Analyzing Downhole Logging Data

STUDENT NAME: .....

STUDENT ACTIVITY

SCIENTIFIC OCEAN DRILLING

Objective(s)/Outcome(s)

Students will be able to interpret data from downhole logging to explain why the process is done and what it allows scientists to learn about the ocean floor.

Materials

Per Group:

- computer with internet access
- color copies of Figures 3 and 4

Background

After ocean sediment cores have been brought up on research vessels, such as the *JOIDES Resolution*, scientists often learn more about what lies beneath the seafloor by lowering special instruments into the borehole to measure physical properties of the sediments and rocks. This process is called logging because the records of the data are called logs.

Data from logging adds more knowledge about Earth's history because some of the seafloor materials will not be recovered by drilling. Some substances are too hard or too weak for complete recovery. This creates gaps in the cores. But logs provide continuous records that give information about the missing layers. Also, when the cores are brought to the surface, temperature and pressure conditions are very different from where materials originally lay, and so the cores may expand or be altered in the process of bringing them to the ocean's surface.

Logging measurements, by contrast, are made in situ (in the place where the layers are located), so they help correct core properties that were disturbed or changed. Strings of instruments attached together are lowered by an electrical wireline into the borehole to measure sediment and rock properties, as represented by Figures 1A and B. This operation allows scientists to study such variables as stratigraphy (what kinds of rock and sediment layers are under the seafloor); mineral composition; porosity (amount of space between the particles); locations of fractures and faults; and cycles in the stratigraphy that may reveal patterns of climate change or other events in Earth's history.

Activity

1. Make observations of two ocean sediment cores: **1228A** and **1326C-D**.

    a. On each image database, you will find links to images of core segments and sections taken from seafloor drilling sites. Use Figure 2 as a guide for how the images are organized:
    - "Leg" is the expedition number.
    - "Site" is the specific hole where the core was collected.
    - "H" is the specific core taken from the site (e.g., core 1228 was collected in 4 large units, labeled A, B, C, and E).
    - "Cor" is the segment number (e.g., core 1228A was brought up in 23 segments).
    - "Depth" in meters below seafloor (mbsf) is how deep in the seafloor each segment/section was taken.
    - "Image Link" takes you to image files ("Core_" files contain multiple sections listed below them).

STUDENT NAME: .....

