IITB-Monash Research Academy

An Indian-Australian research partnership

Indian Institute of Technology Bombay | MONASH University

Project Title:	Multi-Modal Geoscientific Data Fusion for Concealed Mineral Targeting in the Aravalli-Delhi Orogen Using Deep Learning	
Project Number	**IMURA1269**	
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Research Clusters: **Research Themes:**

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	*1*	***Artificial Intelligence and Advanced Computational Modelling***
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Circular Economy*
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Health Sciences*
5	***Earth Sciences and Civil Engineering (Geo, Water, Climate)***	5	*Smart Materials*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	***Sustainable Societies***
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Infrastructure*
8	*HSS, Design, Management*		

The research problem

Exploration of the deep-seated mineral deposits such as REE, Lithium, copper, PGE, and other critical minerals is crucial for the growth of the Indian economy and sustainable development. Identification of these deposits requires the whole mineral systems approach, which includes (i) understanding the lithospheric architecture to constrain the favourable geodynamic setting, (ii) the fluid/metal source-migration pathway-trap zone, and iii) Identification of various magmatic occurrences and their geological overprinting in time and space. As mineral systems are the result of multi-scale processes extending from the surface to the mantle, they are expected to provide different litho-tectonic imprints at various depth scales. Therefore, the present project aims to conduct a comprehensive analysis of multi-modal geoscientific datasets in the Aravali-Delhi Orogen to develop advanced exploration strategies for targeting the deep-seated mineralization. This includes imaging

the 3-D subsurface structure of the mineral-rich belts through the joint inversion of multi-modal geophysical and petrophysical data, which aids in the identification of possible pathway zones for ore fluid migration, such as shear zones and litho-contacts. Furthermore, integrating the 3-D subsurface structural model with interpretation derived from geological, geochemical, remote sensing, and drill-hole datasets within a deep learning framework will generate robust mineral prospectivity models and identify potential regions relevant for greenfield and brownfield exploration.

Project aims

The project aims to employ advanced Bayesian techniques for the joint inversion of multi-modal geophysical and petrophysical datasets, facilitating the creation of robust subsurface structural models and enhancing uncertainty quantification. Additionally, it intends to develop a deep learning framework for integrating multi-modal geoscientific data and generating robust mineral prospectivity models that minimise uncertainty and optimise drilling strategies.

How skills/experience of the IITB and the Monash supervisor(s) support the proposed project

- Dr. G. Srinivasa Rao specialises in joint inversion modelling and the integration of multi-source geophysical datasets using AI/ML data-driven techniques.
- Dr. Prabhakar Naraga has expertise in Metamorphic evolution of supracrustal belts and high-grade terranes; Mineral geochemistry to trace metamorphic processes, and fluid interactions in diverse geological settings
- Prof. Peter Betts has many years of experience in structural geophysics and addressing large-scale tectonic problems.

What is expected of the student when at IITB and when at Monash?

At IIT Bombay, the student will carry out the acquisition of petrophysical data, as well as the compilation and analysis of multi-modal geophysical data using advanced joint inversion and deep learning techniques. While at Monash, the student will perform a petrophysical and geochemical analysis of rock samples and conduct structural and lithological interpretations of multi-modal geophysical, geochemical, and remote sensing datasets.

Expected outcomes

The proposal is expected to result in a PhD degree and peer-reviewed publications. Beyond academic achievement, the proposal also holds significant potential for advancing the exploration of

concealed minerals and the development of AI-based decision-support tools for prospectivity mapping.

How will the project address the Goals of the above Themes?

By leveraging multi-modal geoscientific data within the AI-driven framework and modelling, the project enhances our ability to image the deep crustal architecture, understand the mineral system framework, and identify fluid migration pathways and ore trap zones.

How well the IITB and the Monash supervisor(s) know each other

The collaborators know each other well.

Potential RPCs from IITB and Monash

Dr. Sakthi Saravanan Chinnasamy: Expert in Ore Geology and Mineral Exploration

Dr. Bharath Shekar: Expert in Seismic Imaging and Inverse Problems

Dr.Fabio Capitanio: Expert in Geodynamic modelling

Capabilities and Degrees Required

Essential Qualifications: Post-graduate (M.Sc/ M.Sc(Tech)/ M.Tech/ Int. M Tech/ Int. MSc. Tech) degree in Applied Geophysics/Geophysics/Marine Geophysics or BS-MS degree in the relevant field of Earth Sciences

Desirable:

- Experience in handling geophysical datasets.
- Good background in machine learning and deep learning concepts.
- Adequate knowledge in computer programming, such as Python and Julia highly desirable

Necessary Courses

Exploration Geophysics

Geospatial Predictive Modelling

Introduction to Machine Learning in Geophysics

Communication Skills

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

K**eywords** relating to this project to make it easier for the students to apply.

Deep Learning; Joint inversion; Multi-modal data fusion; Mineral Prospectivity modelling