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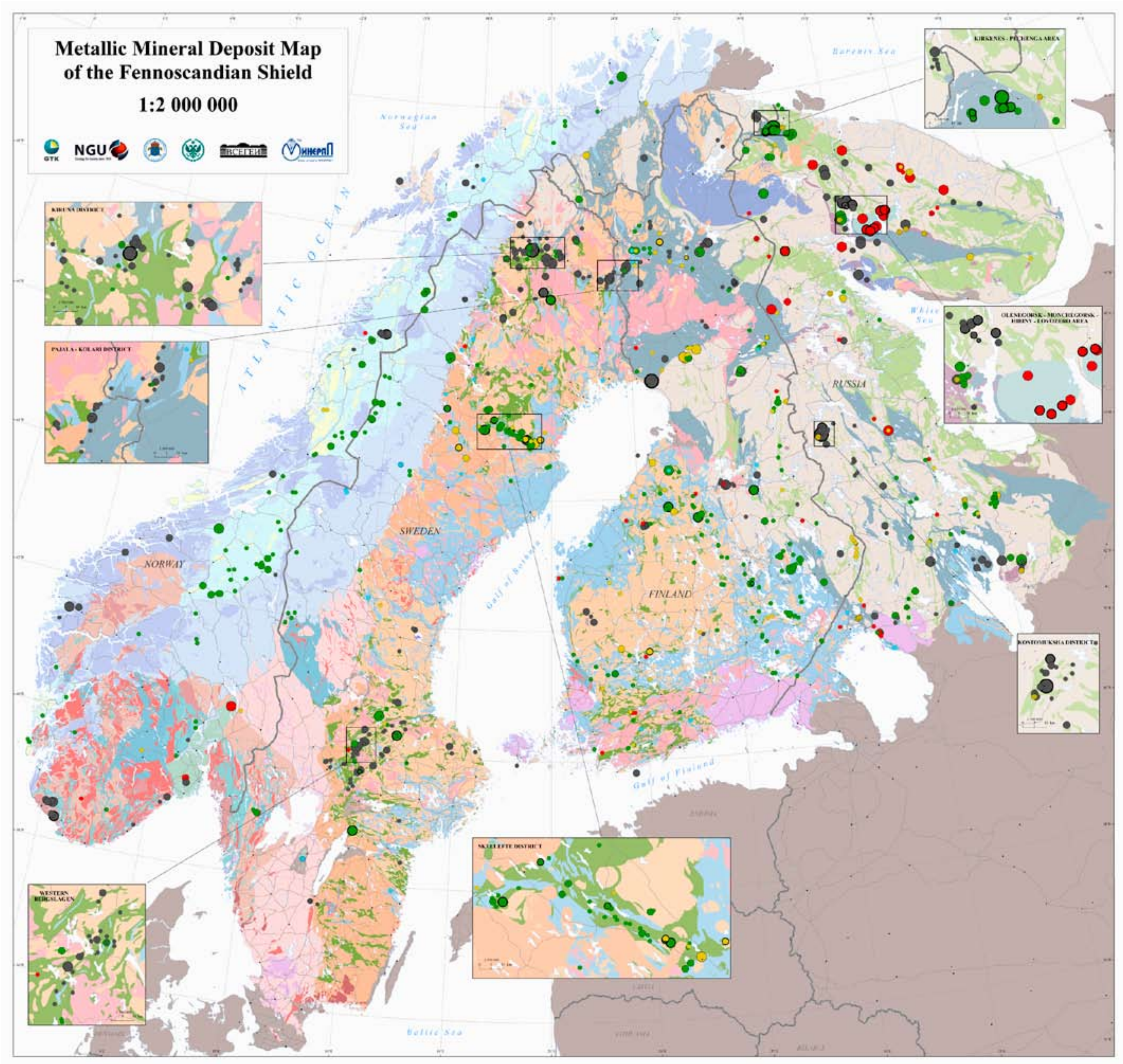

Fennoscandian Ore Deposit Database – explanatory remarks to the database

Pasi Eilu, Anders Hallberg, Torbjörn Bergman, Vyacheslav Feoktistov, Margarita Korsakova, Stanislav Krasotkin, Eero Lampio, Vasily Litvinenko, Pekka A. Nurmi, Morten Often, Nikolay Philippov, Jan Sverre Sandstad, Victor Stromov & Mikko Tontti

GTK

GEOLOGIAN TUTKIMUSKESKUS **GEOLOGICAL SURVEY OF FINLAND**

Tutkimusraportti 168 Report of Investigation 168

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FENNOSCANDIAN ORE DEPOSIT DATABASE – EXPLANATORY REMARKS TO THE DATABASE

Espoo 2007

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The public-domain Fennoscandian Ore Deposit Database (FODD) contains data on more than 900 metal mines, unexploited deposits and significant occurrences within Fennoscandia (the Precambrian shield and the Caledonides; Norway, Sweden, Finland and NW Russia). Information on the deposits includes the location, mining history, tonnage and commodity grades with a comment on data quality, 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, which should not be confused with the present industrial resource and reserve standards. In this report, we describe the structure and guidelines along which the database is constructed, and how the deposits and detailed data are selected, classified and presented in it. The information in the database is collected from public sources of data including published literature, archive reports, press releases, company Internet pages, and interviews of exploration geologists. The database is constructed as a joint project between the Geological Survey of Finland (GTK), the Geological Survey of Norway (NGU), the Federal Agency of Use of Mineral Resources of the Ministry of Natural Resources of the Russian Federation (ROSNEDRA) – VSEGEI, SC Mineral (Russia), and the Geological Survey of Sweden (SGU). The FODD is hosted by the exploration pages of the Geological Survey of Finland (http://en.gtk.fi/ExplorationFinland/FODD) and is accessible via the Internet through the web pages of the participating organisations.

