HW-5.1: DETERMINING NORMAL COMPACTION TREND (NCT)

This homework supplements the discussion over the derivation of normal compaction parameters discussed in (Flemings, 2021). We will use various approaches to determine the normal compaction trend (NCT). We will use the Eugene Island 33#1 well to determine the NCT (Fig 1). This well has the most complete suite of shallow log data that is close to the 330 A20 well where we wish to predict pressure. In this well, pressures are approximately hydrostatic to 5,000 feet. We will use the spreadsheet **'NCT_Spread_sheet_and_PPP_EI-330'** to interpret the normal compaction trend parameters for the 331 #1 data.
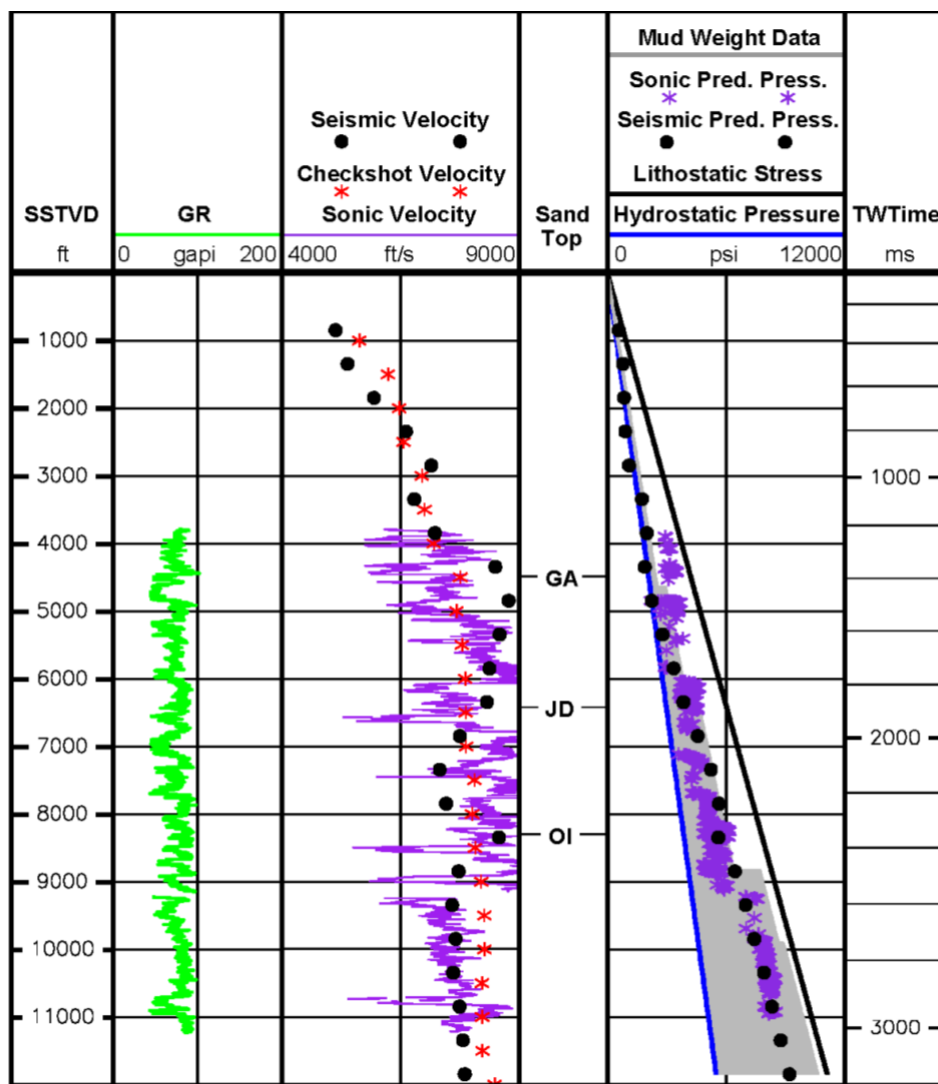

