MICA
Minerals Intelligence Capacity Analysis

DOCSHEET

Mineral deposits groups and types

An overview of the varying styles and types of mineral deposits.

Scope

Mineral deposits and ore deposits are of many different types and occur in all geological environments (Cox and Singer, 1986; Dill, 2010; Jébrak and Marcoux, 2015). The main types of geological ore deposits of importance can be divided into:

- metallic deposits;
- non-metallic deposits;
- fossil fuel deposits.

Mineral deposits are classified in different ways, according to the:

- presence of certain metals or minerals and commodities being mined;
- form of the orebody;
- tectonic setting in which the deposit occurs;
- geological setting of the mineral deposit;
- genetic characteristics/model for the origin of the ore deposit, including formation temperature and fluid chemistry.

Mineral deposits are usually classified by ore formation processes and geological setting. However, for non-metallic deposits, i.e., industrial rocks and minerals, the classification used is largely based on the end use (e.g., building raw materials, chemical, fertilizer). However, mineral and ore deposits rarely conform precisely to the pigeon-holes into which we would like to place them. Many may be formed by one or more basic genetic processes, creating ambiguous classifications. Often ore deposits are given a name from the location from which they were first described, for example Broken Hill-type lead-zinc-silver deposits or Carlin–type gold deposits.

As stated by W. Pohl (2011), '… a stringent genetic classification of mineral deposits is very difficult. One reason for this is that many ore deposits represent a position in a complex multi-dimensional space of well-defined end members. Some practicians of exploration and mining think little of genetic models and prefer a pragmatic and empirical classification. Many scientists employ nongenetic terms of classification, such as granite-related or sediment-hosted stratiform deposits. Economic geologists use terms such as deposit styles or deposit types, e.g., copper porphyry type, orogenic gold. Attribution to certain styles and types is determined by descriptive attributes and relations to certain rocks associations, e.g., turbidite-hosted gold deposits, alkaline igneous association. The advantage of descriptive terms is that they facilitate communication and that changes of genetic understanding do not enforce new terms. This also solves the problem of classifying deposits of intermediate position between genetic end members. Yet, genetic concepts are a strong element in finding new ore deposits. Therefore, genesis must be reflected in ore deposit classification.'

A current challenge involves generating a classification with a limited - but sufficient – number of entries which are agreed by a majority of stakeholders. This work has been carried out by the INSPIRE Expert Group for Mineral Resources when establishing the INSPIRE MR data model (INSPIRE Thematic Working Group Mineral Resources [2013]). The related code lists (or vocabularies) 'Mineral Deposit Group Value' and 'Mineral Deposit Type Value' (Schubert et al., 2014) have been submitted to the IUGS/CGI/GTWG[1] in charge of the EarthResourceML (ERML) data model (EarthResourceML, 2013), which is the 'international' world-wide version of the INSPIRE MR data model, for acceptance and validation (currently under way):

Hkey	Term-Deposit Group	Term-Deposit Type	Parent
A	**residual/surficial**		
A01		bauxite	residual/surficial
A02		calcrete	residual/surficial
A03		gossan	residual/surficial
A04		laterite	residual/surficial
A05		phosphorite	residual/surficial
A06		anthropogenic deposit	residual/surficial
B	**placer**		
B01		eluvial placer	placer
B02		alluvial placer	placer
B03		shoreline / marine placer	placer
B04		eolian placer	placer
B05		paleoplacer	placer
C	**sedimentary**		
C01		banded iron formation (BIF)	sedimentary
C02		oolitic iron / ironstone	sedimentary
C03		sedimentary manganese	sedimentary
C04		phosphorite	sedimentary
C05		stratiform barite	sedimentary

[1] http://www.cgi-iugs.org/tech_collaboration/geoscience_terminology_working_group.html.

