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# Earthquakes, Glaciers, and Sediments, Oh My! Subjects: Earth Science, Environmental Science, Life Science/Biology Grades: 9-12

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# EARTHQUAKES, SEDIMENTS AND GLACIERS, OH MY!

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**Grade Level**
Middle School

**Subject area**
Earth Science, Environmental Science

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**Focus**: Sediment patterns: What layers in the sediment tell us about Earth history.

**Target grade level/subject**: 9th Grade Earth Science.

**VA Science Standards Addressed**

- ES.1 – elapsed time, direction, distance, depth, technology, collection, analysze, report, profiles, maps, latitude and longitude.
- ES.2 – science explains and predicts, earth systems, observation and logic, evidence
- ES.5 – rock cycle (erosion of rock into sediment and delivery to the ocean)
- ES.7 – geologic and tectonic processes
- ES.9 – relative dating
- ES.10 – sea floor and tectonic processes

**Learning Objectives/Outcomes**

A. Students will identify how earthquakes and glaciers weather, erode, and transport sediments from continents to the sea floor.

B. Students will recognize what sediments are made of and distinguish between sediments with different grain sizes and elements.

C. Students will draw on knowledge gained in the first two objectives to conduct a team analysis on data they collect in a mock observational study of sediment layers from the sea floor.

D. Students will explain their group analyses, and together the class will infer the earth history events which deposited the sedimentary layers. They should come away understanding how geologist can study Earth history from sediments.

**Total Length of time required for the lesson**: Approximately 2.5 hours in class, with half that time for teaching background material and half for the activity. Advanced prep outside of class is about 3 hours to print materials, rearrange the classroom, and make the sediment layers and bins.

**Key Vocabulary/Concepts**:

- Plate tectonic boundary types
  - http://oceanexplorer.noaa.gov/facts/plate-boundaries.html

- Convergent boundary
  - http://www.kidsgeo.com/geology-for-kids/0046-convergent-boundaries.php
  - https://www.youtube.com/watch?v=BlymeytlMiM
    - I recommend watching just the first 25 seconds

- Earthquake epicenter vs hypocenter
  - http://earthquake.usgs.gov/learn/glossary/?term=hypocenter

- Where do glaciers form (or rather WHAT do glaciers form!):
  - **Fjord**: long, narrow, deep inlet of the sea between high cliffs typically formed when a glacially carved valley is submerged
  - http://photos.nouvelles-frontieres.fr/Produits/NOR00350_norct010.jpg
  - http://www.siwallpaperhd.com/wp-content/uploads/2015/09/panoramic_valley_wallpaper-724x407.jpg

- Glacier anatomy:
  - **Accumulation area**: high in the mountains, where the snow builds up faster than it melts
  - **Firn line (snow line, equilibrium)**: the point where the snow stops and only ice is left
  - **Ablation zone**: This is the region past the snow line, where more ice/snow melts than accumulates each year.
  - **Crevasses**: large cracks that form as the glacier slowly moves and breaks
  - **Lateral Moraine**: regions along the sides and front of the glacier where a lot of rock and dirt have been picked up as it rubs along the bottom and sides of mountains
  - **Terminus**: The end of the glacier where it melts.
  - **Terminal moraine**: the pile of rock and sediment that forms at the end of the glacier as it melts and any picked up rubble falls out.
  - http://images.slideplayer.com/21/6291654/slides/slide_30.jpg
  - http://www.indiana.edu/~sierra/papers/2008/gray_clip_image002.jpg
  - http://www.pacificalpineguides.com/wp-content/uploads/2013/05/anatomy-of-glacier800_2.jpg

- Glacial mass balance
  - **Mass balance**: More snow accumulates than melts each year, and it is successively compressed into ice over decades and centuries. It is important to note that mass balance effects whether a glacier is "advancing, receding, or in equilibrium." The glacier itself never stops sliding down hill, but the **position** of the terminus (the bottom end where melting occurs) will change.
  - http://www.antarcticglaciers.org/modern-glaciers/introduction-glacier-mass-balance/
  - https://www.youtube.com/watch?v=loI584OFVpE

- Glacier erosion
    - **Plucking**: the glacier breaks up rock beneath it by freezing and thawing cracks (same way we get pot holes!) and then freezing the rock into the bottom of the glacier and dragging it along as it moves. Through this it breaks and grinds rocks down into finer grained sediments. This is also how glaciers slowly carve valleys and fjords.
    - https://www.youtube.com/watch?v=4wNOrFy17WE

- Calving
    - The process of large ice bergs breaking off at the terminus of a tidewater glacier
    - https://www.youtube.com/watch?v=zA6KCs_O73Q
    - https://www.youtube.com/watch?v=1s5-IvHVDqg
        - I recommend watching 0:50-1:20.

- Outburst flood
    - An outburst flood can occurs when you have a lake dammed by a glacier, either alongside the glacier or in a sub- (beneath) glacial lake, and the dam breaks or floats when the lake water levels build up enough.
    - https://en.wikipedia.org/wiki/Glacial_lake_outburst_flood
    - https://www.youtube.com/watch?v=8ScHkS_cqk4
    - https://www.youtube.com/watch?v=8rPDYG8NZYs
    - https://www.youtube.com/watch?v=f-r1uCZUrzA

- Particle/grain size
    - http://www.encyclopedia.com/doc/1O13-particlesize.html

- Turbidity current
    - http://www.britannica.com/science/turbidity-current
    - https://en.wikipedia.org/wiki/Turbidity_current
    - https://www.youtube.com/watch?v=8gYJJjxY8g0

- Bathymetry/topography
    - http://oceanservice.noaa.gov/facts/bathymetry.html

- Turbidite
    - http://www.britannica.com/science/turbidite

**Background Information**:

This activity is based off real research happening in Prince William Sound, Alaska. This body of water is located along the Aleutian Megathrust Boundary, an active convergent boundary of the Pacific plate. Severe earthquakes are a frequent occurrence here. There are also glaciers flowing into the Sound; the Columbia Glacier is one of the most intensively studied glaciers in the world and it terminates in PWS. The Copper River, located about 100 km east of the Sound, also plays as a major contributor to sediments deposited within the Sound. Student will take mock cores which encompass sediment layers deposited by earthquake, glacial, and river activity. They will deduce the epicenter of the earthquake and the flood and seasonal deposits from the glacier and river.

