MICA
Minerals Intelligence Capacity Analysis

# *FACT SHEET*

# Geostatistical Estimation

Geostatistical estimation is a technique based on probability theory that is used to compute regionalized variables, such as the metal content or grade in a deposit.

## Scope (conceptual model & main characteristics)

Geostatistical estimation is a technique based on probability theory that is used to compute regionalized variables, the values of which depend on their position in space, such as the metal content or grade in a deposit. The techniques are generally related to interpolation methods and use statistical models to quantify the uncertainty associated with spatial estimation and simulation. A key component of geostatistical estimation is a measure of the uncertainty associated with the modelled quantities (ore resources etc.). This factsheet deals with Geostatistical Estimation as a mineral deposit modelling tool.

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

These techniques were developed for the modelling of ore resources however geostatistics can be applied to any spatial dataset, including environmental (e.g. spread of pollution), social (e.g. mortality maps of disease). This factsheet deals with the technique as applied to mineral deposits.

With respect to ore estimation it is common practice to assign values to a 3-dimensional array of cells each cell measuring *x* by *y* by *z* metres. Sometimes the cells are equidimensional. The values for each cell are then combined to give a global estimate of the resource within the orebody as a whole.

| Input parameters | -> which parameters are needed to run the method |
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Borehole coordinates (XYZ data), borehole inclination, borehole direction, borehole survey data, intercept (from – to, interval), grade data, density, core recovery, , variogram model, type of kriging, , orebody shell or envelope, geological model (ore host, hanging wall and footwall lithologies; fault data; mineralogy; alteration).

| 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…<br>-> could be qualitative data or quantitative data, and also tacit knowledge, hybrid, etc. |
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All available data regarding a deposit is used to generate the best model including: ore host, hanging wall and footwall lithologies; fault data, mineralogy; alteration. . This is primarily based on geological mapping and borehole logging and in some cases interpretation of geophysical data.

| Model used (if any, geological mathematical, heuristic…) | -> e.g., geological model for mapping<br>-> 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…<br>-> can also be a scenario |
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The starting point for any geostatistical estimation exercise is the variogram model. The variogram model provides the input parameters for the kriging estimates including any directional anisotropy.

| 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…<br>-> **parameters** could possibly refer to geographic co-ordinates, scale, commodities considered, genesis of ore deposits and others… |
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See input data

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| 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…)<br>-> for foresight methods can also be plausibility, legitimacy and credibility… |

Temporal extent: Present to future

Temporal resolution: resolution for resources and environmental issues measured in years.

Spatial extent: Individual deposit scale

Spatial resolution: Resolution dependent on scale of dataset

Accuracy/Plausibility: mineral resource estimation and calculation is covered by various international reporting codes for mineral resources, e.g NI 43-101, JORC and PERC.

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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 $m^2$year land use.<br>-> for foresight methods the outputs are products or processes |

Outputs for the mineral resources industry include an estimate of the quantity and quality of minerals or metals in a mineral deposit with quantifiable uncertainties.

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

Mineral resources estimation and calculation is covered by the various international reporting codes for mineral resources, e.g NI 43-101, JORC and PERC. Statistical techniques are used to quantify the inherent uncertainty created by the dataset.

| Main publications / references | -> e.g. , ILCD handbook on LCA, standards (e.g. , ISO)<br>-> can include reference to websites/pages<br>-> references to be entered with their DOI |
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http://inspire.ec.europa.eu/codelist/ExplorationActivityTypeValue/geostatisticalEstimates

http://www.crirsco.com/

Bustillo Revuelta, M. 2018. Mineral Resources: From exploration to Susteinability Assessment. Springer.

| Related methods | -> List of comparable methods, their particularities…<br>-> link to one or several other existing fact sheet(s) |
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Kriging, Mineral resource estimation, 3D block model

| Some examples of operational tools (CAUTION, this list is not exhaustive) | -> e.g., software… Only give a listing and a reference (publication, website/page…)<br>-> **should be provided only if ALL main actors are properly cited** |
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Several commercial software packages are available to carry out this work.

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