

# Radiocarbon Dating:

## Can You Predict Volcanic Eruptions?

### This lecture supports the California Content Standards

#### Grades 9-12 Earth Science Content Standards

"Standards without asterisks represent those that all students are expected to achieve in the course of their studies. Standards with asterisks represent those that all students should have the opportunity to learn."

#### Dynamic Earth Processes

##### **3. Plate tectonics operating over geologic time has changed the patterns of land, sea, and mountains on the Earth's surface.**

As the basis for understanding this concept, students know:

- a. features of the ocean floor (magnetic patterns, age, and sea floor topography) provide evidence for plate tectonics.
- b. the principal structures that form at the three different kinds of plate boundaries.
- c. how to explain the properties of rocks based on the physical and chemical conditions in which they formed, including plate tectonic processes.
- d. why and how earthquakes occur, and the scales used to measure their intensity and magnitude.
- e. two kinds of volcanoes, one with violent eruptions producing steep slopes and the other with voluminous lava flows producing gentle slopes.
- f.\* explanation for the location and properties of volcanoes that are due to hot spots and those that are due to subduction.

#### Biogeochemical cycles

##### **7. Each element on Earth moves among reservoirs in the solid Earth, oceans, atmosphere, and organisms as part of biogeochemical cycles.**

As a basis for understanding this concept, students know:

- a. the carbon cycle of photosynthesis and respiration, and the nitrogen cycle.
- b. the global carbon cycle in terms of the different physical and chemical forms of carbon in the atmosphere, oceans, biomass, and fossil fuels, and the movement of carbon among these reservoirs.
- c. movement of matter among reservoirs is driven by the Earth's internal and external sources of energy.
- d.\* the relative residence times and flows of carbon in and out of its different reservoirs.

#### Structure and Composition of the Atmosphere

##### **8. Life has changed Earth's atmosphere and changes in the atmosphere affect conditions for life.**

As a basis for understanding this concept, students know:

- a. the thermal structure and chemical composition of the atmosphere.
- b. how the composition of the Earth's atmosphere has evolved over geologic time including outgassing, the origin of atmospheric oxygen, and variations in carbon dioxide concentration.
- c. the location of the ozone layer in the upper atmosphere, its role in absorbing ultraviolet radiation and how it varies both naturally and in response to human activities.

#### California Geology

##### **9. The geology of California underlies the state's wealth of natural resources as well as its natural**

### **hazards.**

As a basis for understanding this concept, students know:

- a. the resources of major economic importance in California and their relation to California's geology.
- b. the principal natural hazards in different California regions, and the geological basis of those hazards.
- c. the importance of water to society, the origins of California's fresh water, and the relationship between supply and need.
- d.\* how to analyze published geologic hazard maps of California and use the map information to identify evidence of geological events of the past and predict geological changes in the future.

## **Grades 9-12 Chemistry Content Standards**

### **Atomic and Molecular Structure**

**1. The Periodic Table displays the elements in increasing atomic number and shows how periodicity of the physical and chemical properties of the elements relates to atomic structure.**

As a basis for understanding this concept, students know:

- a. how to relate the position of an element in the Periodic Table to its atomic number and atomic mass.

### **Nuclear Processes**

**11. Nuclear processes are those in which an atomic nucleus changes, including radioactive decay of naturally occurring and man-made isotopes, nuclear fission, and nuclear fusion.**

As a basis for understanding this concept, students know:

- a. protons and neutrons in the nucleus are held together by strong nuclear forces which are stronger than the electromagnetic repulsion between the protons.
- b. the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions: change in mass (calculated by  $E=mc^2$ ) is small but significant in nuclear reactions.
- c. many naturally occurring isotopes of elements are radioactive, as are isotopes formed in nuclear reactions.
- d. the three most common forms of radioactive decay (alpha, beta, gamma) and how the nucleus changes in each type of decay.
- e. alpha, beta, and gamma radiation produce different amounts and kinds of damage in matter and have different penetrations.
- f.\* how to calculate the amount of a radioactive substance remaining after an integral number of half lives have passed.
- g.\* protons and neutrons have substructure and consist of particles called quarks

## **Grades 9-12 Physics Content Standards**

### **Waves**

**4. Waves have characteristic properties that do not depend on the type of wave.**

As a basis for understanding this concept, students know:

- a. waves carry energy from one place to another.
- b. how to identify transverse and longitudinal waves in mechanical media such as springs, ropes, and the Earth (seismic waves).
- c. how to solve problems involving wavelength, frequency, and wave speed.

## **6th Grade Science Content Standards**

### **Focus on Earth Science**

#### **Plate Tectonics and Earth's Structure**

**1. Plate tectonics explains important features of the Earth's surface and major geologic events.**

As the basis for understanding this concept, students know:

- a. the fit of the continents, location of earthquakes, volcanoes, and midocean ridges, and the distribution of fossils, rock types, and ancient climatic zones provide evidence for plate tectonics.
- b. the solid Earth is layered with cold, brittle lithosphere; hot, convecting mantle; and dense, metallic core.
- c. lithospheric plates that are the size of continents and oceans move at rates of centimeters per year in response to movements in the mantle.
- d. earthquakes are sudden motions along breaks in the crust called faults, and volcanoes/fissures are locations where magma reaches the surface.
- e. major geologic events, such as earthquakes, volcanic eruptions, and mountain building result from plate motions.
- f. how to explain major features of California geology in terms of plate tectonics (including mountains, faults, volcanoes).
- g. how to determine the epicenter of an earthquake and that the effects of an earthquake vary with its size, distance from the epicenter, local geology, and the type of construction involved.

### **Shaping the Earth's Surface**

#### **2. Topography is reshaped by weathering of rock and soil and by the transportation and deposition of sediment.**

As the basis for understanding this concept, students know:

- a. water running downhill is the dominant process in shaping the landscape, including California's landscape.
- b. rivers and streams are dynamic systems that erode and transport sediment, change course, and flood their banks in natural and recurring patterns.
- c. beaches are dynamic systems in which sand is supplied by rivers and moved along the coast by wave action.
- d. earthquakes, volcanic eruptions, landslides, and floods change human and wildlife habitats.

### **Grades 9-12 Investigation and Experimentation Standards**

#### **1. Scientific progress is made by asking meaningful questions and conducting careful investigations.**

As a basis for understanding this concept, and to address the content the other four strands, students should develop their own questions and perform investigations.

Students will:

- a. select and use appropriate tools and technology (such as computer-linked probes, spread sheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.
- b. identify and communicate sources of unavoidable experimental error.
- c. identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
- d. formulate explanations using logic and evidence.
- e. solve scientific problems using quadratic equations, and simple trigonometric, exponential, and logarithmic functions.
- f. distinguish between hypothesis and theory as science terms.
- g. recognize the use and limitations of models and theories as scientific representations of reality.
- h. read and interpret topographic and geologic maps.
- i. analyze the locations, sequences, or time intervals of natural phenomena (e.g., relative ages of rocks, locations of planets over time, and succession of species in an ecosystem).
- j. recognize the issues of statistical variability and the need for controlled tests.
- k. recognize the cumulative nature of scientific evidence.
- l. analyze situations and solve problems that require combining and applying concepts from more than one area of science.
- m. investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings. Examples include irradiation of food, cloning of animals by somatic cell nuclear transfer, choice of energy sources, and land and water use decisions in California.
- n. know that when an observation does not agree with an accepted scientific theory, sometimes the

observation is mistaken or fraudulent (e.g., Piltdown Man fossil or unidentified flying objects), and sometimes the theory is wrong (e.g., Ptolemaic model of the movement of the sun, moon and planets).