28.2.2022

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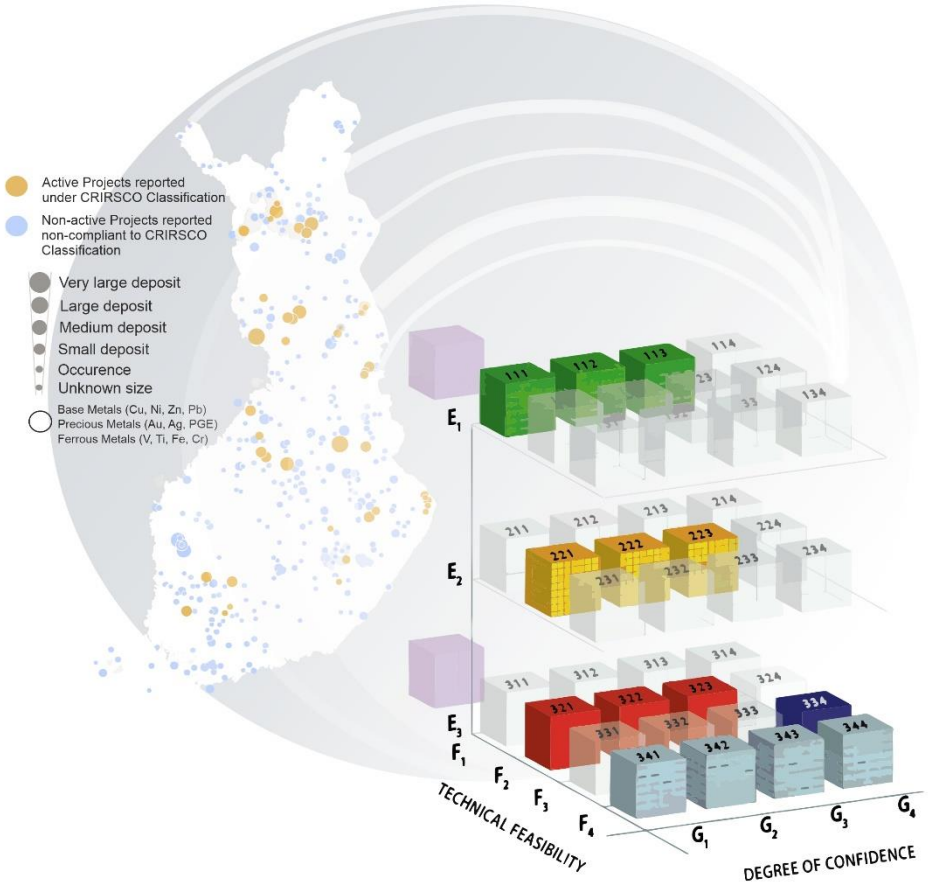

Mineral resources of Finland classified according to the UNFC code

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GEOLOGICAL SURVEY OF FINLAND **DOCUMENTATION PAGE**

28.2.2022

Authors
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Type of report
GTK Open File Work Report

Commission by
GTK

Title of report
Mineral resources of Finland classified according to the UNFC code

Abstract

The United Nations Framework Classification for Resources (UNFC) classification system has been integrated to the Finnish national mineral deposit database at GTK. We can now present all mineral resources of Finland in a consistent and harmonised way. The classification takes into account geology, technical studies, permitting, and social and economic aspects of the deposits irrespective of when and how a mineral resource has been reported. This provides a better view on the stocks “in the ground” which can be used, for example, in more accurate forecasts on potential critical raw materials and the possibility for future supply from European sources.

The main caveat for achieving harmonised, unbiased, UNFC classification is the variability of background information, needed for classifying and quantifying projects into UNFC. If the available reporting does not include all the work done on a deposit it may show lower confidence in respect to UNFC classes and not reflect the current situation. This mainly relates to many industrial mineral deposits and mines.

Since 2021, all new resource information per deposit is automatically classified according to the UNFC guidelines. The deposit database also includes information according to the CRIRSCO-compliant categories – these are mapped to UNFC classes according to CRIRSCO–UNFC bridging guidelines, ensuring that no essential information is lost or alternated in regards to commercial projects.

We demonstrate the functionality of UNFC as a tool for more accurate national resource management. One can now request for the current aggregated, UNFC-mapped mineral resources of Finland. This is a useful, practical tool in providing data into the EU mineral resources database, help in understanding the mineral resources of Finland and, importantly, help in mineral policy and other decision making in Finland. Currently, however, the aggregation must be done manually – automatic aggregation is the next step in this context.

Keywords
UNFC, mineral resources, ore reserves, classification systems, mineral economics, databases, Finland

Geographical area
Finland

Mineral resources of Finland classified into UNFC code

28.2.2022

Map sheet			
Other information			
Report serial GTK Open File Work report		Archive code 8/2022	
Total pages 14 p.	Language English	Price 0	Confidentiality public
Unit and section Mineral Economy Solutions; Information		Project code 50402-2010623	
Signature/name Mika Posio		Signature/name Pasi Eilu	

GEOLOGIAN TUTKIMUSKESKUS **KUVAILULEHTI**

28.2.2022

Tekijät
Eilu, P., Eloranta, T., Hokka, J.

