A multi-isotope soil map for Northern Ireland

L. Rock¹ (l.rock@qub.ac.uk), N. Ogle¹, D.J. Creamer¹, N. Zaiman¹, N. Haji Abdul Rani¹, M.R. Cave²

¹School of Planning, Architecture, and Civil Engineering, Queen’s University Belfast
²British Geological Survey, Keyworth, Nottingham

Introduction

Soils play a major role within the functioning of the Earth system, as they are at the interface of different ecosystems, and influence both climate change and water quality (SRAC, 2006).

They also enable one to decipher past events that may have shaped the environment, and provide 'fingerprints' that could be used to assess land use change or mineral exploration (e.g. Woodruff et al., 2009). This is commonly done by analyzing the chemical composition of soil, and less commonly its isotopic composition. The latter though provides a unique tool to study the origin and fate of compounds within the environment (e.g. Fry, 2006). The isotopic composition of soil depends upon various factors, such as geology, cultivation, or atmospheric deposition. This in turn may leave a distinct 'local' isotopic fingerprint.

Objective

To present a research project whose aim it is a) to establish a multi-isotope soil map for Northern Ireland, and b) to assess the potential of such a map to further the understanding of issues such environmental change, traceability, or pollution across Northern Ireland.

Isotope terminology

Isotope = same Element with different mass number A (same Z = number of protons, different N = number of neutrons); e.g. Hydrogen (H) has 2 stable isotopes:

\[ ^1\text{H} \] proton

\[ ^2\text{H} \] neutron

isotopic composition of sample expressed using $\delta$ (%) notation:

\[ \delta^H = \left( \frac{^{2H}}{^{1H}} \right)_{\text{sample}} - 1 \times 1000 \ (\%) \]

Sampling

Soils samples for this project come from the TELLUS project, managed by the Geological Survey of Northern Ireland. About 360 soils samples have been selected from the TELLUS ‘A’ soils sample set (15-20 cm below surface).

The selection was based on having a sample coverage of about one sample every 35 km², and to have samples that represent various combinations of soil types (e.g. Basalt, Climate, Pure Limestone) and soil parent material (e.g. Basalt, Carboniferous Limestone) found across Northern Ireland.

Methods - Analysis

Continuous flow isotope ratio mass spectrometry (CF-IRMS) will be used to determine the following isotopic compositions:

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight (mg)</th>
<th>$\delta^{15}\text{N}$ of total soil Nitrogen (%)</th>
<th>$\delta^{13}\text{C}$ of total soil Carbon (%)</th>
<th>$\delta^{18}\text{O}$ of soil carbonate (%)</th>
<th>Amplitude 28 (mV)</th>
<th>Mass 44 (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (pale):</td>
<td>0.53</td>
<td>7.2</td>
<td>29.7</td>
<td>120</td>
<td>234</td>
<td></td>
</tr>
<tr>
<td>Basalt, Mineral Gley</td>
<td>2.56</td>
<td>7.0</td>
<td>-28.9</td>
<td>457</td>
<td>1141</td>
<td></td>
</tr>
<tr>
<td>B (mid-shade):</td>
<td>5.42</td>
<td>7.2</td>
<td>-29.0</td>
<td>961</td>
<td>2464</td>
<td></td>
</tr>
<tr>
<td>Carboniferous</td>
<td>10.08</td>
<td>6.9</td>
<td>-29.1</td>
<td>1796</td>
<td>4577</td>
<td></td>
</tr>
<tr>
<td>Basal Sandstone, Brown Earths</td>
<td>10.43</td>
<td>4.3</td>
<td>-29.1</td>
<td>1169</td>
<td>4464</td>
<td></td>
</tr>
<tr>
<td>C (dark):</td>
<td>0.57</td>
<td>2.9</td>
<td>-28.5</td>
<td>337</td>
<td>1890</td>
<td></td>
</tr>
<tr>
<td>Organic Alluvium</td>
<td>2.61</td>
<td>2.1</td>
<td>-28.6</td>
<td>1523</td>
<td>8434</td>
<td></td>
</tr>
<tr>
<td>5.15</td>
<td>2.1</td>
<td>-28.6</td>
<td>3185</td>
<td>15231</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.21</td>
<td>2.0</td>
<td>-28.5</td>
<td>7136</td>
<td>25657</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Preliminary results

Test samples were selected based on color to determine the optimum sample weight for isotopic analysis. A regional difference in $\delta^{15}\text{N}$ of total soil Nitrogen could be observed between the three test samples, but not for $\delta^{13}\text{C}$ of total soil Carbon.

Isotope maps - Isoscapes

Maps of the distribution of $\delta$ values across a particular region (e.g. Fry, 2006; Bowen et al., 2009) provide a unique tool to address various problems such as identifying Carbon sources and sinks, or polluting nutrient sources. Another example discussed in the literature is the relationship between $\delta^{15}\text{N}$ of total soil and water availability/rainfall (Handley et al., 1999; Amundson et al., 2003).

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References


Bowen et al., 2009. Isoscapes to address large-scale Earth science challenges. EOS 90(33): 109-110.