Key words (GeoRef Thesaurus, AGI): economic geology, metal ores, data bases, FODD, mines, host rocks, Paleozoic, Precambrian, Proterozoic, Archean, Fennoscandia, Finland, Sweden, Norway, Russian Federation

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Fennoskandian malmiesiintymätietokanta (FODD) sisältää tietoa yli 900 metallikaivoksesta ja hyödyntämättömästä esiintymästä. Kohteita on koko Fennoskandiasta, sekä prekambrisen kilven että Kaledonidien alueelta, Norjasta, Ruotsista, Suomesta ja luoteis-Venäjältä. Esiintymistä on kannassa annettu paikka-, koko- ja arvometallipitoisuustieto, malmin geneettinen tyyppi sekä tietoa kaivostoiminnasta, geologisesta asemasta, iästä, malmimineraaleista ja esiintymän muodosta. Lisäksi on annettu tärkeimmät tietolähteet ja kommentti koko- ja pitoisuustietojen laadusta. Useimpien esiintymien resurssitiedot ovat geologisia *in situ* -arvioita, jotka eivät täytä moderneja malmivara- ja malmivarantostandardeja. Tässä raportissa kuvataan FODD:n rakenne, millä kriteereillä esiintymät luokiteltiin ja valittiin siihen sekä kannassa olevien tietojen kuvailukriteerit. Kaikki esitetty aineisto on peräisin julkisista lähteistä, mm. julkaisuista, arkistoraporteista, lehdistötiedotteista, yhtiöiden Internet-sivuilta ja geologien haastatteluista. Tietokanta luotiin projektissa, johon osallistuivat Geologian tutkimuskeskus (GTK), Norges geologiske undersøkelse (NGU), Sveriges geologiska undersökning (SGU), Venäjän liittovaltion luonnonvarainministeriön mineraalivarojen osasto (ROSNEDRA), Venäjän liittovaltion geologinen tutkimuskeskus (VSEGEI) ja SC Mineral -yhtiö. FODD on sijoitettu GTK:n malminetsinnän englanninkielisille Internet-sivuille (http://en.gtk.fi/ExplorationFinland/FODD), jonne on linkit myös kaikkien muiden kansainväliseen projektiin osallistuneiden organisaatioiden Internet-sivuilta.

Julkaisu on englanninkielinen.

Asiasanat (Geosanasto, GTK): malmigeologia, metallimalmit, tietokannat, FODD, kaivokset, isäntäkivet, paleotsooinen, prekambri, proterotsooinen, arkeeinen, Fennoskandia, Suomi, Ruotsi, Norja, Venäjä

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CONTENTS

INTRODUCTION

Fennoscandia (the Precambrian shield and the Caledonides) has a significant ore potential and potential as a metal-producing region on the world scale (Weihed et al. 2005). The shield has a long history of mining and exploration. For example, archaeological evidence shows that copper was produced from the Falun mine in the Bergslagen province, Sweden, as early as in the 8th century (Eriksson & Qvarfort 1996). Statistics on copper production at Falun are available from the mid-16th century until the closure of the mine in 1992. Large mining operations and extensive exploration have taken place, and very large mines are presently in operation in all Fennoscandian countries. However, the region can still be regarded as under-explored and having a good potential for major discoveries. New mines are currently under development, some of which will become major metal producers in Europe.

Databases covering extensive areas are important working tools for modern exploration. Deposit databases are used in selecting larger areas as targets for more detailed work. Presently, single-country deposit databases of high quality and coverage are variably available from the area (e.g. Bugge 1978, Metallogeny of Karelia 1999, Lafitte 1984, Juve & Grenne 1993, Saltikoff et al. 2000 and 2006, Pozhilenko et al. 2002, Korovkin et al. 2003, Mineral resources of the Republic of Karelia 2005), but there has been no uniform database covering the whole of Fennoscandia, except for those that only include major mines of Europe (e.g. Juve & Størseth 2000, GEODE 2001), and a few more or less global single metal or single genetic type databases (e.g. Gosselin & Dube 2005).

Just like nearly all areas across the globe with an ore potential, Fennoscandia has seen an unprecedented increase in exploration activity during the first decade of the 21st century. Furthermore, the region includes sub-areas where the degree of industrial development still is low, but the mineral potential is exceptionally high. Hence, it is not just the mining and exploration industry but, importantly, also the national decision makers, citizens, and research organisations who would benefit from region-wide presentations and databases of mineral deposit data.

