IMHOTEP'S LEGACY ACADEMY

***SHAPING THE EARTH*—STEM Quiz Study Guide 2025**

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Reviews and Updates

Reviewer	Actions/Comments	Date

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1.0 Introduction

1.1 What will the Tournament Look Like?

The tournament will take place on **6th of December 2025** and last for **70 mins** (1 hour 10 mins). You will work in teams of **4**, ensuring a maximum of **2 high school students**. The tournament will consist of 2 different styles of questions, all of which will be on Kahoot.

- **50** Multiple Choice,
- **5** Short Answer questions.

1.2 How to Read This Guide

1.2.1 Topics You'll Explore in This Study Guide

This study guide is designed to help you prep for **Shaping the Earth quiz Tournament**. It is important to note that not all topics discussed in this study guide will be questions during the tournament. Under each main topic there are key concepts listed, you are **encouraged to do your own research** to understand these topics. The main topics discussed within this study guide are (but not limited to):

I. Erosion and Weathering,
II. Geomorphology,
III. Glaciology,
IV. Seismology and,
V. Black Excellence in Earth Sciences.

1.2.2 What's an "Rename this to better reflect what they are"?

At the end of each review section there will be an "End of Section Quiz." This quiz is meant to test your understanding of the concepts discussed in the section. There will **not** be an answer key provided, and these questions will **not** be on the final quiz. They are meant to guide in the right direction. These are questions for you to do more research to answer the questions, the way the questions are framed are guided for you to understand the potential way the questions will be actually answered on the quiz.

----------Now get to studying, you got this! ----------

2.0 Geomorphology: Earth's Shapes

Key Concepts:

2.1 What Does Geomorphology Actually Mean?

What does "geomorphology" even mean? Well let's break it down, "Geo" means Earth whereas "morphology" is the study of shapes. Combined geomorphology is "the study of earth's shapes." But what are earth's shapes and where do we see them? Take a look outside—do you see any hills, mountains, rivers, oceans, areas of flat land or forests?

Well, these are some examples of earth's shapes or in other words are landforms. Scientifically speaking, **landforms are natural features you see on earth surface**.

However, humans and societies often change earth's landscape, can these still be landforms? Well actually yes, these are called anthropogenic landforms. "anthropo" means human and "genic" means caused by. Therefore, **anthropogenic landforms are earth shapes made/caused by people**. Overall landforms are all around us—weather they are created by natural or human-made! [1]

Figure 1: *Aerial photo of Citadel Hill, NS as an example of anthropogenic landform.*

[1] National Geographic. (2023). Landform. National Geographic INC. https://education.nationalgeographic.org/resource/landform/

2.2 How Are Landforms Classified?

To better understand why specific types of landforms form, scientists group landforms with have similar features together. This is called qualitative analysis—"qualitative" means looking at the observations, like the size of an object rather than numbers like quantitative analysis does. [2]

Think qualitative is the "how and why" whereas quantitative is "how much."

For landforms, scientists look for things like:

I. **Size:** Is it large like a mountain or small like a hill?
II. **Shape:** Is it pointy, flat or curved?
III. **How it formed:** Was it formed from tectonic activity, rivers, wind or ice?

Thought experiment:

Take the role of a geomorphologist (a person who studies geomorphology) and examine this image of Mount Fuji.

Make sure to identify key features using the quantitative analysis list previously given.

Some possible answers:
Steep slope, it has a pointy top (peak), snow on the peak, etc.

2.3 Why Should You Care About Geomorphology?

Landform classification is crucial for **understanding Earth's history** and predicting any future changes. Mountains, for example, reveal tectonic activity and link past processes to current features. Additionally, analyzing landforms helps **identify environmental hazards** like areas of high erosion and/or tectonic activity, potentially saving millions from harm caused by poor infrastructure planning.

[2] Atlas. (2025). *Landform Classification*. Atlas.co. https://atlas.co/gis-use-cases/landform-classification/.

2.4 FURTHER CONCEPTS

WHAT ARE THE KEY GEOLOGIC PREINCABLES AND WHY ARE THEY IMPORTANT?

WHAT ARE ANTHROPOGENIC LANDFORMS?

3.0 Erosion & Weathering ⛏

Key Concepts: Erosion verse weathering and their differences. Types of erosion and weathering, with examples. The ability to explain how and why each type happens. Understand river mechanics.

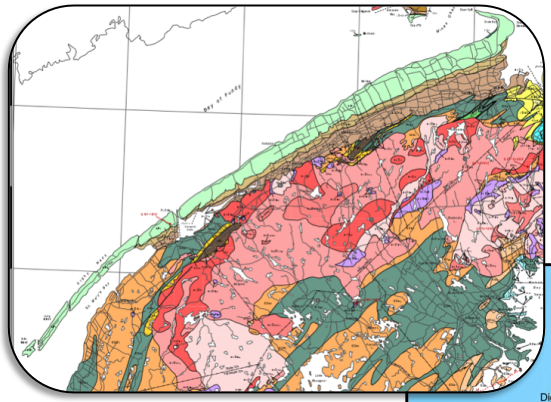


***Figure 2**: Diagram of Digby Neck's basaltic rock (light green) and where it's located in NS. [https://novascotia.ca/natr/meb/download/mg/map/htm/map_2000-001.asp]*

3.1 What Is Erosion?

Erosion is when rocks, soil or sand get ***moved*** by natural forces like rivers, wind or glaciers. Rivers, for example, erode their banks and transport the sediments downstream carving valleys over time.

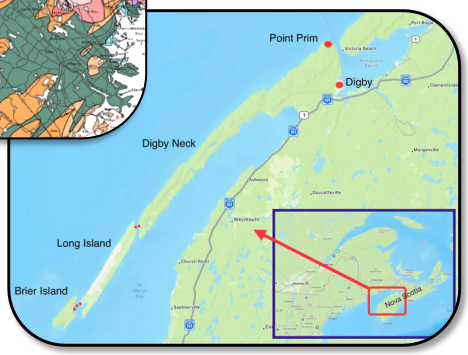


***Figure 3:** Photograph of oceanic basalt. The basalt is highly competent, resisting erosion from the ocean. [Photo credit: Mia Curry, 2025]*

3.2 What Is Weathering?

Weathering ***comes before*** erosion—it initially breaks rocks down into smaller bits but have yet to move from the main rock. The categories of weathering are:

I. **Biological:** Plants and animals break rocks via roots or burrowing.

II. **Mechanical:** Physical natural forces (water and pressure) break apart rocks.

III. **Chemical:** The elements within the rocks change causing rusting, etc.

3.3 How Water Erodes

3.3.1 Flow Velocity and What It Means

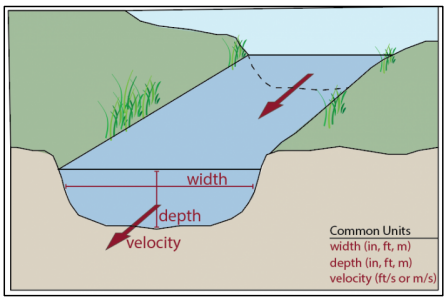
What *is* flow velocity and why is it important to rivers? Well let's first break down flow velocity…

- Flow = direction of water movement.
- Velocity means how fast something goes.
- In other words, flow velocity is the **speed of water moving in a river.**

Understanding this is fundamental when understanding why rivers act the way that they do. Flow velocity dictates areas of deposition, where they curve and more!

