

The corrosion of depleted uranium penetrators in grassland soils

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Depleted uranium (DU) is a by-product of nuclear fuel enrichment and is used in anti-tank penetrators due to its high density, self-sharpening and pyrophoric properties. Military activities have left a legacy of DU waste in the terrestrial environment and, to understand its fate, the mechanisms of corrosion and controlling factors need to be determined.

Laboratory microcosm experiments were designed to investigate the mechanism of DU corrosion in field moist and progressively anoxic waterlogged grassland soil. Microcosms were sacrificed in triplicate over a period of 500 days, and the redox indicators NO_3^- , Fe(II) and SO_4^{2-} , and dissolved and colloidal U concentrations were determined. Soil Phosphor images mapped "hot" particles for analysis by scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX) and X-ray diffraction (XRD). Ribosomal intergenic spacer analysis indicated changes in the microbial community profile.

The water content and biogeochemistry of the soil had a marked effect on the corrosion rate of DU. Corrosion was 40 times faster under field moist conditions than in waterlogged soils, thus complete corrosion of a 120 mm Charm penetrator was calculated to take 90 and 3900 years, respectively.

In the field moist soils, there was initial resistance to corrosion due to a protective uraninite (UO_2) layer, and corrosion accelerated once initial pits formed. This corrosion caused significant changes in the local biogeochemical environment with total depletion of soil NO_3^- and detection of Fe(II). Some of the protruding loosely bound yellow/black corrosion products detached and dispersed into the surrounding soil. SEM-EDX analysis of these particles indicated that they were discrete U oxides, having limited interaction with the soil matrix. XRD analysis suggested that the corrosion products were amorphous oxides such as metaschoepite ($\text{UO}_3 \cdot 2\text{H}_2\text{O}$).

In the waterlogged soils, sparse, shallow crevice-shaped corrosion pits were observed. The biogeochemical environment was important; corrosion was inhibited during O_2^- , Fe(III)- and SO_4^{2-} -reduction, and significant corrosion occurred during NO_3^- -reduction. Through comparison with controls, the presence of the corroding DU increased the rate of progression through the redox cascade (O_2 , NO_3^- , Fe^{3+} , SO_4^{2-}) and changed the microbial community profile.

Distribution of PGE in the layered mafic Dufek Intrusion, Antarctica

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Selected samples from the Dufek Intrusion (Antarctica), the only layered mafic intrusion known within the Jurassic Ferrar large igneous province, have been analysed for platinum-group elements (PGE: Ir, Ru, Rh, Pt and Pd) to investigate the PGE distribution within the exposed ~ 3.5 km thick stratigraphic profile for understanding their fractionation behaviour during low-pressure magma evolution.

Samples analysed to date comprise variably composed gabbroic rocks, anorthosites, pyroxenites and magnetites from both the Dufek Massif and the Forrestal Range (FR) sections, the latter of which is interpreted as representing the upper ~ 1.7 km of the intrusion. Considering the petrographical and geochemical variability, the analysed rocks also show widely varying, lithologically-related PGE compositions with totals ranging from 5 to 792 parts per billion. In nearly all samples, the PGE totals are dominated by Pt-PGE with Ir-PGE often being near or below limits of detection indicating the marked fractionation between the individual PGE.

The highest PGE amounts were determined in magnetite-dominated gabbros and magnetites within the basal ~ 300 m of the FR section; this is a layered sequence of gabbros and anorthosites that contains the most prominent magnetite accumulation observed so far within the Dufek Intrusion in thin layers, laminae and lenses. However, these magnetite-rich rocks exhibit strongly variable PGE totals and ratios, which generally do not correlate with sulphide contents or S and Cu concentrations. The lack of considerable amounts of sulphides and distinct trace element correlations in most of these samples indicate that their PGE composition was not controlled solely by base metal sulphides but by a variety of PGE-bearing phases such as alloys and other platinum-group minerals. Thus, various processes (both high-temperature and subsolidus) leading to the present PGE distribution within the stratigraphic profile of the Dufek Intrusion have to be considered as well.

Analyses of additional samples will gain further information in order to understand the fractionation behaviour of PGE in mafic melts that are derived from melting of a subcontinental lithospheric mantle enriched in crustal fluids.