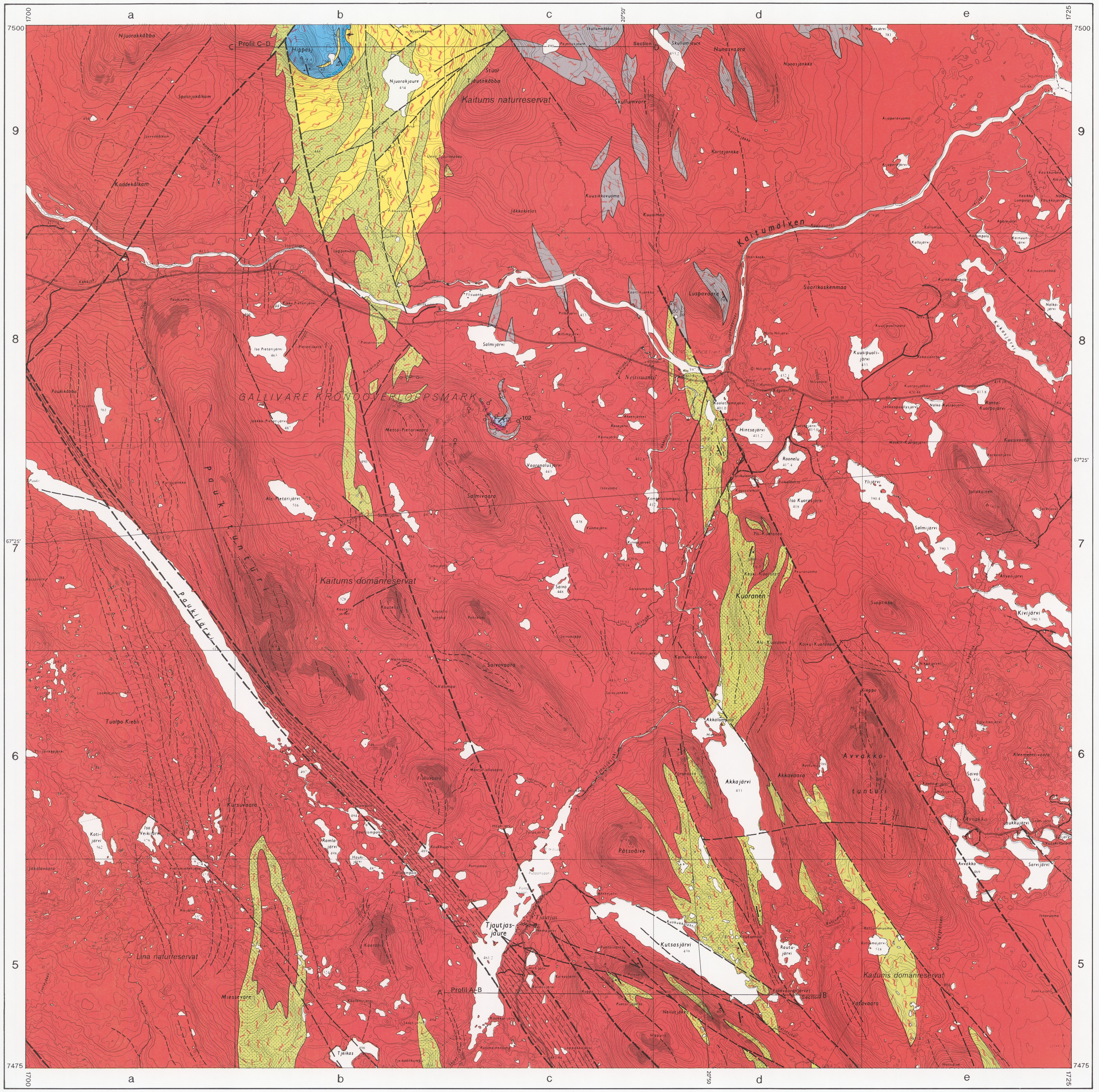
SVERIGES GEOLOGISKA UNDERSÖKNING



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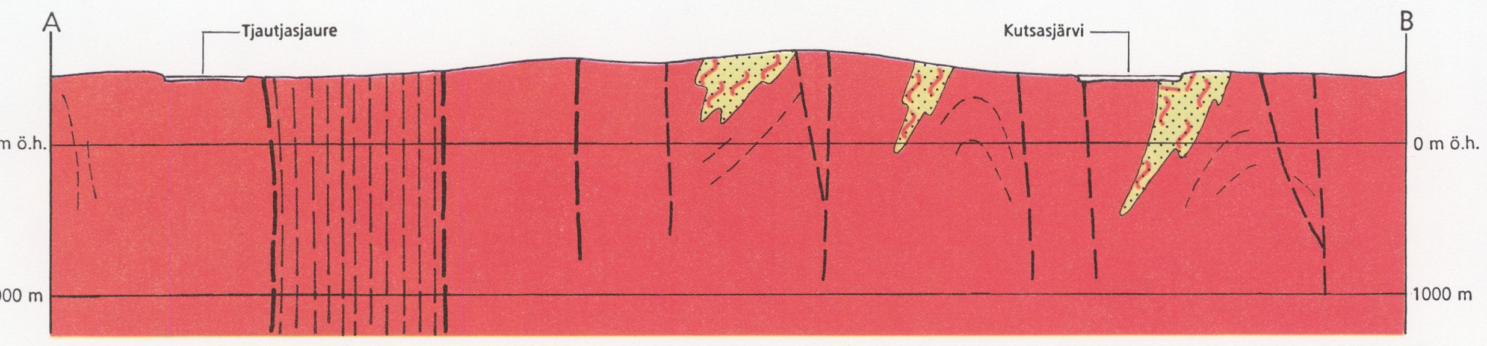