Raportin laji
GTK:n työraportti

Toimeksiantaja
GTK

Raportin nimi
Mineral resources of Finland classified according to the UNFC code

Tiivistelmä
YK:n luokitteluohjeistus ja -rakenne mineraaliresursseille (UNFC) on nyt integroitu GTK:n ylläpitämään Suomen malmiesiintymätietokantaan. Voimme nyt esittää kaikki Suomen malmivarat ja -varannot yhtenäisellä ja harmonisoidulla tavalla, joka ottaa huomioon jokaisen esiintymän geologian, tehdyt tekniset tutkimukset, luvituksen sekä taloudelliset ja yhteiskunnalliset aspektit riippumatta siitä milloin ja miten mineraalivarat ja -varannot on raportoitu. Tämä mahdollistaa sen, että saamme huomattavasti kattavamman ja yhtenäisemmän käsityksen maamme kallioperän tunnetuista varoista ja -varannoista. Suurin ongelma malmien UNFC-luokituksen tulosten luotettavuudessa on informaation puute. Tästä voi seurata se, että tunnettu mineraalivaranto saa todellista heikomman luokan, kun varantojen julkinen raportointi ei sisälläkään kaikkea kohteella tehtyä työtä – tämä ongelma koskee erityisesti teollisuusmineraaliesiintymiä ja -kaivoksia.

Vuodesta 2021 alkaen on kaikki kantaan tuleva vara- ja varantotieto luokiteltu automaattisesti UNFC-ohjeistuksen mukaan. Lisäksi tietokannassa on aina myös CRIRSCO:n mukaan luokitellut mineraalivarat ja -varannot, jos sellaista tietoa on saatavilla. Nämä on aina myös luokiteltu UNFC-luokkiin CRIRSCO–UNFC –siltadokumentin ohjeiden mukaisesti. Tämä takaa sen, että mitään olennaista ei katoa kaupallisten projektien tiedoista.

Eri pyynnöstä saa nyt myös ajankohtaiset, yhteenlasketut, UNFC-luokitellut Suomen mineraalivarat ja -varannot. Tämä on käytännöllinen työkalu, kun toimitetaan tietoa EU:n mineraalivarantotietokantaan, auttaa ymmärtämään Suomen tunnettujen mineraalivarantojen kokonaisuuden ja, mikä tärkeintä, on apuna valtakunnan tason mineraalipolitiikassa ja muussa päätöksenteossa. Toistaiseksi tämä yhteenlasku on tehtävä osittain käsin, koska se ei ole ihan suoraviivaista. Yhteenlaskun automatisointi onkin Suomen malmiesiintymätietokannan kehittämisen seuraava vaihe.

Asiasanat (kohde, menetelmät jne.)
UNFC, mineraalivarat, mineraalivarannot, resurssien luokittelu, mineraalitalous, tietokannat, Suomi

Maantieteellinen alue (maa, lääni, kunta, kylä, esiintymä)
Suomi

Mineral resources of Finland classified into UNFC code

28.2.2022

Karttalehdet			
Muut tiedot			
Arkistosarjan nimi Työraportti		Arkistotunnus 8/2022	
Kokonaissivumäärä 14	Kieli Englanti	Hinta 0	Julkisuus julkinen
Yksikkö ja vastuualue Mineraalitalouden ratkaisut; Tietoratkaisut		Hanketunnus 50402-2010623	
Allekirjoitus/nimen selvennys Mika Posio		Allekirjoitus/nimen selvennys Pasi Eilu	

Contents

Documentation page

1 INTRODUCTION

It is now possible to categorise mineral resources according to the United Nations Framework Classification for Resources (UNFC) classification system (UNECE 2009, 2015, 2020). Accordingly, the Mineral Deposit Database of Finland now includes the necessary vocabularies and fields allowing any resource or reserve data to be classified into UNFC categories.

In this report, we briefly describe why the UNFC code is included into the GTK mineral deposit database, describe how the UNFC classification is done through the METSO interface of the national deposit database, and present the aggregated Finnish mineral resource data (end-2020 situation) in UNFC classes.

Practically all public information on mineral deposits in Finland is available in the GTK Mineral Deposits and Exploration map service (https://gtkdata.gtk.fi/mdae/index.html). If the resource estimate of a deposit is classified according to the UNFC, it will be shown in 'Resources' and 'Calc_method' fields in the web map. Each deposit is linked to a PDF report in the map service. This report contains all the information stored in the mineral deposit database for the deposit.

The work reported here was done under the H2020 project MINTELL4EU and the GTK in-house projects ‘Bedrock and mineral intelligence’ and ‘Geodata and digital solutions’. Data maintenance for the Finnish mineral deposit database will continue under GTK in-house projects.

2 THE UNFC CODE

The UNECE code is created and developed by the United Nations Economic Commission for Europe (UNECE) in cooperation with other United Nations agencies and international organizations, intergovernmental bodies, professional associations and societies and the private sector (UNECE 2020).

The UNFC code provides a global communications tool that transcends language, commodity type, and extraction methodology. This is a harmonised classification that provides an effective management tool for national resource endowment and accounting. It also gives a coherent mineral resource and reserve terminology that aids in transparency and improved comparability of assessments of mineral resource assets which further provide more informed and efficient investment decisions (UNECE 2009, 2015, 2020). One of big benefits achieved is that both CRIRSCO-compliant and non-compliant resources can be reported in a harmonised way by the UNFC code. During past few years, it has become obvious that the use of the UNFC code would be essential in achieving harmonised mineral resource information across Europe (e.g., Bide et al. 2018, Huisman et al. 2018, Wagner et al. 2018 and 2019). Based on this demand and

shown evidence of usability, it is now also integrated into the Finnish mineral deposit database.

The UNFC code is described in several guidelines by the UNECE (2009, 2015, 2020), and its application to various mineral deposit types is described by a few case studies already published (e.g., Gunn et al. 2019, Hokka et al. 2020 and 2021, Aasly et al. 2021). The basis of the code and examples of its application are, hence, not included into this report. Anybody interested should familiarise oneself on the latest guideline reports (UNECE 2015, 2020) and on the case studies mentioned above.