Earthquakes

After an introduction to basic plate tectonics, focus in on how earthquakes are created at convergent boundaries. The frictional and stress forces between the bottom of the overriding plate and the top of the subducting plate lock up until they snap, and you get an earthquake. Make sure to highlight the difference between the epicenter and the hypocenter.

Glaciers

Go over background of glaciers and how they break up rocks. Make sure to highlight that as the glacier moves and plucks, it drags large rocks and grinds them down into finer sediments. Also discuss how glaciers deliver sediment to the sea: 1. Meltwater streams carry sediment out to sea (and in extreme cases outburst floods) 2. Rocks and sediments frozen to the bottom of the glacier float out in icebergs when the glacier calves, and eventually fall to the sea floor when the berg melts. Depending on the level of your class and the detail you want to go into, you can discuss how climate and weather affects the migration of the terminus (mass balance), go into detail on the anatomy, and watch calving videos.

Outburst floods

Outburst floods occur when a glacially dammed lake builds up water pressure as the lake water levels increase (as the lake collects melt and rain water). The dam can be broken or floated (it IS made of ice!) The water comes gushing out as an outburst flood. These floods carry freshwater very heavily laden with glacial sediment to the ocean, and they are actually more dense than saltwater due to their sediment load. They can generate another type of sediment gravity flow that moves along the sea bed known as a hyperpycnal flow. You don't need to differential the hyperpycnal flows from turbidity currents with the students, but they should understand that underwater turbidity currents from earthquakes are a different process than outburst floods which deliver sediment to the sea.

- This is the key idea that will be touched on in the activity. Make sure to show them videos of floods so they get an idea of how much sediment and water comes rushing out! Contrast how clear and blue the water looked in the calving videos!

Sediment

Sediment is finely ground up rocks and soils from the continents that is delivered to the ocean by rivers, glaciers, rain, etc. The processes in this activity that grind up rocks into sediment are glaciers and rivers. **Rivers** grind up rocks by rolling them along the bottom.

Discuss the **seasonality** of sediment delivery to the ocean. Rivers and glaciers deliver more sediment to the ocean during the spring, summer and fall in Alaska because it is warmer and rainier! The glacier melts more and the rivers get more runoff.

**Grain size** is the difference in between the sizes of different sediment particles. Larger grainsizes are heavier than smaller ones, and they will fall through water and be deposited at the bottom of layers white the smaller ones remain suspended in the water for longer.

> If you have a large clear bottle (like a 2 liter) you can put some pebbles and very fine sand in the bottle, fill it with water, and do a brief settling experiment to demonstrate this.

Sediments formed from different types of rocks will have different **minerals**. Minerals are composed of different elements. In our study, we will be looking at three different sediment sources: The Copper River which is eroding rocks in the Wrangell Mountains; The Columbia Glacier which is eroding rocks in the Chugach Mountains, and the Prince William Sound local sediments formed by a mixture of different soil and rock types washed overland by precipitation. This sediment group, called "Local" is derived from the **watershed** of the Sound. The specific minerals found in sediments are indicator that reveal their source – which mountains they came from and by extent which process delivered them to the sea (glacier, river, local watershed runoff).

**Turbidity currents** form when a catastrophic event stirs up a ton of sediment on the sea floor or washes it from land into the ocean. These currents are like a muddy river flowing along the sea floor. Earthquakes can cause a 'landslide' to happen underwater, which turns into a turbidity current. We saw how muddy an outburst flood is! When this reaches the ocean, it can turn into a different type of turbidity current! They move along the sea floor because they are very dense; denser than the sea water; despite being composed of glacial freshwater, the sediments inside the flood make the water very dense. Turbidity currents follow the **bathymetry** because gravity pulls them downhill. They leave behind a pattern in the sediments known as a **turbidite**. Turbidites are unique in their grain size characteristics and their mineral signatures. Since turbidity currents move sediment very long distances, the minerals present in a turbidite may be derived from a source that is very far from where the turbidite was deposited. The grain sizes will also stand out in a turbidite since coarser grains fall out sooner than the finer grains, which leaves a special pattern.

In this activity, you will only be looking at deposits from earthquake turbidity currents. We will be looking at deposits from the glacier, but we are labeling these sediments 'glacier sediment' rather than an outburst turbidite (technically called a hyperpycnite). This is for simplicity in the lab. There is a very bare-bones power point attached. This power point was made for 7$^{th}$ grade classes. It goes into minimal background on glaciers, sediments and rivers, and leaves out seasonality and plate tectonics. If you would like, you can use this as a basis and add as much or little detail as you would like for your class. I highly recommend spending more time talking about glaciers and earthquakes (with videos); these are two very cool topics!

**Student handouts:**

- Core data sheet
- Color coded key of the different 'sediment layers.'
- Prince William Sound maps – Can make laminated color copies for reuse
    - Each group will get a normal map of Prince William Sound with coring locations marked A through E and the latitude/longitude coordinates. The location each group is specifically coring should be clearly specified. NOTE: make sure to hand out the map WITHOUT the earthquake epicenter marked.
    - Each group will also get a map of the bathymetry of the Sound.

**Materials & Supplies**:

- Five 12" rulers with metric units
- Five sets of Color pencils
- Station labels A through E
- Coring device
    - Each team will need a single coring device. It should be a clear hollow cylinder, **open on both ends**, and the inside diameter around 1 inch (or less). Cutting off the base of a plastic graduated cylinder may work. I have used clear florescent light bulb protectors before successfully. THE DEVICE NEEDS TO BE OVER 10 CM LONG! It would be best if they are around 15+ cm long.

**<u>Homemade sediment layers</u>**

This is the hardest part of the whole lesson! Setup is very time consuming. If you are only doing this lesson for a single class, it may not be worth all of the effort. Instead you may consider printing page 10, the key, and cutting each station core picture out. Place this at each station instead of the sediment core bins. It takes fun out of student coring, but still addresses most of the learning objectives and is much cheaper. You might consider making a single example container. Make extra sure to show the first earthquake video in the power point, as it shows footage of a real turbidite!

If this lesson is intended for several classes, then you can prepare containers wide enough to take several cores (make sure students core along the edge of the container to conserve area for others to

core!) I recommend having students help you make the sediment a day or two in advance. I used a prep hour. You could also have accelerated students who have extra time. I would handle the actual layering yourself, so the students don't get to see patterns beforehand, but making them do all the mixing saves a lot of time! Just place the bins in a fridge with a damp paper towel on top and they can go up to a week.