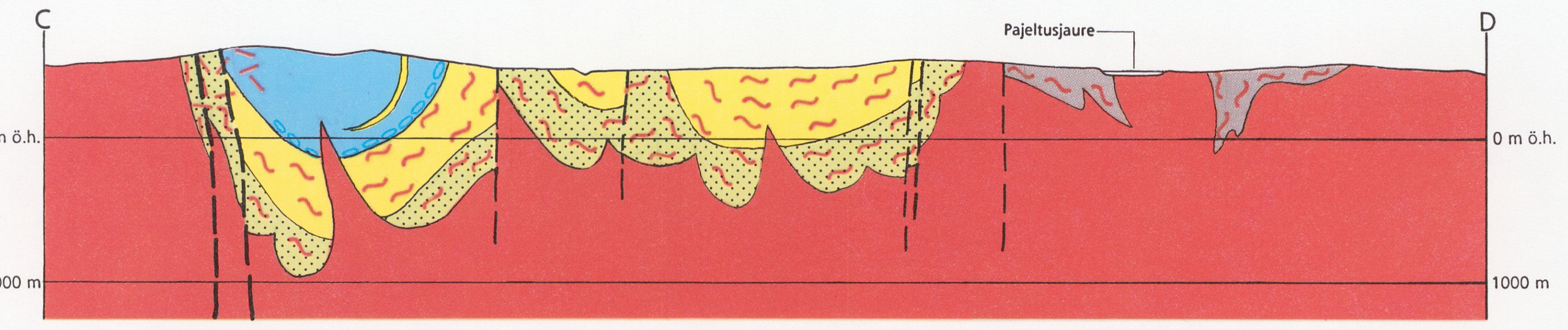

URBERGET / *PROTEROZOIC*

- Diabas, gångar, lagerintrusioner — *Diabase, dykes, sills*
- Förgnejsning — *Gneissification*

Linagranitsviten / *Lina Granite Suite*

- Pegmatit, granit och aplit. Gångar och ådror — *Pegmatite, granite and aplite. Dykes and veins*
- Linagranit — *Lina granite*

Pertitmonzonitsviten / *Perthite Monzonite Suite*

- Monzonit — *Monzonite*

Haparandasviten / *Haparanda Suite*

- Gabbrodiabas, ibland porfyrisk — *Gabbro diabase, in part porphyritic*
- Diorit, granodiorit — *Diorite, granodiorite*
- Gabbro, svag till medelmagnetisk / starkt magnetisk — *Gabbro, weakly to moderate magnetic / strongly magnetic*
- Alkalin gabbro, svag till medelmagnetisk / starkt magnetisk — *Alkaline gabbro, weakly to moderate magnetic / strongly magnetic*

Övre sedimentgruppen / *Upper Sediment Group*

- Kvartsit (Mattavaara kvartsitgrupp) / tunt konglomerat — *Quartzite (Mattavaara Quartzite Group) / thin conglomerate*
- Metaarenit — *Meta-arenite*

Porfyrgruppen / *Porphyry Group*

- Trakyt, porfyrisk (kvarts–pertitsyenit) — *Trachyte, porphyritic (quartz–perthite–syenite)*
- Kvartsporfyr, röd, felsisk — *Quartz porphyry, red, felsic*
- Metavulkanit, röd, felsisk (röd leptit) / Metavulkanit, grå, intermediär (grå leptit) — *Metavolcanite, red, felsic (red leptite) / Metavolcanite, grey, intermediate (grey leptite)*
- Andesit, trakyandesit, dacit, delvis omvandlad till amfibolit — *Andesite, trachyandesite, dacite, partly transformed to amphibolite*
- Kvartsit — *Quartzite*
- Fyllit och glimmerskiffer (± Al-silikater) — *Phyllite and biotite schist (± Al-silicates)*
- Metaarenite / tunt konglomerat — *Meta-arenite / thin conglomerate*
- Skarnbandade sedimentbergarter — *Skarn-banded sedimentary rocks*
- Alkalina–kalkalkalina, intermediära till basiska metavulkaniter och tuffer / lågmagnetiska / medelmagnetiska / starkt magnetiska — *Alkaline to calcalkaline, intermediate to basic metavolcanics and tuffs / low magnetic / moderately magnetic / high magnetic*

