The Geology of Pacific Northwest Rocks & Minerals
Activity 1: Geologic Time

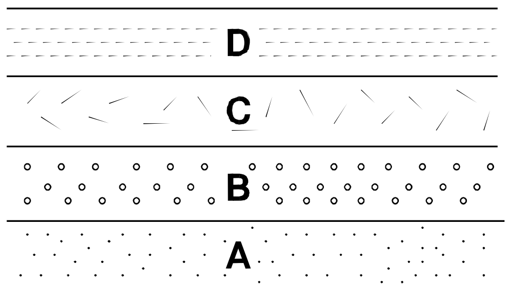
Name: ________________________________ Age: _______________

I. Introduction

There are two types of geologic time, *relative* and *absolute*. In the case of ***relative time*** geologic events are arranged in their order of occurrence. No attempt is made to determine the actual time at which they occurred. For example, in a sequence of flat lying rocks, shale is on top of sandstone. The shale, therefore, must by younger (deposited after the sandstone), but how much younger is not known. In the case of ***numerical time (sometimes called absolute time)*** the actual age of the geologic event is determined. This is usually done using a radiometric-dating technique.

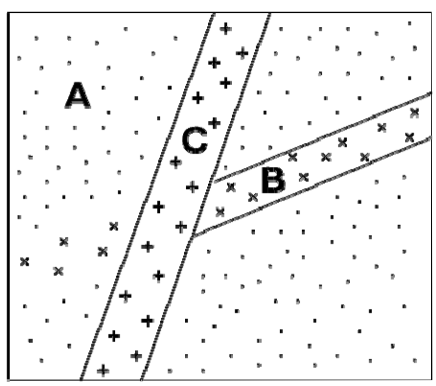
II. Relative Geologic Age

In this section several techniques are considered for determining the *relative age* of geologic events. For example, four sedimentary rocks are piled-up in the following order



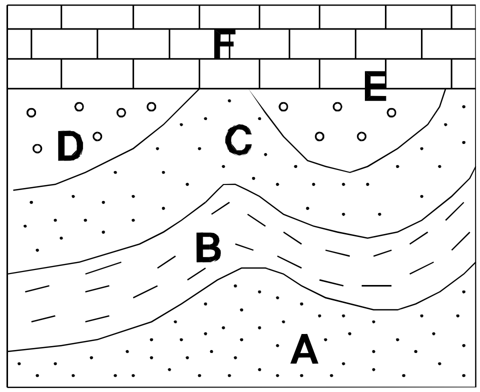
A must have been deposited first and is the oldest. *D* must have been deposited last and is the youngest. This is an example of a general geologic law known as the ***Law of Superposition***. This law states that ***in any pile of sedimentary strata that has not been disturbed by folding or overturning since accumulation, the youngest stratum is at the top and the oldest is at the base***.

As a second example consider a sandstone which has been cut by two dikes (igneous intrusions that are tabular in shape).



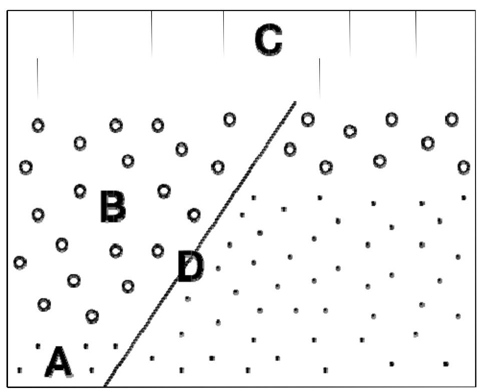
The sandstone, *A,* is the oldest rock since it is intruded by both dikes. Dike *B* must be older than dike *C* since it is cut by dike *C*. The sequence of events, therefore, is deposition of sandstone *A* followed by intrusion of dike *B* and then dike *C*.

As a third example, a sequence of sediments are deposited and then lithified. The resulting sedimentary rocks are deformed (folded), eroded and then covered by an ocean. Subsequent deposition of carbonate shell material leads to the formation of a marine limestone.



The sedimentary sequence *A* through *D* (oldest to youngest) must have been deposited first. This sequence was then folded and subsequently eroded (erosion surface *E*). After erosion, marine limestone *F* was deposited.

As a final example, consider the case in which a fault developed after formation of a sequence of rocks.



In this case rocks *A* and *B* are offset by fault *D*, so they must have been formed prior to faulting. However rock *C* is not offset so it must have been formed after faulting occurred.

