No. 109 December 2024

IAMG Newsletter

Official Newsletter of the International Association for Mathematical Geosciences

Contents

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YouTube

The IAMG now has a YouTube channel! Presentations from past IAMG award winners have been uploaded where available.

The topics include:

- Quantitative simulation and prediction of extreme geological events
- Computational optimal transport
- Tree stumps as "bioindicators"
- Conditioning of random forest for spatial prediction
- Data-driven discovery in mineralogy
- Contaminant source identification in aquifers
- Monitoring of induced seismicity
- Optimal transport and geophysical inversion

https://www.youtube.com/@IAMG-mathgeo

The 37th International Geological Congress in Busan, South Korea was a great success. As well as hosting several session the IAMG awards for 2024 were presented and the annual meetings were held. Along with the five days of presentaions, there were many interesting field trips and workshops. Photos from the event are below and on page 9. The next IGC will be in August 2028 in Calgary Canada.

The next IAMG conference will be held in Zhuhai, China on 8-14 October 2025. Abstract submissions are due by Februry 28th 2025, and more information is on pages 6 and 7.

Katie Silversides

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IAMG annual meeting

Left: IAMG booth

IAMG is on LinkedIn, Twitter and Facebook!

Join the conversation using @IAMG_Math_Geo

The mission of the IAMG is to promote, worldwide, the advancement of mathematics, statistics and informatics in the Geosciences

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PRESIDENT'S FORUM

Our IAMG is approaching its sixtieth anniversary, which we will celebrate at the end of term of this incoming Council. In these many years, it has seen an evolving world, with ever changing ideas about what science is, of what should be the relationship of Science and scientists with the broader society, and, more specifically, of what should be the role of a small scientific association like ours. There was a time when the IAMG had two Treasurers, to be able to keep offering support on both sides of the iron curtain: are we going to have to re-implement that in the near future? There was a time when our Journals were published by different publishing houses, when quantity did not matter over quality: shall we have to rethink the color of our journals, whether they are green or gold? There was also a time when geologists and geoscientists did not have to ask themselves how their everyday work impacts the very future of humanity: how are we going to position ourselves as IAMG when our own members may not share a worldview? These may seem to be far fetched questions, but they will surely reappear during the next four years. For the time being, however, there are more pressing issues to discuss.

The 37th IGC was successfully held in Busan, South Korea, and the IAMG contributed 5 sessions, including one for honoring our awardees and lecturers. After the Covid pandemic made celebrating the 36th IGC in Dehli, India, impossible, this was our opportunity to reconnect with colleagues and friends of the sister associations and of the IUGS. In Busan we learnt that our next chance to meet them will be in 2028 in Calgary, Canada. This will be the second opportunity for IAMG members to gather in Canada during this term of Council, as the IAMG Annual conference in 2026 will be held in Montreal.

According to our statutes we had to hold the Council elections before the venue for IGC 2028 was announced. As a consequence, the post of IGC councillor was left vacant, and the Council later appointed Dr Jeff Boiservt of the University of Alberta, Canada to that post. If choosing the IGC venues with only 4 years in advance is going to be the new rule at IUGS, we might need to discuss changes in our statutes to bring back the right of the members to elect the entire Council.

The statutes and bylaws are our Constitution, they regulate what the IAMG is and how it should work. But a scientific society is nothing but an empty shell without its members, each one of us. The IAMG needs engaged members, there are committee posts and other volunteer positions to be filled, all doing important work in ensuring the scientific supervision of our publications, preparing this newsletter in a timely manner , supporting students and other early career researchers, making the IAMG better known outside the association, organising our annual meetings, keeping our institution working and honoring the achievements of our peers with distinctions and awards. This is demanding work that we all do on a voluntary basis. The past Council implemented some rationalisation and consolidation of the tasks to be done , and this one will continue this good work to ensure that we do things efficiently. But still, there are vacancies to be filled, new blood is needed in all our committees, journals and organisational posts. If you want to help, please send an email to support@iamgmembers.org.

Speaking of vacancies, Tim Coburn has expresed his wish to retire as soon as possible, also from his responsibility as IAMG Treasurer. Since Madalyn Blondes, the 2020 elected Treasurer, had to step down, the IAMG has been experiencing quite a complicated situation with respect to governance. Altogether, I have the impression that the outgoing Council had to deal with one of the most difficult terms of the last 40 years. The Covid pandemic made travel very difficult to impossible, impacting our meetings, the activities of our Distinguished and Matheron Lecturers and also the ablity to hold physical Council meetings. The vacancy at the post of Treasurer made things just worse. I think we owe the outgoing council our deep gratitude. Although our financial situation is not worrying in the short to medium term, it is only thanks to Sean McKenna and Tim Coburn, who have acted as Treasurers in the past two years, that we are coming back to a steady way of doing business. The budget for 2025 will be passed soon and our past tax declarations are being filed as mandated by the US laws, perhaps all these will already have been approved by the time you read this letter. The Council will again have to appoint the next Treasurer, and we are also discussing several changes to alleviate the burden on the Treasurer and to keep institutional memory of the Treasurer tasks and tricks. Hopefully, the IAMG will then be less prone to such a state of turmoil if a Treasurer needs to step down. These will require more changes in the statutes and bylaws.

