The Science of Age Dating

By Philip Scoggins

How do geologists or paleontologists know a fossil is, for example, 105 million years old?
It may not be exact but it is not just a wild guess – its science. There are several methods involved. This simplified version will discuss stratigraphy and two methods of age dating.

STRATIGRAPHY

Nicolaus Steno, in 1669, developed three principles that apply to sedimentary rocks. 1) Superposition is the concept of stacking. Bottom most is the oldest. 2) Original Horizontality: layers are deposited in horizontal units. 3) Lateral Continuity: layers extend latterly until they tapper off or reach the limits of the depositional basin or area.

Geologists compare units and apply these principles to understand the original sequence of the deposits. Earth forces can change the horizontal nature of the rocks. Rock layers can fold and turn them upside down. Knowing the original sequence is part of the solution to a fossil's age.

RELATIVE AGE DATING

Relative age dating is a comparative method. Paleontologists study species from evolution to extinction. The time frame of a species existence is its *range*. Rocks deposited within the species' range will contain fossils of that species. Rocks deposited before or after will not. Knowing the ranges of species and comparing rock sequences can provide a relative age of the rock layers.

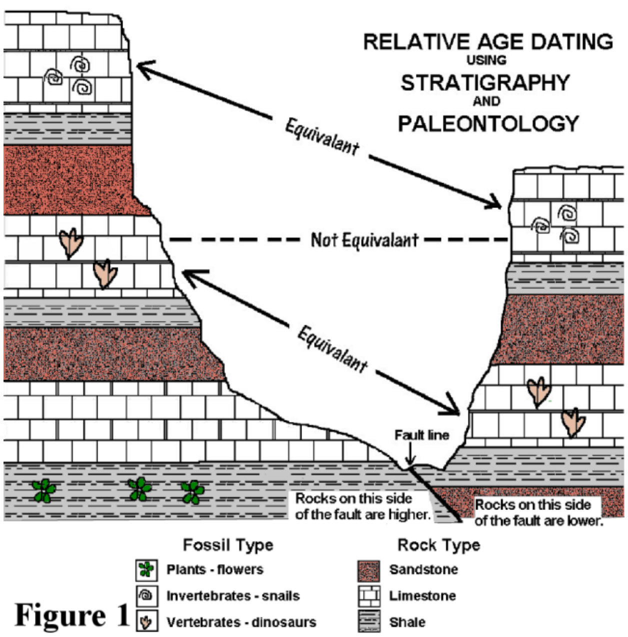

Figure 1

Figure 1 depicts a repeating sequence of deposition found on both sides of a canyon which appear to be equivalent. However, dinosaur fossils in limestone on the left are not in the limestone on the right at the same level. Based on superposition and the fossils' ranges, the dinosaur fossils should not be at the same level as the snail fossils. The right side of the canyon has slid along a fault plane to a position lower relative to the left. That is why the snail fossils on the right side are at the same level as the dinosaur fossils on the left side. Now we know where to look for dinosaur fossils.

Absolute Age Determination or Radiometric dating

Elements or atoms are composed of various combinations of protons, neutrons, electrons, and other particles. An *isotope* is an atom with an imbalance of protons and neutrons. This imbalance causes the mass of the atom to be unstable. Radioactive decay is the process of balancing the mass. Radioactive decay is not a chemical reaction. When an atom experiences radioactive decay, one of two things happen: the atom's composition changes or the atom shifts to a different level of energy. Radioactive decay is the process of changing the original element, parent isotope, to a different element, daughter product. Some isotopes (like uranium) require several stages of decay to finally convert into a stable form (like lead).

A 'half-life' is the amount of time for one-half of the initial parent isotopes to decay into its daughter element. The half-life of Carbon-14 is short and used to measure ages less than 50,000 years old. Table 1 lists some of commonly used isotopes

Table 1

Parent Isotope	Stable Daughter Product	Half-Life Values
Uranium-238	Lead-206	4.5 billion years
Uranium-235	Lead-207	704 million years
Rubidium-87	Strontium-87	48.8 billion years
Potassium-40	Argon-40	1.25 billion years
Carbon-14	Carbon-12 & Carbon-13	5,730 years

used for geologic time-dating.
In the example below, Figure 2, a sample with 40 atoms composed of parent isotopes, left image. After one half-life parent isotopes (20 atoms) account for 50% of the sample. The second half-life leaves 10 parent isotopes of the 40 original isotopes. If the isotope is Urandium-235, the half-life is 704 million years. 704 +704 means 108 million years pass between origin and the second half-life of the sample.