Mellersta sedimentgruppen / *Middle Sediment Group*

- Biotitskiffrar och gnejs — *Biotite schists and gneiss*

BETECKNINGAR / *SYMBOLS*

- Järnmalm i skärpning; numrering enligt SGUs förekomstregister — *Iron ore prospect; number according to SGU mineral deposit register*
- Kopparmalm i skärpning; numrering enl. ovan — *Copper ore prospect; number as above*
- Mo — Molybdenmineralisering — *Molybdenum prospect*
- 402 844 — Mineralförekomst; numrering enligt SGUs förekomstregister — *Mineral deposit; number according to SGU mineral deposit register*
- Gruvöppning — *Open pit mine*
- m — Muskovit — *Muscovite*
- g — Granat — *Garnet*
- • A29 — Kemisk analys med analysnummer — *Chemical analysis with number*
- * 1866±10 — Provpunkt för radiometrisk åldersbestämning (U-Pb-datering av zirkoner/monazit) med bergartsålder i miljoner år — *Sample site for radiometric age determination (U-Pb dating of zircon/monazite) with rock age in Ma*
- 35 — Förskiffring med gradtal för stupning / brant / vertikal / okänd stupning — *Foliation, schistosity, dip in degrees / steep / vertical / dip unknown*
- 50 — Lagring med gradtal för stupning / stupningsriktning / brant / vertikal — *Bedding, dip in degrees / dip direction / steep / vertical*
- Strukturella formlinjer relaterade till penetrativ platisk deformation (flygmagnetisk tolkning) — *Form lines of tectonic foliation related to penetrative, ductile deformation (from aeromagnetic data)*
- 35 — Geofysiskt bestämd strykning eller bergartskontakt med gradtal för stupning / stupningsriktning / vertikal — *Lithological contact determined from geophysical data, dip in degrees / dip direction / vertical*
- Regionalt lineament (förkastning eller sprickzon), i allmänhet geofysiskt indikerat — *Regional lineament (fault or fracture zone), generally derived from geophysical interpretation*
- Lineament (förkastning eller sprickzon), i allmänhet geofysiskt indikerat — *Lineament (fault or fracture zone), generally derived from geophysical interpretation*
- Nautanens deformationzon (NDZ) — *Nauntanen Deformation Zone (NDZ)*
- Uppåt i lagerföljd — *Way-up direction*
- 25 — Veckaxel med gradtal för stupning — *Fold axis, plunge in degrees*
- Kärnborrhål, vertikalt / med stupningsriktning — *Drillhole, vertical / with dip direction*
- A–B — Geologisk profil — *Geological section*
- Bergart som ej finns på detta kartblad — *Rock unit not present on this map-sheet*
- Bergartsgräns — *Lithologic boundary*
- Observerad häll — *Observed outcrop*
- Höjdkurvor, 20 m ekvidistans — *Contour lines, interval 20 metres*

Fältarbeten som ligger till grund för de geologiska kartbladen 28K Gällivare har utförts under skilda perioder.

I arbetena har S. Danielsson, L. Carlson P. Gerdin, B. Gustavsson, I Källberg, R. Larsson, B. Lindell, H. Lindros, P. Padget, F. Ros, L. Rönnbäck, K-A Sandahl, A. Theolin, F. Witschard deltagit för SGU och M. Duncan och H. Zweifel för Boliden Mineral AB.

Den slutliga sammanställningen av kartbladet samt design- och layoutarbeten har utförs av Fred Witschard, 1995–1996, reproduktionsarbetena av Ingemar Källberg.

Referens till kartan: Witschard F., 1996: Berggrundskartan 28K Gällivare, 1:50 000. – SGU Ai 98–101.

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Geografiska längden är räknad från Greenwich. Gauss' projektion
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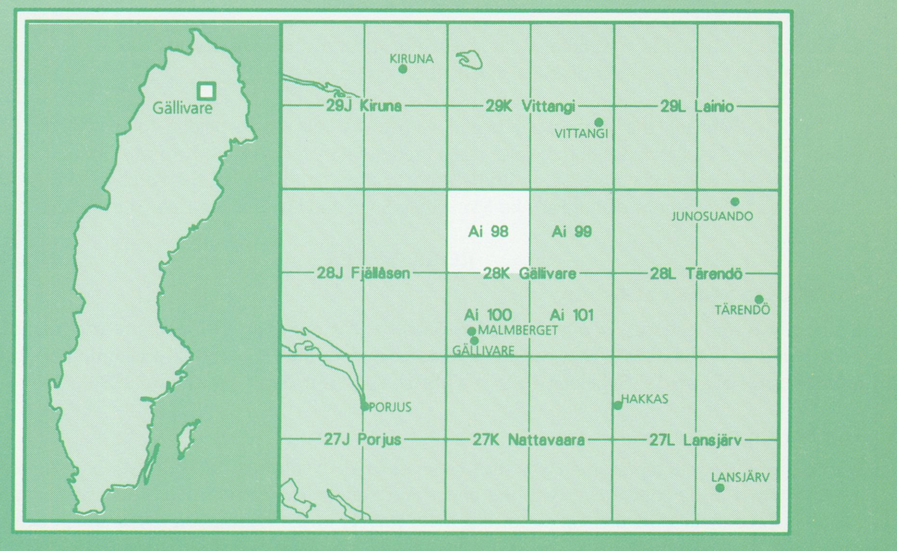
SGU serie Ai nr 98

