Elmvale Groundwater Observatory (EGO)

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A dedicated water sampling facility for trace metals research
ORIGINAL ARTESIAN WELL
depth 12.8 m
flow 10 L/min

typical chemical composition:
pH 8
ca. 175 mg/l carbonate alkalinity
Ca 27.8 ± 0.4 mg/l
Mg 23.1 ± 0.3 mg/l
Na 6.9 ± 0.2 mg/l
K 1.7 ± 0.0 mg/l
Si 8.7 ± 0.1 mg/l
(n=30)
March 2010

No tritium has been found to date
PARNELL:
Depth 8.5 m
$^3$H: 9.5 ± 0.9; 10.0 ± 0.9; 10.6 ± 0.9
(tritium units)

TEMOLDER:
Depth 9.1 m
$^3$H: 14.3 ± 1.3; 15.1 ± 1.1
(tritium units)

But tritium is found in other nearby springs
View of the Elmvale Clay Plain (with its abundant springs) from the Simcoe Uplands, with Blue Mountain in the distance (seen from French’s Hill).

**Simcoe Lowlands:**
- lacustrine sediments
- clay and silt
- groundwater **DISCHARGE**

**Simcoe Uplands:**
- glacial deposits
- boulders, gravel, sand
- groundwater **RECHARGE**
Simcoe Uplands
(glacial deposits)
rocks, gravel, sand
coarse-grained, permeable

Simcoe Lowlands
[Elmvale Clay Plain]
lacustrine deposits
silt, clay
fine-grained, impermeable

Limestone bedrock

channels of sand
(permeable, water-bearing layers)
.ie. the aquifer

not to scale
Location of original artesian flow: this supplies water to house and barn

Location of three dedicated groundwater research wells
EGO-1, constructed in **316 surgical stainless steel**, installed May 2009. Used to determine stratigraphy and water flow rate, but also for groundwater research.

Original artesian flow. The brass tap was replaced with stainless steel by Tommy Noernberg (May 2007), and the depth of the well recorded.

EGO-2, constructed in **acid-washed high density polyethylene (HDPE)**, installed September 2009. For trace metals research.

Both valves were made by Tommy
21.5.09 Using a rotary rinsing drill, after ca. 5 ft of soil and 30 ft of clay, the aquifer was reached consisting of ca. 8 ft of sand. Christian Scholz described the stratigraphy.
Schematic illustration of the stratigraphy of the research wells

Soil: medium sand, abundant fine sand
Silt, with some fine sand
Lacustrine clay, with some silt
Fluvio-glacial medium sand: coarse sand, some fine sand and fine gravel

DEPTH
- 1.5 m
- 1.5 m
- 13.1 m
- 14.7 m

316 (surgical) stainless steel

pH  CaCO₃ (%)
7.4  7.6  7.8  10  30
Particle size analysis, aquifer material (medium-coarse sand)

55.9 % medium sand (630-200 µm)
32.3 % coarse sand (2000-630 µm)
HDPE tubes (purchased from Carl Hamm GmbH, Essen, Germany, manufactured by Rotek in Denmark) were leached in nitric acid for two weeks and packed twice in polyethylene, before shipping to Canada.

SEPT 2009: installation of EGO-2 (HDPE)

This valve, constructed of Teflon and polypropylene, was dismantled, leached in acid, and packed twice in polyethylene, prior to shipping to Canada.
Hydrological studies of the area indicate that the hydrological gradient is from E to W.
Based on the hydrology, the polyethylene well was located upstream of the stainless steel well to minimize the risk of contamination.

This small cabin was constructed by Stephen Ogden, not only to protect the wells, but also to provide a “clean” location which would allow water sampling to be undertaken regardless of the weather.
Main Floor Sampling Area

Each well has an insulated cover to ensure that the water does not freeze in winter

All measurements in cm
Both wells flow continuously at a rate of ca. 1 L/min. The volume of water in the wells is exchanged ca. 50 times per day.

to watch and listen to the water, check out YouTube “groundwater research wells”
Clean Air Cabinet, HDPE well

To eliminate the risk of sample contamination by ambient air, clean air cabinets were designed by James Zheng who also kindly supplied the filters and loaned us the portable laser particle counter.

Clean Air Cabinet, SS well
The cabinets each rest on a wooden frame (since replaced with plexiglas) with serrated edge to allow the filtered air to exit the base of the cabinets well below the sampling zone.

Sliding doors provide access for sampling the artesian flow at the height of the outlet, under the stream of filtered air.
Particle Counts:

In cabin, ambient air, before sampling, > 1.5 M particles > 0.3 μm per ft³

In cabin, ambient air, after sampling, > 6.4 M particles > 0.3 μm per ft³

In Clean Air Cabinets during sampling, ZERO particles > 0.3 μm per ft³

In May of 2011, two room air filters were added, to improve the quality of ambient air.
Water sampling in CAC, HDPE well

Water sampling in CAC, SS well

Suiting up for water sampling........
In cabin, ambient air:
> $1.5 \times 10^6$ particles $> 0.3 \, \mu m$ per ft$^3$

In clean air cabinets:
zero particles $> 0.3 \, \mu m$ per ft$^3$
James measuring air quality in the cabin, and within the cabinets, March 2011, using laser particle counter.

