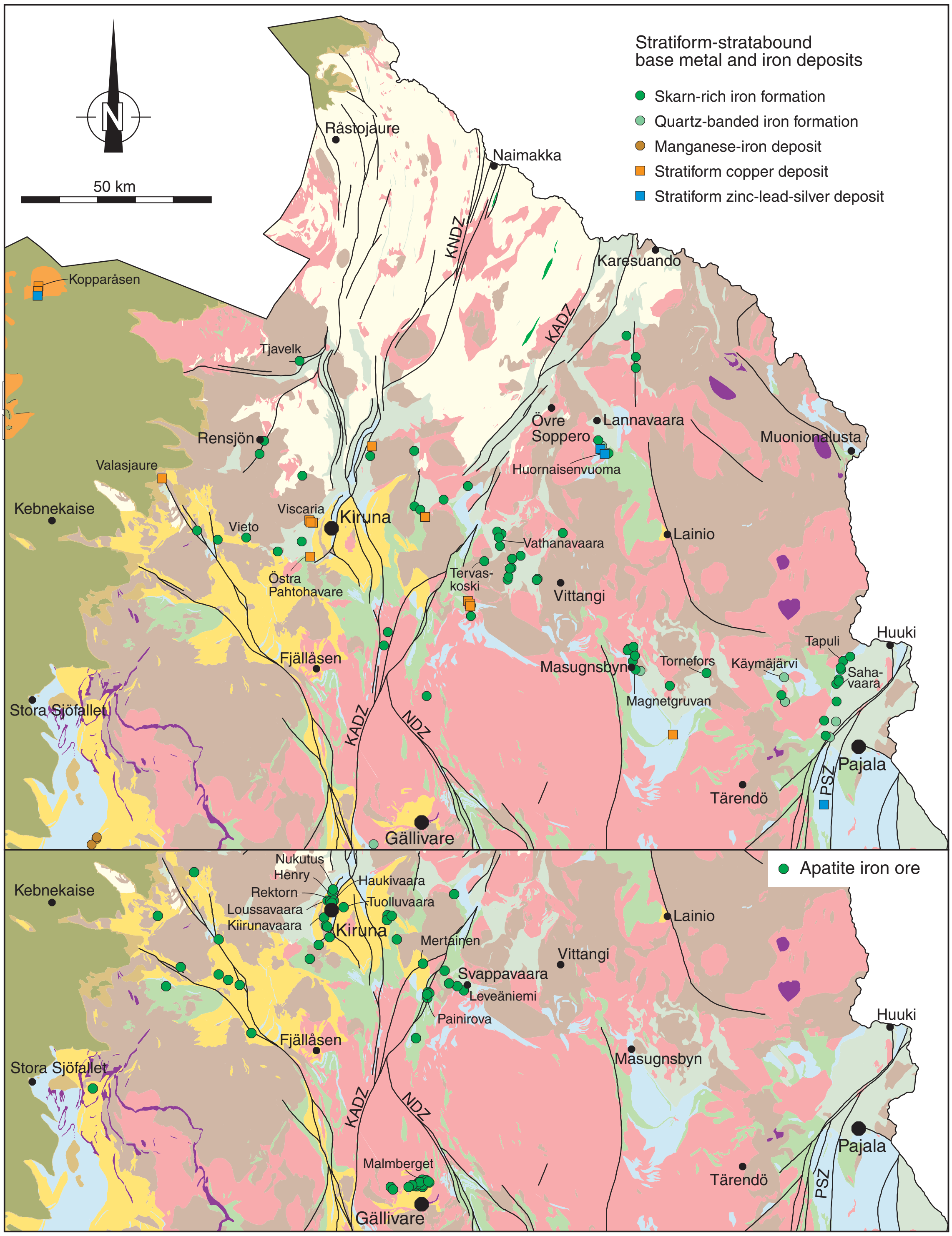


Figure 4. Simplified bedrock map of northern Norrbotten with occurrences of apatite iron ore and stratiform and stratabound base metal and iron deposits. KADZ = Karesuando–Arjeplog deformation zone, KNDZ = Kiruna–Naimakka deformation zone, NDZ = Nautanen deformation zone, PSZ = Pajala shear zone. Modified from Bergman et al. (2001).

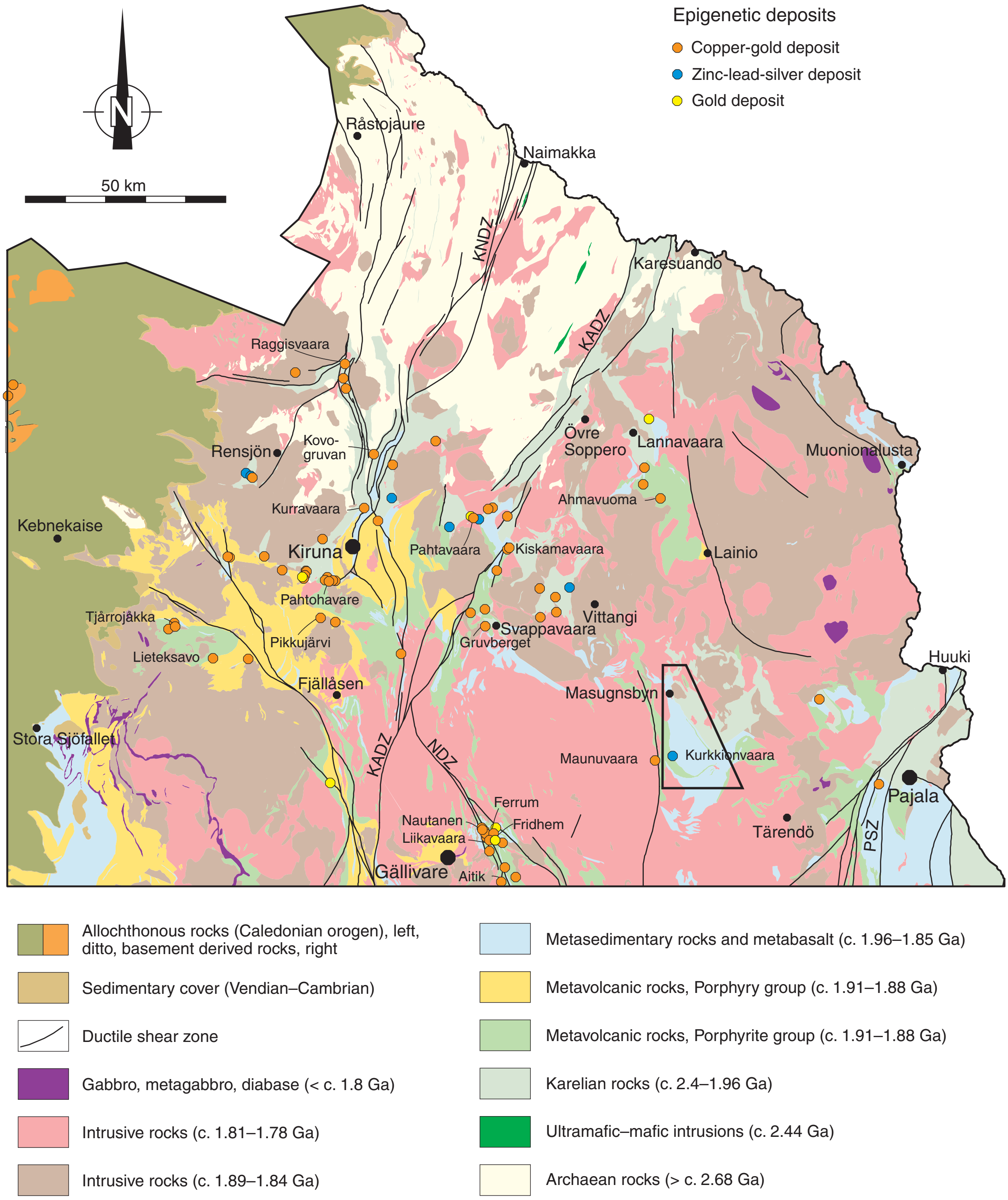


Figure 5. Simplified bedrock map of northern Norrbotten with occurrences of epigenetic mineral deposits. KADZ = Karesuando–Arjeplog deformation zone, KNDZ = Kiruna–Naimakka deformation zone, NDZ = Nautanen deformation zone, PSZ = Pajala shear zone. Modified from Bergman et al. (2001).

komatiites and basaltic pillow lavas. Graphitic schists and thick units of dolomite and banded iron formations followed deposition of a volcaniclastic unit of basaltic to picritic composition, typical for the uppermost part of the greenstones (Martinsson & Wanhainen 2013). The greenstone group contains stratiform Cu-Zn-Pb deposits in the middle and upper parts (Martinsson & Wanhainen 2013), whereas the Porphyry group hosts economically important apatite iron ores, e.g. the Kiirunavaara and Malmberget deposits (Fig. 4).

The northern Norrbotten area is characterised by an approximately north-north-east to north-north-west structural grain with a highly variable degree of deformation (Bergman et al. 2001). Intense deformation and high-grade metamorphism is found in the eastern part of the area, e.g. in the Pajala shear zone. Another important regional zone is the Karesuando–Arjeplog deformation zone, which transects the central part of the area (Fig. 5). There is evidence for at least two major phases of Svecokarelian deformation and metamorphism. The first phase of deformation and metamorphism occurred in the Archean. An event of folding, uplift and erosion prior to deposition of Svecofennian volcanic rocks has been suggested by Ambros (1980).

The Paleoproterozoic supracrustal rocks were intruded by the calc-alkaline, 1.89–1.88 Ga old Haparanda suite and the alkali-calcic, 1.88–1.86 Ga old Perthite monzonite suite, which are considered comagmatic with the Svecofennian volcanic rocks of the Porphyrite and Porphyry groups, respectively (Bergman et al. 2001, Witschard 1984b). An early Svecokarelian deformation and metamorphic event affected the Haparanda suite intrusions, but seems to mainly predate Perthite monzonite suite intrusions (Bergman et al. 2001). The Aitik Cu-Au-Ag deposit has been suggest to represent a porphyry copper system related to a 1.89 Ga quartz monzodiorite, later modified by hydrothermal and metamorphic events (Fig. 5, Wanhainen et al. 2012). 1.80–1.79 Ga old minimum-melt granites and pegmatites, referred to as Lina granite, occupy large areas of Norrbotten (Öhlander et al. 1987). These are not easily distinguished from older leucocratic granites. Coeval with the S-type rocks of the Lina suite are c. 1.80 Ga old I- to A-type magmatic rocks in Norrbotten belonging to the Edefors suite. These rocks are related to the Transcandinavian igneous belt that forms a 1 500 km long, north–south trending belt along the western part of the Svecokarelian domain. Younger events of metamorphism and deformation occurred at 1.86–1.85 Ga and c. 1.80 Ga (Bergman et al. 2006).

THE MASUGNSBYN KEY AREA

Masugnsbyn is the name of a small village situated 70 km to the north-east of Gällivare and 90 km to the east-south-east of Kiruna, on the Kiruna–Pajala road between Vittangi and Junosuando. Iron ore was discovered at Masugnsbyn already in 1644, the first discovery of iron in Norrbotten (Geijer 1929). A blast furnace (masugn) built soon after appears to be the northernmost of its kind in the world, situated at latitude of 67°27'. The operation of the blast furnace ended 1805, but the ore at Magnetgruvan was mined intermittently on a small scale until at least 1870 (Geijer 1929). The settlement at the deposit was named Junosuando Masugnsby after the nearest village 20 km to the east, now shortened to simply Masugnsbyn.

The Masugnsbyn iron ores form a more or less regular sheet which apparently is concordant with the stratigraphy of the surrounding supracrustal rocks in a structure defined as the Masugnsbyn syncline (Padget 1970, Witschard et al. 1972). Mafic volcaniclastic units of the Veikkavaara and Vinsa groups, i.e. the upper part of the Greenstone group, are overlain by the Svecofennian Pahakurkio and Kalixälv groups, consisting of arenitic to pelitic metasedimentary rocks and minor intermediate volcaniclastics units (Martinsson 2004, Martinsson & Wanhainen 2013, Padget 1970). The Masugnsbyn iron ores and a unit of dolomite occur in the top part of the greenstones. Dolomite is currently mined in a quarry at Masugnsbyn by LKAB for use as an additive in producing iron pellets.

TOPOGRAPHY

The topography in the area is typical for this part of Sweden with bogs and low, wooded hills, culminating at Jakkumus (530 m, Fig. 6). The river Kalixälven cuts the key area in an east-south-easterly direction just south of Masugnsbyn. The river Torne älv flows in the same direction. A striking feature in the landscape east of Masugnsbyn is the Rautajokk canyon (Isokursu),

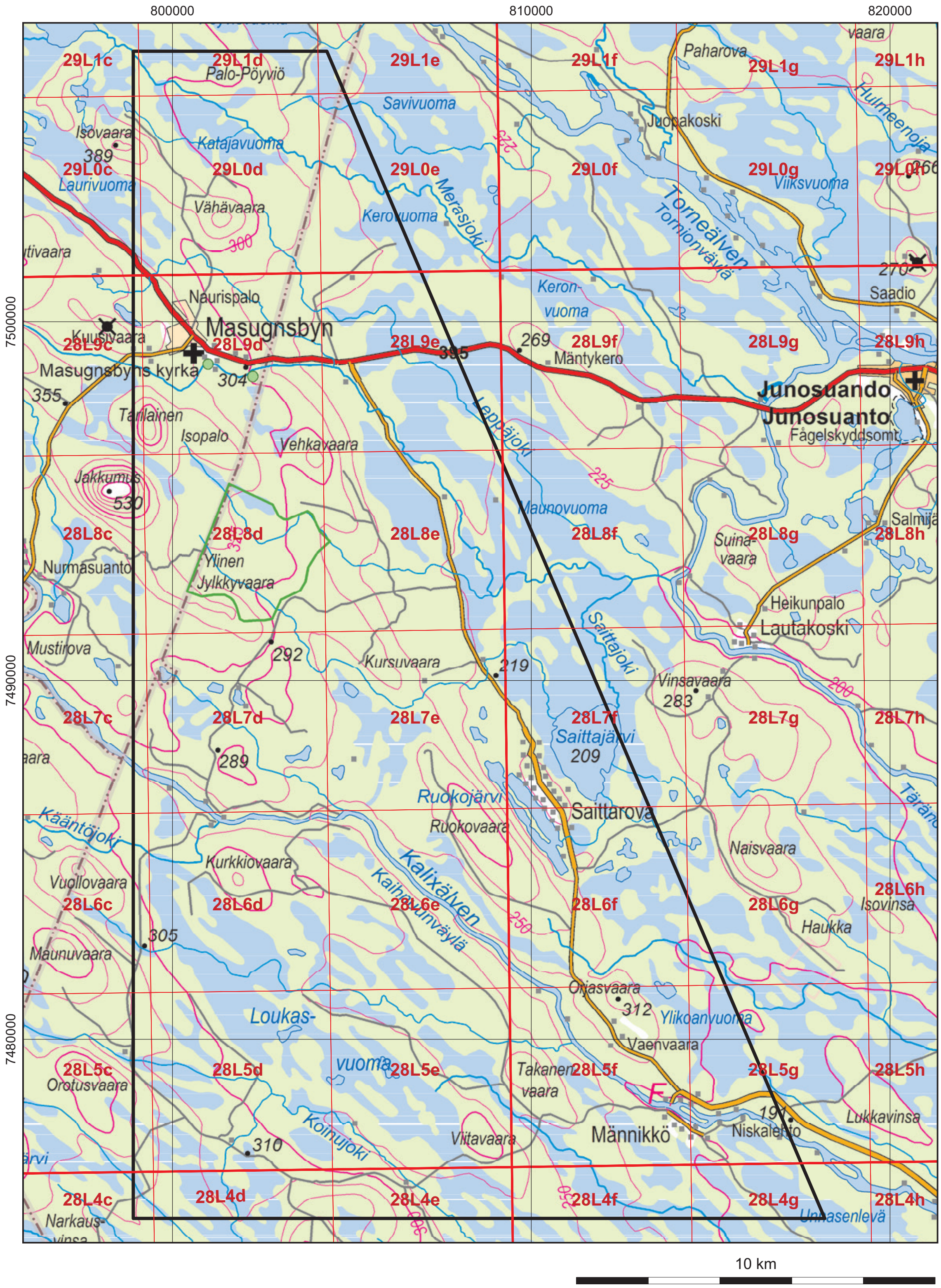


Figure 6. Topographic overview of the Masugnsbyn key area (ur Lantmäteriets Översiktskartan). Black polygon shows the extent of the study area. RT90 index squares are shown in red.

cut in granite and followed by the creek Rautajoki. The glaciofluvial erosion zone has exposed part of the Masugnsbyn ores, which is where the original discovery was made (Geijer 1929). Most of the area is, however, covered by Quaternary sediments, mainly glacial deposits, and

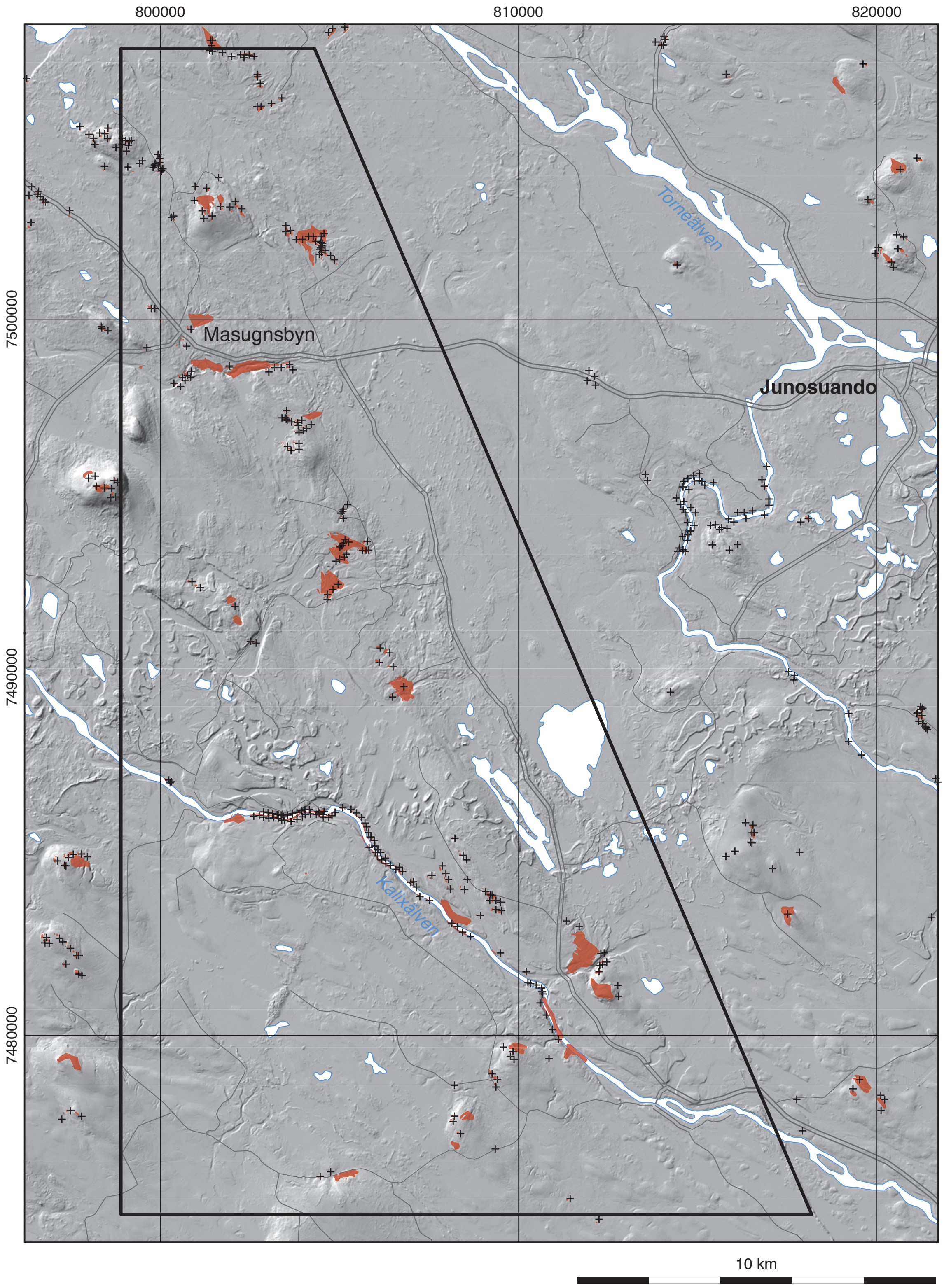


Figure 7. Outcrops shown as red polygons and black crosses with 2 m elevation data (from Lantmäteriet) as background.

peat. The exposure of the bedrock within the key area is only 0.8% (Fig. 7). Therefore the interpretation of the surface bedrock geology relies heavily on other data, including geophysical information and drillings.

The main part of the key area is located in the eastern part of the map 28L Tärendö NV (RT90), but small parts are located within the map sheets 28L Tärendö NO, SO and SV, as well as within 29L Lainio SV (Fig. 6). Index squares with a size of 5 x 5 km (RT90) are shown in some of the maps below as a guide to locations of objects in the Tables and text. The topographic vector datasets covering the Masugnsbyn key area include Lantmäteriet's topographic maps at the scale 1:250 000 (Översiktskartan) and 1:100 000 (Vägkartan). Topographic information at a more detailed scale are aerial orthophotographs (1:20 000) and Fastighetskartan (1:10 000), both available as georeferenced raster colour images, the orthophotographs also in IR. High resolution 2 × 2 m elevation data (Lidar) is also available and will be useful in locating old mine pits in the planned mine inventory of the area.

BEDROCK GEOLOGY OF THE KEY AREA

Background data concerning the bedrock geology of the Masugnsbyn area is extensive (Table 2, Appendix 1). SGU's databases include bedrock maps, observations, lithogeochemistry and age determinations etc. (Figs. 8–9, Table 3). Many of the old field geological maps and diaries, as well as exploration maps and reports were scanned in the SGU project Geodigitalia, and are now available as raster images and pdf documents.

The most detailed bedrock maps covering the Masugnsbyn key area are 1:50 000 scale maps of 28L Tärendö (SGU Af 5–8, Padget 1970) and 29L Laino SV (SGU Af 11, Witschard 1970). These maps have been scanned and rectified and formed the basis for SGU's bedrock map databases in vector format (Table 2, Fig. 8).

Geijer (1930) described the geology of the ore field "Masugnsbyfältet" in the northern part of the key area and included a bedrock map at the scale 1:12 000. The geological map of the Pajala district (1:200 000) by Eriksson (1954) covers most of the key area. Regional bedrock maps at the scale 1:400 000 of the Norrbotten area are those of Geijer (1930) and Ödman (1957). A more recent regional bedrock compilation of Norrbotten has been done by Henkel & Sjöström (SGU unpublished) in the form of a vector based, digital bedrock map called NBDIG. Bergman et al. (2000) compiled regional bedrock maps of the northern Norrbotten area at the scale 1:250 000, based on new observations and the available, old 1:50 000 scale bedrocks maps.

Padget (1970) and Witschard (1970) have given the most comprehensive description of the bedrock geology of the Masugnsbyn key area as part of their mapping of the Tärendö and Laino map areas. Other important sources of bedrock information are from e.g. Bergman et al. (2001), Eriksson (1954), Geijer (1930), Kumpulainen (2000), Martinsson (2004), Niiniskorpi (1986a) and Ödman (1957), and references quoted in the text below. See also Appendix 1 for a literature compilation for the Masugnsbyn key area.

Supracrustal rocks

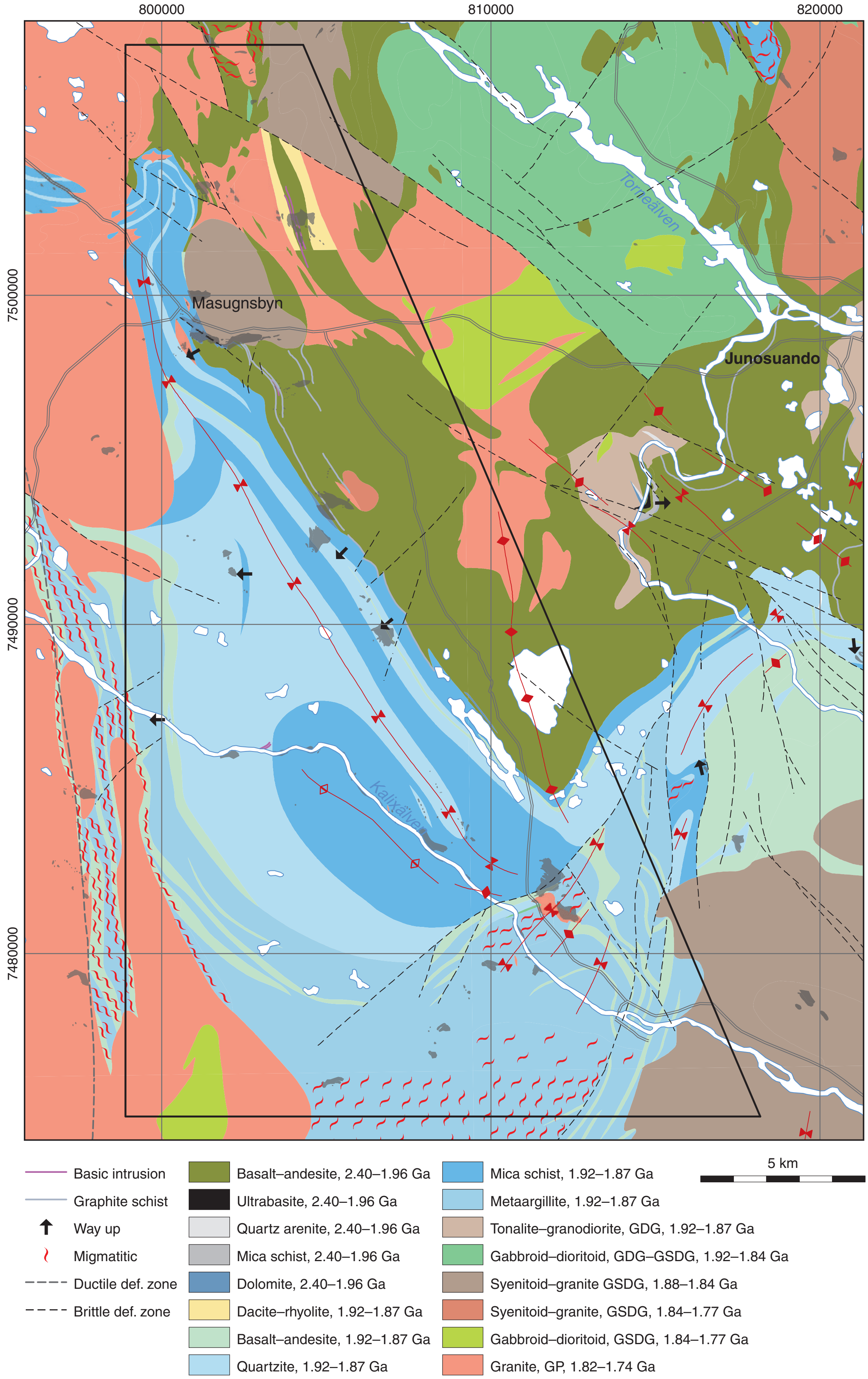
At Masugnsbyn, Karelian greenstones of the Veikkavaara greenstone group are overlain by the Svecofennian, clastic metasedimentary rocks of the Pahakurkio, Kalix älv and Rissavaara groups (Fig. 10, Padget 1970, Martinsson & Wanhainen 2013). The Veikkavaara greenstone group constitutes the upper part of the Greenstone group whereas the Pahakurkio, Kalix älv and Rissavaara groups are units of the Middle sediment group (Witschard 1984a). The description below of the stratigraphy and lithological units of the Masugnsbyn area is mainly from Padget (1970).

