

465.420 Geothermal Energy, Fall 2009

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Homework #4

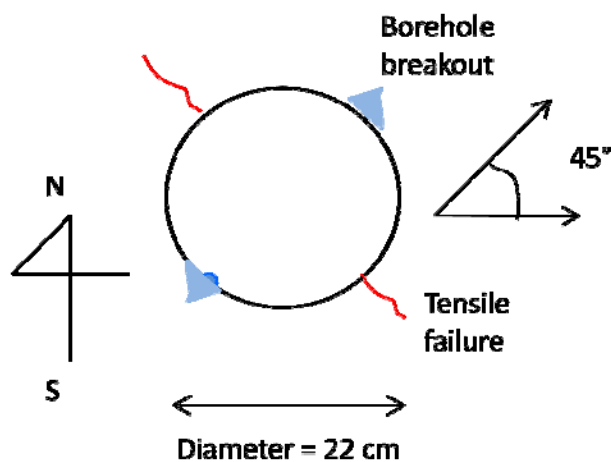
1. A borehole with the diameter 22 cm was drilled into a formation up to 1 km depth in which the thermal gradient is known to be around $50^{\circ}\text{C}/\text{km}$. Due to the lack of budget, in situ stress measurement campaign could not be carried out. The only clue we have about the in situ stress is the borehole observation. At 1 km depth, a borehole breakout was started to be observed as shown in the below when the mud pressure was maintained as hydrostatic pressure. When we increased the mud pressure to two times of hydrostatic pressure, we then observed a new tensile fracture at the same depth in the direction shown below.

- 1) Determine the direction and magnitude of maximum and minimum horizontal stress (5).
- 2) When water from the surface was injected into the borehole, in which depth are we going to see a tensile fracture around the borehole? (5)

Laboratory test on rock samples revealed the following physical properties of rock.

Elastic modulus: 20 GPa, Poisson's ratio: 0.25, Uniaxial Compressive Strength(UCS): 132 MPa, Tensile Strength: 14 MPa, Linear Thermal Expansion Coefficient: $1 \times 10^{-5} /^{\circ}\text{C}$.

In answering above questions, make your own assumptions as necessary. Note that the casing is not considered in assessing the stability of the borehole for this particular question.



2. Read the articles in New York Times and Telegraph which reports on the seismic hazard due geothermal energy development in a few locations including Basel, Switzerland.

<http://topics.nytimes.com/topics/news/business/energy-environment/geothermal-power/index.html?scp=2&sq=geothermal%20basel&st=cse>
<http://www.telegraph.co.uk/news/worldnews/1543048/Green-energy-project-gives-Swiss-the-shakes.html>,

Explain in English why such events happen. What is your view on this issue? In discussing this, you need to explain whether we can prevent this, and what the lessons are that we can learn? (10)

You may use Korean for question 1. Due by 9am 16 Nov 2009. Late submission by 9am 18 Nov 2009 with 20% penalty.