KIGAM Korea Institute of Geoscience and Mineral Resources

INTERNATIONAL SCHOOL FOR GEOSCIENCE RESOURCES (IS-Geo)
KOREA INSTITUTE OF GEOSCIENCE AND MINERAL RESOURCES (KIGAM)

PUBLIC CUSTOMIZED TRAINING COURSE ON

“Applied Geophysical inversion for resource exploration: From basic inverse theory to practical applications”

The **International School for Geoscience Resources** of KIGAM presents an intensive training course on **“Applied Geophysical inversion for resource exploration: From basic inverse theory to practical applications”**. The course will take place at the Ara room of International School for Geoscience Resources of KIGAM in Daejeon (Korea) in **August 24 to 28, 2015** and will include the following topics.

Topics	Date	Instructor
Day 1 (6 hours) Classical inverse theory and linear inversion	August 24	Yaoguo Li (CSM)
Day 2 (6 hours) Practical solutions of inverse problem	August 25	
Day 3 (6 hours) Nonlinear inversion; potential-field inversion	August 26	
Day 4 (6 hours) Remanent magnetization; Case histories	August 27	
Day 5 (6 hours) DC resistivity and IP inversions	August 28	

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Ministry of Science, ICT and Future Planning

COURSE INFORMATION

- ## Agenda

  ▪ This course will discuss the classical inverse theory and its application in the quantitative interpretation of geophysical data acquired in the resource exploration, engineering, and geotechnical applications. The focus of geophysical methods will be static-field based methods such as gravity, magnetic, DC resistivity, and induced polarization method.

- ## Course Covered

  ▪ Various geophysical data, including gravity, magnetic, DC resistivity, induced polarization (IP), and electromagnetic (EM) data, play an essential and critical role in modern mineral exploration. Their applications range from regional structural mapping, prospect-scale delineation of mineralization, to direct deposit detection. The interpretation of geophysical data for geologic information has evolved from qualitative anomaly hunting to quantitative analyses and extraction of specific information about subsurface. Much of the quantitative interpretation utilizes the applied geophysical inversion. This is because the above geophysical methods are based on static or diffusive fields and the information in the subsurface is scrambled in the observed data. Applied geophysical inversions are required to unravel the signals in the data so as to obtained location specific information. As such, applied geophysical inversion has become a ubiquitous tool in exploration geophysics.

  This short course is designed to give geophysicists and geologists a concise but in-depth discussion of the basics of applied geophysical inversion, its application to commonly used geophysical data, and computational aspects for solving large-scale problems. The focus will be on understanding inverse problems, its practical implementation, and special approaches required for different data types. The course materials will also be illustrated using various case histories.

  Specific topics include:
  - Introduction to geophysical inversion
  - Classical linear inversion by minimum norm model construction
  - Practical solution by singular value decomposition
  - Tikhonov regularization
  - Nonlinear inverse problem
  - 3D Inversion of gravity and magnetic data
  - Inversions of magnetic data in the presence of remanent magnetization
  - Inversion of DC resistivity and induced polarization (IP) data
  - Case histories

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Course Requirements: Prerequisite

- Knowledge of basic geophysics, linear algebra, scientific computing, and numerical optimization.
- Course language will be English.

Who should attend?

- This course is designed for scientists or engineers involved in geophysical exploration for mineral and energy resources.
- Those in engineering and environmental applications can also benefit from this course.

- **Summary of topic contents and learning objectives**
  - Understanding the basic concept, philosophy, and methodology of linear and nonlinear inverse theory.
  - Familiarity with its application to the quantitative interpretation of data acquired in applied geophysics.
  - Understanding practical strategies for solving large-scale inverse problems.
  - Introduction to approaches for incorporating prior information into the inversions.

- **Day 1. Classical inverse theory**
  - Introduction to geophysical data interpretation by inversion
    (1) Rationale for geophysical inversion
    (2) Parameter estimation and generalized inversion
    (3) Simple examples of geophysical inversion
  - Basics of geophysical inversion
    (1) Data, model, forward mapping, and kernel functions
    (2) Illustration of non-uniqueness
    (3) Linear versus nonlinear problems
  - Minimum norm model construction: Basic principles
    (1) Smallest model
    (2) Flattest model
    (3) Smallest deviatoric model
    (4) Weighted smallest model
    (5) Illustration with the two-data gravity problem

- **Day 2. Practical solutions of inverse problem**
  - Practical solution of inverse problems-I: Ideal scenarios without noise
    (1) Model discretization
    (2) Singular value decomposition (SVD) solution
    (3) Interpretation as a spectral decomposition
  - Practical solution of inverse problems-II: Realistic scenarios with noise
    (1) Nature of data noise
    (2) Data misfit
    (3) Truncated SVD solution
    (4) Concept of filtering function in SVD solution
  - Practical solution of inverse problems-III: Tikhonov regularization
    (1) An alternative filtering function in SVD solution
    (2) Tikhonov regularization formulation using a smallest model norm
    (3) Connection with SVD solution
    (4) Extension of Tikhonov regularization to general model objective functions

- **Day 3. 3D gravity and magnetic inversions**
  - Nonlinear inversion of geophysical data

(1) Nonlinear relationship of geophysical data
(2) Linearization and sensitivity
(3) Choice of regularization parameters in nonlinear inversions

- 3D potential-field inversion
  (1) Basics of magnetic problem
  (2) Fundamental difficulties associated with magnetic inversion
  (3) Depth weighting
  (4) Bound constraints
  (5) Practical issues of inversion: regional-residual separation
- Computational aspects of large-scale inverse problems
  (1) Conjugate gradient solution
  (2) Operator compression
  (3) Primal logarithmic barrier method

Day 4. Magnetic inversion under difficult conditions

- Inversion of magnetic data affected by strong remanent magnetization
  (1) Direction estimation
  (2) Amplitude inversion
  (3) Magnetization inversion
- Case histories
  (1) Magnetic inversions in mineral exploration
  (2) Amplitude inversion in mineral and oil & gas exploration
  (3) Gravity gradient inversion

Day 5. DC resistivity and induced polarization inversions

- Inversion of DC resistivity data
  (1) Basic DC equation
  (2) Numerical forward modeling
  (3) Inversion of data from different array configurations
  (4) Depth of investigation
- Inversion of induced polarization (IP) data
  (1) Definition of IP data
  (2) Apparent chargeability and dilation equation
  (3) Numerical modeling
  (4) IP inversion as a two-step process
- Case histories

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About the instructor – *Dr. Yaoguo Li*

Dr. Yaoguo Li is an Associate Professor in the Department of Geophysics at the Colorado School of Mines, and leads the Center for Gravity, Electrical and Magnetic Studies (CGEM). His research focuses on inverse theory; inversion of gravity, magnetic, electromagnetic, and sNMR data arising from applied geophysics; and their application to resource exploration, environmental, and hydrological problems. His interests include both algorithm development and implementation of practically applicable inversion software. He has developed or co-developed many algorithms and software packages, including DCIP2D, DCIP3D, GRAV3D, MAG3D, GG3D, BININV3D, AMP3D, and GGSURF3D for inverting different types of geophysical data.