3.3.1.1 How do we measure it and why does it matter?

Flow velocity is measured in **centimeters per second (cm/s).** Scientist figure this out by seeing how long it takes water—or sediment—to travel a certain distance.



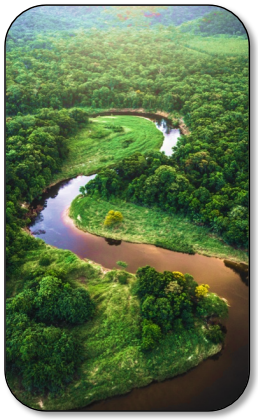
Key points to understand:

- If the water **moves faster**, it has more energy to pick up and **move bigger** rocks and soils (transportation).
- Once it **slows** down it **deposits** (drops) what it was carrying.

Figure 4: *A cross-section of a river, showing how flow velocity moves. This figure shows ft/s and m/s however this activity with solely focus on cm/s for measuring velocity.*

3.3.1.2 Is Flow Veloicty Uniform in Speed?

When something being **uniform**, it means everything is the same and stays consistent**.**



3.3.1.3 But if you look at nature—is it really uniform?

Technically no! Sure, natural laws (like gravity) are consistent, but the way things show up in nature is wildly diversity and complex. Silly enough, nature is often *consistently inconsistent.*

3.3.1.4 So, what does this have to do with rivers?

Given that nature isn't perfectly uniform, flow velocity doesn't stay the same everywhere. This is caused by **friction** Anywhere in the river where water hits:

- **The bottom** slows water down (rocks and sand).
- **The sides** slow it down (riverbanks).
- **The surface** slows it down a bit (air resistance).

3.3.2 *Sediment Movement*

In a river, sediment movement occurs at three main times, depending on flow velocity and particle size: transport (suspended or bed load), erosion, and deposition. Scientists illustrate this with the Hjulström curve.

Figure 5: *Hjulström curve illustrating particle size vs. flow velocity*

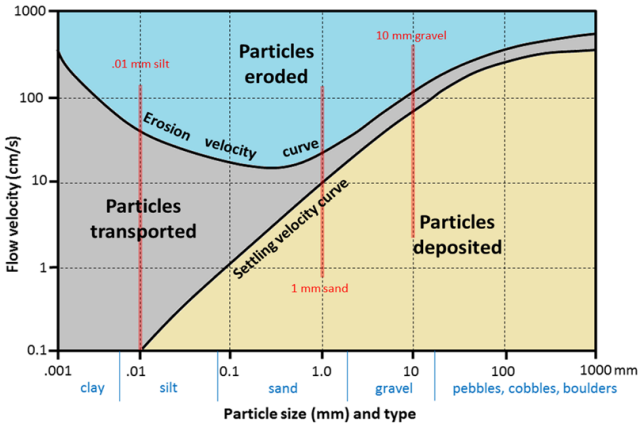


Table 1: *Types of sediment load in a river.*

LOAD TYPE	DESCRIPTION
SUSPENDED LOAD	Small sediments carried _____ the stream (mud, silts, sands etc.)
DISSOLVED LOAD	Ions _____ in the water (e.g. salts and calcites).
BEDLOAD	Heavier material that rolls and drags along the _____.

3.4 Glacial Erosion

3.4.1 *PLUCKING*

Glaciers pick up rocks and sediments, freezing them into their base, and deposit them as they slow or melt. This process, called glacial plucking, is evidenced by large areas of massive boulders—depositional features indicating the area of lower velocity, not the rocks original plucked location.

3.4.2 *ABRASION*

Glacial abrasion occurs when the glacier doesn't pick up rocks (due to size or slow movement) but instead scrapes them, leaving glacial striations on the bedrock, mainly competent rocks metamorphic rock like granite.

3.5 Biological Weathering

Biological weathering caused by animals, humans or plants breaking down the surrounding sediment.[3]

3.5.1 ROOT WEDGING

Root wedging occurs when a plant enters rock cracks and gradually pries it apart as it grows. Typically, the plant wedges into the rock as a seed and expands outward, causing this type of weathering. As seen in the image, the tree's root is embedded in the rock, exerting pressure as it grows, causing the rock to break.

Figure 6: *Photo of a tree root wedging between a boulder [https://imgur.com/gallery/root-wedging-0PEruLI].*

3.5.2 ANIMAL INFLUENCE

This weathering occurs when animals break down rocks to create burrows or meet any of their other survival needs. For example, rock-boring angelwing clams erode and weather rock to survive.

Figure 7: *Weather rock caused by angel clams*

[3] Johnson, C., Affolter, M., Inkenbrandt, P., & Mosher, C. (2019, November 4). *5.2: Weathering and Erosion*. Geosciences LibreTexts. https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/05%3A_Weathering_Erosion_and_Sedimentary_Rocks/5.02%3A_Weathering_and_Erosion.

3.6 Mechanical Weathering

Mechanical weathering is where the rocks are broken down into finer pieces.

Another form of mechanical weathering I won't detail is salt wedging. Salt wedging is where evaporates settle in rock cracks, gradually enlarging them as salt accumulates.

3.6.1 PRESSURE EXPANSION

The Earth's interior is under high pressure, but rocks resist stress. When brought to the surface by tectonic activity (erosion and uplift), they quickly revert to their natural state. Rapidly decreasing the pressure and temperature causing the rocks to snap. Like a frozen glass shattering when hot water is poured on it.