3 GTK'S IMPLEMENTATION OF UNFC CODE IN THE MINERAL DEPOSIT DATABASE

3.1 Use of the UNFC classification in the METSO interface

First step of implementing UNFC code in the mineral deposit database was to integrate the UNFC classification into the METSO user interface. METSO contains vocabulary for calculation method (e.g., 'JORC code', 'NI43-101', 'non-compliant resource estimate'). Two new values were added to this vocabulary: 'UNFC Code' and 'UNFC code, reclassified', latter being used when reclassifying existing information. At the same time, the combinations of the UNFC resource categories were added to Category vocabulary which earlier contained only CRISRCO categories (e.g., measured, indicated, inferred) and the category 'poorly estimated mineral resources' for non-compliant mineral resource estimates. These changes allow the user to classify resources according to the UNFC code. Also new value 'UNFC' was added to 'Ore measure type' field which indicates the type of the estimation, earlier this field contained only values 'Resource' and 'Reserve'.

The resource categorisation in the database takes place when a GTK employee feeds in data through the METSO interface into the deposit database. It is essential to note that in this work *no new resource estimate is done*. It is just reclassifying the existing information into UNFC categories, following guidelines by the UNECE (2015, 2020) and the case study examples given in the related reports (e.g., Hokka et al. 2020). The information becomes visible in public domain in the GTK Mineral Deposits and Exploration web map (https://gtkdata.gtk.fi/mdae/index.html) when the update of this web map is done.

Technically, the UNFC classes are given in the METSO interface (Figure 1) as follows (otherwise, just as any resource reported):

- The UNFC classes are given in the METSO *Resources and Reserves* page of a deposit
- Value in the *Ore Measure type* field is 'UNFC'.

- Value in the *Calculation Method* field is 'UNFC Code, reclassified'.
- Values in the fields *Calculation year* and *Date* are those when the UNFC classes were defined for the deposit, so not the year of the original resource estimation.
- Value in the field *Company* is 'Geological Survey of Finland', because the mapping into UNFC categories is done by GTK personnel.
- Importantly, information in the *Comments* field should tell when the original resource estimation was done and why the resources (± reserves) have been reclassified according to the UNFC.
- *Category* contains UNFC code (e.g., 334, 344). One UNFC resource estimate can have several categories.
- *References* for the entry should include the reference where the mapped resources and reserves were originally reported and a reference to such UNFC guidelines which were followed in the mapping to UNFC classes. So far, the latter reference has been Hokka et al. (2020).

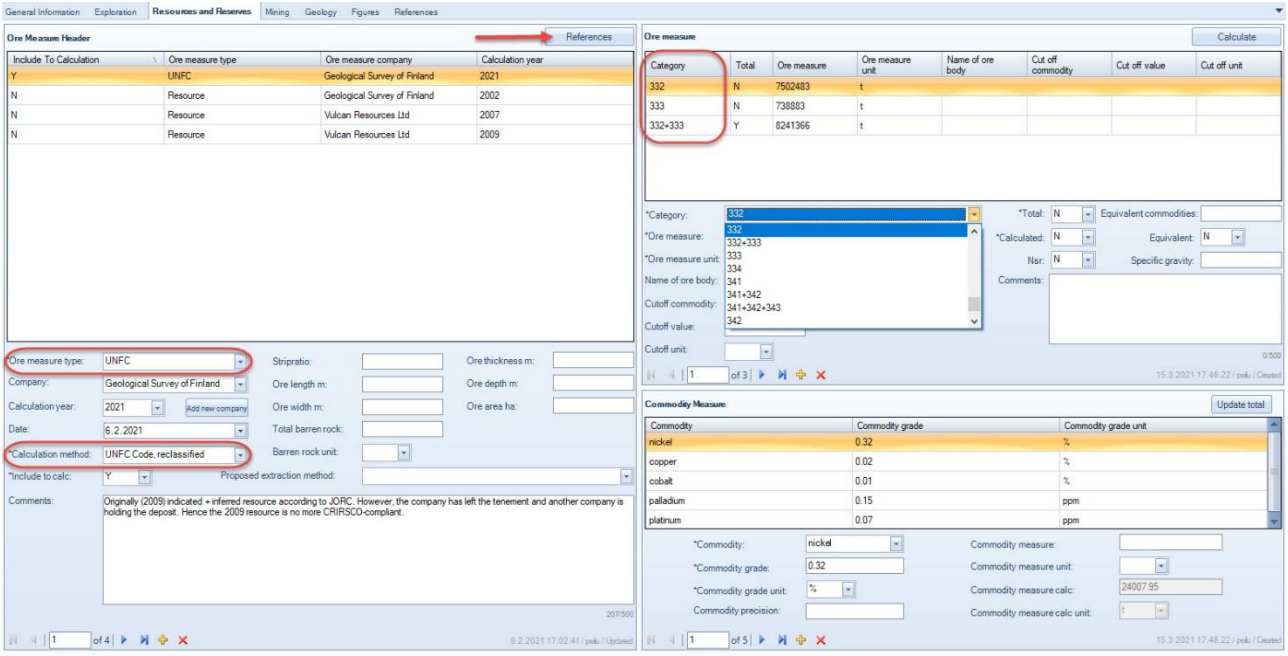

Figure 1. Metso user interface, Resources and Reserves page. Fields needed for input UNFC classification are marked with red.

