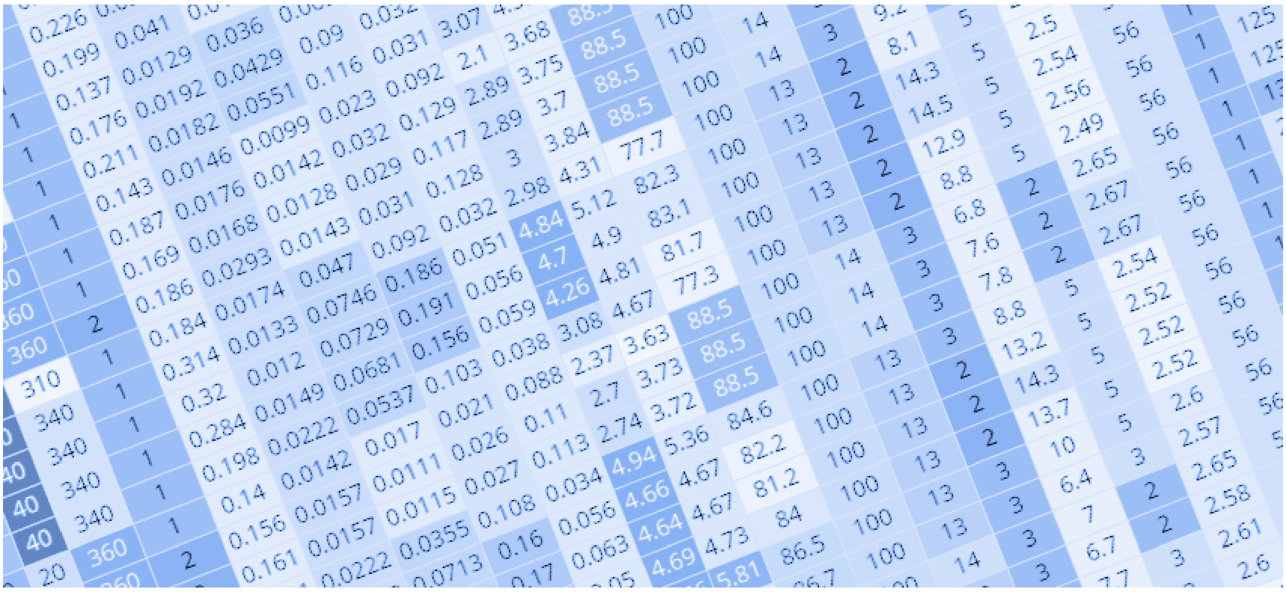
GEOMETALLURGY SOFTWARE

Data Guide



Introduction

This guide is provided to help Cancha users collect the data that should be on hand before attempting to start a geometallurgical model.

There are examples for early stage projects, late stage projects, and operations.

While this document explains what data to collect, the Cancha User Manual explains how to operate the Cancha software.

Early Stage Projects

When conducting metallurgical sampling for a preliminary economic assessment, or scoping study, there is not usually a lot of information about mine planning. Geological information and assay data may be limited, as will the overall deposit understanding and interpretation.

The samples for early stage projects are often aimed at metallurgical flowsheet development, and are less concerned with mapping geometallurgical variability. There is usually a limited quantity of drill core available for metallurgical sampling, and the existing core may be spoiled by oxidation, over sampling, or animal infestation.

Geometallurgical understanding in the early stage projects are critical, as it will direct data collection campaigns in later stages.

Advanced Projects

In advanced stage projects, the focus often changes from flowsheet development, and instead focuses on risk reduction by improving understanding of geometallurgical variability.

Usually at this stage there is dedicated funding toward metallurgical drilling, with the goal of achieving a "representative sample" population for the project.

Engineering and investment decisions will be made on the geometallurgical predictions, so they should be well substantiated and communicated.

Operations

Operating mines usually have a great understanding of the geology, mine plan, and parameters that may influence geometallurgical targets.

In some cases, they may actually have fewer features available, as they have reduced costs for geochemical analysis and core logging, for example, in order to reduce in-fill drilling costs.

On the other hand, it is expected that they would have existing block models, mine plan, metallurgical testwork, and existing plant performance data.

Why is getting data an issue?

From the mid-1990's, geologists and mining planners have undergone a digital transformation of their work flow. Drill logs that were done on paper were replaced by spreadsheets, and later databases that are populated by digital logging tablets, or core scanning technologies directly.

Mine plans that were done on paper sections are now ubiquitously done with brute force optimization by powerful computers working in 3D.