- Recipe:
  - 1 part baking soda
  - ½ part cornstarch
  - ¼ part water
  - Food coloring

- First mix the baking soda and corn start together by hand. Gently massage all chunks outs.

- Next, set aside the dry ingredients. Mix the food color and water together and thoroughly blend in the colors. Make sure you reach the desired color and intensity. You will want to use a LOT of food coloring so the water reaches a deep hue (see appendix)

- Now add the water to the dry mixture and mix it by hand. You can avoid dying your skin colors if you pour the water in the center of the bowl and slowly tossing in handfuls of the dry mixture until the water has fully soaked in. Mix until it has the texture of moist soil. It should be crumbly but packable (see appendix).

- It is important that you make enough for four batches of different colors. You will be filling five bins, each with 10 cm deep of 'sediment.' The width and length of the bin depends on what you have available, so make enough with your dimensions in mind.

  - Colors and coding:
  - Yellow: Copper river Sediment
  - Blue: Columbia Glacier Sediment
  - Green: Local Prince William Sound sediment
  - Red/brown: Turbidite layer

- The sediment mixture shouldn't swiftly deteriorate or dry out, so you can make it up to a few days in advance. Covering it may help, but is unnecessary. It only takes a few minutes per batch to make.

- Bins to set up the sediment layers
    - You need five bins. The bin should be between at least 12 cm deep. It must be opaque, so that students cannot see the layers before coring. The wider the bin is, the more sediment you need to make. I recommend using something tall, but relatively narrow (quart sized milk or juice cartons, see appendix). Alternatively if you plan to give the lesson to multiple classes, you can use wider bins and get several cores out of each bin before a new batch needs to be made. Using a narrowing coring tube will also allow you to get more cores per bin.
    - When filling the bins, put a small ruler in along the edge and mark the top height of each layer (see appendix). Pack each layer gently; packing it too densely makes it hard to core. You should push down until you meet resistance and only compress it a bit more from there. Make the entire surface (edges included) relatively horizontal.

All of my example photos were done using 5 quart sized milk carton. My coring devices were 1" diameter fluorescent light bulb protector tubes. I am able to take about 4 cores per carton this way (meaning I can service up to 4 classes, 1 core per container per class, with one setup). The total supplies needed are roughly:

- Yellow: 2 cups baking soda, 1 cups corn starch, ½ cup water
- Red: 3 cups baking soda, 1.5 cups corn starch, ¾ cup water
- Blue: 2 cups baking soda, 1 cup corn starch, ½ cup water
- Green: 3 cups baking soda, 1.5 cups corn starch, ¾ cup water

Total: 10 cups of baking soda (about 5 boxes), 5 cups corn starch (1 to 2 boxes, size dependent)

**Classroom/Lab setup**:

For the activity, the class will be broken into five groups. I suggest each group be separated at different tables around the classroom. The idea is that they will each be responsible for gathering and analyzing a sediment core from different regions of the Prince William Sound, as marked on the maps. The orientation of the groups around the room should roughly reflect the orientation of the core locations on the map (line through the center of the room with one group to the side for the Station E: Columbia Bay core). Reference the map of the Prince William Sound in the appendix to see the marked coring locations.

## Procedure

**Advanced preparation of Lab Materials**: 2 – 3 hours

Before the activity, the teacher should purchase, mix, and set up the sediment layers in the bins at each station. This can be done several days in advance of the actual activity. All five station layer colors and thickness are outlined below:

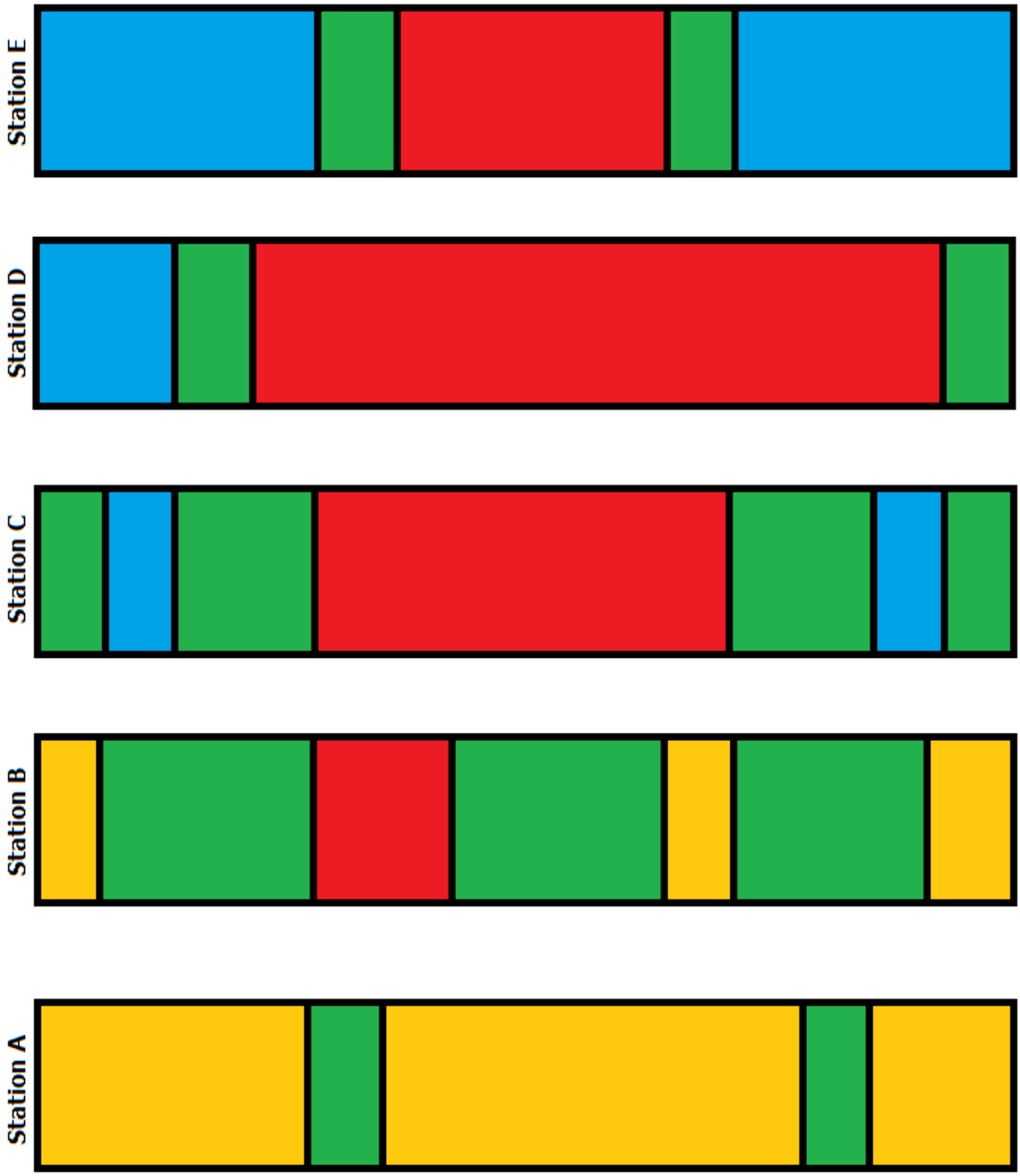
- Station A: Hinchinbrook Entrance
  - Top layer: 3 cm Yellow copper river sediment
  - 1 cm Green PWS sediment
  - 3 cm Yellow copper river sediment
  - 1 cm Green PWS sediment
  - Bottom layer: 2 cm Yellow copper river sediment

