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Ingeniería de Minas
FACULTAD DE CIENCIAS
FÍSICAS Y MATEMÁTICAS
UNIVERSIDAD DE CHILE

Diploma in Geo-Statistics for Ore Body Evaluation



Version: October 2016

Director: Prof. Xavier Emery

Presentation

The Department of Mining Engineering offers the **Diploma in Geo-Statistics for Ore Body Evaluation**.

The program is oriented to **engineers, geologists and others related engineering professionals**. This program provides students with a broad-based fundamental knowledge of ore body modelling, sampling, geo-statistics, and its practical approximation to resource and reserve evaluation, quantification of uncertainty, and categorization. It is also designed to **strengthen students' communication, problem-solving, critical thinking, and teamwork skills**.



Objectives

The objective of the Diploma is to provide students with state-of-the-art and advanced theoretical and practical tools for geological resources and mining reserves evaluation.

Location: Department of Mining Engineering, Faculty of Physical and Mathematical Sciences - Universidad de Chile, Av. Tupper 2069, Santiago.

Time: Monday to Friday from 9:00 to 13:00 and from 14:00 to 18:00.

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Note 1: *The Department of Mining Engineering has the right to suspend the Diploma if the number of students is not enough to ensure minimum administrative conditions and the quality of the program.*

Note 2: *If one of the lecturers or professors needs to be replaced, the program has the commitment to find a new one with similar background.*

Course description

The Diploma considers 5 intensive courses of one-week length (240 hours) covering different areas of Geo-Statistics and personal work (80 hours) between modules. Here you can find a brief description or contents of the courses of the Diploma. Courses consider among their activities exercises with the supervision of assistants.

Students are required to have adequate English language skills so that they can study the complementary material.

1. Geological Ore Body Models

Introduction: Concepts and definitions. The Mining Business. **Hydro-thermals mechanisms:** Source of hydrothermal fluids, styles of alteration and mineralization, Hydro-thermal alteration processes, stability of sulfides, transport and precipitation of metals in hydrothermal fluids. **Ore Body Models:** Porphyry Copper Type deposits. Skarn Type Ore deposits. Epithermal type deposits. Strata-bound copper deposits. Fe oxide Cu-Au deposits. Sedimentary exhalative deposits. Mississippi Valley type deposits.

1. Geo-Statistics applied to Ore Body Evaluation

Introduction: Objectives and applications of geo-statistics. The geo-statistical model. **Exploratory analysis of data:** Preliminary Validations and exploratory Tools: univariate, bivariate, multivariate, and spatial. Representativeness of data; debundling. Definition of geological units; contact analysis. **Variographic analysis:** Experimental variogram. Definition and properties of a theoretical variogram. Basic variogram models and nested models. Nugget effect. Anisotropy modelling. Practical recommendations. Cross validation. **Resource Estimation:** Traditional view. Kriging construction, plan, and properties. Kriging variations and block kriging. Elements of categorization of resources and reserves. Elements of geostatistical simulation.

2. Sampling and Quality Control for Ore Body Evaluation

Introduction. Sampling constant and error evaluation: Fundamental error. Parametric method. Heterogeneity test. Nomograms. Granulometry distribution. Sampling design. **Additional errors:** Segregation, delimitation, extraction, and preparation errors. Analysis of errors: Ingamells test. **Control and quality assurance:** Introduction to QA/QC. Outcome treatment for duplicates. Outcome treatment for standards. **Special sampling topics:** Principles, codes and good practices. Economic impact of sampling in reserves evaluation. **Site visit.**

3. Geology and Grades Geo-Statistical Simulation

Introduction: Exploratory and variographic data analysis. Simple and ordinary Kriging. **Principles of geo-statistical simulation:** The probabilistic model in geo-statistics. Kriging vs. Simulation. Conditional vs. non conditional simulation. Simulation models and validation examples. Post-processing and application examples. **Simulation of grades and continuous variables:** Gaussian transformation, multi-Gaussian model, main simulation algorithms, and data conditioning. Practical aspects and application examples. **Simulation of geological units and categorical variables:** Truncated Gaussian model and Pluri-gaussian model. Practical aspects and

application examples. **Geo-Statistical simulation applications:** Rock type and grade uncertainty. Combined modelling of geological units and grades. Resources and reserves categorization

4. Special Topics in Geo-Statistics

Multivariable Geo-Statistics: Introduction, data analysis, variograms, kriging and co-kriging. Modelling of geological uncertainty: co-simulation. Continuous and discrete variables. **Special Topics:** Recoverable resource estimation: multi-Gaussian kriging, disjunctive kriging, uniform conditioning, and others.

5. Categorization and Resources and Reserves Report

Categorization and Report of Resources and Reserves: Introduction. International Codes for the report of resources and reserves. Principles of categorization. Categorization methodologies. **Final presentation of individual work**

Each program's module will be evaluated through tests/readings/presentations/reports and/or a final exam. The minimum passing grade is 4,0 on a scale from 1,0 to 7,0.

Professors and Lecturers

- **Prof. Brian Townley, Geologist**, Ph.D. in Geology, Queen's University, Canada
- **Prof. Xavier Emery**, Civil Engineer, Docteur en Géostatistique, Ecole Nationale Supérieure des Mines de Paris, France.
- **Dr. Eduardo Magri**, Mining Engineer, Ph.D. in Mining Engineering (Geo-Statistics Reservoir Evaluation), University of Witwatersrand, South Africa.
- **Prof. Antoni Magri**, Agronomist Engineer, Ph.D. in Engineering from Cornell University (2007).
- **Mr. Alejandro Cáceres**, Geologist, M.Sc. in Geology, University of Chile .

Application and Admission Requirements

There are limited positions and are offered in strict order of registration. Candidates fulfilling the following requirements, may apply to the Diploma:

- Hold a bachelor degree in a discipline related to the program. They may also apply those who hold a professional degree which level, content and duration of studies correspond to an equivalent to the degree of Bachelor of the University of Chile.
- Curriculum Vitae

- Application Form

Each application will be resolved by the Academic Director of the Program, who will decide the acceptance or decline of the admission, based on the information presented.

Interested people registering the Diploma must apply to the program by sending the documents described above to: diploma@minas.uchile.cl

Fees

The cost of the Diploma is US\$11,000.

- Enrollment: US\$ 500 (when being accepted in the program)
- Module 1: US\$ 3,000. - (units 1 and 2)
- Module 2: US\$ 3,500. - (units 3 and 4)
- Module 3: US\$ 4,000. - (units 5 and 6)

- All candidates must pay an enrollment fee of US\$ 500 -CLP \$ 350,000. This amount will be discounted from the total cost.
- Students that are sponsored by their companies must send a letter of support and a payment order.

Certification

After requirements are fulfilled, the student will receive a **Diploma in Geomechanics Applied to Mining**, issued by the Faculty of Physical and Mathematical Sciences of the University of Chile.