HOW TO READ A ROCK

VOL. 1 CURRICULUM GUIDE

How to Read a Rock: A Graphic Novel on Ocean Science (Volume 1) was written to educate, entertain, and inspire kids ages 10 to 14 (Grades 5 to 9). It was also written to be a teaching tool for educators of this age group, to help teachers reach their standards while providing examples to students of how these science concepts apply in the real world. This guide identifies concepts and standards reached by the graphic novel and presents activities and resources that teachers can use to expand upon the reading experience.

STEM concepts covered by *How to Read a Rock (Volume 1)*

Earth science concepts

- Cores of sediment and rock layers reveal Earth's history
- Rock formations are records of both massive events and slow natural processes in Earth's history
- Water and ice can weather and erode landscapes
- Earth's climate has changed in the past to produce ice ages
- Natural events on land can cause changes in the ocean
- Radioactive decay allows scientists to find the ages of rocks, sediment, and living remains

Physical science concepts

- Bodies in motion tend to stay in motion and bodies at rest tend to stay at rest unless other forces act upon them
- Gravity in a vacuum pulls down objects of different masses at the same rate

Scientific method concepts

- Scientists answer questions by making observations to gather large amounts of data; then they look for patterns and cause and effect relationships in the data to find answers
- Technology allows scientists to gather data from places where the human body could not survive
- Technology allows scientists to make observations and take measurements that cannot be observed by human senses

Next Generation Science Standards (NGSS) covered by *How to Read a Rock (Volume 1)*

Most of the states in the US have either adapted NGSS as their state science standards or have based their state standards on NGSS. Below are the Next Generation Science Standards addressed by *How to Read a Rock (Volume 1)*.

Fifth Grade

5-ESS2-1 Earth's Systems

Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Middle School (6th – 8th)

MS-ESS1-4 Earth's Place in the Universe

Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.

MS-ESS2-2 Earth's Systems

Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.

MS-ESS2-4 Earth's Systems

Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.

MS-PS2-2 Motion and Stability: Forces and Interactions

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

High School (9th – 12th)

HS-ESS2-1 Earth's Systems

Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

HS-ESS2-2 Earth's Systems

Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-5 Earth's Systems

Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-PS2-2 Motion and Stability: Forces and Interactions

Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

HS-PS1-8 Matter and its Interactions

Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

Enrichment and Reinforcement Resources

There are many free resources available that can help students learn more about scientific ocean drilling after reading *How to Read a Rock*.

Video Game

Stories from the Cores are three-video-games-in-one that put players into the roles of scientists studying real deep-sea cores to solve a mystery. These games are available to download for free and are usable on both PC and Mac devices.

One of the games, *Mysteries of the Core*, is about the same catastrophic glacial floods covered in *How to Read a Rock (Volume 1)*. The game:

- includes information related to the cores and the glacial flooding event not found in the comic
- exercises critical thinking skills in players
- provides an animated visualization of the floods.

In the other two games, students study cores to learn about life under the seafloor and the extinction of the dinosaurs.

Students can play the game on individual devices, or the game can be played as a classroom activity on a screen/smartboard at the front of the class. Since the game is mainly about thinking and making decisions, the class can come to a consensus about which choices to make in the game.

You can find download instructions and a trailer for the game here:
https://joidesresolution.org/for-educators/download-stories-from-the-core/

Still from *Mysteries of the Core*

Videos

These are brief, professionally produced videos that can help students learn more about how scientific ocean drilling helps us understand our planet and answer questions they may have had after reading *How to Read a Rock (Volume 1)* about how and why drilling at sea is done.