FIGURE 1A. THE BOREHOLE LOGGING PROCESS

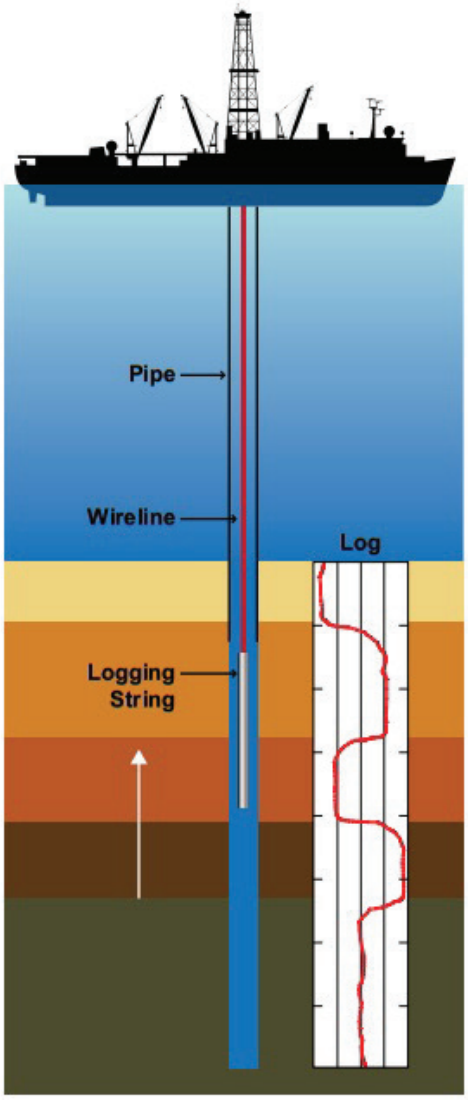
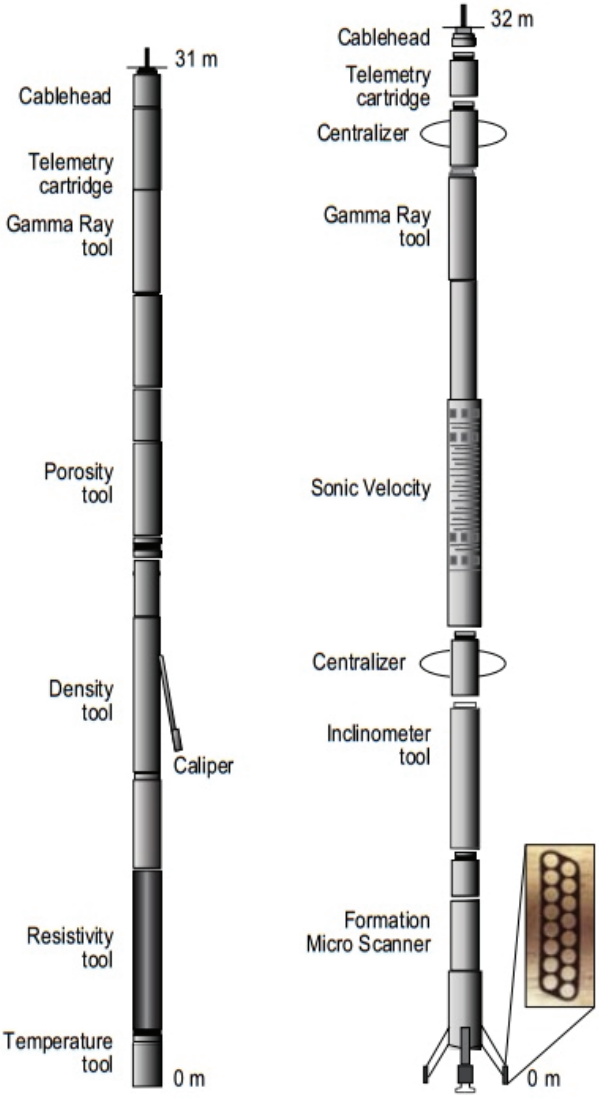


FIGURE 1B. BOREHOLE LOGGING INSTRUMENTS



Credit: ODP

FIGURE 2. IMAGE DATABASE

Leg	Site	H	Cor	T	Depth (mbsf)	Format	DPI	Image Link
201	1228	A	1	H	0.000	PDF	300	Core_1
201	1228	A	1	H	0.000	JPG	254	Section_1
201	1228	A	1	H	1.410	JPG	254	Section_2
201	1228	A	1	H	2.910	JPG	254	Section_3
201	1228	A	1	H	4.410	JPG	254	Section_CC
201	1228	A	2	H	4.900	PDF	300	Core_2
201	1228	A	2	H	4.900	JPG	254	Section_1
201	1228	A	2	H	6.400	JPG	254	Section_2
201	1228	A	2	H	7.900	JPG	254	Section_3
201	1228	A	2	H	9.400	JPG	254	Section_4

Credit: IODP

STUDENT NAME: .....

b. Click through at least 5 images for each core (1228A and 1326D) and make observations of what you notice about how similar or different the segments look (compare the segments from each core to each other as well as to the other core). Note any unique features. Zoom in as needed to see detail within the core images.

c. For Core 1228A, open the image for segment 10H (**Core_10**), which was identified as containing both shale and sand. Describe how scientists might tell the difference between the two types of sediment. Hypothesize where each sediment type is located within this core segment.

d. For Core 1326C-D, open the images for segments C9 (**Section_4**) and D3 (**Section_2**). How does the appearance of these two sections compare? Look at each individually and then side-by-side to make comparisons.

e. Gas hydrates were identified as common near the bottom of "Section_4". **Read about gas hydrates** to learn how they form and why they are important to study.

f. Describe what the gas hydrates in the bottom of "Section_4" look like, then compare this core to "Section_2". Are gas hydrates also found in "Section_2"? How can you tell?

