PETE 331 20.12.2023

HOMEWORK 5 – FRACTURING

Due date: **DECEMBER 27, 2023 (WEDNESDAY)**

Homework should be prepared and typed with a word processor. Homeworks may be submitted in pdf or Word (.doc, .docx) formats. The homework files will be uploaded to ODTUClass.

Your solutions to homeworks problems must <u>show all the steps and calculations clearly.</u> You can use Excel to draw graphs or to make calculations. <u>You should also upload the Excel files</u> (or any associated files that you have used) in ODTUClass, <u>in the designated section.</u> Note that your report, no matter where you have solved the questions, must contain all your steps.

Anyone who presents a copied assignment, or receives unauthorized help in their assignment, will get **zero.**

For late homework submission: If delivered within one day after the due date, 20% off. If delivered within one week after the due date, 50% off. Homeworks will not be accepted after one week.

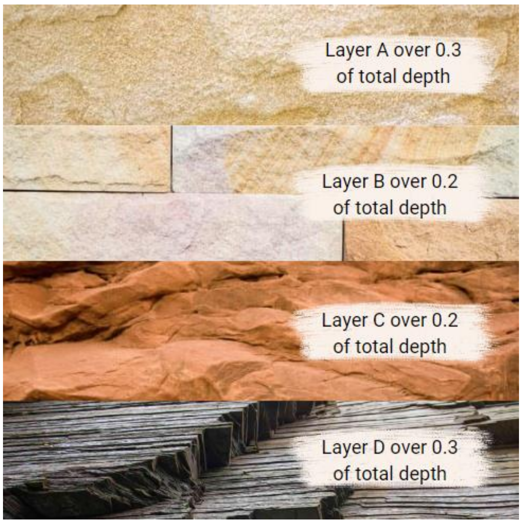
Note that values of some parameters in some questions (which are indicated with letters) will be determined using your student ID#. Consider your ID number as abcdefg (e.g. if your ID# is 2105825 then g=5, f=2, e=8, …). The values should be calculated by the provided formula using digits.

Hint: See Example problems in Chapter 13 and 14 of Guo's Book

<u>Question 1:</u>

You are tasked to select an adequate proppant for the stimulation program of Metu-1 well. To aid with the selection process, various tests and surveys have been taken throughout the history of this well, and the available data is listed:

- An evaluation of the drilling plan, as well as the completion plan of the field suggests that the reservoir section is located at [11500 + e*100] ft.
- Density logs taken at the field have recorded the densities throughout various depth intervals. The responsible log engineer has analyzed the well logs for you, and suggests that the following densities are observed throughout the overburden:
    - [140 + c] lbm/cuft for layer A
    - [150 + d] lbm/cuft for layer B
    - [160 + e] lbm/cuft for Layer C
    - [170 +f] lbm/cuft for Layer D
- The overburden is modeled in the following figure:



- Based on your company policy, you may assume that your overburden may be estimated as the arithmetic average of the densities effective over the depth fractions. Based on this policy, the overburden density may be estimated by one of the following formula:

$$\rho_{overburden} = \sum_{i=1}^{n} \rho_i * x_i \text{ where } x_i \text{is the fraction of } i_{th} \text{ layer within the total depth}$$

- The tests taken at various points of drilling and completion operations suggest that the reservoir pressure can safely be assumed as [6500 + (g*100)] psi. This information concurs with the data obtained from nearby wells drilled at the same reservoir.
- Mechanical tests are carried out on the core samples taken from the reservoirs. The tests are carried out in a way such that the results reflect the properties of the reservoir rocks. The following results are listed in the geomechanical tests:
    - Deformability tests are carried out using sensitive strain gauges. Two sets of strain gauges are used to measure transverse and longitudinal deformation. The longitudinal strain (ε_{Long}) is measured to be 0.006, and the corresponding transverse strain ($\varepsilon_{Transverse}$) is found to be 0.0015. (Hint: Deformability tests give information about the Poisson's Ratio).
    - Biot's constant was obtained as 0.72.
- Based on the current contracts, your company must meet a specific production quota after the fracturing. Upon reviewing the production rates, you expect the pressure drawdown during the production period to be [1500+g*100].

