Advanced Techniques in Mining and Exploration Geology

Professional Development Training

Course Location:
Building 034, Room 127
College of Science & Engineering
James Cook University
Townsville, QLD, Australia

Dates:
18th — 28th April 2017

Course Leaders:
Assoc. Prof. Zhaoshan Chang
Assoc. Prof. Carl Spandler
Dale Sims, Consultant
Dr Ioan Sanislaw
Dr Arianne Ford

FEES*

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<thead>
<tr>
<th>Module</th>
<th>EGRU Member</th>
<th>Non-EGRU Member</th>
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<tr>
<td>Module 1</td>
<td>$440.00</td>
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<td>Module 2</td>
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<td>Module 3</td>
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<td>Module 4</td>
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*AU inclusive of GST

Enquiries:
EGRU
07 4781 4726
egru@jcu.edu.au
Course Description

Module 1— Mineral geochemistry and its application in exploration

In the recent years mineral geochemistry has been demonstrated to contain subtle primary signatures of hydrothermal mineralising systems, and can be used as indicators up to ~10km from orebodies, and as vectors towards orebodies. This tool was only developed and became available in the past decade with the development of laser ablation – inductively coupled Plasma – Mass Spectrometry (LA-ICP-MS) analytical methods. This module will cover the LA-ICP-MS methodology and the application of mineral geochemistry in exploration.

Module 2—Structural controls of mineralisation

This module will look at the principles behind structural controls on mineralisation through analysis of structures, geomechanical modelling, case studies and practical exercises. Structural controls are explained by the interactions of stress, deformation, fluid flow and heat. The module will present a selection of modern structural geology and spatial analysis techniques that have practical applications in exploration and mining geology.

Module 3—3D geological modelling of hard rock deposits using Leapfrog Geo

This module aims to enhance attendees’ data analysis and communication skills through the application of Leapfrog Geo, an industry-leading 3D modelling and communication package. The hands-on training will include a major overview of software functionality on a training dataset then will move on to attendees working up a number of real-world datasets. This will enable students to apply the analysis to their own data if desired. The modelling will explore the relationships between lithology, alteration and structure to identify and model controls on fluid flow / metal distribution and hence exploration projection. The underlying principles behind the software application and geological parameters will be discussed as will ways to ensure optimisation of modelling outputs. There will be a strong focus on relaying findings and understanding to peers using the software during the course.

Module 4—Modelling the spatial distribution of mineral deposits

This module will introduce the concept of fractal and multifractal analysis and their practical applications in mineral exploration and mining. Fractal analysis of the spatial distribution of mineral deposits will be discussed, as well as evaluating geological complexity and complexity gradients which can provide insights into controls on mineralisation. The concept of multifractal analysis will be presented to investigate the distribution of geochemical data and its practical application in geochemical anomaly mapping.

Presenters

**Zhaoshan Chang** is an Associate Professor and the Director of EGRU (Economic Geology Research Centre) at James Cook University. He has studied a wide spectrum of mineral systems, including porphyry-, skarn-, epithermal-, IOCG- deposits, W-Sn, and sediment-hosted gold deposits in 14 countries. He works closely with the mineral industry on exploration-oriented research projects, looking for far field signals, discriminators and zoning patterns in mineralogy, texture, spectral feature, whole rock and mineral geochemistry, plus isotopic compositions that can be directly used in exploration. His research mainly involves the investigation of the spatial and temporal distribution of alteration and mineralization, dating, fluid composition and evolution, formation conditions and the understanding of the genesis of ore systems.
Carl Spandler is an Associate Professor, who uses petrology and geochemistry to research aspects of the evolution of the Earth’s crust and mantle, and the formation of metalliferous ore deposits. His areas of expertise include microanalysis of minerals for trace elements and isotopes, hydrothermal fluid geochemistry and magmatic ore deposits.