3.2 Reclassification of the resources

Reclassification of the resources requires a process where the information of a deposit is reviewed, and the resources classified according to the UNFC code. In addition to Finnish examples on how to apply the UNFC code in less clear cases, as described in Hokka et al. (2020), we give below another deposit example, a case where several UNFC classes are given, depending on the commodity and on when, how and by whom the

latest resource for a commodity was originally reported. This example is the Terrafame Sotkamo mine, previously known by the name Talvivaara:

- Cobalt, copper, nickel and zinc: The latest Reserve is 525.2 Mt @ 0.25 % Ni, 0.52 % Zn, 0.14 % Cu, 0.019 % Co and additional Resource 923.8 Mt @ 0.25 % Ni, 0.52 % Zn, 0.14 % Cu, 0.019 % Co (Terrafame 2020, David Garcia-Balbuena, pers. comm. 2020). As the company does not report detailed categories of the reserves and resources, albeit tells that the data are according to the JORC (2012) guidelines, all the reserves go into the UNFC category 111+112 and all resources into 221+222+223 when the resource information is mapped into UNFC categories.
- Uranium: The latest resource is Measured 800.5 Mt @ 17 ppm U, Indicated 504 Mt @ 17 ppm and Inferred 748.3 Mt @ 18 ppm U (Talvivaara 2012). These resources were reported by the previous holder of the deposit and are not confirmed by the current owner, hence the UNFC categories for U are downgraded into 331, 332 and 333, respectively.
- Manganese: The latest resource is 1004 Mt @ 0.3 % Mn, all in the Inferred category (Talvivaara 2008a, 2008b). Also this was reported by the previous holder of the deposit and is not confirmed by the current owner, hence the UNFC category for Mn is downgraded into 333.
- Molybdenum, silver and vanadium: The latest resources are 302.5 Mt @ 0.0101 % Mo, 2.7 ppm Ag, and 0.0626 % V (Heino 1986). This is an old, historic, resource with a low data density, hence the UNFC category for the resource is 334.

3.3 Mapping and harmonising resources to UNFC code

Mapping and harmonising all the resource and reserve estimates from the mineral deposit database to UNFC code was done with ETL-tool (Safe Software FME). Basically, three different data types were processed (Figure 2):

1. If a deposit has a CRIRSCO-compliant resource (± a reserve), no reclassification is done in the METSO and the original categories are directly mapped by using the CRIRSCO–UNFC bridging document (UNECE 2015).
2. If there is an old ‘historic’ resource or a resource otherwise not compliant with the CRIRSCO codes, and it is obvious that the data density is low and/or not much of information is available on the resource, we map the resource into UNFC class 334.
3. If the deposit is reclassified to the UNFC code by GTK, no mapping is needed

As a result, an aggregated mineral resources tonnage table was created where all the resource/reserve information is mapped and harmonized to the UNFC code. This aggregating process can be run regularly to have up-to-date table of the mineral resources of Finland.

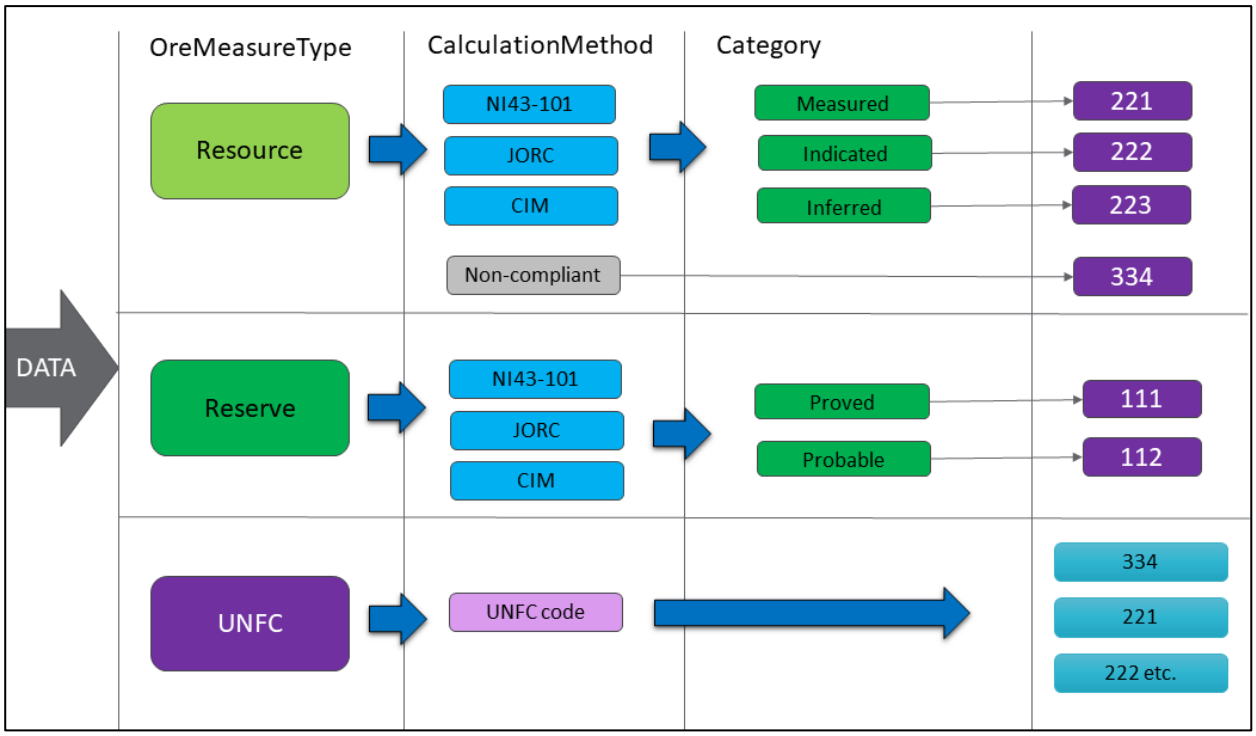

Figure 2. Simplified mapping process from METSO primary data to UNFC code.

4 RESULTS: AGGREGATED FINNISH MINERAL RESOURCE TONNAGES CLASSIFIED INTO UNFC CATEGORIES

The aggregated single-commodity resources for Finland, in UNFC classes, are shown in Table 1. This data is according to what has been publicly reported as resources and reserves by end of 2020. It hence does not take into account any decrease in reserves and resources of active mines, nor any updates in resources and reserves reported after 31 December 2020. The perhaps largest addition into the national aggregated resources during 2021, by nominal in situ value, is from the Ikkari deposit, Sodankylä. At Ikkari, the maiden resource is 122.8 tons of gold, all in inferred category (Rupert Resources 2021). This alone adds up the aggregated 223 category for gold from 194.84 to 317.64 t in September 2021.