To answer these needs, the Geological Survey of Finland (GTK), Geological Survey of Norway (NGU), Geological Survey of Russia (VSEGEI), Geological Survey of Sweden (SGU), and SC Mineral (Russia) have set up an uniform metal deposit database covering the whole of Fennoscandia. The Fennoscandian Ore Deposit Database (FODD) presents a set of key features, according to uniform guidelines, of mined and unexploited deposits in the area. The database was published in late 2007 in the public domain via the Internet (at: http://en.gtk.fi/ExplorationFinland/FODD) and is accessible free of charge. In addition, a map on 1:2,000,000 scale presenting the deposits included in the FODD, the Metallic Mineral Deposit Map of the Fennoscandian Shield, will be printed and published in 2008 (Eilu et al. *in press*).

In this report, we describe the structure and guidelines along which the database is constructed, and how deposits and data are selected into, classified and presented in the FODD. Note that the term 'deposit' is used in this report with no indication of the potential economic significance of the occurrence; it is used in the meaning covering all categories from a mine to a potentially exploitable occurrence and to an occurrence of which nothing exact can be said about its economical exploitability. It is also important to understand that mineral resources are in most cases based on *in situ* geological estimates, and the data are generally insufficient to meet industrial mineral resource classifications. In some cases, however, the resource data are in accordance with industrial standards; where the latter is the case, this is stated in the database.

At the time of finalising the first version of the FODD and writing this report, in September 2007, the FODD contained information on 942 deposits: 292 of these are in Finland, 154 in Norway, 237 in Russia, and 259 in Sweden. An annual update of the FODD is planned, and the figures for each country are expected to increase.

DATABASE STRUCTURE

Main principles

It is a major challenge to combine data from countries (or any other sources) with different research and exploration traditions and from deposits of different commodities. This easily results in problems in harmonising the data presentation. However, to produce a database with an uniform style, criteria for data harmonisation are essential. To make the data harmonisation possible at all, and to produce information that can be compared between deposits of different commodities, sizes, styles, and across international boundaries, a number of decisions were made on the FODD structure and guidelines. We have applied the previously published guidelines of deposit maps and databases, and metallogenic presentations, where such guidelines have been seen as applicable to the FODD: some ideas were gathered from Lafitte (1984), Juve and Grenne (1993), Eckstrand et al. (1996), Puustinen et al. (2000), Saltikoff et al. (2000 and 2006), Lydon et al. (2004), and Mineral resources of the Republic of Karelia (2005), among others.

First, the criteria to include (or exclude) a deposit in the FODD were decided on; this matter is discussed in the next subsection. Then, the fields in the database were decided on; these are listed in Table 1. Guidelines for each data field were defined so that the same feature is described by the same key word(s) across the entire region. Also, only a small number of data fields are indicated as compulsory (as marked in Table 1), which should always include data for a deposit. This rule was applied to only include confirmed data in as many fields as possible and to avoid the appearance of unclear or misleading information in the FODD. Nevertheless, when investigating the database, one has to keep in mind that several parties

Table 1. Data fields in the FODD. For details on guidelines and allowed options, see the text.

Field name (# = compulsory field)
ID_Nat
Updated
Name
Alternative_names
#Location (3 fields): Country, Latitude, Longitude
Geological_district
Metallogenic_district
Status
Mining_method
When_mined
Commodities (4 fields): # Main_metals, Other_metals Classification: Metal_group, Metal_subgroup
Size of deposit (5 fields): # Size_category, Resources_Mt, Reserves_Mt, Mined_Mt, # Total_tonnage_Mt
Ore grade
Ore_mineralogy
Host rocks
Adjacent rocks
Age_of_host_rocks
Radiometric_age_of_host_rocks
Age_of_mineralisation
Radiometric_age_of_mineralisation
Regional_metamorphic_grade
Alteration
Genetic_type
Form (3 fields): Shape, Structure, Texture
Tectonic_control
Main direction of deposit (3 fields): Strike, Dip, Plunge
Ore_mineral_distribution
Reference_to_deposit_size
Comments
Bibliography

provided data from various parts of the region. Hence, despite rather strict guidelines set by the Working Group of the FODD, there may be discrepancies or unconformities between deposit descriptions, and one should always investigate the primary data sources before making any significant conclusions on the deposits included into the FODD.

In detail, the guidelines and allowed options for each data field of the FODD are discussed in the subsections below.

Criteria for inclusion of deposits in the FODD

Deposits with the following metals are included in the FODD: Ag, Au, Be, Co, Cr, Cu, Fe, Li, Mn, Mo, Nb, Ni, Pb, Pd, Pt, Rh, REE, Sc, Sn, Ta, Ti, U, V, W, Y, Zn, and Zr. Only such deposits where one or several of these metals form the majority of the value of the case are included, and only when there is a resource estimate of some kind in the primary reports on the deposit. Evaluation of the value of the metal content of a deposit and the relative proportions of the metals in polymetallic deposits for the FODD purposes is described below, in the next subsection.

