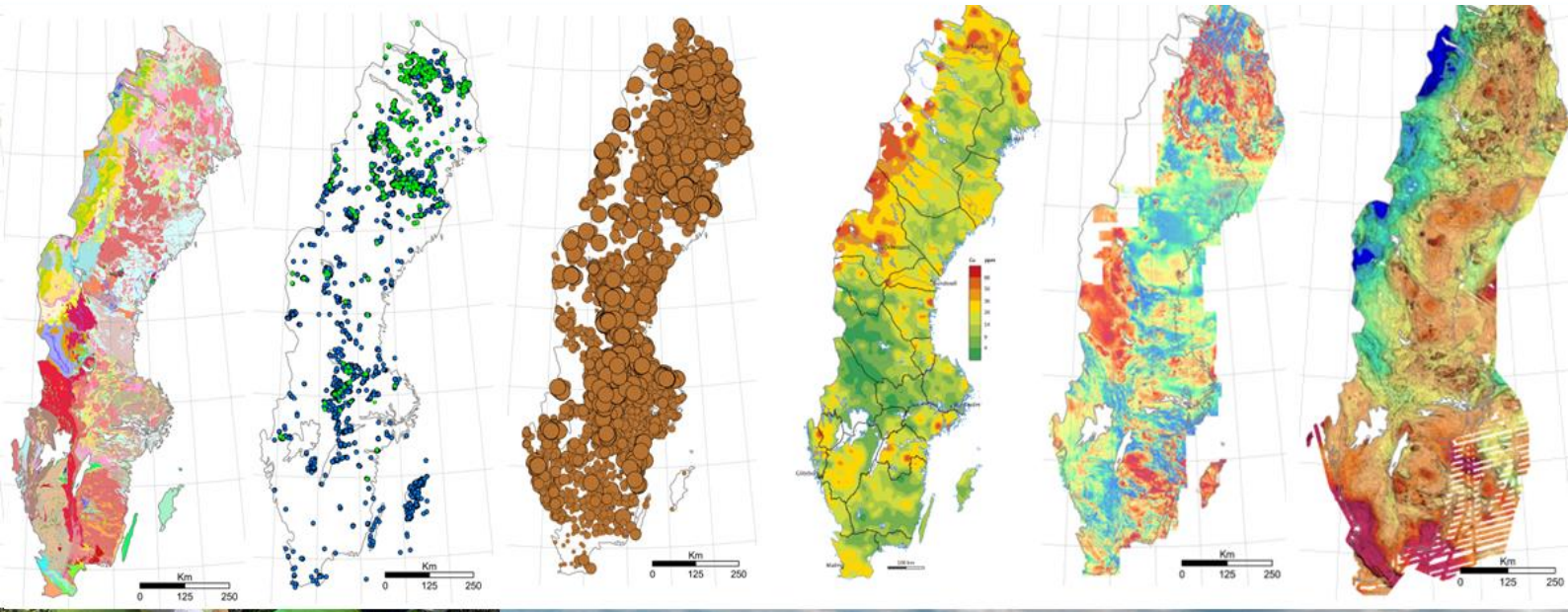
Sveriges geologiska undersökning

Critical raw materials act – article 19

National exploration programme – Sweden



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Diarie-nr: 31-997/2025

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Introduction

Sweden is one of Europe's leading mining countries with a long mining tradition and will play an important role in the EU's efforts to reach raw material resilience. Through the documentation of production and exploration, available in the archives and databases of the Geological Survey of Sweden (SGU), there is good knowledge of iron, base metals (copper, zinc, lead, nickel) and precious metals in the Swedish bedrock. Knowledge of certain critical raw materials (CRMs) is more limited because there has traditionally been low demand for these metals and minerals.

According to statistics (dating back to the 1830s) the total Swedish ore production amounts to almost 4 billion tonnes. Of this total tonnage, iron-ore dominates (64 percent), base metals account for 35 percent (mainly copper, zinc and lead, but also minor amounts of cobalt and nickel) while precious metals (gold and silver) have a share of approximately one percent. Other metals and minerals (including many CRMs such as tungsten, natural graphite and fluorspar) account for less than 0.15 percent.

Through recent projects and initiatives at SGU, including government assignments focussing on innovation-critical metals and minerals, collection of data on CRMs in Sweden has commenced, but there are still knowledge gaps.

The national exploration programme to be carried out in accordance with article 19 of the Critical Raw Materials Act (CRMA) will build on SGUs accumulated knowledge about Sweden's mineral resources and will expand and enhance the knowledge base to support developments in the sector.

The plan is aligned with SGUs long-term plan for bedrock mapping (Antal Lundin & Wedmark 2025). The present five-year plan contains both ongoing and planned projects. Work in some areas are planned to start towards the end of the five-year period. These projects will not finish during the current five-year period and must therefore be continued into the next long-term plan.

The plan is based on costs that corresponds to the basic funding of mapping ore potential areas plus the extra funding that was allocated by the government for the period 2024-2026.

The plan and its implementation may be subject to changes due to external factors, for example changes in the EU list of CRMs or changes regarding financing.

Baseline data

Main geological units and CRM potential

The bedrock of Sweden can be divided into six major lithotectonic units (Fig. 1) which in turn are subdivided in subunits (Stephens & Bergman 2020). The most important lithotectonic unit from an ore-geology point of view is the Svecokarelian orogen where most of the rocks have an age of approximately 2.0–1.8 billion years. Important ore districts within this unit are Northern Norrbotten, the Skellefte district and Bergslagen. Another important major lithotectonic unit with good ore potential is the Caledonian orogen (0.5–0.4 billion years).

Main mining districts

In terms of mineral potential, the country hosts several metallogenic areas and four main classic ore districts (Fig. 1). Sweden currently has 13 active metal mines (Fig. 2). All of these are located within the Svecokarelian orogen, specifically within Northern Norrbotten (5 mines), Skellefte district (5 mines) and Bergslagen (3 mines).

Northern Norrbotten

CRM and host metal/mineral (carrier) potential: Fe, Co, Cu, Mn, natural graphite, P, REE, V.

Norrbotten is a subunit of the Svecokarelian orogen and hosts several iron oxide-apatite (IOA) deposits of which the largest and economically most important are the Kiruna, Malmberget, Svappavaara and Per Geijer deposits. From a CRM perspective the IOA deposits are important due to their content of phosphorus and REEs. Norrbotten also has important Cu, V, Co and graphite deposits.

In terms of produced ore-tonnage Norrbotten stands out with an accumulated production of over 3 billion tonnes. In the year 2023 the iron ore production from Northern Norrbotten accounts for 93 percent of the total iron production in the EU. The **Kiruna** (Kirunavaara) mine operated by the state-owned company LKAB, has been known since the 17th century, but large-scale mining did not start until the early 1900s. As of 2023 a total of ca. 1.2 billion tonnes of iron ore averaging 56 percent Fe have been produced. Present day iron reserves and resources (PERC) are 585 million and 1billion tonnes respectively, giving a total tonnage of the Kirunavaara IOA deposit of nearly 2.8 billion tonnes. In addition to iron, the deposit also has 1.63 billion tonnes resources of 0.018 percent TREO (total rare earth oxides) and 0.36 percent P. The **Per Geijer** IOA deposit is located a few kilometres to the north of the active Kiruna mine. Per Geijer has an inferred resource (PERC) of 1.249 billion tonnes grading 0.174 percent TREO and 2.11 percent P, which makes it one of the largest TREO resources in Europe. The **Svappavaara** area located ca. 50 km east of Kiruna comprises several IOA deposits owned by LKAB with significant iron-ore and P resources. One of these (**Leveäniemi**) is currently mined. The **Malmberget** (IOA) mine in Gällivare operated by LKAB has produced 640 million tonnes of iron-ore grading 51 percent Fe since the start of large-scale mining in the early 1900s. Current iron reserves and resources (PERC) are 338 million and 1.72 billion tonnes respectively. The deposit also has 2.03 billion tonnes resources of 0.022 percent TREO and 0.58 percent P (PERC). **Kaunisvaara** in the eastern part of Norrbotten is an active iron producer operated by the company Kaunis Iron with an annual production of 2.1 million tonnes of iron products. The ore is of the skarn type. The **Aitik** giant porphyry Cu-Au-Ag deposit owned by the Boliden company started production in 1968. The annual production in 2023 was ca. 41 million tonnes. The accumulated ore production during 1968-2023 was 1.03 billion tonnes with 0.24 % Cu, 0.14 grams per ton Au and 1.5 grams per ton Ag. Reported ore reserves and resources (PERC) by end

2023 stand at 1.14 billion and 940 million tonnes respectively. **Viscaria** is an advanced project aiming at restarting operations at the closed Viscaria mine (active during 1982-1997), located close to the Kiruna mine. Viscaria currently has an Inferred + indicated + measured mineral resource (PERC) of 93 million tonnes grading 0.88 percent Cu. Reprocessing of the old mine tailings (12.7 million tonnes) is also considered.

