INVESTIGATION 4

WHAT DOES URANIUM OCCURRENCE AND DISTRIBUTION HAVE TO DO WITH RADON?

INTRODUCTION

There are many factors that influence the behavior and effects of radon. Some are chemical factors; others are physical or biological in nature. Of the *geological* issues and processes that influence radon, the most important is the movement and distribution of uranium beneath the ground surface. Uranium-238 is the ultimate source of most radon found in household air. But uranium is not something that occurs in rocks and just sits there! Over time, geologic processes can cause uranium to move from place to place. A given atom of uranium might be incorporated into several different rock types during its life time. With a half-life of 4.5 billion years, uranium has a long time in which to move around. **In this investigation, you will examine some of the major processes that influence the occurrence, distribution, and movement of uranium within the earth's crust. These processes are fundamental in determining whether or not radon may be a problem in your home.**

OBJECTIVES

To evaluate the ways in which uranium moves through the geologic environment by considering the importance of dissolution, precipitation, and oxidation-reduction reactions.

PROCEDURE

Complete the analyses and questions below.

ANALYSIS

1. When uranium 4^+ (U^{4+}) on a rock surface is oxidized to uranium 6^+, it becomes soluble and can then travel large distances in groundwater. How far it will travel depends on climate (especially amount of rainfall) and permeability of the rocks and soils. What chemical change will make the uranium precipitate back out of solution again as U^{4+}.

2. In the arid southwestern United States, conditions in the rocks and soils are often oxidizing, thus favoring the more oxidized form of uranium (U^{6+}) over the more reduced form (U^{4+}). In contrast to U^{4+}, U^{6+} is highly water soluble. *But*, uranium in the southwest is generally not transported very far from its source rocks underground. Why?

3. The ability of fluids to move through soil or rock is called permeability. Water moves more readily through sandy soil than it does through silt or clay. Soil permeability is the single most important property of *the soil* influencing the movement of radon gas to the ground surface. For layered rocks, like shales and sandstones, permeability is much greater parallel to the lines of layering, rather than perpendicular (at right angles to) the layers. Therefore, permeability (and radon movement in the rock materials), is often in the horizontal plane. When a fracture in the rock is encountered, permeability can shift to the vertical plane, allowing radon gas to move up towards the surface. Examine the illustration in Figure 1. Explain what is happening in this illustration, emphasizing the *processes* involved.

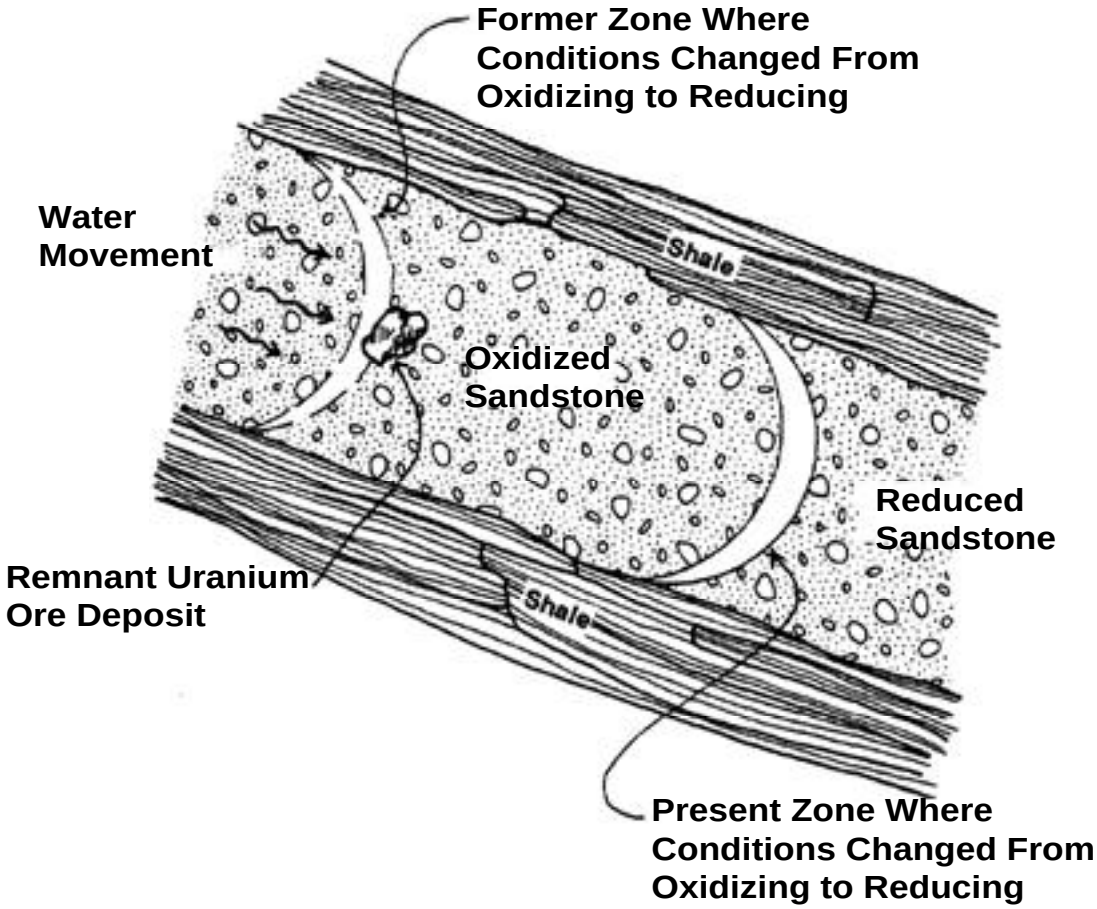

Figure 1. Illustration of the processes that cause the gradual precipitation of uranium out of solution to form a uranium deposit. When the oxidized uranium in solution (U^{6+}) encounters the reducing conditions of the deposit of shale and organic matter, the uranium is reduced to U^{4+}, which is not soluble in water. Over time, more and more uranium precipitates out of solution, eventually forming a rich uranium deposit in the sandstone.

4. House foundations are sometimes built directly on bedrock, and the site is prepared for building by blasting into the bedrock, using dynamite. What effect might this have on radon emanation from the underlying rock materials?

CONCLUSIONS

5. Slightly over five hundred thousand years ago an atom of uranium-238 was transported, far beneath the earth's surface, in a mass of molten rock. It came to rest and became incorporated into granite rock material about two miles west of where your home is now situated. During the subsequent millennia, this atom gradually moved closer to the ground's surface as glaciation and erosion removed some of the overlying materials. At times, it has been dissolved in water; at other times it has been attached to, or incorporated into, several different types of rock. Yesterday, it came up through a fracture in the rocks under your home and made its way into your kitchen, although at that point it was no longer uranium. Early this morning it changed from a gas to a solid state in the air over your bed. Describe in detail how this atom has changed and the major processes responsible for its transformation and movement during the last half million years. You may be creative. There is not just one correct scenario. Your response should emphasize important processes and transformations. (Use additional sheets of paper, as needed.)

6. It is difficult to quantitatively predict radon release from different rocks and soils. The concentrations of uranium and radium in the rocks and soils provide only part of the story. Other factors such as moisture content, permeability, temperature, soil depth, and rock layering all affect radon release (and therefore its possible movement into your home). You have recently been placed in charge of New Jersey's program to identify homes with high radon. How will you use *geological* information in your program?