Berggrundskartan

28K Gällivare NV

Bedrock map

Skala 1:50 000



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1996

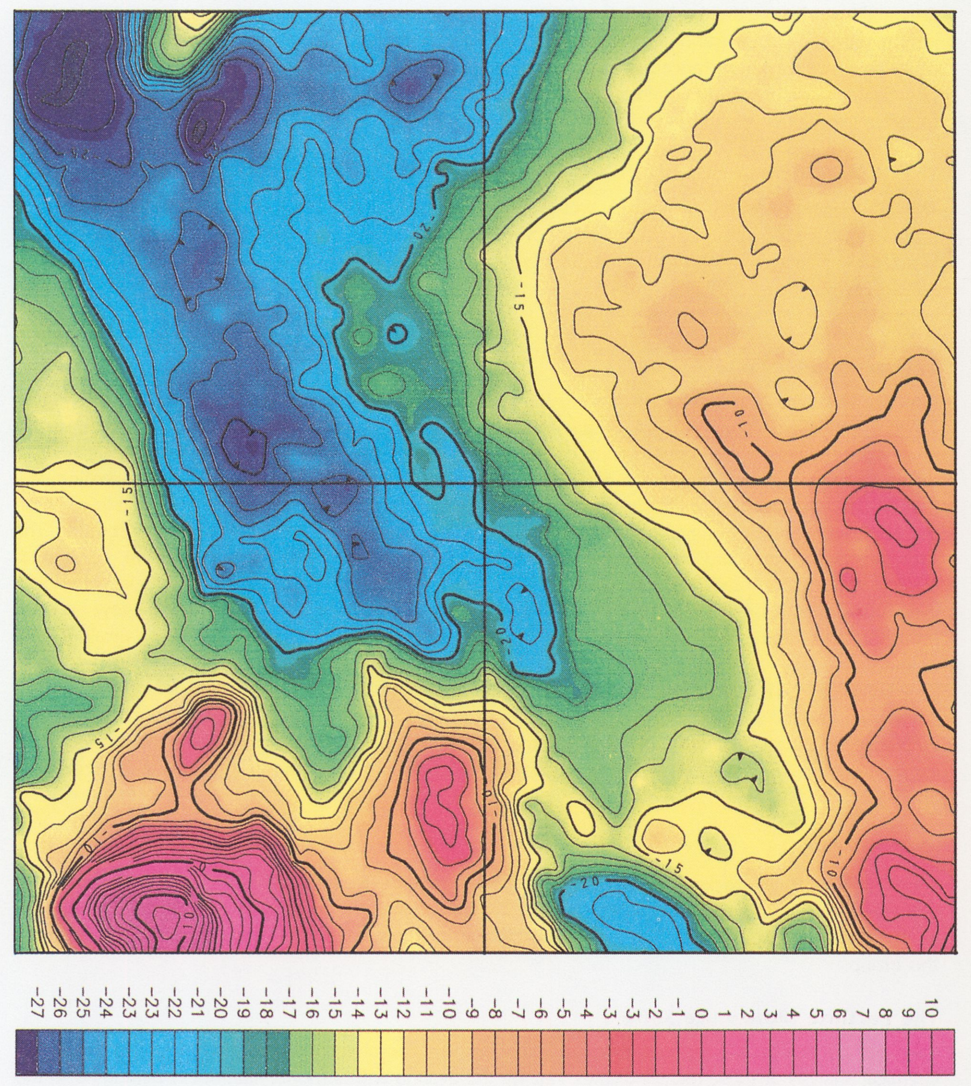


Fig. 1. Tyngdkraftskarta (skala 1:400 000) över de fyra Gällivarebladen (Bougeranomalier). Två markerade strukturer framträder i denna bild. Dels förekommer en kraftig förhöjning av tyngdkraften i den sydvästra delen som sammanfaller med utbredningen av Dundretgabbron. Det framträder också en markerat NNV–SSO-lig struktur som kan knytas till Nautanens deformationszon. Kalibreringssystem: ECS 62. Internationella formeln: 1930. Bougerdensitet: 2670 kg/m³. Uppmätt: 1967–72. Ekvidistans: 1.0 mgal.

Fig. 1. Gravimetric map (scale 1:400 000) of the four Gällivare map sheets. The strong positive anomaly to the southwest is due to the Dundret gabbro. The NNW–SSE structure is correlated with the Nautanen zone of high deformation.

SUMMARY

INTRODUCTION

A summary in swedish is given on map-sheets 28K NO and SV and in English on map-sheets 28K NV and SO.

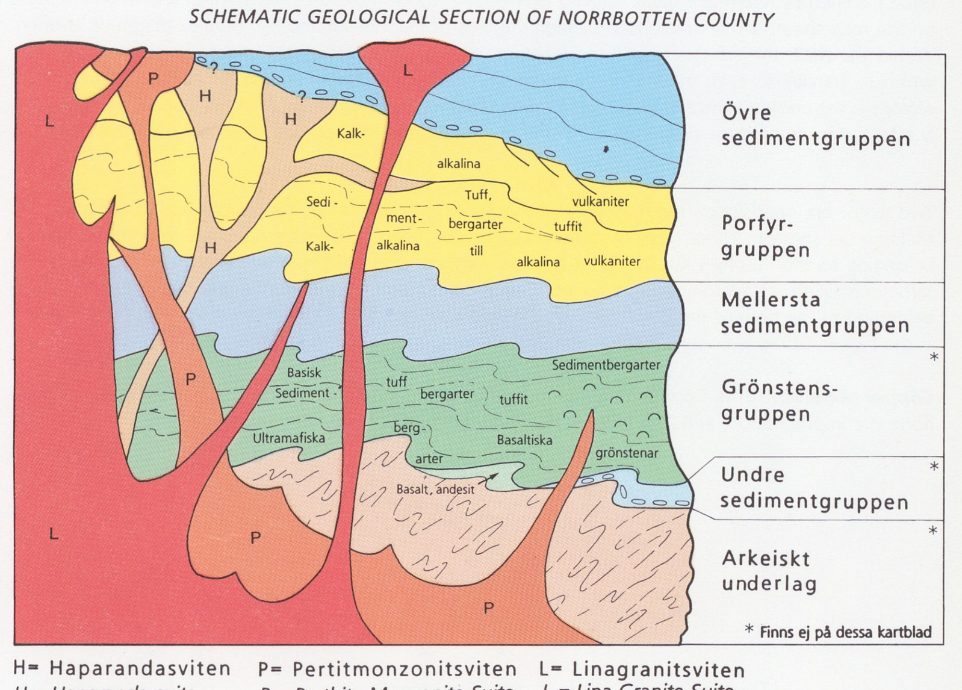
A list of references is given on map-sheets 28K NV and SO.

