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

REGULAR TRAINING COURSE ON
CARBON CAPTURE, UTILIZATION, AND STORAGE (CCUS)

The International School for Geoscience Resources of KIGAM presents an intensive training course on ***Carbon Capture, Utilization, and Storage (CCUS)***. The course will take place at the Ara room of the International School for Geoscience Resources of KIGAM in Daejeon (Korea) **in October 29 through November 10, 2014** and will include the following modules:

Title	Date	Instructor
Module 1. Introduction to geological storage of CO_2	Oct. 29-31	Ms. Ceri Vincent (BGS, UK)
Module 2. Overview of CCUS and Various Aspects of Numerical Modeling	Nov. 3-7	Dr. Tim Scheibe (PNNL, USA)
Module 3. Pilot Sites and Related Subsurface Applications	Nov. 3-7	Mr. George Last (PNNL, USA)
Country Report Workshop	Nov. 10	IS-Geo

Module 1 - Carbon dioxide Capture, transport and Storage (CCS) with a focus on geological storage of CO_2

Summary of course content and learning objectives

International School for Geoscience Resources (IS-Geo)
Korea Institute of Geoscience and Mineral Resources (KIGAM),
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Ministry of Science, ICT and Future Planning

This course will provide an introduction to Carbon Capture Transport and Storage (CCS), as a technology to contribute to the reduction of greenhouse gas emissions, and fit-for-purpose storage site characterisation. The participants would also be instructed and guided in the completion of practical work as part of the course.

Agenda

- Lectures on Day 1 will introduce the participants to the concept of CCS and the principles of the capture, transport and storage components of a CCS project. Lectures will review the technical constraints on selection of a geological site for storage of CO_2. Practical exercises will be undertaken by the course attendees.
- Lectures on day 2 will outline the information needed from site characterisation investigations to obtain permission to store based on the European approach to storage permitting. This will include lectures on risk-based storage site characterisation, prediction of site behaviour, mitigating risks to security of storage and potential corrective measures. Practical exercises will be undertaken by the course attendees.
- Lectures on Day 3. Site characterisation during the injection, post-injection and closure phases of storage will be presented. Appropriate monitoring technologies in response to risk assessment-led site characterisation and an iterative approach to modeling the storage site during injection will be presented. A discussion session on public engagement will be undertaken by the course attendees. The main points of the training course will be reviewed on Day 3.

Course Requirements: Prerequisite

- Knowledge of basic and subsurface geology
- The course language will be in English

Who should Attend?

This course is designed for scientists with an interest in Carbon dioxide Capture and Storage. The course will be of interest geoscientists (geologist, geophysicist, geoscientific modellers and environmental scientists) who wish to understand how to focus geological investigations to derive the information required in order to obtain approval for geological storage of CO_2.

Course Content of Module 1

The course will set the scene for the context of CCS with a focus on geological storage of carbon dioxide (CO_2). The key principles for capture of CO_2 from large point sources and transport of CO_2 will be outlined. The course will cover the full storage lifecycle including storage site screening and selection, pre-injection risk assessment-led site storage characterisation, monitoring during CO_2 injection, site behaviour prediction and verification, potential mitigation and remediation techniques and post-closure site requirements. Illustrations will be drawn from previous and existing CCS projects.

Summary of topic contents and learning objectives

The objectives for the training course are to introduce all aspects of the CCS chain and the storage lifecycle. The main focus will be on geological storage of CO_2. Effective site characterisation methodologies will be introduced. The learning objectives of the course are to understand: i) The role of CCS in reducing CO_2 emissions; ii) the key principles of capturing and transporting CO_2 for storage; iii) the role of geological storage in a full-chain CCS project; iv) how to undertake pre-injection site characterisation that addresses potential risks in order to achieve to secure containment of CO_2 in the subsurface v) Site characterisation during the injection and closure phases, potential mitigation and remediation measures; vi) the need for public engagement.