Skellefte district and the Nickel Line

CRM and host metal/mineral (carrier) potential: As, Co, Cu, Ni, Pb, PGE, Sb, Zn.

This area is part of the Bothnia-Skellefteå lithotectonic subunit of the Svecokarelian orogen. The most common and economically important deposit type in the Skellefte district is volcanogenic massive sulphide deposits (VMS). Most are polymetallic Zn-Cu-Pb ± Au ± Ag deposits. In total more than 150 base and precious metal deposits are known in the Skellefte district. More than 30 of these have been mined during the last 100 years, producing ca. 165 million tonnes of ore in total. The Boliden company currently operates three mines in the Skellefte district (**Kristineberg**, **Renström** and **Kankberg**). In 2024 these three mines produced 1.78 million tonnes of ore that was processed to form concentrates of Zn, Cu, Pb, Au, Ag and Te. In addition, the gold mines **Björkdal** (Mandalay Resources) and the recently opened **Fäbodtjärn** (Botnia Exploration) are presently active. The closed Boliden gold mine (in production between 1926 and 1967) was in addition to gold also a major arsenic producer.

The so-called "Nickel line" which comprises more than 30 Ni occurrences and deposits is located immediately to the south-east of the Skellefte district. Several of the deposits in the Nickel line also contain Cu and Co.

Bergslagen

CRM and host metal/mineral (carrier) potential: As, Bi, Co, Cu, Fe, Mn, natural graphite, Ni, P, Pb, REE, Sb, Zn, W.

The Bergslagen district in central Sweden has more than 10 000 known mineral occurrences and deposits hosting a diverse range of deposit types including banded iron formations, skarn- and carbonate-hosted iron ore, iron oxide-apatite, stratiform and stratabound polymetallic base metal sulphide ores, Mn-oxide ore, Mo in granite and pegmatite, W-skarn and REE deposits.

Archaeological investigations indicate that mining in Bergslagen commenced ca. 400 years BC. The total accumulated mined tonnage recorded in the statistics is ca. 600 million tonnes and three mines are currently active. The most famous mine in Bergslagen was the Falu copper mine that operated for a millennium until closure in 1992. **Zinkgruvan** produced 1.4 million tonnes of (Zn-Cu-Pb-Ag) ore in 2024. The mine is to be acquired by Boliden from Lundin Mining during 2025. The **Garpenberg** mine (owned by Boliden) produced ca. 3.4 million tonnes ore in 2024 that was processed to Zn, Cu, Pb, Au and Ag concentrates. **Lovisagruvan** is a small mine producing ca. 40 thousand tonnes of rich Zn-Pb-Ag ore annually.

Caledonian orogen

CRM and host metal/mineral (carrier) potential: Co, Cu, Ni, Zn.

Volcanogenic massive sulphide deposits, sediment hosted copper deposits and Ni-sulphide mineralisation hosted by serpentines occur within the nappes of the Caledonian orogen.

At present there are no active mines in the Caledonian orogen. In modern times the Stekenjokk VMS deposit has been mined. The Rönnbäcken project is considering extraction of nickel-sulphide from serpentinites occurring within certain thrust sheets within the orogen.

Neoproterozoic and Phanerozoic platformal cover

CRM and host metal/mineral (carrier) potential: Ni, Pb, U, V, Zn.

Sandstone hosted Pb-Zn-Ag deposits and sediment hosted polymetallic U-V-Mo-Ni deposits (alum shale) occur along the eastern front of the Caledonian orogen. Two Sandstone hosted Pb-Zn-Ag deposits in the platformal cover (Laisvall and Vassbo) has been mined in modern times.

Areas with potential outside the main mining districts

Ore potential exists outside the main four classical ore districts. This is manifested by metallogenic areas (and other areas not yet classified as such) containing base metals and critical raw material deposits outside the four ore districts (Fig. 1).

Västernorrland

CRM and host metal/mineral (carrier) potential: Li, Nb, Ta, Sn, W

The Västernorrland areas is part of the Bothnia-Skellefteå lithotectonic subunit of the Svecokarelian orogen. The area stretching from the eastern part of Jämtland County, and into Medelpad and Ångermanland in Västernorrland County hosts an extensive rare element pegmatite field (LCT-type).

Hälsingland

CRM and host metal/mineral (carrier) potential: Co, Cu, Fe, natural graphite, Ti, V, Zn.

Hälsingland in the Ljusdal lithotectonic subunit of the Svecokarelian orogen hosts several graphite deposits, including a previous producer which is now on care and maintenance. The area has a mixed metallogeny with orthomagmatic Fe-Ti-V deposits, epithermal-Au-Cu, massive sulphide Zn-Pb-Cu-Au and stratiform Fe oxide.

Småland-Östergötland

CRM and host metal/mineral (carrier) potential: Cu, Co, Ni, Fe, REE.

This area is part of the Småland lithotectonic unit of the Svecokarelian orogen and has potential for several commodities including base metals and CRMs.

Värmland-Dalsland

CRM and host metal/mineral (carrier) potential: Cu, Fe, Mn.

The Värmland-Dalsland area is polymetallic with several sediment-hosted copper deposits, quartz veins with copper, manganese–iron veins, disseminated nickel in ultramafic rocks and gold-rich quartz veins.

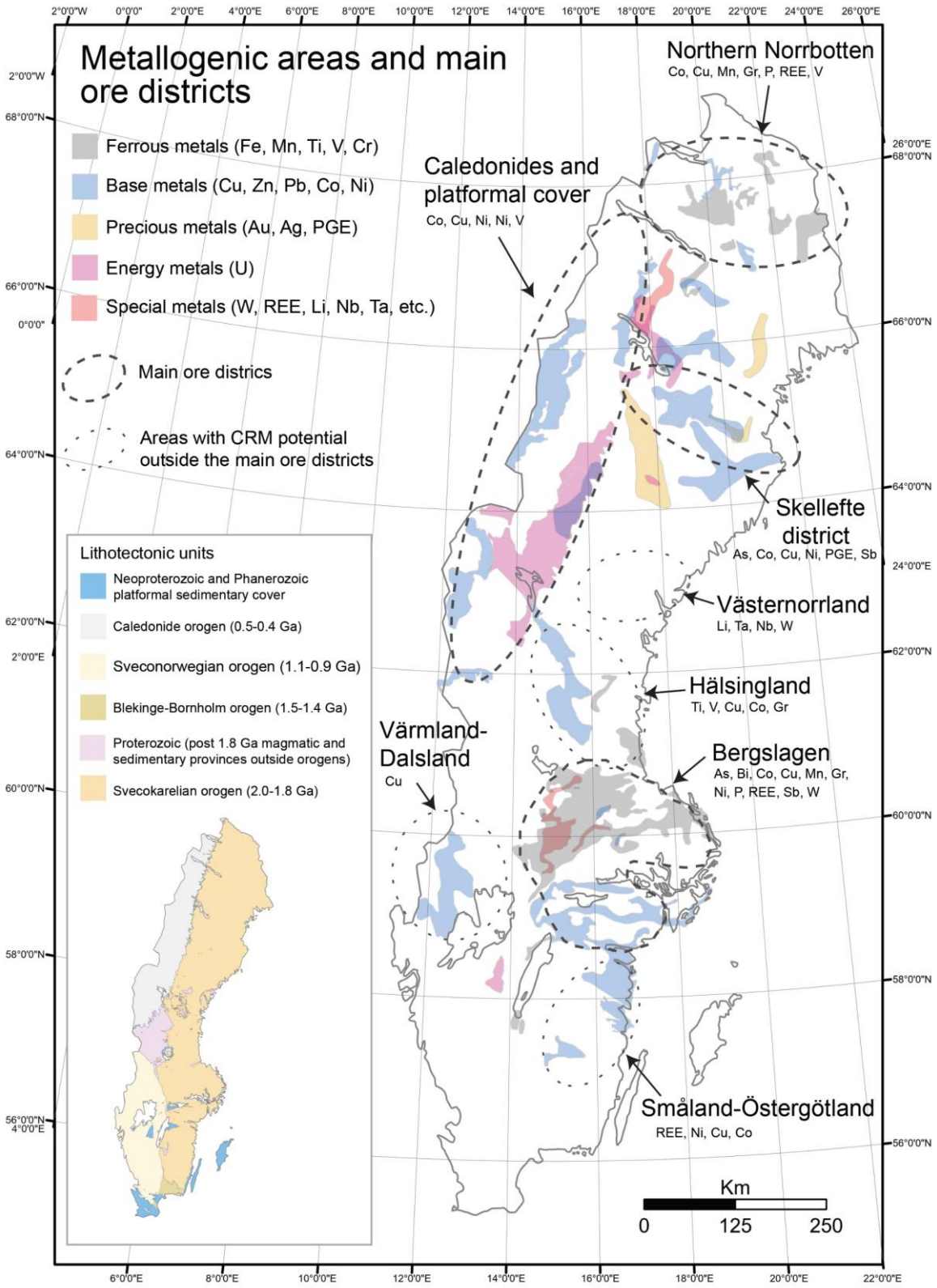

Figure 1. Metallogenic areas and mining districts in Sweden. Areas with potential for CRMs are also shown. Inset map shows the main lithotectonic units (data from SGU:s digital map database 1:1 million). The Svecokarelian orogen is the most important in terms of mineral potential. Note that the exposed Neoproterozoic and Phanerozoic platformal cover units (including alum shale) along the eastern front of the Caledonide orogen is too thin to show up on the map at this scale. Metallogenic areas are from the Nordic Ore Deposit Database (NODD).