Industrial minerals and gems are excluded from the FODD, because these commodities would need a significantly different approach compared to the metals listed above, and because it is typically difficult to obtain any comprehensive data on the former. Hence, for example, talc mines, with or without nickel as a minor by-product, are not included in the FODD. Also excluded are elements not forming any known or even suspected significant deposits within Fennoscandia.

Deposit size classification

In order to compare the economic significance of metal deposits, the value of a deposit has to be estimated. However, the information necessary to compare deposits of different commodities and in different countries within Fennoscandia is not readily available. Formal standards for reporting of mineral resources and reserves have not been used until relatively recently in the Nordic countries. In Russia, on the other hand, reporting standards for mineral resources and reserves do exist, but they are not yet fully compatible with current international standards, for example, with the NI 43–101 or the JORC codes (Australasian Joint Ore Reserves Committee 2004, NI 43–101 2006).

To be able to categorise deposits with different metals and from different countries, we have calculated an "*in situ*" value for the deposits. The method simply multiplies the tonnage, grade, and metal price and does not consider all the obstacles, beside tonnage and grade, that have to be overcome in an successful mining project. *Thus, the figures obtained here from in situ calculations should never be confused with proper ore reserve estimates based on international standards.*

The tonnage and metal grades of a deposit are typically obtained from production statistics and from the latest publicly available resource estimates. For most cases, these values are not in accordance with modern standards, as the estimates were performed before any international standard was formulated; for example, many of the mines included in the FODD have been closed for decades. For a few mines and undeveloped deposits, the reserves and resources are given in accordance with NI 43–101 and/or JORC code, as shown in the reference for the data (mostly a mining company annual report or press release).

The metal prices used in the calculations for the FODD are ten-year averages for the period 1995–2005. For metals that are traded on a metal exchange, for example on the London Metal Exchange (LME), the prices have been obtained directly from these sources (Table 2). Price information for metals that are not traded on a metal exchange have been obtained from other public sources that summarise information from producers, consumers and traders.

Some metals have different prices depending on the compound that is produced and sold. Titanium, for example, has different prices for the pure metal, for rutile, and for ilmenite concentrate. Since the most important producer within Fennoscandia, Tellnes in Norway, is exporting ilmenite and the possible future producers in the area will most likely also produce ilmenite concentrate, the price for titanium contained in ilmenite has been chosen for the FODD. Similarly, the price for rare earth elements is calculated from the bastnäsite concentrate price and the price for iron from the magnetite concentrate price. The type of compound for each metal and the sources of price information is given in Table 2, where all units have been recalculated to SI units and all currencies to US$. The metal prices in Table 2 are given for the contained metal, irrespective of the commercial compound that is hosting the metal.

The obtained "*in situ*" value for a deposit has then been used to classify the deposits into six size categories: 'Very large', 'Large', 'Medium', 'Small',

Table 2. List of metals, metal prices in US dollars, the compound for which the metal prices have been selected, and the main source of information.

Metal	Compound	Average price 1995–2005	Price Sept. 2007	Unit	Source
Cu	Metal	2183	7360	$/t	LME
Zn	Metal	1047	2830	$/t	LME
Pb	Metal	622	3010	$/t	LME
Au	Metal	11.0	22.3	$/g	London Bullion Market
Ag	Metal	0.17	0.40	$/g	London Bullion Market
Ni	Metal	8448	27300	$/t	LME
Co	Metal	40718		$/t	LME
Pt	Metal	17.6	41.7	$/g	Johnson Matthey London, www.matthey.com
Pd	Metal	9.9	10.8	$/g	Johnson Matthey London, www.matthey.com
Rh	Metal	31.0	200.1	$/g	Johnson Matthey London, www.matthey.com
Fe	Magnetite	33.6	84.7	$/t	Metals Consulting International, www.steelonthenet.com
Cr	Ferrochrome	955		$/t	USGS
Mn	Metal	202		$/t	USGS
V	Vanadium pentoxide	11852		$/t	USGS
Ti	Ilmenite	132		$/t	USGS
Co	Metal	40718		$/t	LME
Mo	Molybdic oxide	9583		$/t	USGS
W	Scheelite	9369		$/t	Primary Metals Inc., www.primarymetals.ca
Sn	Metal	5785	14900	$/t	LME
Nb	Niobium oxide	14681		$/t	LME
Ta	Tantalum oxide	100894		$/t	LME
U	U3O8	34314	233980	$/t	The Ux Consulting Company, www.uxc.com
Be	Metal	856610		$/t	USGS
REE(tot)	Bastnäsite	4607		$/t	USGS
Li	Lithium carbonate	23567		$/t	USGS

All prices are for the metal contained in the given compound. USGS refers to USGS Minerals Information at www.minerals.usgs.gov, LME refers to the London Metal Exchange.

