Advanced Petrophysics
PGE 381L, Fall 2023
Unique Number: 20215

Homework Assignment No. 1

August 31, 2023
Due on September 7, 2023, before 11:00 PM

Name: _____ **Solution** _____

UT EID: _____

Objectives:

a) To understand sedimentary environments and their impact on basic petrophysical properties
b) To review background information on geology

Note: Please scan your homework assignment and upload it as one pdf file on the Canvas website before the deadline. Please name your homework document as follows:

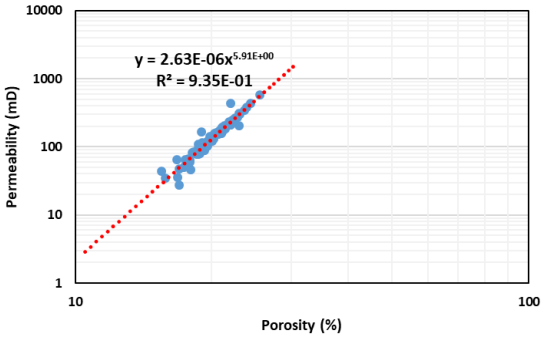
PGE381L_2023_Fall _HW01_lastname_name.pdf

Example: PGE381L_2023_Fall_HW01_Heidari_Zoya.pdf

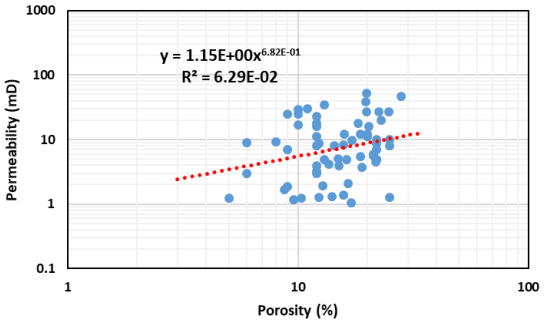
Question 1: Please download the Excel documents "SandstoneData_HW1" and "CarbonateData_HW1". These documents include porosity and permeability core measurements in a sandstone and a carbonate formation. Answer the following questions:

a) Prepare permeability-porosity cross plots for these two data sets. The x and y axes need to be in logarithmic scale.

Sandstone:



Carbonate:



b) Can you estimate permeability at a given depth in the sandstone formation, where porosity is estimated to be 20%? There is no core measurement available at this depth.
If yes, describe the method you design to estimate permeability, and write the estimated permeability below. If no, explain the reason(s).

Yes, there is a good correlation in the sandstone dataset. We can get a relationship between the porosity and permeability and use that relationship for estimation permeability using the porosity value as input.

Estimated Permeability: ~128.5 mD

c) Can you estimate permeability at a given depth in the carbonate formation, where porosity is estimated to be 12.5%? There is no core measurement available at this depth.

If yes, describe the method you design to estimate permeability, and write the estimated permeability below. If no, explain the reason(s).

No, in the case of carbonate dataset, there is not a good correlation between the porosity and permeability, which can be used for permeability estimation.

Question 2: A petrophysicist is evaluating the possibility of using micro-CT scan imaging for quantifying porosity of a given rock type in a spatially heterogeneous and tight carbonate formation. Would you approve this method? Write at least two reasons to support your decision.

No!

Reasons:

1. Scale
2. Resolution

Question 3: How do permeability and porosity vary vertically in a fining-upward sequence? Explain your answers. You can assume same spherical shapes and packing for the grains throughout this sequence. Write your assumptions.

From bottom to top, the grains change from coarse to fine, the K decreases from bottom to top, porosity can remain almost constant

Assumptions: shape & packing remain the same.

Question 4: We have two carbonate core plugs in the laboratory. Table 1 summarizes core measurements for these two rock samples.

Table 1: Core properties measured in the laboratory

	Porosity	**Permeability**
Rock A	0.15	200 md
Rock B	0.15	10 md

What could be the reason(s) for such different permeability values while porosity is the same in these two rock samples?

Pore space might not be well connected.

Question 5 (Problem 1.1 from your textbook): We received three core samples in the laboratory. We know that one of them is a quartz sandstone. The second one is a limestone and the third one is a dolomite. They are, however, not labeled. How would you identify them? Describe the experiments you would design to label these samples correctly.

1. Assessment of grain density
2. XRD/XRF measurement for lithology/elemental analysis
3. Visual inspection
4. Chemical test: Calcite react with cold HCl, dolomite react with hot HCl, quartz doesn't react.

Question 6: I have slabbed core samples in the laboratory for the depth interval of 9000ft to 9500ft and plan to measure porosity and permeability of the formation at the depth of 9200ft. Is the direction of the core plug that I cut for the permeability measurements important? What about porosity? Write your answer for the following situations. Please explain your answer.

a) Homogeneous and isotropic sandstone **No**
b) Cross-bedded sandstone **Yes**
c) Thinly-bedded laminated shaly sandstone **Yes**
d) Dispersed shaly sandstone **No** (**dispersed shale does not pose that much anisotropy)**
e) Organic-rich mudrock **Yes**

Optional Question:

Question 7: How does size and density of grains affect their deposition? Support your answer with simplified quantitative calculations. Can you use your calculations to explain dominant grain deposition trends in shallow and deep marine environments? List the assumption you made in your calculations.

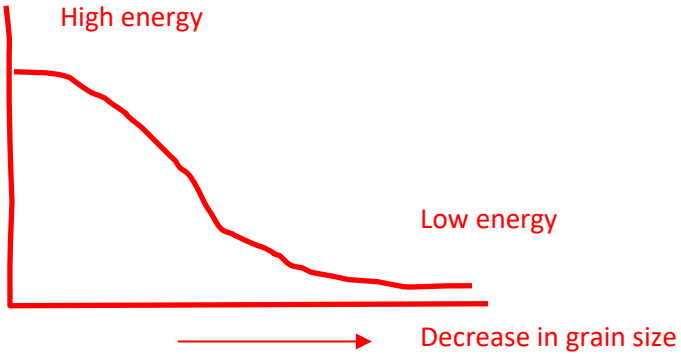
Hint: Consider the forces applied on the grains (e.g., Drag (quantify using Stokes' law) and buoyant forces) at equilibrium. Then, calculate the relative velocity between grains and liquid as a function of grain density, fluid viscosity, and radius of grains.
Assumption: Laminar flow, low NRe, spherical particles, smooth grain surface, isolated particles

$$F_d = 6\pi\mu r v$$

$$F_g = \left(\rho_g - \rho_f\right) g \left(\frac{4}{3}\pi r^3\right)$$

$$F_d = F_g$$

$$v = \frac{2\left(\rho_g - \rho_f\right) g r^2}{9\mu}$$



Faster stream velocity (higher energy) is required for transporting & depositing larger grains.