Day 1. Introduction to Carbon dioxide capture, transport and storage (CCS)

Lectures on Day 1 will introduce the participants to the concept of CCS and the main components of a CCS project. Presentations will include the context and motivation for CCS, methods for capture of CO_2 from large point sources, options for transport to a storage site and the principles and constraints for geological storage of CO_2. Lectures will review storage site types and screening and selection of prospective storage sites. The course participants will participate in a practical exercise on storage site screening and selection as well as a practical exercise in estimation of storage capacity. Pilot and demonstration CO_2 injection/storage sites around the world will be reviewed. Topics and activities for Day 1 include:

- Introduction and context for CCS in reducing emissions
- Key principles and main mechanisms for capturing and transporting CO_2 for storage
- Principles for geological storage of CO_2
- Storage site screening and selection
- Storage site initial capacity estimation
- Practical exercises: storage site screening and estimation of storage capacity
- Review of pilot and demonstration CO_2 injection/storage sites around the World

Day 2. Pre-injection storage site characterisation and risk assessment

Day 2 will outline the information needed to obtain permission to store CO_2 at a prospective storage site, risk assessment-led site characterisation and the role of risk and uncertainty reduction. Subsurface behaviour and trapping of CO_2 will be presented; Methods for storage site measurement, monitoring and verification will be presented. Course participants will undertake risk assessment and monitoring plan preparation exercises.

- Subsurface behaviour of CO_2 and trapping mechanisms
- Regulatory issues relating to storage of CO_2 based on the European approach
- Technologies and techniques for site characterisation and monitoring.
- Pre-injection, risk assessment-led storage site characterisation, risk and uncertainty reduction, potential remediation techniques and preventative measures planning

- Practical exercises: monitoring technologies for storage site characterisation and risk assessment
- Initial site performance prediction

Day 3. Injection and post-injection site characterisation and course review

Lectures on Day 3 will present storage site characterisation during the injection and post-injection phases of storage site operation. Lectures will include understanding site behaviour through monitoring, measuring and verification of site behaviour, potential mitigation and remediation techniques and post-closure requirements will be presented. The need for public engagement activities relating to CCS will be presented. Course attendees will undertake a discussion session on public engagement. The main points of the training course will also be reviewed.

- Injection phase: monitoring and verification of site performance; updating performance prediction and risk assessment, potential remediation techniques
- Post-injection phase: monitoring and verification; closure plan; post-closure monitoring plan.
- Public engagement
- Discussion session: public engagement activities
- Review of main points of course

Module 2 - Overview of CCUS and Various Aspects of Numerical Modeling

Summary of course content and learning objectives

This course will provide the student with a general introduction to Carbon Capture Utilization and Storage (CCUS). The introductory material will include motivation for CCUS, discussion of critical social and technical issues, and an overview of proposed solution

approaches. Following this introduction, the remainder of the module will focus on numerical modeling approaches and methodologies that are being used to evaluate, design and monitor implementations of geologic storage of CO_2 (carbon sequestration). The lectures will be presented by the leader of the modeling thrust area of PNNL's Carbon Sequestration Initiative. This module will be coordinated with Module 2 to provide the students a practical application-based context for the numerical modeling methods being presented. Each day, three one-hour lectures will be presented, alternating with three one-hour lectures of Module 2. In addition to presenting the current state-of-the-art of simulation technologies, this module will also introduce students to a number of important science questions that are guiding current research and model development in geological carbon sequestration. The overall objective of this module is to provide students with the background understanding necessary to effectively apply numerical models to carbon sequestration problems, and will prepare students for the STOMP modeling short course to be offered the following week.

