KIGAM Korea Institute of Geoscience and Mineral Resources

INTERNATIONALSCHOOL FOR GEOSCIENCE RESOURCES
KOREA INSTITUTE OF GEOSCIENCE AND MINERAL RESOURCES (KIGAM)

Regular Training Course on GROUNDWATER THEORY AND APPLICATION

The **International School for Geoscience Resources** of KIGAM presents a training course on Groundwater Theory and Application. The course will take place at the Ara room of International School for Geoscience Resources of KIGAM in Daejeon (Korea) from June 24th through July 9th, 2013 and will include the following programs:

Module	Duration	Leading Instructor
Module 1. Groundwater Basics and Hydrogeological Investigations Topic 1. Groundwater Basics Topic 2. Hydrogeological Investigations	6.24 ~ 6.29	Prof. Frank W. Schwartz Prof. Eung Seok Lee
Module 2. Groundwater Contamination and Remediation Topic 1. Groundwater Constituents, Isotope Basics, Age Dating Topic 2. Introduction to Contaminant Hydrogeology	7.1 ~ 7.5	Prof. Frank W. Schwartz Prof. Eung Seok Lee Dr. Changryol Kim
KIGAM LAB & K-Water Tour	7.8	Dr. Yongcheol Kim
Country Report Workshop	7.9	IS-Geo

Course Agenda and Learning Objectives

Groundwater is an important, readily available source of freshwater for countries around the world. Not surprisingly, the rate of groundwater utilization has increased in the face of growing populations and the decrease in available surface-water sources. Now, groundwater is mined from aquifers at rates far in excess of their natural replenishment.

Among the available sources of freshwater groundwater is the most important. The quantities of water stored in major aquifers can be large and relatively uncontaminated. Although locally important, surface water can fluctuate dramatically in its availability according to monsoon or snowmelt cycles, and is readily contaminated from agricultural and urban runoff. Thus, given the importance of groundwater now and in the future, it is essential that decision makers recognize the potential vulnerabilities associated with the over-exploitation of groundwater.

The goal of this intensive training course then is to provide participants with a broad understanding of basic groundwater concepts, which bear on groundwater utilization as a resource, and with necessary measures to provide for its sustainability. To achieve this goal, the course combines lectures, hands-on practical exercises and field work. It links both theory and practice in a way designed to highlight the importance of each. Specific learning objectives of the program are (i) to develop fundamental knowledge on the water cycle, basic concepts of groundwater flow, field investigation, and water chemistry; (ii) to use illustrative problems and field exercises to foster a deep understanding of these basic concepts; (iii) to apply theory and concepts to problems of water supply development, water-resource assessments, contamination assessments, and water-source remediation; and (iv) to develop practical know-how in basic field measurements through field exercises.

The study of groundwater is complicated by the fact that to a large extent the resource is hidden below the ground surface. Moreover, the flow of groundwater is dependant in a critical way on the patterns of recharge, the architecture and hydraulic characteristics of aquifers and confining beds and pumping from wells. The first part of the course provides a clear understanding of these basic concepts from both a

theoretical and practical perspective. Particular emphasis is provided on the basics of flow through porous media, field methods used to describe groundwater flow, and ideas of regional groundwater flow.

By its very nature, groundwater is a field-oriented science. Thus, the next major segment of the course explores field hydrogeology including drilling and sampling, well-design and installation and both surface and borehole geophysics. These techniques are designed to provide a foundation for students to develop an understanding of the architecture of aquifers and confining beds, and their important role in groundwater flow. Carefully designed exercises illustrate how these ideas are used in practice. Another essential focus for field investigations is aquifer testing including both the design of field tests and the interpretation of test results. By combining classroom work with a field exercise on the KIGAM site, course participants will come away with a thorough understanding of this essential component of groundwater-resource assessments.

Discovering groundwater is only a first step in determining its potential as a water supply for drinking water or irrigation. To a significant extent, the chemical quality of groundwater dictates its potential usability. Groundwater can be impaired due to either natural salinity or contaminants from a variety of human activities. Careful sampling and chemical analysis thus is required as part of an overall assessment. The course touches on the chemical constituents found in natural groundwater and the most common contaminants. A framework for evaluating water quality is provided by water quality standards and maximum contaminant limits (MCLs). This introduction leads naturally to a detailed treatment of contaminant hydrogeology including the key types of contamination problems, families of contaminants and their health implications, and mechanisms important for understanding the spread of dissolved and non-aqueous phase contaminants. A series of exercises focus on conceptualizing problems of contamination and techniques needed for investigating contaminant spills. Time permitting; we survey the most common approaches for cleaning up contaminant spills.