The four map-sheets Gällivare NV, NO, SV, and SO, are dominated by Proterozoic rocks, recording mainly events of the Svecokarelian orogeny. The complete geological evolution of Northern Norrbotten, as demonstrated on the Kiruna, Vittangi and Stora Sjöfallet map-sheets, is schematically summarized on the diagram below.

(Fortsättning på kartans baksida / continued on the back of this map sheet)

SCHEMATISK GEOLOGISK PROFIL FÖR NORRBOTTENS URBERG

SCHEMATIC GEOLOGICAL SECTION OF NORRBOTTEN COUNTY



H= Haparandasviten P= Pertitmonzonitsviten L= Linagranitsviten
H = Haparanda suite P = Perthite Monzonite Suite L = Lina Granite Suite

GEOLOGICAL EVOLUTION

The complete geological evolution of northern Sweden, best observed on the map sheets Kiruna, Vittangi and Stora Sjöfallet, can be summarized in the following manner:

1) An **Archaean basement** formed prior to 2700 Ma, consisting mainly of granitoid gneiss/migmatite terrains, locally with remnants of an Archaean cover sequence of basalt-andesite.
2) A greenstone belt, resting on a basal conglomerate and thin quartzite (Lower Sediment Group), is represented by the thick **Greenstone Group**, in its upper part dominated by mafic tuff, tuffite, schist and metasedimentary rocks with carbonate-rich horizons. It is considered to have been deposited prior to ca 2000 Ma ago, probably during a phase of rifting.
3) Further rifting was simultaneous with the deposition of the **Middle Sediment Group**, mainly consisting of quartzite, metarkose and schist, with interlayered conglomerates.
4) The **Porphyry Group**, with volcanites of mafic to intermediate composition at the base and overlain by intermediate to acid porphyries, was deposited in the western part of Norrbotten during the period 1910–1860 Ma ago.
5) The **Upper Sediment Group**, represented within the present map sheets by the Snavva–Sjöfallet Group, was deposited shortly after the emplacement of the Porphyry Group.
6) Gabbros and diorites of the **Haparanda Suite**, mainly exposed in the eastern part of northernmost Sweden, were emplaced 1890–1860 Ma ago.
7) The **Perthite Monzonite Suite** was intruded during the phase of waning orogenic activity around 1880–1860 Ma ago.
8) From about 1800 Ma, vast areas were invaded by rocks of the **Lina Granite Suite**.
9) The area is cut by younger **diabase dykes** of uncertain age.

On 28K Gällivare, the stratigraphy begins with rocks believed to belong to the Middle Sediment Group, followed by the deposition of volcanic and sedimentary rocks of the Porphyry Group. Gabbros and diorites of the Haparanda Suite were intruded shortly after deposition of the Porphyry Group. This was followed by the intrusions of the Perthite Monzonite Suite and later, of the Lina Granite Suite.

ROCK TYPES

The Middle Sediment Group

Biotite-schists and gneisses, poorly exposed in Gällivare NW, represent the southern extension of formations found on Vittangi SW. They are thought to belong to the "Kilavaara kvartsitgrupp" (Vittangi SE, Eriksson and Hallgren 1975) belonging to the Middle Sediment Group (Witschard 1984).

The Porphyry Group

The Porphyry Group is represented by a thick series of rocks of volcanic, volcanoclastic or sedimentary origin, presumed to be concordant with the underlying Middle Sediment Group. Rocks of this group are found in three main structural zones striking NNV–SSE: **1)** to the west of the "Nauntanen deformation zone (NDZ, see below), **2)** within the NDZ, where highly magnetic, brecciated and foliated trachytes and trachy-andesites alternate with tuffs and tuffites and subordinate sedimentary rocks, and **3)** to the east of the NDZ, sedimentary rocks (mainly meta-arenites) predominate over volcanics.

The NDZ is believed to include the lowest rock units of the Porphyry Group. Potassic, alkaline volcanics (trachytes, trachyandesites, alkaline basalts) predominate over sediments. They are strongly tectonized, recrystallized and seldom display primary textures. The occurrence of sparce trachytic texture, the distribution of major elements (mainly the alkalis), Ni-Ti-Zr ratios and the distribution of REE elements, all indicate that the majority of these rocks are probably of volcanic/volcanoclastic origin. Rocks of the NDZ are generally highly magnetic and the zone consists of a succession of thin magnetic layers, generally concordant with the boundaries of the main structure.

Strongly granitized or gneissified rocks of volcanic or volcano-sedimentary origin, of intermediate (alkaline to calc-alkaline) composition, form NNW–SSE-striking belts in the SW, SE and NW quadrants, where they merge to the north with the volcanic zone south of Svappavaara. On the map, these rocks have been subdivided into three main types according to their level of magnetization.

Higher up in the stratigraphy, mainly to the east the NDZ, rocks of sedimentary origin (meta-arenite with subordinate carbonate/skarn or phyllite layers, with thin conglomerate layers) predominate over volcanic rocks. Cross-bedding and graded bedding are common. Subordinate layers of amphibolite, basalt, andesite, dacite, lapilli-tuffs, agglomerate and tuffite indicate a vaning phase of volcanism.