What is the International Ocean Drilling Program (IODP)?
The IODP is a scientific organization that uses scientific ocean drilling to do research. Their scientists retrieved and studied the cores in *How to Read a Rock (Volume 1)*. This video introduces students to the IODP, why scientific ocean drilling is important, and some of the amazing things IODP scientists are learning.
https://www.youtube.com/watch?v=0nydKlpZdIU

How does a drillship drill and retrieve cores from under the ocean?
This playlist contains six videos, all about one minute in length, that shows the technology that the IODP scientific drilling research ship the *JOIDES Resolution* (the ship that retrieved the cores in the graphic novel) uses to drill into the seafloor.
https://www.youtube.com/playlist?list=PLroDmZEKRHPMPV3ZirPQpkdEmedXy9hzz

360 Tour of the *JOIDES Resolution*
The *JOIDES Resolution* is the research ship that retrieved the cores in *How to Read a Rock (Volume 1)*. These videos can be controlled by the viewer to give 360 tours of the actual places on the ship where drilling and research (and sleeping) are done.
https://joidesresolution.org/about-the-jr/jr-vessel-tour/

How does science work?
This video shows how the scientific method has been so effective at allowing us to understand our world by using research done on the *JOIDES Resolution* as examples.
https://www.youtube.com/watch?v=i9tsdAQBcfM

Drill Down Deeper Information Sheets

These two-sided information sheets, created to be supplemental materials for the *In Search of Earth's Secrets* traveling exhibit, can be downloaded as PDFs and will also enrich and reinforce the information students learned in *How to Read a Rock (Volume 1)*.

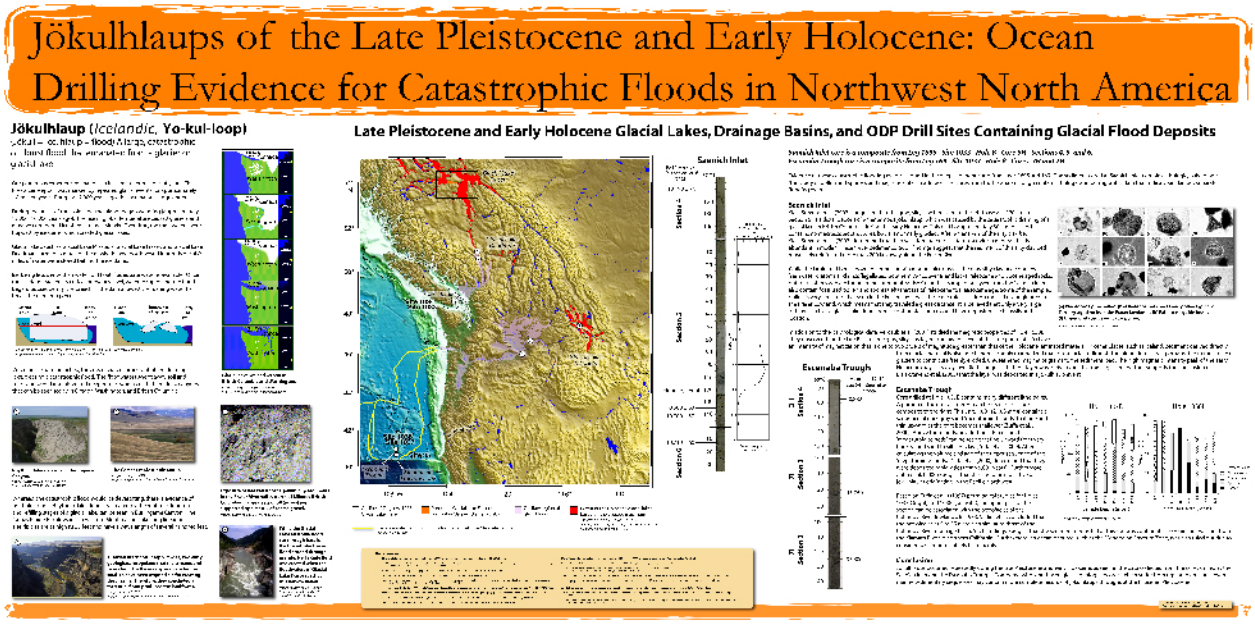
What is a Core?
Learn more about cores, including one of the Saanich Inlet cores with evidence of the Pacific Northwest glacial floods.
https://joidesresolution.org//wp-content/uploads/2018/03/WhatIsACore-DrillDown.pdf