2. Obtain a copy of Figure 3, which shows the downhole logging data from the two ocean sediment cores you observed in Step 1.

a. The maps show where each site is located. Look closely at the latitude and longitude markings or landforms shown.

b. Identify and record the hemisphere and ocean from which each core was collected.

3. Observe the data for each coring site.

a. As you first examine these logs, you may feel overwhelmed by the amount of data they contain. Focus on patterns in the data, then you will likely start to recognize anomalies that stand out.

b. As you examine the logs, pay special attention to the range of values at the top of the Gamma Ray and Resistivity columns. Consider why the ranges may be different and what that might tell you about the sediment and rocks found at each site.

c. The typical ranges for two of the logged properties are shown in Table A:

TABLE A: TYPICAL RANGES OF PHYSICAL PROPERTIES MEASURED IN SEAFLOOR BOREHOLES

Material (sediment/rock)	Gamma Ray units	Resistivity (Ω.m)
Sand	20–80	0.1–2.0
Shale	50–180	0.1–2.0
Hard Rock (e.g., basalt)	<20	10–50,000

d. Annotate the graphs to identify trends, anomalies, and questions you might have.

STUDENT NAME: .....

e. Look at the section of each graph that is enclosed in boxes. The key shows a specific sediment of interest within each of these sections.

f. Revisit the image of segment "**Core_10**" of Core 1228A. Identify at what depth this core segment was collected and find the corresponding depth on the graph. How does the downhole logging data compare for areas of sand versus shale?

g. Revisit the images of Core 1326C-D, **Section_4** and **Section_2**. Identify at what depth each core segment was collected. Study the downhole logging data that corresponds to each section. How does the data differ when gas hydrates are common in the sediment versus when they are sparse?

Analysis

1. Use data from borehole 1228A to describe trends in the data for sand and shale.

a. Which reading do you think is least useful in determining sediment type and why?

2. Use data from borehole 1326C-D to describe trends in data can help identify areas with high concentrations of gas hydrates.

a. Read a description of how downhole logging data is used by technicians and scientists to identify sediment layers that contain gas hydrates (**section 3, on page 5 of this article**). Describe how this information agrees with or contradicts the data you have from score 1326C-D.

3. Obtain a copy of Figure 4, which shows downhole logging data for a third core: 1246A-B. Summarize the trends in data and note anomalies in the data. (While PEF data can also be used to identify materials within a sediment core, it will not be discussed here.)

a. Use what you have learned to choose two sections of this core (**image database**) to discuss in terms of how the downhole logging data can give insight into the sediment types within the core.

STUDENT NAME: .....

Synthesis

1. Conduct research to learn about the conditions of each coring site you have studied (1228, 1326, and 1346). Questions you may want to investigate include:

   a. How deep is the ocean at the drilling site?

   b. How close is the drilling site to a continent?

   c. Is there tectonic activity nearby to the site?

   d. What seafloor/geologic features are in the area?

   e. Why were scientists interested in monitoring this site?

2. Summarize how the environment of the seafloor determines the types of sediments that will be found in specific locations.

