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Project #3

Comparing the Rock Cycle to Sediment Found in Different Geologic Areas (Activity for High School Students)

INTRODUCTION

Sediment found in any given area contain rocks and minerals that tell its geologic history from parent rock to final deposition. The plate tectonic theory explains how Earth's lithosphere is constantly in motion, which is caused by the convection of heat through its mantle. By knowing if the area contains igneous, sedimentary, or metamorphic rock you can better identify sediment found in the United States and internationally.

OVERVIEW

Plate tectonics is caused by the convection of heat through Earth's mantle. Convection is a transfer of heat through a fluid (liquid or gas) that is caused by molecular motion. Cooling at the surface forms a strong outer shell or lithosphere (Press et al. 14). This process has broken the lithosphere down to numerous plates that move together (convergent), spread apart (divergent), or slide against one another (transform). The interaction between these plates increase temperature and pressure, which forms different rocks and minerals. The process of weathering and erosion create the sediment we find in rivers and oceans.

Igneous rocks form when magma from the mantle crystallizes as it makes its way through the lithosphere. This type of rock can either solidify beneath the lithosphere (intrusive), or above (extrusive). Intrusive rocks are coarse-grained, which are formed by the slow cooling process of minerals within the melt. These rocks are generally associated with plate convergence, which can

cause intrusion of magma into the solid crust at depth. Granite is a great example of an intrusive igneous rock, and contains large interlocking crystals (Press et al. 77). Extrusive igneous rocks are rapidly cooled, and usually cool due to a volcanic eruption. Divergent plate boundaries are most associated with mid-oceanic ridges (oceanic-oceanic plates). These ridges are formed from the upwelling of magma that pushes these plates apart. Due to the the fast cooling of minerals, these rocks are glassy (obsidian) to very fine-grained (basalt) in texture.

Sedimentary rocks are formed from the burial of layers of sediment (sand, mud, and calcium carbonate) that are deposited on land, or sea (Press et al. 76). Lithification compacts and cements these sediment grains together forming rocks like sandstone and limestone. Sandstone is made from the deposition of sand sized grains of a mineral or rock, and limestone consists of calcium carbonate. Once these rocks are formed on the surface they experience weathering and erosion. Weathering is the physical and chemical processes that break up and decay rocks into fragments (Press et al. 78). These fragments are moved to their spot of deposition through erosion. Due to its formation, sedimentary rocks can be found at any respective plate boundary.

Metamorphic rocks are formed from high temperature and pressure that cause the rock to change its mineralogy, texture, or chemical composition while maintaining a solid form (Press et al. 80). These rocks can be igneous, sedimentary, or metamorphic and experience temperatures high enough for the rock to experience recrystallization (Press et al. 80). Metamorphism occurs due to the interaction between tectonic plates, and creates regional or contact metamorphism.

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Regional metamorphism occurs where high temperatures and pressures cover a large region. Where high temperatures are located in smaller areas, such as rocks near and in contact with an intrusion, rocks are transformed by contact metamorphism (Press et al. 80). These rocks are most associated with convergent plate boundaries, but can also form in any area that has increased in temperature and pressure.

PROCEDURE

For this activity I have provided magnified sediment sample photographs provided by Charles Lindgren (The Science of Sand, https://www.scienceofsand.info). By reading the overview you should be able to correlate the sediment with its correct rock type (igneous, sedimentary, or metamorphic). You should also be able to distinguish if this rock originated from a convergent or divergent plate boundary, or caused by intrusion. We will not worry about transform plate boundaries, because they focus more on the plates movement rather than the creation of rock.

SEDIMENT ANALYSIS

Looking at this sediment and reading the description you help you determine the origin of these samples. You can use other online resources to guide included mineral information to determine what type of rocks they belong to. This will tell you where your sediment lies within the rock cycle (igneous, sedimentary, or metamorphic), which relates to its geologic plate boundary.

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OBJECTIVES

*The learner will investigate different rocks that make up the Rock Cycle and be able to classify.

*The learner will investigate these different rocks and be able to relate them to plate tectonics.

*The learner will also compare and contrast between intrusive and extrusive igneous rocks.

*The learner will relate angularity and sorting to the deposition of sediment.

*The learner will relate this information to different geologic areas on Earth.

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SAMPLE #1

Photo 1: Lindgren, Charles. Mile Beach: Reid State Park, Maine. Science of Sand. 16 April 2020.

DESCRIPTION

This sediment contains the minerals quartz, plagioclase, alkali feldspar, and muscovite. Most of the rocks that make up these minerals contain coarse grains that can be seen with your "naked-eye". The type of rock that is most relevant in this sample is syenite, which is very similar to granite and contains very little quartz (high in feldspar content).

QUESTION #1

What type of plate boundary formed this sediment?