Drilling the Deep
Get a closer look at the drill bits used in deep sea drilling and learn more about life at sea.
https://joidesresolution.org//wp-content/uploads/2018/03/DrillingtheDeep-DrillDown.pdf

***Ocean Drilling Evidence for Catastrophic Floods in Northwest North America* poster**

https://joidesresolution.org/wp-content/uploads/2017/08/Glacial-Flood-PosterJVF.pdf

This poster uses images, graphs, and text to present the scientific results of two IODP expeditions that found evidence of catastrophic glacial floods in the Pacific Northwest, including the expedition discussed in the graphic novel. Scientists use posters like this at conferences to share the findings of their research projects with other scientists. The poster is available as a PDF that can be zoomed into, scrolled through, and read on any device. It can also be presented on a smartboard or another screen so the class can read it together. Below are suggestions for how to use this poster with students.



Reading Comprehension Questions

On the next page you will find questions you can share with students to assess their comprehension of the poster. An answer key is found on the following page.

Students Create a Similar Poster for Younger Students

Using the ***Ocean Drilling Evidence for Catastrophic Floods in Northwest North America*** poster as a model, have students work alone or in teams to create posters to teach younger students (3rd or 4th grade) about the ice age glacial floods and the role sea floor cores played in providing evidence for these occurrences. The posters can be simplified versions of this poster. Be sure students consider what images (maps, photos, illustrations, graphs, etc) would be best to include in the poster to help 3rd and 4th graders understand this information. Students should also use the *How to Read a Rock* graphic novel as a source of information for this project.

Reading comprehension questions for *Ocean Drilling Evidence for Catastrophic Floods in Northwest North America* poster

After reading the poster, answer these questions.

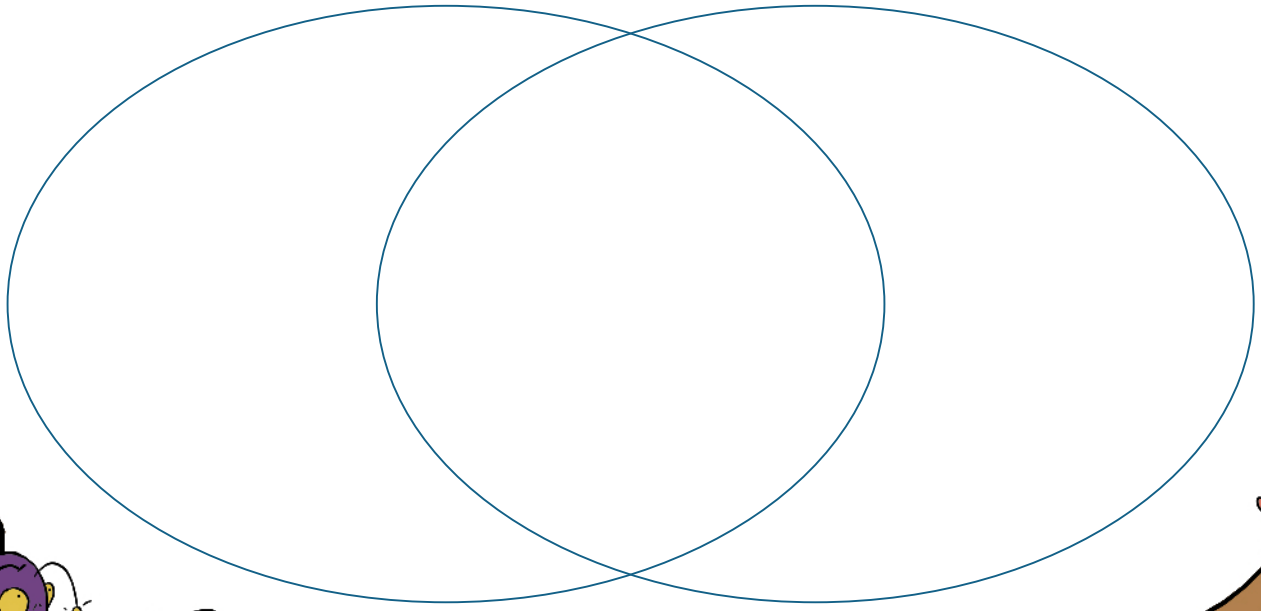
1. What is a Jökulhlaup in your own words? What language does the word come from?