The summit of the Porphyry Group consists of calc-alkaline (with subordinate alkaline), acid porphyries and fine-grained volcanics (leptites), exposed mainly in the Malmberget area. They are host to the iron ores and have been described by Geijer (1930). The main type is a red leptite/gneiss (seldom porphyritic), with either microcline and plagioclase, or with microcline only. Quartz content is moderate to low. The other types, of less importance are: grey or greyish-brown leptite/gneiss, and veined gneiss with sillimanite. Skarn, skarn-breccia and ore-breccia are subordinate. The porphyries and leptites are similar to those found in connection with apatite-rich iron ores, in the Kiruna and Vittangi map sheets.

The Upper Sediment Group

This group is represented by relatively well-preserved clastic rocks, found in two areas: **1)** to the east of Gällivare, where red and grey porphyries are overlaid by grey meta-arkose. **2)** to the far north (9d), where quartzite is exposed at the southern extremity of a basinal structure. This series of rocks, described by Eriksson and Hallgren (1975) belongs to the "Maattavaara Quartzite Group" consisting of quartzites, with intraformational, polymict conglomerates.

The Haparanda Suite

Rocks of this suite display a range of intrusion ages situated between 1890 and 1860 Ma (Welin et al. 1971, Skiöld and Öhlander 1989a). Field contacts and aeromagnetic interpretation indicate that probably all of the gabbros and diorites occurring on 28K Gällivare were emplaced somewhat later than the rocks of the Porphyry Group. These rocks are mainly calc-alcaline or tholeiitic, alkaline types representing only about 20%. The **Dundret gabbro** has an E–W-elongated, oval shape. It displays concentric layering on the aeromagnetic map due to alternating layers of different composition and magnetite content. The rocks are tholeiitiques and the main types represented are: magnetite-norite, olivine-gabbro, norite and, close to the core, an ultrabasic rock with low silica and high MgO content (34.4%). The Dundret gabbro is surrounded by a dioritic contact rim, sometimes porphyritic, varying in thickness from a few hundred metres up to a kilometre. The **Vassara gabbro**, to the northeast of the Dundret gabbro, is alkaline, with extreme low SiO_2 content (35–45%), and high contents of TiO_2 (2–4%), FeO_{tot} (13–18%) and P_2O_5 (1–4%). **NNW–SSE-elongated diorite massifs** are found to the east and west of the NDZ. They are sometimes foliated along the main geological trend (NNW–SSE), indicating their probable synkinematic emplacement. A monzodiorite, representing the footwall of the Aitik copper deposit, has a radiometric zircon age of 1873±24 Ma (P. O. Persson, unpublished). The ore zone here is interpreted as tectonized, altered monzodiorite.

Gabbro–diabase

These slightly alkaline rocks often display large, porphyroidal feldspar crystals. They have been emplaced either as dykes or as small massifs. The gabbro diabases are often slightly alkaline and probably belong to the Haparanda Suite. The gabbro, forming the hanging wall of the Aitik copper deposit, belongs to this group.

The Perthite Monzonite Suite

This suite of rocks is only exposed to the very south of the map sheet. The rock exposures are sparse and chemical analysis of these rocks indicates that we are dealing with a monzonite. Rocks belonging to this suite are described in greater detail by Witschard (1975). They have been emplaced during a vaning phase of the Svecokarelian orogeny (1880-1860 Ma, Skiöld and Öhlander 1989a).

The Lina Granite Suite

The Lina granite is the most commonly exposed rock type on the map sheet. Its emplacement is estimated to have occurred from about 1800 Ma (Skiöld 1987, 1988). The Lina granite is pink, medium-grained and contains toughly equal amounts of quartz, plagioclase and microcline. A pegmatite, cutting the Aitik copper ore zone, has a radiometric (monazite) age of 1747 Ma.

Undifferentiated diabase intrusions

These rocks are found mainly as steep dipping dykes. Some of these diabases are post-Lina granite (region between Dundret and Aitik), with texture varying from fine-grained to doleritic.

Metamorphism and deformation

Metamorphism. Rocks of this region have generally been affected by a metamorphism of the lower amphibolite facies. High temperature metamorphism (sillimanite gneisses), related to granite emplacement, has been observed in the Malmberget region and in the meta-sediments to the east of the NDZ. Scapolitization, frequently observed in the NDZ, corresponds to a phase of retrograde metamorphism. Rock **alteration**, associated with ore formation, is discussed below.

Fold tectonics. The extensive zone of acid volcanics and porphyries, hosting the Malmberget iron ores, is a basinal structure displaying a tectonic style very different from the rest of the Gällivare map sheets. Concentric patterns on the (processed) aeromagnetic map around and within the Malmberget structure, suggest that we are dealing with large, complex, volcanic calderas (Witschard, 1996), the ore consisting of relatively thin sheets, dipping steeply to the south and folded slightly along southward-dipping fold axes. According to this interpretation, the ores ought to be controlled by rather arcuate structures of the calderas. Most of the map sheet (with the exception of the Malmberget–Dundret region), is intensely folded along NNW–SSE-trending folds with relatively flat fold axes. The NDZ is probably affected by very tight, isoclinal folds. The fold axes lie mainly parallel the main strike of the deformation zone and the axial planes dip steeply to the west.