The Veikkavaara greenstone group consists dominantly of mafic volcaniclastic rocks. Padget (1970) defined three units: a lower unit of massive basaltic greenstone, a middle unit of pelitic schist and quartzite (Suinavaara quartzite) and, at the top, basaltic greenstones with graphite schist and carbonate horizons. Varieties of the upper greenstones are light-green, fine-grained,

Table 2. Maps and datasets covering bedrock geology and mineral resources of the Masugnsbyn key area.

Reference	Title	Code	Scale	D*	GIS
Geijer 1930	Berggrundskarta över trakten kring Masugnsbyn	SGU C351	1:12K	x	Raster
Padget 1970	Bedrock map 28L Tärendö NV	SGU Af 5	1:50K	x	Raster
Padget 1970	Bedrock map 28L Tärendö NO	SGU Af 6	1:50K	x	Raster
Padget 1970	Bedrock map 28L Tärendö SO	SGU Af 8	1:50K	x	Raster
Padget 1970	Bedrock map 28L Tärendö SV	SGU Af 7	1:50K	x	Raster
Witschard 1970	Bedrock map 29L Lainio SV	SGU Af 11	1:50K		Raster
Ödman 1957	Precambrian geology of the Norrbotten county	SGU Ca 41	1:400K	x	Raster
Geijer 1930	Geological map of the iron bearing region Kiruna-Gällivare-Pajala	SGU C366	1:400K	x	Raster
Eriksson 1954	Geological map of the Pajala District, North Sweden	SGU C522	1.200K	x	Raster
Bergman et al. 2000	Regional geological and geophysical maps of Northern Norrbotten: Bedrock map (east of the Caledonian orogen)	SGU Ba 56:1	1:250K	x	Raster
Bergman et al. 2000	Regional geological and geophysical maps of Northern Norrbotten: Metamorphic, structural, and isotope age map	SGU Ba 56:2	1:250K	x	Raster
Bergman et al. 2000	Regional geological and geophysical maps of Northern Norrbotten: Mineral and bedrock resource map	SGU Ba 56:3	1:250K	x	Raster
GTK-SGU-NGU	Maps of Northern Fennoscandia (Nordkalottproject)		1:1M		
Stephens et al. 1994	Geological map of Sweden.	SGU Ba 52	1:3 M		Raster
Bergman et al. 2012	Bedrock map of Sweden	SGU K423	1:1M		Raster
Eilu et al. 2013	Metallogenic map of the Fennoscandian Shield		1:2M	x	R/V
Eilu et al. 2013	Metallic Mineral Deposit Map of the Fennoscandian Shield		1:2M	x	R/V
Koistinen et al. 2001	Geology of the Fennoscandian Shield		1:2M		R/V
SGU-database	National bedrock map database		1:1M		Vector
SGU-database	Local bedrock map database		1:50K		Vector
SGU-database	Regional bedrock map database		1:250K		Vector
SGU-database	BMOD – bedrock map database		1:50K–250K		Vector
SGU-database	Norrbotten NBDIG (Sjöstrand & Henkel, unpublished)		1:250K?		Vector
SGU-database	Bedrock observations (rock types, texture, structure, key minerals etc)				Vector
SGU-database	Bedrock Age Database (published radiometric age determinations)				Vector
SGU-database	Lithogeochemistry Database (SGU analyses and external analyses)				Vector
SGU-database	Mineral and bedrock resources				Vector
SGU-database	Outcrops, from the Norrbotten regional soil map		1:250K		Vector
SGU-database	Drillholes				Vector
SGU-database	Drillcores (cores stored at SGU's Malå archive)				Vector
SGU-database	Ballast & industrimineral				Vector
SGU-database	Mineral Law Register (MRR10) exploration permits				Vector
SGU-database	National Interests (Riksintressen) mineral				Vector
SGU-dataset	Carbon & Oxygen isotope analyses				Vector
SGU-dataset	Sm-Nd isotope analyses				Vector
SGU-dataset	Alteration minerals, Norrbotten (from old field diaries)				Vector
SGU-dataset	Metamorphic key minerals, Norrbotten (from old field diaries)				Vector
SGU-dataset	Mineralized boulders SGAB/SGU				Vector
SGU-dataset	Mineralized outcrops LKAB				Vector

D* = Map description



800000
810000
820000
7500000
7490000
7480000
Masugnsbyn
Junosuando
Torneälven
Kalixälven
5 km
Basic intrusion
Graphite schist
Way up
Migmatitic
Ductile def. zone
Brittle def. zone
Basalt–andesite, 2.40–1.96 Ga
Ultrabasite, 2.40–1.96 Ga
Quartz arenite, 2.40–1.96 Ga
Mica schist, 2.40–1.96 Ga
Dolomite, 2.40–1.96 Ga
Dacite–rhyolite, 1.92–1.87 Ga
Basalt–andesite, 1.92–1.87 Ga
Quartzite, 1.92–1.87 Ga
Mica schist, 1.92–1.87 Ga
Metaargillite, 1.92–1.87 Ga
Tonalite–granodiorite, GDG, 1.92–1.87 Ga
Gabbroid–dioritoid, GDG–GSDG, 1.92–1.84 Ga
Syenitoid–granite GSDG, 1.88–1.84 Ga
Syenitoid–granite, GSDG, 1.84–1.77 Ga
Gabbroid–dioritoid, GSDG, 1.84–1.77 Ga
Granite, GP, 1.82–1.74 Ga

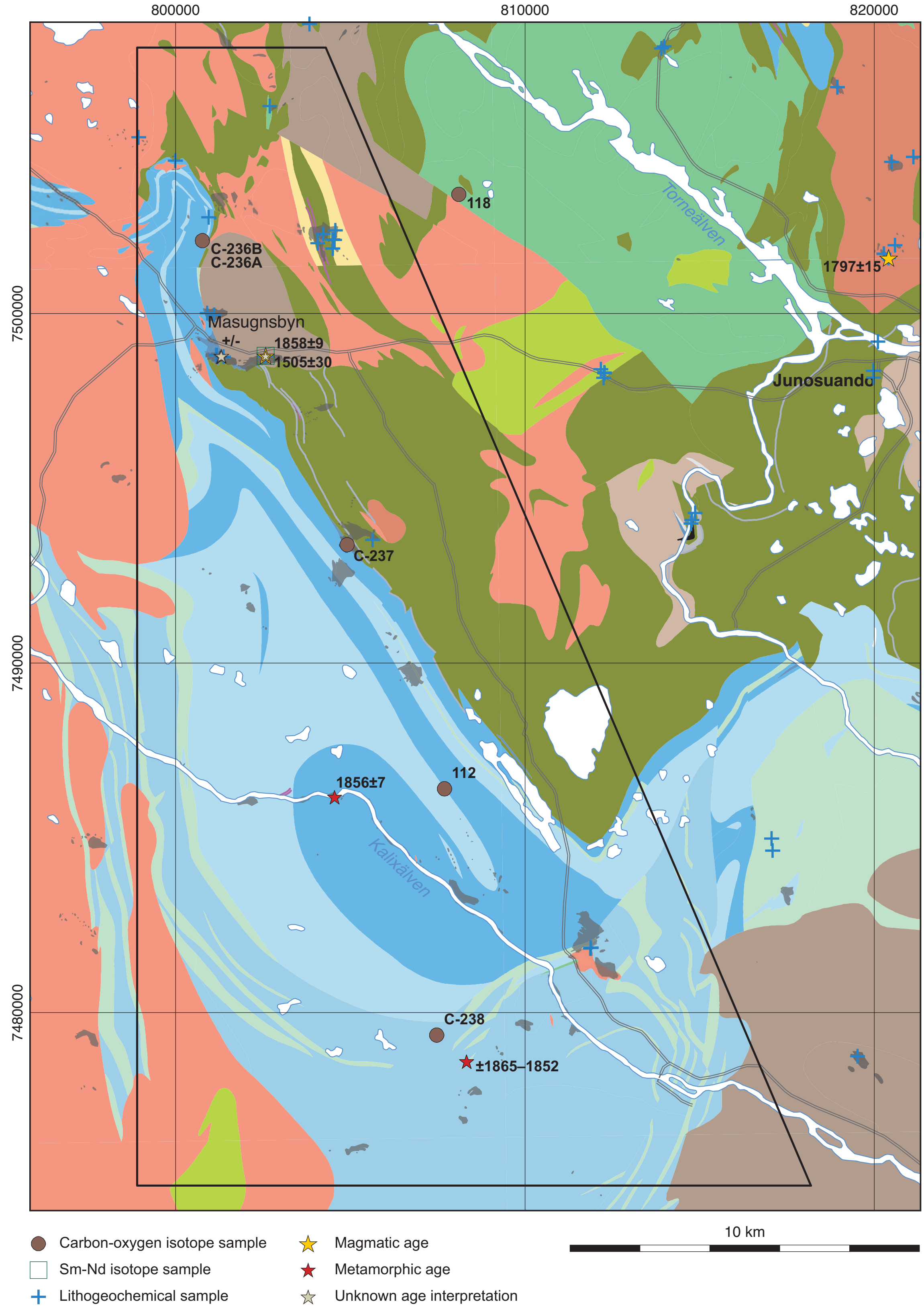


Figure 9. Bedrock observations and analyses in the Masugnsbyn key area (from SGU's databases).

Figure 8. Bedrock geological map of the Masugnsbyn area (modified from SGU's bedrock map database).

Group	Sub-group (formation)	Id	Member	Thickness (m)
Upper sediment group	Rissavaara quartzite	4		
Porphyrite group & Middle sediment group	Kalixälv group	3d	Semipelitic, pelitic and basic schists	
		3c	Limestone	
		3b	Conglomerate at Saarikoski and Tiankikoski	
		3a	Amphibolitic schist	
	Pahakurkio group	2d	Quartzite	1800
		2c	Pelitic schist	1000
		2b	Quartzite	430
		2a	Pelitic schist	600
Greenstone group	Veikkavaara greenstone group	1c	Basaltic greenstone with graphite schist, carbonate layers and bif	1500
		1b	Pelitic schist and quartzite (Siinavaara quartzite)	100
		1a	Basaltic greenstone	2000

Figure 10. Stratigraphy of the Masugnsbyn-Tärendö area, modified from Padget (1970) and Witschard (1984b).

cross-bedded tuffs and coarser-grained hornblende-rich types, more reminiscent to lavas or intrusive sills. Rocks of the Veikkavaara greenstone group form a V-shaped area between Masugnsbyn, Saittajärvi and Junosuando, clearly outlined as a high magnetic, banded sequence on the aeromagnetic map, but it is poorly exposed (Figs. 8 and 20). Padget (1970) estimated the thickness of the layered sequence from profiles to 2 000–3 000 m. Graphite-bearing horizons in the greenstones are well known from electromagnetic measurements (Fig. 22). The marked alternation of magnetic and less magnetic layered greenstones between the graphitic horizons could reflect a depositional feature. The primary banding is further accentuated by secondary growth of garnets or magnetite in distinct layers (Padget 1970). At the top part of the greenstones there are lenses of limestone which, in part, are dolomitic, as in the well-known Masugnsbyn dolomite currently quarried by LKAB.

Minor, basic intrusions seem to be concordant or semi-concordant with the banded Veikkavaara greenstones. All are recrystallised and amphibole altered and are considered as metadolerites (Padget 1970). On the northern slope of Veikkavaara (28L 9 d) there is a body of gabbro dolerite which is slightly discordant to the layering of the greenstones. A schistose, ultrabasic marginal facies of the gabbro contains relict magmatic olivine surrounded by secondary alteration minerals, such as serpentine, tremolite and magnetite.

The Pahakurkio group (Padget 1970) comprises arenitic to pelitic metasedimentary rocks west and on top of the Veikkavaara greenstone group (Eriksson 1954, Geijer 1930, Kumpulainen 2000, Niiniskorpi 1986a, Padget 1970). Pahakurkio means "the difficult rapids" and is spelt Pahakurkkio on the topographic maps (Niiniskorpi 1986). The Pahakurkio group has been divided into four lithological units of alternating pelitic schist and quartzite. These are, from bottom to top: pelitic schist (2a), quartzite (2b), andalusite and sillimanite bearing pelitic schist (2c) and quartzite (2d, Fig. 10). According to Niiniskorpi (1986) the quartzites are rarely pure quartzite, but rather feldspar- and mica-rich. He also noted occurrences of graphite-bearing schists, cherts and abundant carbonate and skarn rocks within the Pahakurkio group.

The different units in the Pahakurkio group display a fairly simple assemblage of facies types and could, according to Kumpulainen (2000), consequently be treated as members, and the rank of Pahakurkio group could be changed to the Pahakurkio formation. Heavy mineral layers and cross-bedding are common in the arenitic units and locally also ripple and rill marks are found, which suggests a coastal depositional environment with presence of wave and possibly storm activity. The successions also display characteristic features indicating vertical facies changes into relative water depth where graphite-bearing shales represent deposition in stagnant waters beneath the storm wave base. Changes in relative water depth could either depend on real sea level changes, changes in input of clastic material or subsidence of the basin floor (Kumpulainen 2000).

According to (Padget 1970), the Pahakurkio group is best exposed along the Kalix älv between Pahakurkio and Saarikoski (28L 6 d–e) and at Syväjoki and Hietajoki, south-south-east of Masugnsbyn (28L 7 e). Together, the outcrops at Syväjoki and Hietajoki constitute an almost complete succession. Cross-bedding is a common feature of the quartzites, and numerous way-up determinations all show younging to the west. The lowermost beds of the Pahakurkio group are poorly exposed, but there are no indications of conglomerates or any marked discordance to the Veikkavaara greenstones. Instead, the slight discordance evident on a regional scale could be due to thickening of the uppermost unit of the greenstones towards Masugnsbyn. The lowermost beds of the Pahakurkio group exposed in the Rautajoki stream (28L 9 d) consist of mica schist and locally quartzite. Cross-bedding in the latter establishes a younging of the beds to the west and shows that the Pahakurkio group is younger than the Veikkavaara greenstones, here locally represented by the Masugnsbyn dolomite.

Units of greenschist are conformable within both the two lowermost members of the Pahakurkio group (2a & 2b), and seem to have a considerable lateral extent evident from the aeromagnetic map. The greenschist is scapolitised and has an unknown primary origin. Above the greenschist there are well-bedded, cross-bedded quartzites (2b) that grade upwards into andalusite-bearing pelitic schists (2c) via a transition zone in which the thickness and frequency of pelitic layers increase progressively. Layers rich in calc-silicates may represent a carbonate-bearing horizon in the sequence. In the Syväjoki section (28L 7 e), pebbly, conglomeratic beds occur in the quartzites. The pebbles consist of quartz, quartzite and a dark rock, possibly greenstone (Padget 1970). Dark bands in cross-bedded quartzites contain heavy minerals, such as rutile, tourmaline, zircon, ilmenite and apatite, but are not significantly magnetic. Quartzitic rocks in the uppermost member of the Pahakurkio group (2d) are well exposed along the Kalix älv between Pahakurkio and Saarikoski (Padget 1970). The quartzite is extremely well-bedded, flat or gently dipping, and locally show ripple and rill marks.

Rocks of *the Kalixälv group* are poorly exposed west and south of the Pahakurkio group. Outcrops occur along the Kalix älv, but also west and south-west of the river (Padget 1970). The aeromagnetic map reveals alternating high and low magnetic bands, in contrast to the overall low magnetic intensity of the Pahakurkio group. The high-magnetic sheets were assumed to be basaltic rocks (Padget 1970). However, Niiniskorpi (1986a) suggested that the high magnetic layers represent volcaniclastic rocks of intermediate composition, based on core drillings and geological mapping.

The lowest exposed unit is a c. 20 m thick conglomerate immediately above an unexposed high-magnetic band at Saarikoski. The latter is taken as the basal member of the formation. Well-rounded pebbles consist of quartzites and metabasic rocks. The conglomerate passes upwards into a rather dark, fine-grained hornblende-bearing quartzite. Distinct cross-bedding shows that beds young to the west, and therefore the Kalixälv group overlies the Pahakurkio group (Padget 1970). Based on core drillings in Kurkkionvaara Niiniskorpi (1986a) suggested that rocks west of the basal conglomerate consists of altered, intermediate volcaniclastic rocks of trachyandesitic composition. At Tiankikoski, c. 13 km downstream from Sarikoski, a polymict c. 30 m thick conglomerate contains rounded pebbles of gabbro, syenite, granite, felsic volcanic rocks and quartzites (Eriksson 1954, Ödman 1939). Below the conglomerate is a carbonatic greenstone, and above, a quartz-mica schist and locally gabbroic greenstone. Padget (1970) places the conglomerates at Saarikoski and Tiankoski at the same stratigraphic level based on similarities in the nature of pebbles and spatial correlations of the units based on the pattern in the aeromagnetic map. To the west and south-west, an increasing degree of migmatitisation affects

Table 3. Radiometric age data from the Masugnsbyn area.

ID	N	E	Locality	Lithology	System	Method	Material	Age type	Age (Ma)	Age min	Age max	Interpretation	Reference
165	7498791	802567	Masugnsbyn	Granite	Rb-Sr	ID-TIMS	Whole rock	Isochron age	1505±30			not known	Welin 1980, Gulson 1972
355	7498831	801366	Masugnsbyn	Iron ore	U-Pb	ID-TIMS	Uraninite	u.i. age		1755	1825	not known	Welin 1980, Welin & Blomqvist 1966
707	7498791	802567	Masugnsbyn	Granite	U-Pb	ID-TIMS	Zircon	u.i. age	1858±9			Magmatic age	Skiöld & Öhlander 1989
1398	7501593	820409	Viiksvaara	Monzonite	U-Pb	ID-TIMS	Zircon	u.i. age	1797±15			Magmatic age	Bergman et al 2001
1625	7486167	804551	Pahakurkkio	Metaargillite	U-Pb	ID-TIMS	Monazite	u.i. age	1856±7			Metamorphic age	Bergman et al 2006
1626	7478607	808329	Takanenvaara	Paragneiss	U-Pb	ID-TIMS	Monazite	u.i. age		1852	1865	Metamorphic age	Bergman et al 2006

the sedimentary rocks and therefore any natural, upper stratigraphic limit for the formation is not known. Between Pahakurkio and Saarikoski exposures of quartzite are cut by a number of dyke-like bodies (28L 6 d). These have a north-easterly strike and dip c. 45 degrees to the south-east. The dykes are foliated with a variable intensity of deformation. According to the description of Padget (1970), the dykes seem to have an intermediate composition with a sub-parallel orientation of tabular andesine plagioclase.

South-east of the key area at Haukkalaki (28L 6 g) and at Tärendö älv (28L 7 g), there is a poorly sorted conglomerate with pebbles of andesite and hornblende porphyry (Padget 1970). The conglomerate is considered to occur as accumulations on the eroded surface of porphyritic rocks underlying the conglomerate. Andesite porphyry occurs north and north-east of the hill Haukkalaki (28L NO 6 g, 7 g, 7 h). It is typically massive and characterised by tabular 1–2 mm long phenocryst of subhedral plagioclase ($An_{10–15}$) in a darker matrix. The porphyry is also characterised by irregular levels of magnetic intensity without any consistent pattern which might denote layering and seems in general to be discordant to the other rocks. It was suggested to be of intrusive origin by Padget (1970), whereas Eriksson (1954) considered it to belong to the Porphyrite-porphyry group. An intermediate metavolcanic rock in the Käymäjärvi area, 35 km east of Masugnsbyn key area, was dated at 1882±3 Ma (SGU unpublished, MSWD = 1.1, TIMS U-Pb zircon, titanite).

Niiniskorpi (1986a) noted that both the Pahakurkio and the Kalixälv groups consist of a similar type of metasedimentary rocks, i.e. metapelites and quartzites, which makes it difficult to distinguish between these units. Occurrences of graphite-bearing schists and carbonate rocks within the Pahakurkio formation in turn complicate the delineation between the Pahakurkio and Veikkavaara groups. The quartzite on Rissavaara (28L 2 e), south of the key area, is according to Padget (1970) possibly younger than the Kalixälv group, for tectonic reasons. The quartzite is completely recrystallised and surrounded by granitic rocks.

Plutonic rocks

The supracrustal sequence is intruded by granitic, syenitic and gabbroic rocks of various ages, i.e. rocks belonging to the 1.92–1.88 Ga Haparanda suite, the 1.88–1.86 Ga Perthite monzonite suite, the c. 1.80 Ga Edefors suite and the 1.81–1.78 Ga Lina suite. The assignment of intrusive rocks to either the Perthite monzonite suite or the Edefors suite is difficult as field characteristics and the geochemical signature of the suites are similar and radiometric age determinations are few in the area. In the northern part of the key area, the Masugnsbyn granite is dated at 1858±9 Ma using discordant U-Pb TIMS zircon data (Fig. 9, Table 3, MSWD = 6, Skiöld & Öhlander 1989). The rock is isotropic, with perthitic microcline, quartz and minor amounts of mafic minerals. An albite-rich marginal phase occurs close to the contact to the supracrustal rocks. An ε_{Nd} (1.87 Ga) value is calculated at –2.5 from a Sm-Nd isotope whole-rock analysis, indicating a minor contribution of Archean crust in the melt source (Skiöld & Öhlander 1989).

The area south-east of the Masugnsbyn key area is dominated by granites, syenites and gabbro. Padget (1970) placed the granites in the Lina suite, whereas Bergman et al. (2001) suggested that the rocks belong to the Edefors suite (1.81–1.78 Ga Granite-syenite-diorite-gabbro, GSDG). However, 30 km towards the south-east, in the Narken area (27L 9 j), a nearly isotropic metagranite sample was dated at 1872±4 Ma (MSWD=1.4, n=4, TIMS, U-Pb zircon, SGU unpublished). The granite is co-magmatic with gabbroic rocks and was assigned to the Perthite monzonite suite, and is also suggested to be the affinity of the rocks south-east of the Masugnsbyn key area. In the map area 28L SO, the Tärendö gabbro occupies a 22 × 6 km large area, and there are also several smaller gabbro intrusions surrounded by granite. 1.81–1.78 Ga GSDG rocks of the Edefors suite occur at Junosuando. A monzonite intrusion was dated at 1797 ±15 Ma (SGU unpublished, MSWD = 9, n = 5, TIMS, U-Pb zircon).

The area west of Masugnsbyn is dominated by granite and associated pegmatite of the Lina suite. A sample taken 12 km west of the Masugnsbyn key area was dated at 1794±24 Ma (Skiöld 1988, Vettasjärvi granite, MSWD=0.6, TIMS, U-Pb zircon).

Structures

The Masugnsbyn area is located in a structural domain between the north-north-east to south-south-west oriented Karesuando–Arjeplog deformation zone in the north-west, the north-north-east to north-east oriented Pajala shear zone in the east, and the north-west trending Nautanen deformation zone in the south-west (Fig. 5). This structural domain show variable foliations and complexly folded supracrustal rocks (Bergman et al. 2001). A north–south trending, ductile shear zone borders the western margin of the Masugnsbyn key area. The supracrustal sequence in this key area forms large scale fold and fault structures which have north-east or north-west trends, thus intersecting at high angles. The main tectonic features include the Kalix älv dome, the Masugnsbyn syncline, the Saittajärvi anticline and the Oriasvaara syncline with the associated Kalixälv fault (Figs. 11–13, Padget 1970). The fold axial planes are oriented in north-westerly direction, except for the Oriasvaara syncline that has a north-easterly trend, parallel to the Kalix älv fault.

The Kalixälv dome is located between Saarikoski and Tiankikoski on the Kalix älv, with good exposures of rocks along the river. The dip of the beds is low to moderate but increases outwards from the centre of the dome (profiles I and IV in Figs. 11–12). Cross-bedding in the quartzites indicates younging of the beds outwards from the centre of the dome.

The Masugnsbyn syncline is a long narrow structure extending from the village of Masugnsbyn south-eastwards in the direction of the hill Oriasvaara (Figs. 11–12). North of Masugnsbyn, a fold closure is apparent on magnetic maps. The fold axis plunges to the south and the structure is probably cut off by the Kalix älv fault in the south.

The Saittajärvi anticline, east of the Masugnsbyn syncline, forms a V-shaped structure outlined by the contact between the Veikkavaara greenstone and Pahakurkio groups, with a north–south orientation of the fold axial surface and a southerly plunge of the fold axis (Figs. 11–12). The south-west facing limb of the fold is remarkably straight, where beds have a steep or vertical dip and may even be overturned to the south-west. The poorly exposed south-east facing limb also has a constant strike evident from the aeromagnetic map, but seems to have more gentle (40–60°) dips towards south-east (Fig. 13).

The Oriasvaara syncline, south-east of the Kalixälv fault, has a fold axis plunging to the south-west, causing the structure to open in that direction. Locally, the structure is affected by strong transverse folds and faults with north-west or west-north-west orientation. The Oriasvaara syncline is bound to the north-west by the north-easterly orientated Kalixälv fault and is in tectonic contact with both the Masugnsbyn syncline and the Kalixälv dome (Figs. 11–12). Movements along the Kalixälv fault have down-thrown the south-eastern block.