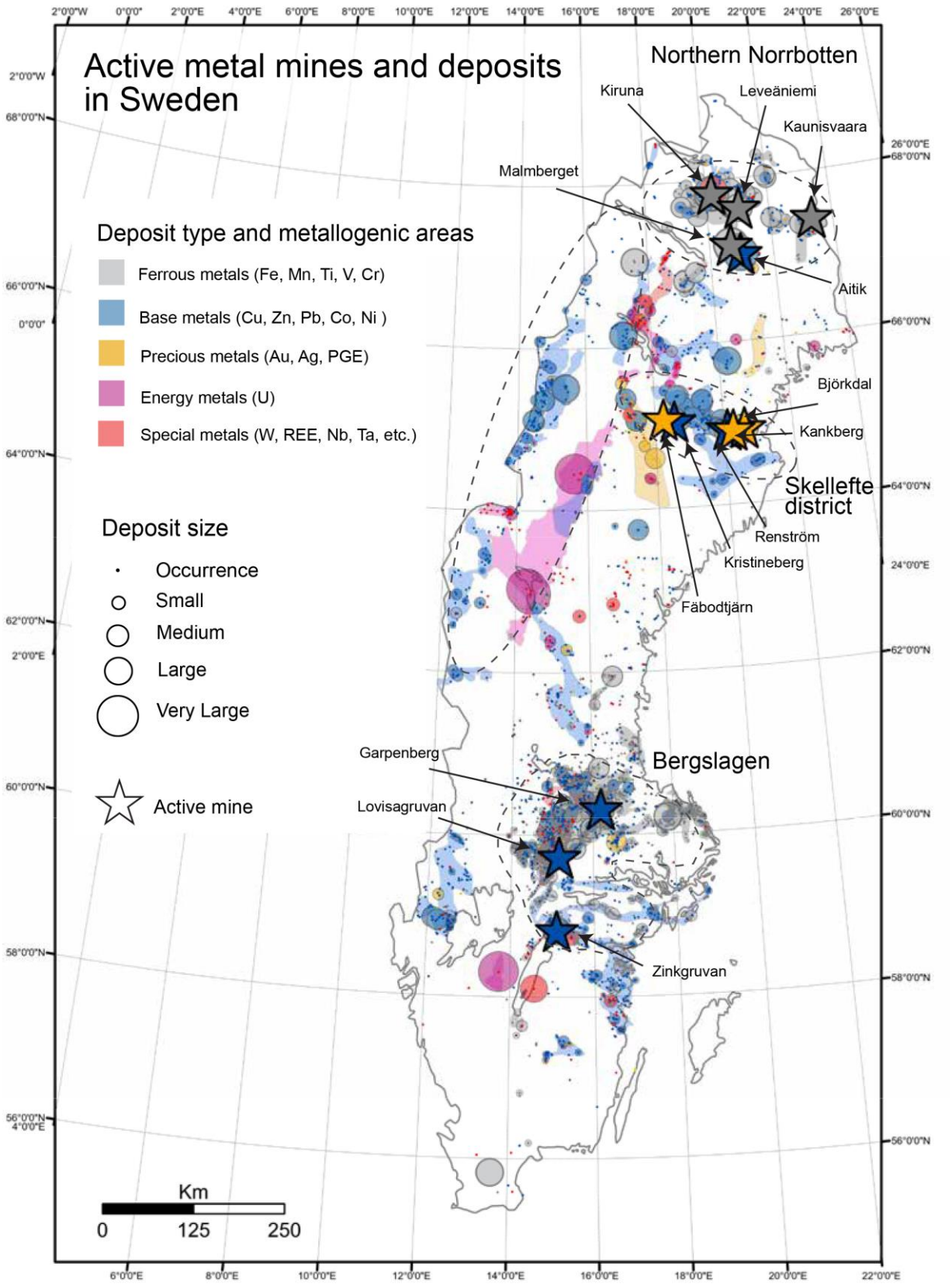

Figure 2. Active metal mines, mineral deposits and occurrences in Sweden. Data from NODD, SGU:s database of Ores and Concentrators and SGUs database of Swedish Mineral- and Bedrock occurrences.

Description of existing datasets

SGU has several relevant datasets that cover large parts of the country with geological, geophysical and geochemical base data. All SGU data are now free of charge and most databases are downloadable from the SGU website. Data is provided in open formats without restrictive conditions licensed under the Creative Commons Zero (CC0). The data formats are JSON, GeoJSON, CSV, GeoPackage, as well as TIFF format for raster data.

Drill cores

The Mineral Resources Information Office in Malå hosts SGU:s national drill core collection with close to 4 million meters of drill cores from more than 22 000 boreholes from all over Sweden. The collection is one of the largest in the world. Many of the drill cores have associated drilling and core logs, results from geophysical borehole measurements, chemical analyses, and more. Much of the analogue documentation has been scanned. Besides this documentation on the existing drill cores there are logs for about 8,000 boreholes for which no longer exist. Historic core can be sampled and analysed.

Hyperspectral Infrared Drill Core Imaging Data

SGU has scanned a carefully selected subset of cores in the SGU archive using infrared technology. The goal was to make the drillcore archive more accessible and add value to the archive by creating an open-file database of optical and reflected infrared drillcore imagery that could be a complement to the physical core that is stored at Malå. Approximately 1600 drill cores (a total of 233,000 meters) were scanned with modern hyperspectral infrared imaging technology using a SisuROCK scanner which is an along-track (push-broom) scanning system capable of imaging whole core trays in a single scan. It was equipped with an imaging system consisting of an RGB camera for high-resolution optical images, a compact full-spectrum visible-near infrared and short-wave infrared (VNIR + SWIR) camera ("Fenix") in the wavelength range 380-2500 nanometres (nm) and a long wave infrared (LWIR) camera ("OWL-C") covering the area 7500-12000 nm.

Digital geological map databases

Bedrock 1:1 million

This dataset provides a general picture of Sweden's bedrock. The map image shows the distribution of different rock units and large deformation zones (fracture zones, faults and plastic shear zones). The rock units can consist of one or more rock types and the former are generally the most common. The age of each rock unit is reported, as well as which lithotectonic unit it belongs to.

Bedrock 1:50 000 – 1:250 000

Bedrock 1:50 000 – 1:250 000 describes important features of identified geological units, their geometry, the material that makes up the units and geological events they have undergone. The map is based on geological field observations in combination with interpretation of analysis results and geophysical data. There is also information about bedrock structures and properties.

The Nordic ore deposit database

The Nordic ore deposit database (NODD) is a collaboration between the geological surveys and institutions in Denmark and Greenland, Estonia, Norway, Finland and Sweden. The database is open file and is accessible for download at the website of the geological Survey of Finland (GTK). The NODD is a direct continuation of the FODD (Fennoscandian ore deposit database)

which existed between 2003-2022. The original FODD cooperation included Russia, but not Greenland. Since the full-scale invasion of Ukraine, Russia has been excluded from the cooperation. In 2022 Greenland was included. NODD is now a comprehensive database that contains information about approximately 1500 metal ore deposits and almost 500 industrial mineral deposits in the Fennoscandian area (Finland, Sweden, Norway, Estonia) and Greenland. Information about operating mines, closed and historical mines as well as unexploited deposits with resource estimates are included. The deposit information includes the location, mining history, tonnage and commodity grades, geological setting, age, ore mineralogy, style of mineralisation, genetic models, and the primary sources of data. Information on mineral resources is mostly based on in situ geological estimates. The Swedish part of the database comprises approximately 850 Swedish ore deposits.

One of the main outputs of the NODD is a map with accompanying descriptions of the main metallogenic areas in Fennoscandia (Eilu et al. 2012). The areas have been grouped into the following categories ferrous metals, base metals, precious metals, energy metals and special metals. The Swedish part contains a total of 40 metallogenic areas which are shown in Fig. 1 and Fig. 2.