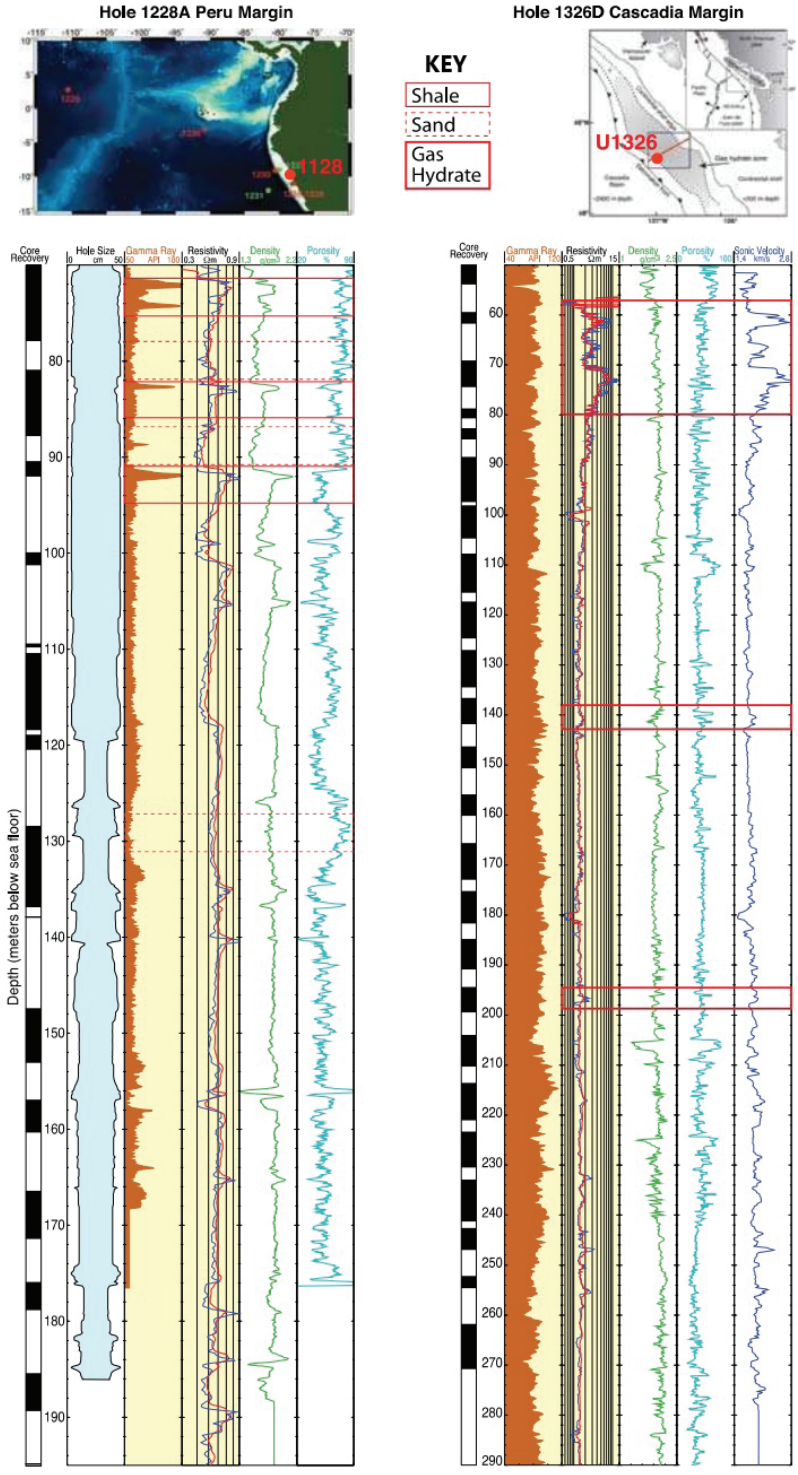
Extensions

1. Locate downhole logging data for other ocean coring sites. How does the data differ from the sites studied in this lesson? How do the environmental conditions of these locations compare to the sites you studied, and how might differences in these conditions affect the data collected in this area?

STUDENT NAME: .....