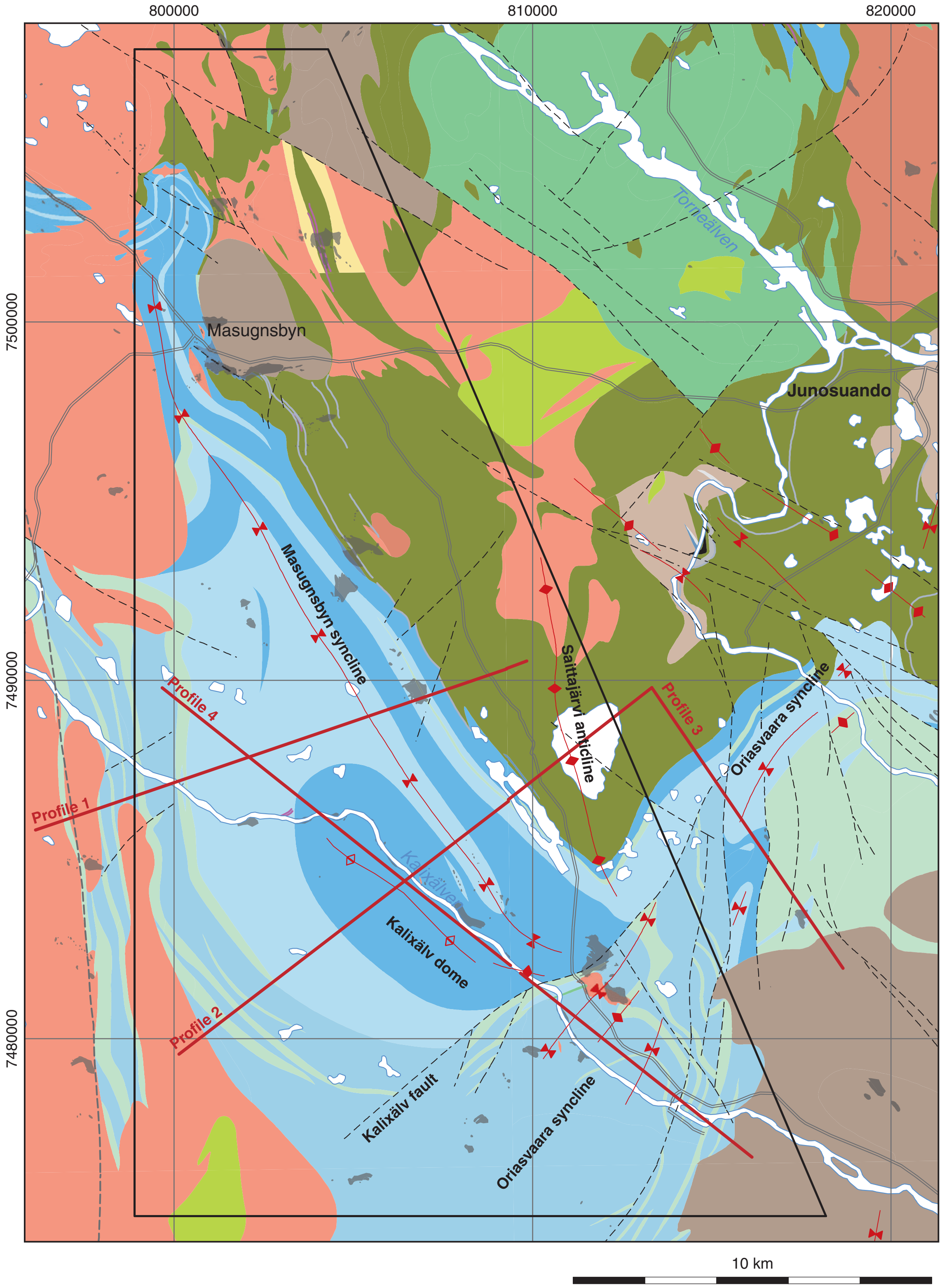


Figure 11. The bedrock map shows the main tectonic features of the Masugnsbyn area and the location of profiles.

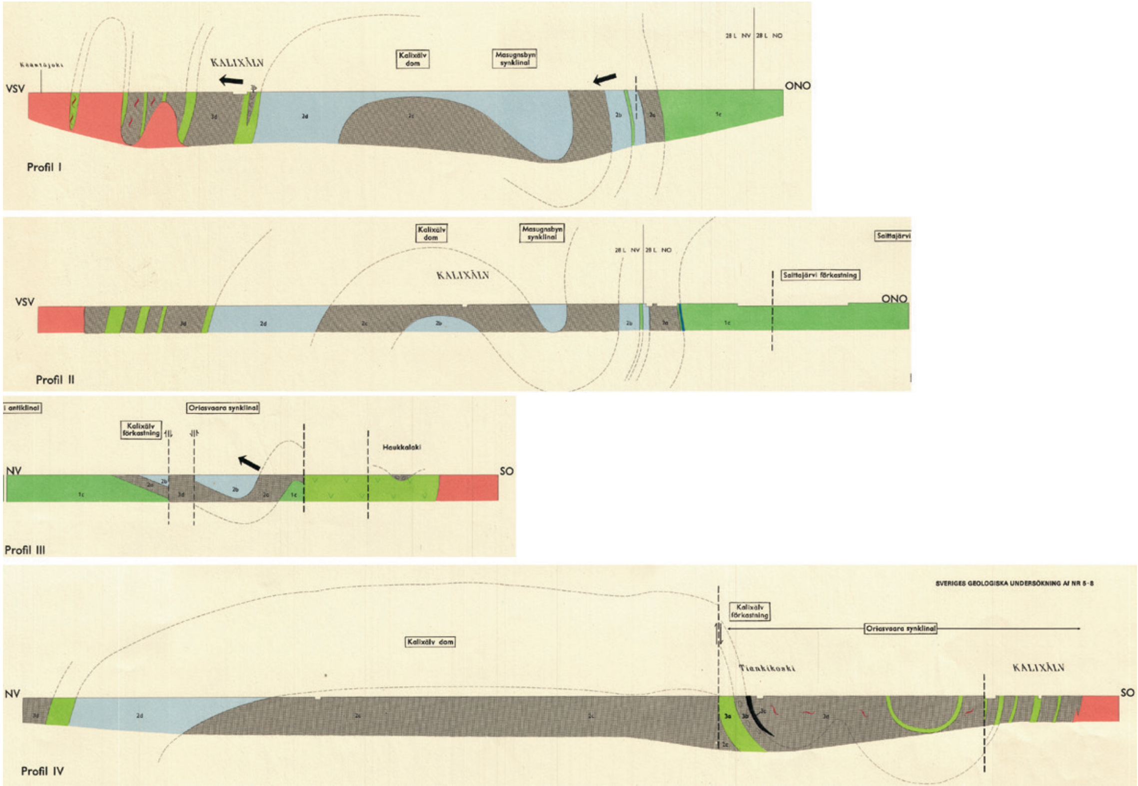


Figure 12. Vertical sections marked as profiles 1–4 in figure 11 (from Padget (1970).

Metamorphism

The metamorphic grade in the Masugnsbyn key area reaches medium to high grade and generally increases towards the south and west where migmatitic paragneiss occurs next to adjacent granitic intrusions (Fig. 14). In the central part of the area, the clastic sedimentary rocks of the Pahakurkio group still show primary textures and structures such as cross-bedding (Padget 1970). The shales are metamorphosed to andalusite-bearing mica schists, and the sandstones are recrystallised to quartzites with metamorphic biotite (Kumpulainen 2000, Padget 1970). Other secondary minerals include muscovite, scapolite and amphibole (Fig. 15). The higher grade gneisses in the southern part of the area contain bundles of parallel sillimanite needles, growing at the expense of biotite, and locally minor cordierite and andalusite. The metamorphic mineral association 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). The increasing metamorphic grade towards the adjacent granite intrusions suggests that heat from the intrusions were responsible for the metamorphic conditions, i.e. that the alteration is contact metamorphic.

The primary mafic minerals in the Veikkavaara greenstones are altered to amphibole, giving the rocks their dark green colour, hence the term greenstones. The amphibole is commonly a green pleochroic hornblende, but non-pleochroic, pale-coloured amphibole is also quite common (Padget 1970). Almandine is locally found together with hornblende and plagioclase, and also as garnetiferous layers in the basaltic greenstone at Veikkavaara (28L 9 d). The composition of the plagioclase (An_{10-50}) and the presence of hornblende together with almandine suggest the rocks are in the garnet amphibolite facies of regional metamorphism (Padget 1970).

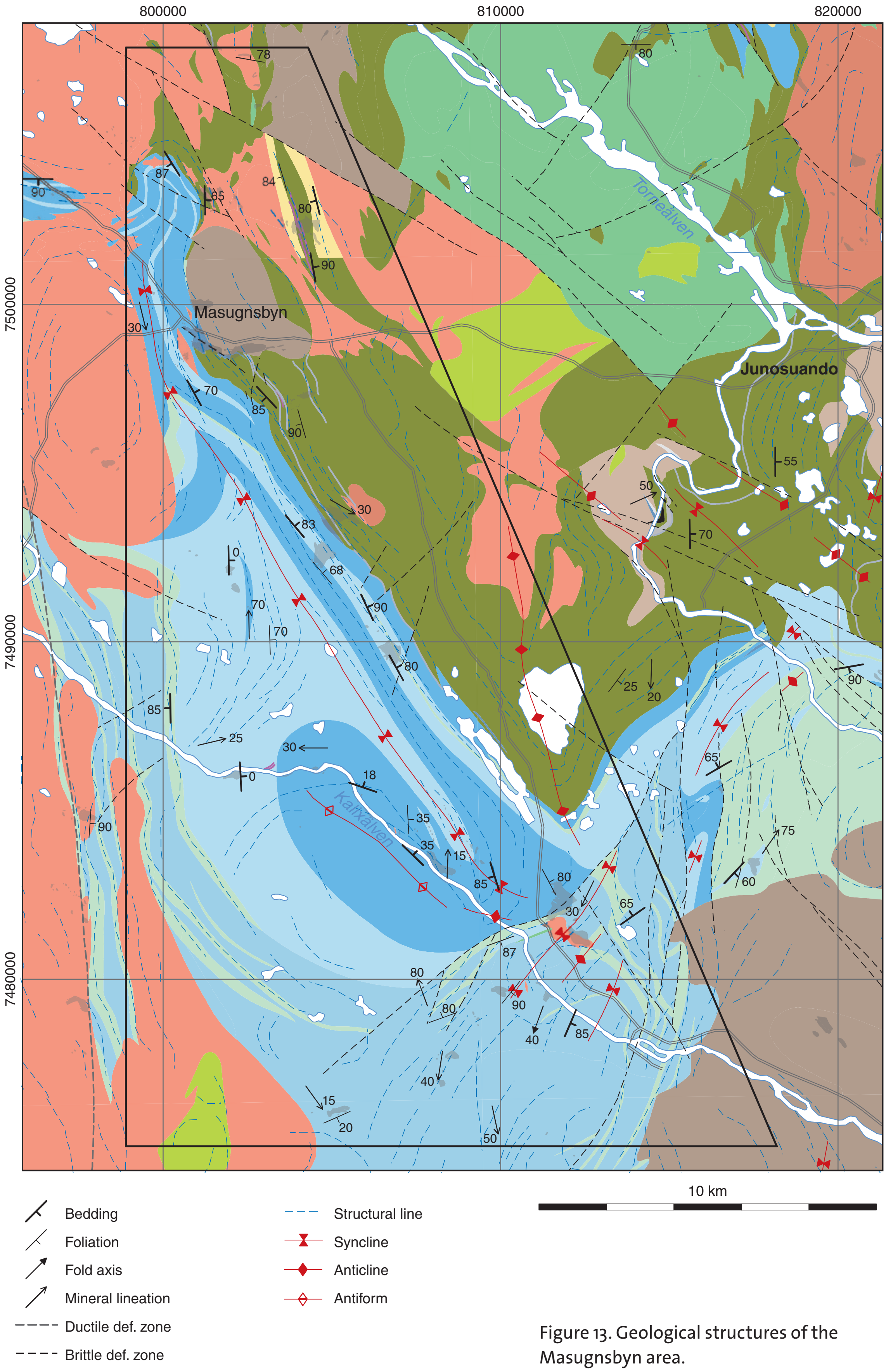


Figure 13. Geological structures of the Masugnsbyn area.

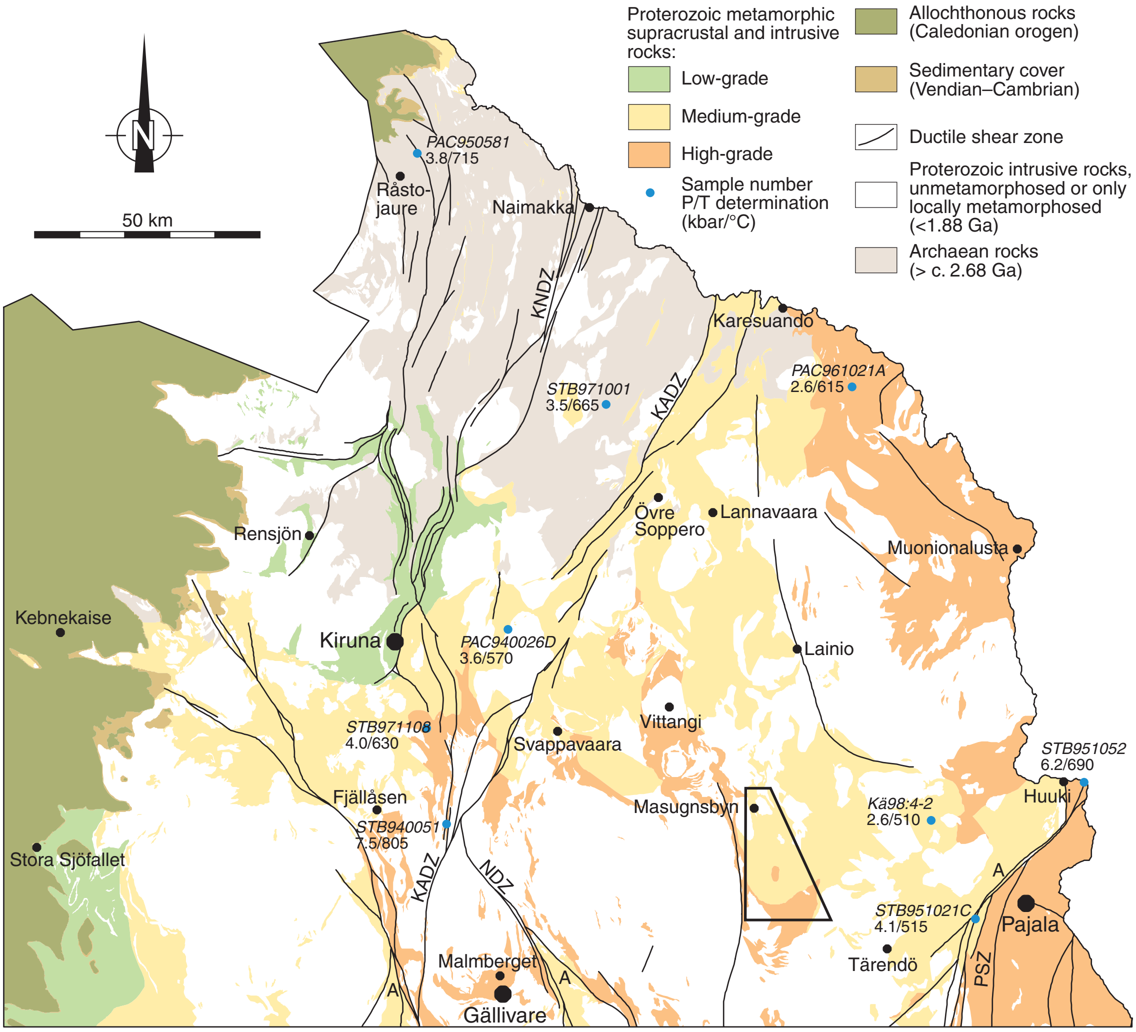


Figure 14. The metamorphic map of northern Norrbotten shows high-grade rocks in the eastern and south-central parts of the area and low-grade rocks in the Kiruna and Stora Sjöfallet areas in the west. Most of the Masugnsbyn area is of medium metamorphic grade, but the southern part contains high-grade, sillimanite-bearing, migmatitic paragneisses. KADZ = Karesuando–Arjeplog deformation zone, KNDZ = Kiruna–Naimakka deformation zone, NDZ = Nautanen deformation zone, PSZ = Pajala shear zone (modified after Bergman et al. 2001).

Monazite has been dated from two localities, one sample from an andalusite-bearing meta-argillite at Pahakurkio (28L 6 e) and one weakly migmatitic paragneiss sample at Takanenvaara (28L 5 e) in the higher-grade area south-east of Pahakurkio. Bergman et al. (2006) treated the monazite data from the Pahakurkio analysis and two Takanenvaara analyses separately, with regression forced through a lower intercept at 300±300 Ma. The single monazite analysis from the Pahakurkio sample has an upper intercept age at 1856±7 Ma, whereas the two Takanenvaara analyses record 1856±4 and 1861±4 Ma, thus in the interval 1852–1865 Ma. A weighted average $^{207}Pb/^{206}Pb$ age of the two Takanenvaara monazite analyses can be calculated at 1857±3 Ma (2σ) using the data of Bergman et al. (2006), suggesting an age of metamorphism at c. 1.86 Ga (Table 3).

Hydrothermal alteration

Growth of secondary, potassium-bearing minerals such as muscovite and microcline has occurred in the pelitic rocks of the Pahakurkio and Kalix älv groups (Fig. 15). Metamorphic hornblende in the basic or semibasic rocks is commonly replaced by biotite, whereas any excess iron forms magnetite (Padget 1970). Scapolite alteration is widespread in the greenstones with a characteristic spotted appearance of rounded, light coloured crystals or aggregate (Fig. 15) s. It is also found as veins, and is clearly a late, secondary, post-metamorphic phase (Padget 1970). Tourmaline alteration of the greenstone as well as plagioclase alteration has also been noted.

Skarn minerals are intimately associated with magnetite ore at Masugnsbyn in a steeply dipping, 70–100 m wide zone with diopside, tremolite-actinolite and phlogopite, and more rarely serpentine and chondrodite. The formation of skarn minerals has been attributed to contact metasomatic or metamorphic alteration by nearby perthitic granite (Geijer 1929, Ödman 1957). The marginal phase of the granite is albite altered. A c. 5% discordant U-Pb analysis of uraninite included in chondrodite skarn from the Magnetgruvan gives, together with regression of three other samples from northern Sweden, an upper intercept age at 1825 Ma (Welin 1980, Welin & Blomqvist 1966), whereas the U-Pb zircon age of the granite is 1858±9 Ma (Skiöld & Öhlander 1989).

MINERAL RESOURCES

Background data concerning mineral resources of the Masugnsbyn key area are extensive with abundant publications from exploration activities (see Appendix 1). Mineral resources from SGU's databases are listed in Table 2. They include mineral and bedrock resources data (MDEP), drillhole data, SGAB and LKAB data on mineralised boulders and outcrops, exploration permits etc. and are also shown in Figures 16–17 and Tables 4–8.

Of economic interest in the Masugnsbyn area are layers of skarn-rich iron formations and dolomite between the Veikkavaara greenstones and the overlying metasedimentary rocks, but also graphite layers within the volcaniclastic greenstones, as well as base-metal, sulphide mineralisations in the metasedimentary and metavolcaniclastic rocks (Frietsch 1997, Geijer 1929, Grip & Frietsch 1973, Niiniskorpi 1986a, Padget 1970, Witschard et al. 1972).

An inventory of the mineral deposits in Norrbotten will start this summer and SGU's Mineral & bedrock database will continuously be updated. A more comprehensive summary of the mineralisations of the Masugnsbyn area will be presented later in connection with the report from that work. Below is a short summary of the mineral deposits within the Masugnsbyn key area and its closest surroundings.

Iron mineralisations

The Masugnsbyn iron ores

Iron mineralisations occur north of Masugnsbyn in an 8 km long, in general north–south trending zone apparently concordant with the stratigraphy on top of the Veikkavaara greenstones (Fig. 18, Table 4, Frietsch 1997, Geijer 1929, Witschard et al. 1972). 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 contain concentrations of economic interest and have therefore been subject to systematic drilling and ore calculation (Witschard et al. 1972).

The skarn iron ore at Magnetgruvan in the southernmost part of the area was discovered already in 1644 as the first of all iron deposits in Norrbotten (Geijer 1929). The operation of the blast furnace ended 1805, but the ore at Magnetgruvan was mined intermittently at a small scale until at least 1870 (Geijer 1929). Exploration recommenced in 1914 by AB Nordsvenska Malmfält which led to the discovery of several new iron occurrences by diamond core drilling around the 1920's (Asplund 1920, Geijer 1929, Högbom 1919, Table 8).

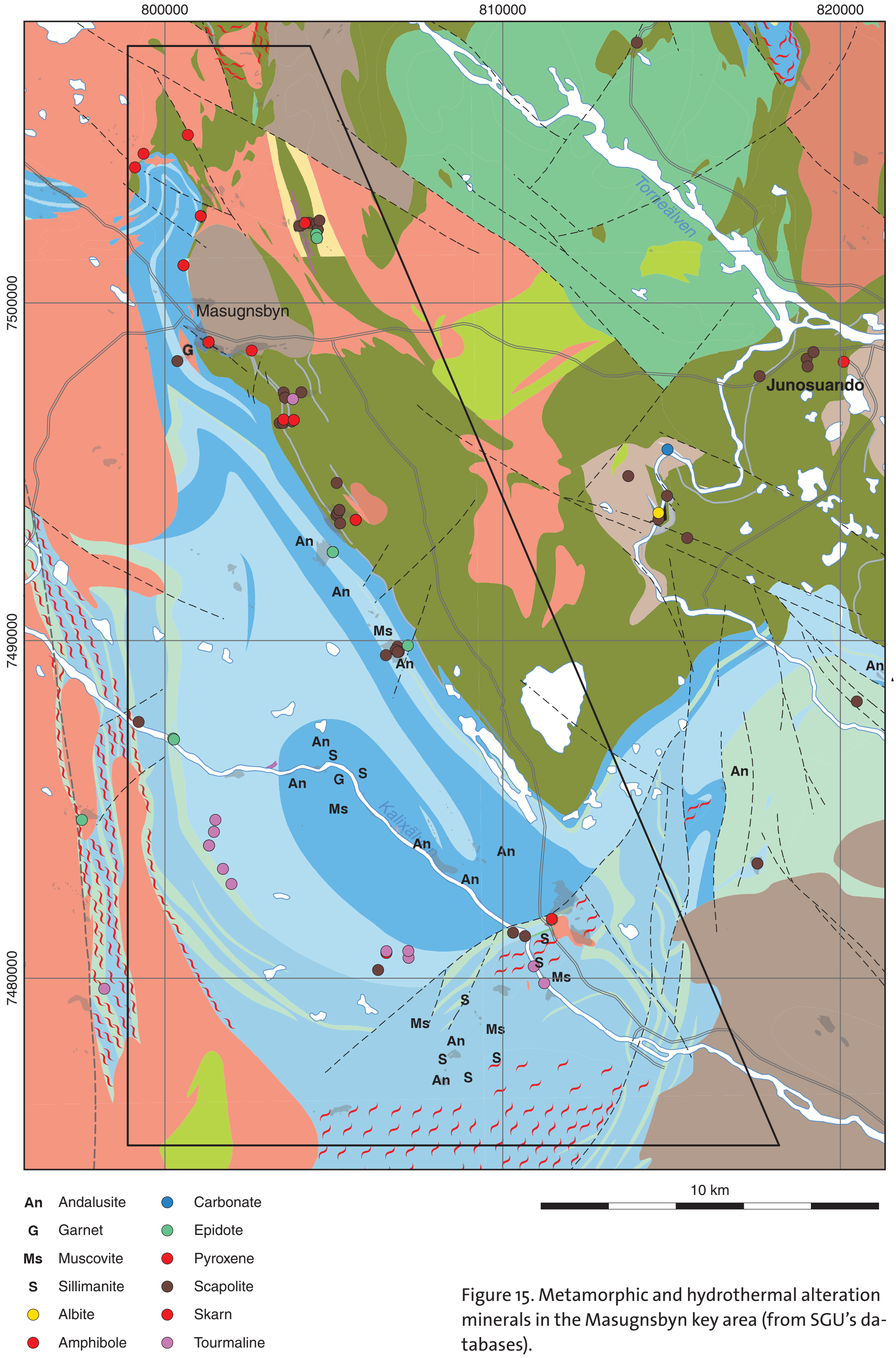


Figure 15. Metamorphic and hydrothermal alteration minerals in the Masugnsbyn key area (from SGU's databases).

