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Predicting metal mobilisation during CO_2 storage: the role of synchrotron XFM

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During geological storage of CO_2 several processes can potentially mobilise or sequester metals to or from groundwater. In lab and field experiments, metal release has been assumed to be from mineral dissolution, or Ca-induced ion exchange. However, improved predictive geochemical models are needed, especially when injecting into low salinity aquifers, or if CO_2 leaks to overlying drinking water aquifers. Identifying the minerals that host specific metals result in improved predictions e.g., if they are hosted in labile carbonates, metals may be more of a concern than if hosted in silicate grains or sulphides. Sandstone reservoir and cap-rock cores of differing lithologies from a low salinity CO_2 storage site were characterised using SEM-EDS, QEMSCAN and XRD. In experiments at reservoir conditions, with pure or impure CO_2, dissolved Mn was correlated with Ca where calcite was present, or with Fe from quartzose cores. Other released metal correlations were also rock mineralogy dependent with Zn, and Co weakly to moderately correlated with Ca, Si, or Fe especially on impure CO_2 reaction. Hence, metals were present in the cores but had several potential sources which were fine-grained or mixed necessitating a high resolution technique. X-ray fluorescence microscopy was performed on the XFM beamline at the Australian Synchrotron, Victoria, Australia, on 6 core thin sections to produce high resolution metal maps. Calcite cemented cap-rock, for example, hosted Mn in the calcite, and Co in Fe-rich silicates (including chlorite, mica) and sulphide. Increasing scan dwell times showed no As, Pb, Cr, Zn, or Ni in the calcite cement. Very small amounts were instead associated with mainly pyrite and sphalerite. This favourably suggests that if CO_2 dissolves the calcite cement it is unlikely that significant concentrations of metals would be released, except Mn. The next step is building specific metal hosting mineral scripts for predictive models, and XFM of precipitated material to see if metals are subsequently sequestered. This could lead to engineered remediation strategies. These techniques are applicable to understanding metal mobilisation controls during hydraulic stimulation of shales and coal, or water reinjection for aquifer recharge or geothermal energy.