Discovery Under the Ocean Floor

STUDENT NAME: ....

STUDENT ACTIVITY

Objective(s)/Outcome(s)

Students will be able to analyze ocean sediment cores to describe the sediment and rock types found on the floor of the South China Sea and how these relate to how tectonic conditions have changed the area over time.

Materials

Per Group:

- color copies of Core Lithology handouts
- computer with internet access

Per Student

- data table

Background

Layers of sediment and rock on the ocean floor are like a historical record of Earth's geological processes. Terrigenous sediments, which originate from land (such as when a river erodes rocks and washes sand and silt into the ocean), reveal a wealth of information about the surrounding terrestrial environment. These sediments, carried to the ocean by rivers and wind, build up in distinct layers over time. By examining the composition and thickness of these layers, geologists can infer past climatic conditions, erosion rates, and even changes in land elevation. For instance, a sequence of fine-grained terrigenous sediments (like silt) may indicate periods of high sedimentation from river systems, reflecting either increased rainfall or more intense weathering of the landmass.

In contrast, basalt layers on the ocean floor provide clues about tectonic activity and volcanic processes. Basalt forms from the rapid cooling of lava at mid-ocean ridges, where tectonic plates pull apart and magma rises to fill the gap. Basalt flows can also occur at areas of subduction, where a tectonic plate melts as it is forced down into the mantle, forming a volcanic arc above areas of melting. Variations in basalt composition, such as changes in mineral content or isotopic signatures, can also indicate shifts in volcanic activity or tectonic movements. By studying these basalt layers, scientists can reconstruct the history of plate interactions and volcanic events, offering insights into the dynamic processes shaping the oceanic crust and influencing global tectonics.

Both terrigenous and igneous layers can be observed by collecting cores from the seafloor. Expedition 349 was conducted by scientists aboard the *JOIDES Resolution*, to take cores from sites in the South China Sea, which is known to have a complicated tectonic history. The analysis of these cores have given insight into plate movement and both volcanic and earthquake activity and how they have altered the area.

Activity

Part 1

1. Study Figures F1 and F2 from the **Expedition 349 Summary**. Be sure to read the captions for more information on what each map shows.

   a. The red circles indicate where cores were taken from the seafloor. You will be focusing on Sites U1435 and U1431.

Developed in collaboration with the American Geosciences Institute

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b. Areas that show a sharp change in depth can indicate trenches caused by subduction zones. In Figure F1, these trenches are located near three of the red arrows: in the Pacific and Indian Oceans, and the Philippine Sea. The subduction zone and trench in the Philippine Sea continue southward, parallel to

c. Look also at Figure F6-B from the **Expedition 349 Summary**. This image shows a cross-section of the area in which the cores were taken.

d. Use information from the maps and images to hypothesize what you expect to find in the cores taken at Sites U1435 and U1431. Both hypotheses should include:

- the percent or ratio of sediment versus rock you expect to find in the cores,
- the geologic features you would expect to find at each location (e.g., faults, folds, fossils, and others),
- an explanation for your hypothesis using evidence from the map.

2. Obtain core lithology (rock types and characteristics) diagrams for Sites U1435 and U1431. The depth of the core is measured in meters below sea floor (mbsf).

    a. The “Core” and “Recovery” columns tell about the core collection process. These columns do not need to be used in your assessment of the cores. You will use the graph later in the analysis.

    b. The “Lith. Unit” (Lith. = Lithologic) column indicates sections of the core that scientists have identified based on the Geologic Time Scale and how these cores correlate to sediment and rocks that have been described and studied during other expeditions.

    c. For now, focus on “Age” and “Lithology,” which indicates the types of rocks and sediments within the core. In the data table, add a brief description of the sediment types in each layer, including the age. You will add a brief description of the environmental conditions that created each layer in step 3.

3. Access an **interactive map from Deep-time Digital Earth** that shows how tectonic activity has changed Earth over time.

    a. Note the Geologic Time Scale indicated above the globe (Eon at the top, then Era, Period, Epoch, and Age). Time is shown in millions of years ago (Ma). Refer to the **Geologic Time Scale** created by the Geological Society of America as needed.

    b. Try out the map by clicking on different segments of time. Observe how the map changes. Click on the globe and drag your mouse to turn the globe or click the 10th icon down on the menu to get the globe to spin to see different areas.

    c. Click on the 11th icon down on the menu to switch to flat maps (2D or Columbus). All the maps will show the same changes, but some views might be easier to interpret.

    d. Reset the map to present time by clicking on “Phanerozoic” or by hitting the refresh button on your browser.