Fig. 1: 331B10 well. This is along the same path as the 331#1. Pore pressures are approximately hydrostatic to at least 4000 feet and perhaps 6,000 feet.
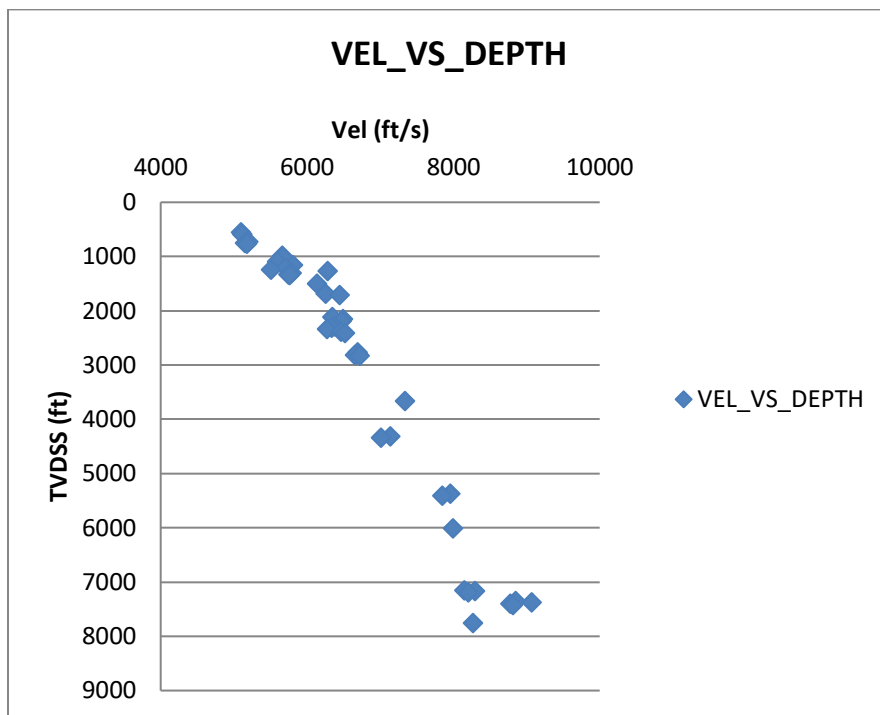
Fig. 2: Mudstone picks from the Eugene Island 331 #1 well. This exploration well had the most complete log of the shallow section and is thus used to determine compression parameters.

HUBBERT APPROACH:

To determine the parameters n_o and β, we first calculate the porosity from the sonic log (see (Flemings, 2021) Chapter 5).

$$n = 1 - \left(\frac{dt_{ma}}{dt}\right)^{\frac{1}{f}} \qquad \text{Eq. 1}$$

$$dt_{ma} = 220 \frac{\mu sec}{m} \qquad \text{Eq. 2}$$

$$f = 2.19 \qquad \text{Eq. 3}$$

Hubbert's compression relationship is as follows:

$$\sigma_v' = \sigma_v - u \qquad \text{Eq. 4}$$

$$u = \sigma_v - \sigma_v{}' \qquad \text{Eq. 5}$$

$$n = n_0 e^{-\beta \sigma_v{}'} \qquad \text{Eq. 6}$$

$$u = \sigma_v - \frac{1}{\beta} \ln\left(\frac{n_o}{n}\right) \qquad \text{Eq. 7}$$

To calculate n_o and β, we perform an exponential regression on a plot of hydrostatic effective stress vs. n_dt (Figure 3)
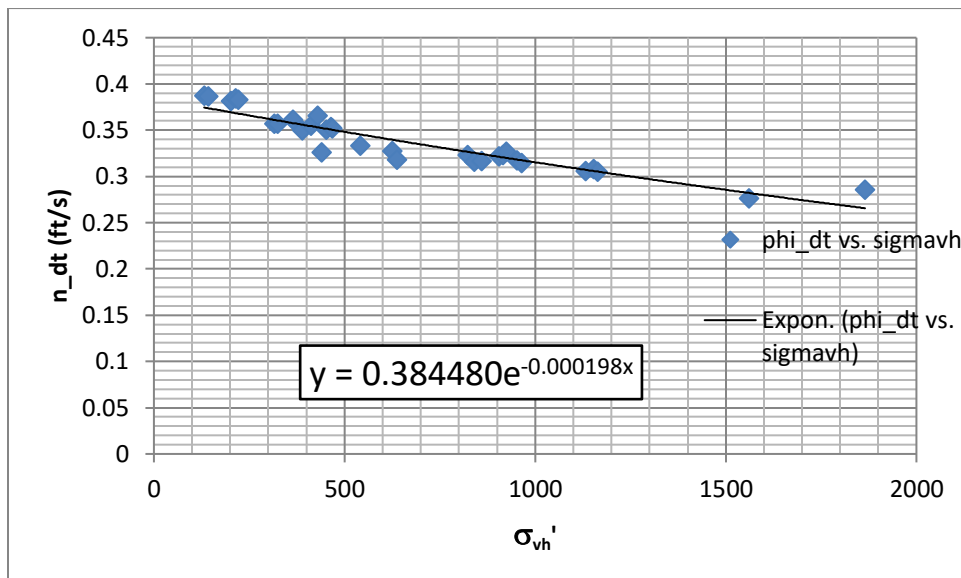

Fig 3. Plot of hydrostatic effective stress (σ_{vh}') vs. porosity (n) calculated from sonic log (Eq. 1). Exponential regression parameters are shown (Eq. 6). See Figure 5.11 (Flemings, 2021).