In the election I ran for president with a program to implement these changes, in collaboration with the elected Council. This does not happen in a few days: changes in the statutes or the bylaws require months of discussion, preparation and a binding general referendum. We will most probably have one such referendum during this term. When the moment arrives, I will again use this forum to request that all members participate in this very important process.

Before contributing to the IAMG conferences or volunteering in governance posts, voting in elections and referendums is the most elementary form of participation in an association. The meagre turnout at the past election does not leave us as association

in a good light, with around 75% of the members not using their right to vote. I personally find this low turnout a very worrying signal. There are surely many different reasons and, given the secrecy of the ballot, it is going to be a tough task to remediate this situation. I do not want to play the blame game, we are humans: I for instance forgot the Council election two periods ago. But I am afraid that some of our life members may not be emotionally engaged with IAMG anymore or perhaps simply have changed positions and forgot to update their contact details. There can be many other reasons: If you have any suggestion of why we have such a low level of participation or any ideas of how to change that, do not hesitate to contact us at council@iamgmembers.org.

Finally, I would like to close this letter by encouraging every member to participate in our next forum: the 23rd annual conference of the IAMG to be held in October 2025 in Zhuhai, China. The deadline for short abstract proposals is 15th April 2025. Please, contribute! Come to Zhuhai! This is also a great way to show your committment to the IAMG.

Raimon Tolosana Delgado

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Distinguished Lecturer Updates

Distinguished Lecturer 2025
Jeff Boisvert

Dr. Jeff Boisvert is a professor in Civil and Environmental Engineering, School of Mining and Petroleum Engineering, at the University of Alberta and co-director of the Centre for Computational Geostatistics (CCG). His research focuses on spatial modeling and geostatistics in the fields of mining, energy, and wildfire. He uses spatial numerical models to improve decisions in mine design, resource/reserve estimation, wildland fire management/response, and well planning/ placement/management.

Lecture 1: The future of machine learning and model validation in the earth sciences: The good, the bad, and the ugly

The earth sciences are being transformed by advances in machine learning (ML) and artificial intelligence. From optimizing mineral exploration and hydrocarbon production to improving wildfire prediction and management, these methods offer exciting opportunities for modeling and decision-making. However, these advances bring challenges with model validation, which is critical for ensuring that predictions are robust, reasonable, and actionable.

This lecture will delve into the evolving role of ML in the mining, hydrocarbon, or wildfire industry, highlighting successes, pitfalls, and future prospects. “The Good” will explore case studies and implementations where ML has significantly improved modeling, decision making, and inference. “The Bad” will examine common pitfalls, including data biases, overfitting, and the misuse of algorithms without understanding domain constraints. Finally, “The Ugly” will confront the ethical and operational risks posed by poorly validated models, emphasizing the importance of transparency and domain experts.

We will discuss best practices for integrating ML into earth sciences while addressing the complexities of model validation. At the request of the attendees, the focus of this lecture will be on mining, hydrocarbon, or wildfire applications.

Lecture 2: Understanding, incorporating, and assessing the impact of uncertainty in our decisions: Why are we still so reluctant?

Uncertainty is an inherent aspect of decision-making in the earth sciences, particularly in mining, hydrocarbon, and wildfire domains. Whether estimating ore reserves, forecasting hydrocarbon production, or predicting wildfire behavior, uncertainties arise from data limitations, model assumptions, and complex natural processes. However, often there is still a reluctance to fully embrace uncertainty in decision-making frameworks. Why do we hesitate to quantify, incorporate, and communicate uncertainty? What are the consequences of this reluctance? What opportunities are we missing?

This lecture explores the technical, psychological, and organizational barriers to addressing uncertainty in earth sciences. We will examine real-world examples where underestimating uncertainty led to costly errors, as well as cases where effectively managing uncertainty improved outcomes. By contrasting these scenarios, we will highlight and quantify the critical role uncertainty plays in making informed decisions. Key themes include strategies for quantifying and visualizing uncertainty, integrating uncertainty into predictive models, and fostering a cultural shift toward embracing probabilistic thinking. At the request of the attendees, the focus will be on applications in mining or wildfire management.

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Distinguished Lecturer 2024
Report from Michael Pyrcz

Michael has decided to focus on US Universities during his tour as IAMG distinguished lecturer. This was in part a reaction to his observation at Geostats 2024 that the USA may need more promotion of IAMG than perhaps Europe, which was part of his original plan.