Fault Tectonics. On aeromagnetic maps, two main sets of faults are observed: **1)** a **NNW–SSE** set, comprising the NDZ, and **2)** a **NW–SE** set which is younger than the former and offsets it along a system of sinistral en-echelon faults. A third, less important set of faults, strikes **NE–SW.** To the east of Dundret, some of these fractures have been intruded by diabase dykes. The **Nauntanen deformation zone (NDZ),** limited by two major faults running NNW–SSE is by far the most prominent deformational feature on the map sheet. It is characterized by high degrees of magnetism and by complex magnetic layering. Within the NDZ, the schistosity and the foliation, profoundly affecting the rocks, are planar structures which lie parallel to each other. The main difference observed between the Nauntanen and the Aitik regions is the predominance of brittle deformation in the former, while the Aitik ore zone is predominantly affected by ductile-type deformation. To the northwest, the NDZ grades into a narrow shear zone.

Mineralization

Two major ore deposits on the map sheet are actually exploited: Aitik, for copper and minor gold, and Malmberget for iron. Three types of mineralization have been encountered and are interpreted here as belonging to the Porphyry Group: **1)** at the base, copper and gold mineralization (Nauntanen–Aitik–Järbojokistråket) **2)** skarn-type iron mineralization found among meta-sediments and andesites, also belonging to the base of the Porphyry Group (Salmivaara, 8c), and **3)** apatite-rich iron ore (Malmberget) in the higher, acidic members of the Porphyry Group.

Copper Mineralization. Copper mineralization often displays a double aspect: **1)** an early phase of stratiform ore impregnation, and **2)** a later phase of discordant, fracture-filling mineralization.

The Aitik Deposit. This deposit is situated about 15 kilometres to the east-southeast of Gällivare. Its reserves are estimated to about 250 million tons of ore. The ore grades are: Cu = 0.38%, Au = 0.22 g/t and Ag = 4 g/t. The mine is exploited by Boliden Mineral AB. The length of the ore is 2.5 km, for an average width of about 500 m. It strikes N 20° W and dips 40-50° to the west. Its discovery dates back to 1930. Mining started in 1967. The geology of the Aitik deposit has been described by Zweifel (1976) and by Duncan (1988). The **foot wall** consists mainly fine-grained, porphyritic quartz-biotite gneisses, biotite gneisses with hornblende shlieren, a discordant porphyritic quartz-biotite gneiss and a coarse-grained amphibole-epidote gneiss. The **main ore zone** is separated from the foot wall and from the hanging wall by shear zones (Duncan 1988). It can be subdivided into two broad lithological units: **1)** a fine-grained quartz-biotite gneiss in the lower part, usually containing garnet porphyroblasts, and **2)** muscovite schists, in the upper part. The *mineralization* consists of thin veinlets and fine disseminations of chalcopyrite. *Alteration* is generally associated with shearing (Duncan 1988). Potassic alteration (excess of potassium in the lower part of the ore zone), Phyllic alteration (muscovite schists) and a local propylitic alteration (chlorite-sericite-magnetite and accessory epidote) characterize some areas of the ore zone. The occurrence of scapolites indicates that we are dealing with the lower amphibolite (retrograde) facies of metamorphism. Hydrothermal alteration, consisting mainly of scapolitization and tourmalinization (quartz-tourmaline veinlets) and epidote-rich zones, is generally found in association with shear zones. The **hanging wall** is made up of gabbro and of hornblende-banded gneiss overlaid by quartz-biotite gneiss, presenting in places augen-type textures. ***Deformation:*** The ore is situated in a ductile shear zone, near the brittle–ductile interface, as indicated by the presence of some cataclastite. Boudinage is common throughout the mine. The ***petrochemical characteristics*** of the rocks of the Aitik ore zone indicate that we are dealing mainly with rocks of igneous (volcanic) origin (Duncan 1988). A recent investigation (Witschard 1996) indicates that the foot wall and the main ore zone correspond to tectonized and altered monzodiorite and that the hanging wall consists of highly deformed and altered gabbro diabase. According to this interpretation, the Aitik copper ore ought to belong to the classic "porphyry" type, associated with plutonic (monzonitic) intrusions and with shearing. The hanging wall is cut by numerous pegmatites (sometimes folded or boudinaged).

The Liikavaara East Deposit: This deposit lies about 3 kilometres to the east of Aitik. The principal rock type is a fine-grained quartz-biotite schist or gneiss with small, randomly orientated plagioclase phenocrysts, indicating a probable volcanic origin. Chalcopyrite is the only mineral of economic importance. Calcite is found throughout the mineralized zone. Pyrrhotite, pyrite and chalcopyrite occur as thin laminae and disseminations parallel to the foliation. Late-stage mineralization consists of veinlets discordant to the foliation. Copper grades are 0.2–1%.