We also show in the aggregated data the 'undiscovered' resources of Finland for those metals that have so far been assessed, derived from Rasilainen et al. (2010, 2012, 2014, 2016, 2017, 2018, 2020) and Eilu et al. (2015). Note that the 'undiscovered' resources cannot be linked to any individual deposit. Hence, they are not included in the deposit database, and are presented separately in Table 1. Note that due to restrictions of the assessment method (lack of relevant reference data) undiscovered resources in a few significant deposit types in Finland, such as the Talvivaara and Kevitsa types, have not been estimated; see further details on the issue in Rasilainen et al. (2012, 2014).

Table 1. Aggregated Finnish mineral resources, end-2020 data, classified into UNFC categories. Note that also the regionally estimated 'undiscovered' mineral resources are included. All values are in metric tonne.

UNFC class	111	112	111+112[1]	221	222	223	222+223[1]	221+222+223[1]	331	332	333	334	343	344[2]	Total	Total[2]
Antimony												2,554			2,554	2,554
Beryllium												182	787		969	969
Calcite[3]												106,000,000			106,000,000	106,000,000
Chromium oxide			10,295,333					27,661,567						350,000,000	37,956,900	387,956,900
Cobalt	6,936	7,910	99,788	4,822	27,026	30,538		184,756	1,483	11,764	39,102		36,935	108,000	451,059	559,059
Copper	62,124	352	735,280	100,074	824,850	977,754	64,350	1,305,920	346,107	33,836	103,493	688,273		9,669,000	5,242,413	14,911,413
Dolomite[3]												803,864,000			803,864,000	803,864,000
Gold	15.54	129.69		37.87	100.35	194.84	2.24		39.27	5.69	12.33	41.01		1,451	579	2,030
Graphite					539,000	737,900									1,276,900	1,276,900
Iron				6,291,393	3,854,517	4,004,717	11,761,100		57,864,800	3,123,600	19,901,200	120,403,968			227,205,295	227,205,295
Kaolin												37,250,000			37,250,000	37,250,000
Kyanite												14,905,600			14,905,600	14,905,600
Lead				9,331	11,880	7,326						86,785		150,000	115,322	265,322
Lithium oxide	39,285	52,751		8,548	28,745	23,744						7,936		1,098,000	161,009	1,259,009
Manganese												379,240	3,012,600		3,391,840	3,391,840
Magnesite[3]												3,612,000			3,612,000	3,612,000
Molybdenum												41,116		100,000	41,116	141,116
Nickel	156,691	179,697	1,327,620	104,449	538,895	496,867	99,900	2,332,000	1,383	55,846	24,485	319,151		5,871,000	5,636,984	11,507,984
Niobium pentoxide												12,878	751,322		764,200	764,200
Palladium	7.48	12.48		57.36	178.33	163.58	21.76			2.44	7.52	133.11		12,000	584	12,584

Footnotes are all in the next page

Table 1. Continued.

UNFC class	111	112	111+112[1]	221	222	223	222+223[1]	221+222+223[1]	331	332	333	334	343	344[2]	Total	Total[2]
Phosphorous pentoxide		15,755,000		10,944,000	42,638,940	624,000						42,013,230,000			42,083,191,940	42,083,191,940
Platinum	11.84	18.72		17.62	58.75	67.49	8.00			1.09	0.15	75.93		5,600	260	5,860
Rare earth oxides												40,687			40,687	40,687
Rhodium												3.61			3.61	3.61
Scandium												2,180			2,180	2,180
Silver				466	348	302						1,677		2,100	2,793	4,893
Talc[3]												13,158,000			13,158,000	13,158,000
Tantalum												285	12,684		12,969	12,969
Tin												1,440			1,440	1,440
Titanium				369,856	213,983	281,745	3,064,795					18,105,000			22,035,380	22,035,380
Tungsten												2,300			2,300	2,300
Uranium						1,260			7,344	12,402	7,293	4,731			33,030	33,030
Vanadium				89,728	53,357	131,948	88,655					829,000			1,192,688	1,192,688
Wollastonite[3]												421,123			421,123	421,123
Yttrium												10,372			10,372	10,372
Zinc	99,483	121	2,731,040	150,067	134,232	52,216		4,850,560				829,315		1,820,000	8,847,034	10,667,034
Zirconium												499,428			499,428	499,428

1 These are combined categories: data is given in these columns where reserves and/or resources are reported, but more detailed information on resource or reserve classes is not available. Most of these data are from the Kemi and Terrafame Sotkamo mines.

2 Median value of undiscovered resources in Finland. The value Total[2] includes the 'undiscovered' resources. As the 'undiscovered' resources cannot be linked to any individual deposit, they are not included in the deposit database, and are presented separately in this table. Note that due to restrictions of the assessment method (lack of relevant reference data) undiscovered resources in a few deposit types, such as the Talvivaara and Kevitsa types, could not be estimated.

3 For these industrial minerals, only low-density data is available and only from some exploration projects. There is no resource data available from the talc and carbonate rock mines and very little from mine development projects. This means that large volumes of resources are not included into this table nor exists anywhere else beyond the companies running and developing the mines. This lack of information from talc mines and deposits also affects to the nickel and cobalt data (for minor extent?).

5 VISUALISATION OF UNFC CODE

The GTK team made a preliminary proposal for the visualisation of the UNFC code in the Mintell4EU project (Eloranta, 2021). This visualisation was made on a dataset that was extracted from updated GTK's Min4EU dataset. Prior to data extraction, all the resource and reserve data was mapped into the UNFC code using bridging document and by re-classifying old data according to UNFC amended with GTK's guidelines (Hokka et al. 2020, UNECE 2020).