At this stage Michael has completed visits to the University of Houston, Penn State, Rice University, Stanford, and Montana Tech.

During these visits, he typically spent the whole day engaging with faculty and students. During one of the visits he was invited to guest lecture in a regular course. The IAMG lectures were well-attended and sparked a lot of enthusiasm and insightful questions.

Key messages which he shared include:

- Geoscience and subsurface engineering are the original data science.

- It's essential to retain our domain expertise while applying data science in subsurface modeling.

- Our unique skills and knowledge in geostatistics remain critical to the field.

Michael says that he met many graduate students who are not familiar with the IAMG, confirming his impression that the USA may need more attention. But he was truly inspired by the exceptional students and dedicated professors he has met along the way. This trip has deepened his pride and appreciation for our scientific community.

The following universities are also included on the DL tour: Oklahoma University, Viginia Tech University, and there are another 2 or three universities on his list.

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IAMG Student Chapter Freiberg Welcomes a New Generation

In late November, the IAMG Student Chapter Freiberg hosted an information session for students interested in shaping its future.

President Raimon Tolosano-Delgado introduced IAMG's vision and student opportunities, sparking lively discussions over barbecue and "Glühwein."

A new group of students began forming ideas for future programs, with Jörg Benndorf from TU Bergakademie Freiberg stepping in as academic advisor.

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International Applied Geochemistry Symposium 2024

The International Applied Geochemistry Symposium (IAGS) was held in Adelaide Australia from 14th – 18th October and was organised by the Association of Applied Geochemists (AAG).The symposium included a technology session that was chaired by Peter Dowd and included a keynote presentation by Renguang Zuo entitled "Big data analytics and Artificial Intelligence driven geochemical mapping".

In addition, Renguang was awarded the AAG Gold Medal. The photograph below shows Renguang being presented with the AAG Gold Medal.

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Dear fellow (mathematical) geoscientists,

The conference theme of the 23th Annual Conference of the International Association for Mathematical Geosciences is data-driven discovery in geosciences.

Zhuhai is located at the southern tip of the Pearl River Delta of Guangdong Province. It faces Hong Kong to the east across the sea and joins Macau to the south and Zhongshan to the north. The completion of the Hong Kong-Zhuhai-Macao Bridge makes Zhuhai the only city in the mainland that connects Hong Kong and Macao by land. Zhuhai is a gardenlike coastal city with 146 charming islands. There are not only long coastlines and excellent beaches, but also a large number of parks which are scattered in every corner of the city. In October, the weather in Zhuhai is usually quite pleasant. Temperatures typically range from 20°C to 28°C (68°F to 82°F), with moderate humidity and less rainfall compared to the summer months. It's a great time for outdoor activities and sightseeing.

Sun Yat-sen University (SYSU) (https://www.sysu.edu.cn/sysuen/index.htm) is one of the top comprehensive universities in China. It has five campuses and ten affiliated hospitals in Guangzhou, Zhuhai, and Shenzhen. SYSU serves 68,781 students, including 33,686 undergraduates, 24,295 master's students, and 10,800 doctoral students.

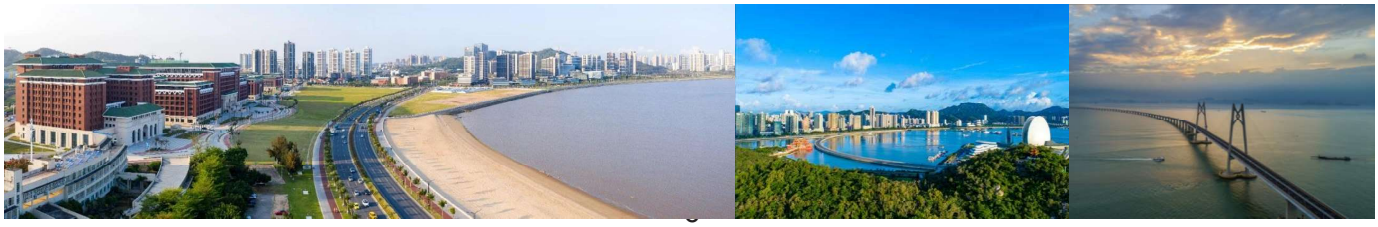
The conference will be held on Zhuhai campus of the Sun Yat-sen University (SYSU) and is surrounded by mountains on three sides and faces the sea on the fourth and is known for its beautiful scenery and pleasant landscapes. The campus is home to about 20 schools and faculties covering a full array of disciplines, including earth sciences and engineering, atmospheric sciences, marine sciences and engineering, physics and astronomy, geospatial engineering, mechanical engineering, software engineering and artificial intelligence, etc.

