MICA
Minerals Intelligence Capacity Analysis

FACT SHEET

3D Modelling (Geological)

3D geological modelling is the creation of 3 dimensional models of the earth's subsurface geology.

Scope (conceptual model & main characteristics)

3D geological modelling is the creation of 3 dimensional models of the earth's subsurface geology. A model is the 3D equivalent of a 2D geological map. Models are typically computer generated and specific software is available for developing, manipulating and viewing models.

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

Basic geological modelling will focus on rock types but the models can also be thematic in nature and record information on hydrogeology, mineral resources, engineering properties, soil type, geological hazards and any other dataset which may benefit from 3-dimensional representation.

3D modelling is an essential tool within the mineral industry, particularly during the generation of a resource estimate where the geometry of a mineral deposit must be well constrained. Exploration can also be guided by 3D models of the geology, particularly in planning drilling programmes.

Used to demonstrate or aid visualization of a mineral deposit.

Due to its application at almost any scale, 3D modelling can be used as an initial tool for mineral reconnaissance, i.e. to highlight areas with the appropriate geometries for further investigation, or for detailed mapping, i.e. to fully understand the geometry of an ore-body.

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

Geological data including lithology (descriptions, mineralogy, classification), structural information (dip and strike, faults, folds, foliations, linear features), age and age relationships, outcrop information, subsurface information (e.g. drill hole data).

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.

Any geophysical information such as seismic, gravity or magnetic data.

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

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…

3D Modelling can be undertaken at almost any scale depending on what the end use requires. Models are generally created at similar scales to the appropriate geological maps of the area.

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…

Most models are static conceptual models of the geology of a specific area. They cannot show variation through a temporal period. There are dynamic modelling tools available, commonly referred to as 4D models which show geology evolving over time. Similar to geological mapping, a reinterpretation of evidence can alter the conceptual model of the geology of an area and hence models are updated. In addition, geological mapping carried out at a more detailed scale or the generation of new sub surface information (drilling or geophysics) can result in new geological models being produced.

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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

The output is a three dimensional model, typically generated within a specific computer program and subject to manipulation by the viewer. Standard software allows for a viewer to rotate the model through all axes and specific components can be selected as viewable or removed as required.

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

As modelling is primarily reliant on the observations made by an expert in the field, it is a highly interpretive process and the errors associated with it can be very difficult to quantify as they will be reliant on the available geological map, boreholes and whether the expert's interpretation of other sub surface data is accurate. The greatest uncertainty of interpretation will be in poorly constrained areas or areas with a high degree of geological variance.

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

Fallara, Francine, Legault, Marc and Rabeau, Olivier (2006). 3-D Integrated Geological Modeling in the Abitibi Subprovince (Québec, Canada): Techniques and Applications. Exploration and Mining Geology, Vol. 15, Nos. 1-2, pp. 27–41. http://web.cim.org/geosoc/docs/pdf/EMG15_3_Fallara_etal.pdf

Berg, R.C., Mathers, S.J., Kessler, H., and Keefer, D. A., 2011. Synopsis of Current Three-dimensional Geological Mapping and Modeling in Geological Survey Organization, Champaign, Illinois: Illinois State Geological Survey, Circular 578. http://library.isgs.uiuc.edu/Pubs/pdfs/circulars/c578.pdf

Turner, A. K.; Gable, C. (2007). "A review of geological modelling. In: Three-dimensional geologic mapping for groundwater applications, Workshop extended abstracts," (PDF). Denver, Colorado. Archived from the original (PDF) on 2008-11-21.

Kessler, H., Mathers, S., Napier, B., Terrington, R. & Sobisch, H.-G (2007). "The present and future construction and delivery of 3D geological models at the British Geological Survey". (GSA Denver Annual Meeting. Poster)

Wycisk,P., Gossel W., Schlesier, D. & Neumann, C (2007). "Integrated 3D modelling of subsurface geology and hydrogeology for urban groundwater management" (PDF). International Symposium on New Directions in Urban Water Management. Archived from the original (PDF) on 2008-12-17.

Kessler, H., Mathers, S., Lelliott, M., Hughes, A. & MacDonald, D. (2007). "Rigorous 3D geological models as the basis for groundwater modelling. In: Three-dimensional geologic mapping for groundwater applications, Workshop extended abstracts," (PDF). Denver, Colorado. Archived from the original (PDF) on 2008-12-03.

Kevin B. Sprague & Eric A. de Kemp. (2005) Interpretive Tools for 3-D Structural Geological Modelling Part II: Surface Design from Sparse Spatial Data http://portal.acm.org/citation.cfm?id=1046957.1046969&coll=&dl=ACM

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

Geological Mapping

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**

Standard CAD software for generating 3D models. Most GIS programs also include a 3D component. There is also a range of commercially available software.

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

National geological Surveys. Eurogeosurveys. Consultants.