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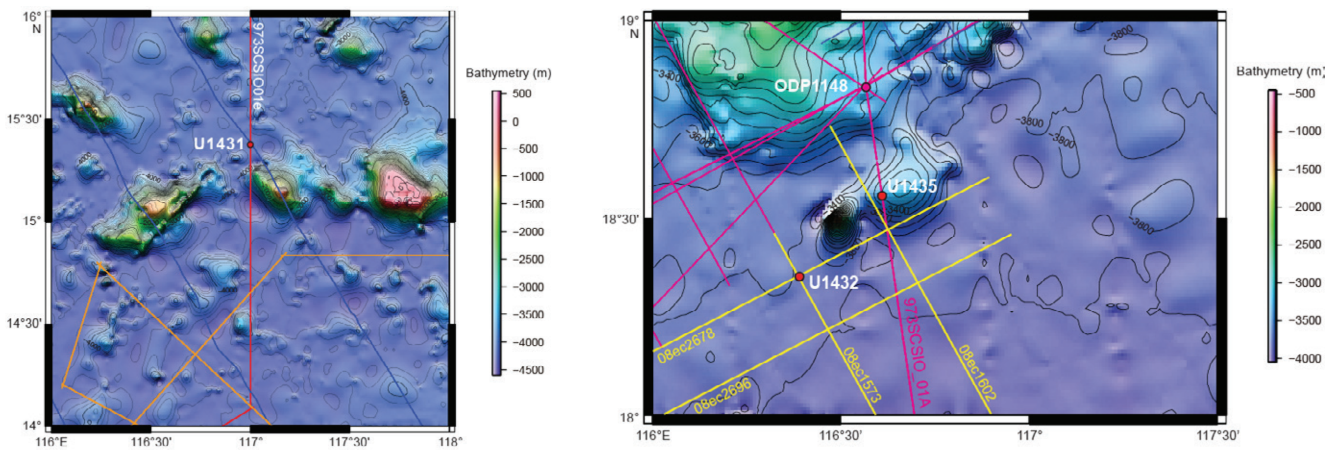
e. Click on the globe icon on the menu to the right of the screen (6th icon down, when you hover over it, its name will show “Switch graticule”). This will turn on latitude and longitude lines.

f. Clicking on the globe will allow you to indicate a specific point. Click on your hometown so a “target” appears on this spot. Click through different time frames to see how your area has changed over time.

g. You will now do this with the two drilling sites from Expedition 349, focusing on the time frames in which each core was formed. Use the coordinates on Figures A to approximate the placement of each site (U1431 and U1435) on the interactive map.

FIGURE A. LOCATION OF SITE U1431



Credit: Li et al., 2015

h. Start with Site U1431 by placing the “target” on the map. Start with the Ypresian Age, which ranges from 56 to 47.8 Ma. In the data table, briefly describe the conditions that existed at Site U1431 during this Age, then click on the rectangle to the right of the Ypresian to move to the next Age. Continue to summarize the changes you see, though for some time frames, you may note that the same conditions continue to exist.

i. Repeat step h with Site U1435.

Analysis

1. How deep was Site U1431 cored, and how does this compare with Site U1435?

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a. Which core contains older sediment or rock? How do you know?

b. Use the graphs of sedimentation rate to explain the difference between the thickness of various layers within the cores. Use specific data from the graph or cores to support your explanation.

c. Consider what you have learned about each site's location to explain the differences in sediment accumulation.

2. At which site were more microfossils found (i.e., calcareous nannofossils, planktonic foraminifera, radiolarians)? Use evidence from the graph to explain how you know this. How does this relate to the depth of each site?

Synthesis

1. Look at the summaries of data reported at **Site U1431** and **Site U1435**. Especially look through the images of these reports to see parts of the cores that contained unique sediment, rocks, or evidence of geologic events.

a. Summarize at least two unique features found in each core. Reference specific images from each report to support your summary.

b. Compare your observations to your initial hypotheses. Were your hypotheses accurate? If so, describe the evidence you found that was consistent with your hypotheses. If not, describe the evidence that contradicts your hypotheses.

2. Look at the map of all drilling sites for Expedition 349 (**Figures F2 and F6-B**). How would you expect cores from Site U1432 to compare to the other sites that you studied during this investigation? Explain your reasoning.

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3. Compile evidence from images, graphs, and the Expedition 349 summary to discuss how ocean sediment cores can help describe the complex tectonic history of the South China Sea.