This course is structured to appeal to those with a diverse background. Participants will enjoy a student-focused learning environment that moves at a pace dictated by your abilities and understanding. You will come away with a foundational understanding of groundwater appropriate for supporting national water agendas.

Module 1. Groundwater Basics and Hydrogeological Investigations

Topic 1. Groundwater Basics (6.24-25)

This module will address the concept of a water cycle, water budgets from a hydrologic and groundwater perspective, the development of ideas of sustainability and basic concepts of flow through porous media and the controlling parameters. Another focus of this module is regional groundwater flow, the historical development of ideas and basic concepts. The exercises in this module will explore groundwater flow velocities and the construction of hydrogeologic cross-sections. The objectives of this module are to provide students with a clear understanding of fundamental concepts of the occurrence of water and the quantitative description of its flow, and the historical development of foundational ideas.

Content of topic

- **Day 1. Groundwater Basics**
  - Water Cycle
  - Water budgets for lysimeters and a small watershed
    - Exercise: Water budget calculation
    - Exercise: Estimating runoff ratios
  - Groundwater basics
    - Exercise: Hydrualic head estimation

- **Day 2. Theory of Groundwater Flow**
  - Groundwater basics
    - Exercise: Application of Darcy's Law
  - Flownet theory and applications
    - Exercises: Flownets
  - Regional groundwater flow
    - Exercise: Preparation of hydrogeologic cross-section

Topic 2. Hydrogeological Investigations (6.26-29)

This module will cover key aspects related to the field practice of hydrogeology including, drilling and sampling, geophysical approaches, and the design and installation of piezometers and monitoring wells. It will provide a basic introduction of the theory of flow to wells and the application of this theory in aquifer testing, and regional water resource assessments. Exercises will provide instruction in correlation of lithologic data, and the interpretation of aquifer test results. Field demonstrations and exercises will let students observe aquifers in the field and common geophysical techniques. The objective of this

module is to provide students with a basic understanding of basic field methods and their relationship to theoretical concepts.

- **Content of topic**
  - **Day 3. Field Investigations, Aquifers**
    - Aquifers
      - Transmissivity and storativity
    - Types of aquifers
    - Common drilling and sampling methods
    - Geoprobe – revolution in shallow investigation
      - Exercise: Geoprobe data analysis
      - Piezometer – design, theory and installation
    - Well development and hydraulic head measurements
  - **Day 4. Aquifers, Flow to Wells, Aquifer Tests**
    - Aquifers
      - Exercises: Aquifer storage
    - Flow to wells, aquifer tests
      - Theis
        - Exercises: Type-curve methods
      - Cooper-Jacob
  - **Day 5. Aquifer Tests**
    - Flow to wells, aquifer tests
      - Hantush-Jacob
      - Neuman
    - Slug test:
      - Hvorslev
      - Bouwer and Rice methods
    - Superposition and bounded aquifers
      - Exercises: impermeable and recharge boundaries
  - ***Day 6. Field Exercise I: Aquifer Tests and Data Interpretations***
    (Dr. Yongcheol Kim, Prof. F. W. Schwartz, Dr. Eung Seok Lee)
    - *Head Measurement*
      - *Measure water table depth from top of casing using electrical tape*
      - *Convert water table depth to elevation head*
    - *Hydraulic test*
      - *Data logger installation*
      - *Performing slug test(injection/withdrawal)*
      - *Performing pumping test*
    - *Groundwater sample collection (non-pumping well)*

- *Bailer*
- *Peristaltic pump*

- *Filtering and water chemistry measurements (Bypass from pumping well)*
  - *Demonstrate filtering process with filtering equipment*
  - *Water chemistry measurement such as EC, pH, Temp., DO, ORP using flow-through cell and peristaltic pump*
  - *Compare water chemistry result between samples collected by bailer and peristaltic pump*
- *Borehole inspection using borehole camera*
  - *Water table and wellbore structure*
  - *Fractured rock structure such as fault, joint, vein*
- *Data interpretation (lecture and exercise)*
  - *Estimate hydraulic gradient and direction*
  - *Interpretation of aquifer test data using commercial software, 'Aqtesolv'.*

Module 2. Groundwater Contamination and Remediation

Topic 1. Groundwater Constituents, Isotope Basics, Age Dating (7.1–2)

This module provides an overview of basic concepts of aqueous geochemistry and isotope hydrology. It begins with an introduction of the variety of dissolved mass found in natural water, measures of concentration and types of water analyses. It includes a discussion of water standards and how they are used and how water evolves chemically in the subsurface. This module presents an overview of environmental isotopes and how they are used in water studies such as karst hydrogeology. It concludes with laboratory measurements and an overview of tritium and CFC methods in age determinations. Exercises focus on assessing the quality of water analyses and interpreting age dates. The objectives of this module are to provide students the basic tools to interpret geochemical and isotopic data in the context of groundwater and contaminant investigations.