Figure 8: *Pressure expansion on granite [Johnson et al., 2019]*

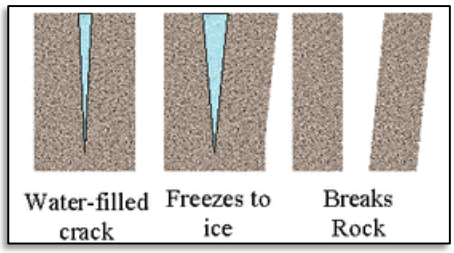


Figure 9: *Diagram of frost wedging [https://caitlinsearthchangingsurfaceinfo.weebly.com/frost-wedgingexfoliation.html].*

3.6.2 FROST WEDGING

Frost wedging, like root wedging, occurs when water seeps into cracks in rocks. Then when it freezes and expands; it widens the cracks. This cyclical process depends on weather and temperature, which is why roads and sidewalks often crack or break after winter.

3.7 Chemical Weathering

Chemical weathering involves the chemical breakdown of rocks; once weathered, restoring them to their original state is nearly impossible.

Figure 10: *Photo of large evaporate outcrop formed by karst topography. [Photo credit: Mia Curry, 2025]*

3.7.1 DISSOLUTION

Dissolution occurs when dissolved elements like Na+ and Cl- are suspended in water and are removed as the water evaporates. As these elements exit suspension, they rapidly form stable chemical compounds called evaporates (salts) or carbonates ($CaCO_3$), which are found throughout Nova Scotia and worldwide. Evaporates are mainly impure salts, containing additional elements beyond Na+ and Cl-.

3.7.2 Oxidation

Oxidation is potentially the most known form of chemical weathering, as it's also known as rusting. For example, when iron interacts with atmospheric oxygen, causing rust.

3.7.3 HYDROLYSIS

Hydrolysis is when carbon dioxide dissolves in water forming carbonic acid. The dissolved carbonic acid drives two main weathering reactions: one forming evaporates, and another involving feldspathic minerals (containing silicon and aluminum) that produce clay.

Equation 1: *Hydrolysis Reaction*

feldspar + carbonic acid (in water) → **clay** + [[metal cations (Fe++, Mg++, Ca++, Na+, etc.) + bicarbonate anions (HCO3-) + silica (SiO2)]

Don't memorize the formula. Just understand how and why this reaction occurs.

3.8 END OF SECTION QUIZ

WHAT MINERAL IS AFFECTED BY OXIDATION?

WHAT IS IMBRICATION AND WHAT CAUSES IT?

4.0 Glaciology ❄

Key Concepts: Understanding glacier origins, the two main types, and the key features of ice ages—historic events, deposition and erosional features, and periods of dominance.

4.1 How do Glaciers Form?

Glaciers develop through the accumulation and freezing of snow and ice. The weight of the snow exerts significant pressure, forming a dense mass that gradually slides downward, gathering additional snow and debris along the way.

4.2 Types of Glaciers

Figure 11: *Photo of a continental glaciers [https://www.cbc.ca/news/climate/argentina-glacier-1.7535766].*

Continental glaciers are your stereotypical glacier—think of Greenland or Antarctica. This category of glacier has mass ice sheets that cover vast areas of lands in **extreme** polar climates. These glaciers do not flow downhill, instead it grows by sliding ice from the thickest parts to the thinnest. Consider how grains of sand settle into a triangle when sprinkled from one spot. [4]

Alpine glaciers originate on mountains, making them smaller and more common in **temperate** polar regions. They are **slope-controlled**, unlike continental glaciers. These glaciers have a zone of accumulation, a zone of ablation, and an equilibrium line. [11]

Table 2: *Alpine glacier zones.*

NAME	DEFINITION
ZONE OF ACCUMULATION	More _____ formation than melting.
EQUILIBRATION LINE	The _____ between the two zones.
ZONE OF ABLATION	More ____ formation than ____.

[4] Earle, S.(2015). 16.2 How Glaciers Work. *Opentextbc.ca*. https://opentextbc.ca/geology/chapter/16-2-how-glaciers-work.

4.3 What are Ice Ages exactly?

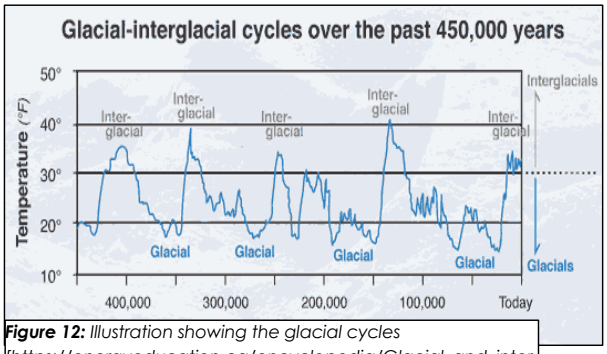


Figure 12: *Illustration showing the glacial cycles [https://energyeducation.ca/encyclopedia/Glacial_and_interglacial_periods]*

Ice ages are periods characterized by substantially colder global temperatures, during which large regions of Earth are covered by extensive ice sheets and glaciers. Ice ages begin gradually and end relatively rapidly. Given that melting ice generally happens faster than its accumulation. Consider the contrast between snowfall accumulation and ice melting, e.g. the seasons changing from winter to spring. There are two major ice age periods, interglacial and glacial.

There are many reasons as to why the Earth shifts from these periods, such as: higher concentrations of carbon dioxide, large-scale volcanic eruptions such as Large igneous provinces (LIPs) among many others. During Earth's history there have been at least five major ice ages.[5]

Table 3: *Historic ice ages [https://science4fun.info/ice-ages/].*

NAME	AGE (MA)	DESCRIPTION
HURONIAN	_,___—_,___	Greenhouse gasses were completely _____ due to reduction in volcanic activity.
_____	720—630	Most severe ice age, turning Earth into a complete _____.
ANDEAN—SAHARAN	___ to ___	Occurred during the late _____ and early Silurian time periods.
_____	360—260	It is named after Karoo, _____ _____, as glacial ____ from this ice age were discovered there.
_____	2.5—Present Day	A semi-_____ period, as most of our ice caps are in Greenland and Antarctica.

[5] *Ice Ages - Major Ice Ages (Causes + Facts) - Science4Fun*. (2019, March 1). Science4fun.info. https://science4fun.info/ice-ages/.

4.3.1 Ice Age Cycles

4.3.1.1 INTERGLACIAL PERIOD

An interglacial period is a warm phase in Earth's climate, characterized by global temperatures exceeding -1°C or 30°F respectively. During this time, ice retreat and melting rates surpass ice formation leading to higher sea levels.

4.3.1.2 GLACIAL PERIOD

A glacial period is a cold phase in the global climate, characterized by temperatures dropping below -1°C or 30°F respectively. During this time, ice advancement and sea level decreases of approximately 100m globally are prominent. Lastly, glacial periods last seven to nine times longer than interglacial.