HANDOUTS

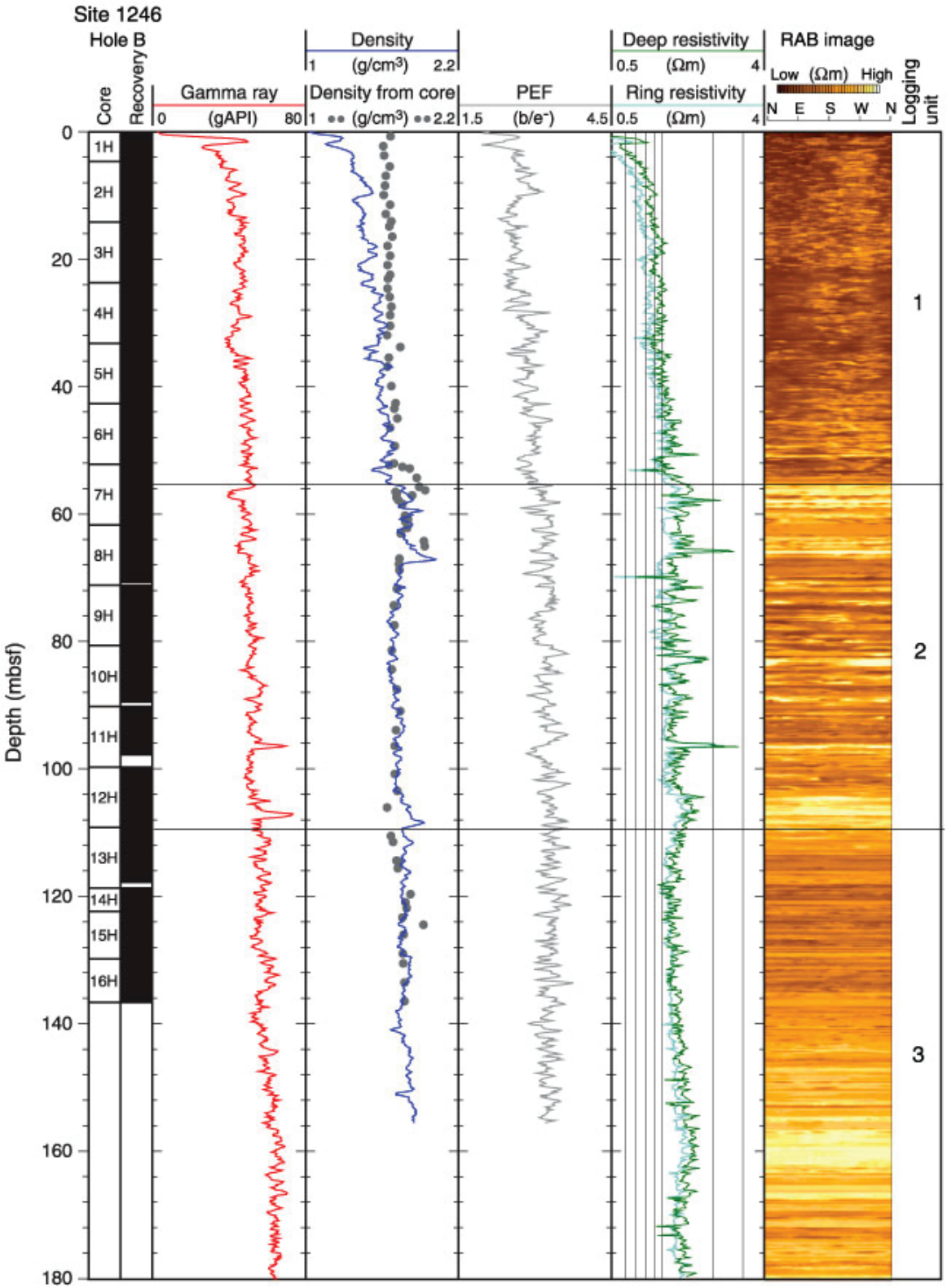
FIGURE 3. DOWNHOLE LOGGING DATA FOR TWO OCEAN SEDIMENT CORES



Credit: Modified from Leg 201 and 311, ODP/IODP, respectively.

STUDENT NAME: .....

FIGURE 4. DOWNHOLE LOGGING DATA FOR CORE 1246A-B



Credit: Leg 204, ODP.