The time has come for metallurgical testwork to catch up with the rest of the team.

Geometallurgy is usually done by a geologist or a metallurgist

Geologists

Geologists often try to reduce geometallurgical data into the equivalent of an assay interval, without taking into consideration the complex and non-additive interactions between test parameters, sample characteristics, and the consequential results.

Metallurgists

Since metallurgists typically use Excel to solve all problems, they are not used to working with the giga-byte sized drilling and block model data stores that are the daily tools of the trade for our earth science colleagues. Metallurgists need to learn how to ask for this information, and to work with it.

Conclusion

Depending on the point of view, the data requirements, workflow, and conclusions from a geometallurgical investigation can vary. All team members need to be empathetic and take the time to explain what they have, and what they need. One may not have basic knowledge of the nature of the other's data, and visa versa. Use simple language, ask for explanations, and above all do not feel that you are the only one that does not understand!

Who has the data?

Drilling database

The project drilling database is usually held by the exploration geology team. Some companies have global information system (GIS) staff to maintain and control the quality of the data. Whoever is in charge should have the data, code legends, and knowledge of what has not been imported yet. Geometallurgical features like RQD, may not have been processed due to lack of priority, budget, or interest. The geometallurgist will often need to use diplomacy to get the data required.

Drilling photos

The central data team may not have the photos. You may need to check with the site exploration team. The photos may be on a portable hard drive or similar and weigh many giga-bytes.

Block models

The models are typically populated by resource geologists, so they are the ones that control the block model file, legend codes, and contents.

However, it can be useful to talk to the mine planning engineer, who may be able to add useful additional data such as mine plan phase, NSR, destination (waste, float, leach, stock).

Shells

Mine planning engineers can usually produce pit shells or phase shells.

Geological models for lithologies, alterations, or mineralization zones can usually be sourced from the geological modeller. In early stage projects, these may not exist yet. If they are very complex models, it may be necessary to work with the modeller to simplify the model for geometallurgical interpretation.

Metallurgical samples

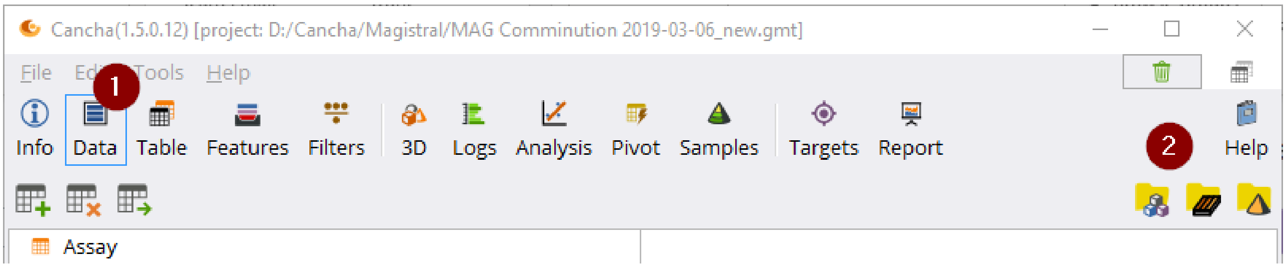
The project metallurgists may not have the exact origin for metallurgical samples, or the geological logs of the samples that were taken. If the metallurgy team does not have that, then the geological team likely has it.

The project metallurgists probably have metallurgical test parameters and test results for each sample.

It could be that sample characterization data, such as automated mineralogy results, may not be available in an interactive data format. Often metallurgical data is only available as pdf format, in which case there is no other option but to digitize the data manually.

Formatting the data

Cancha provides templates for importing table data.



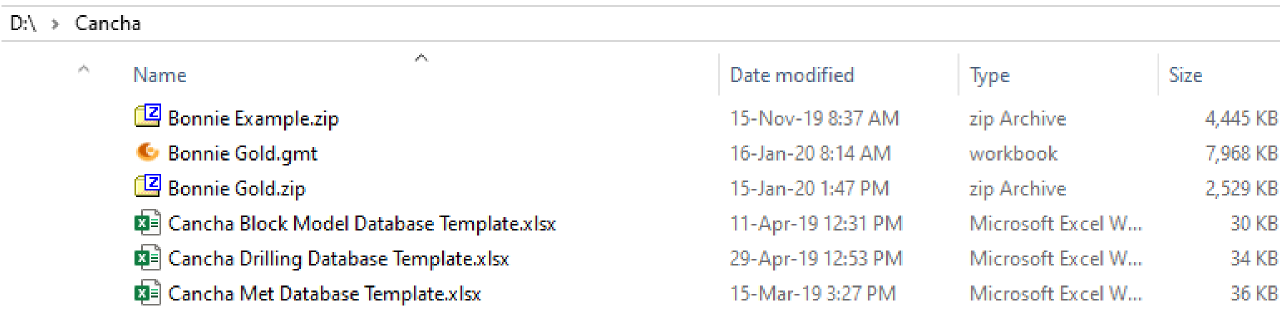
1. In the Data area
2. Click these icons:

    Drilling database template

    Block model template

    Metallurgical data template

Blank Excel files will be created in your default Cancha folder by clicking on any of these template icons:



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Name	Date modified	Type	Size
Bonnie Example.zip	15-Nov-19 8:37 AM	zip Archive	4,445 KB
Bonnie Gold.gmt	16-Jan-20 8:14 AM	workbook	7,968 KB
Bonnie Gold.zip	15-Jan-20 1:47 PM	zip Archive	2,529 KB
Cancha Block Model Database Template.xlsx	11-Apr-19 12:31 PM	Microsoft Excel W...	30 KB
Cancha Drilling Database Template.xlsx	29-Apr-19 12:53 PM	Microsoft Excel W...	34 KB
Cancha Met Database Template.xlsx	15-Mar-19 3:27 PM	Microsoft Excel W...	36 KB

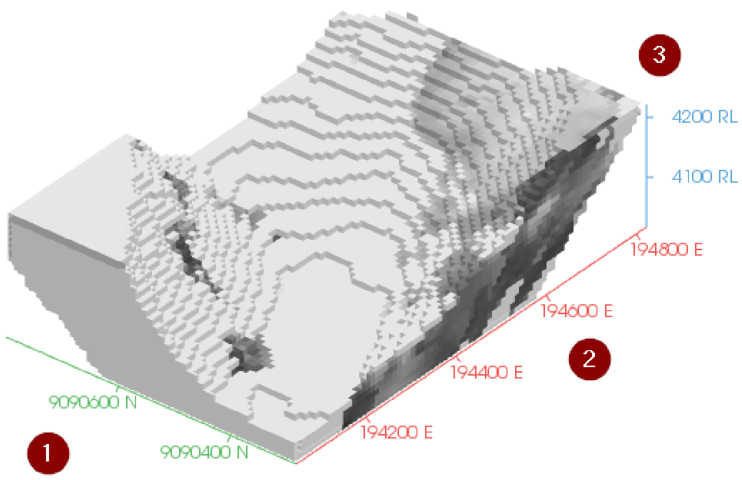
Block model data

The most popular and useful block model is a regularized model that breaks the deposit up into uniformly sized blocks on a regular grid.

Large open cut mines may use something like a 20 x 20 x 10 m block, which is 20 m wide, 20 m deep and 10 m tall.

Small underground mines that need more precision may use much smaller blocks, like 5 x 5 x 1 for example.

Cancha has trouble dealing with block models that are on a rotation of the Earth's cartesian coordinates. Rarely some mines rotate the block model to align it on a diagonal axis. Cancha does not support this. You can still import blocks, but visualizations and data projections may be misleading.



1. **Northing**, where larger numbers are further to the north.
2. **Easting**, where larger numbers are further to the east.
3. **Relative Level** (RL), where larger numbers are higher altitude.

Some databases use other terms for N, E, RL. We don't use Alt for altitude in Cancha, because it can be confused with "alteration".

Terms like ijk, n, and AsbE, AbsN, etc. can also be shown in the block model. The only coordinate columns that are useful to Cancha are the N, E, and RL columns that are in the same system as the Drill Hole Collar database, and the system that any 3D mesh data is recorded in.

Beware that sometimes projects change between standards. Different systems can have errors of up to a few hundred meters, so be careful that all of the project data is in the same system. Most projects these days have changed to the **WDS-84** system.

