

Depleted uranium

Its hazards and uses

by Barry Smith, *Keyworth*

As a survey organisation responsible for the identification of mineral resources, the BGS has always been involved in studying the occurrence and natural distribution of uranium and its associated minerals. In the early parts of the twentieth century exploration primarily focused on the use of uranium as a pigment in glass and ceramics manufacture, whilst for the past 60 years the focus has shifted towards its use as a source of nuclear energy. The need for uranium resources and its presence in wastes associated with the nuclear fuel cycle has resulted in the BGS undertaking a number of scientific studies on behalf of both the regulator and nuclear power industries to investigate the environmental behaviour of this heavy element. As a result of such studies, and our experience in undertaking studies in the area of environment and health, the

BGS was commissioned by the World Health Organisation (WHO) and the Royal Society to undertake two separate reviews on the hazards associated with depleted uranium.

Naturally occurring uranium is found in virtually all rocks, soils and waters in the Earth's surface and near-surface environment. It contains several isotopes, mainly uranium-238, uranium-235 and uranium-234. For its use as a nuclear fuel such uranium must be enriched in ^{235}U to promote and maintain a nuclear chain reaction. During the enrichment process, the unwanted isotopes of uranium (^{238}U) are removed, producing as a by-product a form of uranium depleted in ^{235}U . Naturally occurring uranium is typically 0.7% ^{235}U whilst depleted uranium is typically less than 0.2% ^{235}U . The removal of a large proportion of the more radioactive ^{235}U also means that depleted uranium is significantly less radioactive (by at least a factor of two) than either uranium ore as removed from the ground, or chemically purified natural uranium. The chemical and biological behaviour of depleted uranium is identical to that of natural uranium so studies on the latter can inform us about the behaviour of the former.

As a by-product, depleted uranium has been produced in large quantities and stockpiled by the nuclear fuel industry who have sought to find useful end products for this material. Initially it was felt that depleted uranium could be used in fast breeder reactors to produce other fissile elements such as plutonium. These could then be used to increase feedstocks for the continued production of nuclear power, given a potential shortage of natural uranium ore. Despite the successful demonstration of such processes, the expected proliferation of nuclear energy has not happened and, at the same time, larger reserves of uranium ore have become available. The use of depleted uranium by the nuclear industry has therefore been restricted to its use as a shielding agent, which utilises its high density and relatively low radioactivity, in fuel canisters, shipping containers for radioactive sources, and as collimators in equipment used in nuclear medicine. Elsewhere, depleted uranium has been used as a counterweight in aircraft and in both an offensive and defensive capacity in warfare.

When alloyed with a small amount of titanium, depleted uranium produces extremely effective armour-piercing warheads and protective armour. Whilst such materials have been developed since the 1970s, their first reported major use under battlefield conditions was in the Gulf War and later in the Balkans conflicts. It is now believed that more than ten countries possess depleted uranium weapons systems. In the manufacturing processes and during deployment, controls are such that the hazards to the workforce or military personnel are minimised by stringent controls. However, when used in military conflict or testing, depleted uranium can become more widely dispersed resulting in an increased potential risk to the environment and human health.

Like many heavy metals the toxicity of uranium to humans has been widely studied. However, unlike metals such as cadmium, exposure to uranium may also result in health effects due to the presence of its inherent radioactivity. In both cases exposure must occur to a receptor (e.g. groundwater, human, ecosystem) before any resultant risk may be quantified. Because of this, it is important to consider scenarios in which exposure to depleted uranium may occur and their relative importance.



