Plants: The Ultimate Selective Leach

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Sample the Trees or Shrubs

“Biogeochemistry”
(Phytogeochemistry)
Biogeochemistry and Geobotany
Plants associated with minerals

Visual approach
BIOGEOCHEMISTRY

The chemical composition of plants

Chemical Approach
Poison Milkvetch
(*Astragalus pattersonii*)
Colorado

Selenium indicator plant

Used in U roll-front Exploration
(Cannon, 1960)
Fireweed (Epilobium)
BIOGEOCHEMISTRY

Technology to Discover Mineralization and Define Underlying Geology
To better target
BIOGEOCHEMISTRY

The chemical composition of plants
OUTLINE

- Why
- How
- Results
Use Plant Chemistry for:

- Delineating stratigraphy
- Delineating structure/faulting
- Outlining mineralization

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RATIONALE
Why use plants?
Power of Plants

- Complex – 425 million years
- Sophisticated abilities to select elements that they need
- Tolerate metals they don’t need
- Store those they don’t need (often in extremities such as bark and twig ends and tree tops)
Earliest form of vascular plant – *Cooksonia*  Lower Silurian (~425 my)
Precambrian Life

- Bacteria
- Fungi
- Algae
# Metals in Primitive Life Forms (Lepp, 1992)

<table>
<thead>
<tr>
<th>Metals</th>
<th>Bacteria</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>40</td>
<td>3</td>
</tr>
<tr>
<td>Co</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Cu</td>
<td>40</td>
<td>1.6</td>
</tr>
<tr>
<td>Pb</td>
<td>49</td>
<td>10.4</td>
</tr>
<tr>
<td>Ni</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Ag</td>
<td>35</td>
<td>5.4</td>
</tr>
</tbody>
</table>
‘Barrier’ Mechanisms

(i.e. a type of selective extraction [leach] of elements)
FLUORINE

Conc.

Distance (km)

PINE BARK (NON-BARRIER)
HIGH BARRIER SPECIES

After Kovalevsky, 1987
## Correlations: Bark v. Soil Horizons

<table>
<thead>
<tr>
<th>Soil Horizon</th>
<th>Douglas-fir Bark ( n = 12 )</th>
<th>Engelmann Spruce Bark ( n = 13 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( Au )</td>
<td>( Au )</td>
</tr>
<tr>
<td></td>
<td>( As )</td>
<td>( As )</td>
</tr>
<tr>
<td>Forest Litter</td>
<td>( .13 )</td>
<td>( .48 )</td>
</tr>
<tr>
<td></td>
<td>( .10 )</td>
<td>( .58 )</td>
</tr>
<tr>
<td>A - Horizon</td>
<td>( .63 )</td>
<td>( .65 )</td>
</tr>
<tr>
<td></td>
<td>( .63 )</td>
<td>( .65 )</td>
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<tr>
<td>B - Horizon</td>
<td>( .60 )</td>
<td>( .79 )</td>
</tr>
<tr>
<td></td>
<td>( .55 )</td>
<td>( .80 )</td>
</tr>
<tr>
<td>C - Horizon</td>
<td>( .76 )</td>
<td>( .90 )</td>
</tr>
<tr>
<td></td>
<td>( .64 )</td>
<td>( .88 )</td>
</tr>
</tbody>
</table>
Relationships between the Organic world of Plants and the Inorganic world of Rocks
Trees

- Extensive root systems – roots, rootlets and mycorrhizal fungi can be 100s of kilometres in a single plant!

- On a hot summer’s day a large tree can transpire 100 to 150 litres of water (with dissolved metals that precipitate in the plant tissues)
Mineral Phases in Plants
SEMs
Silica phytoliths on grass
Ca oxalate in bark of W. hemlock twig
Fe, Zn, S phase within western hemlock twig
Heterogeneity of Plants
# VARIATIONS AMONG SPECIES AND TISSUES

<table>
<thead>
<tr>
<th>Tree</th>
<th>Tissue</th>
<th>Au ppb</th>
<th>As ppm</th>
<th>Mo ppm</th>
<th>Sb ppm</th>
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</thead>
<tbody>
<tr>
<td>Douglas fir</td>
<td>Twig</td>
<td>35</td>
<td>1600</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>Needle</td>
<td>23</td>
<td>130</td>
<td>&lt;1</td>
<td>2</td>
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<tr>
<td>Douglas fir</td>
<td>Bark</td>
<td>53</td>
<td>250</td>
<td>&lt;1</td>
<td>8</td>
</tr>
<tr>
<td>Western Hemlock</td>
<td>Twig</td>
<td>200</td>
<td>710</td>
<td>&lt;1</td>
<td>8</td>
</tr>
<tr>
<td>Western Redcedar</td>
<td>Twig</td>
<td>7</td>
<td>11</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Western Redcedar</td>
<td>Needle</td>
<td>5</td>
<td>6</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Western Redcedar</td>
<td>Bark (all)</td>
<td>8</td>
<td>12</td>
<td>&lt;1</td>
<td>1</td>
</tr>
<tr>
<td>Western Redcedar</td>
<td>Bark (outer)</td>
<td>31</td>
<td>46</td>
<td>&lt;1</td>
<td>11</td>
</tr>
<tr>
<td>Red Alder</td>
<td>Twig</td>
<td>14</td>
<td>4</td>
<td>57</td>
<td>0.5</td>
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<tr>
<td>Red Alder</td>
<td>Bark</td>
<td>&lt;5</td>
<td>4</td>
<td>4</td>
<td>0.3</td>
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<tr>
<td>Douglas Maple</td>
<td>Twig</td>
<td>12</td>
<td>6</td>
<td>4</td>
<td>1</td>
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</tbody>
</table>