'Showing', and 'Potentially large'. The term 'Very large' is only used for the four largest mines in the entire region: Kirunavaara, Kostomuksha, Kemi, and Zhdanovskoe (at Pechenga). For the rest of the large deposits, the term 'Large' is used instead of the term 'World class' to avoid misleading indications of a large economic ore deposit, and to avoid placing too much value on certain deposits. In addition, the size category 'Potentially large' is used for such cases where no exact tonnage and/or grade data are available, but the local geology and exploration work so far carried out at the site suggest a significant possibility of a large deposit. For example, some of the less extensively drilled PGE occurrences in layered intrusions are in the 'Potentially large' class, but may later move into other classes if more drilling takes place and proper resource estimates are published. The size category 'Showing' includes cases where there is an *in situ* resource estimate, but the size is below the category 'Small'.

For the boundaries between the size classes 'Large', 'Medium', 'Small' and 'Showing', the following procedure was used. First, we set the boundary value between the classes 'Medium' and 'Small' at equivalent to 100,000 t copper, as calculated according to the 1995–2005 average prices for the entire deposit in question. Then, the lower boundary for the class 'Small' was set at 1/100 of the Medium-Small boundary and the lower boundary for the class 'Large' at 6 x the Medium-Small boundary. These boundary values were set following the principles previously used in similar studies (e.g., Lafitte 1984, Saltikoff et al. 2000); we found no significantly differently set, consistently formulated boundaries elsewhere. Notably, Lydon et al. (2004) used a similar approach to compare different deposits in Canada, although they had access to more reliable tonnage and grade data than we had for the FODD. For polymetallic deposits, we summarise the value for all metals in a deposit but, to simplify matters, exclude those metals that contribute <10% of the total calculated *in situ* value of the deposit. Of course, there still remain many potential problems, and everyone using the FODD is naturally free to set up their own size classes and other categories based on whatever rules they see as significant.

Guidelines to the data fields

Guidelines for each data field of the FODD are described here. The description proceeds in the same order as the data fields appear in the database (Table 1). As a general rule, information given in a data field (with two exceptions) does not exceed 255 characters. This limit is set for the data to be easily transferred (exported) into and presented in any worksheet or database format. Only for the fields 'Reference_to_deposit_size' and 'Comments' can this size limit be exceeded. This exclusion is important as these two fields can be used for commenting on information in the other fields of the database and for providing additional information that does not fit into other data fields.

ID_Nat

The ID number for a deposit is defined by a letter plus four digits and forms the ID code for each case. Deposits in Norway have a code in format 'Nxxxx', Sweden 'Sxxxx', Finland 'Fxxxx', and Russia 'Rxxxx'. This national coding means that there is no danger of cases from different countries being mixed.

Updated

The date when any data for the deposit was updated in the database is given here. Only the latest updating time is shown for each deposit. The format to be used is 'yearmonthday'; for example, '30 June 2006' is given as '20060630'

Name

The most commonly used name for the deposit.

Alternative_names

Any other name(s) used at any time for the deposit or dominant parts of it.

Location (3 fields): Country, Latitude, Longitude

The name of the country and information on the location. Latitude and longitude are given in decimal degrees (style 'xx.xxxxx') with datum WGS84. If only one coordinate pair for a camp (group, knot) of deposits exists, the location information is preferably given for the largest deposit.

Geological district, Metallogenic district

For the geological district, the name of an extensive schist or greenstone belt, plutonic domain or a similar large subarea of Fennoscandia is given. Similarly, the name of the metallogenic district is given if the data provider sees that the case is within a distinct metallogenic district. Names for the districts entirely within one country are decided by the FODD party of that country. Names and extents of districts crossing international boundaries are agreed between the FODD parties of the countries in question.

Status

Options: 'Active mine', 'Closed mine', 'Not exploited', 'Historic'.

'Not exploited' means not mined, but there is a resource estimate of some kind. The category 'Historic' includes all mines that were closed before 1920. Consequently, the category 'Closed' includes all mines closed after 1920. The year 1920 was selected as a boundary, because it was regarded as a major turning point in the development of modern mining methods for most of the region.

Mining method

Options: 'Open pit', 'Underground' and 'Open pit and underground'.

When mined

Years when the mine has been in production (i.e., active).

Commodities

Potential commodities of a deposit are listed in the data fields: 'Main_metals', 'Other_metals', 'Metal_group', and 'Metal_subgroup'. The main and other metals are presented in order of decreasing importance, as calculated from our guideline formulae and sorting tables described in the subsection Deposit size classification. The reason for sorting according to decreasing importance is that most people will read the list in this way in any case: the most important first. Commodities with a calculated economic significance of >10% of the entire deposit will go into the field 'Main_metals' and those of <10% into the field 'Other_metals'. Options for the fields 'Metal_group' and 'Metal_subgroup' are given in Tables 3 and 4.

Table 3. Options for the field 'Metal_group'.

Metal_group	Most of the value of a deposit comes from these metals
Precious metals	Ag, Au, PGE
Base metals	Co, Cu, Ni, Pb, Zn
Ferrous	Cr, Fe, Mn, Ti, V
Special metals	Be, Li, Mo, Nb, REE, Sc, Sn, Ta, W, Zr
Energy metals	U, Th

Table 4. Options allowed for use in the field 'Metal_subgroup'.