2. When did the Holocene time period begin and what happened when it started?

3. Name two places on land in the Pacific Northwest where evidence of the catastrophic glacial floods can be seen.

4. Name two kinds of evidence for the glacial floods that were found in the cores from the Saanich Inlet that weren't found in the cores from Escanaba Trough (Hint: one comes from plants and the other is related to magnets).

Use the left side of the Venn Diagram to identify three things you only learned in the comic. Use the center to identify three things you learned in both the comic and the poster. Use the right side to identify three things you learned only in the poster.



***Ocean Drilling Evidence for Catastrophic Floods in Northwest North America* poster Answer Key**

After reading the poster, answer these questions.

1. What is a Jökulhlaup in your own words? What language does the word come from?

   A flood caused when a glacier dam creates a glacial lake and then the glacial dam gives out and the lake water bursts out as a flood. It is an Icelandic word.

2. When did the Holocene time period begin and what happened when it started?

   The Holocene started 12,000-10,000 years ago when the Earth warmed and glacial ice sheets started melting, bringing the last ice age to an end.

3. Name two places on land in the Pacific Northwest where evidence of the catastrophic glacial floods can be seen.

   There are more than two options mentioned in the poster:
   - *Rhythmic lake deposits in Burlingame Canyon*
   - *Camas Prairie Ripple Marks*
   - *Jökulhlaup sediments in the Fraser River valley north of Lillooet, British Columbia*
   - *Hell's Gate*

4. Name two kinds of evidence for the glacial floods that were found in the cores from the Saanich Inlet that weren't found in the cores from Escanaba Trough (Hint: one comes from plants and the other is related to magnets).

   - *Pollen and spores from land plants that are of Paleocene to Pleistocene age*
   - *Clay layers that are more intensely magnetized than other layer, indicating they may be glacial in origin*

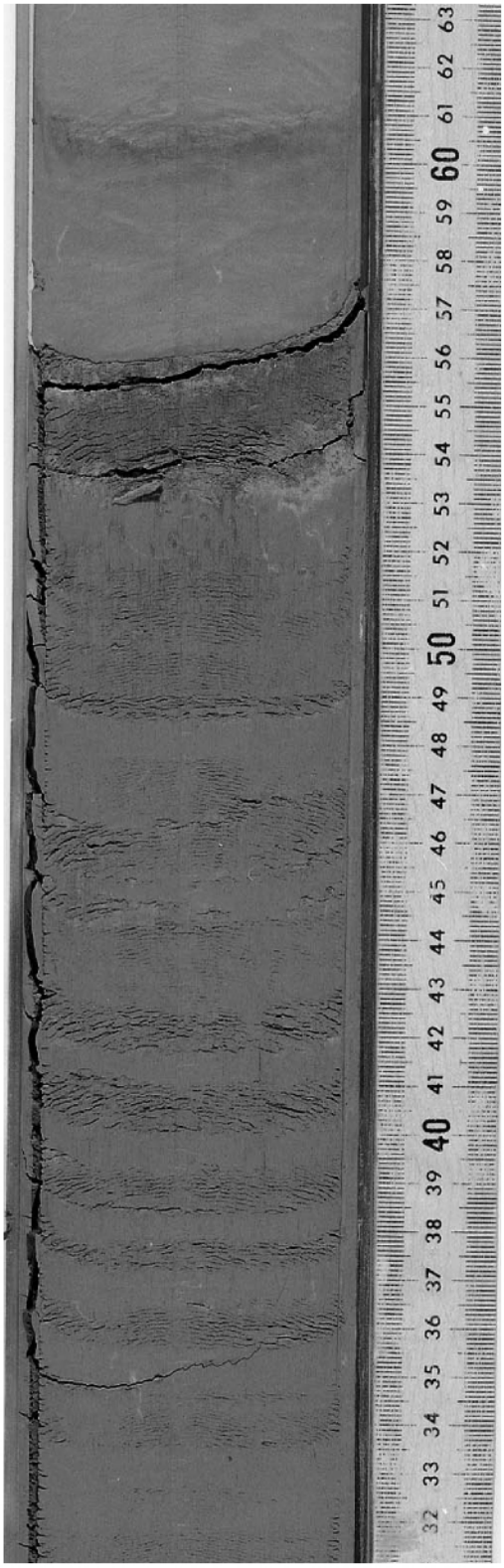
Use the left side of the Venn Diagram to identify three things you only learned in the comic. Use the center to identify three things you learned in both the comic and the poster. Use the right side to identify three things you learned only in the poster.

