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The Earth is naturally radioactive, in fact, radioactivity is crucial for the Earth system since the slow decay of radioactive elements, especially uranium, thorium and potassium, produces approximately half of the heat that drives major processes such as continental drift, ocean spreading, plate tectonics and ore deposition. The remaining heat was created by friction generated both as the Earth accreted from space dust and as the core spins. Volcanoes, earthquakes

and large-scale hot springs are processes by which the Earth loses internal heat to the surface.

Natural energy

Radioactive decay helps to produce a temperature gradient beneath our feet, so that at a depth of two kilometres below Southampton the rocks and their pore waters attain a temperature of over 70 degrees centigrade. This geothermal energy has been exploited to help heat

Radioactivity in the environment

The hazards and benefits

by David Holmes



The Strokkur geyser, part of a major geothermal field at Geysir, Iceland, ejects a column of water and steam 30 metres into the air every few minutes. Hot springs help the Earth to lose internal heat to the surface and the geothermal energy may be exploited to heat buildings.

buildings in the city centre since 1986, a pioneering scheme within the UK. During the early history of the Earth there were higher levels of radioactive elements producing more heat. Our planet is cooling, but only very slowly.

Radioactivity and health

Radioactivity is ubiquitous in rocks and soils, and hence in our building materials and homes. Some natural radioactivity presents a hazard. For example, radon gas formed as a naturally occurring decay product of uranium-238 can be a cause of lung cancer, and in the UK it is believed to kill about 3000 people a year. Knowing that radon may be present at a particular location allows the problem to be mitigated through building construction and ventilation.

Uranium itself can be ingested in food and water. Its distribution varies around the UK and, although the levels are low, the health effects remain to be fully appreciated. In some cases uranium can be introduced into the environment through human activity, for instance through the use of depleted uranium for industrial and defence purposes — although in such cases the chemical toxicity of the element poses a greater hazard than its radioactivity.

Where is radioactivity found?

Radionuclides derived from the Earth are found in air, water and soil, in the food we eat and the water we drink and also in our bodies. There is nowhere on Earth that has no natural radioactivity, although some areas are more radioactive than others. Geochemical maps based on the systematic collection and analysis of soils, waters and sediments for the naturally occurring radionuclides (including uranium, potassium and thorium) can be used to demonstrate the variation in natural radioactivity. Maps prepared using airborne radiometric methods are particularly valuable for examining the distribution of man-made isotopes, in the environment, and comparing this against a baseline of natural radioactivity. Not all radioactivity studied at the BGS is from natural sources or has a natural distribution. Some has been produced or relocated by man as part of nuclear power generation, mining or manufacturing. Such material can have an impact on human health and it is important to know where it is in the environment and how it interacts with people.

Radioactive waste management

An important issue in government is to provide the means to ensure the safe management of radioactive wastes. One option being considered is to store, prior to disposal, man-made radioactive wastes underground. Understanding the chemical processes that dissolve and concentrate radioactive elements in rocks can aid the search for suitable locations. For example, the Oklo natural nuclear reactor in Gabon demonstrates the ways in which a nuclear fission reactor was moderated naturally approximately 2000 million years ago,



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Open-cast uranium mine at Oklo, Republic of Gabon. The uranium at Oklo was sufficiently concentrated by natural processes 2000 million years ago for fission reactions to occur. Oklo provides a natural analogue for a very old radioactive waste repository.

and the environmental impacts that resulted. Large uranium ore deposits are of comparable size and concentration to many proposed nuclear-waste facilities and illustrate the behaviour of radioactive waste isolation.

Materials used to package wastes also have analogues in nature. Copper is used to make canisters for high-level waste. Native copper (copper as a metal not an oxide ore) exists at several places in the world, including the south-west of England. Detailed study can reveal information on corrosion rates and how copper reacts in various geochemical environments. Other geological materials, such as clays are used to limit the migration of groundwater into radioactive waste canisters. Our understanding of the behaviour of such minerals is vital in ensuring the continued protection of the environment.

Forensic radioactivity

Radioactive elements decay at a known rate and can act as clocks allowing the dating of rocks and archaeological material. They help in arranging time lines of events that explain the history of both the Earth and life as it evolved. The ratios of radioactive elements can also be an aid in environmental studies as they can define the source of pollutants and track them as they are moved around by water or in the atmosphere.

Working with radioactivity

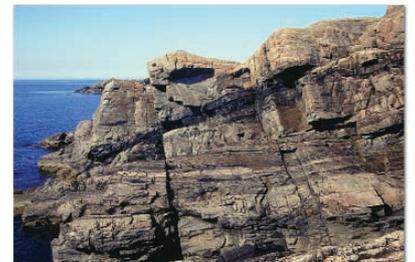
The Survey collects, stores and disposes of rocks, soils and waters that contain radioactivity. All material is assessed and handled within a licensed regulatory framework to protect the staff and public. Recently, after a review, we have significantly reduced our holding of radioactive material to minimise any risks to health. We are also constructing a handling facility that will assess all incoming material for chemical, biological and radioactive hazard prior to it entering any laboratory or workspace. This facility will be available to other researchers.

Radioactivity in the environment impacts on people in many ways. The BGS holds large amounts of data that are useful in understanding how it got there, where it may move to, and how it can affect human health. However, this understanding needs to be improved. The organisation will continue to research all these issues and provide impartial advice to the nation. ■

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Native copper. The study of natural copper deposits in south-west England is providing information on the potential longevity of high-level radioactive waste canisters.



Banded and folded Lewisian gneiss, Scourie Moor, north-west Scotland. The decay of radioactive elements allows ancient rocks such as these to be dated with a high degree of confidence. Lewisian gneiss is one of Britain's oldest rocks and has been dated as about 2700 million years old.

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