Course Content of Module 2

- Introduction to CCUS and the Global Carbon Challenge
- Numerical Simulation Software Tools
- Supporting Tools (Data Management, Workflow, Visualization)
- Underlying Physics of Geological Carbon Sequestration
- Overview of Numerical Methods
- Applications of High-Performance Computing
- Parameter Estimation and Uncertainty Quantification
- Scale Issues in Numerical Modeling of Multiphase Flow
- Modeling Coupled Flow and Geomechanics
- Modeling Geochemical Reactions
- Microbiological Issues in Geological Carbon Sequestration

Course Requirements

The following items are beneficial, but not mandatory to attend the course:

- Knowledge of basic earth sciences concepts
- Knowledge of basic porous media flow concepts
- Knowledge of species transport in porous media
- Knowledge of heat transport in porous media
- Knowledge of geochemical concepts
- Knowledge of geomechanical concepts
- Knowledge of numerical methods for partial differential equations
- Course language will be English

Day 1. Overview of CCUS and Introduction to Numerical Modeling

The opening day will provide the students with a general introduction to the problem of increasing atmospheric carbon dioxide (CO_2), and to Carbon Capture, Utilization and Storage (CCUS) as one part of a strategy to mitigate CO_2 accumulation. The general introduction will focus on the scope of the global CCUS problem and motivate the need for reliable numerical simulation tools to assess and design site-specific implementations of geological carbon sequestration. Lecture two will provide an overview of field-scale simulation tools that are currently available, with a broad description of their capabilities and limitations. The third lecture will introduce a range of tools that are needed to support the core simulators, including tools for management of complex data sets, oversight of simulation workflows, and analysis and visualization of simulation outputs.

- 10:00 Introduction to CCUS and the Global Carbon Challenge
- 15:30 Field-Scale Simulation Tools for Geological Carbon Sequestration
- 16:30 Data Management, Workflow Management, and Visualization

Day 2. Physical and Chemical Processes of Geological Carbon Sequestration

The second day of the course will focus on conceptual and mathematical descriptions of those physical and chemical processes that play significant roles in geological carbon sequestration. Key processes and conceptualizations to be presented include multiphase flow in porous media, phase transitions and inter-phase dissolution, equations of state, density-driven flow, brine acidification and chemical reactions, and geomechanical deformations coupled to flow. These will be presented in terms of general conceptualizations of the processes as well as specific mathematical representations

commonly used in formulating numerical simulators. The three lectures will be organized by general classes of processes (lecture 1: physical flow processes; lecture 2: biogeochemical reaction processes; lecture 3: geomechanical processes).

- 11:00 Multiphase Flow in Natural Porous Media
- 13:30 Brine Acidification and Biogeochemical Reactions
- 16:30 Geomechanical Deformation Coupled to Multiphase Flow

Day 3. Numerical Methods

The third day of the course will focus on numerical methods that are used to solve the partial differential equations (PDEs) and other equations that arise from the conceptual models and theories presented on Day 2. The first lecture will address methods of discretising PDEs, which convert them into systems of linear and non-linear algebraic equations. The second lecture addresses methods of obtaining solutions to these (typically large) systems of equations. In cases where these systems of equations become extremely large (with hundreds of thousands to hundreds of millions of unknowns), high-performance computing methods can be applied to facilitate timely solution. Parallelization and high-performance computing will be addressed in the third lecture.

- 10:00 Spatial and Temporal Discretization Methods
- 13:30 Solution of Large Systems of Linear and Non-Linear Equations
- 15:30 High-Performance Computing Applications

Day 4. Model Parameterization and Uncertainty Quantification

The fourth day of the course will focus on a wide range of issues associated with reservoir characterization and selection of model parameters. The first lecture will provide an overview of a variety of approaches commonly used in model parameterization and an introduction to associated issues and problems. The second lecture will introduce specific methodologies of calibration, inverse modeling and data assimilation, and the third lecture will address sources of model predictive uncertainty (both parametric uncertainty and structural uncertainty) and new developments in quantifying and reducing uncertainty.