C06		evaporite	sedimentary
D	**sediment-hosted**		
D01		carbonate-hosted	sediment-hosted
D02		sandstone-hosted	sediment-hosted
D03		shale-hosted (incl. SEDEX)	sediment-hosted
E	**ultramafic / mafic igneous rocks**		
E01		layered complex	ultramafic / mafic igneous rocks
E02		mafic to ultramafic effusive volcanism	ultramafic / mafic igneous rocks
E03		mafic to ultramafic intrusion	ultramafic / mafic igneous rocks
E04		komatiite	ultramafic / mafic igneous rocks
E05		anorthosite	ultramafic / mafic igneous rocks
E06		ophiolite	ultramafic / mafic igneous rocks
F	**felsic-intermediate igneous rock related**		
F01		granitic igneous rocks and pegmatites	felsic-intermediate igneous rock related
F02		greisen	felsic-intermediate igneous rock related
F03		porphyry	felsic-intermediate igneous rock related
F04		iron oxide copper gold (IOCG)	felsic-intermediate igneous rock related
F05		iron oxide apatite (IOA)	felsic-intermediate igneous rock related
G	**contact metamorphism**		
G01		skarn and carbonate replacement	contact metamorphism
G02		hornfels	contact metamorphism
G03		polymetallic manto	contact metamorphism
G04		Carlin-type carbonate-hosted Au-Ag	contact metamorphism
H	**alkaline igneous rocks**		
H01		kimberlite and lamproite	alkaline igneous rocks
H02		carbonatite	alkaline igneous rocks
H03		unsaturated and saturated syenitic and alkali granitic igneous rocks and pegmatites	alkaline igneous rocks
I	**epithermal**		
I01		low-sulphidation	epithermal
I02		high-sulphidation	epithermal
J	**marine volcanic association**		
J01		mafic volcanism Cu–Zn massive sulphide deposits	marine volcanic association
J02		bimodal and felsic volcanism Cu-Pb-Zn VMS and transitional magmatic deposits	marine volcanic association
K	**metasomatic replacement/hydrothermal shear/vein**		
K01		vein, including polymetallic and 5 element vein (Bi, Co, Ni, Ag, U)	metasomatic replacement/hydrothermal shear/vein

K02		orogenic gold	metasomatic replacement/hydrothermal shear/vein
L	**bulk rock material**		
L01		aggregate	bulk rock material
L02		dimension stone	bulk rock material
M	**energy**		
M01		organic	energy
M02		non-organic (incl. U)	energy
N	**other**		
N01		meteorite impact	other

Contexts of use, application fields	-> contexts (e.g., environmental, economic, social assessment) -> which types of stakeholder questions are concerned? -> link to published studies that implement the method

The uses of this classification are many. The deposit group and type is important for numerous applications, including:

- The identification of exploration methods;
- The confidence with which predictions can be made about a deposit;
- The main commodity(ies) to be exploited and the by-products that may be recovered. Note: a commodity is generally not linked to a single deposit group or type, but some may appear preferentially in one type or in association with another commodity – see also the '**Major metals and their companion metals metallogeny. The so-called 'by-products'**' docSheet;
- The design of the mine (e.g., surface vs underground) and of processing facilities, and thus the environmental impact and the land use challenges;
- The quantity of mining waste generated (dumps and tailings) and their characteristics.

Input parameters	-> which parameters are needed to run the method

- Not applicable

Type(s) of related input data or knowledge needed and their possible source(s)	-> which types of data are needed to run the method, from which sources could they come… -> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc.

The classification presented in this document is fully INSPIRE compliant, and is thus the one which is used in several Knowledge Data Platforms such as:

- the IKMS (Integrated Knowledge Data Platform) – EU-FP7 EURare project: http://eurare.brgm-rec.fr/
- the EU-MKDP (European Union Minerals Knowledge Data Platform) – EU-FP7 Minerals4EU project: http://minerals4eu.brgm-rec.fr/
- the EU-UMKDP (European Union Urban Mining Knowledge Data Platform) – H2020 ProSUM project: http://prosum.brgm-rec.fr/

Model used (if any, geological mathematical, heuristic…)	-> e.g., geological model for mapping -> e.g., mathematical model such as mass balancing, matrix inversion, can be stepwise such as agent -based models, dynamic including time or quasidynamic specifying time series… -> can also be a scenario

- Not applicable

System and/or parameters considered	-> **the system can be described by its boundaries**. These can refer to a geographic location, like a country, or a city, the time period involved, products, materials, processes etc. involved, like flows and stocks of copper, or the cradle-to-grave chain of a cell phone, or the car fleet, or the construction sector, or the whole economy… -> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others…

- Not applicable

Time / Space / Resolution /Accuracy / Plausibility...	-> to which spatio-temporal domain it applies, with which resolution and/or accuracy (e.g., near future, EU 28, 1 year, country/regional/local level...) -> for foresight methods can also be plausibility, legitimacy and credibility...