- **Content of topic**
  - **Day 1. Water Resource Assessments, Mass in natural water**
    - Climate, surface water, groundwater assessments
    - Ions, measures of concentrations, epm balance
    - Exercise I
    - Water analyses, drinking water standards
    - Plotting chemical data, ionic strength
    - Equilibrium, kinetics
    - Exercise II, III

- **Day 2. Water Sampling, Isotope Basics, Age dating**
  - Flow and chemistry in karst aquifers
    - Exercise IV
  - Treating water samples in the field and laboratory
  - Environmental isotopes basics
  - Water isotopes
  - Solute isotopes
  - Age dating: Carbon-14, Tritium, CFC

Topic 2. Introduction to Contaminant Hydrogeology (7.2–5)

Contaminant hydrogeology brings together knowledge from other parts of the course and adds new ideas of physical and chemical transport. This module will explain how contaminants originate in groundwater and how they are organized for study. It will discuss the difference between problems of dissolved contaminants and those involving LNAPLs and DNAPLs. This section will explain the key processes involved in contaminant migration and develop conceptual models. Exercises and case studies will help focus learning on the most important lessons. The objective is to provide an introduction to the subject that will provide a good understanding of the topic and integrate theory and practice.

- **Content of topic**
  - **Day 2 - continued. Contaminants in Water, Theory of Contaminant Transport**
    - Contaminants and types of contamination
      - Families of contaminants
      - Contaminant plumes in groundwater
        - Exercise: Cape Cod. MA case study I
      - Pollutants in urban runoff
        - Exercise: Leon County, FL case study
    - Advection
      - Exercise: Advection at Otis Air Base
    - Dispersion
      - Quantitative treatment of dispersion
  - **Day 3. Theory of Contaminant Transport - continued, NAPLs**
    - Dispersion
      - Quantitative treatment of dispersion
      - Exercises: Tracer tests, Estimation of dispersivity
    - Key chemical reactions – sorption and biodegradation
    - Retardation
      - Exercise: sorption and retardation
    - NAPLs

- Organic compounds
- Residual saturation and patterns of spreading
- Vapor transport

Day 4. NAPLs, Case Studies, Remediation

- NAPLs
  - Petroleum hydrocarbons
  - NAPL site investigations
- Exercise: DNAPL spreading
- Case study: Savage Well Superfund Site
- Remediation
  - Containment
  - Systems for recovering LNAPLs
  - Designing injection/withdrawal systems

Day 5. Remediation - continued, Modeling Basics

- Remediation
  - In situ chemical oxidation
  - Permeable reactive barriers and controlled-release system
  - Bioremediation
  - Borehole logging
    - Exercise: Lithologic and borehole log correlation
    - Case studies in contaminant cleanups
- Culminating activity
- *Field Exercise II: Geophysical field excursion (All afternoon with Dr. Kim Changryol, KIGAM)*

  - *Introduction to Environmental Geophysics for Site Investigations*
  - *Field Demonstration*
  - *Case Studies*.

KIGAM LAB & K-Water Tour (7.8)

- ***Geological Museum Tour***
- ***Excursion to K-Water***
  - ***Cheong Ju filtration plant***
- ***Daecheong Multi-purpose Dam***

Country Report Workshop (7.9)