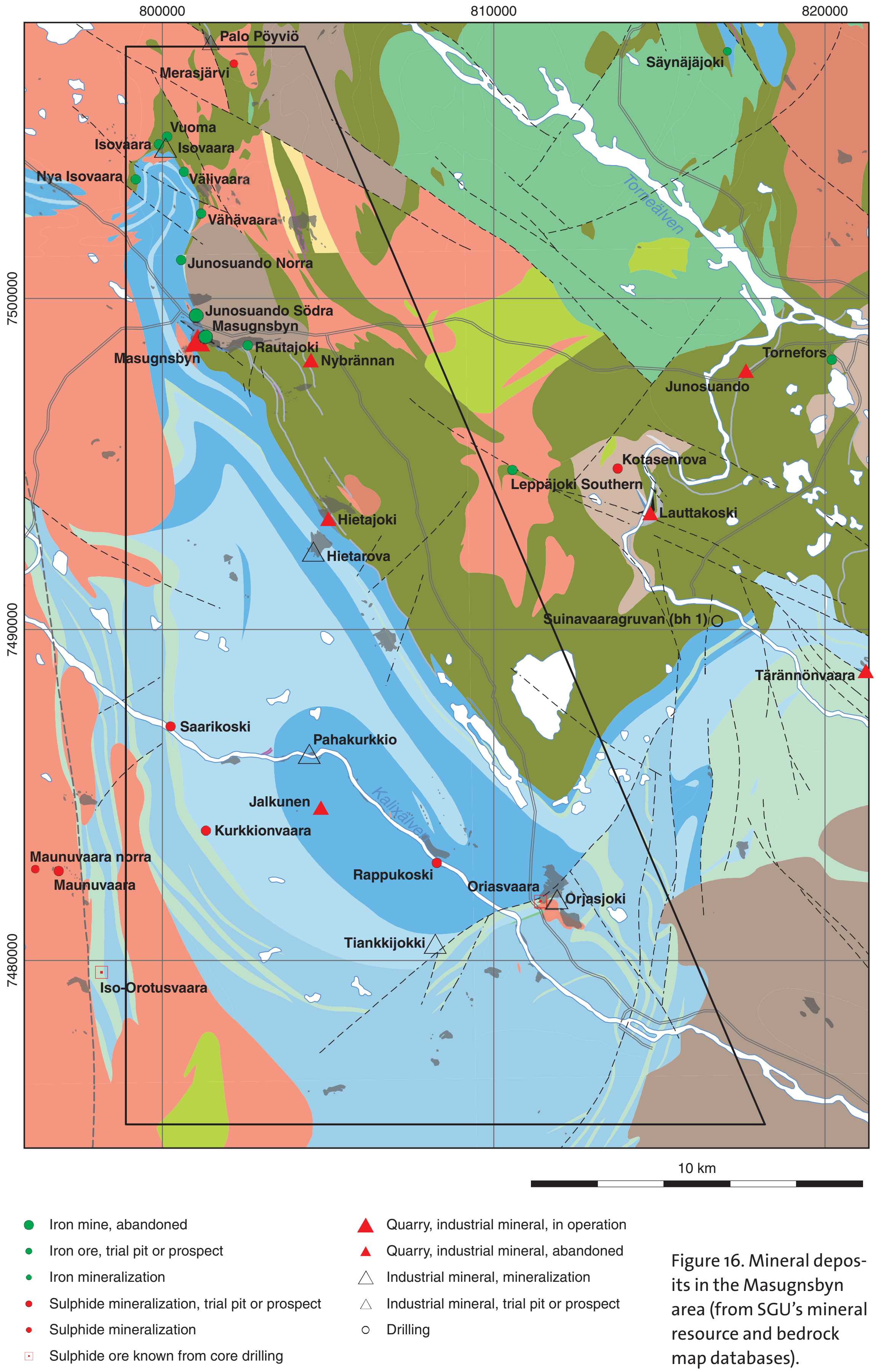
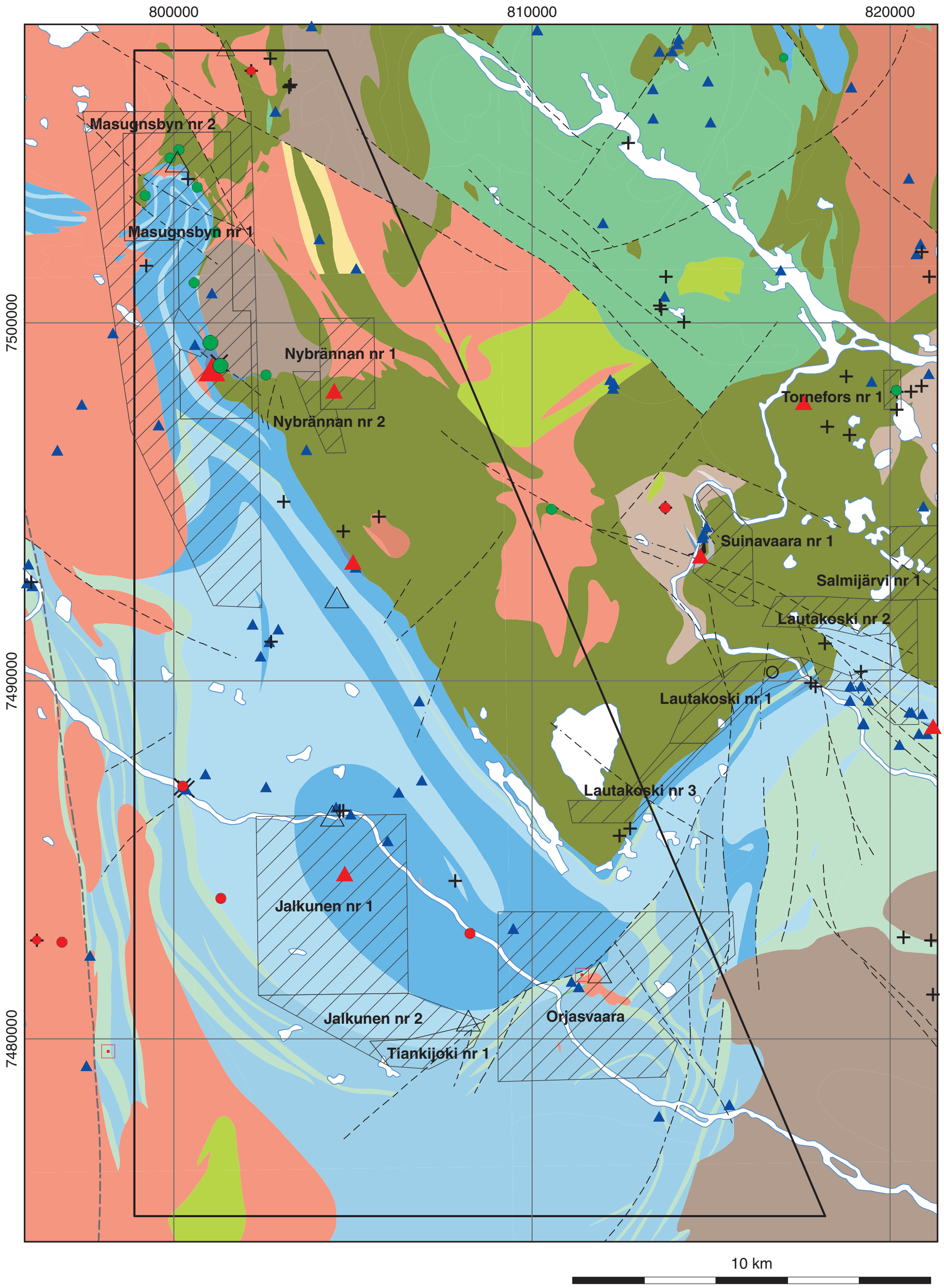


Figure 16. Mineral deposits in the Masugnsbyn area (from SGU's mineral resource and bedrock map databases).



- Mineraljaktsfynd tom 2013
- boulders mineralized SGAB
- Outcrops mineralized LKAB
- Iron mine, abandoned
- Iron ore, trial pit or prospect
- Iron mineralization
- Sulphide mineralization, trial pit or prospect
- Sulphide mineralization
- Sulphide ore known from core drilling
- Quarry, industrial mineral, in operation
- Quarry, industrial mineral, abandoned
- Industrial mineral, mineralization
- Industrial mineral, trial pit or prospect
- Drilling
- Metaller och industrimineral, beviljade

Figure 17. Exploration permits, core drillings, mineralised boulders and mineralisations in the Masugnsbyn area (from SGU's databases).

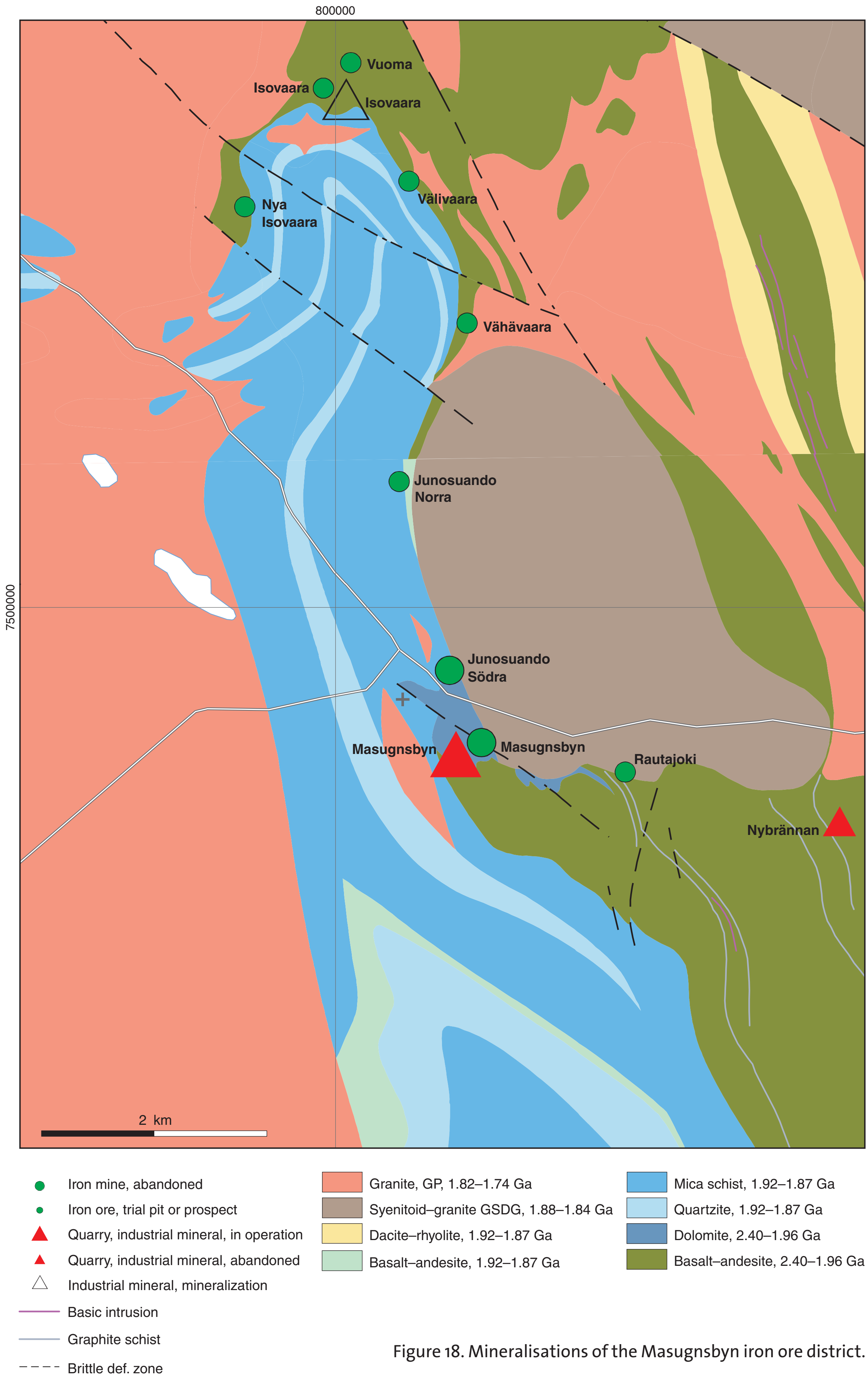


Figure 18. Mineralisations of the Masugnsbyn iron ore district.

Table 4. Mineral deposits in the Masugnsbyn area, see figure 16 for locations (from SGU's mineral and bedrock resources database).

Name	Map	Main_type	Commodity	Occurrence	Host rock	Alteration	Reference	Status
Hietajoki	28L 8e	Industrial min.	dolomite				SGU R&M 54, SGU C 699, pro8009, pro7938	closed mine/ quarry
Hietarova	28L 8e	Industrial min.	andalusite	dissemination	mica schist		Brap 86006 p. 20	anomaly
Isovaara	29L 0d	Industrial min.	dolomite				SGU R&M 54, SGU C 699, SGU C 604, SGU C 351, MiS 2	prospect
Jalkunen	28L 6e	Industrial min.	graphite	dissemination	mica schist-graphitic schist		k8638	anomaly
Junosuando	28L 9g	Industrial min.	graphite	dissemination	graphitic schist		SGU Af 5-8	anomaly
Lauttakoski	28L 8g	Industrial min.	soapstone, talc	massive	tuffite, serpentinite, metadiabase		SGU C 676, Brap 86006	significant prospect
Masugnsbyn	28L 9d	Industrial min.	dolomite				SGU R&M 54, SGU C 351, Prap 91007, Prap 90027	mine/quarry
Nybrännan	28L 9e	Industrial min.	graphite	dissemination			SGU Af 5-8, Brap 00730, Prap 90068, SGU Ca 17	closed mine/ quarry
Orjasjoki	28L 6f	Industrial min.	limestone, dolomite				SGU R&M 54, Brap 00745	anomaly
Pahakurkkio	28L 6e	Industrial min.	sillimanite, andalusite	dissemination	schist gneiss		SGU Hällobs. field n. STB951056, SGU Af 5–8, Brap 86006	anomaly
Palo Pöyviö	29L 1d	Industrial min.	graphite	dissemination	calc-silicate, tuffite, graphitic schist, metadiabase		SGU C 366, SGU C 284 p. 68	prospect
Suinavaaragruvan	28L 7g	Industrial min.	graphite	dissemination	tuffite, graphitic schist, metadiabase		Prap 90068 p. 53, SGU Af 5–8	anomaly
Tiankkijokki	28L 5e	Industrial min.	graphite, Zn	dissemination	mica schist, graphitic schist		ki8305	anomaly
Tärännönvaara	28L 7h	Industrial min.	andalusite	dissemination	mica schist		Brap 86006	anomaly
Isovaara	29L 0d	Iron-oxide	pyrite, Fe	banded/layered	quartzite, calc-silicate	skarn	SGU R&M 92, SGU C 351, Brap 00734	anomaly
Junosuando Norra	28L 9d	Iron-oxide	Fe	dissemination massive	granite, dolomite, calc-silicate	scapolite, skarn, albite	SGU R&M 92, SGU C 351, Brap 00736	anomaly
Junosuando Södra	28L 9d	Iron-oxide	pyrite, Fe	dissemination massive	calc-silicate	skarn, scapolite, biotite, albite	SGU R&M 92, C 351, MiS 2, GFF 106, 219-230, Brap 734, Brap 723	closed mine/ quarry
Leppäjoki Southern	28L 8f	Iron-oxide	pyrite, Fe	dissemination	calc-silicate	skarn	SGU R&M 92, Brap 79505	prospect
Masugnsbyn	28L 9d	Iron-oxide	Fe			skarn	SGU C 351, Brap 00734	closed mine/ quarry
Nya Isovaara	29L 0d	Iron-oxide	Fe	dissemination massive	calc-silicate	skarn	SGU C 604, SGU C 351, MiS 2	anomaly
Rautajoki	28L 9d	Iron-oxide	Fe	banded/layered	dolomite, tuffite	skarn	SGU C 351	anomaly

Name	Map	Main_type	Commodity	Occurrence	Host rock	Alteration	Reference	Status
Säynäjäjoki	29L 1g	Iron-oxide	Fe		greenstone		SGU Af 9–12	anomaly
Tornefors	28L 9h	Iron-oxide	pyrite, Fe	banded/layered	quartzite, calc-silicate	skarn, biotite	SGU R&M 92, MiS 2, Brap 00736	prospect
Vuoma	29L 0d	Iron-oxide	Fe	banded/layered massive	pegmatite, iron formation, calc-silicate, biotite schist	skarn	SGU R&M 92, SGU C 604, SGU C 351, MiS 2, Brap 00723	anomaly
Vähävaara	29L 0d	Iron-oxide	pyrite, Fe	dissemination banded/layered	calc-silicate	scapolite, skarn	SGU R&M 92, SGU C 604, SGU C 351, MiS 2, Brap 00734	prospect
Välivaara	29L 0d	Iron-oxide	Fe	banded/layered	calc-silicate, metasedimentary rock	skarn	SGU R&M 92, SGU C 604, MiS 2	anomaly
Iso-Orotusvaara	28L 5c	Sulphide	Cu, Au	vein	diorite, tuffite		k8637	anomaly
Kotasenrova	28L 8f	Sulphide	Cu	vein	greenstone		Mineraljakten 84382:14a	anomaly
Kurkkionvaara	28L 6d	Sulphide	Pb, Zn, Ag	vein	conglomerate, mica schist, tourmalite	tourmaline, scapolite, albite	ki8511, k8656	anomaly
Maunuvaara	28L 6c	Sulphide	Te, Bi, W, Mo, Cu, Ag	vein dissemination	granite, intermediate volcanic rock		SGU C 283, ki8207, ki8124	prospect
Maunuvaara norra	28L 6c	Sulphide	Cu		pegmatite, biotite schist		Mineraljakten 75088:2 BD	anomaly
Merasjärvi	29L 1d	Sulphide	Mo, Cu	dissemination	granite, greenstone, tuffite		ki8133 p. 7	anomaly
Oriasvaara	28L 6f	Sulphide	Cu, Ag, Au	dissemination	quartzite, greenstone	skarn	mink97010, Brap 82040	anomaly
Rappukoski	28L 6e	Sulphide	Mo, Cu	vein massive	greenstone, calc-silicate , metasedimentary rock	skarn	MiS 2 p. 171–172	anomaly
Saarikoski	28L 7d	Sulphide	Cu, Au		conglomerate		ki8407	anomaly

Table 5. Mineral exploration permits in the Masugnsbyn area, see map in figure 17 for locations (from SGU database at 2014-03-15).

Name	Object id	Area (km^2)	Valid from	Valid to	Mineral	Owners	Status
Jalkunen nr 1	780	2093	2/2/2012	2/2/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Jalkunen nr 2	630	559	7/24/2012	7/24/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Lautakoski nr 1	386	411	6/11/2012	6/11/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Lautakoski nr 2	359	758	7/30/2012	7/30/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Lautakoski nr 3	739	287	7/31/2012	7/31/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Masugnsbyn nr 1	509	1745	10/20/2005	10/20/2015	Cu	Talga Mining Pty Ltd Filial Sweden (100%)	Approved
Masugnsbyn nr 2	752	3087	2/3/2012	2/3/2015	Fe	Talga Mining Pty Ltd Filial Sweden (100%)	Approved
Nybrännan nr 1	831	386	2/1/2012	2/1/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Nybrännan nr 2	569	142	6/11/2012	6/11/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Orjasvaara	478	2596	9/4/2012	9/4/2015	Cu, Au	Norsve Resources PLC (100%)	Approved
Salmijärvi nr 1	500	574	8/15/2011	8/15/2014	Fe	Kiruna Iron AB (100%)	Approved
Suinavaara nr 1	383	380	3/27/2012	3/27/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Tiankijoki nr 1	439	217	2/24/2012	2/24/2015	graphite	Talga Mining Pty Ltd (100%)	Approved
Tornefors nr 1	716	52	8/15/2011	8/15/2014	Fe	Kiruna Iron AB (100%)	Approved
Unnasenrova nr 1	75	2459	9/16/2013	9/16/2014	Cu	Mawson AB (100%)	Prohibited
Masugnsbyn	135	3894	10/8/2013	10/8/2014	Fe	Kiruna Iron AB (100%)	Prohibited
Rousuvuoma nr 1	221	60	4/21/2013	4/21/2014	Cu	Hiltunen, Vesa (100%)	Prohibited
Karhujärvi nr 1	76	1410	11/18/1997	12/24/1999	Au	ScanMining AB (100%)	Expired
Isovinsa nr 2	98	1133	2/18/1999	12/21/2000	Au	ScanMining AB (100%)	Expired
Savijoki nr 1	136	5453	11/16/2000	11/5/2001	Cu	Lake Resources N.L Australia filial (100%)	Expired
Kivivaara nr 1	156	1968	1/7/1998	1/7/2001	Au	ScanMining AB (100%)	Expired
Orjasvaara nr 1	248	1416	1/19/1996	1/2/1997	Cu	Viscaria AB (100%)	Expired
Saarikoski nr 1	250	189	5/20/1997	5/20/2000	Cu	Daler Mining Corporation (100%)	Expired
Männikkö	268	1531	3/4/1999	6/30/1999	Cu	Daler Mining Corporation (100%)	Expired
Isovinsa nr 3	489	126	12/17/2004	12/17/2007	Cu	Hiltunen, Vesa (100%)	Expired
Vehka nr 1	562	2428	2/24/1995	2/22/1997	Cu	Viscaria AB (100%)	Expired
Rantarova nr 1	621	636	11/18/1997	4/21/1999	Au	ScanMining AB (100%)	Expired
Lautakoski nr 101	783	739	12/11/2000	8/25/2003	Cu	Geoforum Scandinavia AB (50%), Holmgren, Sven Erik (50%)	Expired
Isovinsa nr 1	817	527	8/27/1998	8/27/2002	Au	ScanMining AB (100%)	Expired
Naurispalo nr 1	832	1659	12/4/1998	12/4/2001	Cu	Equinox Resources NL Australia filial (100%)	Expired
Haukanoja nr 1	1454	94	3/11/2004	3/11/2007	zink	Hiltunen, Vesa (100%)	Expired
Pikkulaki nr 1	1637	635	1/7/1998	5/28/1998	Au	ScanMining AB (100%)	Expired

Name	Object id	Area (km^2)	Valid from	Valid to	Mineral	Owners	Status
Maunuvaara nr 3	1672	398	2/15/2010	2/15/2013	Fe	Kiruna Iron AB (100%)	Expired
Palolaki nr 1	1679	9533	5/15/2000	5/18/2001	Cu	Lake Resources N.L Australia filial (100%)	Expired
Lovikka nr 3	1681	100	9/30/2009	9/30/2012	Cu	Blackstone Nickel AB (100%)	Expired
Maunuvaara nr 1	1829	99	4/9/2001	4/9/2004	Cu	Mäkinen, Jaakko (100%)	Expired
Junosuando nr 100	1939	7435	8/5/2003	8/5/2006	Cu	Intrepid Minerals Corporation (100%)	Expired
Tarilainen nr 1	2039	675	1/12/1998	5/28/1998	Au	ScanMining AB (100%)	Expired
Nurmavaara nr 1	2229	5709	11/16/2000	11/5/2001	Cu	Lake Resources N.L Australia filial (100%)	Expired
Junosuando nr 1	2251	1810	4/11/1995	4/11/1999	Au	Terra Exploration AB (100%)	Expired
Härkäsaajo nr 1	2354	100	12/17/2007	1/1/2009	Cu	Botnia Exploration AB (100%)	Expired
Junosuando nr 1	2375	26	11/14/1986	11/14/1989	Cu	Viscaria AB (100%)	Expired
Vehkavaara nr 1	2600	2400	4/17/2003	4/17/2006	Cu	Tertiary Gold Limited, c/o Tertiary Minerals plc (100%)	Expired
Lovikka nr 2	2634	12602	4/17/2008	4/17/2012	Cu	Blackstone Nickel AB (100%)	Expired
Hanhijärvi nr 1	2774	415	1/12/1998	5/28/1998	Au	ScanMining AB (100%)	Expired
Junosuando nr 2	2903	1331	9/25/1987	9/25/1990	Cu	Viscaria AB (100%)	Expired
Liivavuoma nr 1	3265	4246	11/16/2000	11/5/2001	Cu	Lake Resources N.L Australia filial (100%)	Expired
Naisaho nr 1	3459	337	1/19/1996	1/2/1997	Cu	Viscaria AB (100%)	Expired
Jylkkyvaara	3542	1000	2/7/1997	1/10/1999	Cu	Geoforum Scandinavia AB (100%)	Expired
Pahturi nr 1	3762	2158	12/13/1994	12/7/1996	Cu	Viscaria AB (100%)	Expired
Viiksjärvi nr 1	3774	1126	11/22/1994	11/22/1997	Cu	Viscaria AB (100%)	Expired
Maunuvaara nr 2	3837	398	2/18/2010	2/18/2013	Fe	Kiruna Iron AB (100%)	Expired
Lovikka nr 4	4015	126	9/30/2009	9/30/2012	Cu	Blackstone Nickel AB (100%)	Expired
Nurmasuanto	4239	3092	3/8/1999	6/30/1999	Cu	Daler Mining Corporation (100%)	Expired
Maunuvaara	4250	1001	2/7/1997	1/10/1999	Cu	Geoforum Scandinavia AB (100%)	Expired
Junosuando nr 2	4259	1409	10/24/1995	10/24/1998	Au	Terra Mining AB (100%)	Expired
Mustamaa nr 1	4270	326	10/14/1998	10/14/2001	Au	ScanMining AB (100%)	Expired

Table. 6. Mineralised boulders (dataset from the SGU Malå office).