As with all classifications of natural phenomena, the Mineral/Ore Deposit Group/Type list will evolve with the progress of science. New discoveries may result in the generation of new classifications or the reinterpretation of existing deposit types.

One of the most striking examples of these last decades, which triggered a serious revision of existing classifications, is probably the discovery in 1975 of the giant Olympic Dam deposit in Australia, which launched the interest for iron oxide – copper – gold deposits (latter called 'IOCG'). These deposits became attractive targets for mining companies because of their huge resources and of the polymetallic character of their mineralization (e.g., Cu, Au, Ag, U, REE, Nb, Ta, Co). The IOCG concept was introduced by M.W. Hitzman et al. (1992) and numerous deposits were then classified as IOCG, leading to a great confusion. Since that time the concept has been clarified and simplified, and the classification reappraised. Despite their obvious economic interest, and more than 40 years of exploration and 25 years of scientific studies, the knowledge related to these deposits can still be improved.

Such a classification can thus be used for the re-interpretation of known deposits, and for current exploration activities. It will certainly evolve with more discoveries.

Indicators / Outputs / Units	-> this refers to what the method is actually meant for. Units are an important part but that is most of the time not sufficient to express the meaning. For example, **the indicators used in LCA express the cradle-to-grave environmental impacts of a product or service**. This can be expressed in kg CO_2-equivalent. But also in €. Or in millipoints. Or in m^2year land use. -> for foresight methods the outputs are products or processes

- Not applicable

Treatment of uncertainty, verification, validation	-> evaluation of the uncertainty related to this method, how it can be calculated/estimated

- Not applicable

Main publications / references	-> e.g. , ILCD handbook on LCA, standards (e.g. , ISO) -> can include reference to websites/pages -> references to be entered with their DOI

Cox D.P., Singer D.A. (1986). Mineral deposit models. US Geological Survey Bulletin 1693, 379 p. https://pubs.usgs.gov/bul/1693/report.pdf

Dill H.G. (2010). The "chessboard" classification scheme of mineral deposits: Mineralogy and geology from aluminum to zirconium. Earth-Science Reviews 100, 1–420.
doi:10.1016/j.earscirev.2009.10.011

EarthResourceML (2013).
http://www.earthresourceml.org/earthresourceml/2.0/doc/ERML_HTML_Documentation/

Hitzman M.W., Oreskes N., Einaudi M.T. (1992). Geological characteristics and tectonic setting of Proterozoic iron oxide (Cu-U-Au-LREE) deposits. Precambrian Research, v. 58, p. 241-287.
doi:10.1016/0301-9268(92)90121-4

INSPIRE Thematic Working Group Mineral Resources (2013). D2.8.III.21 Data Specification on Mineral Resources – Technical Guidelines. 156 p. European Commission Joint research Center Publisher. http://inspire.ec.europa.eu/documents/Data_Specifications/INSPIRE_DataSpecification_MR_v3.0.pdf.

Jébrak, M., Marcoux, E. (2015). Geology of mineral resources. The Geological Association of Canada. 668 pp.
ISBN-13: 978-1-897095-73-7

Pohl W. (2011). Economic Geology: Principles and Practice. Wiley-Blackwell, 663 pp.
ISBN: 978-1-4443-3663-4

Schubert C., Vuollo J., Tomas R., Cassard D. and WP5 Partners (2014). Minerals Intelligence Network for Europe – Minerals4EU-WP5. WP5: Common terminology for Minerals4EU – Version 1.0, Minerals4EU Public Report, 330 p.

Related methods	-> List of comparable methods, their particularities… -> link to one or several other existing fact sheet(s)

Related docSheet: **Major metals and their companion metals metallogeny. The so-called 'by-products'**

Some examples of operational tools (CAUTION, this list is not exhaustive)	-> e.g., software… Only give a listing and a reference (publication, website/page…) -> **should be provided only if ALL main actors are properly cited**

- Not applicable

Key relevant contacts	-> list of relevant **types** of organisations that could provide further expertise and help with the methods described above.

Several geological surveys among which BGS, BRGM, GEUS, GSI, GTK… (see http://www.eurogeosurveys.org/).

Glossary of acronyms /abbreviations used	-> Definition
IOCG deposits	Iron-oxyde copper gold deposits