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The geological and microbiological controls on the enrichment of Se and Te in sedimentary rocks

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Selenium (Se) and tellurium (Te) have become elements of high interest, mainly due to their photovoltaic and photoconductive properties, and can contaminate local soils and groundwater systems during mobilisation. Due to their economic and environmental significance, it is important to understand the processes that lead to Se- and Te-enrichment in sediments. The distribution of Se and Te in sedimentary environments is primarily a function of redox conditions, and may be transported and concentrated by the movement of reduced fluids through oxidised strata. Se and Te concentrations have been measured in a suite of late Neoproterozoic Gwna Group black shales (UK) and uranium red bed (roll-front) samples (USA). Due to the chemical affinity of Se and sulphur (S), variations in the S isotopic composition of pyrite have also been measured in order to provide insights into their origin.
Scanning electron microscopy of pyrite in the black shales shows abundant inclusions of the lead selenide mineral clausthalite. The data for the black shale samples show marked enrichment in Te and Se relative to crustal mean and several hundreds of other samples processed through our laboratory. While Se levels in sulphidic black shales are typically below 5 ppm, the measured values of up to 116 ppm are remarkable. The Se enrichment in roll-fronts (up to 168 ppm) is restricted to a narrow band of alteration at the interface between the barren oxidised core, and the highly mineralised reduced nose of the front. Te is depleted in roll-fronts with respect to the continental crust and other geological settings and deposits. S isotope compositions for pyrite in both the black shales and roll-fronts are very light and indicate precipitation by microbial sulphate reduction, suggesting that Se was microbially sequestered. Results show that Gwna Group black shales and U.S roll-front deposits contain marked elemental enrichments (particularly Se content). In Gwna Group black shales, Se and Te were sequestered out of seawater into pyritic shales at a higher rate than into crusts. Se enrichment in roll-fronts relates to the initial mobilisation of trace elements in oxidised conditions, and later precipitation downgradient in reduced conditions.
Results highlight the potential for sedimentary types of Se- and Te-bearing deposits. The enrichment of elements of high value for future technologies in sedimentary rocks deserve careful assessment for potential future resources, and should be monitored during exploration and mobilisation due to the potential contamination effects. This work forms part of the NERC-funded ‘Security of Supply of Mineral Resources’ project, which aims to detail the science needed to sustain the security of supply of strategic minerals in a changing environment.