- 10:00 Approaches to Model Parameterization
- 13:30 Model Calibration and Inverse Modeling
- 15:30 Uncertainty Quantification

Day 5. Scale Issues in Geological Carbon Sequestration Modeling

The fifth day of the course will shift to a more fundamental perspective of processes involved in carbon sequestration. In particular, we will examine processes at a range of

scales that are smaller than those resolved by commonly-used simulators, specifically from the molecular scale to the pore scale. This set of lectures will provide the students with deeper understanding of fundamental processes and how they relate to model conceptualizations at larger scales. The first lecture will focus on fundamental process descriptions and their impact on larger-scale phenomena, and will also present some experimental methods used to elucidate these processes. The second lecture will introduce a class of simulation tools designed to simulate multiphase flow, transport, and reaction processes at a detailed level. The final lecture will discuss linkages between these detailed process models and more conventional reservoir-scale simulators, including some new directions in multiscale simulation.

- 10:00 Molecular and Pore-Scale Processes in CO_2 Sequestration
- 13:30 Pore-Scale Simulation Methods
- 16:30 Linking Sub-Grid Processes to Reservoir-Scale Simulators

Module 3 - Pilot Sites and Related Subsurface Applications

Summary of course content and learning objectives

This course provides the student with geologic and other background material and examples for many of the technical topics covered in Module 1. The introductory lecture will include a review of the important factors in site selection for geologic storage of carbon dioxide; a brief review of social issues; and a risk-based approach to

selection, characterization, monitoring, and closure of Carbon Capture and Storage (CCS) sites. Following this introduction, the remainder of the lectures will provide the students with a practical, application-based context for the numerical modelling methods being presented in Module 1. Lecture topics for Module 2 include differences in storage of CO_2 in carbonate, sandstone, and reactive reservoirs such as basalts. Separate lectures will cover CCUS, primarily in CO_2 enhanced oil recovery (CO_2 EOR), with emphasis on application in the Southeast (SE) Asian and Pacific realms; and monitoring technologies to detect and mitigate potential for induced seismicity and leakage from the storage reservoir. The importance of public engagement will be explored with examples, and finally we will cover aspects of shale-gas exploration and production; hydraulic fracturing; and secondary recovery and CO_2 storage potential in shales and coal-bed methane reservoirs. The lectures will be presented by George Last, who has over 38 years in geologic and hydrogeologic research, and who applies subsurface characterization expertise to research in the geologic storage of anthropogenic CO_2.

Each day, three Module 2 one-hour lectures will be presented, alternating with three one-hour lectures of Module 1. The overall objective of Module 2 is to provide students with background understanding of the geologic, characterization, and social issues involved in siting and operating CCS and CCUS projects, and an understanding of the sources of data for building geologic and numerical models.

Course Content of Module 3

- Site Selection and Risk Reduction
- Carbon Dioxide Storage in Carbonate Reservoirs - with relevance to SE Asian and Pacific Realms
- Carbon Dioxide Storage in Sandstone Reservoirs - with relevance to SE Asian and Pacific Realms
- Carbon Dioxide Storage in Basalts and Fractured Crystalline Rock Onshore and Offshore
- CCUS and CO_2 Enhanced Oil Recovery (CO_2 EOR)

- Challenges of CO_2 Storage and CO_2 EOR in SE Asian and Pacific Realms
- Introduction to Monitoring of CCS and CCUS Sites
- Geophysical Monitoring
- Other Monitoring Technologies
- Public Engagement
- Shale-Gas Exploration, drilling, and Hydraulic Fracturing
- Shale-Gas and Coal-Bed Methane - Secondary Recovery and CO_2 Storage

Course Requirements

The following items are beneficial, but not mandatory to attend the course:

- Knowledge of basic earth sciences concepts
- Knowledge of basics of Petroleum Geology
- The short-course language will be English

Day 1. Overview of the Geologic Storage of CO_2 in Sedimentary Reservoirs

The opening day will provide the students with a general introduction to regional natural and anthropogenic CO_2 sources and potential geologic sinks; site screening and site selection for geologic storage of CO_2 (CCS); the differences between CCS and CCUS; and the peculiarities and challenges of carbon dioxide storage in the most common sedimentary rock reservoirs. The introductory lecture will focus on site selection and concepts of reducing geologic uncertainty and risk in CCS. Lecture two will provide an overview of CO_2 storage in carbonate reservoirs, and Lecture 3 will examine geologic storage in sandstone reservoirs with relevant examples. Both Lecture 2 and 3 will include examples from our regions of interest.