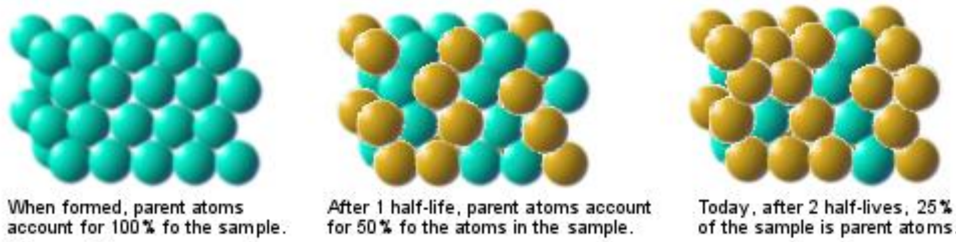

Figure 2

TYING IT ALL TOGETHER
Example: In Figure 3, two stratigraphic units, one in North America, one in Europe both have several layers of volcanic ash. The age of each ash layers are determined by radiometric dating using uranium-235. Age is expressed in units of 1 million years (megaannum or Ma). The ages of the ash layers in this example are identical on both continents for the convenience of explanation.

Fossils found below the 110 Ma layer can only be said to be older than 110 million years. One species of snail, Snail A, lived on both continents before 110 Ma and lived in varying environments based on the rock types containing the fossils.

A different species of snail, Snail B, has a *range* bracketed between 110 Ma and 88 Ma. The 95 Ma ash layer is important maker bed because without it, Snail B could only be said to have evolved somewhere between 110 and 88 Ma. Snail B is found below the 95 Ma layer verifying it evolved sometime between 110 and 95 Ma.

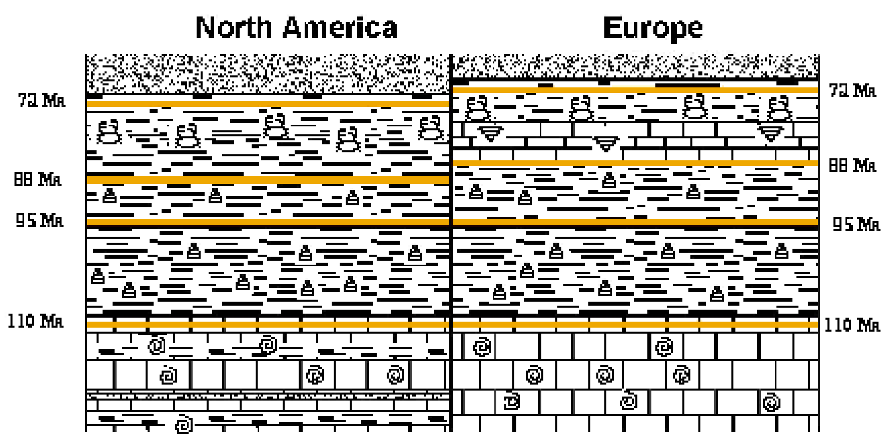

Figure 3 Snail A Snail B Crustacean Micro fossil

Notice a difference between North America (N.A.) and Europe between the 88 to 72 Ma ash layers. In N.A., shale was deposited above 88 Ma, in Europe, limestone was deposited. When shale was deposited in Europe, a species of crustacean identical to the species in N.A. appears. Additionally, the crustacean is found towards the top of the section in N.A. So some unknown amount of time passed before its appearance. Fortunately, a microfossil with a very narrow and know range is found in the European limestone. This type of fossil is termed an *index fossil*. The microfossil's range is from 83 to 79 Ma. Therefore the crustacean evolved after 79 Ma. Now its range is known to be between 79 and 72 Ma.

Reference:
Coch, Nicholas K. and Ludman, Allen, *Physical Geology*, New York, New York, Macmillan Publishing Co., 1991
Wikipedia.com for various confirmations and clarifications. (Accessed Jan. 2011)