Bedrock observations

The bedrock observations database contains point-data with information about bedrock observations and measurements from outcrops, and other localities where bedrock is exposed (e.g. tunnels, drillholes). The information is based on field assessments and measurements. The database contains observation results, e.g., rock type and structure, and measurement results, e.g., orientation of layering/foliation and magnetic susceptibility. New field observation data has been continuously added to the database since the early 1990s.

Swedish mineral and bedrock occurrences database

The Swedish Mineral- and Bedrock occurrences database is a comprehensive database that contains point data with information on Sweden's mineral and rock occurrences, as well as subordinately also occurrences of natural gas and oil. The database currently contains approximately 20,000 records. The data includes small occurrences such as mineralised outcrops, abandoned and active mines or quarries as well as mineral deposits known through core drilling. For all records there is information about name, location, location accuracy, economic status, and which metal, mineral or rock type is of interest at the location, as well as literature references. Many of the records contain information about host rock, mineral composition, and age of formation. For old mines there is also information about dimensions of the pits.

Ores and concentrators

The Ores and concentrators database is comprised of two main datasets:

Ores is an economic database that contains detailed information about deposits that are either currently in production, have been in production or has historic or modern resource estimates. Where applicable the data includes location, genetic type of deposit, activity status (active, closed, historic), mining period, mining method, main metals, waste-rock tonnage, production tonnage, resources and reserves, total tonnage and metal grades.

Concentrators contains information about active and closed processing plants (concentrators). The data includes location, activity status (active, closed, historic), period of activity, processing method, processed tonnage (incoming ore to concentrator), tonnage of produced concentrate and tonnage of mining waste (tailings). Metal grades for incoming ore and produced concentrate

is included where available. The tonnages of tailings have been calculated as the difference between the tonnage of incoming ore and the produced concentrate.

Geophysical databases

Airborne geophysics, magnetic field

The database contains data on variations in the magnetic field before and after subtraction of the geomagnetic reference field (DGRF 1965.0). The measurements are carried out from 1960 onwards by aircraft flying at low altitude. Data files contain values for discrete data points. The distance between data points varies depending on where and when the data was recorded.

Altitude above ground, line separation and navigation systems have been modified over the years. Sensors have also been updated with improved sensitivity and resolution. The distance between data points varies from about 6 up to 40 metres, depending on the measurement system used. Line separation is normally 200 metres over land, and between 400 and 1000 metres over larger open sea areas and 2000 metres over the northern most mountain range. Up until 1994 the nominal survey altitude was 30 metres above ground. From 1995 onwards the nominal survey altitude is 60 metres.

Airborne geophysics, electromagnetic field, VLF

SGU airborne geophysical measurements use the so-called VLF (Very Low Frequency) method, which is a conceptionally simple but effective method to obtain information on the electrical conductivity of the ground. The method measures magnetic fields generated by currents in the ground that are induced by interaction with radio waves from transmitters in the VLF band.

The database contains information on the magnetic component (H) of the electromagnetic field in the VLF band (frequencies 15–30 kHz), which varies depending on the electrical conductivity of the ground. The measurements are carried out by aircraft flying at low altitude. Measurements are made with a three orthogonal axes receiver coils that measures both amplitude of face of the magnetic vector components. The depth influencing the measurements depends on how well the ground conducts electricity. It typically ranges from a couple of hundred metres in crystalline bedrock to a few tens of metres in thick layers of conductive clay.

Airborne surveys have been carried out since 1973. Altitude above ground, line separation and navigation systems have been modified over the years. Between 1973 and 1990 information was recorded from one transmitter (GBR in England), which produce information on the electrical conductivity of the ground that is dependent on the direction to the transmitter (emphasizes structures in the direction to the transmitter). From 1991 onwards data from three orthogonal magnetic components are recorded from two transmitters simultaneously, which enables directionally independent information to be produced. From these data tipper, peaker and apparent resistivity and current can also be calculated.

The distance between data points varies from 16 to 60 meters, depending on the measurement system used. Line separation is normally 200 metres over land, but larger line separations may occur, including 2000 metres in the northern most mountain range. Up until 1994 the nominal survey altitude was 30 metres above ground. From 1995 onwards the nominal survey altitude is 60 metres.

Airborne geophysics, gamma radiation

Gamma radiation is a part of our natural environment. Some of the radiation originates from the ground beneath us, that is, from the bedrock and soil.

The database contains information on concentrations of the naturally occurring radioactive isotopes K-40 (potassium), U-238 (uranium) and Th-232 (thorium), in the uppermost part of the bedrock and soil. The concentrations are calculated from data collected by aircrafts flying at low altitude. Concentration values represent the average over an area down to a depth of a few decimetres. Radiometric equilibrium is presupposed for concentrations of uranium and thorium. Airborne surveys have been carried out since 1968. Altitude above ground, line separation and navigation systems have been modified over the years. Sensors have also been updated with improved sensitivity and resolution. NaI detectors with crystal volumes ranging from 6 up to 16 litres have been used in the measurements. System calibration is performed with the use calibration pads with known concentrations of K, U and Th, located at Dala Airport. Calibration for background and cosmic radiation is carried out through flights at different altitudes above a larger open sea area.

The distance between data points varies from 16 to 60 metres, depending on the measurement system used. Line separation is normally 200 metres over land, but larger line separations may occur, including 2000 metres in the northern most mountain range. Up until 1994 the nominal survey altitude was 30 metres above ground. From 1995 onwards the nominal survey altitude is 60 metres.

Airborne geophysics, slingram

Slingram data from airborne surveys were collected by LKAB and SGU between 1980 and 1991. The method is based on a coil transmitting a constant electromagnetic signal at a fixed frequency, while a receiver coil, located at a fixed distance from the transmitter coil, records the resulting electromagnetic field. The primary field from the transmitter is reduced, which gives the field induced by electrically conductive structures in the ground. The data provided refers to information about the induced field, from which the electrical conductivity of the ground can be calculated. The measuring system consists of one or more pairs of coils. Two different measuring systems have been used: Slingram 80 and Slingram 84. Slingram 80 used one frequency (3720 Hz), while Slingram 84 used two frequencies (910 Hz and 7040 Hz). Lower frequencies reflect properties from a greater depth. LKAB used only Slingram 80. SGU used both systems.

The nominal survey altitude is 30 metres above ground. The nominal line separation varies between 100 and 800 metres. The distance between data points varies between 20 and 40 metres.

Airborne geophysics, electromagnetic field, TEM, resistivity

Helicopter-borne transient electromagnetic (TEM) measurements have been commissioned by SGU and flown by the company SkyTEM Aps within several areas of Sweden to map the electrical conductivity of the ground. Data is predominantly available in areas with sedimentary bedrock, but also in areas with the purpose to map soils (e.g. clays).

Helicopter-borne TEM is an electromagnetic method where a large current is sent to a coil, suspended by wire beneath the helicopter, whereby currents in the ground are induced. By modelling and inversion, it is possible to obtain the distribution of resistivities from the surface down to a certain depth of investigation. Depending on the geological conditions, the depth of investigation can vary a lot between different data points. In general, the maximum depth of investigation is about 200 metres, but can be up to 250 metres.

The database contains data collected between 2013 and 2019. In general, the surveys have been flown in straight parallel lines with about 200 metre line spacing. Flight direction varies between the different survey areas. SGU has performed data processing and inversion of the raw data to produce resistivity data. The distance between data points varies from about 30 to 40 metres.

Bouguer anomaly

The SGU geophysical ground measurement database contains information from individual ground gravity measurements all over Sweden. From the measurements, Bouguer anomalies (mGal) have been computed in the reference field RG82. The number of measurements varies across the country. The measurements have been carried out by SGU and several other organisations. SGU started to systematically collect gravity measurements in the late 1950s in connection with an iron-ore inventory programme in Norrbotten. National regional measurements commenced in the 1960s as support to SGUs bedrock mapping. Today, gravity measurements are mainly carried out in areas where there are ongoing or planned mapping programmes. The position for each measurement, the terrain corrected Bouguer anomalies, and the accuracy for each measurement are disclosed in the dataset.

Geochemistry databases

Lithogeochemistry

The lithogeochemistry database contains information about different elements in rock samples from Sweden. Sampling has mainly taken place in connection with regular fieldwork at SGU. Some analytical values are derived from the literature. The analyses have been performed using various so-called analysis packages and analysis methods. Different laboratories have been used over time. The lithogeochemical database comprises positional data, short descriptions, and lithogeochemical analyses of rock samples. The total number of elements analysed varies.

Till geochemistry

The database contains information about elements and pH in till, sediments and soil in Sweden. The data is a result of multi-year geochemical mapping programmes at SGU. Sampling of till has typically been done by hand in the C-horizon, with a sampling depth of 0,6 – 1,0 m below the surface. The data includes coordinates, and chemical analyses, but the amount of information about the sample, preparation procedures, analytical method and laboratory may vary. Different methods have been used over time.

