

Predictive Geometallurgy and Geostatistics Lab Queen's University

Annual report 2020

This report summarizes the ongoing research of the Predictive Geometallurgy and Geostatistics Laboratory at Queen's University in Kingston, Ontario, Canada. This year, two students graduated with a Master of Applied Science, two new students joined the group, we had two visiting Ph.D. students from Universidad de Chile and one Master in Geology student doing a summer internship.

The following two Master in Applied Science theses were completed in this period:

- Maria Bolgkoranou, M.A.Sc. (Dec. 2019), "[Multivariate Geostatistical Simulation of Compositional Data Using Principal Component Analysis](#)"
- Ilkay Cevik, M.A.Sc. (Sep. 2020), "[Machine learning enhancements for knowledge discovery in mineral exploration and improved mineral resource classification](#)"

The work in this annual report includes that of the six current graduate students, two visiting Ph.D. student and one graduate summer intern. The research group is composed of:

- Mehmet Altinpinar, M.A.Sc. student
- Sebastian Avalos, Ph.D. student
- David Casson, Ph.D. student
- Fouad Faraj, Graduate summer intern
- Mauricio Garrido, visiting Ph.D. student (Geology)
- Kasimcan Koruk, M.A.Sc. student
- Carlos Moraga, visiting Ph.D. student (Mineral Processing)
- Victor Petryshen, M.A.Sc. student
- Alvaro Riquelme, Ph.D. student

Three faculty collaborate with the lab, supporting the research and co-advising students:

- Willy Kracht, Adjunct Professor – The Robert M. Buchan Department of Mining (Queen's University) and Associate Professor – Department of Mining Engineering (U. de Chile)
- Asli Sari, Assistant Professor – The Robert M. Buchan Department of Mining (Queen's University)
- Brian Townley, Associate Professor – Department of Geology (U. de Chile)

Fifteen contributions are available this year, totaling 270 pages, and including diverse topics related to predictive modeling in the mining value chain. Industrial collaboration with SRK Consulting Canada, through Mitacs, and Natural Research Council (NRC) have also contributed to new ideas and models,

applied to different problems. An NSERC Alliance project in collaboration with ArcelorMittal was also approved and will start in the next month.

As always, we welcome industrial and academic collaboration. This provides opportunities to fund new graduate students and novel research, and directly benefits industrial partners. If interested, please send a note to julian.ortiz@queensu.ca.

Julian M. Ortiz

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Director, Predictive Geometallurgy and Geostatistics Lab
Queen's University

September 2020

Table of contents

Ortiz JM (2020) <i>An Introduction to Sequential Gaussian Simulation</i> , paper 2020-01	7
Faraj F, Ortiz JM (2020) <i>An unsupervised clustering approach for the geostatistical domaining of univariate data</i> , paper 2020-02	20
Avalos S, Ortiz JM (2020) <i>Multiple-point statistics: tools and methods</i> , paper 2020-03	33
Riquelme A, Ortiz JM (2020) <i>A short note on a Multi-Gaussian model for multivariate estimation and simulation</i> , paper 2020-04	61
Riquelme A, Ortiz JM (2020) <i>Investigating the application of random fields on manifolds in geostatistical modeling</i> , paper 2020-05	70
Casson D, Ortiz JM (2020) <i>Variograms of order w to measure departures from multiGaussianity</i> , paper 2020-06	90
Cevik SI, Ortiz JM (2020) <i>Machine learning in the mineral resource sector: An overview</i> , paper 2020-07	106
Altinpinar M, Ortiz JM (2020) <i>Review of causal inference and modeling</i> , paper 2020-08	130
Altinpinar M, Sari YA, Ortiz JM (2020) <i>Synthetic high-resolution ore deposit model and mine plan</i> , paper 2020-09	147
Garrido M, Townley B, Ortiz JM (2020) <i>Validation of geostatistical simulations of porphyry deposit through geological approach using ioGAS</i> , paper 2020-10	170
Avalos S, Ortiz JM (2020) <i>A guide for pseudoflow in python</i> , paper 2020-11	186
Avalos S, Ortiz JM (2020) <i>Ultimate pit policy via sequential Gaussian simulation</i> , paper 2020-12	195
Moraga C, Kracht, W, Ortiz JM (2020) <i>Mineral processing modeling: a review</i> , paper 2020-13	211
Moraga C, Kracht, W, Ortiz JM (2020) <i>Geometallurgical modeling of generic mineral processing plants</i> , paper 2020-14	237
Garrido M, Townley B, Ortiz JM, Castro J (2020) <i>Integrating geometallurgical best practices in CIM definition standards guidelines</i> , paper 2020-15	257

Journal and Conference Publications and Presentations

Publications in book chapters, peer-reviewed journals and international conferences are listed below for the period 2019-2020. These are not included in this report, since the copyright belongs to the corresponding publishers, but can be requested for personal use or research purposes directly to julian.ortiz@queensu.ca.