Both the poster and the graphic novel discuss the Pacific Northwest glacial floods that occurred during the last Ice Age. They also both discuss evidence for the floods found on land and in the cores drilled from the Escanaba Trough. Only the poster discusses the cores drilled in the Saanich Inlet and data found within it. Only the poster introduces terms like "Jökulhlaup" and "Holocene." Only the comic provides background information on concepts like radiometric dating and Galileo.

Comparing Cores

These are photos of cores retrieved from the Escanaba Trough. Observe the cores closely and then answer the questions.

Core A:



Comparing Cores

These are photos of cores retrieved from the Escanaba Trough. Observe the cores closely and then answer the questions.

Core B:

Comparing Cores Questions

1. How would you describe the colors of the A core in comparison with the B core? Do you see any differences in color within just the A core? Do you see any differences in color within just the B core? Describe the differences you see.

2. How would you describe the textures and patterns (shapes, dots, stripes, etc) of the A core in comparison with the B core? Do you see any differences in the textures and patterns within just the A core? Do you see any differences in the textures and patterns within just the B core? Describe the differences you see.

3. How would you describe cracks and fractures within the A core in comparison with the B core?

4. Which core do you think is sediment and which ones do you think is rock?

5. Which of the cores do you think came from a deeper place under the seafloor?

Comparing Cores Answer Key

1. How would you describe the colors of the A core in comparison with the B core? Do you see any differences in color within just the A core? Do you see any differences in color within just the B core? Describe the differences you see.

   The A core is darker in color than the B core. The A core is a dark gray with some areas darker than other, and the bottom band lighter gray than the rest. The B core is mostly a lighter gray with dark spots and white edges.

2. How would you describe the textures and patterns (shapes, dots, stripes, etc) of the A core in comparison with the B core? Do you see any differences in the textures and patterns within just the A core? Do you see any differences in the textures and patterns within just the B core? Describe the differences you see.

   The A core is smooth in some places and has little cracks in other places that form dark bands. This is different from the B core, which looks speckled and splotchier.

3. How would you describe cracks and fractures within the A core in comparison with the B core?

   There are many tiny cracks in the A cores that are close together and from horizontal bands. There are a couple of horizontal, curved cracks that go from one side to the other. There is also a long vertical crack that goes up the right side of the core. It's hard to tell is the cracks in the A core go all the way down and break up the core into multiple pieces. The cracks in the B core up obviously break the core into multiple pieces. There even appears to be a piece missing. The B core also has cracks that are at more of a diagonal to the edge of the core than the A core cracks.

4. Which core do you think is sediment and which ones do you think is rock?

   The A core is sediment, and the B core is rock.

5. Which of the cores do you think came from a deeper place under the seafloor?

   The B core is from deeper under the seafloor than the A core, because the sediment falls on the rock at the bottom of the ocean and is therefore above it.