4.3.2 Evidence Of Past Ice Ages

4.3.2.1 DEPOSITIONAL SEDIMENTS

Glacial till consists of poorly sorted, angular sediments of varying sizes, formed through grinding and movement within a glacier.

Glacial flour consists of finer particles than sand, that have been grinded by glaciers. This sediment is often dissolved in glacial lakes, giving them a milky appearance.[6]

Figure 14: *Photo of glacial till.* [13]

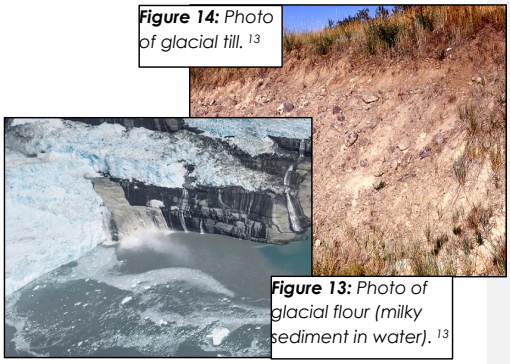


Figure 13: *Photo of glacial flour (milky sediment in water).* [13]

Commented [MC1]: pick a image from NS

Figure 15: *Photograph of glacial striations at Mount Rainier National Park [https://serc.carleton.edu/details/images/38033.html].*

4.3.2.2 EROSIONAL FEATURES

Glacial striations show glacier **flow directions.** An example of this at Point Pleasant Park in Nova Scotia, nearby the Prince of Wales Tower National Historic Site multiple intersecting striations are present. So, you must identify which striations overlay others.

[6] National Park Service. (2018). *Glacial Till and Glacial Flour (U.S. National Park Service)*. Nps.gov. https://www.nps.gov/articles/glacialtillandglacialflour.htm.

4.4 END OF SECTION QUIZ

5.0 Plate Tectonics

Key Concepts: Understand Earth's layers. The difference between the atmosphere and the lithosphere. What creates plate boundaries and their types, and how p- and s-waves are measured.

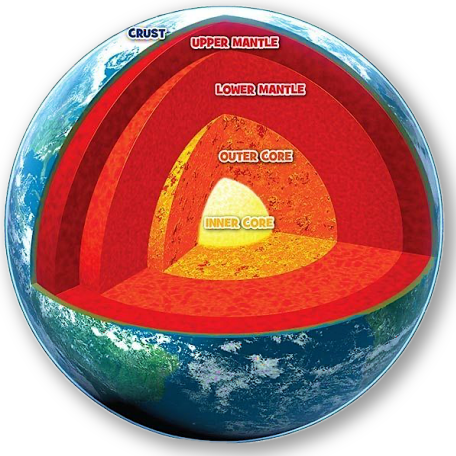
5.1 Earth's Layers

The Earth's layers are broken up into four distinct layers: **inner core, outer core, mantle and crust.**

I. **The inner core** is solid iron with trace amounts of nickel about 2500km in diameter.[7]

II. **The outer core** is liquid metal—mainly iron plus nickel with trace amounts of Sulphur and oxygen.

III. **The mantle** is home to ultramafic solid rock and is where metamorphism happens. While these rocks are solid, there is movement due to the convection currents present from the outer core.



IV. **The crust** is where we (humans) live, and it makes up about 1% of Earth.

There are two types of crust: continental and oceanic. Oceanic crust is thinner, denser and mafic, whereas continental crust is the opposite.[8]

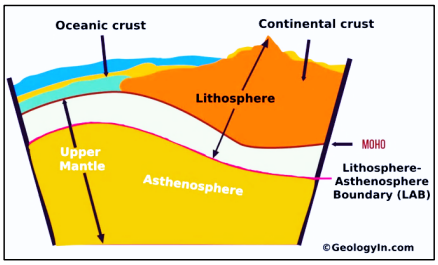
[7] National Geographic Kids. (2018, November 7). *Structure of the Earth! | National Geographic Kids*. National Geographic Kids. https://www.natgeokids.com/uk/discover/geography/physical-geography/structure-of-the-earth/

[8] Panchuk, K. (2021). 3.1 Earth's Layers: Crust, Mantle, and Core. *Opentextbc.ca*. https://opentextbc.ca/physicalgeologyh5p/chapter/earths-layers-crust-mantle-and-core/

5.1.1 ASTHENOSPHERE VS. LITHOSPHERE

Making up the bulk of the earth's layers, the mantle is a significant part in the Earth's history. Giving this, scientists have further broken up the mantle into lower and upper layers, due to their distinct properties.

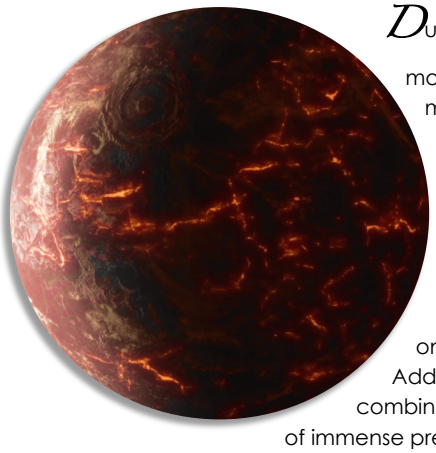
***Figure 16**: Diagram of the asthenosphere and lithosphere.*



The **upper mantel** is home to two important sub-layers: **asthenosphere and lithosphere.** The asthenosphere, though solid, behaves plastically and is more ductile near the core due to higher heat, bending under stress rather than breaking. Convection creates circulation, causing movement within the asthenosphere. Above it lies the lithosphere, a rigid, brittle layer consisting of the Earth's crust (what we live on) that supports tectonic plates. These two layers, working with convection currents, drive tectonic plate movement. [9]

5.2 Plate Boundaries

5.2.1 What Creates Plate Boundaries?



During the Hadean Eon the earth was a giant molten ball constantly being bombarded with meteorites and planets. As time progressed, the mantle and crust began cooling first as it was more exposed to the elements in space compared to Earth's inner layers—like how a lake in the winter freezes.

As the cooling progressed, different areas on the surface cooled at varying rates. Additionally, along with crustal shrinkage, the combined weight of the mantle there was a build-up of immense pressure and stress underneath the surface. All the pressure must escape, through weak points in the crust where **fractures** formed…

[9] Desonie, D. (2025, June 2). *CK12-Foundation*. Flexbooks.ck12.org. https://flexbooks.ck12.org/cbook/ck-12-middle-school-earth-science-flexbook-2.0/section/3.18/primary/lesson/lithosphere-and-asthenosphere-hs-es/.

