Resolving the baseline isotopic fingerprints of Carbon Dioxide (CO$_2$) and Methane (CH$_4$) at Carbon Management Canada Research Institutes Field Research Station, Canada

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Abstract

Carbon capture and storage, at the commercial scale, has the ability to mitigate and directly reduce atmospheric anthropogenic CO$_2$ emissions resulting from the combustion of fossil fuels. Despite considerable research and demonstration of the technologies involved, concerns still exist over the ability to accurately monitor the migration of CO$_2$ injected into the subsurface for storage.

In this study, we aim to assess the viability of using the inherent isotopic compositions of industrially sourced CO$_2$ to monitor the fate and migration of CO$_2$ injected for storage. Determining the isotopic fingerprints contained in both the innate reservoir fluids and the injected CO$_2$, would allow for a better understanding of the processes that can change the geochemical fingerprint of CO$_2$ during injection, storage and any subsequent migration. This will then establish the effectiveness of using inherent isotopic fingerprints as tracers.

The Carbon Management Canada Research Institute, in collaboration with the University of Calgary, have developed a purpose built Field Research Station (FRS) near Brooks, Alberta. The FRS allows for the controlled, shallow, subsurface release of industrially sourced CO$_2$, which will enable a large-scale study of how CO$_2$ behaves if it migrates from a storage site at depth. CO$_2$ will be injected into a predominantly water filled, sandstone formation at a depth of 300m. A range of geophysical and geochemical monitoring techniques are being carried out via two wells to monitor for CO$_2$ breakthrough, and for evidence of increased gas migration at the surface from either CO$_2$ or methane.

In order to further understand the geochemical profile of the site, baseline samples were collected prior to CO$_2$ injection from injection, monitoring and water wells in November 2016, March 2017 and July 2017. Methane and water samples have been analysed for their stable and noble gas isotopic signatures.

Noble gases have been previously demonstrated to be useful tracers in studying the origin of gases within the subsurface, due to their inert nature. Whilst they exhibit no changes in their isotopic
compositions via chemical processes, they can alter their elemental and isotopic compositions through physical processes, and therefore can be used to effectively trace any changes.

Noble gases are more soluble in methane than in water, and initial baseline results from FRS data has shown $^{20}\text{Ne}$ and $^{36}\text{Ar}$ concentrations of below Air Saturated Water due to gas stripping - the preferential removal of atmospheric $^{20}\text{Ne}$ and $^{36}\text{Ar}$ from groundwater into methane. Stable isotopic data derived from methane, shows $\delta^{13}\text{C}$ indicative of a biogenic origin, in agreement with published data obtained during drilling. Comparisons of isotopic data obtained from the three sampling windows will be undertaken to identify any seasonal variations to baseline conditions, due to the wide range of annual mean temperatures (-11.3 to 18.3 °C).

Through the establishment of baseline gas and water fingerprints at the FRS, our objective is to identify any isotopic changes induced through the injection of $\text{CO}_2$. In turn, this work may provide new and additional information to the global problem of accountability of carbon capture and storage security and deliver a cost-effective site monitoring technology.

Word Count (505)