Subgroup	Deposit examples
Precious metals	
PGE	Konttijärvi, SJ-Reef
Au-Cu(-Co)	Enåsen, Pahtohavare, Kopsa, Saattopora, Bidjovagge
Au	Åkerberg, Björkdal, Kutemajärvi, Suurikuusikko, Pampalo, Pahtavaara, Rybozero, Lobash-I
Ag vein type	Kongsberg
Base metals	
Ni-Cu(-Co)	Lappvattnet, Hitura, Kotalahti, Petchenga, Monchegorsk, Allarechka, Lovno, Eastern-Vozhma
Ni-Zn	Talvivaara
Cu	Viscaria
Cu-Co	Outokumpu
Cu-Zn-Pb(Au-Ag)	Bergslagen VMS, Aijala–Orijärvi region VMS, Hammaslahti, Pyhäsalmi, Vihanti, Lökken, Severo-Vozhma
Zn-Pb	Zinkgruvan
Pb-Zn	Laisvall
Pb(-Zn) vein type	Korsnäs
Cu-Au	Aitik, Boliden, Paroinen
Ni-Mg	Aganozero Ni-bearing serpentinite
Ferrous	
Cr	Kemi, Koitelainen, Aganozero
Fe-Ti-V	Mustavaara, Otanmäki, Tellnes (orthomagmatic style), Tzarevskoe, Kosmozero, Pudozhgora, Eletozero, Zaga
Kiruna	Kiruna, Malmberget
IF	Porkonen–Pahtavaara, Björnevatn, Kostomuksha, Korpanga, Olenegorka
	Fosdalen, magnetite skarns
Other oxide	Bjørkåsen
Other sulphide	
Ti	Engebø
Mn(-Fe)	Bergslagen Mn(-Fe) skarns
Kovdor	Kovdor, Afrikanda
Special metals	
Mo	Mätäsvaara, Nordli, Lobash
Sn-W	Bergslagen skarns
Sn-Li	Järkvissle
Li-Nb-Ta	Rosendal, Fen, Polmostundra, Kolmozero
Nb-Ta	Sokli, Eletozero-I, Sallanlatva
REE-Sc-Zr	Khibiny, Lovozero
Zn-Sn	Pitkäranta, Kitelja
Energy metals	
U	Ranstad, Paukkajanvaara, Palmottu, Karhu

Size of deposit

The size of the deposit is described by five data fields: 'Size_category', 'Resources_Mt', 'Reserves_Mt', 'Mined_Mt, and 'Total_tonnage_Mt'. Options for the field 'Size_category' are: 'Very large', 'Large', 'Medium, 'Small', 'Showing', and 'Potentially large'. Deposits are placed into the size categories according to guidelines given in the section 'Deposit size classification'. The tonnages are given in millions of tonnes of ore and *in situ* values are used in all data fields. Total tonnage means all of the resource: the total mass of ore contained in the deposit, including produced ore, reserves and resources. Data in the fields 'Resources_Mt' and 'Reserves_Mt' is only given when such information is available in resource estimate report(s) on the deposit.

Ore grade

In addition to the commodity lists mentioned above, there is a data field for each metal that potentially forms a commodity in the deposit. In an ore grade data field, numerical data are provided on how many per cent or parts per million (grams per tonne) of the main or potential by-product metal there are in the ore. Average contents of only these elements in ores are given.

Ore mineralogy

Ore minerals are listed in order of decreasing abundance. There are two fields, 'Ore_mineralogy1' and 'Ore_mineralogy2'. The latter field is used to continue the list started in the first field, if a large number of ore minerals are known and the full list is longer than the allowed 225 characters for a field.

Host and adjacent rocks

The host rock fields give the name(s) of the rock type(s) hosting the ore. A metamorphic name is given if the ore is hosted by a metamorphosed rock. There are two fields for host rocks and four for the adjacent rocks, and one rock type name per field is given. An option list of more than 400 rock type names is included in the database. The IUGS recommendations (e.g., Streckeisen 1967 and 1980) are followed in the option list where possible.

'Adjacent rock' is used instead of 'wall rock'. This is strictly to avoid the very common confusion between host rock and wall rock: it is never clear which of the two is in fact meant for a deposit before carefully reading the original description, and not necessarily even when having seen all the primary information. For example, an auriferous quartz vein in a basaltic rock is clearly hosted by that mafic rock; however, some sources refer to the mafic rock as the 'host rock' and others as the 'wall rock' for the ore. In such a case, we decided that, in the FODD, the mafic rock should be called the host, not the vein. Note that in nearly all cases of an auriferous quartz vein, there also is at least some ore-grade gold in the rock hosting the vein (e.g. McCuaig & Kerrich 1998). The same holds for any syn- or epigenetic mineralised mass of rock, be that a disseminated chromite deposit in a layered intrusion, sulphide dissemination or stockwork in metasedimentary rocks, or a magnetite mass in a skarn. This also results in the definition of 'Adjacent rock' in the FODD: a rock type enclosing or in contact with the host rock, but not containing any potential ore.

For the FODD, only the following metallic deposits are regarded as host rocks by themselves: BIF (oxide, carbonate and sulphide facies), large masses of massive magmatic oxides (e.g., chromitite), and deformed and displaced (during deformation) massive sulphide masses where there is no obvious host rock, but only unmineralised rock units around (adjacent) the sulphide mass.