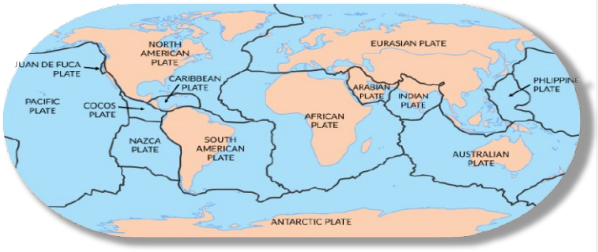
Commented [MC2]: Muilple choice: what is the lithosphere classified as? Mantle, curst, lithosphere, tectonic, none of the above.

Commented [MC3R2]: Maybe: upper mantle, lower mantle, crust, none of the above.

…from the above processes. The locations of these fractures are where the plate boundaries are now!

However, there are lots of theories on additional causes for the fracturing of the tectonic plates, some are volcanism, gravitational forces—Slab pull and Ridge push—and potentially impacts from meteorites.

Figure 17: *Diagram of all plate boundaries on earth. [https://earthhow.com/7-major-tectonic-plates/]*



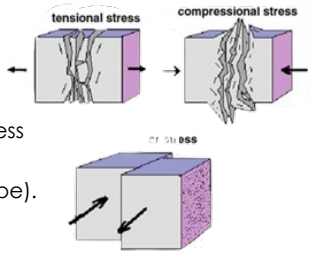
5.2.2 Force vs. Stress

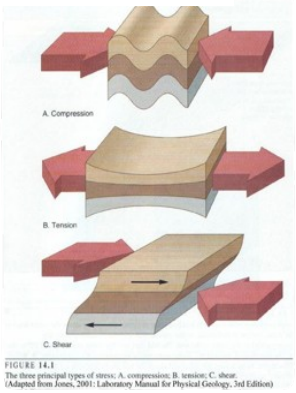
Table 4*: Definition of force, stress and strain.*

	DEFINITION	IN OTHER WORDS…
FORCE	Is the **act** of pushing or pulling on an **object**, and the strength required to do that task.	
STRESS	The **amount of force** pushing or pulling on something **over its surface area.**	Is the _____ acting on the object.
STRAIN	Is the **deformation** (change in shape) that happens to the object **due to the stress**.	Is how the object _____ due to the force applied to an object

Given that the definition of stress, is generalized as **the amount force applied to a surface area,** various factors can create stress. And the different mechanisms that creates stress result in different forms of deformation (change in shape).

Figure 18: *Diagrams of three stress types: tension, compression, and shear [https://slideplayer.com/slide/7621484/]*



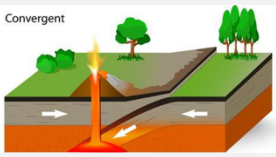
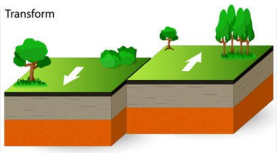


The main forms of stress that affect rock deformation are **compression, tension and shear**. Compressional stress involves where the rocks is being squeezed and tensional is where the rock is being pulled apart. Whereas shear stress causes the rock to be pulled in opposite directions.[10]

5.2.3 Plate boundary Types

Given that we now understand earths layers and what causes deformation, how does this connect to plate tectonics? Well, these stresses create the three types of tectonic movement: convergent, divergent and transform.

Table 5: *Explaination of tectonic boundaries.*

TECTONIC BOUNDARY	DEFINITION	VISUAL
CONVERGENT	Due to compressional stress, each plate is dragged either down or up depending on their density.	
DIVERGENT	Due to tensional stress, each plate is pulled apart, and magma fills the gap, forming new crust.	
TRANSFORM	Due to shear stress the plates are dragged in opposite directions.	

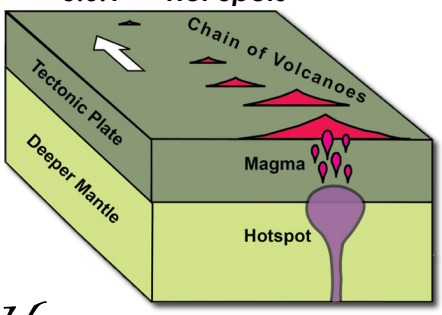
Convergent boundaries are affected by ridge push, where denser (oceanic) plates slide down into the mantle due to gravity. Whereas at divergent boundaries are affected by slab pull which is when rising magma pushes plates apart as it cools. [11]

[10] Panchuk, K. (2021, August 20). *13.1 Stress and Strain*. Opentextbc.ca; BCcampus. https://opentextbc.ca/physicalgeologyh5p/chapter/stress-and-strain/
[11] Explain ridge push and slab pull as a cause of plate movement. (n.d.). Internet Geography. https://www.internetgeography.net/flashcard/explain-ridge-push-and-slab-pull-as-a-cause-of-plate-movement/

The outlier with this list are transform boundaries, as unlike divergent or convergent boundaries *crust is neither created nor destroyed*. This movement also creates two types of faults: dextral (right lateral) and sinistral (left lateral). This naming scheme depends on which plate is "moving" towards you. For instance, table 7 shows a left lateral (or sinistral) fault since the left sides arrow is moving (or pointing) towards me.

5.3 Tectonic Events

5.3.1 Hot Spots



Hot spots are caused by mantle plumes that originate deep in the Earth, underneath the tectonic plates. Mantle plumes are areas (like bubbles) of rising magma in the mantle. Once the magma reaches the lithosphere it begins to melt the surrounding rocks forming a volcano on land.

The plumb stays in a **fixed location** while the volcano moves with the tectonic plates, as the original location of the magma is **beneath the mantle**. This creates a series of islands that follows the plate movements, a prime example of this is Hawaii. [12]

5.3.1 Tsunamis

Tsunamis result from massive sudden changes in the ocean like earthquakes, volcanoes, or meteorite impacts. They radiate in all directions from their source. As they approach shallow waters and land, their height increases and wavelength shortens, making them more evident and dangerous; in deep oceans, they are less visible.[13]

Draw a diagram of the tectonic setting of an earthquake

[12] Lillie, R. (2020, February 11). *Hotspots - Geology (U.S. National Park Service)*. Www.nps.gov; National Park Service. https://www.nps.gov/subjects/geology/plate-tectonics-hotspots.htm
[13] Helmenstine, A. (2023, August 23). *What Is a Tsunami? Definition and Explanation*. Science Notes and Projects. https://sciencenotes.org/what-is-a-tsunami-definition-and-explanation/

5.4 Seismology

Seismology is simply the study of earthquakes by measuring the waves they output.