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# SULLIVAN – Lodgepole Pine (Ash)

<table>
<thead>
<tr>
<th></th>
<th>Top Stem</th>
<th>Lower Twigs</th>
<th>Outer Bark</th>
<th>Roots</th>
</tr>
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<tbody>
<tr>
<td>Ag</td>
<td>ppm</td>
<td>1</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>As</td>
<td>ppm</td>
<td>9</td>
<td>9</td>
<td>52</td>
</tr>
<tr>
<td>Au</td>
<td>ppb</td>
<td>&lt;5</td>
<td>&lt;5</td>
<td>20</td>
</tr>
<tr>
<td>B</td>
<td>ppm</td>
<td>1150</td>
<td>400</td>
<td>260</td>
</tr>
<tr>
<td>Cd</td>
<td>ppm</td>
<td>52</td>
<td>95</td>
<td>143</td>
</tr>
<tr>
<td>Cs</td>
<td>ppm</td>
<td>110</td>
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<tr>
<td>Cu</td>
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<td>400</td>
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<td>158</td>
</tr>
<tr>
<td>Ni</td>
<td>ppm</td>
<td>180</td>
<td>22</td>
<td>14</td>
</tr>
<tr>
<td>Pb</td>
<td>ppm</td>
<td>150</td>
<td>2950</td>
<td>4900</td>
</tr>
<tr>
<td>Zn</td>
<td>ppm</td>
<td>6100</td>
<td>7350</td>
<td>5700</td>
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</table>
Seasonal Variations – Alder Gold (ppb) in twig ash (n = 17)

<table>
<thead>
<tr>
<th></th>
<th>June</th>
<th>August</th>
<th>September</th>
<th>April</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>29</td>
<td>18</td>
<td>17</td>
<td>71</td>
</tr>
</tbody>
</table>

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PLANT SAMPLING AND PREPARATION
Whether or not to Wash Samples
Washed (diamonds) v unwashed (open triangles)

Twigs

Leaves

Averages

Ni ppm

Ni ppm

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Iron - No Difference

Washed (blue) v unwashed (pink)
Cadmium - No Difference

Washed (blue) v unwashed (pink)

Twigs
Leaves
Averages

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Whether or Not to Ash Samples

- **Pro:** Reduction to ash permits concentration of elements from large samples
- **Con:** During ashing, some elements (As, Sb) partially, or completely (Hg) volatilize from some species
- **However,** *Controlled* ignition results in constant losses, therefore distribution patterns are relevant
Element Losses

Analysis of ash [at 475°C] compared to analysis of dry tissue
Elements that are Commonly Only Detected in Ash (ICP-MS) i.e. below detection in dry tissue:

Pt, Pd, Bi, Sb, Te, Tl, In, Re, Th, V, most REE
CONTAMINATION

Precautions
Pb contamination along road

LEAD - Pine Bark - Endako

Fraser Lake Pip e r's G len
Endako Mo Mine
Francois Lake
O ona L ake
Hanson Lake metres

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COBALT in Pine Bark

Unpaved road
CARAMELIA - BC NICKEL (ppm) in Dry Larch Bark

Courtesy of Merit Mining
STRATIGRAPHY and LITHOLOGY
Structural Trends
MERCURY and GOLD
Dry Larch and Pine Bark

Merit Mining Corp.
Caramelia Property, Southern BC
Keep in Mind:

- What are we trying to achieve?
- Why are we using plants?
- How do we use plants?
- Where should we be using plants (rather than soils, rocks, water etc.)?
- What precautions do we need to take?
Be consistent, and, when interpreting the analytical results ask the questions:

- Is there a possible analytical explanation?
- Is there a possible contamination explanation?
- Is there a possible ecological or physiological explanation?
- Is there a possible geological explanation?
Finally, ask the question

Are your interpretations correct, reasonable and justifiable?
CASE HISTORIES
and More Details

Plenary Session
Tuesday, 10:40