ID	Map	B/O	N_SWE	E_SWE	Mineral	Occcurence	Grade
OÖ198/41	28L5g	B	7478161	815509	Chalcopyrite	Dissemination	Isolated grains
TE235/48	28L1h	B	7489460	819387	Chalcopyrite	Dissemination	Poor
TE237/48	28L7h	B	7488222	820253	Chalcopyrite		
OW18/48	28L7g	B	7489858	819182	Chalcopyrite		
OW21/48	28L7g	B	7489854	818882	Chalcopyrite		
OW22/48	28L7g	B	7489854	818882	Chalcopyrite		
OW23/48	28L7g	B	7489854	818882	Chalcopyrite		
VB75/48	28L7g	B	7489453	818867	Chalcopyrite		
MB82/48	28L6f	B	7483082	809471	Chalcopyrite		
GW77/49	28L9h	B	7501472	816931	Chalcopyrite	Dissemination	
OW/49	28L9h	B	7498361	819471	Chalcopyrite		
ATH7/49	28L9h	B	7498582	821068	Chalcopyrite		
MF12/63	28L8c	B	7491503	795812	Chalcopyrite		
MF13/63	28L8c	B	7493255	795939	Chalcopyrite		
MF14/63	28L8c	B	7492729	795896	Chalcopyrite		
MF17/63	28L8e	B	7493174	805065	Chalcopyrite	Dissemination	Isolated grains
ÅN9/63	28L9c	B	7496440	796748	Chalcopyrite		
ÅN10-11/63	28L8d	B	7491446	802912	Chalcopyrite		
ÅN12/63	28L6f	B	7481603	811090	Chalcopyrite		
ÅN13/63	28L6e	B	7486272	804929	Chalcopyrite		
ÅN14/63	28L7e	B	7486467	804527	Chalcopyrite		
MINK992975	28L6f	B	7481455	811292	Chalcopyrite	Dissemination	Poor
BNAG80091	28L7d	B	7487399	800875	Chalcopyrite		
115/44	29L1g	B	7506746	814912	Chalcopyrite		
TE184/49	29LOf	B	7506531	813365	Chalcopyrite		
OW42/49	29L0f	B	7505711	813376	Chalcopyrite		
FR200A/65	29L1f	B	7508189	810144	Chalcopyrite	Dissemination	In places good
FR200C/65	29L1f	B	7508189	810144	Chalcopyrite	Dissemination	Throughout some
FR200D/65	29L1f	B	7508189	810144	Chalcopyrite	Crackfilling	Throughout good
KL11/66	29L1f	B	7507583	813551	Chalcopyrite	Dissemination	Throughout good
KL12/66	29L1f	B	7507583	813551	Chalcopyrite	Dissemination	Throughout good
GW77/49	29L0h	B	7501927	820724	Chalcopyrite	Dissemination	Throughout rich
OB/47	28L7e	B	7487223	806917	Graphite		
OW19/48	28L7g	B	7489858	819182	Graphite		
OW21/48	28L7g	B	7489854	818882	Graphite		
OW22/48	28L7g	B	7489854	818882	Graphite		
OW23/48	28L7g	B	7489854	818882	Graphite		
ATH105/48	28L5f	B	7477835	813539	Graphite		
VB75/48	28L7g	B	7489453	818867	Graphite		
MB76/48	28L7e	B	7486890	806271	Graphite		
MB104/48	28L6e	B	7485536	805964	Graphite		
MF15/63	28L7d	B	7487042	802570	Hematite		
FR200B/65	29L1f	B	7508189	810144	Iron	Dissemination	Throughout some
XX7192731	29L0f	B	7502793	811974	Iron	Breccia	
MB105/48	28L6e	B	7485536	805964	Magnetite	Massive	Throughout rich
BNAG80102	28L7d	O	7486972	800336	Magnetite	Dissemination	
BNAG80103	28L9d	O	7498874	801266	Magnetite	Massive	Throughout rich
115/44	29L1g	B	7506746	814912	Magnetite		
GW77/49	29L0h	B	7501927	820724	Magnetite	Dissemination	Throughout rich
MB82/48	28L6f	B	7483082	809471	Molybdenite	Dissemination	Poor
TR/43	28L9c	B	7497724	797431	Pyrite	Dissemination	
OW23/48	28L7g		7489854	818882	Pyrite		

ID	Map	B/O	N_SWE	E_SWE	Mineral	Occcurence	Grade
VB75/48	28L7g	B	7489453	818867	Pyrite		
MB82/48	28L6f	B	7483082	809471	Pyrite		
OW/49	28L9d	B	7499390	800584	Pyrite		
ÅN9/63	28L9c	B	7496440	796748	Pyrite		
BNAG80101	28L7d	O	7487041	800240	Pyrite	Crackfilling	
BNAG80103	28L9d	O	7498874	801266	Pyrite	Massive	Throughout rich
FW237/66	29L0e	B	7501523	805081	Pyrite	Dissemination	Throughout rich
OÖ198/41	28L5g	B	7478161	815509	Pyrrhotite		
OW18/48	28L7g	B	7489858	819182	Pyrrhotite		
OW19/48	28L7g	B	7489858	819182	Pyrrhotite		
OW21/48	28L7g	B	7489854	818882	Pyrrhotite		
OW22/48	28L7g	B	7489854	818882	Pyrrhotite		
MB216/48	28L9e	B	7496455	803697	Pyrrhotite	Dissemination	Throughout rich
MF16/63	28L7d	B	7490689	802422	Pyrrhotite		
MF17/63	28L8e	B	7493174	805065	Pyrrhotite		
ÅN9/63	28L9c	B	7496440	796748	Pyrrhotite		
FR200B/65	29L1f	B	7508189	810144	Pyrrhotite	Dissemination	Throughout rich

Table 7. Mineralised boulders and outcrops in the Masugnsbyn area from the competition “Mineraljakten”.

Reg NO	Score	Location	Map	N Sweref	E Sweref	Review	Type	Analysis
03156:2,4,6	2	Viiksvaara gravel pit	28L 9h	7501287	821083	Cpy/Py/Po/-min boulders in gravel pit. No significance of min boulder occurence; boulders occur scattered in up to approx. 6-10 m thick till. Bedrock (“granitoid”/monzonite.-Perthite Gr) is exposed at bottom of gravel/till pit	boulder	0.03 ppm Au, 1.10% Cu
73296 BD	2	Pahakurkkio	28L 6e	7486370	804728	Pegmatit i skiffer förande något kopparglans och malakit.	boulder	1,30% Cu
81977:25	2	Junosuando	28L 9h	7498075	820575	Basisk omvandlad vulkanit med kopparkisimpregnation, sliror. Svagt magnetisk. Rik impregnation	boulder	3.9% Cu
03157-1	3	Jukkasvaara	28L 5h	7481239	821186	Rounded boulder in upper till; Cpy/Po min. rock (“greenstone/meta-volcanite). Interesting mineralisation in boulder, but of no significance due to its topographic setting.	boulder	0.56 ppm Au, 0.38% Cu, 2.64% Zn
91079	3	Rousuvuoma	28L 9f	7500479	813562	Med grävmaskin uppgrävda stora bergstycken på ett kalhygge. Antingen ett stort block eller häll/hällnära. Basaltisk bergart med fläckar och sliror av kopparkis, malakit och azurit.	outcrop	2300 ppm Cu; 15,5% Fe
91080	3	Rousuvuoma	28L 9f	7500379	813603	Kantigt block av amfibolit med ställvis god halt kopparkis troligen mot 1% bitvis. Ett hundratal meter från förmodad häll (1079).Ytterligare ett liknande äldre ej insänt block finns.	boulder	
74059 BD	3	Junosuando	28L 9h	7497570	820181	Blocket hittades i vattenledningsdiket. Vid besök var diket igenfyllt och blocket hade lagts tillbaka i diket	boulder	0.8% Cu
78169	3	Pöyviönpalo	29L 1d	7507373	802691	90x80x40 cm. Blocket består av malmkvartsit. Ena sidan rikt impregnerad av kopparkis. I andra sidan förekommer mera magnetkis men även finkornig kopparkis. (Ni-reagens)	boulder	1.44% Cu
79458:14-16	3	Rimojärvi	29L 0d	7504012	800399	50x60x70 cm. Rostig, glasig malmkvartsit. Rikligt impregnerat av FeS, FeS2 och jämnt impregnerat med kopparkis	boulder	458:14: 0.30% Cu,
79475:21	3	Puuroharjut	28L 7d	7491093	802717	Upp till 10 m bred kvartsgång, ca 40 m lång. Enstaka uppstrickande hällar i kanter och i mitten. Största delen ren och homogen kvarts, ställvis föroreningar av mikroklin och järnföreningar	outcrop	
82428:01,03	3	Junosuando	28L 9g	7498502	818769	5 cm bred kvartsgång. Sidoberget är troligen förskarnad vulkanit. Malmmineral: scheelit (impregnation rel. svag), kopparkis (små fläckar), molybdenglans (små sliror)	boulder	
85417:45	3	Koronpesänjärvi	28L 9g	7497095	818237	Dioritblock med svavel- och kopparkisimpregnation genom hela blocket.	boulder	0.17 ppm Au
87001:20	3	Lautakoskivägen	28L 6f	7485670	812437	Kalksten	boulder	

Reg NO	Score	Location	Map	N Sweref	E Sweref	Review	Type	Analysis
87277:03	3	Masugnsbyn	29L 0c	7501597	799230	Inom ett ca. 100mx200m stort område ligger 10-tals sulfidförande (magnet- och svavelkis, med spår av koppar) lokala kantiga block, av lava tuffit, skarn och kvartsrika bergart (chert?).	boulder	
87360:04	3	Junosuando	28L 9f	7501286	813733	Flera block av basisk vulkanit. Delvis skarniga inslag av kemiska sediment (chert). Många block håller Cu i sprickor, körtlar och gles impregnation. Körtlarna kan vara mer än 1cm3 med Cu, i block m. vulkanit o. malakit.	boulder	
87466:67	3	Kalttiniemi	29L 0f	7505022	812685	Analys: 0.01 ppm Au, 0.07% Cu. Grönsten med kopparkis och pyrit som impregnation och fläckar.	boulder	
87901	3	Pahakurkkio	28L 7e	7486368	804628		boulder	
88597 (796/87:100)	3	Pahajärvi, Lautajärvi	28L 6f	7485874	812734	Ljust brunröd kalksten.	boulder	
90062:1,2.	3	Lautakoski	28L 7g	7491044	818166	Block av sur vulkanit som för kopparkis- magnetkis. Analyshalter 0,83% Cu, 0,02% Ni.N: 7489000 Ö: 1784400	boulder	
90132:36	3	Lautakoski	28L 7g	7490257	819176	Relativt ojämn mineralisering i blocken.	boulder	
93392 BD	3	Viiksvaara	29L 0h	7501979	820874	Karl Karkea. Kornstorlek och färg varierar inom ett stort massiv av monzonit. I framgrävd häll har en blå tint noterats på uppträdande kvarts. Kvarts är annars sällsynt i bergarten.	outcrop	
94340:13	3	Vehkavaara	28L 8e	7494582	805721	Roger Fredriksson och ALU-grupp. Ljus fin wollastonit i block. Urvittrad block	boulder	
95120:10	3	Palo-Pöyviö	29L 1d	7506598	803215	Vesa Hiltunen och ALU-grupp i Junosuando, Pajala. Litet kantigt block. Analys: 0.22% Mo. Ny typ i området. Bör kanske följas upp.	boulder	
95120:11	3	Palo-Pöyviö	29L 1d	7506578	803215	Vesa Hiltunen och ALU-grupp i Junosuando, Pajala. Litet kantigt block. Halten zinkblände är otillräcklig men fyndet är intressant.	boulder	
95325:01	3	Palo-Pöyviö	29L 1d	7506649	803264	Vesa Hiltunen och ALU-grupp i Junosuando, Pajala. Litet kantigt block. Analys: 0.36% Cu	boulder	
04355-1	4	Isovinsa	28L 6h	7482752	821137	20x40 cm block. Skarnomvandlad diorit med kvarts även med molybdenglans, ej rostig yta	boulder	0.25 ppm Au, 0.6 ppm Ag, 1.26% Cu
75088:2 BD	4	Maunuvaara	28L 6c	7482759	796176	Häll av mörkgrågrön biotitgnejs delvis genomådrad av ljusröd pegmatitisk granit, mineraliseringen består av bornit och något kopparglans. På släppytorna förekommer azurit och malakit.	outcrop	1.98% Cu

Reg NO	Score	Location	Map	N Sweref	E Sweref	Review	Type	Analysis
78451	4	Nurmasuanto	28L 8c	7492756	796016	Ett tiotal block. Ljust gulbrun, finkornig och massformig dolomit av “Masugnsbytyp”.	boulder	
79002	4	Lautakoski	28L 7g	7489841	817912	Några kubikmeterstora kantiga block, hållande huvudsakligen täljsten genomdragna av ett par karbonatstenhorisonter och tunna tremolit-skikt. Färgen är grågrön på täljstenen.	boulder	
79074	4	Palo-Pöyvio	29L 1d	7507035	802159	Granit och granitiserad grönsten går i ca E-W riktning en 15-20 m bred och 180-200 m lång rostig zon som på 2-3 ställen innehåller i areal mindre än 1m2 stora mineraliseringar av molybdenglans, svavel- och sporadiskt med kopparkis.	outcrop	
811063:01	4	Lautakoski by	28L 7g	7489939	817781	Barytgångar (körtlar) i en karbonatbergart. Gångar ca 20-30 cm breda	outcrop	
84382:14a,b	4	Kotasenrova	28L 8f	7494836	813717	Utgöres av intermediär-basisk vulkanit, något skarnig -kalkig. Enstaka kopparkiskorn oregelbundet framförallt i kalkiga sliror. Mindre partier något rikare på kopparkis. Malakit uppträder oregelbundet.	outcrop	
85782:68	4	Junosuando	28L 9h	7498229	820873	Kvartsitiskt block med rik kopparkis mineralisering, huvudsakligen som tunna sprickor.	boulder	
89018:17	4		28L 8e	7494169	804727	Block av kraftigt silicifierad bergart. Kan vara en kvartsit. Kopparkis som impregnation och spridda korn med arsenikkis.	boulder	1.19% Cu, 1.15% As, 0.14 ppm Au, 4.8 ppm Ag
90507	4	Trappukoski	28L 6e	7484410	807853	Tom Hiltunen och Niklas Johansson. 30-tal lokala kvartsblock de största 0,5 m stora.Kvartsen ser bra ut, ofta klar och “glasig”. I bissa block är dock kvartsen sammanvuxen med andra pegmaitmineral.	boulder	
90508:2-3	4	Vekkavaara	28L 8d	7494997	803066	Elof Bertil Niemi och Vesa Hiltunen. Ren dolomit. Gulaktig sannolikt mycket hällnära	boulder	
86141:30	5	Junosuando	28L 9h	7498070	820175	Mineraliserade block med höga Cu halter.	boulder	3.81% Cu, 3 ppm Ag, 0.44 ppm Au
120091	2-	Rousuvuoma	28L 9g	7500017	814239	Genomgående halt kopparkis.Kraftigt magnetiskt, (magnetit).Spår av amfibol. Beskrivning: 30x20x20 cm. Skarnig hornbländerik grönsten av samma typ som Vesas 1:a pris 2009. Små blåsor med ansamlingar kopparkis, jämt spritt.	boulder	
101118	2+	Onkijärven Harju	28L 9g	7496864	818863	Skivformad, klart kantig basalt med små ansamlingar finkornig fält-spat. Främst i samband med ställvis god impregnation kopparkis, men även något utspritt i övriga bergarten. Trots sin ringa storlek väcker provet ett visst intresse.	boulder	0.46% Cu, 0.12 ppm Au

Reg NO	Score	Location	Map	N Sweref	E Sweref	Review	Type	Analysis
07256:2-5	3(+)	Jukkasjärvi, Isovinsa	28L 6h	7482844	820364	Block 130x120x? Cm. Ett halvdussin kantiga vittrade dolomitblock. Med ett par undantag, helt friska inuti. Wollastonit fanns på ytan i två block, bl a det största. Övriga block i halvmeters storlek. Blocken uppgrävda vid ny skogsbilväg		
04355-2		Isovinsa	28L 6h	7482752	821137	10x20 cm block. Folierad amfibolit med pyrit- och kopparkis. Rostig yta	boulder	<0.01 ppm Au, <0.2 ppm Ag, 0.1% Cu

Table 8. Drill core associated with mineral deposits in the Masugnsbyn area.

Idcode	Name	N-SWE	E-SWE	Year	Depth	Azim	Dip	Log	Map	Scan	Anal	Meas	Ref	Prev. Owner
HIE78062	Hietajoki	7493253	804955	1978	70	0	45	X	X	X	X		Pro 7938	LKAB
HIE78063	Hietajoki	7493280	804997	1978	70	0	45	X	X	X	X		Pro 7938	LKAB
HIE78064	Hietajoki	7493315	805053	1978	75	0	45	X	X	X	X		Pro 7938	LKAB
HIE78065	Hietajoki	7493345	805097	1978	75	0	45	X	X	X	X		Pro 7938	LKAB
HIE78066	Hietajoki	7493410	804851	1978	75	0	45	X	X	X	X		Pro 7938	LKAB
HIE78067	Hietajoki	7493446	804894	1978	75	0	45	X	X	X	X		Pro 7938	LKAB
HIE78068	Hietajoki	7493473	804936	1978	45	0	45	X	X	X	X		Pro 7938	LKAB
HIE78069	Hietajoki	7493500	804978	1978	75	0	45	X	X	X	X		Pro 7938	LKAB
ISV001	Isovaara	7504605	799892	1915	0	0	45	X		X			Brap 718	Nordsvenska malmfält
K-JAL-1	Jalkunen	7485167	804522	1986	255	90	60	X		X	X		K 8638	NÖN/LKAB/NSG/VOLVO
K-JAL-2	Jalkunen	7486064	804332	1986	226	90	60	X		X	X		K 8638	NÖN/LKAB/NSG/VOLVO
K-JAL-3	Jalkunen	7484620	804775	1986	118	90	60	X		X	X		K 8638	NÖN/LKAB/NSG/VOLVO
JUN002	Junosuando	7501161	800424	1915	141	0	45	X			X		Brap 718	Nordsvenska malmfält
JUN003	Junosuando	7501051	800483	1915	100	0	45	X			X		Brap 718	Nordsvenska malmfält
JUN004	Junosuando	7500790	800522	1915	107	0	45	X					Brap 718	Nordsvenska malmfält
JUN005	Junosuando	7500594	800574	1915	112	0	45	X			X		Brap 718	Nordsvenska malmfält
JUN006	Junosuando	7501512	800488	1915	48	0	45	X					Brap 718	Nordsvenska malmfält
JUN007	Junosuando	7501616	800712	1915	19	0	90	X					Brap 718	Nordsvenska malmfält
JUN008	Junosuando	7499444	801013	1915	51	0	45	X					Brap 718	Nordsvenska malmfält
JUN009	Junosuando	7501457	800550	1915	10	0	90	X					Brap 718	Nordsvenska malmfält
JUN010	Junosuando	7501263	800524	1915	10	0	90	X					Brap 718	Nordsvenska malmfält
JUN011	Junosuando	7501090	800559	1915	25	0	90	X					Brap 718	Nordsvenska malmfält
JUN012	Junosuando	7500693	800575	1915	74	0	45	X					Brap 718	Nordsvenska malmfält
JUN001	Junosuando	7501419	800464	1915	79	0	45	X					Brap 718	Nordsvenska malmfält
KKUR1	Kurkkionvaara	7483956	801265	1982	319	90	70	X		X	X		Ki 8511	LKAB prospektering
KKUR2	Kurkkionvaara	7483778	801358	1982	177	70	70	X		X	X		Ki 8511	LKAB prospektering
KKUR3	Kurkkionvaara	7483591	801430	1982	255	90	60	X		X	X		Ki 8511	LKAB prospektering
KKUR4	Kurkkionvaara	7483718	801246	1982	220	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR5	Kurkkionvaara	7483241	801624	1982	232	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR6	Kurkkionvaara	7484395	801026	1982	314	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR7	Kurkkionvaara	7484218	801122	1982	222	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR8	Kurkkionvaara	7484491	801201	1982	222	70	60	X		X	X		Ki 8511	LKAB prospektering

Idcode	Name	N-SWE	E-SWE	Year	Depth	Azim	Dip	Log	Map	Scan	Anal	Meas	Ref	Prev. Owner
KKUR9	Kurkkionvaara	7484625	801242	1982	137	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR10	Kurkkionvaara	7484376	801402	1982	171	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR11	Kurkkionvaara	7483687	801606	1982	208	90	60	X		X	X		Ki 8511	LKAB prospektering
KKUR12	Kurkkionvaara	7484877	800865	1984	291	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR13	Kurkkionvaara	7483894	801151	1984	240	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR14	Kurkkionvaara	7483520	801299	1984	292	90	60	X		X	X		Ki 8511	LKAB prospektering
KKUR15	Kurkkionvaara	7483344	801395	1984	298	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR16	Kurkkionvaara	7483855	801287	1984	268	70	60	X		X	X		Ki 8511	LKAB prospektering
KKUR17	Kurkkionvaara	7483652	801853	1984	218	320	60	X		X	X		Ki 8511	LKAB prospektering
KKUR18	Kurkkionvaara	7484275	801661	1984	272	315	50	X		X	X		Ki 8511	LKAB prospektering
KKUR19	Kurkkionvaara	7484689	801562	1984	219	225	60	X		X			Ki 8511	LKAB prospektering
KKUR20	Kurkkionvaara	7483640	801291	1985	284	90	60	X		X			K 8612	LKAB prospektering
KKUR21	Kurkkionvaara	7483169	801491	1985	213	90	60	X		X			K 8612	LKAB prospektering
KKUR22	Kurkkionvaara	7482804	801866	1985	287	90	60	X		X			K 8612	LKAB prospektering
MAS049	Masugnsbyn	7498717	801054		0	0	0						K-8806	LKAB
MAS050	Masugnsbyn	7498839	800930		0	0	0						K-8806	LKAB
MAS051	Masugnsbyn	7498868	800967		0	0	0						K-8806	LKAB
MAS052	Masugnsbyn	7498878	801012		0	0	0						K-8806	LKAB
MAS053	Masugnsbyn	7498730	801015		0	0	0						K-8806	LKAB
MAS054	Masugnsbyn	7498753	801000		0	0	0						K-8806	LKAB
MAS055	Masugnsbyn	7498766	800967		0	0	0						K-8806	LKAB
MAS67501	Masugnsbyn	7501339	799860	1967	125	100	60	X			X	X		SGU
MAS67502	Masugnsbyn	7501324	799802	1967	167	0	60				X	X		SGU
MAS67503	Masugnsbyn	7501125	799834	1967	138	0	60	X			X	X		SGU
MAS67504	Masugnsbyn	7500922	799847	1967	159	0	60	X			X	X		SGU
MAS67505	Masugnsbyn	7500906	799789	1967	231	100	60	X			X	X		SGU
MAS67506	Masugnsbyn	7500724	799881	1967	210	0	60	X			X	X		SGU
MAS67507	Masugnsbyn	7500525	799911	1967	160	100	60	X			X	X		SGU
MAS67508	Masugnsbyn	7500330	799954	1967	150	0	55	X			X	X		SGU
MAS67509	Masugnsbyn	7500129	799976	1967	157	0	55	X			X	X		SGU
MAS67510	Masugnsbyn	7500509	799850	1967	202	0	60	X			X	X		SGU
MAS67511	Masugnsbyn	7499930	800008	1967	170	0	55	X			X	X		SGU
MAS67512	Masugnsbyn	7500113	799917	1967	232	100	58	X			X	X		SGU

Idcode	Name	N-SWE	E-SWE	Year	Depth	Azim	Dip	Log	Map	Scan	Anal	Meas	Ref	Prev. Owner
MAS67513	Masugnsbyn	7499745	800089	1967	120	0	55	X			X	X		SGU
MAS67514	Masugnsbyn	7499729	800031	1967	194	0	57	X			X	X		SGU
MAS67515	Masugnsbyn	7499546	800121	1967	156	100	55	X			X	X		SGU
MAS67516	Masugnsbyn	7499353	800173	1967	174	0	60	X			X			SGU
MAS67517	Masugnsbyn	7499339	800119	1967	214	0	62	X			X	X		SGU
MAS67518	Masugnsbyn	7499175	800282	1967	104	0	55	X			X	X		SGU
MAS67519	Masugnsbyn	7498965	800271	1967	154	0	55	X			X	X		SGU
MAS68501	Masugnsbyn	7499150	800187	1968	197	100	55	X			X	X		SGU
MAS68502	Masugnsbyn	7498781	800356	1968	143	100	60	X			X	X		SGU
MAS68504	Masugnsbyn	7498953	800229	1968	207	0	60	X			X	X		SGU
MAS68505	Masugnsbyn	7501685	800070	1968	135	100	60	X			X	X		SGU
MAS68506	Masugnsbyn	7502086	800178	1968	77	100	85	X			X			SGU
MAS68507	Masugnsbyn	7498757	801197	1968	151	0	60	X			X	X		SGU
MAS68508	Masugnsbyn	7498910	801150	1968	121	0	55	X			X	X		SGU
MAS68509	Masugnsbyn	7502619	800467	1968	202	130	60	X			X	X		SGU
MAS69501	Masugnsbyn	7503440	799356	1969	100	0	60	X			X	X		SGU
MAS69504	Masugnsbyn	7504499	799058	1969	87	0	60	X				X		SGU
MAS69505	Masugnsbyn	7504985	799756	1969	136	0	60	X			X	X		SGU
MAS69506	Masugnsbyn	7504782	799965	1969	136	100	60	X			X	X		SGU
MAS70501	Masugnsbyn	7503400	800448	1970	104	0	60	X			X	X		SGU
MAS70502	Masugnsbyn	7502846	800560	1970	137	0	60	X			X	X		SGU
MAS85025	Masugnsbyn	7498763	801089	1985	0	0	0						K-8806	LKAB
MAS85026	Masugnsbyn	7498744	801074	1985	0	0	0						K-8806	LKAB
MAS85027	Masugnsbyn	7498729	801055	1985	0	0	0						K-8806	LKAB
MAS85028	Masugnsbyn	7498730	801059	1985	0	0	0						K-8806	LKAB
MAS85029	Masugnsbyn	7498717	801038	1985	0	0	0						K-8806	LKAB
MAS85030	Masugnsbyn	7498613	801073	1985	0	0	0						K-8806	LKAB
MAS85031	Masugnsbyn	7498636	800976	1985	0	0	0						K-8806	LKAB
MAS85032	Masugnsbyn	7498646	800940	1985	0	0	0						K-8806	LKAB
MAS85033	Masugnsbyn	7498667	800964	1985	0	0	0						K-8806	LKAB
MAS85034	Masugnsbyn	7498693	800903	1985	0	0	0						K-8806	LKAB
MAS85035	Masugnsbyn	7498719	800936	1985	0	0	0						K-8806	LKAB
MAS85036	Masugnsbyn	7498720	800888	1985	0	0	0						K-8806	LKAB