These measured waves are called **seismic waves**. Seismic waves are the releases of energy that radiates outward in all directions and cause shockwaves throughout the sediment.[14] There are two main types of seismic waves—primary (P-waves) and secondary waves (s-waves). Primary waves can pass through solids and liquids, while surface waves cannot pass through liquids. There are also subtypes like Love and Rayleigh waves, (which are a part of **surface waves**) which behave differently depending on the rock or medium they encounter.

Video explaination: https://www.youtube.com/watch?v=KZaI4MEWdc4.

How do you distinguish P-waves from S-waves?
On a seismogram showing velocity versus time, P-waves appear first as a large initial bump, followed later by S-waves. Keep in mind, different materials affect wave speed, but timing remains the key identifier.[15]

5.4.1 Measuring Earthquakes

To measure an earthquake, scientists need a visual record of ground movement, obtained using a seismograph that captures vibrations relative to the instrument's original position. This records seismic waves, enabling scientists to analyze the energy released and its travel through the Earth. Given this, different wave types create different distant images. It is important to understand how to find a p-wave and s-wave on a seismograph.

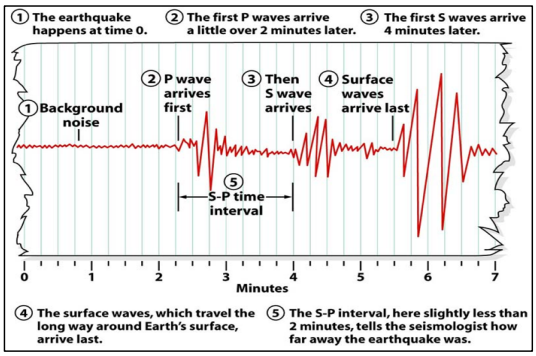


Figure 19: *Diagram of identifying different wave types from a seismograph.*

Commented [MC4]: explain in more depth

[14] Science Learning Hub. (2007, July 21). *Seismic waves*. Science Learning Hub; Science Learning Hub. https://www.sciencelearn.org.nz/resources/340-seismic-waves
[15] Brooklyn College - Geology Department. (2025). *Plate Tectonics - A Scientific Revolution*. Cuny.edu. https://academic.brooklyn.cuny.edu/geology/grocha/plates/platetec19.htm

5.5 END OF SECTION QUIZ

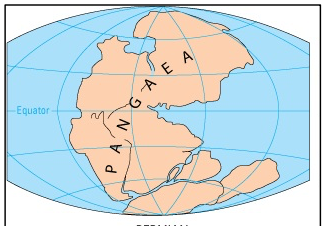
What is the property change between the inner and outer core and why.
What is the difference between Richter scale and moment magnitude?
Why does metamorphism happen in the mantle?
Where is the ring of fire, what is it and what causes it?
How can you locate a primary and secondary wave on a seismograph and how do you ensure it's not noise?
What is paleomagnetism, and what is it connected to?

6.0 Black Excellence in Earth Science

Key Concepts: Supercontinents and their geological links through the rock record and fossils. Why are visible minorities underrepresented in STEM and Earth sciences, and how can we improve diversity?

6.1 Nova Scotia's Geologic Connection to Africa

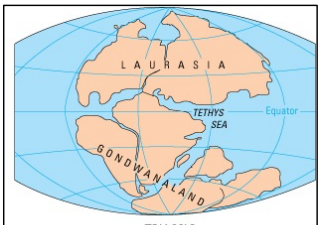
Commented [MC5]: add diagrams of the connection



PERMIAN
225 million years ago

Earth's tectonic plates have formed various shapes depending by the plate boundaries connection with one another—these "shapes" are known as supercontinents. Supercontinents are ever changing, continually and will forever break and reform into new shapes. The most popular and well-known supercontinent occurred over 335-million-years ago, however, that was **not** the only supercontinent. 335-million-years ago Africa and Nova Scotia were not separated across an ocean as they are now; in fact, **they were a part of the supercontinent Pangea.**

This quickly began to change; however, the separation of these contents was **not** a smooth transition. Firstly, a small portion of Africa's crust broke off and then clung to the North American plate; these brought along with it crumbs of Africa's Precambrian rocks. As these two micro-continents floated a crossed the newly forming Atlantic Ocean, both collecting deep-sea sediments and undergoing various glaciations.[16]



TRIASSIC
200 million years ago

Then suddenly….

[16] Schenk, P. E. (1971). Southeastern Atlantic Canada, Northwestern Africa, and Continental Drift. *Canadian Journal of Earth Sciences*, *8*(10), 1218–1251. https://doi.org/10.1139/e71-113

The **sub-continents collided** forming and interconnecting Africa's Anti-Atlas Mountains and North America's Appalachian Mountains, as this tectonic event mixed rocks and fossils. Eventually, as the Atlantic Ocean opened during the Mesozoic, these two *now* continents are forever interconnected though millions of years of geologic history (Schenk, 1971).

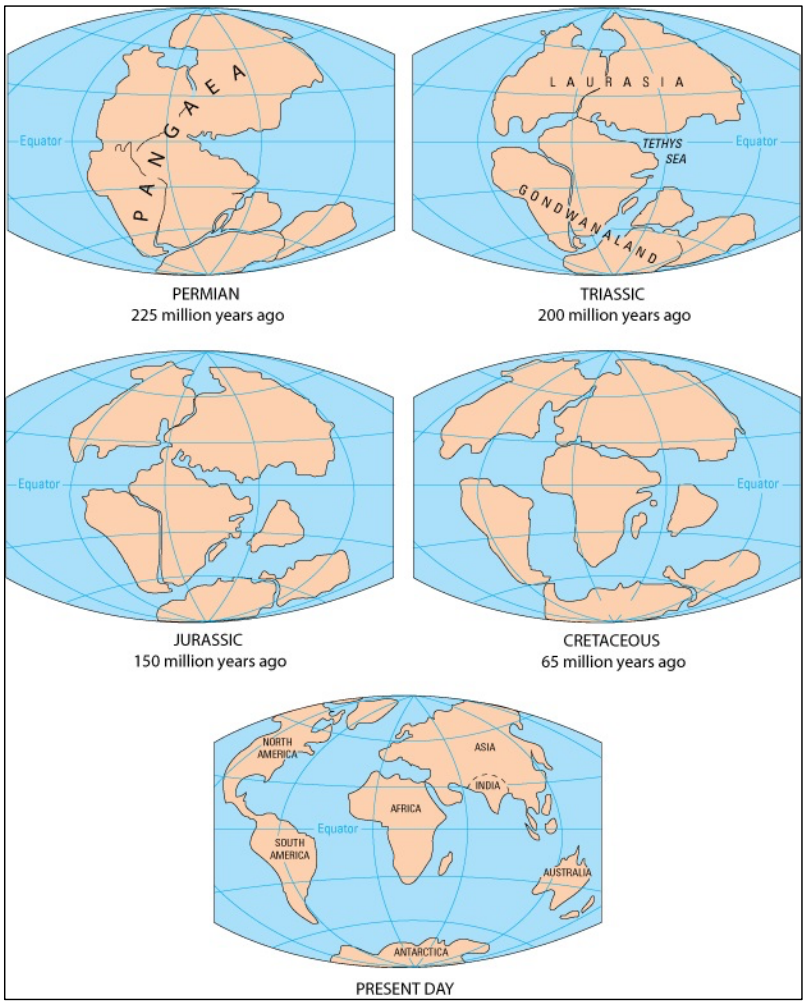
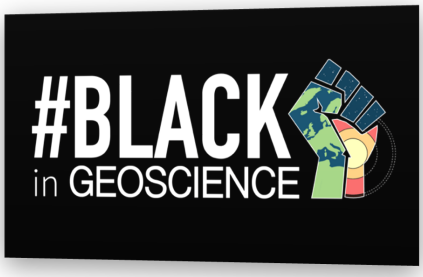


