PROGRESS REPORT FOR ALNGRA10066P

PROJECT TITLE Fixation of atmospheric CO₂ in carbonates derived from ultramafic rocks in New South Wales

INVESTIGATOR(S) Institution and Department
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Other Investigators Dr. Geraldine Jacobsen Dr. Quan Hua Alan Williams
Students Hans Oskierski
ANSTO Investigators Dr. Geraldine Jacobsen
Specialist Committee

SCIENTIFIC OBJECTIVES

The applicant is supervising a PhD project aimed at characterising natural carbonation reactions of ultramafic rocks in New South Wales. Due to their capability of binding CO₂, carbonation reactions promise to be an important factor in reducing CO₂ greenhouse gas emissions to the atmosphere. If fully understood these natural analogues will be crucial in advancing the industrial process of mineral carbonation. The aim of the project is to trace the sources of carbon in the carbonation reactions and to verify the fixation of atmospheric carbon in carbonates that are associated with the weathering and alteration of ultramafic rocks. Furthermore, using the bomb curve, we will attempt to date layers of modern carbonate precipitates on mine tailings to establish a chronology and estimate timing and rates of formation.

PROGRESS REPORT and RESEARCH OUTCOMES

Commonly, cross plots of stable isotopes of carbon (δ¹³C) and oxygen (δ¹⁸O) are used to differentiate between magnesite occurrences and to deduce their sources. However, the sources of carbon cannot always be unequivocally identified, since processes such as microbial respiration or mixing between bedrock-derived and atmospheric carbon can lead to similar, ambiguous carbon and oxygen fingerprints of the Mg-carbonate minerals. The ambiguity in the stable isotope data can be resolved using radiogenic ¹⁴C, thereby confirming the involvement of modern, atmospheric carbon in the carbonation reactions.

Results obtained under ALNGRA10066P are shown in the table below.

Samples AT37-1-1 and AT39-5-1 represent a magnesite vein and a cliff magnesite of the Attunga Magnesite Quarry, respectively. As indicated by their stable isotope signatures, carbon in the magnesites is derived from a soil source while meteoric water is the source of oxygen. Given the superficial position and apparent recent formation of sample AT39-5-1 a contribution of atmospheric ¹⁴CO₂ from the meteoric water seems to be likely but low levels of ¹³C show that there is no significant input of carbon from atmospheric CO₂ into the magnesite. Contents of around 1% modern carbon in both samples are interpreted as derived from the soil. Due to the heterogeneous distribution of ¹⁴C in the soil source, ages based on ¹⁴C content of the magnesite can only be interpreted as estimates.

Sample AT-C2 is a crust that precipitated from water in the mining pond at Attunga Magnesite Quarry. As can be inferred from water levels fluctuating with varying runoff flows to the pond, meteoric water in equilibrium with atmospheric CO₂ and surface run-off dominate the pond water. Contrary, a high pH of 9.2 indicates substantial exchange between the water and basic serpentinite rocks. Thus the observed ¹⁴C content of 61.33 pMC indicates mixing of modern carbon from meteoric waters and older carbon from bedrock-carbonates and/or groundwater. As
a consequence of mixing the carbon derived from two reservoirs, the $^{14}$C age derived from this sample overestimates the real, post-mining age of the precipitate.

Sample D1-1 is a mixture of magnesite and dolomite from the Piedmont magnesite deposit. Due to the late Permian to Triassic age and the hydrothermal origin of carbon in the deposit, the sample was expected to represent a blank containing only dead carbon. To avoid contamination by atmospheric carbon during preparation, the outer rim of the sample was acid-leached prior to CO$_2$ generation. The $^{14}$C content of 0.95 pMC is above the background level of 0.1 to 0.2 pMC and contradicts the genetic interpretation of the deposit in the literature (Brownlow and Ashley 1991). Considering the large differences in the $\delta^{13}$C values measured at ANSTO (-12.8 ‰) and at the University of Newcastle (+3 ‰) it appears that sample D1-1 has been interchanged and that the values measured at ANSTO actually represent sample AT37-1-1. We intend to resolve this inconsistency by new measurements.

The results obtained so far are promising, however, further analysis are required to identify the sources of carbon in the formation of magnesite in differing geological settings. We request that the provisional component of this grant (12 samples) be converted to allow further work on this project.

The University of Newcastle is developing a process for large-scale mineral sequestration of CO$_2$ as an alternative to geological storage of CO$_2$ for the State of New South Wales. If successful, the process could provide a solution to storing CO$_2$ in NSW, transforming the energy intensive industries in the State. The results from the present project will assist in identifying the conditions under which the analogue's processes occurred in nature, affording the optimisation of the process.


### DATA

<table>
<thead>
<tr>
<th>ANSTO code</th>
<th>Sample Type</th>
<th>Submitter ID</th>
<th>$\delta^{13}$C per mil</th>
<th>percent Modern Carbon pMC</th>
<th>1σ error</th>
<th>Conventional Radiocarbon age yrs BP</th>
<th>1σ error</th>
</tr>
</thead>
<tbody>
<tr>
<td>OZM436</td>
<td>Magnesite &amp;</td>
<td>AT37-1-1</td>
<td>-12.6 +/- 0.1</td>
<td>1.05</td>
<td>+/- 0.05</td>
<td>36,620</td>
<td>+/- 380</td>
</tr>
<tr>
<td>OZM437</td>
<td>Serpentineite</td>
<td>AT39-5-1</td>
<td>-13.0 +/- 0.1</td>
<td>0.61</td>
<td>+/- 0.03</td>
<td>40,910</td>
<td>+/- 400</td>
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<tr>
<td>OZM438‡</td>
<td>Serpentineite qz</td>
<td>AT-C2</td>
<td>-17.3 +/- 0.49</td>
<td>61.33</td>
<td>+/- 0.49</td>
<td>3,930</td>
<td>+/- 70</td>
</tr>
<tr>
<td>OZM439</td>
<td>Magnesite and Dolomite</td>
<td>D1-1</td>
<td>-12.8 +/- 0.1</td>
<td>0.95</td>
<td>+/- 0.04</td>
<td>37,410</td>
<td>+/- 340</td>
</tr>
</tbody>
</table>

* = A small mass correction has been applied to this sample (refer note 3)

Signature of Investigator preparing the report for
After signing this report please fax this page with your signature for our files

Proj: ALNGRA10066P
Date: 08/08/2010

### PUBLICATIONS / REPORTS arising as a result of your work.

**PhD STUDENTS**

Hans Christoph Oskierski,
Conferment of PhD anticipated in April 2012.

Title: Paleogeological analogues to mineral sequestration of CO$_2$: Natural carbonation of ultramafic rocks in the Great Serpentinite Belt, New South Wales, Australia.