Learning objectives include being able to:

- Identify the origins of large sources of both natural and anthropogenic CO_2 in China, Southeast Asia and the Pacific Rim
- Describe the characteristics of regional areas that are favourable for geologic storage of CO_2
- Describe the difference between CCS and CCUS
- Identify the components of a robust storage site
- Differentiate between geologic uncertainty and risk
- Discuss the similarities and differences of geologic storage in carbonate and sandstone reservoirs

- 11:00 Site Screening, Site Selection and Risk Reduction
- 13:30 CO_2 Storage in Carbonate Reservoirs - with aspects relevant to SE Asian and Pacific Realms
- 14:30 CO_2 Storage in Sandstone Reservoirs - with aspects relevant to SE Asian and Pacific Realms

Day 2. Geologic Storage of CO_2 in Non-Sedimentary Reservoirs and in Enhanced Oil Recovery Projects (CO_2 EOR)

The second day will provide students with an overview of CO_2 storage in "unconventional" non-sedimentary reservoirs, as well as the basics, efficiency, and challenges of CO_2 storage in enhanced oil recovery (EOR) reservoirs. The first lecture will explore the special case of mineral trapping of CO_2 in basalts, and the potential for offshore storage. Lecture two will examine the differences between CO_2 storage in saline reservoirs and CO_2 utilization in enhanced oil recovery, and Lecture 3 will examine the potential and challenges of CO_2 storage and enhanced oil recovery in our regional areas of interest.

Learning objectives include being able to:

- Describe how mineral trapping works in basalts and what the special considerations are for storing CO_2 in basalts both onshore and offshore
- Compare the relative efficiency and risks of CO_2 storage in saline reservoirs versus EOR reservoirs
- Identify on maps, general areas of potential geologic CO_2 storage sites and CO_2 EOR in our areas of interest
- Discuss the challenges of CO_2 storage in EOR projects

  - 10:00 CO_2 Storage in Basalts and Fractured Crystalline Rock, Onshore and Offshore
  - 14:30 CCUS and CO_2 Enhanced Oil Recovery (CO_2 EOR)
  - 15:30 Challenges of CO_2 Storage and CO_2 EOR in SE Asian and Pacific Realms

Day 3. Monitoring CO_2 Storage Sites and CO_2 EOR Sites

The third day will explore the motivation and methods for monitoring active and post-closure sites, as well as the types of data generated by different monitoring technologies. We will also discuss mitigation technologies and strategies. The first lecture will introduce the objectives and tools of monitoring, standard borehole technologies, and the differences for CCS and CCUS sites. The second lecture will cover microseismic monitoring, and time-lapse 2D, 3D, vertical seismic profiling (VSP), and cross-well seismic

technologies. The third lecture will examine electrical-resistivity-based (ERT) monitoring and site-wide surface deformation monitoring.

Learning objectives include being able to:

- Describe the most common leakage paths for CO_2, and the changes that escaping supercritical CO_2 may undergo
- List mitigation strategies for CO_2 or brine leakage from the reservoir
- Identify some of the most common borehole-based monitoring methods
- Describe in general terms how time-lapse seismic technologies work and some of their limitations
- Discuss some of the limitations of surface deformation monitoring

    - 11:00 Introduction to Monitoring CCS and CCUS sites
    - 14:30 Geophysical Monitoring
    - 16:30 Other Monitoring Technologies

Day 4. Public Engagement and Success of Pilot Sites

The lectures and discussions during Day 4 will provide students insights into the critical role of public engagement, with examples of successful projects and projects that were adversely impacted or were terminated due to negative public perception. The first lecture will introduce the elements and best practices of successful public engagement. The second lecture will present public engagement case histories and include discussion of possible cultural differences in public perception. Lecture 3 will review and summarize important elements of site selection, characterization, operation, and closeout of CCS and CCUS projects, and will include time for discussion of special topics of interest.