- Station B: Central Sound South
  - Top layer: 1 cm Yellow copper river sediment
  - 2 cm Green PWS sediment
  - 1 cm Red turbidite sediment
  - 2 cm Green PWS sediment
  - 1 cm Yellow copper river sediment
  - 2 cm Green PWS sediment
  - Bottom Layer: 1 cm Yellow copper river sediment

- Station C: Central Sound North
  - Top layer: 1 cm Green PWS sediment
  - 1 cm Blue Columbia Glacier sediment
  - 1 cm Green PWS sediment
  - 4 cm Red turbidite sediment
  - 1 cm Green PWS sediment
  - 1 cm Blue Columbia Glacier sediment
  - Bottom Layer: 1 cm Green PWS sediment

- Station D: Northern Sound
  - Top layer: 2 cm Blue Columbia Glacier sediment
  - 1 cm Green PWS sediment
  - 6 cm Red turbidite sediment
  - Bottom Layer: 1 cm Green PWS sediment

- Station E: Columbia Bay
  - Top layer: 3 cm Blue Columbia Glacier sediment
  - 1 cm Green PWS sediment
  - 2 cm Red turbidite sediment
  - 1 cm Green PWS sediment
  - Bottom Layer: 3 cm Blue Columbia Glacier sediment




**This is a sketch of how the cores should look based off the 10 cm scale outlined here.**

**DO NOT SHOW THE STUDENTS!!! This is purely a teacher setup reference!**

This is also what the sketches the students make should look like. I expect the sketches to be made to scale and with color pencils on the attached description sheet. They should use the color key to write out sediment type and layer thickness in centimeters next to each layer.

***Day 1: Content Introduction*** **–** 1 hour to 1 hour 20 minutes

The introduction material (in the background section) should be taught over the course of the first class session. If the class has already learned about the introduction material, then the teacher can skip to the 2nd day and give a brief overview of any new material as necessary. Depending on how in detail the teacher wants to go, the introduction material can be taught over two class sessions.

Earthquakes

- Plate tectonics
- Earthquakes generated by friction at convergent boundary
- Epicenter vs hypocenter

Glaciers (absolutely must hit concepts)

- How glaciers erode via plucking and grinding
- How they deliver sediments to the sea

If you do not have time to go into all details about mass balance, calving, anatomy, etc. you may skip it.

Sediments

- How sediments are formed (particularly by rivers and glaciers rolling, plucking and grinding)
- Seasonal changes in sediment delivery due to changes in melting and precipitation
- Grain size
- Minerals as an indicator of where sediments came from
- Turbidity currents
- Turbidites

***Day 2: Lab Activity***

- **Setup (before class)** – 15 minutes

At each group table there should be the following:

- Pre-made bin with sediments
- Pre-made Coring device
- 12” ruler
- Color coded sediment key
- Bathymetry map
- Normal map WITHOUT THE EARTHQUAKE EPICENTER
- Station Label A through E so the students know where they are coring on the map
- 1 core data sheet per student or group, as the teach prefers
    - Need colored pencils!

▫***Brief overview intro*** – 10 minutes

Begin by telling the class they are going to be field geologist today! We have turned the classroom into the Prince William Sound (PWS) and will take sediment cores just like real scientists have done.

Prompt the class to recall what they discussed in the first lesson. Earthquake epicenters vs hypocenters. Glacier erosion and outburst floods. Give them a little background on the PWS in the context of what they learned in class the day before, i.e. it is along a convergent plate boundary and it has a large, famous tidewater glacier (meaning it terminates in the ocean) called Columbia Glacier along the northern coast. Ask them to remember how the glacier and earthquakes may impact the sediments in the PWS. They should be able to identify that glacial outburst floods deliver a large amount of sediment to the PWS and earthshaking can generate underwater turbidity currents which mobilize sediments along the seafloor. Also see if they can state how seasons may influence sediment patterns.

▫***Lab Activity*** – 15 minutes

- Break kids into five groups and designate their table and coring site
- Explain how they should core. You could make a small demo bin and give them a demonstration at the front of the classroom. To take a core, place the corer (clear tube) on the top of the sediments and push straight down. You may twist the corer gently to help ease it in. It is better if you do not place a cap or hand on the open top so that air pressure doesn't build up and compress the sediments as you go in. When it is time to pull the corer back out, placing a hand on top may help create a vacuum and keep the sediments in (but generally this is not necessary).
- Tell them to measure the thickness of each layer with their ruler, sketch the layers in their cores to scale (similar to the included sketches), and describe the sediments in their core using the color key. They may estimate their measurements to the nearest cm for simplicity.
- Within their groups, have them analyze the layer patterns at their site by following the guiding questions on the data sheet.

▫**Discussion** – 15 minutes

Have the class come together, with their core sketches/notes, site and bathymetry maps. Leave the actual cores at the tables to avoid messes. Everyone can compare their layers from different parts of the sound and try to understand what happened. Lead the discussion so that they draw on concepts from Day 1 and assess how well they are applying this knowledge.

