

“ uranium has unique properties that have had a profound influence, not just on modern human civilisation, but on the evolution of the Earth itself ”

Uranium, the heaviest naturally occurring element in the Earth, is radioactive with two long-lived isotopes uranium-235/uranium-238. These were created in the early stages of our solar system and the global inventory of uranium-235/uranium-238 has been around for the full 4500 million years since our planet formed. This element has unique chemical and nuclear properties that, in spite of its low abundance in nature (much less than one part per million of the Earth), mean it has had a

a host of medical studies that uranium is a chemically toxic heavy metal, and that its radioactivity, though unavoidable, is not beneficial. There appears to be no benefit, however small, in the exposure of humans to uranium. This contrasts with a number of other trace metals that play a critical, carefully balanced role in our metabolism. Uranium is, of course, widely known for its pivotal role as the primary source of fissionable nuclear fuel and for the fissionable components in some atomic weapons. More recently,

The paradox of uranium

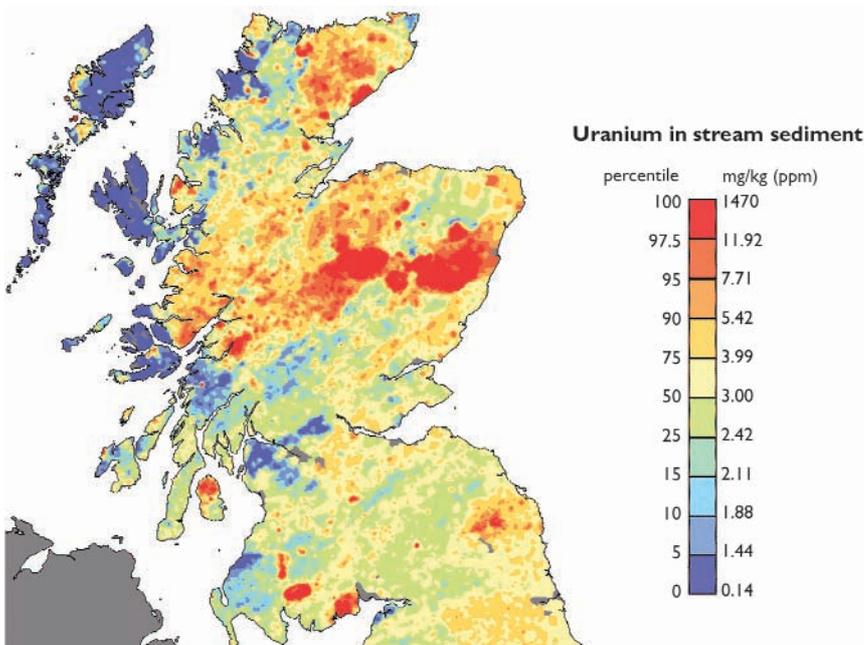
A hazard to human health, yet fundamental to the development of our planet

by Randall Parrish

profound influence not just on modern human civilisation, but on the evolution of the planet itself. The importance of uranium to the evolution of our planet has been widely underappreciated. It is reasonably well established through

it has been used in munitions as a heavy armour penetrator deemed essential by some military authorities as an effective weapon. However, its use in all of these applications has the potential to lead to wide-ranging chemical and radiological pollution.

In modern western society, the use of uranium-related materials is highly restricted. At the same time, decisions have been made that the use of uranium for various purposes outweighs the environmental and health risks when conducted in a regulated context. These benefits, of course, include its contribution to electrical energy generation, potentially providing a very long-term source of energy as a partial substitute for fossil fuels while reducing carbon dioxide emissions. There is much ongoing debate, both in Britain and elsewhere, about the virtues and problems the long-term use of uranium for peaceful and



Uranium exists all around us in the environment. This map shows the uranium content of stream sediments from northern England and Scotland, from the G-BASE geochemical database; warmer colours indicate higher concentrations.



military applications. In particular, the use of depleted uranium munitions in recent conflicts in Iraq is alleged to have caused illness in soldiers and civilians.