Book chapter

1. Ortiz JM, Kracht W (2020) **Casos Aplicados: Big Data en Geometalurgia**, in Big Data en Minería [Spanish], Ruiz del Solar J (Ed.), Beauchef Minería, p. 102-129. http://www.beauchefmineria.cl/wp-content/uploads/2020/09/Estudio_BIGDATA.pdf

Journal papers

1. Avalos SA, Kracht W, Ortiz JM (2020) **An LSTM approach to SAG mill operational relative-hardness prediction**, Minerals, 10 (9), 734. <https://doi.org/10.3390/min10090734>
2. Avalos S, Ortiz JM (2020) **Recursive Convolutional Neural Networks in a Multiple-Point Statistics framework**, Computers & Geosciences, 141, 104522. <https://doi.org/10.1016/j.cageo.2020.104522>
3. Avalos SA, Kracht W, Ortiz JM (2020) **Machine Learning and Deep Learning Methods in Mining Operations: a Data-Driven SAG Mill Energy Consumption Prediction Application**, Mining, Metallurgy & Exploration, 37(4): 1197-1212. <https://doi.org/10.1007/s42461-020-00238-1>
4. Garrido M, Sepulveda E, Ortiz JM, Townley B (2020) **A Methodology for the Simulation of Synthetic Geometallurgical Block Models of Porphyry Ore Bodies**, Natural Resources Research. <https://doi.org/10.1007/s11053-020-09692-6>
5. Santibáñez-Leal FA, Ortiz JM, Silva JF (2020) **Ore-waste discrimination with adaptive sampling strategy**, Natural Resources Research, 29: 3079-3102. <https://doi.org/10.1007/s11053-020-09625-3>
6. Calderón H, Santibáñez F, Silva JF, Ortiz JM, Egaña A (2020) **Geological facies recovery based on weighted l1-regularization**, Mathematical Geosciences, 52(5): 593-617. <https://doi.org/10.1007/s11004-019-09825-5>
7. Haas J, Moreno-Leiva S, Junne T, Chen P-J, Pamparana G, Nowak W, Kracht W, Ortiz JM (2020) **Copper mining: 100% solar electricity by 2030?**, Applied Energy, 262, 114506. <https://doi.org/10.1016/j.apenergy.2020.114506>
8. Díaz GF, Ortiz JM, Silva JF, Lobos RA, Egaña AF (2020) **Variogram-based descriptors for comparison and classification of rock texture images**, Mathematical Geosciences, 52(4): 451-476. <https://doi.org/10.1007/s11004-019-09833-5>
9. Ortiz JM, Kracht W, Pamparana G, Haas J (2020) **Optimization of a SAG mill energy system: integrating rock hardness, solar irradiation, climate change and demand side management**, Mathematical Geosciences, 52(3): 355-379. <https://doi.org/10.1007/s11004-019-09816-6>

Conference papers

1. Jelvez E, Morales N, Ortiz JM (2019) ***Impact of geological uncertainty at different stages of the open-pit mine production planning process***, in: Topal E. (eds), Proceedings of the 28th International Symposium on Mine Planning & Equipment Selection – MPES 2019, Springer Series in Geomechanics and Engineering, 83-91.
2. Garrido M, Ortiz JM, Sepulveda E, Farfan L, Townley B (2019) ***An overview of good practices in the use of geometallurgy to support mining reserves in copper sulfides deposits***, Procemin-Geomet 2019, 6th International Seminar on Geometallurgy, Santiago, Chile, November 20-22, 2019, 12p.

In addition to these papers, several presentations, posters and webinars were delivered this year:

1. Ortiz JM (2020) ***Predictive geometallurgical modeling***, presented to AngloAmerican, Toronto, ON, March 2, 2020.
2. Ortiz JM, Cevik SI, Avalos S, Kracht W, Leuangthong O (2020) ***Machine learning and deep learning in predictive geometallurgical modeling***, presentation at PDAC, Toronto, ON, March 4, 2020.
3. Cevik IS, Ortiz JM, Olivo GR (2020) ***A combined multivariate approach analyzing the geochemical data for knowledge discovery: the Vazante-Paracatu Zinc district, Minas Gerais, Brazil***, poster, PDAC-SEG student mineral colloquium, Toronto, ON, March 3, 2020. Wins 3rd place in Master's category.
4. Ortiz, J. M. (2020) ***Panel Discussion: Challenges, Innovation & AI in Mining: Chile – Canada***, webinar invited by Redicec (Red de Investigacion Chile Canada), September 23, 2020. <https://youtu.be/jWKjQSez-4>
5. Ortiz, J. M. (2020) ***Geostatistics and machine learning for resource estimation and classification***, webinar [Spanish] invited by Instituto de Ingenieros de Minas de Peru, September 15, 2020. <https://www.facebook.com/watch/?v=1148970302167164>

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