

## Peer Review Report

# Review Report on Multi-isotope geochemical baseline study of the Carbon Management Canada Research Institutes CCS Field Research Station (Alberta, Canada), prior to CO<sub>2</sub> injection

Original Research, Earth Sci. Syst. Soc.

Reviewer: Stephanie Flude

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### EVALUATION

#### **Q 1** Please summarize the main findings of the study.

This study carries out an important baseline geochemistry survey of a CO<sub>2</sub> storage field-test site. It not only documents the baseline conditions which will be valuable for all future work in the area, but it also identifies which inherent geochemical tracers will be useful for monitoring CO<sub>2</sub> breakthrough and leakage once injection starts

#### **Q 2** Please highlight the limitations and strengths.

The study is well-written, and comprehensive. It is an excellent example of how future CO<sub>2</sub> storage project baseline monitoring studies should be conducted. While every storage site will be different and the monitoring tools proposed for this site may not be relevant elsewhere, it adequately illustrates the logical processes that should be explored when choosing which tracers to employ and will provide inspiration for future monitoring projects. This work achieves its own aims and objectives and will be of interest to academia and industry alike.

#### **Q 3** Please comment on the methods, results and data interpretation. If there are any objective errors, or if the conclusions are not supported, you should detail your concerns.

No major concerns. The reported methods are all standard, well established procedures. The conclusions are supported by the data and discussion. See detailed manuscript comments for some minor clarifications.

#### **Q 4** Check List

Is the English language of sufficient quality?

Yes.

Is the quality of the figures and tables satisfactory?

Yes.

Does the reference list cover the relevant literature adequately and in an unbiased manner?

Yes.

Are the statistical methods valid and correctly applied? (e.g. sample size, choice of test)

Not Applicable.

If relevant, are the methods sufficiently documented to allow replication studies?

Yes.

Are the data underlying the study available in either the article, supplement, or deposited in a repository? (Sequence/expression data, protein/molecule characterizations, annotations, and taxonomy data are required to be deposited in public repositories prior to publication)

Yes.

Does the study adhere to ethical standards including ethics committee approval and consent procedure?  
Not Applicable.

If relevant, have standard biosecurity and institutional safety procedures been adhered to?  
Not Applicable.

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**Q 5** Please provide your detailed review report to the editor and authors (including any comments on the Q4 Check List):

Line 155 - you use CO<sub>2</sub> injection in present tense, which is a bit confusing as the paper refers to baseline conditions before CO<sub>2</sub> injection begins. If injection has already begun, maybe give the date it began. Otherwise, change reference to CO<sub>2</sub> injection at the site to future tense. Not essential, but a figure showing the timeline of site completion might be helpful for the reader.

Line 259 - misplaced comma

Line 291-293 - "gases derive from..." - be careful not to over-interpret these diagrams. Fields are plotted based on empirical evidence. Better to say e.g. that values plot in the field associated with biogenic acetate formation, rather than state that the gases derive from this. Treat the plot as a line of evidence, not wholesale proof.

Line 329-330 - could this observation be the result of differential release of gases from the host minerals, rather than differential migration?

Line 478 - "atmospheric contamination"? or an "atmospheric component"? Contamination might imply an unrepresentative component introduced during sampling, rather than a component that represents the actual fluid being sampled. The casing vent scenario you discuss is somewhere in between. But if leaving the casing vent open is common practice and likely to occur during monitoring as well as your baseline sampling, then this should maybe be considered a representative component, rather than contamination.

Line 516-7: does the density value include porosity? Or is it dense-rock-equivalent?

Line 521 - is this also Andrews et al 1991?

Section 6.1. There seems to be an implicit acknowledgement here that monitoring for increases in CH<sub>4</sub> (desorbing from coal as CO<sub>2</sub> is adsorbed) could be useful, albeit not as a standalone tool. Is there a reason why this hasn't been explicitly recommended?

Section 6.2. This section strikes me as overly pessimistic about how useful d<sup>13</sup>C values would be. If the measured CO<sub>2</sub> is going to be representative of all the injected CO<sub>2</sub>, its d<sup>13</sup>C values of ~-34‰ are unlikely to overlap significantly with most natural CO<sub>2</sub> sources. Looking at Figure 1 in Flude et al 2016, the only naturally occurring CO<sub>2</sub> source this might be confused with is CO<sub>2</sub> derived from bacterial oxidation of methane. Oxidation increases the δ<sup>13</sup>C of the residual methane, and in line 598-599 you suggest this is by up to 10-20%. You note in line 588 that the measured methane is all 25-34% lower than the injected CO<sub>2</sub>. This suggests that CO<sub>2</sub> produced by oxidation of baseline methane would still be distinguishable from injected CO<sub>2</sub>.

Lines 616-617 - missing an "is"

Line 634 - you are saying that you are doing a mixing analysis that assumes significant mixing doesn't take place. I think you need to either delete or qualify your "mixing" listed in on line 634.

Line 651 - analytical errors - what level? 1 or 2 sigma?

Various points in the paper: when you talk about analytical errors, would it be better to refer to "analytical uncertainties"?

Section 6.3 - be careful with use of language here. There are a couple of areas where it could be easy to misinterpret what you have written as meaning that you are actually detecting injected CO<sub>2</sub> in the baseline samples, rather than hypothetically.

Table 2. Please just create a separate heading with the correct orders of magnitude for the CO<sub>2</sub> samples - I was thoroughly confused about some of the discussion because I hadn't noticed the "x10<sup>-9</sup>" label on the left of this section.

Table 3 - it might be helpful for the reader if air values were included

Figure 2: Explain the red boxes

Figure 4: Should "thermal" be "thermogenic"?

Figure 6 - please standardise solid or dashed line for the air value between panels A and B

## QUALITY ASSESSMENT

<b>Q 6</b> → Originality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 7</b> → Rigor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 8</b> → Significance to the field	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 9</b> → Interest to a general audience	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 10</b> → Quality of the writing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>Q 11</b> → Overall quality of the study	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>