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CHEM.3040 - FORENSIC SCIENCE II
GEOLOGIC TIME AND GEOLOGIC MAPS

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 ***absolute time*** the actual age of the geologic event is determined. This is usually done using a radiometric-dating technique.

II. Relative geologic age

There are several "Laws" that are used to establish relative geologic time.

- ***Law of Original Horizontality*** – sedimentary layers were initially flat lying or close to flat lying.
- ***Law of Superposition*** - 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. While this may seem to be a simple observation, this principle of superposition (or stratigraphic succession) is the basis of the geologic column which lists rock units in their relative order of formation.
- ***Law of Faunal Succession*** - species change as a function of time and once a species becomes extinct it does not re-appear in the geologic record.

III. Absolute Geologic Age

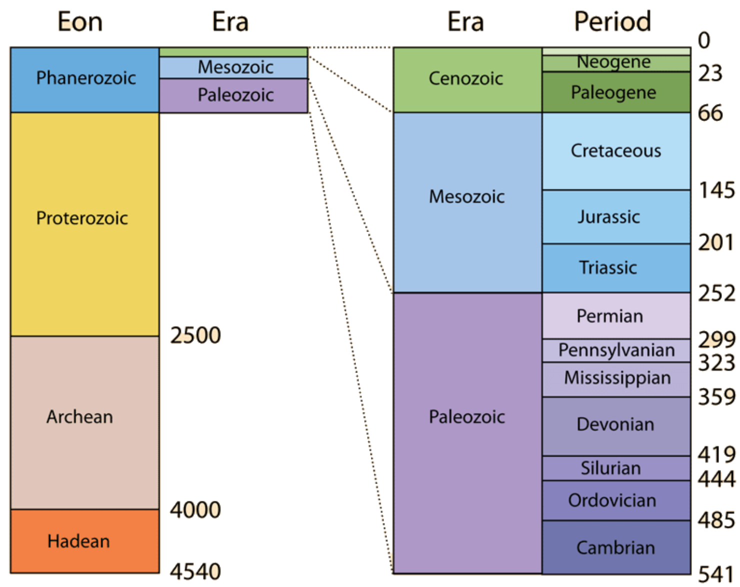
The time of formation of a rock or mineral can be determined by measuring the amounts of naturally occurring radioactive elements, such as uranium, rubidium or potassium, in the rock or mineral and the amount of their radioactive decay products in the rock or mineral. Since the rate of decay of a radioactive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

Generally one can only determine radiometric ages for igneous and metamorphic rocks. In the case of igneous rocks we can determine the time at which the magma solidified and for metamorphic rocks we can determine the time of peak metamorphism. Except in rare cases we cannot directly determine a radiometric age for a sedimentary rock. This means that there is often some ambiguity about the age of a sedimentary rock.

Radiometric dating has numerous applications and has been used to establish the long history of the earth. The best estimate for the age of the earth is 4.5 billion years and the oldest dated materials on earth are zircons from a meta-conglomerate in the Jack Hills of Western Australia. Some of the zircon grains from this meta-conglomerate gave ages of 4.4 billion years, very close to the age of the earth. The instructor's web site has pictures of this area in WA.

IV. The geologic time scale.

The geologic time scale was largely developed in the 19th century. The basic principles used to establish the geologic time scale are the *Law of Superposition* and the *Law of Faunal Succession*. What geologists (or more correctly, at that time, naturalists) did was to establish the order in which sedimentary rocks were deposited (the stratigraphic sequence). They then used the fossils in these rocks to identify rocks of similar time in other locations. Major divisions in the geologic time scale were based on what appeared to be major changes in conditions at the earth's surface. For example the Mesozoic Era was the "Age of the Reptiles", at least in the popular media an era associated with dinosaurs. This era came to an end with a major change (generally believed to be a large impact event) that led to the extinction of the dinosaurs and the rise of mammals. Hence, the Cenozoic Era is referred to as the "Age of the Mammals". The geologic time scale is based on the sedimentary record, and it is a relative time scale.



Geologic time and the geologic column

Since, in general, we cannot date sedimentary rocks, absolute ages for the geologic time scale are determined by radiometrically dating igneous and metamorphic rocks. How these radiometric ages are then assigned to the sedimentary rocks is a bit of an arcane exercise that we will not discuss here. Suffice it to say that these ages are continually revised and that the absolute geologic ages are subject to change.

V. Geologic maps

Geologic maps show, for a given area, the types of rocks and their ages. These maps present basic geologic information that can be used in a variety of ways. The most famous geologic map (sometimes referred to as "The Map that changed the world") is William Smith's map of the British Isles, considered to be the first geological map. The map was published between 1815 and 1817. Smith's work was of such high quality that modern geologic maps of the British Isles still bear a great similarity to his original work.

All geologic maps have a legend that identifies the types of rock in the area, their sequence, and their relative age. The rocks are grouped together into formations (mapable rock units) that may consist of only one rock type or several similar rock types. These formations are then arranged in stratigraphic order and their geologic ages are shown.

VI. Geologic maps and forensic science

Geologic maps are often used in forensic science to establish the origin of a rock. A common example is the material switch in which rocks are substituted for a valuable commodity. By identifying the type of rock and, in certain cases using fossils to determine its age, one can compare the rock to the lithologies (rock types) that are exposed in the areas where the switch might have taken place. This comparison is done using geologic maps of the areas of interest. Once the location where the switch took place has been identified, further investigation may lead to the perpetrators of the crime.

1. With reference to the *Geologic Map of Southeastern Utah*, what types of rocks (formation names and rock types) occur in the NE corner of the map area?

2. This problem uses the *Geologic Map of the Winnemucca Quadrangle, Nevada* (CSI Las Vegas territory). A body is discovered on Hayden Ranch (SW area of map). A bloody rock is found with the body (specimen provided). Identify the rock. Does this type of rock occur anywhere in the area covered by this geologic map (see the Legend)? The answer is most likely yes. Where in the area does this type of rock occur? Do you think the person was killed at Hayden Ranch or might the crime have taken place somewhere else? Explain.

3. Refer to the *Geologic Map of Washington*. A shipment of engine parts from Korea arrives at the Port of Seattle and the containers are transferred to railroad cars and shipped to Detroit. When the containers arrive in Detroit they are found to contain not engine parts but volcanic rocks. A geologist from the University of Detroit is called to the plant. He’s done geologic research on rocks from Washington and his observation of the rocks in the crates suggests that they are Miocene volcanic rocks. Could the replacement of the engine parts with the rocks have occurred in Seattle? If so, what was the likely source of the rocks? One of the dock workers lives in Ellensburg. Is he a possible suspect? Explain.