Biogeochemistry

The database is based on stream-plant chemistry, using both plant roots and whole plants collected from small streams at an average sampling density of one sample per 7 km². The plant samples were analysed for 30 elements using X-ray fluorescence (XRF). A subset of the samples was also analysed for Hg, Cd, Se, Au, Sb, Bi, and Tl using an acid leach method in combination with atomic absorption spectrometry (AAS) and inductively coupled plasma mass spectrometry (ICP-MS).

National exploration programme

Successful mineral exploration requires access to high quality basic geoscientific information. As described in the section "Description of existing datasets" above, SGU has collected and maintains large datasets relevant to exploration. However, parts of the country lack modern data.

The overall purpose of the programme is to strengthen mapping of ore potential areas and to produce relevant geological, geophysical and geochemical information.

Many critical raw materials do not form their own minable mineral deposits but occur at low concentrations in ores mined for other commodities and can therefore be considered as companion metals. In such cases the main metal is the economic driver of mining and extraction, and the critical metals will be by-products. When assessing critical raw materials potential, it is therefore important to consider the carrier metals. For example, several of the Swedish IOA deposits contain REE and phosphorous.

Through the gathered documentation of mining and exploration, available in SGU archives and databases, we have good knowledge of how much iron, base metals (copper, zinc, lead, nickel) and precious metals that have been mined in the past and how much is available in the forms of resources and reserves. The information about other metals, including critical raw materials is more limited. This is because demand for these metals has historically been low, and they have been of little interest to the mining and exploration industry.

Modern geological data will assist in unlocking the potential for base metals and critical raw materials that are crucial for mitigating climate change and for technological developments in medical, defence and other high-tech industries. The information is also valuable for companies to invest in exploration in Sweden which in turn is fundamental for opening new mines as basis for building secure and sustainable value chains.

The national exploration programme includes bedrock mapping, sampling and lithogeochemical analysis and ground and airborne geophysical surveys. Regional soil geochemistry sampling programmes and documentation of ores and minerals through ongoing systematic mine inventory programmes are also included.

SGU is currently exploring the possibility of implementing predictive mapping in the mapping programmes.

SGU has identified subareas (exploration areas) where planned efforts will be focused in the next five years and beyond (Table 1 and Fig. 3). The workplans have been established according to knowledge about the local geology, inferred critical raw material potential and existing data coverage. Hence, the areas differ significantly in scope and planned methods for data acquisition. In general, the selection of the areas is based on a set of criteria including:

- inferred CRM potential
- lack of geological, geophysical and geochemical knowledge or data is not up to date
- existence of certain carrier metals and minerals
- input from stakeholders

A summary of the scope, objectives, impact and timeframe for the planned activities in the individual areas is shown in Table 1. Figure 3 shows where the main areas are located.

Note that some of these activities have already started and will progress as shown in table 1.

Table 1. The selected areas, targeted commodities, objectives and impact expected for the next five years.

Area	Main activities	Main targeted commodities	Objectives and Impact	2025	2026	2027	2028	2029
Northern Norrbotten	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples. 3D modelling in selected areas.	Co, Cu, natural graphite, and other CRMs. Base metals and Fe.	Increased knowledge about Cu, Co and natural graphite. Construction of 3D models. Production of basemaps in areas with high potential for iron, and base metals and associated CRMs.	x	x	x	x	x
Nickel line	Sampling of historic drillcore and outcrops. Lithogeochemical analyses of collected samples. Geophysical investigations.	Ni, Co, Cu, PGE.	Synthesis to increase understanding of Ni and PGE mineralisations.		x	x	x	
Västernorrland	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples. Till mapping and sampling and analyses in selected areas.	Li, Ta, Nb, W, Sn, Sb, PGE and base metals.	Increased knowledge about Li, Ta, Nb, W, Sn, Sb, PGE and base metals in different systems. Synthesis of information.	x	x	x	x	x
Hälsingland-Jämtland	Till geochemistry sampling and analysis.	Metals and minerals, including CRMs.	Systematic regional mapping to detect anomalies in till.	x	x	x	x	x
Hälsingland-Eastern Svealand	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples. Structural studies and 3D modelling in selected areas.	Fe, Ti, V, Cu, Co, natural graphite.	Expand the geological knowledge on the formation of iron, base metals and CRMs.	x	x			
Caledonides	Bedrock mapping, sampling and geophysical investigations in the Storsjö tectonic window.	Cu, PGE.	Mapping and characterisation of the ore-potential for Cu and PGE.		x	x	x	

Area	Main activities	Main targeted commodities	Objectives and Impact	2025	2026	2027	2028	2029
	Lithogeochemical analyses of collected samples.							
Caledonian front, Skåne, Östergötland, Västergötland, Öland	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples.	V, Ni.	Characterisation of CRMs in alum shale.	x	x			
Småland - Östergötland	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples.	REE, Fe, Ni, Cu, Co.	Increased knowledge about the formation and extent of REE, Ni, Cu, Co and other CRMs and base metals.	x	x	x	x	x
Värmland-Dalsland-Bergslagen	Bedrock mapping, sampling and geophysical investigations. Lithogeochemical analyses of collected samples. Systematic documentation of old mines, deposits and mineralisations.	Metals and minerals, including Cu and other CRMs.	Characterisation of the ore-potential for Cu and associated CRMs. Characterisation of metals and minerals in old mines, deposits and mineralisations. Possible new discoveries of CRMs.	x	x	x	x	x

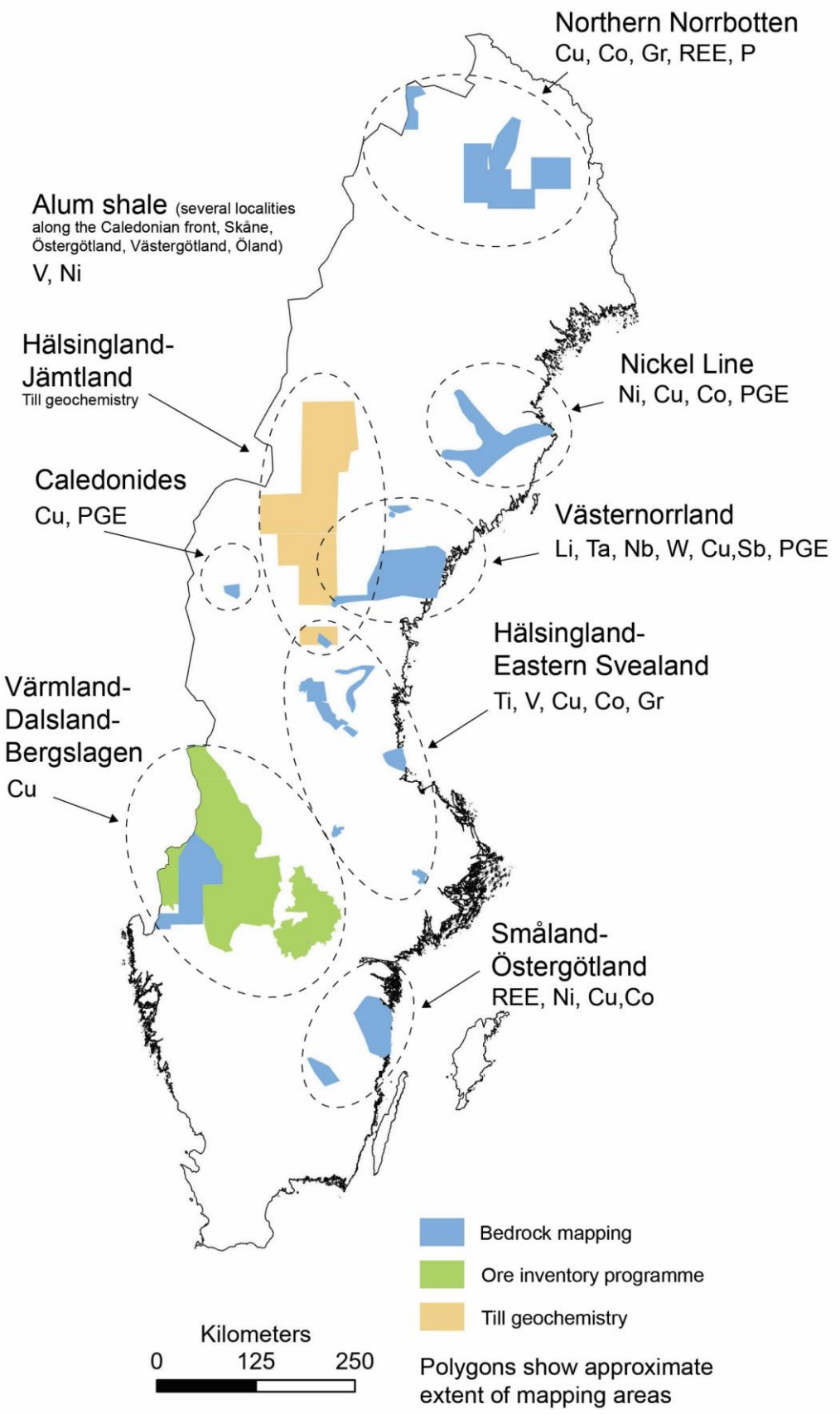

Figure 3. Approximate outline of mapping areas and the main targeted CRM commodities for the national exploration programme. Areas with potential for V and Ni in alum shale are distributed over large parts of the country and are omitted for clarity. Se table 1 and text for details.