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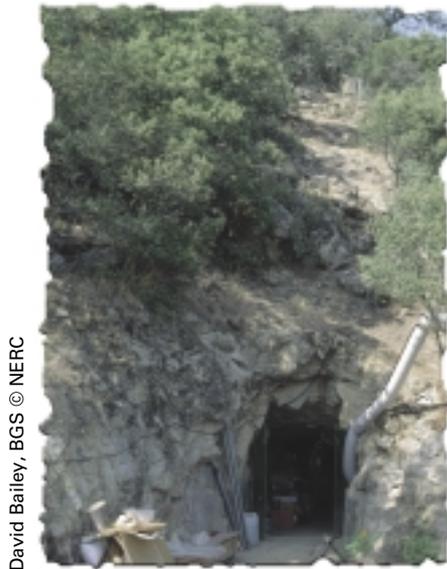
Sampling wells for natural radioactivity in Amman, Jordan.

In the case of military conflicts, the most likely exposure routes are to those actually present in the immediate vicinity of a projectile strike. Obviously such people also face the immediate risks associated with the kinetic impact of the weapon and any resulting fires or explosions. Apart from such extreme situations those likely to be exposed include rescue workers and field staff associated with the clean-up and decommissioning of vehicles and sites attacked by depleted uranium weapons, and any local members of the population re-entering the war zone. In all such cases the main potential exposure routes are related to the inhalation or ingestion of uranium-rich dusts produced by the projectiles' impact. On a longer time scale (e.g. tens to thousands of years) uranium from such dusts or fragments of projectiles may become locally dispersed into the environment and as a result contaminate foodstuffs and drinking-waters. The magnitude of any such contamination depends largely upon the intensity of the military action and the amount of dust produced from each projectile, which is a function of the hardness of the impacted material and the energy of impact.

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To understand the effects of depleted uranium on human health much reliance has to be placed upon extrapolating the results of experiments performed using natural uranium on animals. This is because of the wide number of potential confounding factors, and low statistical power associated with epidemiological studies of chronic human exposures. Similarly, studies of acute exposure may not reflect longer-term effects. Most notable is the negative effect of uranium on kidney function. This is common for many heavy metals and is not unique or particularly enhanced in the case of uranium, indeed it is considered in such circumstances to be less toxic to the kidney than, for example, mercury. Other effects have been noted but are either far less studied than those on the kidney or have been only noted during unrealistically high exposures. In the

case of depleted uranium, such studies have been also undertaken on animals and humans beings, in which fragments have become embedded in body tissues. Interestingly, in such experiments



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An abandoned uranium mine at El Berrocal, Spain, the site of an international collaborative study funded by the EU, on the transport and behaviour of naturally occurring uranium in groundwater.

damage to kidney function has not generally been observed. Despite this, both the WHO and American Agency for Toxic Substances and Disease Registry (ATSDR) have placed very restrictive limits on the amount of uranium that should be ingested per day.

The biological effects of a radioactive material depend to an extent on the nature of the radiation, its intensity, and its location amongst various body tissues. In the case of depleted uranium, studies have clearly demonstrated that the only route of exposure by which significant radiological doses may be observed is through the inhalation of insoluble uranium particulates into the lung. It is therefore perhaps fortuitous that experimental evidence points to particulate materials from projectile strikes being relatively soluble in body fluids. At exposure levels consistent with limits based on the chemical toxicity of uranium, the influence of radiological issues has again been estimated to be relatively small.

In either case if exposure to depleted uranium has occurred there is relatively little that can be done as elimination of uranium from the body is in itself relatively rapid, with only a small proportion of uranium being retained in the body (principally in bone). Extraction from the body with complexing agents such as EDTA have been tried but shown to be relatively unsuccessful and may be more harmful than the effects of uranium itself.

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Currently a wide range of both environmental and health-related studies have been undertaken in the Balkans by teams from UNEP; very few studies have been undertaken in Iraq, because of the political situation. Ongoing studies are being undertaken by the military to investigate risks posed by the use and proving of depleted uranium munitions in the USA and UK. It is likely that current and future studies will involve screening of the local population and combatants for depleted uranium through the analysis of urine; a more extensive epidemiological study of health outcomes of potential exposed combatants and the local populations; and the monitoring of local food, house dusts, and drinking-water supplies.

References/further reading:

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