Figure 20: *Diagram of the moment of the supercontinent Pangea as it forms Earth's current shape.*

6.2 BIPOC Visibility in Earth Science

There's no exact number regarding the amount of Black geoscientists present in Canada, but similarly to other STEM professions it is widely understood that the number is shockingly low. For instance, Dr. Hewitt—a physics professor at Dalhousie University—spoke on a study he conducted reveling that only 1% of people in physics-related fields identified as black (Mortillaro, 2022). While physics is not geoscience, there is still a reasonable connection to be made, given that these are both not as popular STEM fields.



Both cited articles highlight the removal of barriers like, limited access to STEM due to low employment rates, lack of secondary education, and university retention. Underrepresentation within the classroom and in the job force, enables the presence of harassment, discrimination and imposture syndrome to persist. Both barriers are compounded by insufficient inclusivity efforts from institutions and companies. Hindering engagement all the way from education to research and careers, furthering the cycle of limited Black geoscientists (Raji & Ali, 2021).

6.2.1 Brainstorming Activity: Improving BIPOC Visibility

Given what was mentioned as lacking and promoting decreased visibility, how do **you** think we can remove these barriers?

6.2.2 Institutions Furthering Black Visibility in STEM

Many others have also noticed this significant gap of minority presence in STEM and have founded institutions in response. Canadian Black Scientists Network (CBSN), National Association of Black Geoscientists (NABG) and Imhotep's Legacy Academy (ILA) are prime examples. All these institutions have a generalized goal of elevating and celebrating Black scientists while enhancing post-secondary retention rates and boasting black representation in the media.

Can you list their missions, and how they're achieved?

Canadian Black Scientists Network	National Association of Black Geoscientists	Imhotep's Legacy Academy

6.3 Black Excellence in Geology

This section will revolve around your investigation abilities! For each scientist there will be two truths and one lie, it's your job to **find the lie**—be careful, they're sneaky.

Scientist	Background	Focus	Impact
Dr. Rufus Catchings 	Since 1981, Dr. Catchings, a USGS research geophysicist, has authored hundreds of papers and advised various governments. agencies.	Dr. Catchings, a lifelong geophysicist, specializes in tectonic impacts on the subsurface and groundwater hazard mitigation.	Dr. Catchings works bridges science and policy, fostering future scientists while assisting officials in hazard mitigation and resource
Dr. Dawn Wright 	Since 1993, Dr. Wright has taught at Oregon State University and serves as the chief scientist at Esri.	Dr. Wright helped create the **first** GIS data model of ocean and is actively aiding in the field of oceanography.	The ability to map the ocean floor with GIS, safeguards habitats and better respond to climate change.
Evan Forde 	As an oceanographer at NOAA meteorological lab can be found studying the formation of submarine mountains.	Dr. Forde currently focuses on utilizing satellites to measure conditions that form hurricanes.	Along with his various other significant impacts to the field, Dr. Forde was the first African-American to do research in a submersible.

Scientist	Background	Focus	Impact
Dr. Folarin Kolawole 	Folarin earned a degree in technology and geology. Then earned a PhD in geophysics all at the University of Oklahoma where he is currently an assistant professor.	Is a structural geologist who studies the formation and evolution of rifts and faults, with a primary focus on earthquakes and ancient faults.	His researching on seismic activity on sediments in US, South American and Africa allows us to be aware of future environmental risks.
 **Zelma Maine-Jackson**	A hydrogeologist at Washington's Department of Ecology and in her late career she specialized in uranium mining.	Dr. Marine-Jackson, advocates for environmental sustainability by leading cleanup of nuclear waste at the Hanford Site.	Her research and advocacy for proper nuclear waste disposal help protect communities and prolong Earth's finite resources.
Dr. Mack Gipson 	Dr. Gipson held positions in petroleum, founded a geology department and became a professor of geology at the University of South Carolina.	Dr. Gipson focuses on subsurface sedimentary rocks connected to petroleum reservoirs and the minerology of clays.	Dr. Gipson was the first African-American geologist to earn a PhD in 1963 and was a founder of NABGG.

6.4 END OF SECTION QUIZ

7.0 Appendix

7.1 Appendix A: Worksheets for Section 3.2

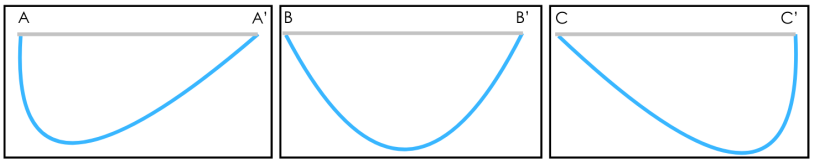
Name: _____ **Date:** _____

Introduction to Flow Velocity

Places that cause friction in rivers are (causes the river to slow):

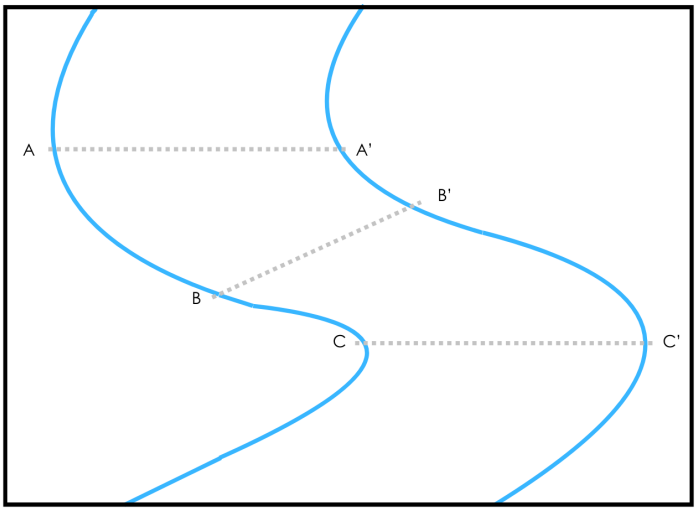
- Bottom of the river (encounters bedload sediment).
- The sides (encounters bank sediment).
- The top (encounters air).