Age of host rocks, Age of mineralisation

Two fields giving the name(s) of the geological period(s) when the host rocks and the ore were formed, respectively. Options to be used are given in Table 5.

Table 5. Options for the fields 'Age_of_host_rocks' and 'Age_of_mineralisation'. Boundaries for the geological periods and eras are from Gradstein et al. (2004).

Palaeoarchaean (3600–3200 Ma)
Mesoarchaean (3200–2800 Ma)
Neoarchaean (2800–2500 Ma)
Palaeoproterozoic (2500–1600 Ma)
Mesoproterozoic (1600–1000 Ma)
Neoproterozoic (1000–542 Ma)
Cambrian (542–488 Ma)
Ordovician (488–444 Ma)
Silurian (444–416 Ma)
Devonian (416–360 Ma)
Carboniferous (360–299 Ma)
Permian (299–251 Ma)
Triassic (251–200 Ma)
Jurassic (200–146 Ma)
Cretaceous (146–66 Ma)
Palaeogene (66–23 Ma)
Neogene (23 Ma to present)
Palaeozoic (542–251 Ma)
Mesozoic (251–66 Ma)
Cenozoic (66 Ma to present)

Radiometric age of host rocks, Radiometric age of mineralisation

Two fields giving the radiometric age(s), with information on the method(s) used and what is dated. The field may, for example, give information such as "1887 ± 5 Ma: zircon U-Pb for the host rock; 1815 ± 7 Ma zircon U-Pb for post-mineralisation granite," as is stated for the Osikonmäki gold deposit.

Regional metamorphic grade

This field gives the peak metamorphic grade of the deposit. Options allowed include: 'Unmetamorphosed', 'Zeolite', 'Prehnite-pumpellyite', 'Greenschist', 'Amphibolite', 'Granulite', 'Blueschist', 'Eclogite', and 'Contact metamorphic'.

Alteration

A list of minerals formed by alteration is given in decreasing order of abundance. No information on the alteration process is given here, as this is subject to interpretation only. Such interpretations can be given in the field 'Comments'.

Genetic type

Genetic type or class of the mineralisation. Options for the genetic types are listed in Table 6. An empty field is preferred if there is significant uncertainty over the genetic type. In order to make searches in the database easier, only one genetic type is allowed for a deposit in this field. The alternative genetic types and possible reasons for the uncertainty can be mentioned in the field 'Comments'. In addition, we have created the class 'Polygenetic' for deposits formed by more than one individual mineralising process. Again, for such a case, the situation can be explained in the 'Comments' field.

Form

Three data fields, 'Shape', 'Structure' and 'Texture', give the most dominant and typical shape, structure and texture of the deposit. The terminology allowed in the fields is given in Table 7. If a deposit also contains other structural or textural types than those listed in Table 7, these are mentioned in the field 'Comments'.

Tectonic control

The major tectonic control of the deposit, for example, a regional or local shear or fault zone, is mentioned here. The nature, orientation and name of the structure controlling the deposit are also given.

Main orientation of deposit

Three fields, 'Strike', 'Dip' and 'Plunge', give the dominant trend of the deposit. The directions are given as degree values or by points of the compass (e.g. 'N-S', 'NW-SE').

Ore mineral distribution

The distribution of ore minerals is given according to the following options: 'Massive' (>50 vol-% ore minerals), 'Semi-massive' (20–50% ore minerals), 'Disseminated' (<20% ore minerals; scattered, even distribution in rock) or 'Irregular' (scattered, uneven distribution in rock).

Reference to deposit size

Information on the quality of the grade and tonnage data are given here. There is typically a bibliographic reference, or several references, where the deposit grade and tonnage and/or other information about the quality of the grade and tonnage data are given. The cut-off grades, if any are reported, and alternative grade and tonnage information are also given here.

Comments

The 'Comments' field serves as a place for explanatory notes for cases where there are ambiguous data and for significant information that cannot be included in the other fields of the FODD. There may be, for example, a mention of variation in the texture, shape, siting, ideas on the genetic type, or on the number of ore bodies. The data sources for this information are also typically mentioned.

Bibliography

The most important references where information on the deposit is given are listed in a separate bibliography table linked to the main data table. One to four references can be given for a deposit, including the most extensive and recent reports.

Table 6. Options for the 'Genetic_type'. Classification is derived from Eckstrand et al. (1996), but some Canadian deposit types are omitted from the table, as they do not occur in Fennoscandia or only relate to industrial mineral deposits.