Data acquisition plan

In this section the main elements of the work plan for selected areas included in the national exploration plan are described. The plan comprises individual areas/regions as outlined in Table 1 and Fig. 3. The work in some of these areas have already started and will continue as indicated.

Where applicable the United Nations Framework Classification for Resources (UNFC) will be used to classify identified occurrences and mineralisations.

Northern Norrbotten

Objective: To update geological, geophysical and geochemical databases and maps. To document and analyse deposits and occurrences of iron ore, base- and precious metals and CRMs to increase the knowledge of these metals and minerals in the region.

Bedrock mapping is ongoing since 2024 in the Kiskamavaara and nearby Kiruna areas. Mapping will commence in 2025 in the Fjällåsen area (south of Kiruna) and is planned in the Gällivare, Masugnsbyn and Sjangeli areas. The aim is to update geological, geophysical and geochemical maps in these ore-potential areas.

The Kiskamavaara area contains known mineralisations and deposits (e.g. the Kiskamavaara Cu-Co deposit and several Fe deposits) and is prospective for CRMs including Co, Cu and graphite. The Kiruna and Gällivare areas contain some of the most important ore deposits in Sweden, e.g. the Kiruna, Per Geijer and Malmberget IOA deposits (containing Fe, REE and P) and the Viscaria and Aitik Cu deposits. In addition, several other iron, base metal, precious metal and graphite deposits occur in the Northern Norrbotten area. The projects in Northern Norrbotten aim at increasing the knowledgebase regarding rock-units, alterations, structures and lithogeochemistry which in turn increases the understanding of the ore-forming processes according to the following work plan:

- Compile existing data from databases and collections at SGU including data from historic drill cores.
- Geological mapping and descriptions of outcrops.
- Sampling and lithogeochemical analyses of outcrop samples.
- Petrographical and mineralogical studies.
- Petrophysical measurements on collected samples.
- Geophysical surveys (airborne and ground) including:
    - magnetic field
    - electromagnetic measurements
    - gravity
    - gamma radiation
- Bedrock data, drill core data and geophysical data will be integrated to create 3D-models in selected areas.

Nickel line

Objective: To produce a synthesis on Ni-Cu-Co and PGE deposits and occurrences based on compilation of existing data and collecting new data from deposits in the Nickel line.

Several nickel–copper mineralisations occurs as disseminated minerals, veinlets and massive ore hosted in metamorphosed Paleoproterozoic mafic to ultramafic intrusive rocks within an east-northeast trending, 15 km broad and 100 km long zone, south-east of the Skellefte district, the so-called "Nickel Line" (Åkerman 1987). The ultramafic intrusives occur as small bodies within metamorphosed sediments, mainly greywackes, also of Paleoproterozoic age. A few nickel-deposits hosted by mafic to ultramafic intrusions are also found north of the Nickel Line and within the Skellefte district proper. Kläppsjö is a layered mafic-ultramafic intrusion located in Västernorrland and hence not part of the nickel line, but inclusion of this intrusion will be considered due to PGE potential. Earlier exploration work and geological studies, including diamond drilling, has demonstrated interesting grades of PGE at Kläppsjö.

Work plan:

- Compilation and assessment of previously gathered data from in databases and collections at SGU.
- New sampling and descriptions of the mafic intrusions and their contact relations to the surrounding rocks.
- Geophysical ground measurements.
- Sampling and lithogeochemical analyses of historic drill core and outcrop samples.
- Petrographical and mineralogical studies.
- Petrophysical measurements on collected samples.
- Produce a synthesis.

Västernorrland

Systematic mapping of CRMs is currently ongoing in eastern and central parts of Västernorrland. Further investigations are planned at Rockliden in the northeastern part of the area.

The main goal is to update the geological, geophysical, and geochemical data within this area and to provide new knowledge and information related to understanding the mineral systems and the genesis of the mineral deposits in the area.

Objective 1: To update the geological, geophysical and lithogeochemical databases and to gain knowledge about the formation of deposits containing lithium, tin, tungsten, niobium and tantalum.

Work plan:

- Bedrock mapping: 1:50 000 and 1:250 000 scale.
- Lithogeochemistry: Sampling and analysis of deposits, occurrences and country rocks.
- Microscopy: Petrography and ore-mineralogical studies of thin sections and polished samples.
- Radiometric dating of deposits and country rocks.
- Petrophysical measurements on collected samples.
- Ground gravity measurements in selected key areas.
- Gamma ray spectrometer measurements in selected key areas.
- Synthesis the structural, geological, geochemical and geophysical data in regional scale.

Objective 2: To update till geochemistry and quaternary geological data and knowledge associated with bedrock geology and mineralisation containing lithium, tin and tungsten.

The occurrence and distribution geochemical patterns in till horizons, especially the C-horizon, reflect partly mineralisation and bedrock geology. The presence of preglacial sediments in till has certain geochemical characteristics. In this sub project the correlation between quaternary geology, soil and till transportation and bedrock geology and mineralisation will be investigated.

Work plan:

- Quaternary geological mapping and documentation in selected sites
- Geochemical sampling and documentation on machine-dug moraine profiles from various soil profiles down to the bedrock, where practically possible.
- The samples will be sieved into different fractions and analysed.
- Compare results and assess which methods provide optimal associations with bedrock, mineralisation or moraine development and soil formation.

Objective 3: To update data and geological knowledge on base-metals (Cu-Zn-Pb) and CRM (Sb).

Rockliden is as an antimony-rich Volcanic Massive Sulphide (VMS) deposit in which the main economic minerals are sphalerite, chalcopyrite, and galena (Boliden 2020). The Rockliden area is characterized by a complex geological setting, including volcanic-sedimentary rocks and multiple phases of deformation and metamorphism.

Despite previous exploration efforts, data coverage in the Rockliden area remains limited. Much of the available information comes from older drilling campaigns and regional-scale mapping, which lack the resolution needed for detailed resource assessment. In particular, there are gaps in geophysical, geochemical, and structural data. This lack of modern and high-resolution data hinders both the understanding of the area's geological evolution and the evaluation of its full mineral potential. As a result, further targeted mapping, updated geophysical surveys are necessary to improve geological knowledge and support potential future exploration.

Work plan:

- Compilation and assessment of previously gathered data.
- Geological mapping.
- Lithogeochemistry: Samples from outcrops will be collected and analysed.
- Petrophysical measurements on collected samples.
- Radiometric dating and mineral chemistry.
- Ground geophysical measurements including magnetic susceptibility, gamma spectroscopy and gravity measurements to support geological interpretations.

Hälsingland – Eastern Svealand

Investigations by SGU are ongoing in several areas in Hälsingland since 2021. One project (planned to finish during 2025) is focussing on mafic intrusions in Gävleborg County with respect to mainly vanadium, but also titanium and iron. Other projects focus on graphite, gold, cobalt, and base metals in the boundary zone between the Bergslagen and Ljusdal lithotectonic units in Gävleborg County.

Objective 1: To expand the geological knowledge on orthomagmatic Fe-Ti-V deposits in mafic intrusions in the area.

Mafic intrusions prospective for Fe-T-V mineralisation occurs at several locations in the Ljusdal lithotectonic unit. The physical properties of the specific rocks, the content of metals and minerals and how and when these were formed, is currently being investigated. The aim is to generate a modern dataset that can be used to understand more about the distribution, size and genesis of these deposits which in turn may be a foundation for further exploration activities. The physical properties of the specific rocks, the content of metals and minerals and, how and when these were formed, have been investigated. The work includes:

- Collation, assessment and analysing of previously gathered data.
- Digitization of existing ground magnetic datasets.
- Sampling and descriptions of the mafic intrusions and their contact relations to the surrounding granitic gneisses.
- Sampling and lithogeochemical analyses of existing drill core, outcrop samples and waste-rock samples from older mining pits have been collected.
- Detailed petrography analysis and ore-mineralogical studies.
- Petrophysical measurements on collected samples to enhance modelling.

- Detailed ground magnetic measurements have been undertaken at anomalies identified from airborne data and previous investigations. Interpretations are ongoing.
- Gravity measurements have been conducted at key locations in the area to give better data for geophysical modelling of larger gravity anomalies in the region.
- Radiometric dating: One of the larger mafic intrusions is dated with the U/Pb method.
- Interpretations of tectonomagmatic environment and Fe-Ti-V ore-formation.