Dale Sims is an industry geologist with over 30 years of experience in hard rock mining and exploration geology. He has been an independent consultant since 2010 although prior to that he held a number of operational and corporate roles with international mining companies working in Australia, Indonesia and around the world. A leapfrog user since 2003 he enjoys delivering staff development training around data quality, 3D domain analysis and resource estimation modelling / communication. As a consultant he is ready to do anything at any time pending availability!

Ioan Sanislav is a lecturer at JCU. He is a structural and metamorphic geologist, with an interest in applying structural and field geology to mineral exploration and geological modelling. He is currently working on gold mineralization in the Archean Tanzania Craton with focus on Geita Greenstone Belt. His past research included manganese and polymetallic deposits in the Carpathians, tectonic evolution of the Northern Appalachians, the Kanmantoo Group in South Australia and the Mount Isa Inlier in Queensland. He is also interested in microstructures, thermodynamic modelling, geochronology and isotope geology.

Arianne Ford is post-doctoral researcher at JCU. Her research focuses on the application of spatial statistics and computational techniques to mineral exploration targeting and resource classification. She is currently working on utilizing existing geological and mineral deposit data to develop GIS-based prospectivity maps to improve the availability of pre-competitive data for the Geological Survey of Queensland. The primary focus of the data analysis will be on the interpretation of hyperspectral remote sensing and geochemical data.

Course Details

Register for this course:
https://alumni.jcu.edu.au/EGRU

Location
Building 034 – Room 127 — Map

Course Notes, Computers and Software
Course notes will be provided in the form of pdfs of the PowerPoint slides, which will be posted on LearnJCU. Registrants will be notified with an access logon and password closer to the start date.
Access to Leapfrog (module 3) - information will be sent closer to the date

Accommodation
Close to University and on the bus route: www.cedarlodge.com.au
Accommodation on JCU Campus: www.jcu.edu.au/jcu-halls/short-stays/enquiries

Catering
This is a fully catered course for industry, so please advise any dietary requirements when registering online.

Enquiries
Judy Botting
07 4781 4726
egru@jcu.edu.au
Course Outline

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<th>Module</th>
<th>Date</th>
<th>Topic</th>
<th>Presenter</th>
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<tbody>
<tr>
<td>1</td>
<td>18 April</td>
<td>Mineral geochemistry and its application in exploration</td>
<td>Zhaoshan Chang</td>
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<td>Carl Spandler</td>
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<td>2</td>
<td>19 April</td>
<td>Structural geology refresher; Orientation and relative timing; Microstructures and vein textures</td>
<td>Ioan Sanislav</td>
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<td>20 April</td>
<td>Fault and fractures; Fabrics shear zones and folds</td>
<td>Ioan Sanislav</td>
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<td>3</td>
<td>21 April</td>
<td>3D Orebody modelling</td>
<td>Dale Sims</td>
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<td>24 April</td>
<td>Fractal analysis of mineralisation</td>
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<td>4</td>
<td>25 April</td>
<td>No teaching—Anzac Day</td>
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<td>5</td>
<td>26 April</td>
<td>Evaluating geological complexity and complexity gradients as controls on mineralisation</td>
<td>Arianne Ford</td>
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<tr>
<td>6</td>
<td>27 April</td>
<td>Multifractal analysis of geochemical data</td>
<td>Arianne Ford</td>
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<td>7</td>
<td>28 April</td>
<td>Masters students exam day—industry participants not required to attend but are welcome to sit the assessment.</td>
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Module 1
In the recent years mineral geochemistry has been demonstrated to contain subtle primary signatures of hydrothermal mineralising systems, and can be used as indicators up to ~10km from orebodies, and as vectors towards orebodies. This tool was only developed and became available in the past decade with the development of laser ablation – inductively coupled Plasma – Mass Spectrometry (LA-ICP-MS) analytical methods. This module will cover the LA-ICP-MS methodology and the application of mineral geochemistry in exploration.