They should see that in Hinchinbrook Entrance (Site A) there were a lot of Copper River sediments, being as it is the site closest to the Copper River. There are small intermittent lays of local PWS sediment because the Copper River produces more sediment during the rainy seasons (Spring through Fall) and less sediment during the dry season (winter). During the dry season, predominantly PWS watershed sediments are deposited. This is not because there is more runoff in the PWS, but simply that the local deposition is not drowned out by the Copper River deposits. So the patterns they see are seasonal!

As samples move toward the central sound, students should see less influence from the River sediments and more influence from local PWS sediments. Seasonal patterns from the Copper River will decrease until they are no longer present. They should also notice the turbidite deposit from an earthquake gets thicker as they move northward.

They will recognize more Columbia Glacier sediment as they get closer to the Glacier. Again there are small intermittent layers of local PWS close to the glacier because glacier melting and sediment delivery dominates during warmer months while PWS signals dominate in cooler months.

Finally, after discussing all the core locations, the class should try to guess where the earthquake occurred based on the bathymetry and the changes in thickness of the turbidite layer. The turbidite will be thicker closer to the epicenter and the turbidity current would have flowed downhill on the bathymetry map. Make sure students understand that they located the epicenter on the surface, and that the hypocenter is deep in the crust along the actual plate interface. After they have made their guess, show them the map with the earthquake marked. It is the Great Alaska Earthquake, which occurred in 1964! This is the 2nd strongest earthquake ever instrumentally recorded in the world! Show them a picture of a real core (appendix/powerpoint).

Another important point to make is <u>that in core E, near the Glacier, the red turbidite layer is relatively thin despite being somewhat close to the epicenter. This is because the coring location is slightly uphill from the main path the turbidity current followed</u>. They can see this by studying the bathymetry map! The turbidity current would have moved downhill from the earthquake epicenter in the north, so it would likely have flowed from the north directly south and only a smaller portion would have moved northwest to the location of core E. The turbidity current moved through the 'Central Channel' of the Sound; the darkest, deepest area oriented roughly north to south. This makes sense, as the flow could not move uphill along the sides of the channel!

- What else do you think geologist can learn from layers in the sediment?
  - ❖ Think about water related events that are highly erosive or destructive! What events are capable of transporting mud and debris to the ocean/lakes?

Some real examples are:

- Deposits from massive storms (like Sandy)
- Deposits from Tsunamis
- Mudslides and avalanche
- River floods
  - Dam break, heavy rainfall, etc.
- Changes in climate, which are reflected by:
  - Changes in the seasonal layer patterns
  - Changes in glacial outburst frequency
- **Industry!**

  Oil and gas are trapped between sediment layers made of different grainsizes! Small grainsizes (muds) are impervious and trap oil and gas, while medium grain sizes (sand) allows oil and gas to travel through. Past high and low sea level fluctuations deposited large amounts of sand and mud layers on top of each other, allowing large quantities of fossil fuels to be captured in certain areas. When we study these layers, we learn where to drill!

▫**<u>Clean up</u>** – 10 minutes

- Have kids return to their tables
- Carefully push sediments out of the core back into the bins
- Put away their pencils, leave their rulers, corer, papers, maps, etc. at the table, throw them out, turn them in, whatever the teacher chooses.

- Can have the students dump the sediments from the bins into the trash. If there are sinks can have students wash out the bins. Or if you will be doing the activity with multiple classes, set the bins aside. I serviced 6 classes with the same set of (appropriately sized) bins before!

▫**Assessment options**– 15 minutes

- Ask them to diagram how sediments are formed by rivers and glaciers. Tumbling and grinding of rocks, washing of soils from the ground by rain
- Ask them to sketch how layers are deposited on the sea floor. Example could include muddy water from a river/glacier pouring into the ocean, and particle falling to the sea floor.

  They can share their diagrams with the class or their subgroups.

- Why are these layers distinct from each other? Minerals and grain size!
- What did the layers in this activity help us do? Reconstruct the story of an earthquake and seasonal variations!

Reading assessment

Students may read the article regarding our Alaska work

http://www.vims.edu/newsandevents/_docs/kuehl_crpws.pdf

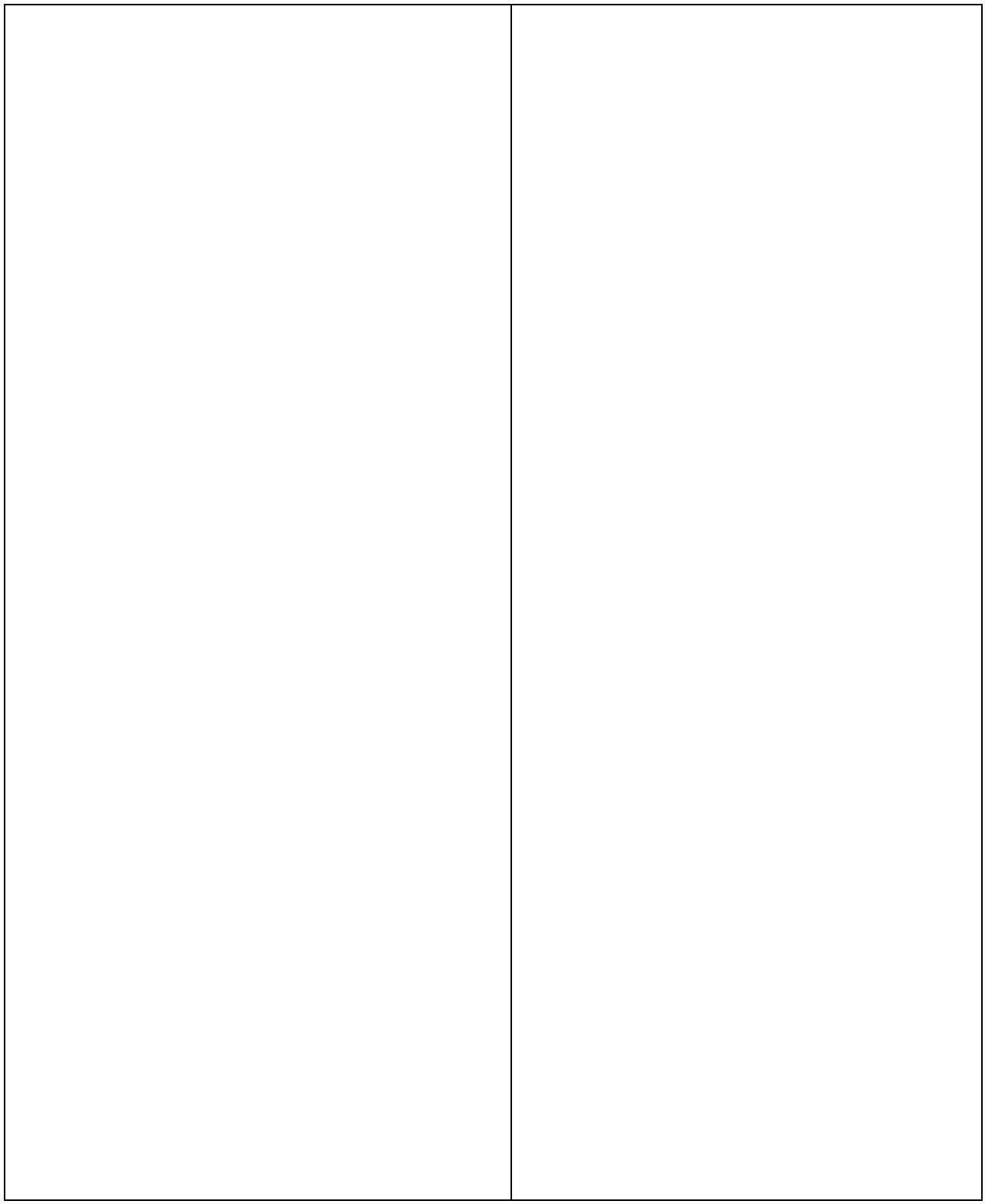
According to the article, South-eastern Alaska experienced a severe snowstorm in January 2012. When the snow melted in the spring and early summer, the water went into the Copper River. How would this impact the sediment delivery to the ocean during spring/summer 2012? As a result, where in the Sound would you take a core to capture a sediment record of this snow storm? What do you think the layer would look like with respect to other layers in the core?