UNFC visualisation, exemplified in Figure 3, shows the values of the UNFC categories in separate layers. Dividing E, F and G category symbols into separate layers will form unique combinations for each UNFC code without the need to update new existing combinations to the symbology.

The same symbology is used for all commodities, and the commodities are divided into commodity specific layers. Since one deposit can have resources with several UNFC codes (depending on data quality and data age per commodity), overlapping points are organised so that the UNFC codes with the highest confidence will be shown on the top.

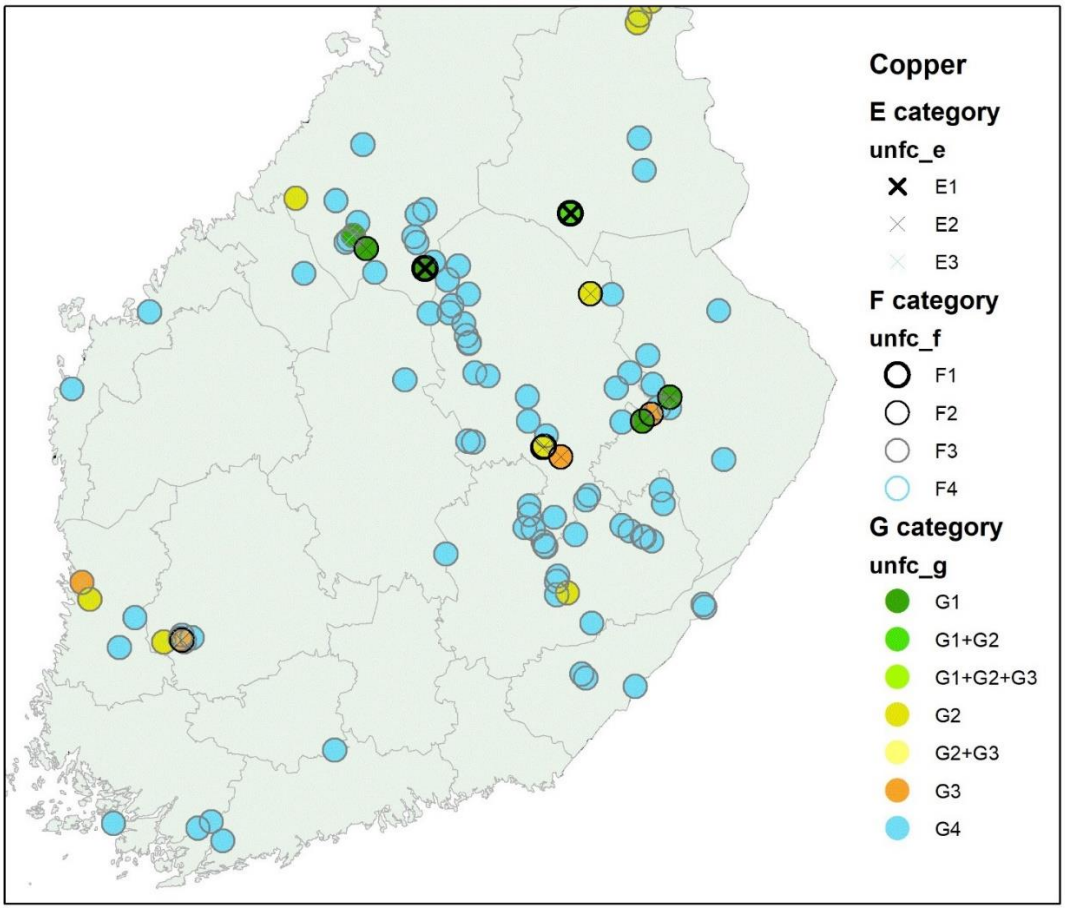

Figure 3. Example of visualisation of copper resources in southern and central Finland mapped to UNFC resource categories.

6 CONCLUSIONS

Based on modifications in the METSO interface and the GTK mineral deposit database, it is now anytime possible to derive the current aggregated, UNFC-categorised, mineral resources of Finland. Currently, the aggregated data needs to be produced from the database by GTK personnel; however, the resource aggregating ETL-process is finalised and can be run regularly. In near future, the aggregating process will be fully automatised. This is a useful, practical tool in providing data into the EU mineral resources database, help in understanding the mineral resources of Finland and, importantly, help in mineral policy and other decision making in Finland. One major example of such needs is when assessing the raw material supply needed for the transition towards low-carbon society in climate change mitigation.

REFERENCES

Aasly, K.A., Pfleiderer, S., Burlet, C., Dedić, Z., Ilijanić, N., Gizdavec, N., Jørgensen, L.F., Nørgaard-Pedersen, N., Eilu, P., Hokka, J., Eloranta, T., Herranen, T., Horváth, Z., Máthé, A., Polonkai, B., Simoni, M., Hibelot, T., Solberg, J.K., Gautneb, H., Heldal, T., Nesheim, H.F., Raaness, A., Coint, N., Rokavec, D., Lundqvist, L. & Ingvald, E. 2021. UNFC pilot case studies compiled as part of Mintell4EU WP4 (Appendix to Deliverable D4.1). 195 p. Online: https://geoera.eu/wp-content/uploads/2021/10/D4.1-Mintell4EU-Case-Study-Overview-Appendix.pdf

Bide, T., Horváth, Z., Brown, T., Idoine, N., Laukó, A., Sári, K., Sőrés, L., Petavratzi, E., McGrath, E., Bavec, S., Rokavec, D., Eloranta T. & Aasly, K. 2018. Final analysis and recommendations for the improvement of statistical data collection methods in Europe for primary raw materials. Deliverable 1.2. of the ORAMA project. 104 p. Online: https://orama-h2020.eu/wp-content/uploads/ORAMA_WP1_DEL1.2_20181130_BGS_v1.0.pdf

CRIRSCO 2019. International Reporting Template for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves, November 2019. 79 p. Online: www.crirsco.com

Eilu P., Rasilainen K., Halkoaho T., Huovinen, I., Kärkkäinen N., Kontoniemi O., Lepistö, K., Niiranen T., Sorjonen-Ward P. 2015. Quantitative assessment of undiscovered resources in orogenic gold deposits in Finland. Geological Survey of Finland, Report of Investigation 216. 318 p. Online: http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_216.pdf.