All other fields are likely useful for geometallurgy and should be imported as features, for example:

- Metal grades
- Geological domains

- Mining phases or periods
- Mining domains
- Resource category
- Net smelter return value
- Block dilution information
- Geotechnical values
- In situ rock density

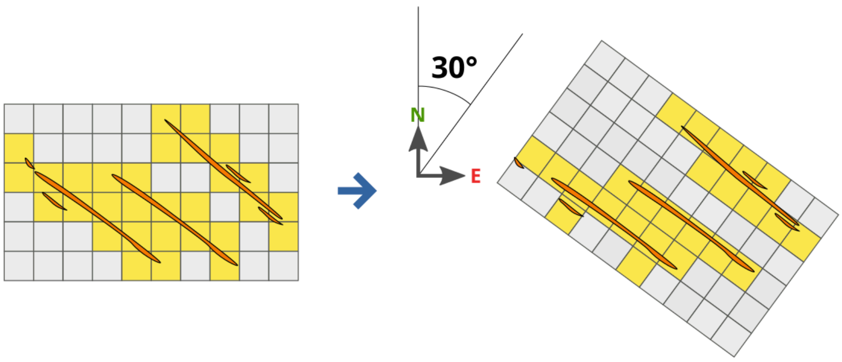
If this data is calculated, but not burned back into the block mode, it is recommended to ask the mine planners to include these fields.

As always, as for full legends and explanations of each field. Codes for lithologies may be given numbers rather than names.

Density in a block model is usually the apparent density in situ, not the specific gravity of the ore that is used in metallurgy.

Block model rotation

Mining engineers sometimes rotate the block model to align with the geological structures to reduce dilution. In this example, the block model has been rotated 30° about the RL (Z) axis.



Block model size

Mine planning software can produce massive block models, from sea level to the heavens.

In geometallurgy we are only interested in some of the blocks.

Culling blocks, it is possible to speed up calculations and loading times significantly. A typical profile follows:

1. Mine planning block model
   Cube of 4000 m x 2000 m x 1000 m x 30 data columns = 240 billion data points
2. In-pit filter
   Cone of 1500 m x 600 m x 400 m x 30 data columns = 6 billion data points
3. Remove waste,
   2:1 strip ratio x 30 data columns = 2 billion data points
4. Remove useless columns of data
   Ore x 15 data columns = 1 billion data points

In a recent example, we reduced a 6 GB block model file to 40 MB. Therefore, ask the miners to clip the file before they send it to you and you will save a lot of time downloading the file from the internet, and loading it into Cancha.

Shells

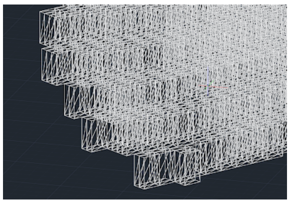
Shells can be imported in [dxf format](). These files can generally be in one of two types:

- Open surface, like a sheet of paper
- Closed volume, like a balloon

In both cases, they can be visualized in the 3D view, and used to create categorical features for drill holes and block models.

The accuracy of the importation process for these files into Cancha depends on the quality of the original file that is imported. If there are sparse nodes then the imported shell may be of low accuracy, as Cancha will interpolate a surface between the nodes.

Note that the dxf format is a general format and the data contained can vary. Some popular mine planning software has the ability to export dxf files of pits that are not surfaces or volumes, rather they are a series of lines. Cancha cannot interpret a dxf file if it does not contain the 3D model as a surface or a volume.



Metallurgy

Metallurgical information should be imported in separate tables, the same way that drilling information is. This will facilitate navigation and analysis of the information in Cancha. In some geometallurgical studies, over 1000 features can be developed for each sample. Keeping the information well organized is important to being able to work quickly and accurately.

Metallurgical information should be imported in separate tables as follows:

Origin. The sample origin table should have the following fields:

- Sample ID
- Drill hole
- From
- To
- Phase

There should only be one sample origin entry for each sample in Cancha.

Characteristics. This group of information describes the characteristics of the sample as it was extracted from the drill core tray, such as:

- Head grades
- Geological parameters such as lithology, alteration
- Geotechnical parameters such as rock quality, density, particle size or moisture content
- Mineralogical information such as mineral assemblage, texture or associations

Each of these can and should be imported as a separate table.

Characteristics tables must have a Sample ID and Phase fields.

Test parameters. This data is test specific. The conditions of the tests, such as particle size, reagent regimes, time, temperature or flowsheet are imported here.

Test parameter tables must have a Sample ID and Phase fields.

Each type of test should be imported as a separate table, for example, comminution, flotation and leaching test parameters should be in separate tables.

Results. Test results are imported here, and may later be declared as targets for geometallurgical analysis. Typical results may include recoveries, reagent consumption or concentrate grades.

Results tables must have a Sample ID and Phase fields.