About the presenter -*Prof. Frank W. Schwartz*

Frank W. Schwartz received B. Sc. M. Sc., and Ph.D. degrees in hydrology from University of Western Ontario, University of Manitoba, and University of Illinois, respectively. Professor Schwartz joined School of Earth Sciences of The Ohio State University in Columbus, OH in 1988 as the Ohio Eminent Scholar in Hydrogeology. He was formerly a Professor of Geology at the University of Alberta. Dr. Schwartz is the author of more than 160 publications and is known internationally for his work on field and theoretical aspects of contaminant hydrogeology and remediation, mass transport, ground-water geochemistry, and watershed hydrology. He has co-authored two textbooks, *Physical and Chemical Hydrogeology* (John Wiley & Sons, Inc., New York, Domenico, P.A. and F.W. Schwartz, 1998), and *Fundamentals of Ground Water* (John Wiley & Sons, Inc., New York, F.W. Schwartz, and H. Zhang, 2003), which are widely used for teaching hydrogeology around the world. Professor Schwartz has received major awards recognizing his status as a scientific leader. He is a recipient of the O.E. Meinzer Award, the Excellence in Science and Engineering Award, the King Hubbert Science Award, and was elected as a Fellow of the American Geophysical Union and Geological Society of America. He served as the first Editor-in-Chief for the Journal of Contaminant Hydrology (1991-2003), and was recently named as the next Editor-in-Chief for the Groundwater. In addition, he has served on a variety of expert panels of the U.S. National Research Council, the U.S. Department of Energy, U.S. Geological Survey, the Lawrence Berkeley National Laboratory, and the US EPA. Dr. Schwartz has taught five educational programs that included 5-day courses in contaminant hydrogeology and remedial technologies (in Valencia, Spain, San Deigo, CA, Lima, OH, and Columbus, OH).

About the presenter- *Dr. Eung Seok Lee*

Eung Seok Lee received B. Sc. and M. Sc. in geology from Yonsei University and Ph.D. in hydrogeology from Indiana University. Dr. Lee joined Department of Geological Sciences of Ohio University in Athens, OH in 2008 as an assistant professor in Hydrogeology. He was formerly a postdoctoral researcher at the University of Saskatchewan, Canada and a research scientist at The Ohio State University. An author of more than 20 publications, Professor Lee has performed sponsored research in the areas of karst hydrogeology, contaminant hydrogeology and remediation (US DOE, DOD), isotope hydrology (NSERC, Canada), acid mine drainage (American Electric Power), and urban runoff management (Global Research Laboratory, MEST, Korea). Dr. Lee has received John Patton Award, Shell Scholarship, and served as an associate editor of journal *Groundwater*. He teaches hydrogeology courses at Ohio University.

About the presenter- *Dr. Yongcheol Kim*

Yongcheol Kim received B. Sc. M. Sc., and Ph.D. degrees in hydrogeology from Seoul National University, South Korea. Dr. Kim researched at CESEP(Center for Experimental Study of Subsurface Environmental Processes) in Colorado School of Mines, Colorado, USA from 2003 to 2005 as a visiting scholar and post doctoral researcher. He joined Korea Institute of Geoscience and Mineral Resources in 2005 as a senior researcher. Dr. Kim has more than 20 publications, four patents registered and eleven patents reviewed. He has performed research in the area of artificial recharge for sustainable groundwater resources, flow and transport in saturated/unsaturated porous/fractured media, DNAPL problems, tracer test, hydraulic tests for site characterization, hydrogeological characterization of volcanic aquifer, karst aquifer, and groundwater contamination problem. Dr. Kim has received Young Geologist Award of Korea. In addition, he has served on expert panels of the Jeju Special Self-governing Province and Wonju Regional Environmental Office.

About the presenter- *Dr. Changryol Kim*

Changryol Kim received B.Sc. in geology and M. Sc. in geophysics from Yonsei University, and Ph.D. in geophysics from Ohio State University. He formerly joined Environment Remediation Section of Korea Rural Community Corporation. Currently, he is a senior researcher of Exploration Geophysics and Mining Engineering Dept. of Korea Institute of Geoscience and Mineral Resources (KIGAM). He has served as a member of the board of directors for Korean Society of Earth and Exploration Geophysicists since 2008. He is an author of more than 25 publications, and is conducting researches in the areas of environmental and engineering applications of geophysical techniques, and mineral resource exploration using integrated geophysical techniques.

GENERAL INFORMATION

• STARTING/END DATE AND LOCATION

✓ June 24 ~ July 9 (2 weeks) at KIGAM in Daejeon, Korea.

• LANGUAGE OF STUDY

✓ The language of instruction is English and all courseware is in English.

• ASSESSMENT AND CERTIFICATION

✓ Participants will receive certificates upon completion of the course.

• REGISTRATION

✓ **Deadline**

- ◆ **Domestic participants** should fill in the application from and send it to E-mail below before 7 days starting date of each module.
- ◆ **Charged overseas participants** should fill in the application form and send it to E-mail below before 30 days starting date of each module.
- ◆ **Overseas nominees covered by KIGAM** should send the nomination form to us before May 27.

• COURSE FEE

✓ The course fee of each module is 500,000 KRW (500 USD) for the public or 200,000 KRW (200 USD) for students (Please note that the accommodation and food expenses are not included).

✓ All expense for **overseas nominees** will be covered by KIGAM, but we are so sorry that some of countries should cover air-ticket and other expenses.