Eloranta, T. 2021. GTK's proposal for visualisation of UNFC. Appendix to MINTELL4EU Deliverable D4.3. 13 p. Online: https://geoera.eu/wp-content/uploads/2021/11/D4.3-Appendix.pdf

Gunn, G., Bide, T. & Kresse, C. 2019. Technical Guidance Note: Practical Exercises in Reporting Resource and Reserve Data according to the United Nations Framework Classification (UNFC). ORAMA Project deliverable D1.5.4. 10 p. Online: https://orama-h2020.eu/downloads/#tab-id-1

Heino, T. 1986. Tutkimustyöselostus Sotkamon kunnassa valtausalueilla Kolmisoppi 1, kaiv.rek.n:o 2819, Kuusilampi 1 ja 2, kaiv.rek.n:o 2838, Kuusilampi 3, kaiv.rek.n:o 2863 ja Kaivoslampi 1, kaiv.rek.n:o 3335. Geological Survey of Finland, Report M06/3344/-86/1/10. 21 p. Online: https://tupa.gtk.fi/raportti/valtaus/m06_3344_86_1_10.pdf

Hokka, J., Eilu, P., Ahtola, T., Kivinen, M., Konnunaho, J., Kuusela, J., Lintinen, P., Törmänen, T. 2020. Application of the UNFC resource code in Finland – Practical guidelines. Geological Survey of Finland, Open File Work Report 46/2020. 31 p., 4 App. Online: https://tupa.gtk.fi/raportti/arkisto/46_2020.pdf

Hokka, J. & Eilu, P., Schjøth, F. & Aasly, K.A. 2021. Report on harmonization issues, data gaps and challenges, reviewing also the quality of Pan-European aggregated inventories for selected commodities. MINTELL4EU Deliverable 4.2. 22 p. Online: https://geoera.eu/wp-content/uploads/2021/10/D4.2-UNFC-Harmonisation-issues-gaps-and-recommendations.pdf

Huisman, J., Baldé, K., Bavec, Š., Wagner, M., Loevik, A., Herreras, L., Chancerel, P., Emmerich, J., Sperlich, K., Modaresi, R., Ljunggren Söderman, M., Forti, V., Mählitz, P., Schiellerup, H., Horvath, Z., Bobba, S., Eilu, P., Anta, M., Aasly, K., Stanley, G., Csaba, V., Kiss, L., Szabo, J. & Nickolova, V. 2018. Recommendations for improving SRM datasets and harmonisation. Deliverable 2.2. of the ORAMA project. 270 p. Online: https://orama-h2020.eu/wp-content/uploads/ORAMA_WP2_DEL2.-2_20181207_UNU_v1.0.pdf

JORC 2012. Australasian Code for Reporting of Exploration Results, Minerals Resources and Ore Reserves, The JORC Code, 2012 Edition. Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists, and Minerals Council of Australia. 44 p. Online: www.jorc.org.

Mineral Deposit Database of Finland. Digital map database [Electronic resource]. Espoo: Geological Survey of Finland [referred 01.09.2021]. Online: http://gtkdata.gtk.fi/MDaE/index.html

National Instrument 43-101 2011. Standards of Disclosure for Mineral Projects, Form 43-101F1 Technical Report and Related Consequential Amendments. Canadian Institute of Mining and Metallurgy. 44 p. Online: http://web.cim.org/standards.

PERC 2013. PERC Reporting Standard 2013. Pan-European Standard for Reporting of Exploration Results, Mineral Resources and Reserves. 61 p. Online: http://www.vmine.net/perc.

Rasilainen K., Eilu P., Halkoaho T., Iljina M. & Karinen T. 2010. Quantitative mineral resource assessment of nickel, copper, platinum, palladium and gold in undiscovered PGE deposits in mafic-ultramafic layered intrusions in Finland. Geological Survey of Finland, Report of Investigations. 180, 338 p. Online: http://arkisto.gtk.fi/tr/tr180/tr180.pdf.

Rasilainen, K., Eilu, P., Äikäs, O., Halkoaho, T., Heino, T., Iljina, M., Juopperi, H., Kontinen, A., Kärkkäinen, N., Makkonen, H., Manninen, T., Pietikäinen, K., Räsänen, J., Tiainen, M., Tontti, M. & Törmänen, T. 2012. Quantitative mineral resource assessment of nickel, copper and cobalt in undiscovered Ni-Cu deposits in Finland. Geological Survey of Finland, Report of Investigation 194. 521 p. Online: http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_194.pdf.

Rasilainen K., Eilu P., Halkoaho T., Karvinen A., Kontinen A., Kousa J., Lauri L., Luukas J., Niiranen T., Nikander J., Sipilä P., Sorjonen-Ward P., Tiainen M., Törmänen T. & Västi K. 2014. Quantitative assessment of undiscovered resources in volcanogenic massive sulphide deposits, porphyry copper deposits and Outokumpu-type deposits in Finland. Geological Survey of Finland, Report of Investigation 208. 393 p. Online: http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_208.pdf.