As the main hosting faculty, the School of Earth Science and Engineering was founded in 1924, formerly known as the department of mineral geology. It now hosts about 100 faculties and staffs and about 400 undergraduate students and a few hundred MSc and PhD students enrolled Geological Sciences, Geophysics or Geological Engineering. The school of earth science and engineering has a Guangdong Key Laboratory of Geological Processes and Mineral Resources Exploration, a Guangdong Key Laboratory of Geodynamics and Geological Disasters and a Guangdong Engineering Center on Deep Earth Geophysical Exploration. It is establishing a new International Center for Research on Big Data and Mathematical Geosciences for Prediction of Extreme Geological Events.

Hope to see you in Zhuhai! Your IAMG2025 organizing team

Important dates

2025/04/15	Short abstract submission deadline	2025/10/09	Short Courses, Registration, Ice-Breaker
2025/07/30	Acceptance notifications to authors		
2025/08/30	Early bird registration deadline	2025/10/10-13	Scientific Sessions
2025/10/08	Short Courses	2025/10/14	Field trips



Keytopics

+ Artificial Intelligence: A new paradigm for geoscience research
+ Big data and geoscience knowledge graphs
+ Cloud computing and geosc. data analysis
+ Compositional Data Analysis
+ Computational Geodynamics
+ Deep-time Digital Earth
+ Extreme geological events and geoscience big data analytics
+ Education of next generation mathematical geoscientists
+ Fractal/multifractal modelling +application
+ Geoinformatics
+ Geostatistics
+ Geological process modelling and simulation
+ Geoscience big data platform and computing power
+ Hydrology and Hydrogeology
+ Hyperspectral methods
+ Machine Learning
+ Mathematical geoscientific contribution to global sustainable development
+ Predictive mapping in geosciences
+ Prediction and assessments of resources in frontier regions
+ Quantitative solutions for global change
+ Remote sensing
+ 3D visualization and virtual reality for geoscience

Suggested focal topical sessions per December 1st

+AI-driven Numerical Modeling and Data Assimilation in Geodynamics
Fan Xiao, Dunhui Xiao, Zenghua Li, Xiaohui Li, Zhankun Liu, Xinguang He
+Spatial Association **Yongze Song**
+Ontologies, Knowledge Graphs, and Large Language Models in Geoscience: Construction and Application
Xiaogang Ma, Chengbin Wang, Anirudh Prabhu
+AI-driven Mineral Prospectivity Modeling **E. John Carranza, Renguang Zuo**
+Machine Learning Applications in Geoscience Research
Enamundram Chandrasekhar, Sang-Mook Lee, Byung-Dal So
+Current Trends in Spatiotemporal Modeling
Dionysios Christopoulos, Sandra De Iaco, X San Liang, Emmanouil Varouchakis
+Data-Driven Innovations for Mineral Exploration Decision-Making: Addressing Present and Future Challenges **Behnam Sadeghi, David Zhen Yin, Rian Dutch, Putra Sadikin, Richard Scott**
+Enhancing Quantitative, Geotechnologies and Programming Skills in Geosciences Education
Francisco Tognoli
+The 3D/4D geological modeling and targeting for mineral exploration
Gongwen Wang, John Carranza, Deng Hao, Zhiqiang Zhang
+Recent developments in constructing geological structures: Beyond conventional methods **Weisheng Hou, Mathieu Gravey, Baoyi Zhang, Nan Li, Yanshu Yin, Jiateng Guo, Qiyu Chen, Xiaohui Li**
+Mining geostatistics, optimization and geometallurgy
Raimon Tolosana Delgado, Jörg Benndorf, Julian Ortiz, K. Gerald van den Boogaart
+Compositional and density data analysis in geosciences
Karel Hron, Alessandra Menafoglio, Jennifer McKinley
+Marginal Seas - Modeling of interfaces between continents and oceans for sustainable development
Jan Harff, Junjie Deng, Joanna Dudzinska-Nowak, Jinpeng Zhang
+Towards Large AI Models for Geosciences
Suihong Song, Xiaocai Shan, Keyu Liu, Xin Li, Mingliang Liu

Abstract submission open!

We welcome contributions from all areas of Mathematical Geosciences and Geoinformatics either to one of our focal topical sessions or to one of the general conference themes around common methods and topics.
Please submit your abstract via the conference website with a title, a short abstract (up to 300 words) and an optional graphical abstract.