Idcode	Name	N-SWE	E-SWE	Year	Depth	Azim	Dip	Log	Map	Scan	Anal	Meas	Ref	Prev. Owner
MAS85037	Masugnsbyn	7498744	800873	1985	0	0	0						K-8806	LKAB
MAS85038	Masugnsbyn	7498672	800926	1985	0	0	0						K-8806	LKAB
MAS85039	Masugnsbyn	7498705	800965	1985	0	0	0						K-8806	LKAB
MAS85040	Masugnsbyn	7498612	801121	1985	0	0	0						K-8806	LKAB
MAS88041	Masugnsbyn	7498683	801041	1988	43	229	68	X			X		K-8806	LKAB
MAS88042	Masugnsbyn	7498692	801032	1988	48	255	-1	X			X		K-8806	LKAB
MAS88043	Masugnsbyn	7498763	800961	1988	60	260	-1	X			X		K-8806	LKAB
MAS88044	Masugnsbyn	7498725	800992	1988	50	60	42	X			X		K-8806	LKAB
MAS88045	Masugnsbyn	7498745	801021	1988	36	58	40	X			X		K-8806	LKAB
MAS88046	Masugnsbyn	7498764	801044	1988	38	56	43	X			X		K-8806	LKAB
MAS88047	Masugnsbyn	7498775	801061	1988	36	57	43	X			X		K-8806	LKAB
MAS88048	Masugnsbyn	7498789	801080	1988	36	56	44	X			X		K-8806	LKAB
ORI86201	Oriasvaara	7481692	811381	1986	125	0	0	X			X		NSG86110	NSG
ORI86202	Oriasvaara	7481788	811387	1986	149	0	0	X			X		NSG86110	NSG
RUO49001A	Ruokojärvi	7486693	808929	1949	0	100	45							
RUO59003A	Ruokojärvi	7485914	809994	1959	0	100	45							
K-TIA01	Tiankijoki	7480191	806308	1982	44	0	60	X			X		K 8652	LKAB
K-TIA02	Tiankijoki	7480188	806308	1982	140	0	60	X			X		K 8652	LKAB
K-TIA03	Tiankijoki	7479671	806315	1982	112	0	60	X			X		K 8652	LKAB
K-TIA04	Tiankijoki	7479766	805914	1982	238	0	45	X			X		K 8652	LKAB
K-TIA05	Tiankijoki	7479955	808205	1982	143	0	60	X			X		K 8652	LKAB
K-TIA06	Tiankijoki	7480163	808009	1982	70	0	45	X			X		K 8652	LKAB
K-TIA07	Tiankijoki	7480516	808220	1982	171	0	45	X			X		K 8652	LKAB
K-TIA08	Tiankijoki	7480504	808120	1982	90	0	45	X			X		K 8652	LKAB
K-TIA09	Tiankijoki	7480783	806501	1985	203	0	45	X			X		K 8612	LKAB
K-TIA10	Tiankijoki	7480722	807201	1985	207	0	45	X			X		K 8612	LKAB
K-TIA11	Tiankijoki	7480503	807204	1985	191	0	60	X			X		K 8612	LKAB
K-TIA12	Tiankijoki	7480567	808303	1985	121	0	45	X			X		K 8612	LKAB
K-TIA13	Tiankijoki	7480457	808305	1985	108	0	45	X			X		K 8612	LKAB
K-TIA14	Tiankijoki	7480210	809358	1985	91	306	45	X			X		K 8612	LKAB
VMA001	Vuoma	7504832	800133	1915	0	0	45	X	3				Brap 718	Nordsvenska malmfält
VMA002	Vuoma	7504844	800239	1915	0	0	45	X					Brap 718	Nordsvenska malmfält
VMA003	Vuoma	7504719	800095	1915	0	0	45	X					Brap 718	Nordsvenska malmfält

Idcode	Name	N-SWE	E-SWE	Year	Depth	Azim	Dip	Log	Map	Scan	Anal	Meas	Ref	Prev. Owner
VMA004	Vuoma	7504825	799957	1915	0	0	45	X					Brap 718	Nordsvenska malmfält
VAH001	Vähävara	7502817	801032	1915	99	0	45	X					Brap 718	Nordsvenska malmfält
VAH002	Vähävara	7502557	801022	1915	96	0	45	X					Brap 718	Nordsvenska malmfält
VLV001	Välivaara	7504108	800433	1915	44	0	45	X		X			Brap 718	Nordsvenska malmfält
VLV73501	Välivaara	7503796	800146	1973	202	0	60	X		X	X	X		SGU
VLV73502	Välivaara	7503940	800066	1973	197	0	60	X		X	X	X		SGU
VLV73503	Välivaara	7503644	800197	1973	187	0	60	X		X	X	X		SGU
VLV73504	Välivaara	7503806	800184	1973	141	0	60	X		X		X		SGU
VLV74501	Välivaara	7503881	800154	1974	142	0	60	X		X		X		NSG
VLV74502	Välivaara	7504030	800093	1974	129	0	60	X		X		X		NSG
VLV74503	Välivaara	7503582	800275	1974	134	0	60	X		X		X		NSG

Magnetgruvan is part of the Junosuando deposit that was investigated by magnetic and gravimetric ground measurements, diamond core drilling and detailed geological mapping of the ore zone by the Geological Survey of Sweden in the 1960s. Aeromagnetic maps of 28L Tärendö and 29L Laino also became available during this time. SGU carried out a drilling programme of the Masugnsbyn iron mineralisations in the years 1967–1970 with 33 holes of a total length of 5488 m. Based on the drilling, the ore tonnage of the Junosuando deposit was estimated to 60 million tonnes of iron ore with an average of 30% Fe, 1.9% S, 0.024% P, 1.3% F and 0.08% Cu. In the smaller Vähävaara deposit, the iron ore resources down to 150 m below surface were estimated to 3.1 million tonnes at 28.8% Fe with in average 2.7% S and 0.048% P (Witschard et al. 1972). The Junosuando deposit is currently being investigated by Talga Resources Ltd and new estimates have resulted in 112 million tonnes of ore at 28.6% Fe JORC Indicated and Inferred resources. The mineralisation occurs within a 65–140 m thick skarn altered zone that is defined by drilling over 5700 m and consists of medium- to coarse-grained magnetite developed within two parallel zones. The footwall zone contains consistently higher iron grades, averaging 35.2% (http://www.talgaresources.com, Martinsson et al. 2013).

The Masugnsbyn iron mineralisations form a more or less regular sheet concordant between the Veikkavaara greenstones and the overlying Pahakurkio quartzitic and metapelitic metasedimentary rocks in a structure defined as the Masugnsbyn syncline (Padget 1970, Witschard et al. 1972). The syncline forms a north–south trending, narrow structure with a south-plunging fold axis. The iron mineralisations occur in the eastern limb of the syncline with a steep westerly dip, but the strike turns westwards as the syncline closes in the northern part, which is apparent on the magnetic maps. The southern part of the Junosuando field is characterised by the presence of a rather thick dolomitic marble. Sulphide- and graphite-rich, fine-grained schists continue from the Junosuando field northwards into the Vähävaara and Välivaara fields. The ore zone generally contains abundant iron-sulphides. The eastern wall rock to the deposits in the Junosuando field is a perthitic granite, which has a 1–2 m wide marginal phase of albite alteration along the contact to the ore-bearing skarn (Geijer 1929, Witschard et al. 1972). The Masugnsbyn granite is a north–south elongated 3.5 × 2.5 km body with an emplacement age of 1858±9 Ma (Skiöld & Öhlander 1989). The contact is generally rather diffuse over up to a few meters and contains more or less skarn relicts and can be rich in sulphides. Thin dykes of granite cut the ore and the wall rock (Grip & Frietsch 1973). The c. 1.80 Ga Lina granite limits the Masugnsbyn syncline to the west and to the north (Padget 1970, Witschard 1970).

The southern iron deposits are classified as skarn iron ores, whereas the mineralisations to the north more have the character of sedimentary, millimetre- to centimetre-wide, quartz-magnetite banded iron ore of an exhalative origin. However, both types also occur together and it is locally difficult to distinguish the two (Padget 1970). In the southern ores, skarn minerals are intimately associated with magnetite in a steeply dipping, 70–100 m wide zone with diopside, tremolite-actinolite and phlogopite, and more rarely serpentine and chondrodite (Padget 1970, Witschard et al. 1972). In detail, the skarn zone is very complex, but different skarn types are usually interbanded more or less concordantly with the stratigraphy. Magnetite is irregularly distributed but tends to concentrate in bands (Geijer 1929, Witschard et al. 1972). Four main skarn-types have been distinguished: tremolite-actinolite-diopside-(augite) skarn, biotite (phlogopite)-rich skarn, serpentine-rich skarn and carbonate-rich skarn. The first is the most common. The biotite-rich skarn is directly associated with the ore zone, and serpentine skarn is late, replacing chondrodite or pyroxene. There is normally a rather regular zoning of the ore zone with increasing amounts of magnetite towards the footwall accompanied by a change from tremolite skarn to serpentine skarn (Martinsson et al. 2013). Chalcopyrite is a minor constituent in the ore and uranium-mineralised fractures are locally found in Magnetgruvan.

The close spatial connection between the skarn iron ores and the perthite granite suggests that the intrusion of granite is responsible for the skarn formation and mobilisation of iron. Geijer (1929) considered the whole mineral paragenesis to be contact metasomatic, with the nearby perthitic granite being the source of the metals, supported by the presence of fluorine in certain skarn minerals (Frietsch 1966). It was suggested that high temperature fluids replaced the carbonate rocks that occur in the uppermost part of the greenstones. Frietsch (1966) argued that the mineral association is due to the effects of regional metamorphism caused by emplacement of Lina granites. The original sedimentary iron ores were recrystallised and mobilised, and the constituent components reacted with each other to form skarn minerals. The locally banded structure seen in the skarn iron ores in Masugnsbyn and in other places is interpreted to reflect the original sedimentary structures. Addition of substances from the granite is not necessary as the chemical components necessary for the skarn formation existed in the layered rocks.

Most skarn iron ores and the banded iron formations in Norrbotten occur within basic volcanic rocks and sedimentary rocks with variable amounts of quartz, carbonate and iron (Frietsch 1966). A striking feature is that the northern iron mineralisations, away from the Masugnsbyn perthite granite but close to Lina granites, have less skarn alteration and more of preserved sedimentary, quartz-banded iron-ore, suggesting that intrusion of the low-temperature, minimum-melt, c. 1.80 Ga Lina granites had less effect than the Masugnsbyn perthite granite. The older, c. 1.86 Ga Masugnsbyn perthite granite seems to be responsible for the contact metamorphic or metasomatic skarn alteration and also enrichment of iron, with higher grade and coarser grain size in the footwall next to the granite.

Leppäjoki

The Leppäjoki iron mineralisation is located 10 km west-south-west of Junosuando (28L 8 f) and is described by Lindroos (1979) and Frietsch (1997). It was discovered 1962 by airborne magnetic measurements performed by SGU. Magnetic and gravimetric measurements were done in 1964–1965 and 1968, and was followed by the diamond core drilling of one hole of 221.14 m. The mineralisation is covered by soil with a depth to the bedrock surface of 12 m. Analyses of sections in the ore zone include Fe and P. Some analyses also include S and Cu.

The iron ores are found in small remnants of greenstones of the Veikkavaara group and are completely surrounded by microcline granite. The greenstones are outlined by a 250 m long and 50 m wide magnetic anomaly extending east–west. The mineralisation consists of magnetite in amphibole skarn and has the shape of two, east–west trending, c. 250 m long layers that dip steeply towards the north. Next to the ore zone there are remnants of banded, biotite-rich greenstone, probably a tuffite. Metabasite dykes cut the ore zone and the wall rock. The northern mineralisation is 5–8 m wide, whereas the southern mineralisation has an average width of 35 m. Magnetite occurs as a fine-grained impregnation in amphibole skarn or as a banding. The skarn rock consists of amphibole, chlorite, quartz and calcite and in some parts also mica. Pyrrhotite and pyrite occur as impregnation and vein filling in the ore. Covering an area of 6650 m^2 down to a depth of 250 m, the southern occurrence contains an estimate of c. 6 million tonnes with, in average, 32.0% Fe, 0.04% P, 0.9% S and 0.04% Cu (Lindroos 1979). However, based on only one drillhole, the shape of the ore body is poorly known, especially at depth.

Tornefors

The Tornefors iron deposit is located just west of the village Junosuando (28L 9 h) and is described by Damberg et al. (1974) and Frietsch (1997). The ore is covered with c. 10 m of soil and was discovered by SGU in 1949 by magnetic measurements followed by six holes of diamond core drillings totalling 808.15 m. Gravimetric measurements were done in 1966 and two additional holes of 316.25 m were drilled in 1970.

The Tornefors skarn iron mineralisation occurs in the greenstones of the Veikkavaara group. It forms a 700 m long and up to 120 m wide, moderately to steeply east dipping, lens-shaped layer which strikes north–south but is gently winding and in the southern part dislocated by two minor faults. Magnetite occurs as bands or schlieren alternating with actinolite–tremolite and diopside skarn and layers of quartzite. In the western part of the zone, serpentine predominates. Locally, pyrite, pyrrhotite and some schlieren of chalcopyrite occur. The ore-bearing zone is intersected by up to 10 m thick dykes of dolerite and uralite porphyrite. Down to 100 m depth the amount of ore is estimated at around 2.6 million tonnes containing approximately 20% Fe, 0.005–0.027% P and 1–5% S.

Immediately west of and in contact with the ore-zone is a fine- to medium-grained, grey, less than 10 m wide limestone horizon that can be followed more than 500 m. Westwards there is a strongly foliated and biotite-rich agglomeratic greenstone, where graded bedding indicates younging towards the east. Not far to the east there is a granodiorite intrusion.

Dolomite

Masugnsbyn

According to a summary by Martinsson et al. (2013), dolomite is mined in a quarry in Masugnsbyn by LKAB, who use the dolomite as an additive in the iron pellet production (Fig. 18). The total production is about 4 million tonnes. The quarry was previously run by Norrbottens Järnverk AB from 1952 to 1972. The SiO_2 content is as low as 1.5%, which is essential for industrial purposes. Olivine, amphibole, chlorite, pyrite and calcite occur in minor amounts. The dolomite is present as a c. 100–200 m thick unit in the uppermost part of the Veikkavaara greenstones, between the greenstones and the metasedimentary rocks of the Pahakurkio group rocks. At the quarry, the dolomite is thickened and exceeds 300 m in thickness. The dolomite deposit in Masugnsbyn is further described in many publications, e.g. Müllern (1966), Padget (1970), Shaikh (1974), Shaikh et al. (1989).

Isovaara

At Isovaara (29L 0 d), c. 5 km north of Masugnsbyn, there is a 140 x 70 m large occurrence of dolomite that is detected down to 20 m depth (Fig. 18). The occurrence is limited to the north by pyroxene-biotite skarn and quartzite. The rock is, however, of poorer quality compared to the dolomite in Masugnsbyn, and contains chlorite, quartz, muscovite, amphibole, scapolite and sulphides (Fig. 16, Shaikh 1974, Shaikh et al. 1989).

Hietajoki

Hietajoki is an occurrence of dolomite situated c. 7 km south-east of Masugnsbyn (Fig. 16). It is located in the same stratigraphic position as the Masugnsbyn dolomite, in the border between the Veikkavaara greenstones and sedimentary rocks of the Pahakkurkio group (Bida 1979, Shaikh 1974, Shaikh et al. 1989). The carbonate rock strikes N30–50°W and dip steeply (80–85°) towards the east. The estimated length of the dolomite deposit is, as interpreted from geophysical data, at least 2 km. Bedrock sampling under soil suggests a length of 1 km and a rather constant thickness of about 200 m (Bida 1979). The occurrence has been investigated by diamond core drilling by SGU and LKAB, and is calculated to contain 9 million tonnes of dolomite down to 55 m (Shaikh et al. 1989). It consists of a rather pure dolomite, which passes into skarn banded limestone and limestone with schist bands towards the greenstones in the north-east (Shaikh 1974, Shaikh et al. 1989). The dolomite contains rather constant values of magnesium and calcium (21% MgO and 30% CaO), but variable amounts of silica (0.5–3% SiO_2) and iron (0.5–1.5% Fe_2O_3), attributed to impurities like tremolite, quartz and limonite (Bida 1979).

Orjasjoki

At Orjasjoki, ca 20 km south-south-east of Masugnsbyn, there is a 40 000 m^2 occurrence of dolomitic limestone, which has been included in the Kalixälv group, i.e. in the northern limb of the Oriasvaara syncline (Padget 1970, Shaikh 1974, Shaikh et al. 1989). The limestone is found within mica schist, above a unit of greenstone, and is cut in the south-west by granite and pegmatite. The limestone strikes N50–60°E and dips 70–90° towards the south. In the western part, the limestone has a thickness of 90 m, but it thins eastwards to 50 m. Analyses show a composition of weakly dolomitic limestone, where the magnesium content seems to be bound to included serpentine. The limestone is medium-grained, white to yellowish brown and it locally contains serpentine, olivine (chondrodite) phlogopite, tremolite, diopside, apatite, titanite and traces of garnet and sulphides (Shaikh 1974, Shaikh et al. 1989).

Lautakoski soapstone deposit

A soapstone deposit occurs near Lautakoski, c. 15 km east-south-east of Masugnsbyn along the banks of the Tärendö älv (Fredholm 1886, Shaikh 1972, Svenonius 1916). The soapstone is interpreted as an alteration product of ultrabasic rocks, and occur as a narrow, 1 km long fragmented zone within a large body of gabbroic rocks intruding supracrustal rocks of the Veikkavaara greenstones. Mineralogically the soapstone is dominated by talc, chlorite, carbonate and magnetite. SGU has performed trenching, followed by a ground magnetic survey in 1967 and drilling, the operations being completed in 1969. Ten diamond drill-holes totalling c. 950 m were drilled (Shaikh 1972).

Graphite

Graphitic schists are important members of the upper part of the Veikkavaara greenstone group. Though rarely exposed, their presence can be easily detected by electromagnetic methods (Padget 1970). Known occurrences include e.g. Jalkunen, 28L 6 e (Niiniskorpi 1987), Junosuando, 28L 9 g (Padget 1970), Nybrännan, 28L 9 e (Gerdin et al. 1990), Palo Pöyviö, 29L 1 d (Geijer 1918, Gerdin et al. 1990), Tiankkijokki, 28L 5 e (Gerdin et al. 1990, Niiniskorpi 1983) and the Suinavaaragruvan, 28L 7 g (Gerdin et al. 1990, Padget 1970). The graphite schist at Suinavaara seems to be the most interesting with an estimate of c. 125 000 tonnes of graphite with 29% C and 1.9% S (Gerdin et al. 1990).

Sulphide mineralisations

Sulphide mineralisations of the Masugnsbyn area that are in the current version of SGU's Mineral and bedrock resources database (MDEP) are listed in Table 4. These occurrences are shortly described below. The planned inventory survey of the mineralisations in the Masugnsbyn area intends to update the information in the database.

Merasjärvi

At Merasjärvi (29L 1 d), c. 8 km north-north-east of Masugnsbyn, there are outcrops with a molybdenum mineralisation containing 0.2–0.3% Mo in granite-veined (?) greenstone and gabbro. Cu-Mo-bearing boulders of skarn contain 100–300 ppm Mo and 0.2% Cu, and as best 2900 ppm Mo (Lehto 1981).

Maunuvaara

In the north-west part of the mountaintop of Maunuvaara, 17 km south-south-west of Masugnsbyn, there is an old copper mine, known from the 17th century during which time the ore was processed in the Svappavaara kopparverk (also named Magnovaara, Geijer 1918, Hermelin 1804, Tegengren 1924). The mine is water-filled and surrounded by some 100 tonnes of overgrown waste rock. The bedrock at the deposit is described as a fine-grained, grey, plagioclase-hornblende bearing gneiss, intruded by a light red to white, isotropic granite and some pegmatite. The granite is seen in outcrops on the north-western slope of the mountain and the fine-grained gneiss in the waste rock material. The ore consists of chalcocite with small amounts 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. Hermelin (1804) also mentioned copper deposits at the mountains Vuolovaara and Rovavaara 2 km north-east and 10 km north-west of Maunuvaara, respectively.

Niiniskorpi (1982) described exploration work at Maunuvaara from the early 1980s, including geological mapping and boulder prospecting, geochemical sampling of bog peat and stream sediment, and magnetic and electromagnetic measurements (VLF and IP). According to Niiniskorpi (1982) there is a 7.5 km long zone with small, separated copper mineralisations occurring as centimetre- to decimetre-wide quartz-hornblende veins in tuffite or locally skarn rocks, surrounded by granite. Copper concentrations are variable but reaches a few percent. The gold content is generally below 2 ppm, but one sample contained 6.5 ppm. There are also samples that are anomalous in molybdenum (200 ppm) and tungsten (2900 ppm). Bog peat samples show Cu, Mo- and Sn-anomalies, but the mineralisations are hard to trace with geophysics.

Iso-Orotusvaara

At Iso-Orotusvaara (28L 5 b), c. 20 km south of Masugnsbyn, there is a weak Cu-sulphide mineralisation (<0.12% Cu) in intermediate tuffs or tuffites of the Kalixälv group (Niiniskorpi 1986b, Niiniskorpi 1986c). The mineralisation was detected by soil geochemistry and diamond core drilling (Niiniskorpi 1986b, Niiniskorpi 1986c). Pyrite and pyrrhotite with or without chalcopyrite occur as a weak dissemination or locally as crack fillings. Traces of bornite and chalcocite are found in quartz-amphibole filled veins in one of the three drill-cores. Also granite dykes intruding the tuffs contain traces of sulphides, such as chalcopyrite and molybdenite.

Kurkkionvaara

The Kurkkionvaara Zn-Pb-Cu mineralisation (28L 6 d) is located c. 15 km south of Masugnsbyn at the contact between intermediate volcanic rocks of the Kalixälv group and metasedimentary rocks of the Pahakurkio group (Fig. 16). Niiniskorpi (1985 and 1986a) has described the exploration history, mineralisations and geology of the Kurkkionvaara area. Extensive exploration work during 1981–1985 included bog peat and till geochemistry, boulder-prospecting, geophysical surveys, bedrock geological mapping and diamond core drillings. Drilling on soil geochemical anomalies has resulted in discoveries of small, sub-economic Zn-Pb±Cu mineralisations, usually as scattered sulphide veins or fracture fillings with sphalerite and galena, mainly in the metasedimentary rocks of the Pahakurkio group, but also in the overlying quartz-rich conglomerate. Locally, there are richer mineralisations in some fracture zones with total Zn-Pb contents up to a few percent over 0.4–2.0 m. Some of the mineralised zones seem to be correlated with high boron contents and abundant tourmaline. Both ground magnetic and air-borne electromagnetic (slingram) measurements have given strong anomalies related to rich impregnations of pyrrhotite and pyrite in metre-wide zones. The richest concentrations of Fe-sulphides occur in the 10–20 m wide conglomerate horizon above the Pahakurkio group as an impregnation in the matrix. There are traces of chalcopyrite with 500–2000 ppm copper, but low amounts of gold and silver.

Rappukoski

A copper mineralisation occurs at Rappukoski, c. 18 km south-south-east of Masugnsbyn (28L 6 e, Grip & Frietsch 1973). The mineralisation is located to a layer of calcareous skarn in outcrops on both sides of the river Kalixälven. A system of tension fractures created during folding is filled with quartz, calcite, hornblende, chalcopyrite, bornite and molybdenite. Chalcopyrite is also, to some extent, disseminated in the wall rock. The width of the mineralised zones is usually 0.1–0.3 m, but can reach 2 m in connection with folding. The mineralisation contains 1–2% copper and traces of molybdenum. The geology of the area is dominated by metasedimentary rocks of the Pahakurkio group, mainly quartzitic micaschist, but also layers of conglomerate and concordant greenstones, all cut by granite and pegmatite (Padget 1970, Ödman 1939).

Oriasvaara

The Oriasvaara copper deposit is located c. 20 km south-south-east of Masugnsbyn (28L 6 f), east of the road to Tärendö and c. 1 km north of the mountain Oriasvaara. Two zones of mineralisation have been recognised in the supracrustal rocks that have been assigned to the Kalixälv group (Quezada 1976). In the western part the mineralisation is associated with greenstones and quartzites and in the eastern part there is a mineralisation in a limestone horizon. The western mineralisation has an impregnation of sulphides, including pyrrhotite, pyrite, chalcopyrite and trace of bornite, in both greenstones and quartzites. The scapolite altered rocks form a c. 180 m thick unit that generally strikes south-west–north-east. The mineralised zone is bounded by mica schist to the north and east, by pegmatite to the south, and appears to continue westwards as indicated by geophysical maps. Analyses of mineralised rocks give up to 1.3% Cu and a few analyses of gold give up to 0.5 ppm (Carlson 1982a, Carlson 1982b, Quezada 1976). 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.

SOIL GEOCHEMISTRY

The soil geochemistry database contains 436 physical samples within the Masugnsbyn area. Examples of some elements are given in Figure 19. A clear lead and zinc anomaly is associated with the Kurkkionvaara sulphide mineralisation, situated just south of the river Kalix älv.

Several studies show that the stratigraphy in northern Norrbotten is complex with two or more generations of till, which complicates the interpretation of till geochemical surveys (Fagerlind 1981, Lagerbäck 1982). There are two different ice movement directions, an older from north-west and a younger from south-south-west. The older ice movement has left well-developed drumlins and seems to be most important in transporting material.

GEOPHYSICAL OVERVIEW

Airborne data

Airborne geophysical data over the key area and its vicinity were collected by Loussavaara-Kiirunavaara AB (LKAB) during the period 1981–1985. A comprehensive list of the measurements is found in Table 9. The airborne data were collected at 30 m above the ground with a line separation of generally 200 m, except in one area in the south within the key area, which had a line separation of 100 m. The dominating flight direction is east–west but three smaller areas were flown in a north–south direction. The data sampling along the lines is approximately 35 m.

