Geophysical Research Abstracts
Vol. 12, EGU2010-13289, 2010
EGU General Assembly 2010

Using stochastic borehole seismic velocity tomography and Bayesian simulation to estimate Ni, Cu and Co grades.

Lorenzo Perozzi (1), Erwan Gloaguen (1), Stephane Rondenay (2), André Leite (3), Glenn McDowell (3), and Robert Wheeler (3)

(1) Institut National de la Recherche Scientifique, INRS-Eau, Terre et Environnement, Université du Québec, Québec, Canada, (2) Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology , Cambridge, United States, (3) Vale Inco, Toronto, Canada

In the mining industry, classic methods to build a grade model for ore deposits are based on kriging or cokriging of grades for targeted minerals measured in drill core in fertile geological units.
As the complexity of the geological geometry increases, so does the complexity of grade estimations. For example, in layered mafic or ultramafic intrusions, it is necessary to know the layering geometry in order to perform kriging of grades in the most fertile zones. Without additional information on geological framwork, the definition of fertile zones is a low-precision exercise that requires extensive experience and good ability from the geologist.
Recently, thanks to computer and geophysical tool improvements, seismic tomography became very attractive for many application fields. Indeed, this non-intrusive technique allows inferring the mechanical properties of the ground using travel times and amplitude analysis of the transmitted wavelet between two boreholes, hence provide additional information on the nature of the deposit.
Commonly used crosshole seismic velocity tomography algorithms estimate 2D slowness models (inverse of velocity) in the plane between the boreholes using the measured direct wave travel times from the transmitter (located in one of the hole) to the receivers (located in the other hole).
Furthermore, geophysical borehole logging can be used to constrain seismic tomography between drill holes. Finally, this project aims to estimate grade of economically worth mineral by integrating seismic tomography data with respectively drill core measured grades acquired by Vale Inco for one of their mine sites in operation.
In this study, a new type algorithm that combines geostatistical simulation and tomography in the same process (namely stochastic tomography) has been used.

The principle of the stochastic tomography is based on the straight ray approximation and use the linear relationship between travel time and slowness to estimate the slowness covariance model by using the experimental covariances of the travel times. The slowness covariance model is chosen to provide a close match between the computed and the experimental time covariances.

Then, cokriging or, better, conditional simulation of the slowness fields using data is performed. The cokriging provides a smooth interpolation that does not enable to match the observed data (e.g. travel times) . On the other hand, conditional geostatistical simulation helps to select among the many realizations obtained those with the best match to the data. This approach provides much better fit to observed data than obtained from classical inversion, including cokriging, and enables the identification of stable and well-defined features present in most retained realizations.

A sequential Gaussian algorithm, in a Bayesian framework, has been useful to integrating known grades and petrophysical properties to produce many grades realizations of nickel, copper and cobalt. The method used to estimate grades is based on the determination of an in situ relationship between physical properties, measured by geophysics (i.e. P waves velocity) and grades measured on drill cores of the studied area.

This relationship is then applied to the seismic tomography to "update" a prior probability given by grades measured in drill core. Moreover, the stochastic framework of this method allows to produce many realizations of

the grades between boreholes, which can be analysed to quantify the variability of the estimations.

The results obtained from the stochastic tomography improve considerably the understanding of the geological framework of the ground between boreholes. However, the commonly used algorithm like LSQR give a useless result.

Lastly, the Bayesian approach has shown realistic results for the nickel, copper and cobalt estimations.