Suppose we could take a very long core in the Prince William Sound going through all 450 meters of sediment (aka the last 10,000 years) mentioned in the article. How do layers from high and low snowfall winters help us understand climate trends?

Students should grasp that the river water and sediment delivery will be higher due to the large meltwater pulse. Hinchinbrook entrance (in the south of the sound) is where most of these sediments would be deposited, thus where to take a core. The layer from the snowstorm melt would be thicker than other normal layers in the core (in terms of this assignment, it would be an even thicker yellow layer between small, winter green layers). Counting the high/low snow winters through 10,000 years can show patterns in the frequency of such events, which is associated with precipitation and temperature. This shows us long term climate trends.

**Core Data Sheet**

| Sketch | Group Discussion |
|---|---|
| The first thing a geologist always does is describe their cores! Measure your core using your ruler in centimeters. Draw a **sketch to scale** and use color pencils! Once you finish sketching the core, write down the thickness in cm next to each layer and the name of the sediment type according to the color key. | What are the minerals present in your layers according to the key? How thick are the layers of one sediment type compared to the others? What things are near your core location that could have caused these layers (i.e. the river or the glacier?) Or if you aren't near anything, how does that correlate with the presence or thickness of layers? Is local Sound watershed sedimentation dominant? If there is a turbidite layer present in your core, how thick is it with respect to other layers? You need to share core data with other groups to learn more about the Sound-wide turbidite deposit! Write a few notes to share with other groups! |



**Color Key**

**Yellow**: Copper River Sediment

These sediments have minerals eroded from the Wrangell Mountain by the River, to the east of Prince William Sound. They are carried from the mouth of the River into the Prince William Sound by the Alaska Coastal Current, a strong current flowing to the west through the Gulf of Alaska.

**Blue:** Columbia Glacier Sediment

These sediments have minerals eroded from the Chugach Mountain Range; the mountains where the Columbia Glacier is formed and descends from. They have been very finely ground up.

**Green:** Local Prince William Sound sediment

These sediments have a mixture of minerals from many different rocks around the Prince William Sound region. They are neither purely Wrangell (River) or Chugach (Glacier). Local sediments are deposited from many small creeks around the Sound **watershed**.