Extensions

Read the abstract and introduction of a journal article that used data from Expedition 349 to describe tectonic activity in the **South China Sea: Proto-South China Sea Plate Tectonics Using Subducted Slab Constraints from Tomography**. As with most research, this study also makes use of additional data sets to build a more comprehensive model of the area. Look through the images within the article and identify at least two other types of data that were used in this study. Summarize how each data set contributes to the understanding of the complex tectonic history of the South China Sea region.

SCIENTIFIC OCEAN DRILLING

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HANDOUTS

REPORT SHEET 1: SEDIMENT AND ROCK LAYERS WITHIN CORES FROM SITES U1431 AND U1435

Expedition 349

Site U1431			Site U1435	
Description of Unit in Core: Sediment Type(s), Age, and Environment	**Depth in Core**	**Lith. Unit**	**Depth in Core**	**Description of Unit in Core: Sediment Type(s), Age, and Environment**
		I		
		II		
		III		
		IV		
		V		
		VI		
		VII		
		VIII		
		IX		
		X		
		XI		

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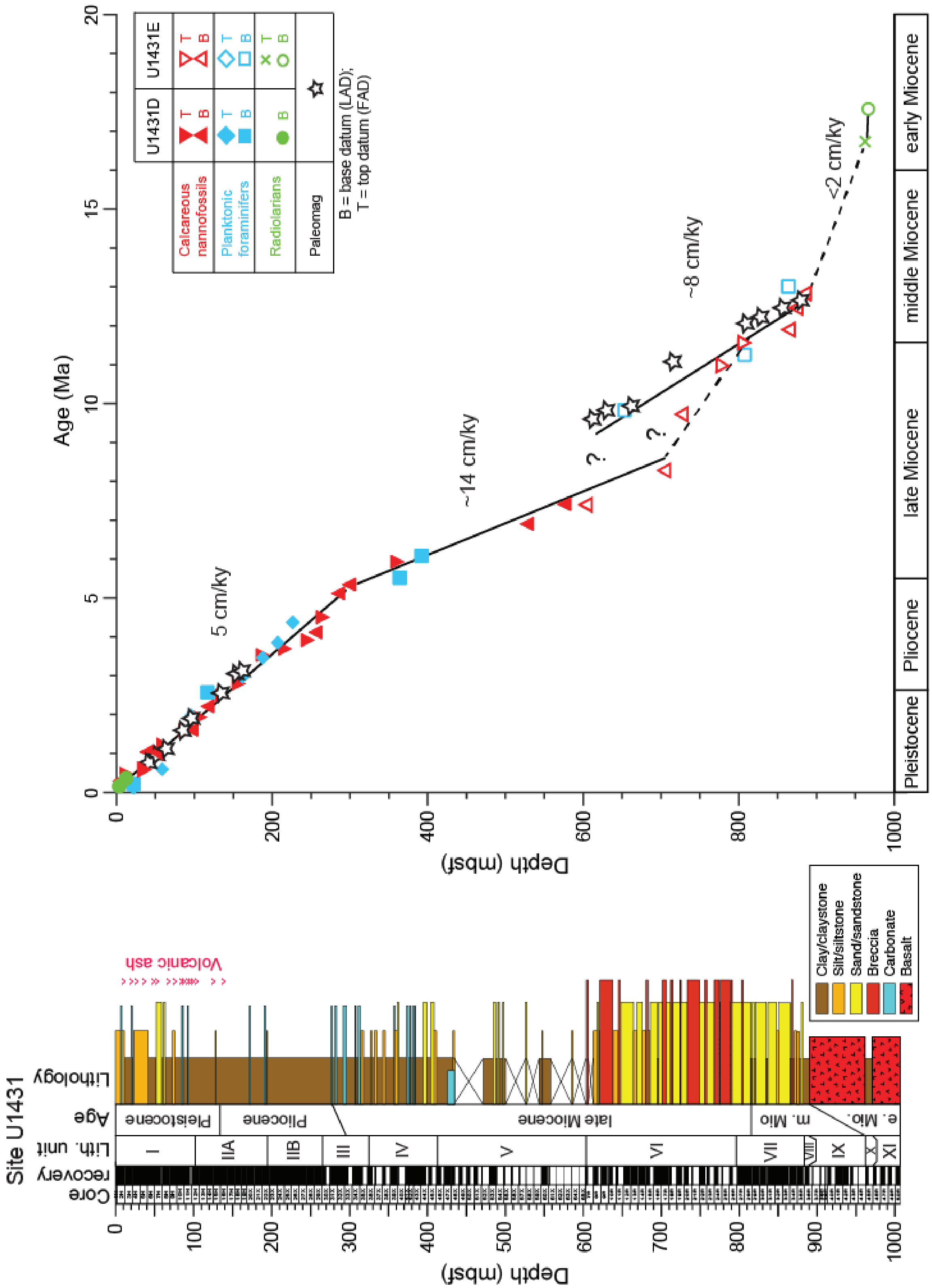
LITHOLOGY AT SITE U1431