Given the magnitude of potential long-term effects on the environment, it is understandable that many people wish to see the use of uranium end. But, the paradox is that this planet would probably be unrecognisable to us if uranium did not exist and, try as we may, we cannot avoid uranium because it is everywhere, naturally, in the air we breathe and the food and water we consume.

All living things through the eons of geological time have benefited from a dynamic Earth rejuvenated by the formation of mountains and deep oceans. New habitats and niches for evolving organisms to occupy have been created, and the climate of the planet has been modified through changes in oceanic and atmospheric chemistry and global topography. You might ask what drives these rather fundamental processes. The simple answer is the internal heat of the Earth — driven primarily by the continuing heat given off as a result of the radioactive decay of uranium. While small in comparison with the Sun's warmth, it is nonetheless the single most important catalyst of our dynamic Earth.

Uranium has, since the Earth formed, provided more than 60% of the planet's internal source of heat (with thorium-232 and potassium-40 providing the balance).

Without radioactivity, it is unlikely that we would have any sea-floor spreading on the modern Earth. There would be no volcanism, no shifting continents, no ore deposits, and the planet would have a fairly

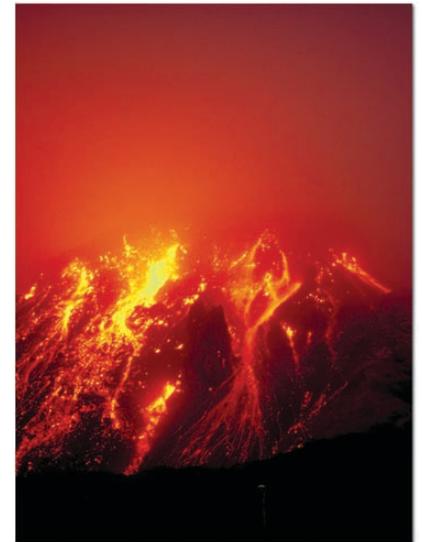


The dynamic Earth: actively changing oceans, topography, volcanism (red dots), and plate movements (plate boundaries shown in yellow), are all driven and influenced by the heat derived from radioactive decay.

uninteresting history probably like that of Mars or the Moon in terms of its internal workings. The cycles of life-supporting elements like carbon, sulphur, and hydrogen would also be strikingly different. The main processes shaping the Earth would likely be wind, rain, and ice-rafting. Periodic ice caps floating on shallow seas would cover a nearly uniform featureless sea floor comprising very old sedimentary layers upon an even older differentiated crustal layer. The terrestrial Earth may never have existed, with life being restricted to the oceans and the atmosphere. A hot spring would have been a rare thing indeed — in a word, an entirely different world than we live on and coexist with. These are good reasons to be thankful that uranium does in fact exist.

The other lasting legacy of uranium is its key to the chronology of Earth history. The uranium decay scheme, with its stable daughter decay products lead-206/lead-207, has allowed geologists to determine the age of rocks and minerals to amazing precision, with uncertainties of as little as several hundred thousand years in rocks more than 3000 million years old. With fossils unavailable, the uranium-lead dating scheme in minerals such as zircon has been the key that has unlocked the colourful and complex dynamic history of the Precambrian Earth. In addition to these insights in older rocks, one of the minor, more short-lived isotopes of uranium, uranium-234 (itself a decay product of uranium-238), has been exploited as one of the most robust and precise methods of dating late Quaternary materials. Analysis of the isotopic composition of coral, calcareous fossils, and speleothems has allowed the intricacies of sea-level fluctuation and glacial cycles driven by climate change to be reconstructed. The insights that these and other (i.e. rubidium-87/potassium-40/neodymium-147) radioactive chronometers have given us into dynamic Earth processes enrich our knowledge and stimulate imaginations.

So, as with most important and valuable things, the same applies to uranium: understand it well, use it wisely, learn to live with and manage its risks, and appreciate both its practical and its intangible benefits. ■



Soufrière Hills Volcano, Montserrat, an example of active magmatic processes driven by heat from the radioactive decay in the Earth.

This image is a product of the DFID programme of work carried out in Montserrat by the BGS.

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