Abstract submission closes April 15, 2025

www.iamgconferences.org/iamg2025

IAMG Journal Reports

Journal Statistics

Mathematical Geosciences:

- 2023 ISI Impact factor: 2.8
- 5-Year Impact Factor: 2.4
- Average review time: 7 days (submission to first decision (median))

Computers & Geosciences:

- 2023 Impact Factor: 4.2
- 5-Year Impact Factor: 4.4
- Average review time: 11 days (submission to first decision (median))

Natural Resources Research:

- 2023 ISI Impact Factor: 4.8
- 5-Year Impact Factor: 4.6
- Average review time: 7 days (submission to first decision (median))

Applied Computing and Geosciences:

- 2023 ISI Impact Factor: 2.6
- 5-Year Impact Factor: 2.7
- Average review time: 5 days (submission to first decision (median))

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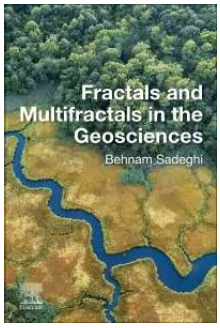
Member News

Fractals and Multifractals in the Geosciences by Behnam Sadeghi

Fractals and Multifractals in the Geosciences details the application of a wide range of multifractal methods, along with the assessment of uncertainty in sample classification and stability of spatial patterns. This book also provides criteria for selection of the most effective combination of data pre-processing and multifractal modeling to extract desired features or signals in the data. The book aims to introduce, apply, and test novel multifractal models that account directly for changes in relationships between variables, as well as the effects of distance between samples and the source of anomalous metal contents. Linked to this will be assessment of the effects of different pre-processing of data prior to application of the models and quantification/model uncertainty in geochemical anomaly maps, associated with sample classification and spatial interpolation. Gaussian simulations such as Sequential Gaussian Simulation and Monte Carlo Simulation will be applied to the new multifractal models developed and a suite of existing models.



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Abduction, exploratory data analysis and data-intensive geoscience

Several conferences in the past few years, including IAMG, AGU, GSA, and IGC, have shown the increasing interest of theories and methods for data-intensive geosciences. Indeed, comparing with 10 or 20 years ago, many of us are now in a data-rich world (we hear the buzz word 'big data' almost every day, right?). In this short essay I would like to discuss a few concepts and present some of our experience.

Personally, I prefer to describe the current situation as data-intensive geoscience, which might be more comprehensive than data-driven geoscience. I have the fresh memory of discussing data-driven and knowledge-driven approaches with my advisor John Carranza during my PhD student time. A few years ago, in a few scientific programs we also brought up the big concepts of induction, deduction and abduction, as well as the method of exploratory data analysis initiated by John Tukey. I tried to draw a diagram to put all those concepts together, and Carranza generously shared a slide from his lectures for me to adapt. The diagram below shows the output.

When I put together all the concepts and analyzed

Abduction	Deduction	Induction
Create hypothesis	Explicate hypothesis	Verify hypothesis
Exploratory	Conceptual	Empirical
Mixed approach	Knowledge-driven	Data-driven
Plausible prediction	General to specific	Specific to general

their relationships, ChatGPT was not published yet. It took me a few days to think and fit them into the structure of one diagram. Now, with ChatGPT I can easily get a summary (and it is a good one) in a few seconds: "Abduction, induction, and deduction are three fundamental reasoning methods used in logic and scientific inquiry. Deduction is a top-down approach that begins with general premises and applies them to specific cases to reach certain conclusions. For instance, if all humans are mortal and Socrates is a human, it logically follows that Socrates is mortal. This method guarantees the

truth of the conclusion as long as the premises are accurate. Induction, on the other hand, is a bottom-up approach. It involves deriving generalizations from specific observations, leading to probable conclusions. For example, if every swan observed so far is white, one might conclude that all swans are likely white. This method forms the basis of scientific reasoning, where repeated observations inform broader theories. Abduction, or inference to the best explanation, starts with an observation and seeks the most plausible hypothesis. For instance, if the grass is wet, one might hypothesize that it rained last night. While abduction doesn't guarantee accuracy, it is valuable for generating hypotheses when dealing with incomplete information. Together, these methods form a comprehensive framework for reasoning, hypothesis generation, and scientific exploration."

There are a few other funny notes about those concepts. Bob Hazen once described Induction and Deduction as methods to study "what we know we do not know", while abduction is to study "what we do not know we do not know". In an article authored by Frits Agterberg in 2001, "Appreciation of Contributions by Georges Matheron and John Tukey to a Mineral-Resources Research Project", he also mentioned the help from Tukey on data-intensive research. In our research, we have successfully applied abduction and exploratory analysis in recent work of mineral informatics. One highlight is the serval datathons we organized, where travel grants were provided for students and early-career professionals to attend the event. In the past three years we have organized four such datathons and another one has taken place in November 2024. We have summarized an informal guideline for the datathon "Bring the right people; provide good coffee and beer; and shake well". The photo below was taken in December 2022 during a datathon at the Earth and Planets Laboratory, Carnegie Institution for Science. The building in the background is the Historic Atomic Physics Observatory, now a storage. The building is known locally as "The Atom Smasher", where Enrico Fermi, Niels Bohr, and other colleagues witnessed one of the first nuclear fission experiments in US on January 28, 1939.

