Predictive Bayesian models for risk modeling of geologic carbon capture and storage leaks using natural analogues

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Modelling the risks of geologic carbon capture and storage (GCCS) involves many conceptual and quantitative uncertainties. In the development of subsurface carbon dioxide (CO_2) injection as a large-scale greenhouse gas solution, the ability to quantify its uncertainties and risks will play a key role. Published GCCS risk analyses have been based on failure mode and effects analysis, fault-tree analyses, and sensitivity analysis. [1] These analyses have been useful in characterizing risks, but have not yielded quantitative information on the likelihood of a leakage or spill occurring.

Leaked CO_2 is difficult to locate and quantify because monitoring techniques are not widely deployed. Moreover, the released CO_2 may be transported, sequestered or diluted based weather patterns and surrounding ecosystems. Changes in barometric pressure, temperature, and make deterministic fate models nearly impossible to deploy since even the presence of CO_2 is difficult to assess. With GCCS, it will be impractical and impossible to collect comprehensive empirical data regarding geologic reservoir leaks. There is a clear need to introduce statistical technique that integrates limited available data with stochastic modelling. Predictive Bayesian statistical techniques have been developed and demonstrated for exploiting limited information for decision support in many other applications, this paper will adapt and apply them to GCCS. [2]

Natural subsurface CO_2 deposits provide a reasonable analogue for the migration pathways and surface leakage scenarios encountered with GCCS. This paper is concentrated on the development of the conceptual predictive Bayesian model based on theory and literature review. This paper will present predictive leakage scenarios modelled on historic natural subsurface CO_2 leakage data collected from national and international databases.

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Sulphides and Ti-Minerals in granulite xenoliths: Tracers of cratonic crust formation

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The trace-element composition of the common accessory minerals in granulites - sulphides (sf), rutile (rt) and ilmenite (ilm) - contains important petrogenetic information regarding the formation and evolution of the continental crust (CC) [1]. Eclogitic rt and ilm are significant hosts to many high field-strength elements (HFSE), but show contrasting partitioning and therefore fractionate geochemically diagnostic trace-element pairs, such as U-Th, Nb-Ta, Zr-Hf, W-Mo and W-Hf [2,3]. Some of the HFSE (e.g. Cr, Co, Sn, Sb, Mo, W) are chalcophile and siderophile elements (CSE), which are measurable in sulphides. A reconnaissance LAM-ICPMS study of Ti-minerals and sf in four mafic granulite xenoliths (MGX) from the Diavik kimberlites of the central Slave craton (Canada) broadly confirms experimental trace-element systematics - with interesting exceptions - and shows that sf strongly partitions Ni, Co, As and Sb, whereas W, Sn ± Mo concentrate in rt, and Cr, Zn, Ga favour ilm.

Bulk-rock CSE abundances, calculated from concentrations in MGX sf, rt and ilm weighted by modes, balance the abundances of W and Pb in CC [4], but show large excesses for Ni, Cr, Co, Sn, Mo, Sb and As. This suggests a cumulate origin for the MGX and enrichment by (seawater?) fluids. Sf- and rt- ± ilm-saturated melting of such lower CC should generate melts depleted in these elements. Since this is not observed in the upper CC [4], upper CC is probably not related to lower CC by igneous processes.

Segregation of sf-bearing cumulates in the lower CC was recently proposed to explain Cu depletion in the upper CC [5]. Sf in MGX have trace-element concentrations within the range of sf inclusions in diamonds from meta-gabbroic source rocks, which have been shown to control Cu, Se, Te, Mo, Re and PGE in the bulk rock [5]. Since only Cu and Se show complementary depletions in CC, the processes generating the crustal CSE pattern must be more complex.

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