Learning objectives include being able to:

- Describe steps in establishing public engagement for CCS and CCUS, and how these steps may vary across the region
- Evaluate actual case histories of pilot projects in the Asian/SE Asian/Australian areas, and identify potential for project failure or success, based on public perception.
- Summarize major elements in site selection, characterization, monitoring, closure and post-closure monitoring. Identify some differences between CCS and CCUS sites.
- List some specific regional differences or limitations of the potential for CCS and CCUS in our regions of interest.

    - 11:00 Public Engagement Introduction and Best Practices
    - 14:30 Public Engagement Case Histories
    - 16:30 Summary of CCS/CCUS Site Selection, Characterization, Monitoring, and Site Closure

Day 5. Shale-Gas Reservoirs: Exploration, Hydraulic Fracturing, and Potential for CO_2 Storage and Secondary Recovery

The final day for Module 2 will provide students with an overview of shale-gas reservoirs; including the history of their development, myths and realities of hydraulic "fracking", and the potential for CO_2 enhanced secondary recovery, and for CO_2 storage in depleted shale-gas or coal-bed methane wells. The first lecture will explore the origin and distribution of shale-gas reservoirs, and the potential for shale-gas reservoir development in our regions of interest. The second lecture will review hydraulic fracturing technology and associated environmental impacts. The third lecture will examine recent research into the feasibility of using anthropogenic CO_2 to enhance natural gas recovery and the feasibility of storing large volumes of CO_2 in pressure-depleted shale-gas wells as well as in coal-bed methane reservoirs.

Learning objectives include being able to:

- Describe how shale-gas reservoirs differ from conventional carbonate and sandstone reservoirs
- List some of the most likely and least likely environmental impacts of "Fracking"
- Identify on maps of Asian and Pacific realms, general areas of potential shale-gas resources, and proximity to sources of large volumes of CO_2
- Discuss the potential and limitations of CO_2 storage and enhancement of natural gas recovery in shale-gas reservoirs and coal-bed methane reservoirs

    - 11:00 Introduction to Shale-Gas, Origin and History of Development.
    - 14:30 Shale-Gas Reservoirs and Hydraulic Fracturing
    - 15:30 Shale-Gas and Coal-Bed Methane- Secondary Recovery and CO_2 Storage

Country Report Workshop (11.10)

About the presenter – *Ceri J Vincent*

Ceri J Vincent graduated with an MSci in geophysics from the University of Leeds in 2000. She has worked for the British Geological Survey for over 13 years on CO_2 geological storage projects. She is also an Honorary Assistant Professor at the Faculty of Engineering at the University of Nottingham (2014 onwards).

Ceri coordinated the SAfECCS project (South Africa – EU Cooperation on CCS) from 2011

– 2013. She also worked on China-EU collaborative projects supporting Chinese experts in assessment of CO_2 storage options including the COACH (Cooperation Action within CCS China-EU) and UK-NZEC (Near Zero Emissions from Coal) projects. She was project leader at BGS for the COACH and SPACEMON projects. Ceri also contributed to earlier CCS projects; GESTCO, CARNOT, GeoCapacity and IEA-GHG Storage Potential of the Indian Subcontinent.