Objective 2: To demonstrate the geological processes that contribute to formation of graphite, gold, cobalt, and base metals deposits by examining alterations, mineralisations, their relation to the stratigraphy and structures, and the structural framework and evolution of the bedrock.

The goal is to update the geological, geophysical, and geochemical data on selected mineralisations and to increase knowledge about their formation processes. The aim is to demonstrate the geological processes that contribute to ore formation by examining alterations, mineralisations, their relation to the stratigraphy and structures, and the structural framework and evolution of the bedrock. 3D modelling in selected areas is used to show relations between mineralisations and the surrounding bedrock.

Base metals and CRMs

Work plan:

- Collecting mineralised samples from outcrops, waste rock, and historic drill cores from deposits in the areas, characterizing these by petrographic studies, lithogeochemical analysis, and isotope analysis.
- Ore mineralogical studies.
- Radiometric dating of country rocks.
- Structural geological investigations.
- Geophysical measurements (magnetic, electromagnetic, petrophysics)
- 3D modelling in selected areas.

Graphite

SGUs mapping in the area around Edsbyn and at various locations in eastern Svealand involves surveying graphite deposits in different geological environments and comparing their quality and formation conditions which aims at gaining knowledge that can contribute to successful exploration for more high-quality graphite deposits. The overall aim of the project is to better define the structural and metamorphic development over time of the graphite deposits and the surrounding bedrock in the Edsbyn area and in eastern Svealand, where other areas of interest have been identified: Norberg, Skällsta, Garpa and Västerby mines.

Work plan:

- Structural field mapping, sampling of graphite and country rocks, magnetic and electromagnetic measurements.
- Ground geophysical measurements including magnetic, electromagnetic and electric measurements.
- Construction of conceptual structural model.
- Characterization of PTt evolution.
- Characterize graphite properties by various methods.

Hälsingland–Jämtland. Regional till geochemistry sampling programme

Objective: Possible reanalysing and reprocessing of previously collected samples combined with new sampling and analysis.

Regional till geochemistry involves analysing the chemical composition of glacial till to identify geochemical anomalies that may indicate underlying bedrock and mineralization. Since till is transported by glaciers from its source, it can provide valuable information about the bedrock over a broad area, especially in regions with poor rock exposure.

One possible activity within this framework is the re-analysis and reprocessing of previously collected samples or data. By applying modern analytical techniques and updated data processing methods, historical datasets can yield new insights that were not possible at the time of original collection.

In addition, new sampling and analysis should be prioritised, preferably in areas where bedrock mapping is currently underway or planned. This integrated approach allows geochemical results to be interpreted in the context of updated geological models, increasing the reliability and usefulness of the data for identifying exploration targets and refining predictive mapping.

Caledonides

Objective: mapping and characterisation of the ore-potential for Cu, PGE, Au in the Storsjö area in Jämtland.

The Storsjö tectonic window exposes Precambrian rocks in the middle allochthon of the Swedish Caledonides. Previous exploration activities in this area including geophysics, boulder hunting, till geochemistry and drilling have identified a Cu-Au-PGE deposit (Bottenbäcken) hosted by mafic volcanic rocks.

The work plan has not been confirmed yet but will include compilation of previously gathered data, bedrock mapping, ground geophysics, collecting and analysis of outcrop samples to assess CRM potential.

Caledonian front, Skåne, Östergötland, Västergötland, Öland

Objective: To characterise alum shale and increase the knowledgebase of chemical compositions including CRMs.

From Finnmark in northern Norway to Skåne (Scania) in southern Sweden black shales (alum shales) of Middle and Late Cambrian and locally of early Ordovician age occur. In Sweden alum shale occurs along the Caledonian front from northernmost Norrbotten to Dalarna. Another important province is in platformal sedimentary cover units in southern Sweden (Skåne, Närke, Östergötland ,Västergötland and Öland). The alum shales are an important potential source of several metals including uranium, vanadium, molybdenum, and nickel.

Work plan:

- Compile available data from existing databases and different sources.
- Sampling and analysis of alum shale from southern, middle and northern Sweden. Samples will be obtained from selected, previously not analysed drillcores of alum shales stored at SGU's drillcore archive in Malå.
- Selected samples may be analysed using XRD or microprobe.
- Update databases and produce a report.

Värmland-Dalsland-Bergslagen

The effort in this area includes ore inventory programmes and a mapping programme.

Ore-inventory programme Örebro County

Objective: to systematically investigate and characterise abandoned mines, trial pits, quarries and showings in Örebro county, many of which may have CRM potential.

Work plan:

- Compilation of existing information to produce a list of potential objects to visit in the field.
- Investigations of waste-rock heaps to assess volumes.
- Sampling and lithogeochemical analyses of collected samples from mineralisations and waste-rock.
- Petrographical and mineralogical studies.

Ore-inventory programme Värmland County

Objective: to systematically investigate and characterise abandoned mines, trial pits, quarries and showings in Värmland county, many of which may have CRM potential.

Work plan:

- Compilation of existing information to produce a list of potential objects to visit in the field.
- Investigations of waste-rock heaps to assess volumes
- Sampling and lithogeochemical analyses of collected samples.
- Petrographical and mineralogical studies.

Mapping in Värmland-Dalsland[1]

Objective: to investigate base metal deposits for possible contents of CRMs.

The Värmland-Dalsland area is polymetallic with several sediment-hosted copper deposits, quartz veins with copper, manganese–iron veins, disseminated nickel in ultramafic rocks and gold-rich quartz veins. Several deposits have been mined in the past, but the only one that has been in production in recent times is the Harnäs gold deposit that was mined from 1993 to 1997. The area hosts two larger sediment-hosted copper–silver deposits. The host rocks in the Dalsland–Värmland area were affected by the Sveconorwegian orogeny at 1.14–0.90 Ga ago. The deformation that occurred during the waning stages of the orogeny is believed to have produced most of the vein deposits in the area whereas the sediment-hosted deposits may have been formed earlier.

The work plan has not been confirmed yet but will include compilation of previously gathered data bedrock mapping, ground geophysics, collecting and analysis of outcrop samples to assess CRM potential.

[1] This project is planned to continue in 2030

Småland–Östergötland

The work in these areas is divided into subprojects with a main goal to upgrade SGU's bedrock map database to a more detailed scale, as well as to sample and analyse the mineralisations in the area with a focus on CRMs. Geological, geochemical, and geophysical data collected during the project will be continuously made available in SGU's databases.

Objective 1: Sample and reassess previously known iron, copper and selenium mineralisations.

Preliminary findings from the Skrikerum area reveal anomalous concentrations of copper, gold, nickel, cobalt, selenium, tellurium, manganese, and REE in several of the sampled mineral occurrences. Recently acquired airborne geophysical data, including magnetic field, gamma spectroscopy and two-transmitter VLF from the area were released in 2024. These datasets will be integral as support for geological interpretations and modelling.

Work plan:

- Bedrock mapping
- Lithogeochemistry: Samples from outcrop and waste-rock heaps are being analysed.
- Petrographical and ore-mineralogical studies.
- Petrophysical measurements will be done on collected samples.
- Ground magnetic measurements, gravity measurements and gamma ray spectrometer measurements are done in selected key areas.

Further analysis and interpretations of the collected data are underway, based on which revisions will be made in SGU's bedrock map database.

Objective 2: To understand the formation and timing of REE and sulphide ores in the area.

The Olserum-Västervik area includes known mineralisations of CRMs, such as the Olserum REE deposit and cobalt-rich sulphide ores at Gladhammar. However, most of the mineralisations in the area have previously not been analysed using modern methods. The key objective is to understand the formation processes and timing of these mineralisations during the area's almost two billion years long geological history. Such knowledge could provide valuable insights to guide future exploration in the area.

Analytical results from sampling of known mineral occurrences show elevated, and in some cases notably high concentrations of among others rare earth elements, phosphate, thorium, copper, titanium, manganese, uranium, zirconium, lead, tungsten, chromium, cobalt, bismuth, and gold.

Work plan:

- Lithogeochemistry: A sampling programme collecting samples from outcrops and waste-rock piles has been initiated and will continue during 2025. Preliminary data from 2024 already show REE and other CRM potential in previously unknown locations.
- Documentation of outcrops.
- Petrophysical measurements on collected samples.
- Radiometric dating.
- Specialised analyses for interpretation of REE mobility in the ore-forming systems.
- Ground geophysical measurements including magnetic susceptibility, gamma spectroscopy and gravity measurements have been performed to support the interpretation of new airborne geophysical data released in 2024 (magnetic field, gamma spectroscopy and two-transmitter VLF).

Objective 3: Mapping and sampling of prospective area with historic Ni-Cu-Co mining.

