

Isotope geochemistry of tellurium: Adsorption and reduction of tellurium oxyanions

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Project Description:

Despite being one of the rarest of the elements on Earth, new and emerging applications of tellurium (Te) in the electronic industry (e.g., optical data storage systems, CdTe photovoltaic modules), in thermoelectric cooling devices, in metallurgy, in various chemicals, pigments, catalysts and rubber compounding agents, have raised the demand for Te in last few decades¹. This increased use will have significant effect on the redistribution and biogeochemical cycling of Te in the environment. For example, landfilling of CdTe photovoltaics may lead to release of Te in the environment. However, little is currently known about the fate of Te in the environment.

The oxidation state of Te controls its solubility and environmental mobility. At near-neutral pH, Te-oxyanions are highly soluble and thus mobile, while reduced Te species are insoluble. Reduction of Te-oxyanions is therefore a promising remediation strategy for Te. In addition, adsorption of Te oxyanions on to minerals (e.g., HFO, MnO₂) immobilizes Te. Stable isotopes of Te may be used to understand these immobilization mechanisms and Te cycling in the environments^{2,3}. This requires a robust understanding of Te isotope systematics during redox reactions and adsorption. Previous work on Te isotopic fractionation is sparse and only a single study has yet been performed on Te isotopic fractionation during reduction of Te oxyanions by microorganisms and abiotic agents². The proposed research will experimentally determine the magnitudes Te isotope fractionation during adsorption of Te various minerals (e.g., HFO, MnO₂), abiotic and microbially mediated redox reactions. This requires development of new analytical techniques in purification chemistry and high precision measurement of Te stable isotopes.

The findings will enhance our understanding of biogeochemical Te cycle, provide a framework for the development of Te isotope systematics in natural environments like mining sites and other contaminated areas, and help design effective remediation strategies for contamination. The results will also help establish Te isotope ratios in geologic samples as paleo-redox proxies.

References:

- (1) Kavlak, G.; Graedel, T. E. Global anthropogenic tellurium cycles for 1940–2010. *Resources, Conservation & Recycling* **2013**, *76*, 21–26.
- (2) Baesman, S. M.; Bullen, T. D.; Dewald, J.; Zhang, D.; Curran, S.; Islam, F. S.; Beveridge, T. J.; Oremland, R. S. Formation of Tellurium Nanocrystals during Anaerobic Growth of Bacteria That Use Te Oxyanions as Respiratory Electron Acceptors. *Applied and Environmental Microbiology* **2007**, *73* (7), 2135–2143.
- (3) Fornadel, A. P.; Spry, P. G.; Haghnegahdar, M. A.; Schauble, E. A.; Jackson, S. E.; Mills, S. J. Stable Te isotope fractionation in tellurium-bearing minerals from precious metal hydrothermal ore deposits. *Geochimica et Cosmochimica Acta* **2017**, *202*, 215–230.

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