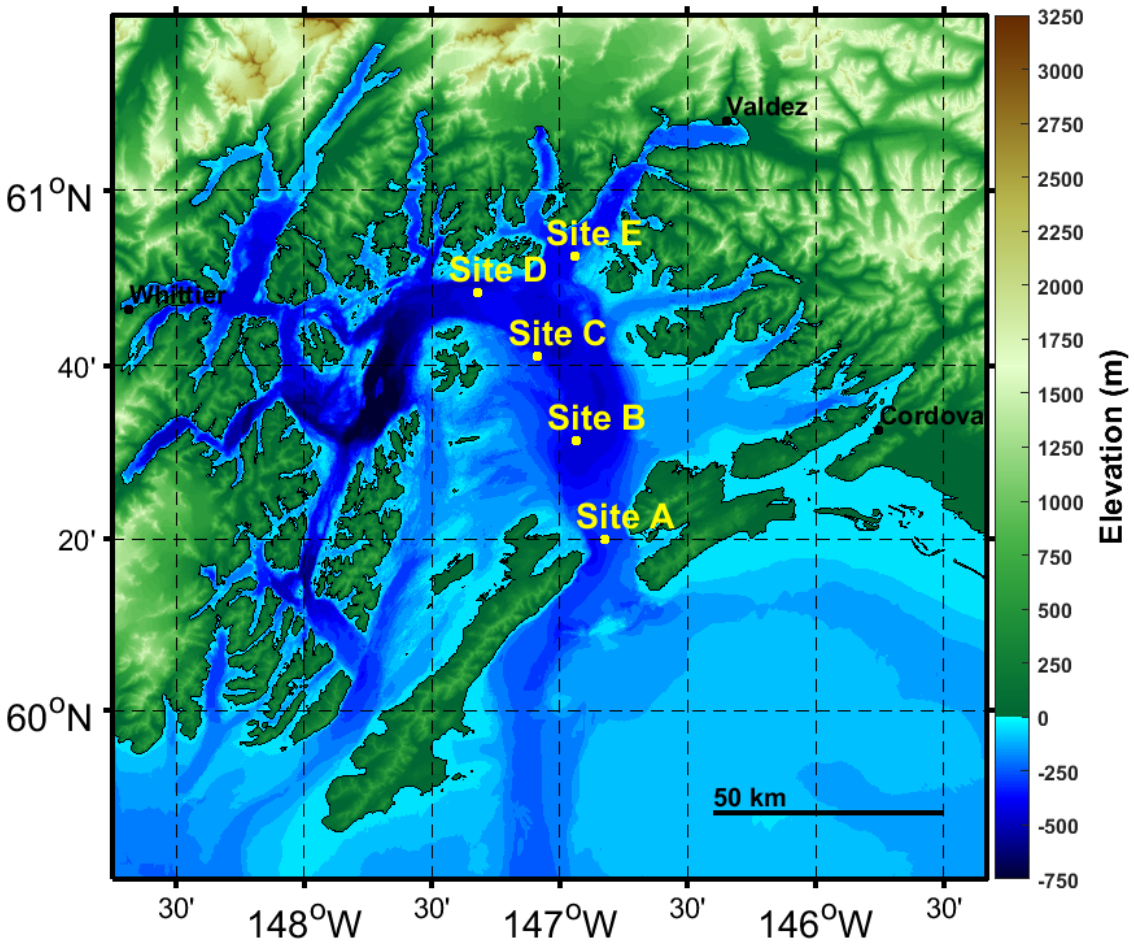
**Red/brown:** Turbidite

These sediments are distinct from all other layers because they have been arranged by grain size! There are coarse sediments on the bottom, and the grain sizes slowly get smaller and finer as you move to the top of this layer. They have a mixture of minerals from all different sediment sources to the Prince William Sound.

Columbia Glacier
Copper River
E 60°52'N 146°56'W
D 60°48'N 147°19'W
C 60°41'N 147° 5'W
B 60°31'N 146°56'W
A 60°19'N 146°49'W
29.1 mi
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2016 TerraMetrics
Google earth

Columbia Glacier
The Great Alaska Earthquake of 1964
E 60°52'N 146°56'W
D 60°48'N 147°19'W
C 60°41'N 147° 5'W
B 60°31'N 146°56'W
A 60°19'N 146°49'W
Copper River
Google earth
Image Landsat
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image © 2016 TerraMetrics
29.1 mi

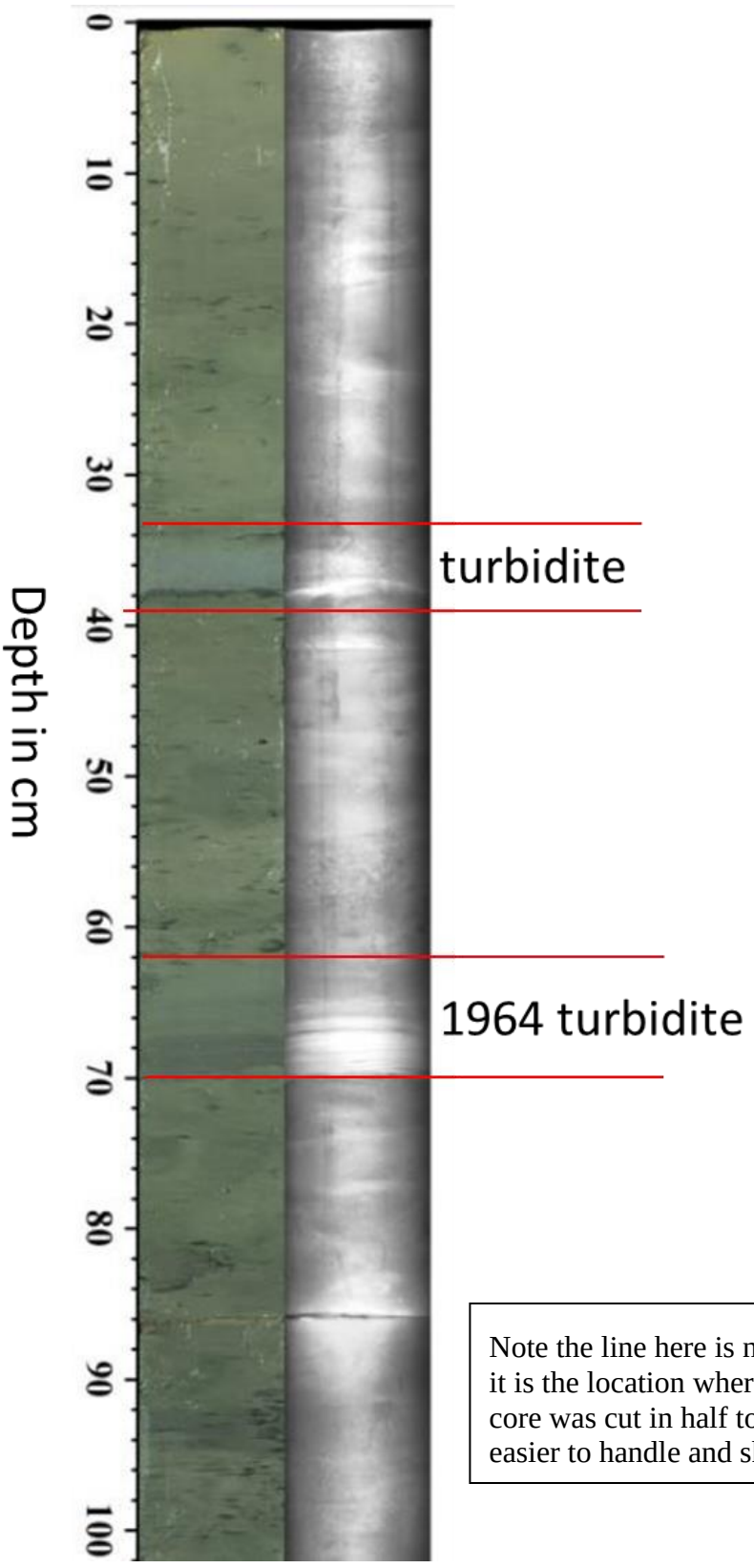
**Bathymetry Map**




Bathymetry is a science word that means 'shape of the seafloor.' It shows areas that are higher and lower than each other. For example, in the Prince William Sound bathymetry map you can see that dark blue represents the deepest areas under the sea, while light blues are shallower.

If an earthquake triggers an underwater landslide, how do you think a bathymetry map can help us predict where that landslide will flow?