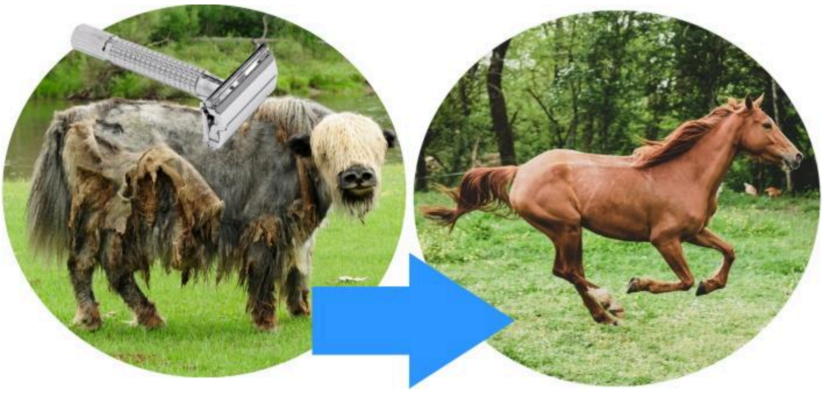
Each type of test should be imported as a separate table, for example, comminution, flotation and leaching test parameters should be in separate tables.

Preparing the data

Shaving the Yak

If the numerical data columns that are imported contain text, or other non-numerical characters, then Cancha will crash!

Shaving the Yak is a important and onerous task for the geometallurgist.



Here is a checklist of steps to get your data in shape for analysis:

- Integrate data. Single tables for drill collars, or sample origin can facilitate the work flow.
- Group similar features. Navigating features is easier when they are grouped together in tables.
  For example, keep head assays and mineralogy in separate tables for metallurgical samples.
- Consolidate data. Often there may be multiple columns in a table that have to be interpreted together as a single feature. Consolidate these columns before importing them.
  For example, zinc assays on drilling may be found as part of an ICP column, but where the assays were high (>1%), a second column shows the results of a zinc determination by AAS. Therefore, it is recommended to create a third column with the best values from each assay, and only use that as the zinc assay feature.
  Another common example is in geological rock type logs. There may be dozens of rock types identified, but a pragmatic review could reduce them to 5 or 6 groups, which would be more useful as potential domain systems.
- Treat null data. Depending on how the data was produced, there may be different terms for null (empty) data values. Common examples include “Null”, “-”, “N/A”, “-999”, or simply no value at all. Cancha only works if null values are given as either empty or “-”.

- Remove data leakage. Data leakage is where the target value is present in a separate feature, but should not be used as a predictor.
  For example, a Bond work index file may have grams per revolution and BWi in separate columns. Model generation will identify this feature as an excellent predictor of hardness, but it should not be used as it comes from the metallurgical testing and not the knowledge of the geological deposit.
- Treat erroneous data. If data is erroneous, do not use it for analysis.
  For example, if metallurgical tests failed due to poor mass balances, incorrect conditions, or spoiled samples, then do not use this data for analysis.
- Rectify duplicates. Have the same features or samples been incorporated twice?
  For example, if duplicate tests were run for quality assurance purposes, then they should be reviewed and removed or treated before use in analysis.
- Review extremes. Most geometallurgical numerical data is greater than zero. Outliers can confuse the clustering and learning algorithms.
  For example, if 99.99% of the data is below 2%, and one value is 30% Cu, then that one value adds more noise than value, and should be removed or reduced.
- Homologize scale. Have ppm, ppb, and % been mixed in the same feature? Metric vs short tonnes? Make sure that all values in a feature are on the same scale.

Photos

We are still working on integrating photos into Cancha, but in the meantime, it is still important to collect photos for your geometallurgical study. There are three main kinds of photos that are recommended:

1. Core photos
2. Typical specimen photos
3. Metallurgical sample photos

Core Photos

The core logging geologists should have a high quality photo of all of the fresh core that was drilled, before it was sampled. This can be an invaluable reference when selecting samples, forming composites, and investigating outliers in geometallurgical models.

Typical Specimen Photos

There may be tens of thousands of core photos, and it can be overwhelming for metallurgists to understand a new deposit when looking at core trays with mixed rock types.

Core logging geologists usually have a "library", "atlas", or "skeleton" of typical samples of each lithology, alteration, and mineralization type.

Getting a duplicate library of labelled rocks is a fantastic tool for the metallurgical team, but if that is not practical, ask for a high quality, labelled photo of each rock type for reference.

Arenisca Feldaspática de Agilización Débil

Arenisca Calcárea

Arenisca Cuarzosa sin Alteración

Pórfido de Cuarzo Feldespato

Metallurgical Sample Photos

Ask the metallurgical laboratory to photograph all samples when they arrive, with the sample details in the image, and a size reference included.