**Case study:** Can Leapfrog be used to model complex geology?

**Company:** Votorantim Metais (a multinational Brazilian company which works with base metals).

**Project:** A lateritic, mafic-ultramafic nickel deposit located in Niquelândia, 300Km north of Brasilia in Brazil. The open pit mine produces nickel carbonate using a hybrid pyro-hydrometallurgical process. The deposit is 26 km (N-S) by 6 km (W-E) drilled at a 25x25m space.

**Data:** Approximately 372,000 metres of drilled cores

**WHAT WAS THE PROBLEM?**

Until 2011, Votorantim Metais used traditional modelling methods (explicit modelling) to construct and update the geological models of the nickel deposit. This involved drawing geological contacts on horizontal and vertical cross-sections and took approximately six months, depending on the skill level of the modeller. Due to the excessive amount of time spent on generating and updating the geological domains, not enough time was available for developing the subsequent stages of mineral resource evaluation.

**GEOLOGICAL CHALLENGES**

- Strong structural variation along ore bodies
- Dips ranging from sub-horizontal to sub-vertical
- Thickness variations from 1 to 120m
- Very large dataset (372,000m of drilled core)

**THE TANGIBLE BUSINESS BENEFITS GAINED BY IMPLICIT MODELLING**

Despite being required to learn a new geological modelling tool, it only took four months to complete work on the lateritic nickel deposit. Using traditional methodology it would have taken at least five months to complete the same model.

The benefits are even more remarkable when considering the time saved as a result of updating the model with new drillholes. It traditionally took three months to update the model with approximately 15,000 metres of new drillings. Using Leapfrog, updating the model took only three weeks.
ASSUMPTIONS

This study used the same geological assumptions that were applied to the traditional model. The lithotypes were grouped into six geological domains, listed by modelling sequence in Leapfrog:

- Bedrock
- Dunite Saprolite (Basic Ore)
- Chalcedony
- Clay (waste)
- Oxide Ore
- Silicate Ore

Geological expertise is essential in defining the relationship between geological contacts and stratigraphic sequence.

MODELLING APPLICATION

In order to model bedrock as a continuous surface, the contact points were extracted directly and interpolated, creating a contact surface for the bedrock. Additional points were included in this process, at the end of the holes that did not intercept the bedrock and, in areas with poor geological information. Both sets of points helped define the bedrock surface.

The dunite saprolite ore bodies have a flat and smooth shape, usually lying on the bedrock surface. This ore type is formed by the weathering process of dunites. To generate this surface, hanging wall contact points from dunite saprolite were used. In addition, in areas where there is no dunite saprolite mineralisation, a minus 2 m offset from the bedrock surface was used to interpolate the dunite saprolite surface (figure 1a). This resulted in a continuous surface along the entire deposit. However, there are only dunite saprolite orebodies where their surface is above the bedrock surface. To guarantee this chronology, Boolean calculations was carried out (figure 1b).

For other rock types exhibiting complex shapes such as strong variations in thickness, length, dip and along the strike, the contact points between the lithotypes were extracted. Once extracted they were converted to a volume function \( f(x,y,z) \) within Leapfrog. Points inside \((>0)\), points outside \((<0)\) and contact point on surface \((=0)\) were then defined. The points were arranged according to the position \((x,y,z)\) related to the contact point. This equation described the infinite numbers of \(x,y,z\) coordinates that lay on the surface. The positive and the negative values increased linearly as they moved away from their point of reference (figure 2). Figure 3a shows the control points that were used for chalcedony modelling and figure 3b shows the geological domain that was constructed from the control points.

Advantages of Leapfrog

- Being able to process a very large dataset of various data formats such as drillhole, channel samples, geologic contact points, structural dataset and topography.
- Having the flexibility to add both points and control lines to the model in order to better reproduce the geology.
- The ability to have the model reproduced to avoid interpretation of subjective bias. This also assisted with due diligence and auditing requirements. Using the same database and parameters (rules), the same isosurfaces and, subsequently, geological domains are created.
- The model can be rapidly built and updated, giving geologists time to evaluate more than one scenario.

The RBF function can easily be fitted by the user to make the model represent the reality as closely as possible. In this study, many different parametric settings were tested to fit the 3D interpolation for each and every lithotype such as isotropic/anisotropic, capping values, nugget effect, resolution, directional bias, and structural trends. This ensured the geometry shapes that best represented the geological deposit were obtained.
Figure 1:
a) Dunite saprolite and bedrock surfaces. The dark grey represents the dunite saprolite presence in the deposit.
b) Dunite saprolite laying on bedrock surface after the Boolean process.

Figure 2:
Positive and negative values increase linearly as they move away from their point of reference (contact point).

Figure 3:
a) Control points that were used for chalcedony modelling.
b) Chalcedony geological domain constructed from the control points.