Appendix



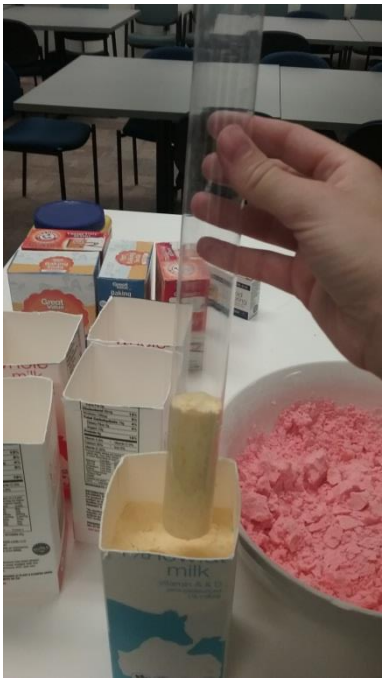

Deep hue of red water before mixing with the dry ingredients. Use A LOT of food color!







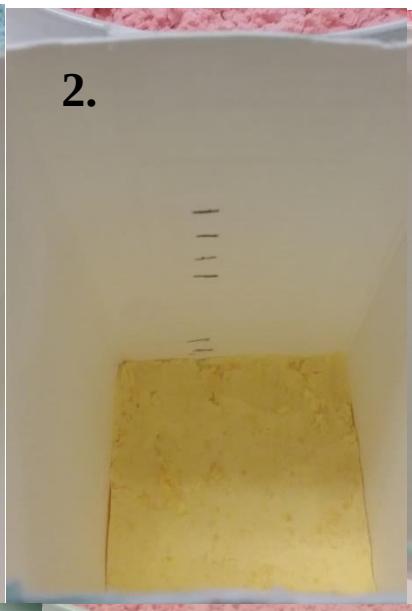

Example of finished bins prepped for a lesson plan using quart milk cartons. I cut each carton to be 15 centimeters tall. I cut the coring tubs (fluorescent light bulb protectors) to be about 30 cm in length so the students had plenty to grip while coring (below).

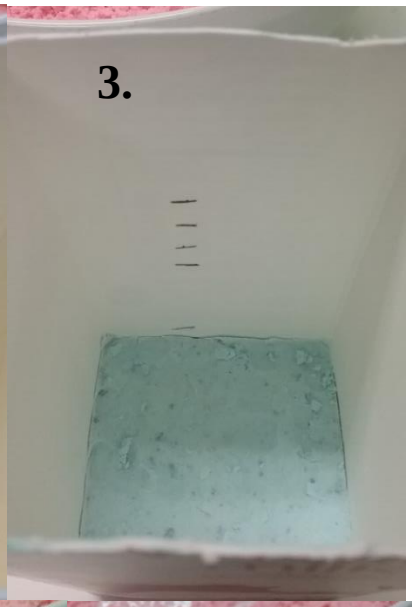


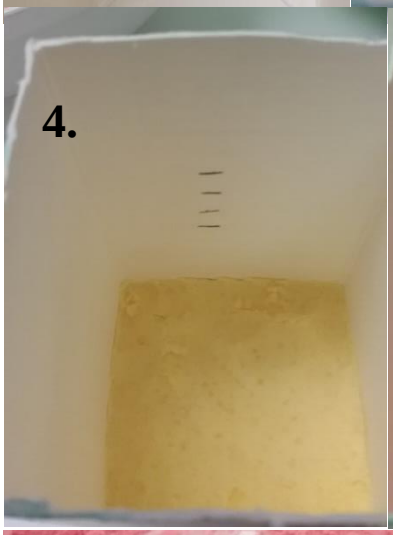
The next page is an example of how I fill the cartons with sediments. First I mark an inside edge with a ruler and pen. Each mark shows the top height of each layer above the layer below it. Then I slowly add mixture and pack it down layer by layer. This example shown below is for a core from a different lesson plan, which is outlined as follows:

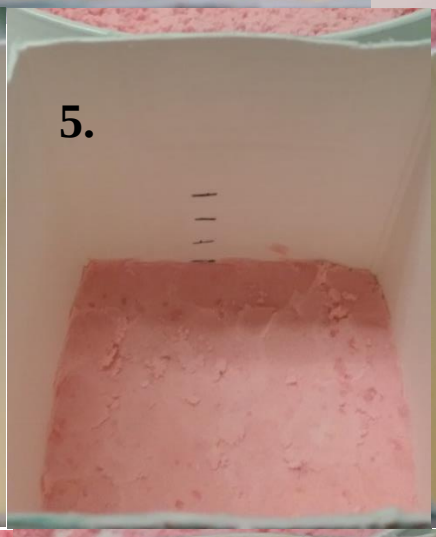
- Station C: Central Sound North
  - Top layer: 1 cm **Yellow** Copper River sediment
  - 1 cm **Blue** Columbia Glacier sediment
  - 1 cm **Yellow** Copper River sediment
  - 4 cm **Red** turbidite sediment
  - 1 cm **Yellow** Copper River sediment
  - 1 cm **Blue** Columbia Glacier sediment
  - Bottom Layer: 1 cm **Yellow** Copper River sediment

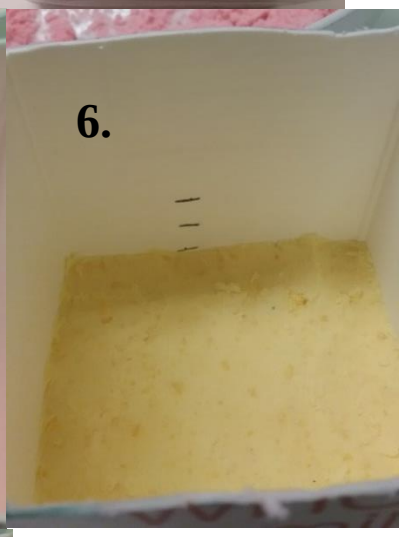

1.


2.

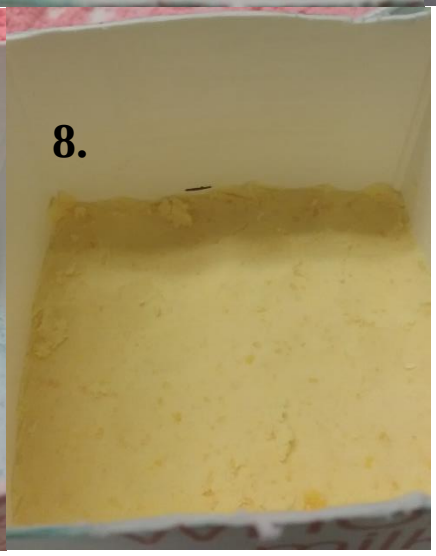

3.


4.


5.


6.


7.


8.