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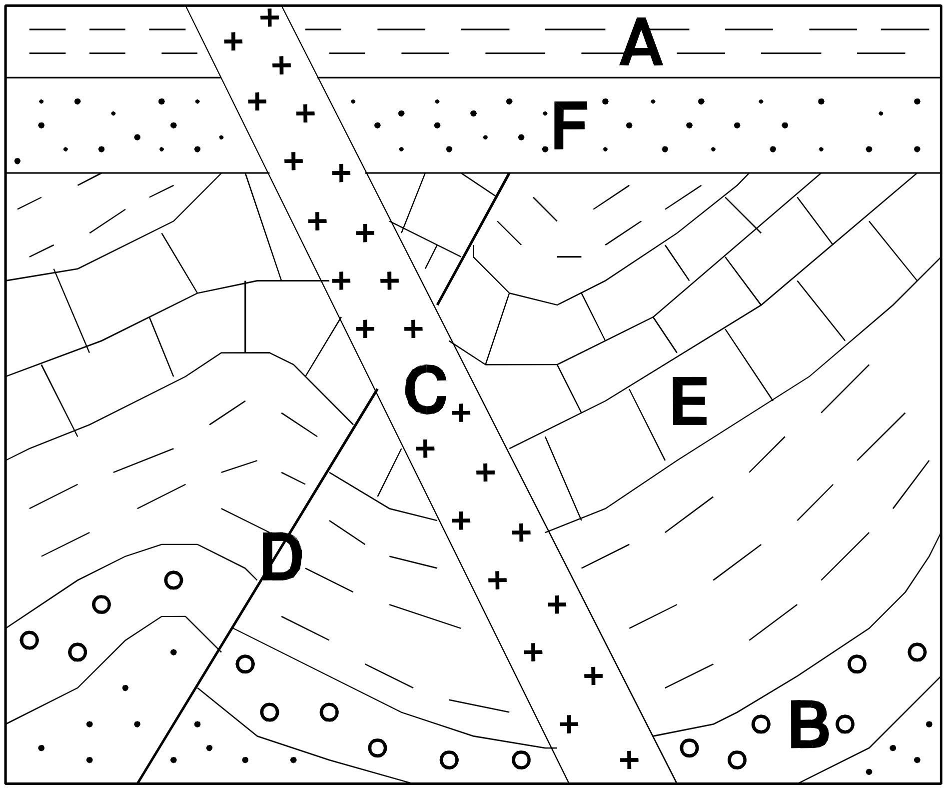
For the geologic cross-section drawn below establish the relative sequence of occurrence for the rocks or events indicated by the letters.



G = Folding

Enter the sequence of events in order from youngest at the top of the table to oldest at the bottom.

	Rock or Event	Criteria used to determine the relative position
Youngest		
Oldest		

III. Numerical Geologic Age

Part A.

The time of formation of a rock or mineral can be determined by measuring the amounts of naturally radioactive elements, such as uranium, rubidium, or potassium, in the rock or mineral and the amount of their radioactive decay products in the rock or mineral. Since the rate of decay of a radioactive element is not changed by any natural process such methods provide accurate numerical ages. Some people consider these numerical ages "absolute" ages.

Numerical ages are determined by examining radioactive elements and their products. The radioactive element, or the element that is said to decay, is the parent isotope. The element that is left behind after the parent decays is called the daughter isotope. Because getting an accurate radiometric age requires knowing the precise amounts of both the parent and daughter isotopes, the rock must have formed in a closed system. Specifically, all of the minerals in the rock must have formed at approximately the same time. This means that most radiometric dating can only be done on igneous and metamorphic rocks. Sedimentary rocks may be made of bits and pieces of rocks that formed at different times, and hence may have amounts of parent and daughter isotopes that are unrelated to the time that the sedimentary rock formed. Isotopes used for dating igneous and metamorphic rocks and minerals include Rb-Sr (rubidium-strontium), U-Pb (uranium-lead), U-Th (uranium-thorium), and K-Ar (potassium-argon). These isotope pairs can be used to age rocks that are generally older than 100,000 years.

Another important radiometric dating isotope pair is ^{14}C-^{14}N (carbon-14 – nitrogen-14). Carbon is an important component of life on planet earth, and so ^{14}C has become a very effective way to age some fossils. Both archeologists and geologists have found this method very useful to age plants and animals, which have been used to constrain the ages of some sedimentary rocks. This isotope pair has its limitations though, as the fossils must be less than ~40,000 years old (due to the half-life of 5,730 years). This method of dating has played a key role in examining some of the earth's more recent climate changes (e.g. global warming and ice ages) and major geologic events (e.g. earthquakes, volcanic eruptions, and tsunamis).

Some problems can arise while trying to radiometrically estimate the age of a rock. For example, sedimentary rocks generally have 'inherited' ages, which come from being made up of older rocks. Heat and pressure can cause some of the daughter and/or parent isotopes to 'leak' from minerals, which can cause inaccurate ages for igneous and/or metamorphic rocks. Sometimes very little of the parent isotope remains, which causes difficulty in accurately calculating a radiometric age. In some instances, small amounts of datable material can also lead to difficulties in getting accurate radiometric ages. Despite these problems, numerical ages are still successfully used to solve significant problems in geology.

Biotite is separated from dike *C* shown in the sequence of events problem. The biotite crystallized from the magma that formed the dike. The age of the biotite is 15.5 Ma.

1. What does this tell you about the age of dike *C*?

2. What does this tell you about the age of rock *B*?

<u>Part B.</u>

1. Use a coin for this experiment. Take this coin and flip it 10 times. Each time, it land with either heads or tails facing upwards. Keep track of the number of heads and the number of tails. Every time a coin lands with "tails up," let's consider that this represents a parent isotope that has decayed to a daughter isotope. Let's also consider that each flip represents a radioactive half-life.

(a) How many parent isotopes remain? ________
(a) How many daughter isotopes? ________
Flip the coin another ten times. Add your results to the initial 10 flips, for a total of 20 flips.
(c) How many total parent isotopes remain? ________
(d) How many total daughter isotopes? ________
(e) How well do these two flip exercises actually eliminate half of the remaining parent isotopes?

(f) Would (d) be improved by making the sample population smaller or larger? <u>Yes</u>/<u>No</u> Why?

2. Sometimes numerical ages are referred to as 'absolute ages' because they give a quantifiable age to the rock. Why might these numerical ages not always be absolute ages?

3. In metamorphic rocks, minerals form at different temperatures and pressures. What could this potentially do to radiometric ages from a metamorphic rock?