Use the spreadsheet **'NCT_Spread_sheet_and_PPP_EI-330'** to perform your own regression on the 331 #1 data.

1. Fill in your regression parameters in the table.

Table 2: interpreted Hubbert parameters.

Depth (ft.) interval of regression	Excel Row Interval	n_0	β *(PSI^{-1})*
0-3000	3-31		
0-5300	3-38		
1200-4300'	12-34		

2. Plot the predicted pressure vs. depth that results from your predicted behavior (use the 2nd tab in the spread sheet). Because you derived your NCT parameters in a zone with hydrostatic pressure, when you predict pressures for the same data, they should also be hydrostatic. This way of plotting the data is one way of visualizing the quality of your NCT determination.

3. Discuss which is your preferred model and why? Summarize what you should see if you've correctly done your job.

BOWERS APPROACH:

Bowers assumed that effective stress was a power law function of velocity (Eq. 2)

$$\sigma_v' = \sigma_v - u \qquad \text{Eq. 8}$$

$$\sigma_v' = \left(\frac{V-5000}{A}\right)^{\frac{1}{B}} \qquad \text{Eq. 9}$$

$$u = \sigma_v - \sigma_v' \qquad \text{Eq. 10}$$

$$u = \sigma_v - \left(\frac{V-5000}{A}\right)^{\frac{1}{B}} \qquad \text{Eq. 11}$$

To constrain the parameters A and B, we plot the hydrostatic effective stress against (v - 5000) (Fig 3)
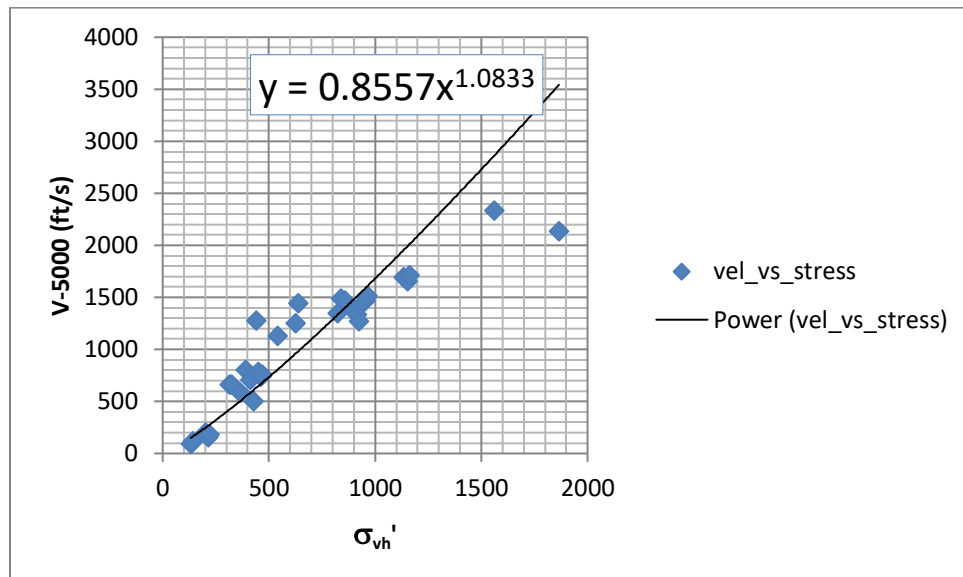

Fig 3: Example plot of hydrostatic effective stress (σ_{vh}') against velocity less 5,000 feet (V-5000).

1. Calculate A and B parameters using the provided spread sheet. Table 1: interpreted Bowers parameters.

Depth (ft.) interval of regression	Excel Row Interval	A	B
0-3000	3-31		
0-5300	3-38		
1200-4300'	12-34		

2. Using the 2nd tab on the spreadsheet, plot the predicted pressure vs. depth that results from your predicted behavior. Because you derived your NCT parameters in a zone with hydrostatic pressure, when you predict pressures for the same data, they should also be hydrostatic. This way of plotting the data is one way of visualizing the quality of your NCT determination.

3. Discuss which is your preferred model and why

Flemings, P. (2021). *A Concise Guide to Geopressure: Origin, Prediction, and Applications*: Cambridge Press.