Topics in Energy and Environmental Geomechanics – Enhanced Geothermal Systems (EGS)

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Introduction
Schedules, Room and Instructors

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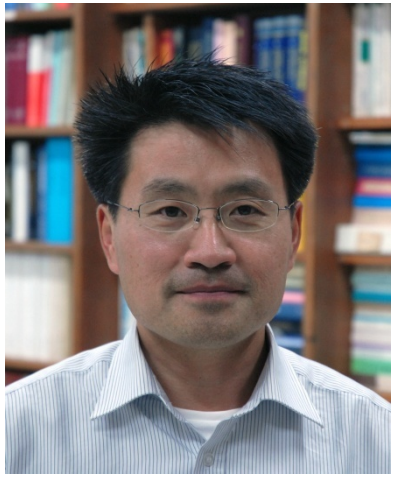
- Lectures (3 credits)
  - Mon : 09:00 – 10:15, 10:30 – 11:45
- Lecture Room: 38-323 (Rock Mechannics Library)
- Instructor and Teaching Assistant
  - Ki-Bok Min, Room:36-303, kbmin@snu.ac.kr
  - Hanna Kim, Room:36-324, kyhn1123@snu.ac.kr
- Teaching materials will be available at eTL



Introduction
Objectives of the course

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- Objective;
  - Understand the theory and practice of geomechanics applied to conventional energy resources, unconventional energy resources, geothermal energy and geoenvironmental engineering
  - Examples: underground storage of CO2, geological repository of nuclear waste, Enhanced Geothermal systems, shale gas production, Mining Engineering, Underground cavern/openings
  - Selected topics will vary each course - EGS this time.
  - Deal with geomechanics components essential for the realization of EGS: Borehole stability, Hydraulic Stimulation, Induced seismicity – these issues are relevant to many other applications.
  - Develop skills to effectively synthesize information and communicate with other people – written, oral and listening skills

Introduction
Overall layout of the course

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- Fundamentals of Geomechanics (75 x 2)
  - Lectures
- Borehole Stability (75 x 4)
  - Lectures + students presentations (15 minutes x 5)
- Hydraulic Stimulation (75 x 4)
  - Lectures + students presentations (15 minutes x 5)
- Induced Seismicity (75 x 4)
  - Lectures + students presentation (15 minutes x 5)
- Drilling Engineering/Well Logging (75 x 2, 75 x 2)
  - Invited lectures
- EGS Case Studies (75 x 2)
  - Lectures + students presentation (25 minutes x 5)

Introduction
Textbooks

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- Textbooks
  - Lecture Notes
  - Jaeger JC, Cook NGW and Zimmerman RW, 2007, Fundamentals of rock mechanics, Blackwell Publishing
  - Fjaer E, Holt RM, Horsurd P, Raaen AM, Risnes R, 2008, Petroleum Related Rock Mechanics, Elsevier*
  - Zoback MD, 2007, Reservoir Geomechanics, Cambridge University Press.
  - Economides MJ, Nolte KG (eds), 2000, Hydraulic stimulation, 3rd ed., Wiley*
  - Valkó P, Economides MJ, 1995, Hydraulic fracture mechanics, 1995, Wiley
  - MIT, 2006, The future of geothermal energy - Impact of Enhanced Geothermal Systems (EGS) on the United States in the 21st century*
  - Huenges E (ed), 2010, Geothermal Energy Systems, Wiley-VCH
  - Shearer PM, Introduction seismology, 2nd ed., 2009, Cambridge Press

*: pdf available

Introduction
Term Project

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- Each student will prepare a term paper and present it during student conference. Proceedings will be published.
- Both report and presentation should be in English.
- Choose a critical geomechanical issue for EGS.
- My expectation: term papers may be publishable in the future with additional work.
- Timeline

✍28 Oct	Submission of proposal (~1 p)	10%
✍8 Nov	Presentation of proposal /progress	20%
✍2 Dec	Presentation of final term paper	30%
✍2 Dec	Submission of final term paper (~15 p)	40%

Introduction
Term Project

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- Topics of term project: It has to be a critical issue for the EGS
  - Renewability of geothermal energy: How renewable is EGS? And what is the role of geomechanical issues?
  - Predictability of enhanced permeability: is this really universal technology?
  - Reliable estimation of *in situ* stress: is there any hope for better estimation in the future?
  - Hazard of microseismicity: Can we estimate the magnitude of induced microseismicity? What are the critical parameters?
  - Cost of drilling: Is the breakthrough possible in this area dominated by empiricism?
  - Quantifying the uncertainty in EGS: How does the different technical issues combine together to increase the uncertainty?

Field Excursion

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- Fri. 8 Nov – Sat. 9 Nov 2013 (Overnight stay, tentative)
  - Invited lecture
  - Excursion to the EGS geothermal drilling site, Pohang
  - Student presentation of project progress in conjunction with undergraduate ‘geothermal energy’ course.

Introduction
Contents of the course

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- Week 1 (2 Sept):Introduction to the course/Climate change & Emerging Subsurface Eng Application
- Week 2 (9 Sept): Fundamentals of Geomechanics
- Week 3 (16 Sept):Borehole Stability
- Week 4 (23 Sept): Borehole Stability
- Week 5 (30 Sept): No lecture (business trip)
- Week 6 (7 Oct) : Hydraulic Stimulation (focus on Hydraulic fracturing)
- Week 7 (14 Oct): Hydraulic Stimulation
- Week 8 (21 Oct): Induced seismicity
- Week 9 (28 Oct): Induced seismicity

Introduction
Contents of the course

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- Week 10 (4 Nov): Drilling Engineering (invited lecture)
- Week 11 (11 Nov): Well logging (invited lecture)
- Week 12 (18 Nov): EGS Case studies
- Week 13 (25 Nov): EGS Case studies
- Week 14 (2 Dec): Student Conference
- Week 15 (9 Dec): Final Exam (closed book or take-home exam)

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Assessment

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- Assessment
  - Homework & presentation : 30 %
  - Final Exam : 30 %
  - Term project : 30 %
  - Participation : 10 %
- Students are expected to do the followings
  - 4 review reports (~3 pages) and presentations (~15 minutes)
  - 1 term paper and presentation
  - Final Exam (closed book or take-home exam)
  - Other home assignments as relevant

Final word

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- Remember that EGS is NOT a proven concept.
- Therefore, critical thinking is essential for understanding and implementing this idea.
- Yet, their geomechanics component is essential for any other subsurface engineering application.
- Ask NOT what your teacher can do for you. Ask what you can do for this course - JF Kennedy
  - http://www.youtube.com/watch?v=2cV