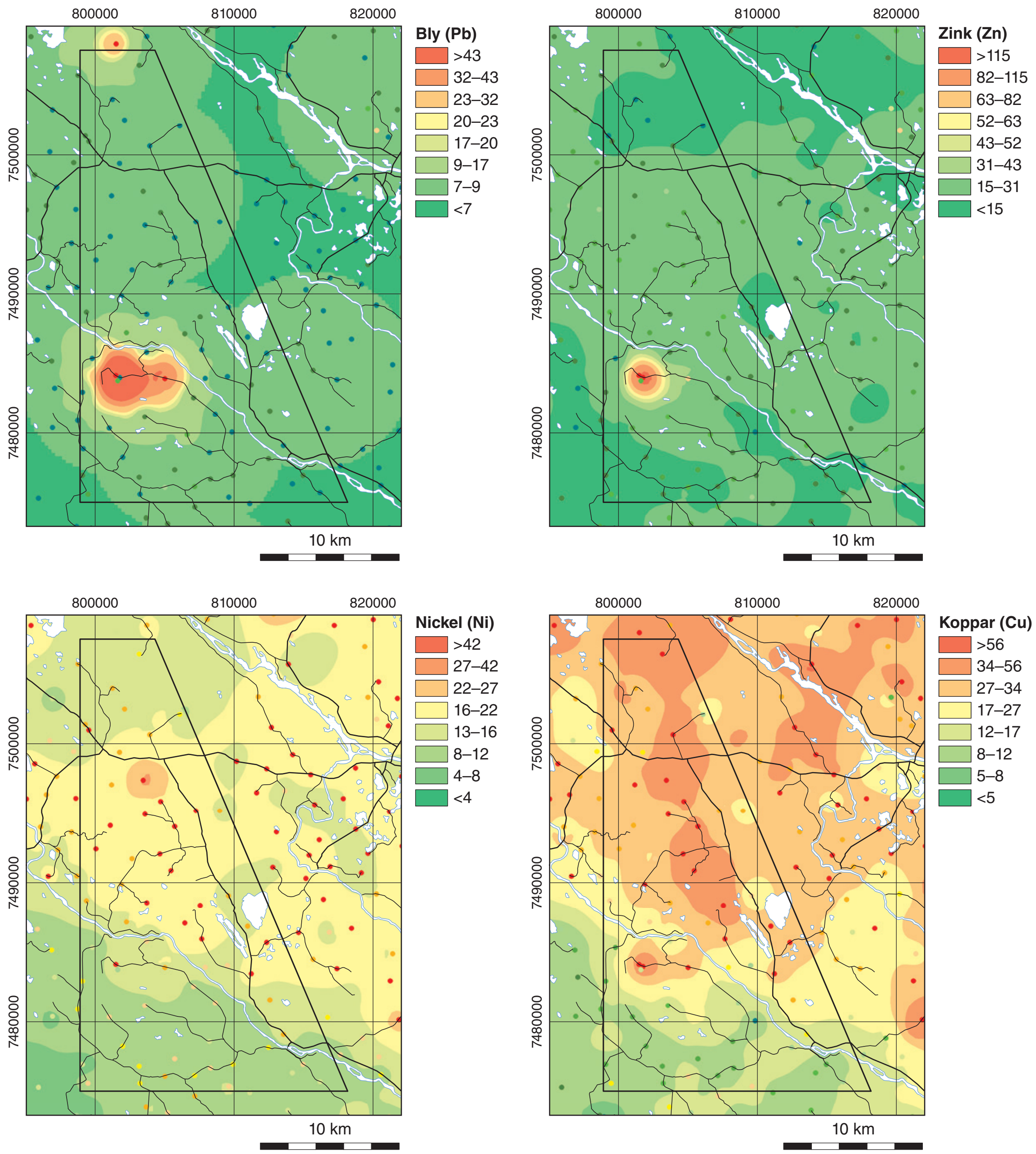


Figure 19. Examples of soil geochemistry maps with the elements Pb, Zn, Ni and Cu. The Kurkkionvaara Zn-Pb-Cu mineralisation is clearly outlined as distinct anomalies.

In all surveys, magnetic, gamma ray radiation and electromagnetic slingram measurements were included. The electromagnetic method VLF has also been used in all areas. However, the registration of signals from one or two transmitters varies and the data coverage is in some cases incomplete (Table 9).

The magnetic anomaly map over the Masugnsbyn key area and its surroundings is shown in Figure 20. The magnetic field within the key area is dominated by low signatures but with several persistent, thin anomalies striking north-north-west. At the centre of the eastern limit of the key area, strong positive magnetic anomalies form a V-shaped structure. A positive anomaly corresponding to a gabbroic rock mass is present in the south-western corner of the key area.

Table 9. Complete list of the airborne geophysical surveys over the Masugnsbyn key area.

Year	Company	Gephysical methods used	Area	Flight direction	Flight line separation (m)	Flight altitude (m)
1985	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters), slingram	Almost entire 28L SO	E–W	200	30
1985	LKAB	Magnetics, gamma spectrometry, VLF (1-transmitter), slingram	Part of 28L SV	N–S	200	30
1982	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters) (50% coverage), slingram	28L NO, 28M NV, part of 29M SV	E–W	200	30
1985	LKAB	Magnetics, gamma spectrometry, VLF (1-transmitter), slingram	Part of 29L SO	E–W	200	30
1981	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters), slingram	Almost entire 28L NV	E–W	200	30
1983	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters) (80% coverage), slingram	29K SV, 29K SO, 29L SO	E–W	200	30
1982*	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters) (80% coverage), slingram	Part of 28K NO and 28L NV	E–W	200	30
1983*	LKAB	Magnetics, gamma spectrometry, VLF (2-transmitters), slingram	28K NO and part of 28K NV, 28L NV	E–W	200	30
1982**	LKAB	Magnetics, gamma spectrometry, VLF (1-transmitter), slingram	Part of 28L NV	N–S	100	30
1982**	LKAB	Magnetics, gamma spectrometry, VLF (1-transmitter), slingram	Part of 28L NO	N–S	200	30
1961**	SGU	Magnetics	28M and 28L	E–W	200	30
1962**	SGU	Magnetics	29K SV and SO	E–W	200	30
1962**	SGU	Magnetics	28K	E–W	200	30
1963**	SGU	Magnetics	29L SV, SO and 29M SV	E–W	200	30
1972**	SGU/LKAB	Magnetics, gamma spectrometry	29K	E–W	200	30
1976**	SGU/LKAB	Magnetics, gamma spectrometry, VLF (1-transmitter)	Almost entire 29K	E–W	200	30

* Radiometric measurements one year later

** Not used for producing maps for this report

The electromagnetic data from VLF and slingram measurements are shown in Figure 21 and 22, respectively. In areas where two VLF-transmitters were used, a peaker map is constructed, and the apparent resistivity and the current density can be calculated (Pedersen et al. 1994). The advantage of the peaker representation is that the location of an anomaly lies directly above its source. For the two-transmitter case, the identification of conductive structures are independent of their strike direction in relation to the VLF-transmitter, which is the case for one-transmitter measurements. The real part of the slingram data also shows conductive structures in the area.

Ground based gravity

The distribution of regional gravity measurements in the area is shown in Figure 23. The point distance is approximately 1 km. A detailed ground gravity survey was performed in 1965 in the area of the Masugnsbyn iron ore (Figs. 23 and 24). The most dense measurements were done with a point distance of 20 m and a line separation of 40 m.

Ground based magnetic, electromagnetic and geoelectric measurements

Several ground based measurements have been carried out within the key area and its closest vicinity in the 1980-ies by SGU. In the area of the Masugnsbyn iron ore, magnetic measurements were performed already in 1965 and 1967 covering the same area as the detailed gravity measure-

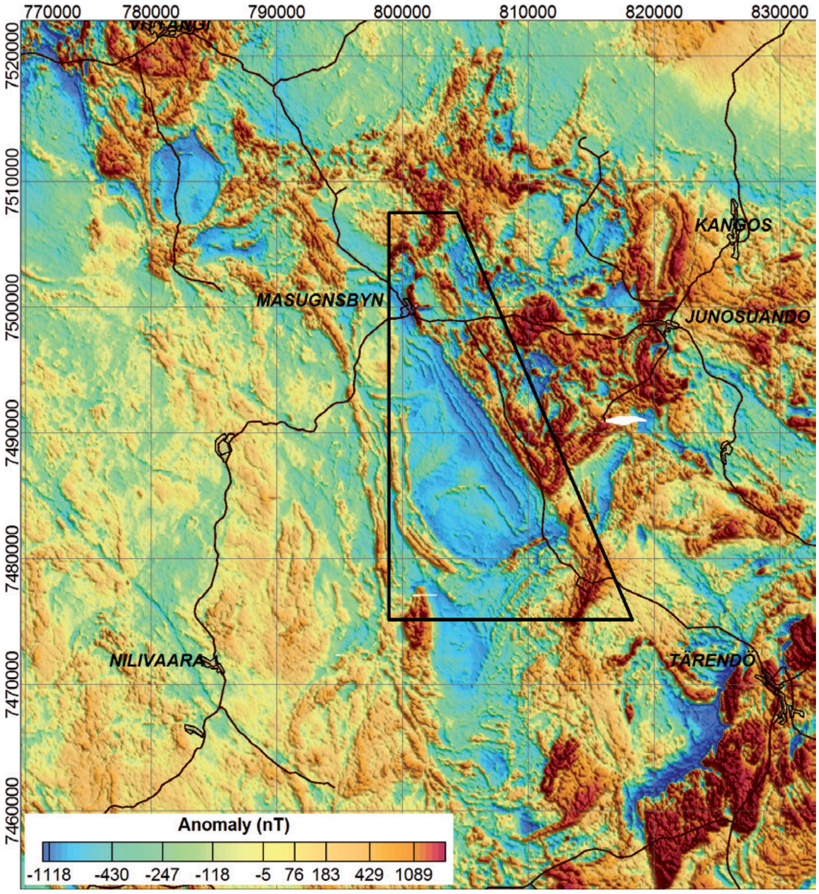


Figure 20. Magnetic anomaly map of the Masugnsbyn key area and surroundings. Main roads and larger villages are shown on the map.

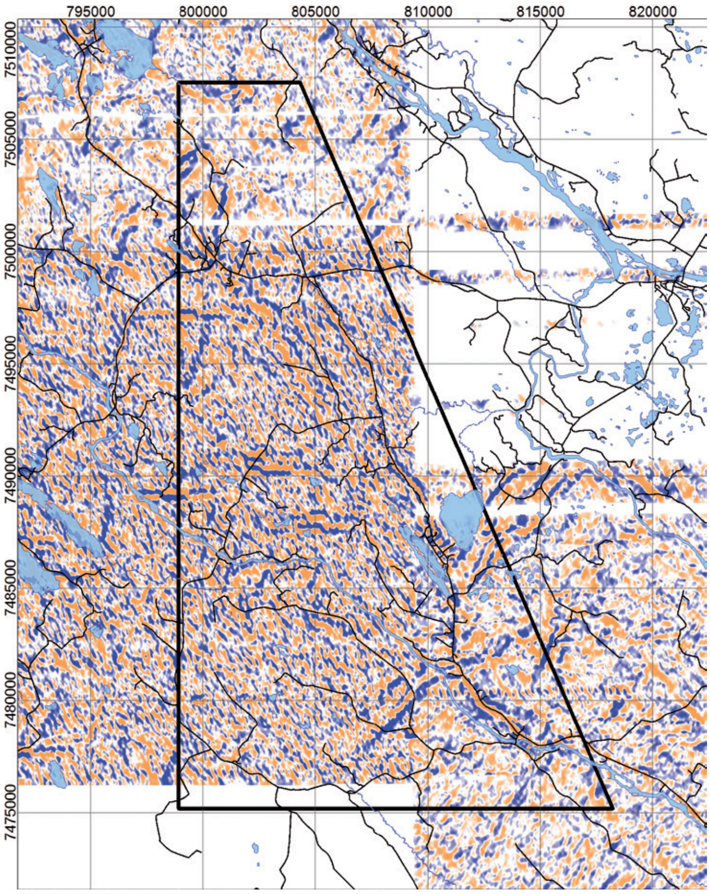


Figure 21. Imaginary part of the peaker VLF data. Dark blue colour indicate conductive structures.

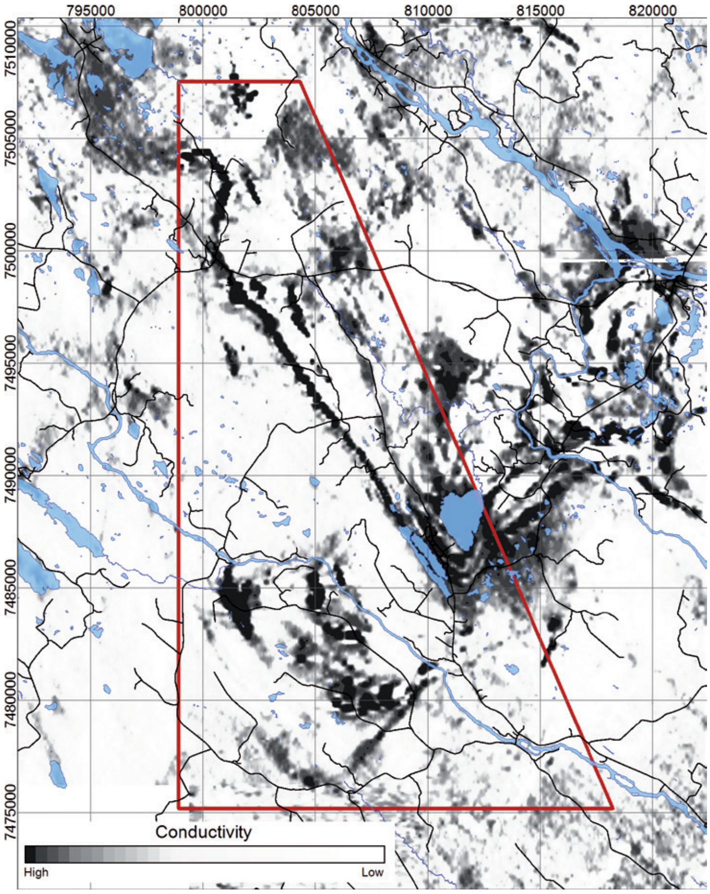


Figure 22. Real part of the slingram data, measured with a frequency of 3720 Hz. Darker colour indicates more conductive structures. The red polygon shows the outline of the Masugnsbyn key area.

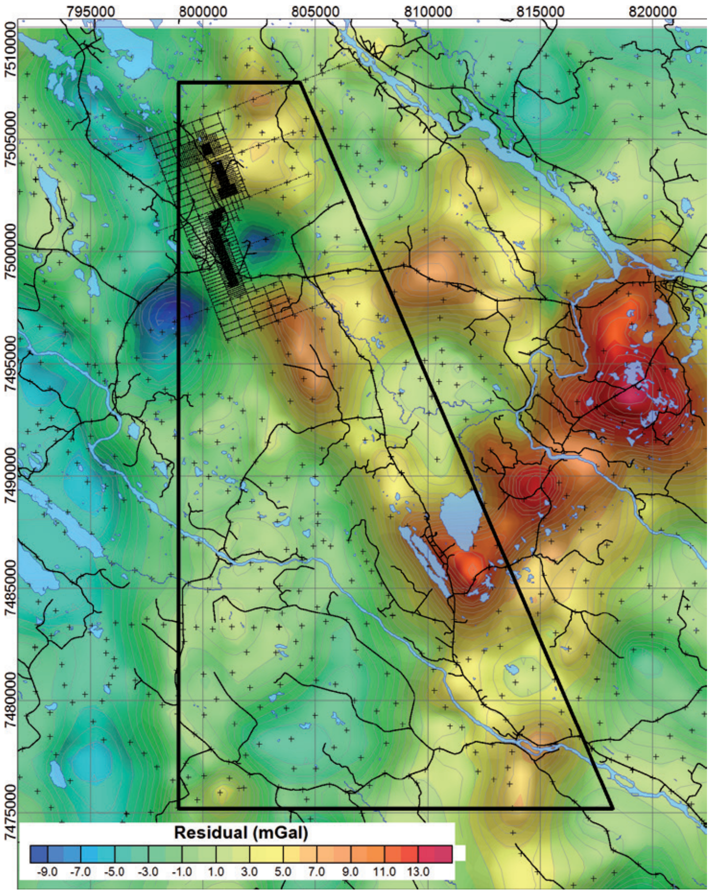


Figure 23. Residual gravity field. The gravity data has been filtered to enhance the response from a depth less than approximately 3 km below the surface. Black crosses show the locations of measurements.

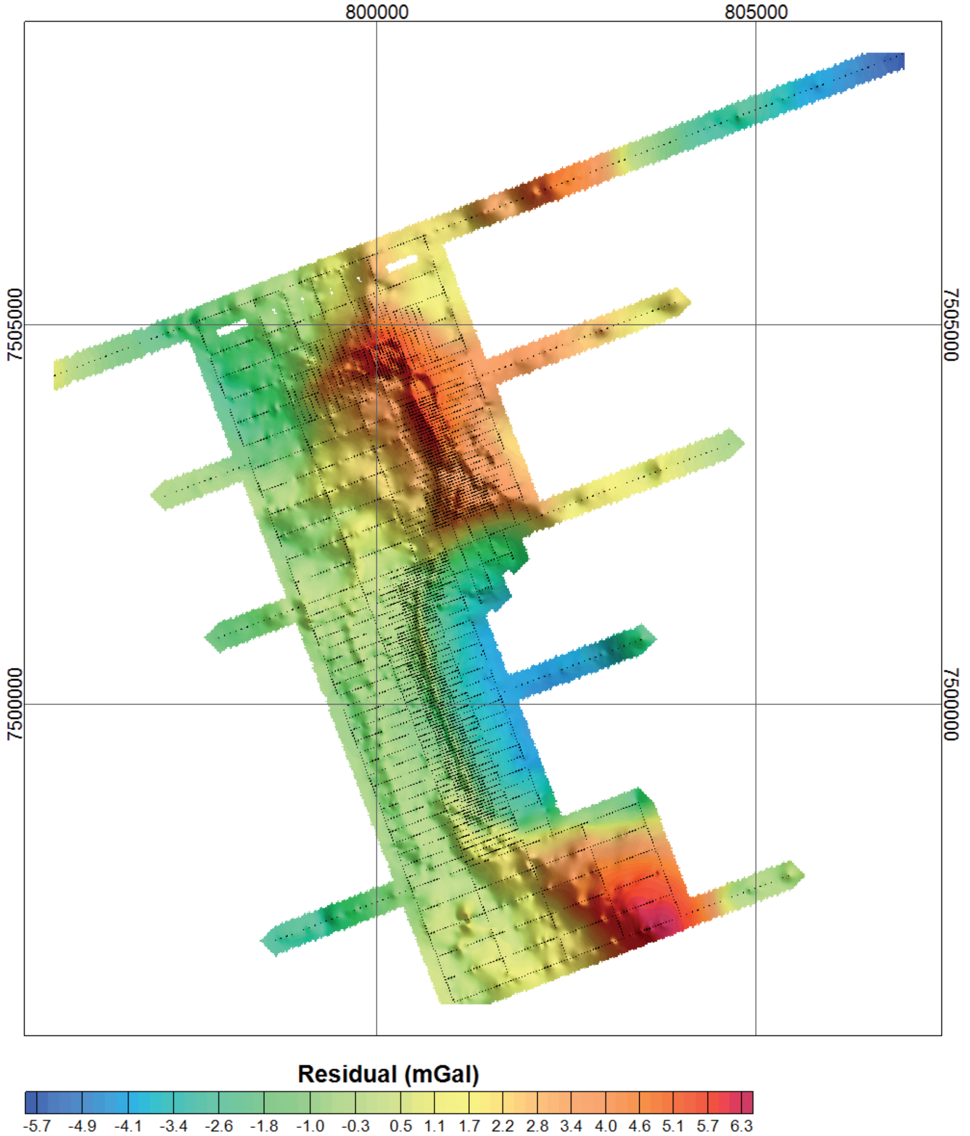


Figure 24. Residual gravity field from detailed measurements in the northern part of the key area. Black dots show the location of measurements.

ments (Fig. 24). Slingram measurements were conducted in a smaller part of the area (Fig. 25) in the 1970ies.

All areas of ground-based measurements are listed in Table 10 and the locations and coverage is shown in Figure 25. At most of the locations, both slingram and magnetic profile measurements has been performed. The exception is in the large area named Saittarova where only ground slingram measurements were performed in order to map the nort-west striking conductive structure which is clearly indicated in Figure 22.

The distribution of single profile measurements, IP, VLF and magnetic, are shown in Figure 26. The main part of the profiles have been measured in 1995 within a regional mapping project (Bergman et al. 2001). West of the key area, four profiles (IPa-d, Fig. 26, Table 11) have been measured with geoelectric methods and data on induced polarisation, self potential and resistivity are available.

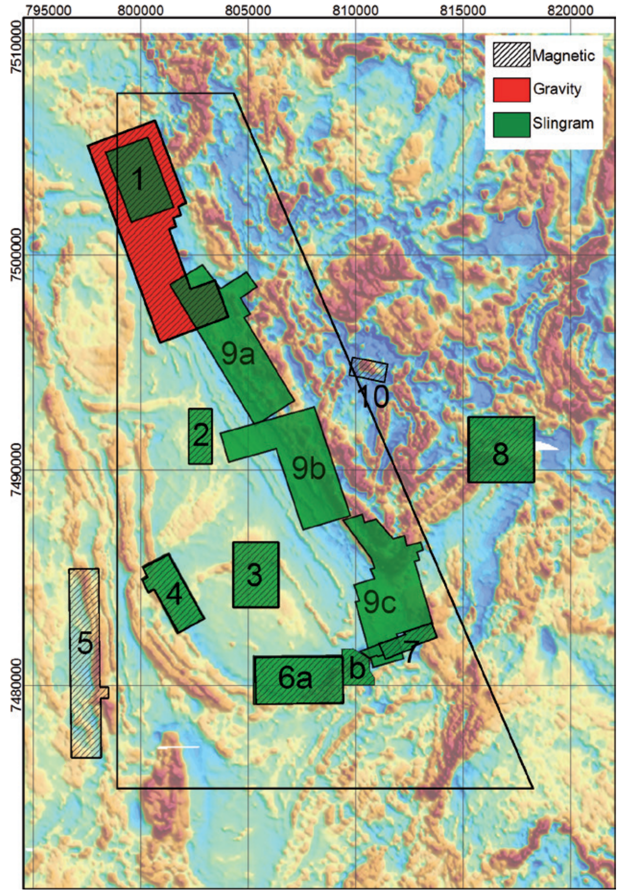


Figure 25. Location of ground magnetic measurements shown on the airborne magnetic map. Red lines show location of ground magnetic profile measurements. The polygon numbers refer to Table 10.

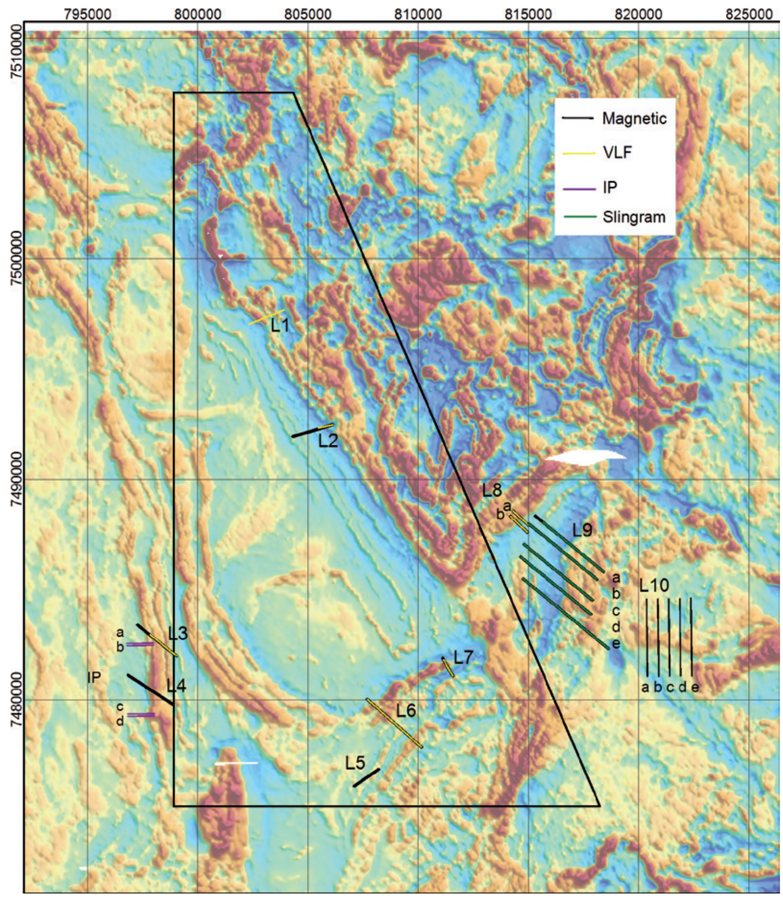


Figure 26. Location of ground profile measurements shown on the airborne magnetic map. Profile ID refers to Table 11.

Petrophysics

There are 331 petrophysical samples within the area shown in Figure 27. The outcrops within the key-area are fairly limited (red polygons in Fig. 27) and the samples are therefore heterogeneously distributed. Most samples have been collected in relation to known mineralisations or deposits of industrial minerals as well as along the river where large outcrops are present. Density, magnetic susceptibility and remanent magnetisation have been measured on all samples. 24 of the samples are orientated and the direction of the remanent magnetisation has been determined.

Table 10. Ground magnetic measurements. The polygon number refers to Figure 25.

Area (polygon no)	Method	Year	Measurement	Line distance (m)	Point distance (m)
1. Masugnsbyn	grav	-	terrain corrected Bouguer anomaly	-	-
	mag	1965, 1967	anomaly	20 (80)	10 (20)
	slingram	1974	Im, SR 18kc/s, coil separation=60 m	80 (40)	20 (10)
	slingram	1974	Re, SR 18kc/s, coil separation=60 m	80 (40)	20 (10)
2. Jylkkyvaara	mag	1983	total field	100	20
	slingram	1983	Im and Re	100	20
3. Jalkunen	mag	1983	total field	100	20
	slingram	1983	Im and Re	100	20
4. Kurkkionvaara	mag	-	total field	100 (50)	20 (10)
	slingram	-	Im and Re	100 (50)	20 (10)
5. Maunuvaara	IP, SP, resistivity				
	mag	1984	total field	100	10
	mag	1981	total field	100	20
6. Tiankijoki	mag				
	slingram	1985	Im, SR 3.6kc/s, coil separation = 40 m	100 (50)	20 (10)
	slingram	1985	Re, SR 3.6kc/s, coil separation = 40 m	100 (50)	20 (10)
	mag	1982	total field	100	20
	mag	1983	total field	50	10
	mag	1983	total field	100	20
	slingram				
7. Oriasvaara	slingram	1967, 1976	Im, SR 18kc/s, coil separation = 40 and 60 m	40	20 (10)
	slingram	1967, 1977	Re, SR 18kc/s, coil separation = 40 and 60 m	40	20 (10)
	mag	1976	anomaly	40	20
8. Lauta	mag	1984	anomaly	100	10
	slingram	1984	Im	100	20
	slingram	1984	Re	100	20
9. Saittarova	slingram	1946	Im, SR 3.6kc/s, coil separation = 40 m	-	-
	slingram	1946	Re, SR 3.6kc/s, coil separation = 40 m	-	-
10. Leppäjoki	mag	1969	anomaly	40 (80)	10 (20)

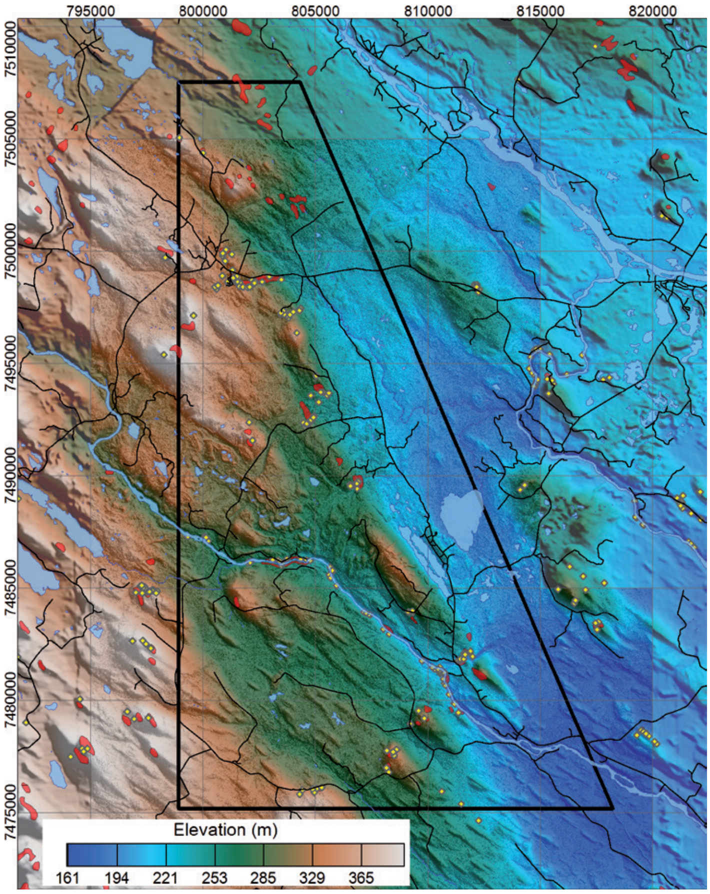


Figure 27. The topography within the Masugnsbyn key area based on LiDAR data (2x2 m DEM). The red areas show outcrops and yellow dots the location of existing petrophysical bedrock samples.

