Homework 3

Due: Feb 20, 2025

This homework uses capillary pressure measurements; they are discussed first for clarification. Capillary pressure is defined as the difference between the pressures of the nonwetting and wetting phases and relates to the characteristic pore size of rock based on the Young-Laplace equation as follows:

$$P_c = P_{nw} - P_w = \frac{2\sigma\cos(\theta)}{r}, \quad (1)$$

where P_c is the capillary pressure, P_{nw} is the nonwetting phase pressure, P_w is the wetting phase pressure, σ is the interfacial tension, θ is the contact angle, and *r* is the characteristic throat radius. The capillary pressure measurements were obtained by mercury injection; thus, mercury saturation determines the wetting phase saturation as follows:

$$S_w = 1 - S_{Hg} = 1 - \frac{V_{Hg}(P_c)}{V_{Hg}(\max)}, \quad (2)$$

where S_w is the wetting phase saturation, S_{Hg} is the mercury saturation, $V_{Hg}(P_c)$ is the mercury volume in the sample at a given capillary pressure, and $V_{Hg}(\max)$ is the maximum volume of mercury in the sample. Figure 1 shows examples of the measurements.

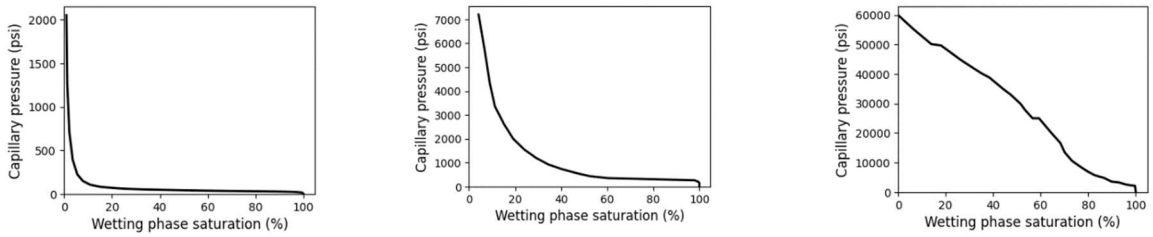

Fig. 1. Three capillary pressure measurements of the collected data.

This homework is based on the data collected from hydrocarbon reservoirs in the US and the Middle East. It uses the characteristic sizes of the rock sample at various wetting phase saturations as its features. Thus, 100 sizes are available that are denoted by r100 to r1, corresponding to the wetting phase saturation decreasing from 100% to 1% (see Fig. 1). The data are posted on CANVAS (hw3_data).

First, divide the data randomly into training and test sets. Then, use regression to determine the sample permeability (listed as “Permeability, nD” in the data file) based on the 100 features. Evaluate your model performance and report the corresponding measures. Also, state your assumptions for receiving credit. It is up to you whether you use porosity as a feature.

Further reading: This is a classic problem in petroleum engineering. You may like to search PetroWiki to find previous studies, such as Winland’s equation and Pittman’s results. Your solution will differ from those because you are expected to use all the features (r1 to r100).