Credit: Li et al., 2015

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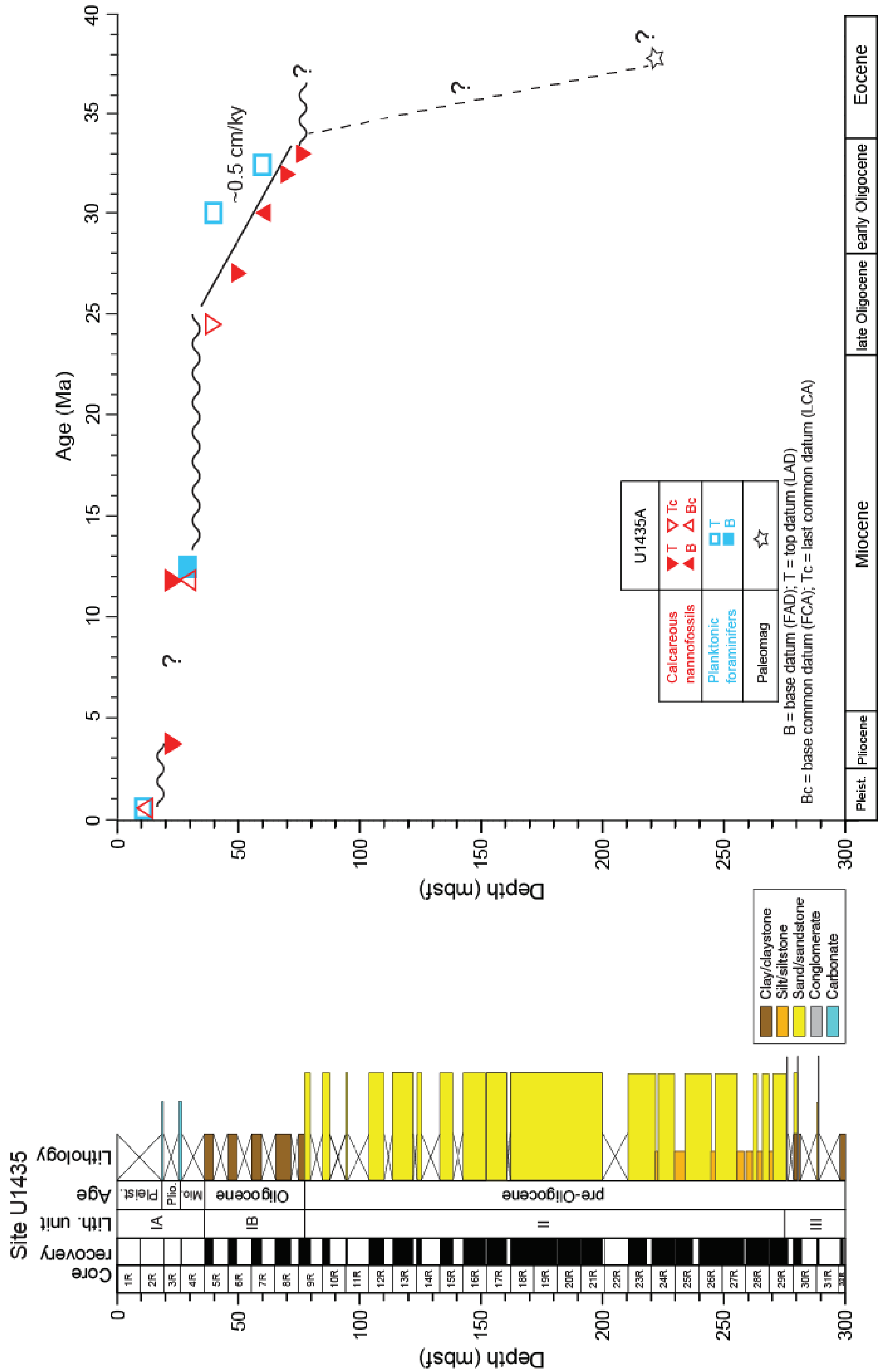
LITHOLOGY AT SITE U1435



Credit: Li et al., 2015