Is it intrusive or extrusive?

_____

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SAMPLE #2

Photo 2: Lindgren, Charles. Underwater volcano off the coast of Tonga. Science of Sand. 16 April 2020.

DESCRIPTION

The rock in this sample contains the minerals feldspar, augite, and hornblende. This rock is very fine-grained, and can have a considerable amount of glass within its texture. The rock seen in this photo is called pumice, and was formed by very fast cooling that made many vesicles (cavities whiten the rock that make it very light and porous).

QUESTION #2

What type of plate boundary formed this sediment?

Is it intrusive or extrusive?

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SAMPLE #3

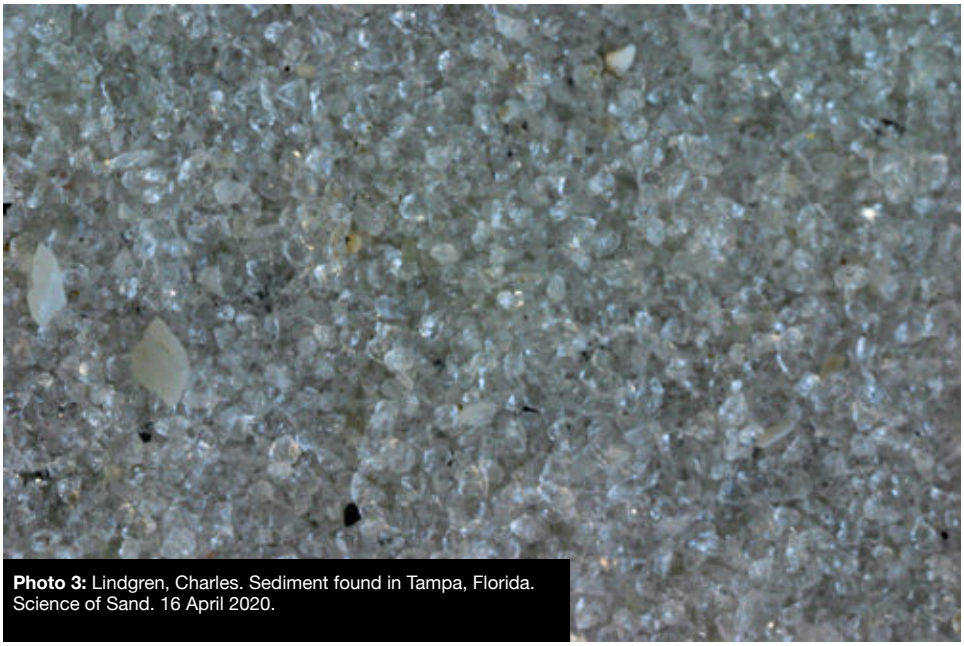

Photo 3: Lindgren, Charles. Sediment found in Tampa, Florida. Science of Sand. 16 April 2020.

DESCRIPTION

This sample contains the minerals quartz and calcite (calcium carbonate). The grains are very well sorted and are sub-rounded to rounded. This angularity of the grains shows that the sediment traveled a great distance before it was deposited.

QUESTION #3

What type of plate boundary formed this sediment?

Did this sediment get deposited from a river or ocean?

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SAMPLE #4

Photo 4: Lindgren, Charles. Sediment found by Mitchell Lucas. Science of Sand. 16 April 2020.

DESCRIPTION

The sediment in this sample contains the minerals chlorite, quartz, feldspar, biotite, muscovite, and pyrite. The rocks within the sample consist of limestone, shale, and sandstone that have undergone increased temperature and pressure. This caused these different rocks to change mineralogy and texture.

QUESTION #4

What type of plate boundary formed this sediment?

Can oceanic plates be metamorphosed?

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ANSWER SHEET

1) Convergence; Intrusive

2) Divergent; Extrusive

3) Sedimentary rocks can be found at any plate boundary; Ocean

4) Convergent; Yes, when two oceanic plates collide the older/denser plate is subducted

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References

Photo 1: Lindgren, Charles. Mile Beach: Reid State Park, Maine. *Science of Sand*. 16 April 2020 <https://www.scienceofsand.info/sand/states/maine/mile.htm>.

Photo 2: Lindgren, Charles. Underwater volcano off the coast of Tonga. *Science of Sand*. 16 April 2020 <https://www.scienceofsand.info/sand/countries/tonga/tongavolcano.htm>.

Photo 3: Lindgren, Charles. Sediment found in Tampa, Florida. *Science of Sand*. 16 April 2020 <https://www.scienceofsand.info/sand/states/florida/tampa.htm>.

Photo 4: Lindgren, Charles. Sediment found by Mitchell Lucas. *Science of Sand*.

Press, Frank, et al. Understanding Earth. New York: W.H. Freeman and Company, 2004.

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