Nauntanen region: Discovered in 1897. No less than seven mines, of which Nauntanen was the largest, were exploited. ***Deformation:*** The **Nautanen deformation zone** (NDZ, see above) is an extensive, NNW–SSE-striking belt of brittle-to-ductile deformation. It is limited on both sides by sharp fault boundaries. The main rock types occurring within it are weakly-to-moderately alkaline, indicating deposition within a compressive-type tectonic environment. Generally speaking, the region is tightly folded and sheared along NNW–SSE-striking axes. Veins and veinlets of quartz, amphibole and tourmaline lie generally parallel to the schistosity (Ros 1980). All of the rocks comprising the NDZ are severely deformed, with a predominance of brittle deformation (cataclysites, breccias, veinlets, etc) over ductile deformation (partial recrystallization and ductile shear-foliation). **Geology:** The rocks are generally fine-grained, recrystallized "gneisses" or schists containing varying amounts of microcline, plagioclase, biotite, amphibole, quartz, scapolite, epidote, with accessory chlorite, tourmaline, apatite, haematite, carbonate and locally (manganese-rich) garnet porphyroblasts. The occurrence of a few, more or less well preserved porphyritic (trachytic) layers speaks for an igneous (volcanic) origin for at least part of this series of rocks. Volcanoclastic and sedimentary rocks have also been observed in the NDZ, indicating that the rocks are probably of the same nature as those found outside it. Rocks of the NDZ have a rich magnetite content and are mainly alkaline (mainly potassic: trachyandesites to alkaline basalts). ***Mineralization:*** Generally, the copper mineralization is found in strongly magnetic zones. The main ore mineral is chalcopyrite. There are two types of mineralization: **1)** diffuse impregnations of "stratabound" type, and **2)** discordant mineralization in veinlets, breccia or shear zones. The ore zones are generally strongly sericitized and often display large garnet porphyroblasts. **Liikavaara**: This mineralization lies a few kilometres to the SSE of Nauntanen. The main rock type is a grey or red, fine-grained banded biotite feldspar "tuffite" with stringers of garnet, carbonate and biotite. The copper mineralization occurs either as impregnations or as vein-fillings (in quartz-tourmaline veins or in skarn-epidote-scapolite rocks). The main ore mineral is pyrite, with subordinate chalcopyrite, bornite and gold. The mineralization is generally associated with shear zones, with muscovite and sericite. **Sorvanen:** lies about three kilometres to the SSE of Liikavaara. Chalcopyrite and some gold are found in folded sillimanite gneisses or in meta-volcanics.

The mineralizations below are found in volcanic, volcanoclastic, or sedimentary rocks to the east of the NDZ. They have been explored by geophysics, geochemistry and by drilling. **Ferrum:** lies about two kilometres to the east of Liikavaara. The mineralization, mainly chalcopyrite with some bornite, is found in small quartz-tourmaline or tremolite veinlets cutting banded meta-arenites. **Fridhem:** lies about two kilometres to the south of the former and consists of parallel gold-bearing veinlets, hosted by meta-volcanics. Gold is found primarily in quartz-poor veins, with zeolites, calcite and chalcocite. **Snålkok:** lies about two kilometres to the east of Fridhem. Copper is found in altered gabbro/diorites, amphibolites, meta-volcanics (quartz-tourmaline veins). Chalcopyrite is the main ore mineral. **Sakakoski** is situated between Lina älv and the village of Liikavaara. The mineralization is associated with dacitic-rhyodacitic, pyroclastic rocks and with arkoses and conglomerates. The mineralization is found in the form of impregnations and as quartz-tourmaline vein-fillings.

Iron Ores

Malmberget: The iron ores of Malmberget, to the north of Gällivare, belong to the Kiruna type and have a high apatite content. They are owned and mined by Luossavaara–Kirunavaara AB (LKAB). The reserves (down to 815 m) are estimated to about 180 million tons of ore with an average Fe grade of 55 to 65%. P_2O_5 varies between 0.04 and 1.2%, depending on the ore bodies. An extensive study of the Malberget region, accompanied by maps (scale 1:8000) was published by P. Geijer in 1930. The **ore-bearing complex** consists of strongly recrystallized rocks, referred to as "leptites" (very fine-grained, equigranular rocks) and as "gneisses" (fine-grained rocks), with transitional stages between the two. Sparse textural features of primary origin, such as feldspar and quartz phenocrysts or amigdoidal structures, indicate a probable volcanic origin for most of these rocks. A distinction has been made in the field between the red and the grey leptites and gneisses. The former consist predominantly of microcline, albite and quartz and the latter of plagioclase (An10, often replaced by scapolite) with or without microcline. These rocks are predominantly calc-alkaline, with subordinate quartz-poor, alkaline types. Except for a few later dikes, all rocks of this complex appear to be older than the ores. Geijer (1930) suggested that the ores must be very closely connected in time with the host rock, although they are younger than the main mass of this complex and that they have an "eruptive" (magmatic) origin. The "quartz-perthite-syenite" (porphyritic trachyte) is younger than the ore-bearing complex. The **ore bodies** have a roughly tabular shape with a moderate-to-steep southward dip (45–80°). The ores often enclose large fragments of the host rock, although the ore bodies are distinctly defined against their wall rock. The **contact phenomena** include ore breccia (wall rock brecciated by and veins of ore), ore banding (parallel ore impregnations) and skarn breccia (hornblende and accessory pyroxene veins). The main **ore mineral** is magnetite. Haematite occurs less frequently, alone or together with magnetite. Apatite is common (average 4.5%). A fine banding between apatite and ore is sometimes observed. A large area of **granite of the Lina type** borders the ore field to the north and west and numerous dikes and irregular intrusions of granite and pegmatite invade the ore belts and the associated rocks. Thermal **metamorphism**, related to granite intrusion, consists in the development of sillimanite and corundum. **Tectonics:** (see above regarding the Malmberget structure). Deformation is often characterized by well marked linear structures, pinch and swell structures and boudinage. The ore-bearing complex is the more competent rock, with coarse quartz and haematite filling the fractures. Two sets of jointing of the ores are described by Geijer (1930): one parallel to the "bedding" and the other at right angles to it.

Salmivaara iron prospect: Salmivaara is a small hill, about 33 km NNE of Gällivare (8d). The region is dominated by granites containing granitized and gneissified remnants of metavolcanics and metasediments. Salmivaara is a skarn-type iron ore, constituting a small, steeply dipping, horseshoe-type fold structure in granite-gneiss terrains, containing remnants of carbonate-rich, skarnic meta-sediments and micaschists, interpreted here as belonging to the Porphyry Group.

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