Problem Set Lecture 6: Acoustic Properties

1. What factors determine the vertical resolution of borehole seismic measurements?

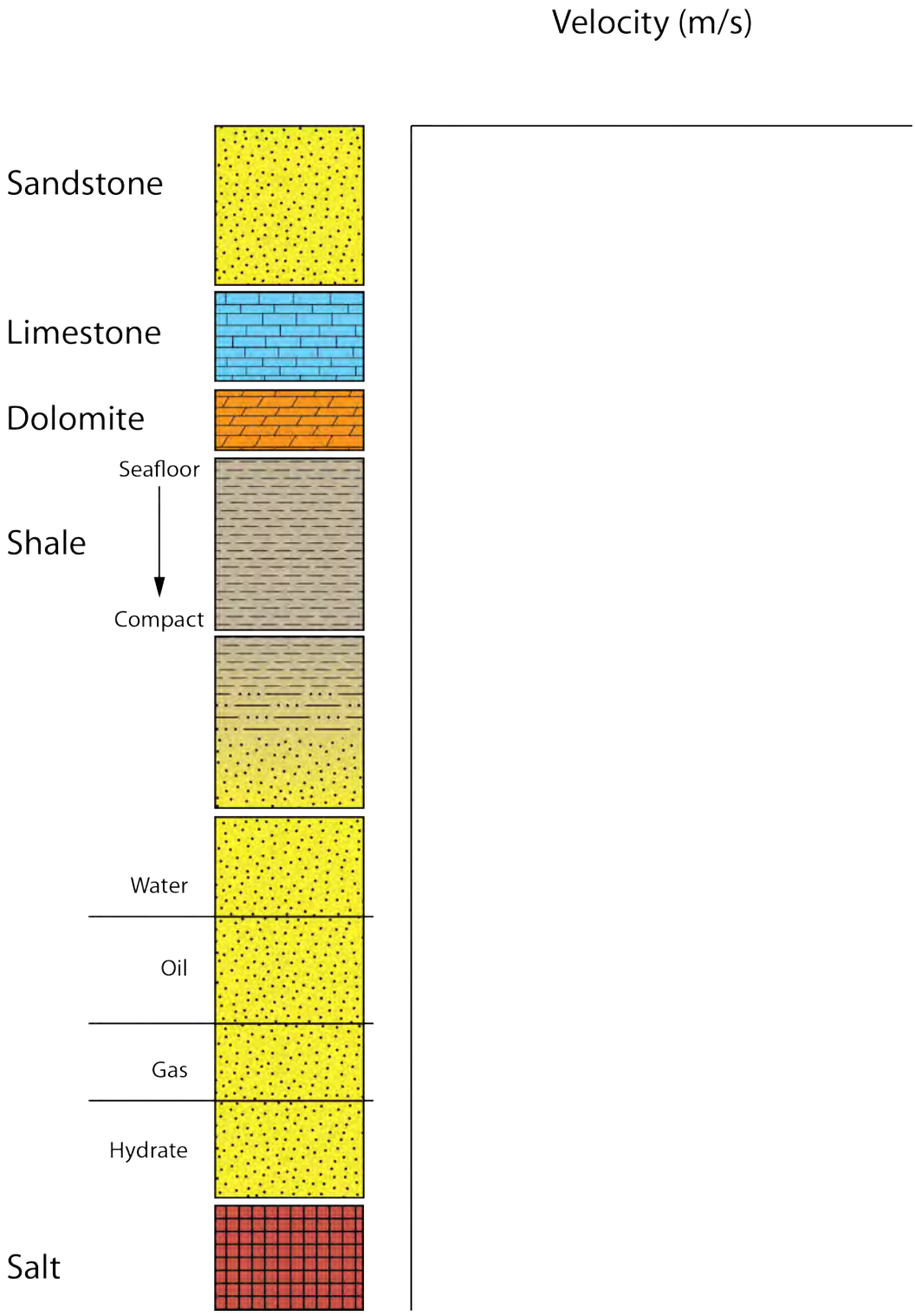
2. Explain why the compressional wave velocity is influenced by pore fluid composition, but the shear wave velocity is not. How can this be used to identify gas zones in a reservoir?

3. Given the following experimentally determined parameters for the Bulk and Shear Modulus, calculate the compressional and shear wave velocity for these clayey sediments. Also calculate the porosity.

Bulk density (g/cm^3)	K (GPa)	G (GPa)	Vp (km/s)	Vs (km/s)	Porosity
1.8	3	2			
2.3	8	5			

4. In the question above you are given the Bulk and Shear modulus of a clayey sediment with different bulk densities? Why do the moduli increase as the bulk density increases?