Rasilainen, K., Eilu, P., Halkoaho, T., Karinen, T., Konnunaho, J., Kontinen, A. & Törmänen, T. 2016. Quantitative assessment of undiscovered resources in stratiform and podiform chromite deposits in Finland. Geological Survey of Finland, Report of Investigation 226. 186 p. Online: http://tupa.gtk.fi/julkaisu/tutkimusraportti/tr_226.pdf

Rasilainen, K., Eilu, P., Halkoaho, T., Heino, T., Huovinen, I., Iljina, M., Juopperi, H., Karinen, T., Kärkkäinen, N., Karvinen, A., Kontinen, A., Kontoniemi, O., Kousa, J., Lauri, L.S., Lepistö, K., Luukas, J., Makkonen, H., Manninen, T., Niiranen, T., Nikander, J., Pietikäinen, K., Räsänen, J., Sipilä, P., Sorjonen-Ward, P., Tiainen, M., Tontti, M., Törmänen, T. & Västi, K. 2017. Assessment of undiscovered metal resources in Finland. Ore Geology Reviews, 86, 896–923. https://doi.org/10.1016/j.oregeorev.2016.09.031

Rasilainen K., Eilu P., Ahtola T., Halkoaho T., Kärkkäinen N., Kuusela J., Lintinen P. & Törmänen T. 2018. Quantitative assessment of undiscovered resources in lithium–caesium–tantalum pegmatite-hosted deposits in Finland. Geological Survey of Finland, Bulletin 406. 172 p. Online: https://tupa.gtk.fi/julkaisu/bulletin/bt_406.pdf

Rasilainen K., Eilu P., Huovinen, I., Konnunaho, J., Niiranen, T., Ojala, J., Törmänen, T. 2020. Quantitative assessment of undiscovered resources in Kuusamo-type Co-Au deposits in Finland. Geological Survey of Finland, Bulletin 410, 32 p. 3 App. Online: http://tupa.gtk.fi/julkaisu/bulletin/bt_410.pdf

Rupert Resources 2021. Maiden Inferred Resource for Ikkari of 49 million tonnes grading 2.5 grams per tonne (3.95 million ounces of gold). Media release 13 September 2021. Online: https://rupertresources.com/maiden-inferred-resource-for-ikkari-of-49-million-tonnes-grading-2-5-grams-per-tonne-3-95-million-ounces-of-gold/

Talvivaara 2008a. Media release 23 June 2008. Online: http://tupa.gtk.fi/karttasovellus/mdae/references/514_Talvivaara/514_Talvivaara026_230608.pdf

Talvivaara 2008b. Media release 4 Dec 2008. Online: http://tupa.gtk.fi/karttasovellus/mdae/references/514_Talvivaara/514_Talvivaara029_041208.pdf

Talvivaara 2012. Talvivaara Mining Company Plc 2012. Talvivaara Operational and Resource Update, Press Release 28 November 2012. Online:

http://tupa.gtk.fi/karttasovellus/mdae/references/514_Talvivaara/514_Press_release_2012_November.pdf

Terrafame 2020. Financial review 2019. Online: https://www.terrafame.com/media/tulosjulkistukset/financial-review/2019/terrafame_financial_review_2019.pdf

UNECE 2009. United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009. United Nations Publication, ECE Energy Series 39. New York and Geneva, United Nations. 20 p. Online: www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/unfc2009/UNFC2009_ES39_e.pdf

UNECE 2015. Bridging Document between the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) Template and the United Nations Framework Classification for Resource (UNFC). UNECE Energy Series No. 42. 7 p. Online: www.unece.org/index.php?id=34487

UNECE 2020. United Nations Framework Classification for Resources, Update 2019. UNECE Energy Series 61. 20 p. Online: https://www.unece.org/fileadmin/DAM/energy/se/pdfs/UNFC/publ/UNFC_ES61_Update_2019.pdf

USGS 2021. Mineral commodity summaries 2021. U.S. Geological Survey. 204 p. https://doi.org/10.3133/mcs2021

Wagner, M., Baldé, K., Bavec, Š., Loevik, A., Herreras, L., Chancerel, P., Emmerich, J., Sperlich, K., Huisman, J., Forti, V., Mählitz, P., Schiellerup, H., Horvath, Z., Bobba, S., Eilu, P., Anta, M., Aasly, K., Stanley, G., Csaba, V., Kiss, L., Szabo, J. & Habib, H. 2018. Deliverable 2.1. of the ORAMA project. Inventory Analysis of data collection methods and sources for the improvement of SRM statistical datasets.

Wagner, M., Bide, T., Cassard, D., Huisman, J., Leroy, P., Bavec, S., Ljunggren Söderman, M., Løvik, A., Wäger, P., Emmerich, J., Sperlich, K., Baldé, C.P., Schjøth F., Tivander, J., Brown, T., Petavratzi, E., Whitehead, D., Tertre, F., Mählitz, P.M., Nikolova V. & Horváth, Z. 2019. ORAMA Project Technical Final Report & Recommendations. 87 p. Online: https://orama-h2020.eu/wp-content/uploads/ORAMA_WP6_DEL6.6_20191115_v.1.0.pdf

APPENDIX: ABBREVIATIONS USED IN THIS REPORT

BGS	British Geological Survey
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
ETL	Extract, transform, load
FME	Feature manipulation engine
GTK	Geological Survey of Finland
H2020	European Union’s Horizon 2020 research and innovation programme
JORC	Australasian Joint Ore Reserves Committee
METSO	User interface for GTK's mineral deposit database
MINTELL4EU	Mineral Intelligence for Europe
NI43-101	National Instrument 43-101: Standards of Disclosure for Mineral Projects, by Canadian Institute of Mining and Metallurgy
PERC	Pan-European Reserves and Resources Reporting Committee
UNECE	United Nations Economic Commission for Europe
UNFC	United Nations Framework Classification for Resources
USGS	United States Geological Survey