Xiaogang Ma

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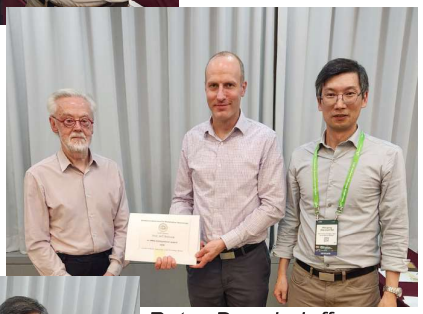
IGC2024

Ute Mueller, Raimon Delgado and Jennifer McKinley

Peter Dowd, Jennifer McKinley and Xiaogang "Marshall" Ma



Peter Dowd, Jeff Boisvert and Xiaogang "Marshall" Ma

Peter Dowd, Joao Felipe Costa, and Xiaogang "Marshall" Ma

Right: Jennifer McKinley, Jeff Boisvert and Joao Felipe Costa

Conference dinner

Student Journal Research Grants: 2023 Reports

CG-2023-6: Nurassyl Battalgazy, Australia - Application of Deep Learning in Resource Estimation

Abstract: As active mineral deposits continue to be depleted and new outcropping mineral deposits become more rare, the exploration of new undeveloped orebodies is becoming more challenging and expensive, exploration and evaluation of new ore bodies present significant challenges due to their complex geological structures. New undeveloped orebodies tend to have more geological complexity, and thus, grade control by traditional geostatistical methods can often be very challenging given the complex geological structure of deposits. Traditional geostatistical methods, such as kriging, often struggle to accurately estimate ore grades in these environments, especially when confronted with high nugget effects in variogram modelling and insufficient drillhole density. These limitations can lead to suboptimal mineral resource estimations. This research investigates the application of Machine Learning (ML) and Deep Learning (DL) techniques, specifically Convolutional Neural Networks (CNNs), to enhance resource estimation in complex geological settings. One of the main objectives of this research is to build an intelligent system that will search for patterns to understand the characteristics of the dataset, so that it is used in predicting ore grades on unknown samples that follow the distinctive attributes of orebody (geometry, structure). Unlike conventional methods that primarily focus on spatial continuity, DL approaches can simultaneously incorporate multiple input features such as structural information. The findings suggest that while DL offer promising results in handling complex geological structures and integrating multiple data inputs, they should complement rather than replace traditional geostatistical methods. High-quality data and careful model integration are critical for leveraging DL's full potential, which is the main limitation of the DL technique.

CG-2023-7: Tobi Ore, USA - Diffusion Implicit Models Based Seismic Inversion

Abstract: Solving seismic inverse problems involves the reconstruction of structures and properties of the subsurface from seismic data. This is crucial in various fields such as energy exploration, earthquake seismology, and civil engineering for infrastructure assessment as accurate imaging of subsurface structures helps in making informed decisions. This is achieved through inversion, which is a computationally demanding non-linear, ill-posed optimization problem that is highly dependent on the quality of the initial model and is plagued by issues such as cycle skipping. To address this, several data-driven approaches have been proposed that leverage the advancement of deep learning. In this study, we propose a novel framework, InversionDDIM, that leverages the generative capability of the diffusion model by reformulating it for seismic inverse problems to generate the initial velocity model. This architecture distinguishes itself from previous encoder-decoder and GAN-based data-driven seismic waveform inversion methods through its superior performance on complex synthetic datasets. This framework is not limited to only velocity inversion. It has the capability to predict any reservoir properties with a link to the seismic amplitude and for simultaneous inversion. We anticipate our model to be a starting point for more sophisticated applications of diffusion models in geophysics.

CG-2023-11: Jianwei Chen, China - Intelligent Fault Detection Based on 3D Seismic Data Using Vision Transformer Model

Abstract: Automatic fault detection in seismic data is a critical task in seismic interpretation, especially for oil and gas exploration. While traditional CNN models like FaultSeg3D have shown some effectiveness, they struggle with complex fault features, particularly small-offset and long-distance faults. This paper introduces a Transformer-based model — Seismic Axial Transformer U-Net (SATU-Net), which improves fault detection by leveraging the Transformer's strong global context modeling capabilities. SATU-Net incorporates an axial self-attention mechanism to enhance depth feature capture. Experiments on synthetic datasets and the Kerry subset of real seismic data demonstrate that SATU-Net outperforms FaultSeg3D in metrics such as loss, IoU, and Dice, showing improved continuity and resolution in fault detection. These findings highlight the significant advantages and application potential of the Transformer-based architecture in seismic fault detection.