The Vetlanda area in Småland includes several small historical mines and more than 30 known occurrences of different types. Most of the mines were active in the late 19th century. The Kleva gabbro-hosted Ni-Cu-Co deposit, the Ädelfors Au quartz vein deposit, the Fredriksberg mafic-hosted Cu deposit and the Sunnerskog Cu skarn are all examples of historic mines. The largest producer was Kleva which was mined intermittently between 1845-1919 and produced ca. 55 000 tonnes of ore.

The work plan has not been confirmed yet but will include:

- Compilation and assessment of previously gathered data
- Sampling and lithogeochemical analysis of deposits, occurrences and country rocks.
- Bedrock mapping.
- Petrography and ore-mineralogical studies.
- Ground geophysical measurements

Data processing and modelling

SGU will use in-house standard procedures and techniques for data collection and processing. When practically possible, the processing of data (geophysics, geochemistry, microscopy) will use the same standardised procedures for all the investigated areas where similar methods are used. However, some analytical work (e.g. lithogeochemical analyses) will be undertaken as procured services from external providers.

Initial indications of anomalous concentrations of CRMs in analysed samples will be noted and followed up with more detailed investigations if possible.

Lithogeochemistry: Lithogeochemical analyses are planned to be performed by external laboratories. Three rock standards will be used for quality control of each sample batch. Details can be found at the SGU website:
https://resource.sgu.se/dokument/produkter/lithogeochemistry-description.pdf

Till geochemistry: Details regarding regional till geochemistry sampling and analysis can be found at the SGU website (in Swedish):
https://resource.sgu.se/dokument/produkter/markgeokemi-regional-provtagning-beskrivning.pdf

Airborne geophysics, magnetic field: Details regarding Airborne geophysics, magnetic field can be found at the SGU website:https://www.sgu.se/en/products/geological-data/geophysics--geological-data/magnetic-field/

Airborne geophysics, electromagnetic field, VLF: Details regarding Airborne geophysics, electromagnetic field, VLF can be found at the SGU website:
https://www.sgu.se/en/products/geological-data/geophysics--geological-data/electrical-conductivity/

Airborne geophysics, gamma radiation: Details regarding Airborne geophysics, gamma radiation can be found at the SGU website: https://www.sgu.se/en/about-sgu/tasks-and-activities-new/geological-mapping-surveys/geophysical-mapping/gamma-radiation/

Airborne geophysics, slingram: : Details regarding Airborne geophysics, slingram can be found at the SGU website: https://www.sgu.se/en/products/geological-data/geophysics--geological-data/electrical-conductivity/

Airborne geophysics, electromagnetic field, TEM, resistivity: Details regarding Airborne geophysics, electromagnetic field, TEM, resistivity can be found at the SGU website:
https://www.sgu.se/en/products/geological-data/geophysics--geological-data/electrical-conductivity/

Bouguer anomaly: Details regarding gravity measurements can be found at the SGU website:https://www.sgu.se/en/products/geological-data/geophysics--geological-data/gravity/

SGU intends to develop and implement innovative techniques in the methodology that is used for data collection, mapping and processing. This will be realised according to the points below.

New geophysical methods to enable better mapping in 3D

Application of geophysical methods are fundamental for understanding the subsurface bedrock and to enhance knowledge about mineralisations and deposits at depth. A combination of different physical parameters complements each other and give the best results. Therefore, SGU has engaged consulting companies specialising in modern airborne gravity and transient electromagnetic measurements. The measurements are made in selected areas where SGU conducts bedrock mapping, and the results will be implemented in the interpretation of bedrock and in 3D modelling. Data produced in these areas also form the basis for exploration and mining companies directly.

Use of UAV systems in geophysical investigations

SGU intends to further develop and implement UAV systems for detailed geophysical measurements.

Modern analytical methods to increase knowledge about ore-forming processes

In addition to chemical analyses for main and trace elements and microscope analyses, analyses of mineralogy using scanning electron microscope are used to understand processes and geological conditions during formation of ore deposits.

Equip, modernise and increase SGUs laboratory capacity and instrument park

A new ICP-MS instrument was installed at SGU in 2023. The instrument was commissioned in early 2024 and is used to analyse main and trace elements in till. As the capacity of the modern instrument is significantly higher than that of the old instrument, SGU will be able to reduce the accumulated backlog, produce results at a faster pace and develop the methodology.

It is important to be able to characterise mineralogy, not least CRM mineralogy. The procurement of a new XRD (X-ray diffraction) instrument has started.

The SGU calibration pads for airborne and ground gamma spectrometry need to be maintained and adapted to ensure long-term access to this facility, which is unique of its kind in Europe. Procurement is expected in 2025.

The completion of a new instrument for radiomagnetotelluric measurements (RMT) begun in 2024 and is planned to be used in 2025 to map electrical conductivity. Discussions have been initiated with potential suppliers of equipment to SGU's petrophysical laboratory.

Use drilling techniques to drill and analyse the bedrock in 3D

Procurement of drilling services is in progress.

Use "Prospectivity Mapping" to obtain better results and interpretations

Today, prospectivity mapping is used and developed within Horizon Europe's research-funded projects. The plan is to implement the methodology in SGU's regular activities in key areas.

Enhanced dissemination of information

As the first Swedish authority, SGU have made the surveys databases available for free unrestricted download from SGUs website. In addition to databases, SGU's reports and maps are also available for download free of charge.

Data management plan

SGU maintains several in-house databases to store geological, geophysical and geochemical data. A brief description of these databases is in the previous section "Base data". Quality control and review of the input data is done according to established routines at SGU.

Data collected through the national exploration programme will be integrated into the existing SGU databases as much as possible. If practically possible SGU will use the same databases for all the investigated areas where similar datasets are generated. Some of the datasets (e.g. certain data from mineral resources) are automatically exported and harvested to the MIN4EU database and displayed on the EGDI portal.

The data is continuously published on the SGU website and can be downloaded in several different open formats without restrictive conditions licensed under the Creative Commons Zero (CC0). The data formats are JSON, GeoJSON, CSV, GeoPackage, as well as TIFF format for raster data. JSON stands for JavaScript Object Notation, and CSV is usually interpreted as Character-Separated Values. Both are compact, text-based formats used for exchanging data. GeoJSON is an open standard based on JSON but also includes the geographic component in the form of support for different geometry types, such as points, lines, and areas. GeoJSON files can be opened in QGIS, for example.

GeoPackage is a file-based database format adapted for geographic information. GeoPackage is an open, non-proprietary standard developed by the Open Geospatial Consortium, OGC, and can be used in a large number of GIS and database clients, such as QGIS or ArcGIS.

API Viewing Service – WMS services are also available at the SGU website. SGU's viewing services are aimed at users who want our information as ready-made images in their own systems or applications. SGUs viewing services are based on the standardized Web Map Service (WMS) call interface developed by the Open Geospatial Consortium, OGC.

SGU maintains map viewers that can be used to show the different datasets such as lithogeochemistry, mineral occurrences, deposits, geophysics etc. A subset of the mineral resources data (including data on CRMs) is also automatically exported via a harvesting mechanism to the European Geological Data Infrastructure (EGDI).

A full description of available formats and database structures can be found at the SGU website:

https://www.sgu.se/en/products/geological-data/

Map viewers can be accessed at the SGU website:

https://www.sgu.se/en/products/maps/map-viewer/

Plan to engage with industry, academia and civil society

The main channel for communication to industry, academia and civil society is the SGU website, newsletters and social media. Data from the national exploration programme will be published continuously at the SGU website.

SGU provides fundings for research in Earth science to Swedish universities. The aim is to meet society's need for applied geology and contribute to a sustainable development. In 2025 focus has been on research on critical and strategic metals and minerals but also includes those that are not currently classified as critical or strategic according to the EUs critical list, but which are of great importance for Sweden's technological development and energy supply.

SGU maintains biannual councils where SGU, industry and other stakeholders meet to inform and discuss recent developments and plans for further work.

Plan to monitor, evaluate and update the national exploration programme

Evaluation and monitoring can be done through SGUs biannual councils where SGU, industry and other stakeholders meet to inform and discuss recent developments and plans for further work.

Follow-up and monitoring of the progress of the individual subprojects will be done according to the detailed project plans/work plans for each project. Each project will have a project leader, detailed workplans, budget and assigned personnel. Many projects will create interim progress reports. The project leader and the management team at the Department of mineral resources at SGU will review the progress year by year. A final report will be released when each subproject is finished.

Available resources for designing and implementing the national exploration programme

The national exploration programme will be a natural continuation of already ongoing mapping programmes at SGU, and the design and implementing are done at the Department of Mineral Resources at SGU.

Notably, the plan is aligned with SGUs long-term plan for bedrock mapping (Antal Lundin & Wedmark 2025). The five-year plan contains some projects that SGU plans to initiate towards the end of the period. These projects will not finish during the period and must therefore be continued into the next long-term plan.

The plan is based on costs that corresponds to the basic funding of mapping ore potential areas plus the extra funding that was allocated by the government for the period 2024-2026.

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