A UNIQUE RESEARCH PROGRAM in Québec

DEVELOPMENT OF A SAMPLING STRATEGY FOR MINE WASTE CHARACTERIZATION

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Introduction

• Validity of environmental evaluations is directly related to the representativeness of the samples used in the study

• For studies performed on tailings ponds and waste rock piles, there is no clear procedure, nor a precise number of samples required
Introduction

• Guidelines: MEND reports 4.1.1 (Canect 1989) and 4.5.1-1 (Senes 1994)
  – Presented some sample collection methods
  – Separate the area to sample in sectors according to anticipated variations in particle size and/or geochemistry

• BC AMD Task force (SRK 1989): relationship between the mass of the geologic unit and number of samples to collect
Introduction

- Issues with mine waste: lot mass, heterogeneity
- Other fields: contaminated soils (Boudreault et al. 2016), geotechnique (Phoon and Kulhawy 1999), recycled material sorting (Maris et al. 2014)
Objective

To develop a sampling protocol based on Gy’s Theory of Sampling (TOS) (Gy 1979), applicable to mine tailings and waste rock, to improve representativeness of environmental assessments.

This presentation:

– to investigate the number and position of sampling points on a tailings pond during a sampling campaign.
Sampling

- Inactive tailings pond, stiff surface, no hardpan
- 480 m by 120 m grid, square mesh of 30 m by 30 m
- 85 samples collected
- Sampling tool according to Gy
Sample characterization

• Analytical procedure
  – Particle size distribution: Microtrak S3500
  – Total S and C: Eltra C/S-800 induction furnace
  – XRF: Niton XZ3t 900 portable x-ray spectrometer

• Geostatistical procedure
  – Lot characterization: experimental variograms
  – Sampling grid optimization: differential mapping using Surfer
### Results: characterization data

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Median</th>
<th>Variance</th>
<th>COV</th>
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</thead>
<tbody>
<tr>
<td>S (%)</td>
<td>0.656</td>
<td>2.751</td>
<td>1.375</td>
<td>1.349</td>
<td>0.188</td>
<td>0.353</td>
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<tr>
<td>Ca (%)</td>
<td>0.54</td>
<td>1.24</td>
<td>0.93</td>
<td>0.95</td>
<td>0.03</td>
<td>0.147</td>
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<tr>
<td>Fe (%)</td>
<td>2.46</td>
<td>5.42</td>
<td>4.05</td>
<td>4.00</td>
<td>0.377</td>
<td>0.483</td>
</tr>
</tbody>
</table>
Results: sample mass

• Evaluation of sample mass to minimize FSE:

\[ \sigma^2 = \frac{Cd^3}{m_s}, \text{ where } C = f_{glm} \]

• For a 1% standard deviation, a sample mass of 32.6 g, doubled for error in sample preparation, so 65 g

• Sampling campaign: near 1 kg
Results

S, Ca and Fe concentration maps (85 samples), interpolation: normal kriging
Optimization: number and location of sampling stations

• Variograms: range obtained between 50 and 60 m

• Maps redrawn with samples every 60 m: blue points (27 samples)
Optimization of number and location of sampling stations

Mean relative difference:
- S: 3.6%
- Ca: 4.4%
- Fe: 0-50%

Extrapolation map for 60 m x 60 m sampling grid

Differential map for S
Optimization of number and location of sampling stations

• Proposed protocol:
  – First step would be to determine the correlation distance between a pair of points
  – Start from a random point, collect samples every $2^n$ steps in perpendicular directions, and use portable XRF
  – Obtain experimental variogram and range
Optimization of number and location of sampling stations

• With 17 data points:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Model</th>
<th>Range (m)</th>
<th>Sill</th>
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<tbody>
<tr>
<td>S</td>
<td>Exponential</td>
<td>72</td>
<td>0.04</td>
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<tr>
<td>Ca</td>
<td>Exponential</td>
<td>90</td>
<td>0.045</td>
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<tr>
<td>Fe</td>
<td>Linear</td>
<td>-</td>
<td>0.15</td>
</tr>
</tbody>
</table>

• Determine sampling grid spacing to apply to entire tailings area
Conclusions

• Sampling mine waste is not an easy task

• Development of a sampling plan for tailings:
  1. Evaluate heterogeneity using experimental variograms, and extract the range from the models;
  2. Establish the sampling grid according to information found in step 1;
  3. Use standard extrapolation methods, such as normal kriging, to estimate the parameters value throughout the sampled area.
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