MG-2023-2: Camilla Fagandini, Italy - Simultaneous identification of contaminant source characteristics and aquifer parameters with Ensemble Smoother

Abstract: In the field of groundwater, accurate delineation of subsurface characterization is critical for designing effective remediation strategies. Hydrogeophysics emerges as a powerful tool for improving the understanding of aquifers by enabling the combination of non-invasive geophysical techniques (i.e., electrical resistivity tomography - ERT) and hydrological variables. This project enhances subsurface characterization by integrating ERT with field concentration observations through the Ensemble Smoother with Multiple Data Assimilation (ES-MDA). The validation of this approach uses real data measured through laboratory experiments. The experimental device (sandbox), which simulates a phreatic aquifer, offers controlled conditions, reproducibility, and flexibility for subsurface research. The sandbox includes a two-dimensional aquifer model, an ERT acquisition system with a 32-electrode array, and tracer tests for monitoring flow patterns and transport dynamics. Once the inverse approach was tested on synthetic data, it was applied using data collected in the laboratory. Two problems were investigated: Case 1 estimated hydraulic conductivity from concentration data, while Case 2 compared synthetic resistivity values to observed data. Future research will focus on refining measurement systems and exploring advanced modelling techniques to better characterize subsurface environments and improve groundwater management strategies.

MG-2023-3: Zhiyi Chen, China -Modelling fluid flow in hydrothermal mineralization system based on physics-informed neural networks

Abstract: Fluid flow in porous media is fundamental to hydrothermal mineralization systems. Traditional methods for simulating fluid dynamics, especially in systems governed by thermal-hydraulic-mechanical-chemical (THMC) coupling, often require expensive labeled data and face challenges in maintaining flux continuity across heterogeneous geological models. This study introduces a Physics-informed Convolutional Neural Network (PICNN) to model transient two-phase slightly compressible Darcy flow in 2D porous media without labeled data. By incorporating a finite volume method-based loss function, PICNN ensures flux continuity across heterogeneous cells and provides reliable pressure distribution predictions, offering a promising alternative to traditional numerical solvers, particularly in situations where physical constraints are essential and labeled data acquisition is costly.

NRR-2023-7: Lei Luo, China - Estimates of Global Porphyry Cu Resources Using Revisited Tectonic

Abstract: For a long time, advanced theoretical and methodological systems of mineral resources prediction and evaluation have played an important role in mineral resources exploration. However, many mineral resource prediction methods are based on two-dimensional geology, geophysics, geochemistry and remote sensing data to calculate the distribution of mineralization probability on the surface and evaluate resource potential, lacking effective portrayal and evaluation of mineral resource potential at different depths. In addition, classical quantitative mineral resource prediction and evaluation methods tend to focus on "static spatial correlation analysis of mineral control elements", without considering the deep-time dynamic evolution process of "source-transport-storage-metamorphism-preservation" of mineralization system. The conventional tectonic diffusion model of treating the mineralization rate parameter simply as a constant, which is not in line with the actual situation, so it is necessary to further constrain this parameter. In this report we use the zircon U-Pb age distribution to constrain the mineralization rate parameters, obtain simulation results under the conditions of changing mineralization rate, and compare with the traditional unconstrained model. The simulation results of porphyry copper deposits show that during 0-300 Ma, a total of 34,440 porphyry copper deposits were formed globally (1.2×10 11 t copper resources), the total data of 28,270 deposits (9.8×10 10 t) were stripped away, accounting for 82.1% of the total number of deposits, and 5,990 porphyry copper deposits (2.1×10 10 t) existed within 0-3 km depth of the earth's crust which accounts for 97.1% of the total number of existing deposits.

NRR-2023-12: Dazheng Huang, China - Exploration geochemical anomaly identification and uncertainty evaluation

Abstract: Geochemical anomaly detection is crucial for mineral exploration but often challenged by uncertainties from sparse sampling, spatial variability, and model limitations. This study combines sequential Gaussian co-simulation (SGCS) with Monte Carlo (MC) Dropout-based deep learning models, specifically Convolutional Neural Networks (CNNs), to address these uncertainties. SGCS generates multiple realizations of geochemical data, allowing for the quantification of spatial variability and uncertainty at unsampled locations. These realizations are used to augment the CNN training dataset, improving the model's robustness in detecting anomalies. Additionally, MC Dropout is incorporated into the CNN to assess prediction uncertainties, providing critical insights for decision-making. The method was applied to a gold-mineralized region in northwestern Sichuan Province, China, demonstrating its effectiveness in detecting geochemical anomalies and quantifying associated uncertainties. This integrated framework enhances anomaly detection and risk assessment, offering a robust solution for improving exploration strategies in uncertain environments.