Please make the most economical selection from the following proppant list based on:

- Hard reservoir rocks
- Soft reservoir rocks

Proppant Type	Offered Strength (psi)	Cost ($)
Weak Silica Sand	300	5000
Spherical Hard Proppant	7500	8500
Rubber-Based Soft Proppant	7500	8500
Homogeneous Ceramic Proppants	6000	12500
Sintered Bauxide Proppants	15000	17500
Zirconium Oxide Proppants	17000	18950

Question 2:

METU-2 well is drilled at a quartz-dominated sandstone, and the reservoir zone is intersected at [6500+(e+100)]ft. The field has been selected as a candidate for hydraulic fracturing, and numerous parameters must be planned for the fracturing operation. Numerous tests have been carried out on the field, and the available information are as follows:

- Geomechanical tests have been carried out on the samples that have been preserved at reservoir conditions. Two sets of strain gauges were used to measure the longitudinal and transverse deformation on the body. The findings are listed as:
    - The longitudinal strain (εLong) is measured to be 0.005, and the corresponding transverse strain (εTransverse) is found to be 0.00125. (Hint: Deformability tests give information about the Poisson's Ratio).
    - Biot's poroelastic constant was obtained as 0.70.
    - Tension tests have been carried out on the rock sample. It was observed that the rock failed at 1000 psi when exposed to tensile forces.
- The data from nearby wells have revealed that the pore pressure gradient of the region is 0.43 psi/ft.
    - Density logs taken from the field revealed that the reservoir section is overlain by multiple layers, and the densities of each layer are calculated as [140 + c] lbm/cuft for layer A, [150 + d] lbm/cuft for layer B, and [160 + e] lbm/cuft for Layer C
    - Correlation of logs shows that Layer A occupies 30% of the total depth until the reservoir section, while layers B and C occupy 35%, respectively.
- Microseismic studies revealed that the tectonic stress in the region is [1800+(g*20)] psi

When you speak with the fracturing contractor, they inform you that their trucks have specific adaptors, and not all tubing configurations can be used. Based on the previous local experience, you decide on using a configuration that has been exceptionally successful on a nearby well fractured by the same contractor. The configuration is as follows:

- The fracturing fluid rheology will be measured by a well-defined viscosity of 14 cP, and the corresponding fracture fluid has a specific gravity of 1.17.
- The tubing string will feature an inner diameter of 2.441 in.
- The injection rate is determined as 6.4 bpm.

Based on the available information, your task is to determine the breakdown pressure, maximum expected injection pressure at the surface, and hydraulic horsepower requirement for this fracturing operation. As per company policy, you are to use Economides and Nolte's approximation to calculate the frictional pressure drop when applicable.

Question 3:

You are tasked to evaluate whether a well would benefit from hydraulic fracturing in the METU-4 field, which is located in Western Turkey. The field is drilled as a vertical well, and it resides in the center of a drainage area of [61+2*f] acres. The well features a diameter of [0.4+0.05*f] ft.

- The well tests taken from the field indicate that the early-time data can be used to determine the skin factor of the well as [4+0.75*g]. In the mid-time region, the average permeability of the region is calculated as [3 + 0.3*e] mD.
- The fracturing simulations indicate that the local formation is most likely to be fractured as an 850 ft fracture in its total length. When this result is encountered, the most likely fracture width is observed to be 0.15 in, and the average permeability at the center of such fractures is [240000 +g*5000]mD.

Given the above conditions, you are asked to calculate the fold of increase in well productivity in the most likely simulation case assuming steady-state flow condition.

Note that your company policy requires you to undertake your calculations with two methods, which are the "Fracture conductivity vs. Equivalent Skin Factor Graph (Cinco-Ley & Samaniego, 1981)" and "Valko et al. Correlation." Refer to these methods, use both of them individually to find the effective skin factor, and compare the results. Discuss (if any) the reason for the differences, and state which method is more reliable in the given operation.