Air quality was also measured outdoors, when fresh snow was also sampled (for comparison with the groundwater).
With more than 5 M particles per ft³ of air in the cabin during sampling, it becomes clear why water sampling must take place within the cabinets.

Adding the two room air filters has improved the ambient air quality by better than a factor of ten.

May 2011
During water sampling, within the clean air cabinets, there are no measurable particles.

May 2011
University of Heidelberg, Germany, where all the trace metal measurements were made, until 2010

Stefan Rheinberger made the ICP-MS measurements during 2009 and 2010.

Dr. Michael Krachler who made all of the ICP-MS measurements until 2008
Comparing the composition of groundwater with atmospheric inputs (obtained by collecting and testing snow) allows the natural filtration of water by soils to be quantified. In the case of Pb, for example, removal is estimated to be on the order of 99.995%.
## Elements Depleted in Groundwater, Relative to Snow

<table>
<thead>
<tr>
<th>M/Z</th>
<th>Element (ng/L)</th>
<th>Stainless Steel Well (n=10)</th>
<th>HDPE Well (n=10)</th>
<th>Arctic Ice (Devon Island, 3.3 K to 7.9 K yr BP) n=6</th>
<th>Snow, 6.3.11, Springwater Township (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>Sc</td>
<td>1.1 ± 0.1</td>
<td>1.2 ± 0.1</td>
<td>0.65 ± 0.17</td>
<td>3.9 ± 2.0</td>
</tr>
<tr>
<td>52</td>
<td>Cr</td>
<td>2.2 ± 0.3</td>
<td>1.5 ± 0.4</td>
<td>4.1 ± 1.3</td>
<td>323 ± 553</td>
</tr>
<tr>
<td>60</td>
<td>Ni</td>
<td>37.4 ± 7.1</td>
<td>32.6 ± 6.0</td>
<td>NA</td>
<td>249 ± 294</td>
</tr>
<tr>
<td>109</td>
<td>Ag</td>
<td>0.64 ± 0.29</td>
<td>0.65 ± 0.30</td>
<td>0.67 ± 1.2</td>
<td>5.0 ± 4.5</td>
</tr>
<tr>
<td>111</td>
<td>Cd</td>
<td>3.6 ± 1.1</td>
<td>3.6 ± 1.1</td>
<td>2.3 ± 0.8</td>
<td>12.3 ± 14.3</td>
</tr>
<tr>
<td>121</td>
<td>Sb</td>
<td>3.0 ± 0.5</td>
<td>3.0 ± 0.4</td>
<td>0.10 ± 0.04</td>
<td>44.7 ± 48.6</td>
</tr>
<tr>
<td>208</td>
<td>Pb</td>
<td>3.0 ± 0.9</td>
<td>1.0 ± 0.3</td>
<td>5.1 ± 1.4</td>
<td>552 ± 607</td>
</tr>
<tr>
<td>209</td>
<td>Bi</td>
<td>0.05 ± 0.02</td>
<td>0.04 ± 0.01</td>
<td>0.10 ± 0.05</td>
<td>5.4 ± 5.3</td>
</tr>
<tr>
<td>232</td>
<td>Th</td>
<td>0.48 ± 0.25</td>
<td>0.54 ± 0.27</td>
<td>NA</td>
<td>6.4 ± 3.7</td>
</tr>
</tbody>
</table>

From W. Shotyk. *A dedicated “clean lab” sampling facility for studying the natural filtration of trace metals by soils: the artesian springs of the Elmvale Groundwater Observatory.* The 22nd V.M. Goldschmidt Conference, June 24-29, 2012, Montreal, Quebec.
# Elements Enriched in Groundwater, Relative to Snow