1. Introduction

2. LA-ICP-MS techniques
   - Overview / principles
   - Instruments
   - Procedures
   - Data reduction

3. Trace element features of minerals and their application in exploration
   - Alunite
   - Chlorite
   - Epidote
• Pyrite
• Magnetite
• Quartz

Module 2

This module will look at the principles behind structural controls on mineralisation through analysis of structures, numerical modelling, case studies and practical exercises. The module will present a selection of modern structural geology and spatial analysis techniques that have immediate and practical applications in exploration and mining geology.

1. Structural geology refresher

This session revises some fundamental aspects of structural geology that may be ignored, forgotten or never taught.

- What happens to deformed rocks – Where (kinematics), why (dynamics) and how (mechanics)
- How to describe deformed rocks
- Strain and strain histories, pure, general and simple shear
- Stress, states of stress in the Earth, sources of stress
- Mechanics and rheology

2. Orientation and relative timing – Tools of the trade

A range of modern and practical techniques to analyse and present spatial and orientation data including eigenvector analysis, circular and spherical statistics. Reconstruction of deformation histories based on overprinting relationships.

3. Microstructures and vein textures and mechanics – An overlooked resource

Microstructures are a powerful resource that is commonly under-utilised in mineral exploration. The range of common microstructures is presented, focusing on those visible under the petrological microscope, and their implications for deformation and mineralisation will be drawn out.

Vein textures are particularly well visible in the microscope. A classification of textures and their meanings will be given, and the kinematic and dynamic interpretations.

4. Fault and fractures – Nuts and bolts of discrete deformation

- Failure and reactivation of faults
- Pore fluid pressure effects
- Fault geometries
- Fault controls on mineralisation – case studies

5. Fabrics, shear zones, and folds – Nuts and bolts of distributed deformation

- Types of fabric
- Two types of shear zones
- Shear sense determination
- Shear zone hosted mineralisation
- Folds and mineralisation

6. Geomechanical modelling

- An introduction to Geomechanics
- Coupled Processes: Deformation and Fluid Flow
Module 3

The training will commence with a brief overview of the history of Leapfrog and how it differs from conventional geological modelling packages, particularly in the way it creates models directly from the data using ‘implicit’ modelling techniques. A simple workflow procedure will be reviewed as will the application of isotropy and anisotropy in modelling processes.

The course will then move onto techniques for modelling categorical (lithology, alteration etc) and numerical (assay, geotechnical) data and look at applying anisotropy through global and local methods. The comparison and correlation of models will be explored for investigation of controlling aspects of the mineralised system. Oriented core and structural data modelling processes will be addressed as will the registration of raster and vector data. Scene file export and movie creation will be reviewed along with all other major components of the software.

Training will occur on JCU provided PCs although attendees can bring their own PC laptops to use if they are suitably specified for the software. Testing of hardware can be undertaken prior to the course. Training licences will be provided at no additional cost and attendees can bring their own data to work on which will be treated as confidential. Advice can be provided on what files/formats will be required for this opportunity.

Module 4

This module will introduce the concept of fractal and multifractal analysis and their practical applications in mineral exploration and mining. Fractal analysis of the spatial distribution of mineral deposits will be discussed, as well as evaluating geological complexity and complexity gradients which can provide insights into controls on mineralisation. The concept of multifractal analysis will be presented to investigate the distribution of geochemical data and its practical application in geochemical anomaly mapping.

1. Fractals and multifractals

The use of potential for fractals in mineral exploration remains underutilised. Some aspects of fractals to be covered include:

- Fractals: the basics
- Spatial distribution of mineral deposits
- Ore grade-tonnage relationship
- Fractal aspects of veins and faults
- Multifractals – advancing from fractals

2. Autocorrelation (Fry analysis)

An advanced technique for recognising patterns of mineralisation

3. Evaluating geological complexity and complexity gradients

- Why is geological complexity important for hydrothermal mineralisation?
- How do we calculate geological complexity using fractal box counting?
- What data quality considerations need to be taken into account in fractal box counting?

4. Multifractal analysis of geochemical data

- Comparing multifractal analysis of geochemical data vs. mineral production data
- What do thresholds in the results tell us about the mineralisation?