1. Circle the spots where the river will **be the fastest.**
Hint: look at the bottom of the page.



2. Mark the spots indicated in question 1 on the lines and connect them, this is the line of fastest flow.

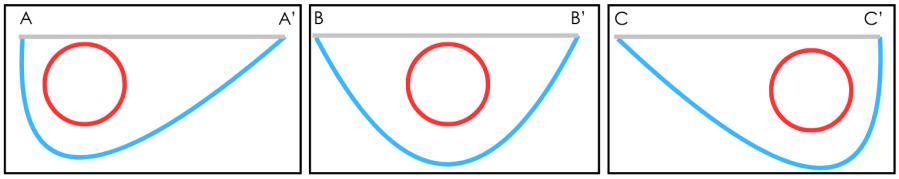
Make sure you follow the outside curve and no straight lines (nature isn't perfect).



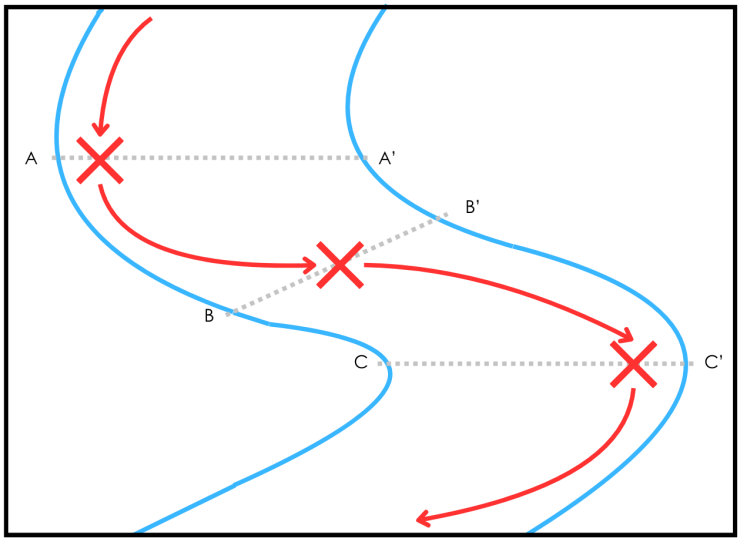
Answer Sheet

Introduction to Flow Velocity

1. Circle the spots where the river will be the fastest.



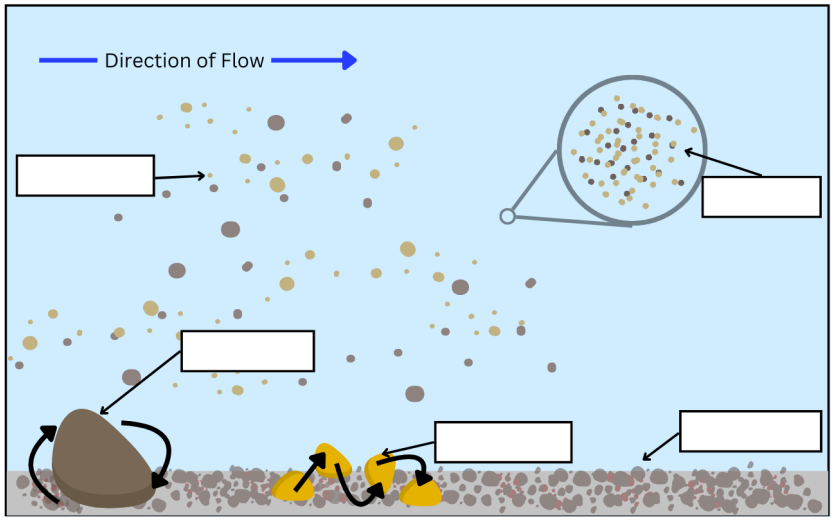
2. Mark the spots indicated in question 1 on the lines and connect them. **Make sure you follow the outside curve.**



Name: _____ **Date:** _____

Introduction to Sediment Movement

Label where each type of sediment movement is.



Word Key

☐ **Bedload**

This sediment is deposited on the riverbed.

☐ **Dissolved load**

These are ions (Na+, Cl-) present in the water, you cannot see them with the naked eye.

☐ **Suspension**

These rocks hover in the water instead of settling on riverbed due to environmental energy.

☐ **Traction**

These rocks roll along the riverbed, unable to be in full suspension due to low flow velocity.

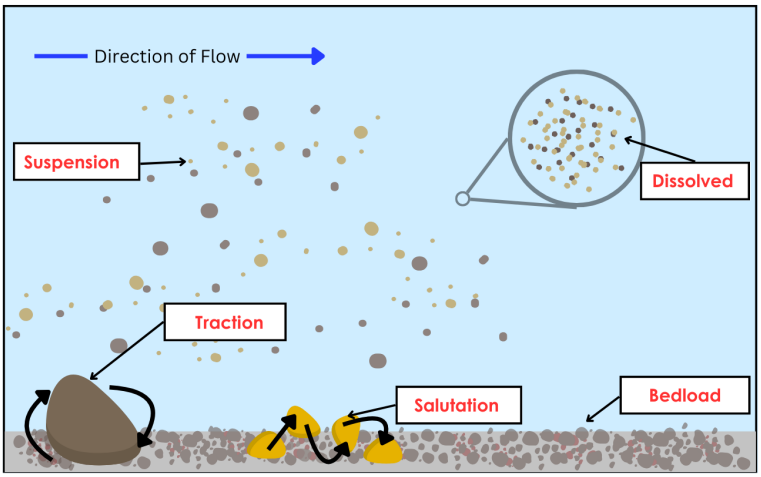
☐ **Salutation**

These rocks bounce along the riverbed unable to be in full suspension due to low flow velocity.

Answer Sheet

Sediment Movement Intro

Label where each type of sediment movement is.



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