<table>
<thead>
<tr>
<th>M/Z</th>
<th>Element (ng/L)</th>
<th>Stainless Steel Well (n=10)</th>
<th>HDPE Well (n=10)</th>
<th>Ancient Arctic Ice (Devon Island, 3.3 K to 7.9 K yr BP)</th>
<th>Snow, 6.3.11, Springwater Township (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Li (µg/l)</td>
<td>5.0 ± 0.4</td>
<td>4.7 ± 0.3</td>
<td>NA</td>
<td>0.05 ± 0.01</td>
</tr>
<tr>
<td>75</td>
<td>As</td>
<td>1685 ± 152</td>
<td>1608 ± 133</td>
<td>3.0 ± 0.7</td>
<td>28.7 ± 7.5</td>
</tr>
<tr>
<td>74</td>
<td>Ge</td>
<td>8.6 ± 0.2</td>
<td>8.7 ± 0.1</td>
<td>NA</td>
<td>4.5 ± 1.7</td>
</tr>
<tr>
<td>98</td>
<td>Mo</td>
<td>1764 ± 145</td>
<td>1710 ± 103</td>
<td>0.82 ± 0.09</td>
<td>528 ± 592</td>
</tr>
<tr>
<td>184</td>
<td>W</td>
<td>207 ± 51</td>
<td>209 ± 46</td>
<td>NA</td>
<td>58.1 ± 24.0</td>
</tr>
<tr>
<td>185</td>
<td>Re</td>
<td>1.8 ± 0.5</td>
<td>1.7 ± 0.4</td>
<td>NA</td>
<td>0.25 ± 0.35</td>
</tr>
<tr>
<td>238</td>
<td>U</td>
<td>1143 ± 311</td>
<td>1144 ± 280</td>
<td>0.50 ± 0.18</td>
<td>3.4 ± 2.8</td>
</tr>
</tbody>
</table>

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Elements neither Enriched nor **Depleted** in Groundwater, Relative to Snow

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<th>M/Z</th>
<th>Element (ng/L)</th>
<th>Stainless Steel Well (n=10)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Be</td>
<td>2.4 ± 0.3</td>
<td>2.3 ± 0.4</td>
<td>NA</td>
<td>1.5 ± 0.4</td>
</tr>
<tr>
<td>59</td>
<td>Co</td>
<td>14.4 ± 0.3</td>
<td>15.5 ± 0.4</td>
<td>2.5 ± 1.0</td>
<td>12.7 ± 8.9</td>
</tr>
<tr>
<td>205</td>
<td>Ti</td>
<td>1.0 ± 0.3</td>
<td>1.1 ± 0.3</td>
<td>0.24 ± 0.05</td>
<td>0.7 ± 0.3</td>
</tr>
</tbody>
</table>

All of the trace element data shown here was obtained by sampling the groundwater in acid-washed HDPE bottles, provided by Dr. James Zheng of the Glaciology Division, Geological Survey of Canada, Ottawa.

From W. Shotyk. A dedicated “clean lab” sampling facility for studying the natural filtration of trace metals by soils: the artesian springs of the Elmvale Groundwater Observatory. The 22nd V.M. Goldschmidt Conference, June 24-29, 2012, Montreal, Quebec.
The HDPE bottles are suitable for sampling for many trace metals, but not for vanadium!
A dedicated sampling facility has been created for the study of trace metals in natural freshwaters.

The concentrations of many elements are at or below the levels found in ancient Arctic ice (3.3 – 7.9 K yr BP).

The extreme “clean lab” methods, procedures and protocols which have been developed for the study of polar snow and ice, must be rigorously employed.

Some elements are depleted in the groundwater, relative to atmospheric inputs (e.g. Cr, Ni, Sb, Pb), whereas others are enriched (Li, As, Mo, W, Re, U), during the evolution of the groundwater.

NEWS UPDATE: announcing EGO-3
In May of 2012, we added a third well, stainless steel well, EGO-3.
Installing EGO-3, Elmvale ONT May 2012
Approximately 60 m of sediment core was collected, requiring an additional 7 days. The stratigraphy varied from varved lacustrine sediments to glacial till.
But finally, at 190 ft, aquifer sand was reached and it proved to be artesian
The well was allowed to run for 2-3 days, to allow the particles to be flushed out
The well was constructed entirely of 316 surgical stainless steel, including this valve.
We are deeply indebted to Jamie Archer and his experienced crew at Canadian Soil Drilling for their time, skills, and expertise.
A second cabin was constructed later that summer, again by Steve Ogden, to house the new well. This cabin is smaller than the first, but provides enough space for another clean air cabinet to protect the water during sampling.
SPECIAL THANKS TO:

Jamie Archer and Peter Fleming, Canadian Well Drilling, Midhurst ONT

Rick Buckley, President, Pro Core Drilling, Brantford, ONT

Stephen and Neil Ogden, Ogden Farms, Parry Sound, ONT

University of Heidelberg:
Werner Aeschbach-Hertig, Andreas Funke, Michael Krachler, Stefan Rheinberger, Christian Scholz,
THANKS ALSO TO:

Andy Bajc, Ontario Geological Survey, Sudbury, ONT
Ian D. Clark, University of Ottawa
Michael Goodsite, Aarhus University, DK
Riley Mulligan, McMaster University, Hamilton ONT
Tommy Noernberg, University of Alberta
Martin Otz, NanoTrace Technologies, USA
Michael Powell, M Powell International, London ONT
Stephen Hillier, James Hutton Institute, UK
Claudio Zaccone, University of Foggia, IT
James Zheng, GSC, Ottawa, CAD

AND finally
the elmvale foundation

a federally registered charity
(84826 6193 RR0001)

for environmental science education

www.elmvale.org
celebrate water
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