2024 Recipients

Computers & Geosciences Research Scholarship

CG-2024-2: Qiuyi Lin, Domain adversarial neural network driven by synthetic datasets for mapping mineral prospectivity. China University of Geosciences, China

CG-2024-4: Yerniyaz Abildin. Hybrid Domaining Framework. University of Adelaide, Australia

CG-2024-5: Miguel Bernecker. D4Xgui - a processing tool for baseline correction and standardization of carbonate clumped isotope raw data. Institut für Geowissenschaften, Goethe-Universitüt Frankfurt am Main, Germany

CG-2024-13: Baran Can Yucel. Development of AI based workflows for geostatistical modeling. The Pennsylvania State University Energy Institute, United States

Mathematical Geosciences Student Award

MG-2024-1: Haitao Shang. Probing how the stochastic evolution of geosphere and biosphere influences Earth's sustainability and habitability: A machine-learning approach. University of Oregon, United States

MG-2024-2: Ahmed Merzoug. Static and Dynamic Model Checking of Conditioning Generative Artificial Intelligence Models for Subsurface Modeling. The University of Texas at Austin, United States

MG-2024-3: Bin Wang. Data-driven mineral big data mining in support of mineral exploration. China University of Geosciences, China

Natural Resource Research Student Award

NRR-2024-3: Fanfan Yang. Deep learning algorithm coupled mineral systems for mineral prospectivity mapping. China University of Geosciences, China

NRR-2024-4: Yuepeng Zhang. Research on Prediction and Evaluation of Extreme Geological Events in the Tethys Tectonic Domain Driven by Big Data. State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan, China

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Germany

McGill COSMO
Stochastic Mine Planning Laboratory

POST-DOCTORAL RESEARCH FELLOW POSITIONS IN Geostatistics and Stochastic Simulations

Post-doctoral research fellow positions are available at the COSMO research group at McGill University (http://cosmo.mcgill.ca). COSMO is a collaborative laboratory dedicated to the development of new orebody modelling and optimization frameworks for production planning needed to create value across the entire mining-mineral value chain. The related industrial environment requires particular focus on 'high-order' and 'multi-point' spatial mathematical models of geological uncertainty, which generate inputs for optimization frameworks and other applications. Research is funded by the National Sciences and Engineering Research Council of Canada (NSERC) and a consortium of major mining companies: AngloGold Ashanti, BHP, De Beers/AngloAmerican, IAMGOLD, Kinross Gold, Newmont, and Vale.

Job description

Successful candidates will work on several of the related research areas:

- New data-driven, high-order stochastic simulations
- High-order data analytics, related deep learning methods
- High-order simulation of multiple categorical variables
- Joint high-order simulation of multiple corelated variables
- Construction of data-based continuous training images
- Applications in modelling mining deposits or environmental problems or other areas as per the interests of the applicant.
- A commitment to – and in accordance with circumstances, a track record in – equity, diversity, and inclusiveness (EDI) is preferred.

Candidates will have the opportunity to apply their developments at sites worldwide, test newly developed methods on real-life applications and gain substantial experience with advanced digital technologies in industrial environments.

In conjunction with their research, candidates are expected to interact with graduate students and industry professionals, and be involved in diverse projects led by the COSMO Laboratory, including global knowledge mobilization activities. The position based in the Department of Mining and Materials Engineering at McGill University, in close collaboration with related research groups such as GERAD, IVADO and McGill's CIM.

Building future career opportunities

Post-doctoral research fellows from our lab develop major career opportunities; for example, our last three moved on to BHP principal scientist (geostatistics and computing), DeepMind research engineer, and faculty at University of Calgary.

Requirements

Candidates are required to have completed (or being close to completion) a PhD in areas including: Applied mathematics, computer science, image processing, mining engineering, reservoir engineering or a related discipline. They should have excellent programming skills (C/C++) and a suitable academic record given the job description above, as well as a suitable publications record.

Terms and conditions

This research fellow position is a full-time employed position for one year with possible extension. Salary is commensurate to qualifications.

Application

The position is available immediately. The application procedure will remain open until the position is filled. If interested, please contact Roussos Dimitrakopoulos at E-mail: roussos.dimitrakopoulos@mcgill.ca or tel. 514 398-4986, and forward a detailed CV, including a list of publications, research interests, and the names of three referees.

McGill University hires on the basis of merit and is strongly committed to equity and diversity within its community. We welcome applications from racialized persons/visible minorities, women, Indigenous persons, persons with disabilities, ethnic minorities, and persons of minority sexual orientations and gender identities, as well as from all qualified candidates with the skills and knowledge to productively engage with diverse communities. McGill implements an employment equity program and encourages members of designated groups to self-identify. Persons with disabilities who anticipate needing accommodations for any part of the application process may contact, in confidence, accessibilityrequest.hr@mcgill.ca or 514-398-3711.