Learning from 1 billion year old copper

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In Canada, the Nuclear Waste Management Organization (NWMO) is responsible for the long-term management of spent nuclear fuel, which involves sealing used fuel bundles in copper-coated carbon steel used fuel containers (UFC) and emplacing them ~500 m underground in a deep geological repository (DGR). In this plan, copper plays a vital role in ensuring the safety of the DGR as it is intended to serve as a corrosion barrier for greater than one million years. Veins and pods of natural copper have long been known to occur in the Lake Superior region of North America where they have been culturally significant to Indigenous peoples for millennia. The natural Lake Superior copper deposits were emplaced close to one billion years ago in lithosphere which has since had a protracted history of glacial overrides and related isostatic adjustment events. In light of this longevity, structural history and exposure to crustal fluids, it has the potential to hold many lessons for DGR specialists and society in general. We present two aspects of our approach. The first is an outline of our efforts to increase cultural competency of non-indigenous scientists in our group while building an understanding of the Indigenous Knowledge system and how it can be respectfully and effectively applied to research. This includes respectful ways in which to collect, and learn from, copper samples. This work directly relates to the important relationships in the context of the NWMO Indigenous Knowledge policy, Reconciliation policy and how both policies apply to the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). In this context we will also present our early field and laboratory observations of natural copper properties through an integrated analysis of chemical and orientation microstructure in tandem with electrochemical behaviour. Techniques in the laboratory workflow include electron microscopy (EDS, EBSD) and atom probe tomography to map impurities and microstructure relative to manufactured wrought copper (phosphorus-doped oxygen free); Auger electron and X-ray photoelectron spectroscopies to determine surface and near-surface composition and chemical environment; and electrochemical methods such as corrosion potential measurements and potentiodynamic polarization scans to probe the corrosion performance. These measurements may inform container design aspects such as optimal fabrication and the role of impurities in corrosion behaviour of electrodeposited and cold spray-deposited copper in a DGR over geological timescales. Taken together, our aim is to come to an appropriately comprehensive understanding of the cultural, geological and material corrosion aspects of natural copper that has
persisted for a time span three orders of magnitude greater than the DGR design requirements. It is our hope that this learning approach to ancient natural copper will play a positive role in seeking social license for DGR planning, while having value for societal education in the global challenge of geostorage.