5. Calculate and draw the compressional and shear wave velocities (in m/s) for the lithologies shown below. What do the high velocities tell us about the inferred porosity of these sediments and rocks?



6. Measurements of the bulk density and compressional wave velocity of surface sediments found in different depositional environments of the North Pacific are provided in the table below.

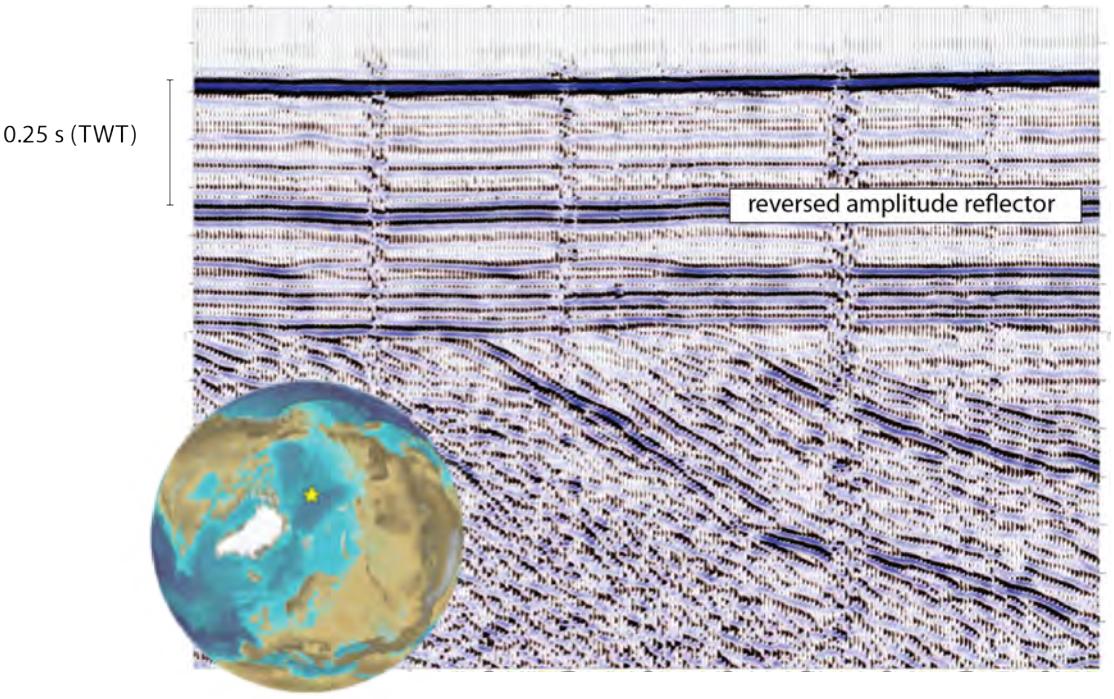
Sediment type	Bulk Density (g/cm3)	Vp (m/s)	Grain density (g/cm3)	Porosity (fractional)	Predicted Velocity (m/s)
Sand (Coarse)	2.03	1836			
Sand (Fine)	1.98	1742			
Sand (Very Fine)	1.91	1711			
Silty Sand	1.83	1677			
Sandy Silt	1.56	1552			
Sand-Silt-Clay	1.58	1578			
Clayey Silt	1.43	1535			
Clayey Silt	1.38	1535			
Slayey Silt	1.41	1531			
Silty Clay	1.42	1519			
Silty Clay	1.24	1521			
Silty Clay	1.37	1507			
Clay	1.26	1505			
Clay	1.42	1492			

A. Using an appropriate grain density, calculate the porosity of these sediments.

B. Use the Velocity-Porosity model of Eriksson and Jarrard (1998) to calculate the compressional wave velocity.

C. Plot the measured versus predicted velocity, and comment on the fit of the predictions to the measured data.

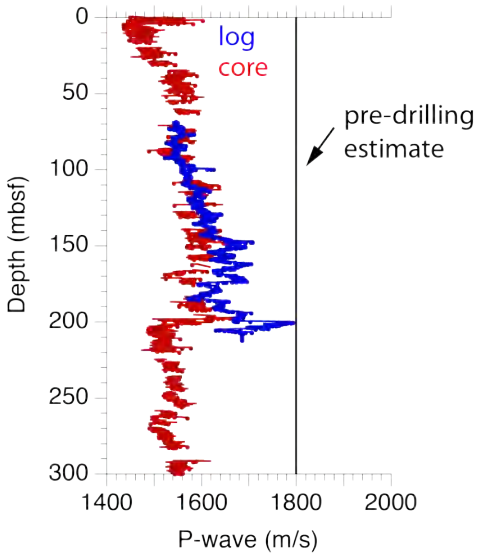
7. Prior to drilling on the Lomonosov Ridge (Arctic Ocean), seismic reflection data was used to estimate an interval velocity of 1.8 km/s. One of the intriguing drilling targets was a strong, reversed amplitude reflector found 0.25 TWT below the seafloor.