Table 11. Ground magnetic measurements. The line number refers to Figure 26.

Profile	Method	Measurement date/year	Point distance (m)	Length of profile (m)
L1	VLF	13-Jul-95	10	1690
L2	VLF	03-Aug-95	10	670
	Mag	03-Aug-95	10	1910
L3	VLF	11-Jul-95	10	1510
	Mag	11-Jul-95	10	2260
L4	Mag	11-Jul-95	10	2430
L5	Mag	30-Jul-95	10	1350
L6	VLF	29-Jul-95	10	3590
	Mag	29-Jul-95	10	3280
L7	VLF	29-Aug-95	10	860
	Mag	29-Aug-95	10	940
L8a	VLF	23-Aug-95	10	920
	Mag	23-Aug-95	10	1050
L8b	VLF	23-Aug-95	10	960
	Mag	23-Aug-95	10	930
L9a-e	Mag, Slingram	1984	20	4000-5000
L10a-e	Mag, slingram	1984	20	3500
IPa-d	IP, resistivity and SP	1980	20	1200

FURTHER WORK

Extensive background material exists for the Masugnsbyn key area, with many detailed geological and geophysical investigations done in connection with bedrock geological mapping and mineral exploration. Data from previous studies provide a foundation to build upon to further enhance the knowledge of the bedrock geology of the area. Increasing knowledge is of essential importance for further mineral exploration. Many excellent studies have been done, but most of these are old. For instance, the most recent bedrock maps in detailed scale of the Tärendö and Laino areas were published by Padget and Witschard more than 40 years ago. The scientific understanding, analytical methods and even terminology have developed considerably since then. Correlation between geological units and understanding of the geological evolution is, for example, hampered by poor or missing time constraints on the formation of rock units. The rapid development of new radiometric dating techniques in the last 10–15 years, using in situ probing techniques like SIMS and LA-ICPMS of single mineral grains, gives better and more easily interpreted age data at a lower cost, and also allows for determination of multiple events recorded in complex single mineral grains like zircon. Also other geochemical analytical methods and geophysical techniques have developed resulting in better and more precise data. It is easy to forget, but the digital era started only some tens of years ago. Today we have completely new tools to process, analyse and visualise geophysical, geochemical and geological data. Available datasets can be integrated and combined using GIS. Even positioning in the field is improved with use of GPS and better topographic maps, not to mention the detailed elevation data from Lantmäteriet.

The available time and resources for new surveys and analyses in the Masugnsbyn key area is very limited, but below we list some general tasks and issues that we hope to solve and understand better:

- Improve the current bedrock geological map by integrating old and new geological and geophysical data. A more detailed bedrock geological interpretation can be achieved using the anomaly pattern seen in the geophysical maps.
- 3D and 4D geological and geophysical modelling to visualise and understand bedrock geology at depth and in time.
- Improve the knowledge about the stratigraphy, geochemical signature and age of supracrustal rocks, and do regional correlations of rock units across Norrbotten. Rock units in the Masugnsbyn key area planned to be sample for geochemisty, Nd-isotopes and geochronology are:
  - Basaltic rocks of the Veikkavaara greenstone group.
  - Intermediate and felsic volcanic rocks north-east of Masugnsbyn in contact with the Veikkavaara greenstones. What are the relations between these volcanic rocks?
  - Quartzitic rocks of the Pahakurkio and Kalixälv groups. Is there any difference between these rock units?
  - Intermediate volcanic (?) rocks in the Pahakurkio and Kalixälv groups.
- Better understand of the structural and metamorphic development of the bedrock.
  - Have rocks of the Veikavaara greenstone group a more complex deformation history than the younger Scecofennian (?) metasedimentary rocks of the Pahakurkio and Kalixälv groups?
  - Is there a discordance beteen the Veikavaara greenstone group and the Pahakurkio group?
  - Improve the poorly contrained c. 1.86 Ga metamorphic age of the migmatitised paragneiss at Takanenvaara (Bergman et al. 2006) by more U-Pb analyses on monazite and possible, secondary zircon rims.

- The granite south-east of the Masugnsbyn key area has an unclear age affinity and will be sampled for U-Pb zircon geochronology to date the intrusion and possibly to relate this age to obtained metamorphic ages in the migmatitic paragneiss.
  - Quantiative constraints of metamorphic P-T conditions including samples from andalusite-bearing metaargillites, sillimanite-bearing migmatitic paragneiss and garnet-bearing greenstone.
- Increase the knowledge about mineralisations and hydrothermal alterations in the area.
  - An inventory of mineralisations of the Masugnsbyn key area is planned, including sampling for petrographic and chemical analyses to characterise mineralisations and associated wall rock alterations.
  - The Masugnsbyn perthite granite will be sampled for SIMS/LA-ICPMS geochronology to better constrain the igneous crystallisation age of the granite with implications for timing of the skarn iron ore formation.

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APPENDIX 1.

Complete list of different types of publications relevant to the Masugnsbyn key area. Selected from the SGU database Georegister with search indexes of map squares defined in Sweref99 coordinatesystem (75H0j, 75I0a, 75I0b, 74H9j, 74I9a, 74I9b, 74H8j, 74I8a, 74I8b, 74H7j, 74I7a, 74I7b).

Author	Year	Type	Reference
Buch, Leopold von	1809	book	Ueber das Vorkommen des Tremolits im Norden. SI: 69-73 IT: Ewald, J., Roth, J., och Eck, H.: Leopold von Buch's Gesammelte Schriften. Zweiter Band. UG: Verlag von Georg Riemer UO: Berlin VO: 1870
Ingri, J.; Torssander, P.; Andersson, P.S.; Mörth, C.-M.; Kusakabe, M.	1997	book	Hydrogeochemistry of sulfur isotopes in the Kalix River catchment, northern Sweden. TI: Applied Geochemistry VO: 12 HÄ: 4 SI: 483-496 SP: eng
Karhu, Juha A.	1993	book	Paleoproterozoic evolution of the carbon isotope ratios of sedimentary carbonates in the Fennoscandian Shield. TI: Geological Survey of Finland, Bulletin VO: 371 SI: 1-78 SP: eng ÖV: doktorsavhandling/dissertation
Kummu, Maria; Strand, Hans-Peter; Awebro, Kenneth	1997	book	Gruvor och bruk i norr. SI: 1-135 SP: sve KA: 1 UG: Kiruna kommun, Pajala kommun och Övertorneå kommun ÖV: Geologisk översikt av Hans-Peter Strand
Mörth, Carl-Magnus	1995	book	Sulfur isotopes used as a tracer of acidification reversal, dispersion of acid mine drainage and sulfur dynamics in small and large catchments. TI: Meddelanden från Stockholms Universitets Institution för Geologi och Geokemi VO: 290 SI: 1-26 SP: eng UG: Stockholms Universitet ÖV: doktorsavhandling/dissertation
Naturmedia UT	1992	book	Guide till Gruvor & Bruk i norr.. UG: Naturmedia UT OU: Kiruna SI: 31 SP: sve
Tegengren, F.R.	1924	book	Sveriges ädlare malmer och bergverk. TI: SGU-CA VO: 17 SI: 406 DI: 1 TA: 40 KA: 90+1
Ödman, Olof H.	1957	book	Beskrivning till berggrundskarta över urberget i Norrbottens län. TI: SGU-CA VO: 41 SI: 151 TA: 18+10 KA: 11+4 PL: 46
Armands, Gösta	1967	essay	Geochemical prospecting of a uraniferous bog deposit at Masugnsbyn, northern Sweden. IT: Aslak Kvalheim (Editor): Geochemical Prospecting in Fennoscandia, Interscience Publishers SI: 127-154 SP: eng
Armands, Gösta; Landergren, Sture	1960	essay	Geochemical prospecting for uranium in northern Sweden. The enrichment of uranium in peat. TI: International Geological Congress. Report of the Twenty-First Session, Norden. VO: 15 SI: 51-66 SP: eng ÖV: Arne Noe-Nygaard, T. Siggerud, O. Vaasjoki (Editors): Proceedings of Section 15. Genetic problems of uranium and thorium deposits
Asklund, B.	1950	essay	Yttrande med anledning av T. Erikssons föredrag: "Berggrunden i Pajalafältet (Norrbottens län)". TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 72 SI: 112-113 SP: sve
Backman, A.L.	1950	essay	Fossil Trapa natans i Hamrånge jämte andra nya växtfossilfynd i Norrland. TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 72 HÄ: 2 SI: 136-138 SP: sve
Bergman, Stefan; Billström, Kjell; Persson, Per-Olof; Skiöld, Torbjörn; Evins, Paul	2006	essay	U-Pb age evidence for repeated Paleoproterozoic metamorphism and deformation near the Pajala shear zone in the northern Fennoscandian shield. TI: GFF VO: 128 HÄ: 1 SI: 7-20 SP: eng UG: Geologiska föreningen KA: 3 TA: 3 DI: 2
Bergman, Stefan; Kübler, Lutz	1996	essay	Berggrundsgeologiska och geofysiska synteskartor över norra Norrbotten. TI: SGU reporter och meddelanden VO: 84 SI: 130-139 SP: sve UG: SGU UO: Uppsala

Author	Year	Type	Reference
Bergman, Stefan; Kübler, Lutz	1997	essay	Berggrundsgeologiska och geofysiska synteskartor över norra Norrbotten. TI: SGU reporter och meddelanden
Bergman, Stefan; Kübler, Lutz	1998	essay	Berggrundsgeologiska och geofysiska synteskartor över norra Norrbotten. IT: SGU-RM VO: 97 SI: 95-1034 UG: SGU UO: Uppsala SP: sve
Bergman, Stefan; Kübler, Lutz	1999	essay	Berggrundsgeologiska och geofysiska synteskartor över norra Norrbotten. IT: SGU-RM VO: 98 SI: 142-144 UG: SGU UO: Uppsala SP: sve
Bergman, Stefan; Martinsson, Olof; Kübler, Lutz	1998	essay	Synthesis bedrock maps of northern Norrbotten, Sweden. IK: 23. Nordiske Geologiske Vintermöde
Bergman, Stefan; Skiöld, Torbjörn	1998	essay	Implications of ca 1.8 Ga metamorphic ages in the Pajala area, northernmost Sweden. IK: 23. Nordiske Geologiske Vintermöde
Bergman, Stefan;Kübler, Lutz;Martinsson, Olof	2001	essay	Description of regional geological and geophysical maps of northern Norrbotten County (east of the Caledonian orogen). TI: SGU-BA VO: 56 KA: 5 SP: sve UG: Sveriges Geologiska Undersökning UO: Uppsala
Bergström, J.; Björklund, A.; Bölviken, B.; Konti, M.; Lehmuspelto, P.; Lindholm, T.; Magnusson, J.; Ottesen, R.T.; Steenfelt, A.; Volden, T.	1987	essay	Regional geochemical mapping in Northern Finland, Norway and Sweden. TI: Journal of Geochemical Exploration VO: 29 SI: 383-383 SP: eng
Billström, Kjell; Frietsch, Rudyard; Perdahl, Jan-Anders	1995	essay	The significance of lead isotopic compositions of galena in Paleoproterozoic mineralisations, northern Sweden. IT: manuskript i Perdahl, Jan-Anders: "Svecofennian volcanism in northernmost Sweden", Doctoral Thesis, Division of Applied Geology, Luleå University of Technology VO: 1995:169 D SI: 1-16 BI: +7 SP: eng
Billström, Kjell; Frietsch, Rudyard; Perdahl, Jan-Anders	1995	essay	The significance of lead isotopic compositions of galena in Paleoproterozoic mineralisations, northern Sweden. Manuscript i Perdahl, Jan-Anders: "Svecofennian volcanism in northernmost Sweden". Doctoral Thesis, Division of Applied Geology, Luleå University of Technology. 1995:169
Billström, Kjell; Frietsch, Rudyard; Perdahl, Jan-Anders	1997	essay	Regional variations in the Pb isotopic compositions of ore galena across the Archaean-Proterozoic border in northern Sweden. TI: Precambrian Research VO: 81 HÄ: 1-2 SI: 83-99 SP: eng
Björck, Jonas; Robertsson, Ann-Marie	1994	essay	Weichselian interstadial and holocene vegetation history at Outojärvi, Norrbotten, N Sweden. TI: Palynonytt VO: 23 SI: 11 SP: eng IK: Abstracts, Nordiskt Palynologmöte, Trondheim maj 1994 ÖV: ingår även som appendix 5 till Miljö och klimat under Weichselinterstadialer i Norra Skandinavien ID: 27681
Byström-Brusewitz, Ann Marie	1975	essay	A vermiculite clay from Junosuando, Pajala county, northern Sweden. TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 97 HÄ: 3 SI: 286-289 SP: eng
Bärtling, Richard	1933	essay	Die lagerstättenkundliche Lapplandfahrt der Deutschen Geologischen Gesellschaft vom 19 Juli bis 4. August 1931. TI: Zeitschrift der Deutschen Geologischen Gesellschaft VO: 85 SI: 1-13 PL: +5 SP: tys
Bölviken, B.; Kullerud, G.; Loucks, R.R.	1990	essay	Geochemical and metallogenic provinces: a discussion initiated by results from geochemical mapping across northern Fennoscandia. TI: Journal of Geochemical Exploration VO: 39 HÄ: 1-2 SI: 49-90 SP: eng

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Fagerlind, Torbjörn	1981	essay	Glacial development in the Pajala district of Northern Sweden. TI: SGU Ba VO:27 SI: 118 KA: +1 UO: Uppsala SP: eng
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Flink, Gust.	1910	essay	Bidrag till Sveriges mineralogi. II. 66. Kalkspat. TI: Arkiv för Kemi, Mineralogi och Geologi VO: 3 HÄ: 35 SI: 109-154 SP: sve ÖV: ingår i större uppsats: Bidrag till Sveriges mineralogi. II. SI: 1-166
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Frietsch, Rudyard	1997	essay	The Iron Ore Inventory Programme 1963-1972 in Norrbotten County. TI: SGU-RM VO: 92 SI: 77 SP: eng KA: 1
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Geijer, Per	1931	essay	Berggrunden inom malmtrakten Kiruna - Gällivare - Pajala. TI: SGU-C VO: 366 SI: 1-225 DI: 3 TA: 1 KA: 5+1
Geijer, Per	1931	essay	Slutreplik rörande Linagranitens åldersställning. TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 53 HÄ: 3 SI: 353-354 SP: sve
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Kleman, Johan	1990	essay	On the use of glacial striae for reconstruction of paleo-ice sheet flow patterns - With application to the Scandinavian ice sheet. TI: Geografiska Annaler VO: 72A HÄ: 3-4 SI:217-236 SP: eng
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Lindroos, Hardy	1980	essay	Regional geological and geophysical interpretation of Precambrian structures in northeastern Norrbotten, north Sweden. TI: GFF VO: 102 SI: 190-190 SP: eng
Lindroos, Hardy; Henkel, Herbert	1978	essay	Regional geological and geophysical interpretations of precambrian structures in northeastern Sweden. TI: SGU C VO: 751 SI: 19 KA: +1 PL: +1 UO: St
Lundegårdh, Per H	1963	essay	Projektering av rum och tunnlar i berg. TI: SGU C VO: 590 SI: 1-70 KA: +1 UO: Stockholm SP: sve
Lundqvist, G.	1943	essay	Norrlands jordarter. TI: SGU-C VO: 457 SI: 166 DI: 1 TA: 7 KA: 12+2
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Mellqvist, Claes;Öhlander, Björn;Weihed, Pär;Schöberg, Hans	2003	essay	Some aspects on the subdivision of the Haparanda and Jörn intrusive suites in northern Sweden. TI: GFF VO: 125 HÄ: 2 SI: 77-85 SP: eng KA: 1 TA: 2 DI: 3 UG: Geologiska föreningen
Niiniskorpi, Veikko	1986	essay	Stratabound tourmaline-rich rocks in Kurkkionvaara area, northern Sweden. TI: Abstracts, Posters & Late Oral Presentations, 7th IAGOD Symposium, Luleå, Sweden. Aug. 18-22, 1986. SI: - SP: eng
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Pontér, Christer; Ingri, Johan; Boström, Kurt	1992	essay	Geochemistry of manganese in the Kalix river, northern Sweden. TI: Geochimica et Cosmochimica Acta VO: 56 SI:
Porcelli, D.; Andersson, P.S.; Baskaran, M.; Wasserburg, G.J.	2001	essay	Transport of U- and Th-series nuclides in a Baltic Shield watershed and the Baltic Sea. TI: Geochimica et Cosmochimica Acta VO: 65 HÄ: 15 SI: 2439-2459 SP: eng
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Skiöld, Torbjörn	1982	essay	Radiometric ages of plutonic and hypabyssal rocks from the Vittangi-Karesuando area, northern Sweden. TI: GFF VO: 103 HÄ: 3 SI: 317-329 SP: eng
Skiöld, Torbjörn; Öhlander, Björn	1989	essay	Chronology and geochemistry of late Svecofennian processes in northern Sweden. TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 111 HÄ: 4 SI: 347-354 SP: sve
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Welin, Eric; Blomqvist, Göran	1966	essay	Further age determinations on radioactive minerals from Sweden. TI: Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO: 88 HÄ: 1 SI: 3-18 SP: eng
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Wik, N.-G.	1996	essay	Industrial Minerals and Rocks in Sweden. TI:Industrial Minerals SI:41-49 SP:eng HÄ: 340
Witschard, Fred	1970	essay	Description of the geological maps Lainio NV, NO, SV, SO. TI: SGU Af VO: 9-12 SI: 1-102 KA: +8 PL: +3
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Åhäll, Karl-Inge; Larson, Sven Åke	2000	essay	Growth-related 1.85-1.55 Ga magmatism in the Baltic Shield
Ödman, Fredrik; Ruth, Thomas; Pontér, Christer	1999	essay	Validation of a field filtration technique for characterization of suspended particulate matter from freshwater. Part I. Major elements. TI: Applied Geochemistry VO: 14 HÄ: 3 SI: 301-317 SP: eng
Ödman, Olof H.	1938	essay	Nya rön beträffande Vakkoformationen och Linagraniten. Geologiska Föreningens i Stockholm Förhandlingar, "GFF" VO 60 HÄ: 4 SI: 667-670 SP: sve
Ödman, Olof H.	1939	essay	Urbergsgeologiska undersökningar inom Norrbottens län. TI: SGU-C VO: 426 SI: 100 KA: 3+1 PL: +31
-	1957	map	Junosuando, el- & magnetisk flygmätning. (Staplar)
-	1957	map	Junosuando, el- & magnetiska flygmätningar. (Staplar)
-	1957	map	Junosuando, magnetisk flygmätning bilaga 5c.
-	1957	map	Junosuando, elektrisk flygmätning bilaga 5b.
-	1964	map	Suinavaara. Karta över El-mätning. Turam mätning från jordad kabel år 1957 vid ett borrhål. Planerat utmål Suinavaara
-		map	Kursuvaaragruvan. Inmutningar.
-		map	Översiktskarta Kiruna-Pajala, 1:200 000
-		map	Hällkarta med överförda hällar och block från fältoriginal, 1:50 000
-		map	Blockkarta 11Lainio 1:100 000
-		map	Lucka mellan Lainio och Torneälvar 1:200 000
-		map	Malmblock 1:100 000
-		map	16: Pajala 1:100 000
-		map	15 Gällivare 1:100000
Bergman, Stefan; Kübler, Lutz; Martinsson, Olof	2000	map	Regionala geologiska och geofysiska kartor över norra Norrbottens län: Magnetisk totalfältskarta. TI: SGU-BA VO: 56:4 KA: 1 SP: sve UG: Sveriges Geologiska Undersökning UO: Uppsala

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Bergman, Stefan; Kübler, Lutz; Martinsson, Olof	2000	map	Regionala geologiska och geofysiska kartor över norra Norrbottens län: Gammastrålningskarta, elektromagnetisk karta(VLF), höjdreliefkarta och bougueranomalikarta. TI: SGU-BA VO: 56:5 KA: 1 SP: sve UG: Sveriges Geologiska Undersökning UO: Uppsala
Bergman, Stefan;Kübler, Lutz;Martinsson, Olof	2000	map	Regionala geologiska och geofysiska kartor över norra Norrbottens län: Berggrundskarta (öster om kaledoniska orogenen). TI: SGU-BA VO: 56:1 KA: 1 SP: sve UG: Sveriges Geologiska Undersökning
Bergman, Stefan;Kübler, Lutz;Martinsson, Olof	2001	map	Regionala geologiska och geofysiska kartor över norra Norrbottens län: Mineral- och bergartsresurskarta. TI: SGU-BA VO: 56:3 KA: 1 SP: sve UG: Sveriges Geologiska Undersökning UO: Uppsala
Bergman, Stefan;Kübler, Lutz;Martinsson, Olof	2001	map	Regionala geologiska och geofysiska kartor över norra Norrbottens län: Karta över metamorfosgrad, strukturer och isotopåldrar. TI: SGU-BA VO: 56:2 KA: 1 SP: sve UG: Sveriges Geologiska Undersökning
Bergqvist, M.	1958	map	Masugnsbyn. Magnetisk mätning. Schmidtvåg (Radioaktiv mosse) 1958.
Bergström, H.	1958	map	Junosuando. El- & magnetisk mätning. Turam respektive Tibergsvåg. Kabelläge 1 & 2 1958.
Bergström, H.	1958	map	Salmijärvi-Junosuando. El- & magnetiska mätningar. Turam respektive Tibergsvåg. Kabelläge 2 (Bh Ryssyjärvi 2A) 1958.
Bergström, H.	1958	map	Junosuando. El- & magnetisk mätning. Turam respektive Tibergsvåg. Kabelläge 4 1958.
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Beyer, M.		map	Saittarovaområdet, 1:20 000
Bolidens Gruv AB		map	Geologiska sammanställningskartor i färg,Norrbottens län, 1:200 000
Bolidens Gruv AB		map	Hällkarta över top kartbladet 16 Pajala 1:200 000
Eriksson, T	1948	map	Suinavaara 1:10 000
Eriksson, T	1949	map	Junosuando, magnetisk Z-anomali enl Tibergs mätning 1:2000
Eriksson, T		map	16 Pajala 1:200 000
Eriksson, Tryggve	1948	map	Detaljskiss över täljstensförekomsten N Lauttakoski by (Suinavaara) 1:10000
Eriksson, Tryggve	1950	map	Geologisk karta över Masugnsbyns dolomitförekomst 1:1000
Eriksson, Tryggve	1950	map	Stakningsplan över Masugnsbyns dolomit förekomst 1:1000
Eriksson, Tryggve	1950	map	16 Pajala 1:200 000
Eriksson, Tryggve	1955	map	Profiler Kiruna- Pajala med skisserad geologisk utveckling, 1:1000 000
Fredholm, K.A.	1880	map	Kopia af KA Fredholms karta af 1880, 1:500 000
Högbom, B.		map	Kopiering av LKAB:s kartor 1:200 000
Johnsonkoncernen	1941	map	Masugnsbyn. Skifteskarta.
Johnsonkoncernen	1941	map	Masugnsbyn. Magnetisk mätning, Tibergsvåg.
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Karlsson, B.;Lundgren, L.-E.	1957	map	Viikisivuoma. El- & magnetiska mätningar. Turam respektive Tibergsvåg 1957.

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Larsson, W.	1941	map	Tärendötrakten 1:200 000
Mohrén, E		map	Berggrundskarta över östra Norrbotten, 1:400 000
Norrbottens Järnverk AB	1959	map	Grafithalter i NJA:s undersökningsdiken på stråket SO om Masugnsbyn 1:200
SGU	1917	map	Vuoma
SGU	1917	map	Isovara - Vuoma - Västra Isovara
SGU	1946	map	Saittarova
SGU	1949	map	Junosuando
SGU	1949	map	Junosuando
SGU	1958	map	Saittarova
SGU	1962	map	Hällkarta blad 11 Lainio 1:50 000
SGU	1966	map	Masugnsbyn
SGU	1967	map	Oriasvaara
SGU	1968	map	Lauttakoski
SGU	1969	map	Leppäjoki
SGU	1969	map	Junosuando området
SGU	1969	map	Masugnsbyn
SGU	1970	map	Leppäjoki
SGU	1970	map	29L Lainio
SGU	1970	map	Tuolpukka, jordprov 1970
SGU	1971	map	Masugnsbyn
SGU	1972	map	Masugnsbyn
SGU	1972	map	Masugnsbyn
SGU	1973	map	Junosuando - området
SGU	1973	map	Lainio, tungmineral 1973
SGU	1974	map	Masugnsbyn
SGU	1974	map	29L Lainio, organiskt bäckmaterial 1973, 1974
SGU	1976	map	Oriasvaara
SGU		map	Kivijänkkä
SGU		map	Kivijänkkä
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