Class	Comments
Palaeoplacer	Gold, PGE and uranium deposits
Stratiform phosphate	Sedimentary-hosted, probably formed as chemical sediments. For example, U-P deposits in the Vihanti region
Stratiform iron	BIFs of all kinds, for example, Porkonen–Pahtavaara, Björnevatn, Kostomuksha
Residually-enriched deposits	Significant supergene enrichment in a deposit. For example, the upper parts of Sokli
Sedimentary exhalative	For example, Hammaslahti
Volcanic exhalative	For example, Bergslagen VMS, Pyhäsalmi, Vihanti, Viscaria
Unconformity	Uranium ± Ni, Co, As, and Au ± Pd
Stratabound clastic-hosted U, Pb, Cu	Sandstone U Sandstone Pb: for example, Laisvall Sediment-hosted stratiform Cu: Kupferschiefer and Redbed types
Volcanic redbed Cu	Voronov Bor
MVT to Irish type Pb-Zn	For example, Zinkgruvan?
Vein uranium	Veins in shear zones, and granite-associated veins
Arsenide vein Ag, U	
Orogenic gold (± Cu, Co)	This equals to 'Mesothermal gold' and 'Greenstone- and slate belt-hosted gold' For example, Åkerberg, Björkdal, Jokisivu, Pahtavaara, Pampalo, Saattopora, Suurikuu-sikko
Epithermal gold	For example, Kutemajärvi
Clastic metasediment-hosted Ag-Pb-Zn	Coeur d'Alene style
Vein copper	
Vein-stockwork Sn, W	Cornwall, Panasqueira and Potosi styles
Porphyry (Cu, Au, Mo, W, Sn, Ag)	For example, Tallberg, possibly Aitik, Kopsa
Skarn (Zn-Pb-Ag, Cu, Au, Fe, W)	For example, the many skarn deposits in Bergslagen
Granitic pegmatite (Li, Nb-Ta, REE, Sn, Zr)	For example, Rosendal
Iron oxide-copper-gold	Olympic Dam−Ernest Henry type For example, Rautuvaara, Hannukainen
Peralkaline rock-associated rare metals (Nb-Ta, REE, Zr)	For example, Khibiny, Lovozero
Carbonatite associated (Cu, Fe, Ti, V, Nb-Ta, REE, U)	For example, Sokli
Mafic intrusion-hosted Ti-Fe±V	For example, Mustavaara, Otanmäki, Tellnes
Magmatic Ni-Cu-PGE	Intrusion- and volcanic-associated deposits. For example, Lappvattnet, Hitura, Kotalahti, Petchenga, Monchegorsk, Konttijärvi, SJ-Reef
Mafic- to ultramafic-hosted Cr	Stratiform and podiform types. For example, Kemi, Koitelainen, Burakovskaja
Polygenetic	For example, Outokumpu, Vuonos, Luikonlahti

Table 7. Options for the three fields of the form of the deposit.

Shape	Structure	Texture
Cigar	Breccia	Banded (Laminated)
Cone	Conformable	Brecciated
Irregular	Discordant	Even-grained
Layer	Fold	Folded
Lens	Stockwork (Vein network)	Foliated
Pipe	Vein	Fracture fill
Plate (X≥Y>Z)	Vein swarm	Mylonitic
Ruler (X>>Y>Z)		Patchy
		Porphyritic

BACKGROUND MAPS

Various images are used as background maps in the Internet version of the FODD. In the FODD map server, the following alternatives are now available: a simple geographic map, a simple and a full geological map of the Fennoscandian shield (Koistinen et al. 2002), a Fennoscandian magnetic map (Korhonen et al. 2002a), and a Fennoscandian gravity map (Korhonen et al. 2002b).

SUMMARY

The new Fennoscandian Ore Deposit Database (FODD) provides information in the public domain on metal mines and major deposits from the whole of Fennoscandia, entirely covering the continental territory of Norway, Sweden and Finland and NW Russia. Information on the deposits includes the location, mining history, tonnage and commodity grades with a comment on data quality, geological setting, age, style of mineralisation, and the primary sources of data. In September 2007, the database contained information on more than 900 mines and deposits across the region: 292 of these were in Finland, 154 in Norway, 237 in Russia, and 259 in Sweden.

The FODD has been designed as a tool for both exploration in northern Europe and for research in economic geology locally and globally. It is also hoped that the database will serve as a tool for political decision making, to give everybody, including the citizens of the area, an idea of the mineral wealth of Fennoscandia and the importance of the mining industry to our countries, as well as making the region even more attractive for investment.

The database was created, and is being kept updated, as a joint project between the Geological Survey of Finland (GTK), Geological Survey of Norway (NGU), Geological Survey of Russia (VSEGEI), Geological Survey of Sweden (SGU), and SC Mineral (Russia). The FODD is hosted by the Internet pages of the Geological Survey of Finland (http://en.gtk.fi/ExplorationFinland/FODD) and is accessible through the Internet pages of all the above-mentioned parties of the FODD project. After publication, the database will be accessible via the Internet free of charge.

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This report describes the structure and guidelines along which the Fennoscandian Ore Deposit Database is constructed, and how the deposits and detailed data are selected, classified and presented in it. The database contains information on deposits and significant occurrences within Fennoscandia (the Precambrian shield and the Caledonides; Norway, Sweden, Finland and NW Russia). Information on the deposits includes the location, mining history, tonnage and commodity grades with a comment on data quality, geological setting, age, ore mineralogy, style of mineralisation, genetic models, and the primary sources of data. The database is in ACCESS® format, and all of its contents are available via the Internet pages of the geological surveys of Finland, Norway, Russia and Sweden.

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