About the presenter – *Dr. Timothy Scheibe*

Dr. Timothy Scheibe is Lead Scientist for Multiscale Modeling and High-Performance Computing at the Pacific Northwest National Laboratory's Environmental Molecular Sciences Laboratory. He received a Bachelor's degree in Geological Engineering from Washington State University, a Master's in Civil Engineering from the University of Washington, and a Ph.D. in Civil Engineering from Stanford University. His research focuses on multiscale simulation of biogeochemically reactive transport in subsurface aquifers and reservoirs, applied to a variety of problems including microbial transport in groundwater, carbon sequestration in soils and the deep subsurface, and bioremediation of metals and radionuclides. He is currently collaborating with computational scientists, microbiologists and geochemists to simulate coupled flow, transport, and biogeochemical processes at cellular, pore and continuum scales using high-performance computational resources. He served as the focus area lead for numerical model development efforts under PNNL's Carbon Sequestration Initiative, and leads a number of other projects involving high-performance computing and multiscale modeling. Dr. Scheibe currently serves on the editorial board of the journal Ground Water (since 2001) and is active in several scientific societies including the American Geophysical Union, the National Ground Water Association, and the Geological Society of America. He has approximately 65 peer-reviewed publications in ISI-indexed scientific journals (http://www.researcherid.com/rid/A-8788-2008). He is frequently invited to lecture at conferences and universities, and in 2010 he served as the Henry Darcy Distinguished Lecturer (sponsored by the National Ground Water Association), in which capacity he gave 65 invited lectures nationally and internationally.

About the presenter – *Mr. George Last*

George Last is a Senior Research Scientist in the Geosciences Group of the Energy and Environment Division at the Pacific Northwest National Laboratory (PNNL). He received Bachelor of Science degree in Geology and a Master of Science degree in Environmental Science (Hydrogeology option) from Washington State University. He is a licensed geologist and hydrogeologist in the States of Washington, Oregon, and Pennsylvania (lapsed).

Mr. Last's technical expertise is in subsurface geology, with over 38 years of experience in applied geology and hydrogeologic research and project management. He has led or contributed to a broad range of geology, hydrogeology, and environmental studies supporting facility siting, hazardous waste site investigations, vadose zone research, groundwater hydrology, and carbon sequestration. His experience includes project scoping and management, drilling and sampling, geophysics, geologic/lithofacies mapping, field and laboratory experimentation, and data analysis. He was a member of the subsurface geology team for drilling of the Wallula CO_2 sequestration injection test well in basalt, and is a task lead for the FutureGen 2.0 CO_2 storage project. He is also the task lead for the National Risk Assessment Partnership (NRAP) groundwater focus group.

Mr. Last has authored or coauthored over 130 technical reports and journal articles. He is a licensed geologist and hydrogeologist in the States of Washington, Oregon, and Pennsylvania (lapsed). He is also a member of a number of professional organizations including the Geological Society of America, American Geophysical Union, American Association of Petroleum Geologists, and the Northwest Scientific Association (Board of Directors).

GENERAL INFORMATION

- **STARTING/END DATE AND LOCATION**
  - ✓ **October 29 through November 10 (3 weeks) at KIGAM in Daejeon, Korea**.
- **LANGUAGE OF STUDY**
  - ✓ The language of instruction is English and the courseware is in English.
- **ASSESSMENT AND CERTIFICATION**

- ✓ A participant will receive the certificate upon completion of the course.

• REGISTRATION

- ✓ **Deadline – By October 8 for a nominee**
  Before 7 days in starting date of each module for someone else except for a nominee
- ✓ **How to Register**
  - Complete and return the attached form, "Nomination form" for a nominee and "Registration form" for someone else except for a nominee to Mr. Seung-Ryeol Hwang (hwang3816@kigam.re.kr) by email
  - Visit at http://isgeo.kigam.re.kr, IS-Geo URL. You can learn more about all training courses in IS-Geo website.

• COURSE FEE

- ✓ The fee for each module contains the access to electronic course notes, the certificate of attendance and the Pre-Course e-Learning.
- ✓ **The fee for a nominee is free.**
  The fee to someone else except for a nominee is 300 US dollars /300,000 KRW in module 1 and 500 US dollars /500,000 KRW in module 2&3 (100 US dollars/100,000 KRW per module for only students).

• CONTACT

- ✓ For more inquires about training courses of IS-Geo, please contact at any time
- ✓ **Mr. Seung-Ryeol Hwang**, Assistant Coordinator by phone at +82-42-868-3816 or by email at Hwang3816@kigam.re.kr