A. What does the presence of a reversed amplitude reflector tell us about the velocity structure of the sedimentary sequence?

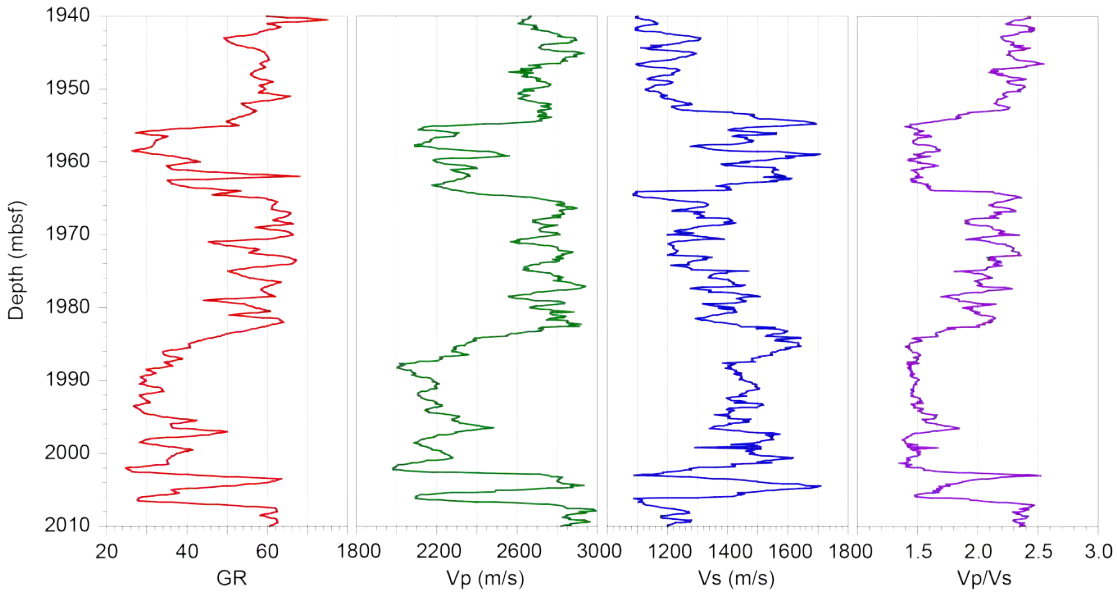
B. Prior to drilling, what would be the predicted depth to the reversed amplitude reflector?

C. After drilling, velocity measurements on sediment cores and from downhole logging were performed. These measurements agree well and define an average velocity of 1600 m/s? What could be some of the reasons for the lower measured values on sediment cores and the logging data?



D. The abrupt lithologic transition responsible for the reversed amplitude reflector was found at 200 mbsf (*see figure above*). Use this true depth to calculate the compressional wave velocity of the overlying sediments. How does it compare with the measured values and those derived from the seismic reflection data?

8. Below are some wire-line logging results from a deeply buried reservoir sequence.



A. First calculate the Vp/Vs ratios for the different lithologies in the table below. These characteristic values are taken from the textbook.

Lithology	Vp (m/s)	Vs (m/s)	Vp/Vs
Sandstone	5750	3050	
Limestone	6400	5750	
Dolomites	7920	6770	
Shales	5080	1790	

B. Based on the Vp/Vs ratio from the logging data, what types of lithologies are present in the logged interval of the borehole?

C. Using on the Gamma-ray log, define the litholgies present in this borehole section. How do the inferred lithologies compare with the lithologies predicted by the Vp/Vs ratio?

D. Calculate the shale content at the points provided in the table below. The maximum gamma-ray reading from the entire reservoir sequence was 65 gAPI, and the minimum 25 gAPI.

E. Looking at the gamma-ray log, what type of lithologic changes are happening between 1982 and 1994 mbsf?

F. Use the Willie-time-averaged equation, Raymer-Hunt-Gardner model and Eriksson and Jarrard model to predict the compressional wave velocity at the points in the table below. For the Wyllie and Raymer-Hunt-Gardner models, use appropriate matrix velocities from the table in the lecture slides.

Depth (mbsf)	Lithology	Vp (m/s)	Vsh	Bulk Density (g/cm^3)	Porosity	Vp (m/s) (Wyllie)	Vp (m/s) (Raymer)	Vp (m/s) (Ericksson)
1967.4		2796		2.41				
1994		2155		2.20				