OIL SANDS EXTRACTION PROCESS - AN EXAMPLE

Diagram from: https://www.2b1stconsulting.com/wp-content/uploads/2012/07/Oil_sand_process.jpg
RUDIMENTARY MASS BALANCE — VOLUMES PER BARREL

Oil Sand Ore + Fresh Water (river + site run-off) + Recycled Process Water = Bitumen + Coarse Tailings + Fine Tailings

From: Kaminsky, Heather (2014) “Introduction to Oil Sands and the Importance of Clay Minerals” CIM Luncheon Presentation
SOURCES OF VARIATION

- Ore body
- Process conditions (dilution ratio, additives etc.)
- Tailings treatment prior to deposition
- Deposition process
- Pond design (depth, size etc.)
VARIATION IN BITUMEN, SOLIDS AND WATER

- Bitumen contents above 5.5% are generally associated with bitumen mats, these can cause significant issues with downstream processes and dredging.

Graph and Statistics are for tailings having fines >50%
Solids content tends to increase with depth as particles settle out of suspension.
The solids content at which something is still fluid depends on nature of the particles involved.
Bitumen content tends to be more variable – high contents can be seen in mats which can occur at several different depths depending on the amount of solids associated with the mat.
BITUMEN MIGRATION
SEGREGATION OF PARTICLE SIZE

Large proportion of pond may be at 100% fines

Variation in clay still shown in 100% fines material.
CLAY VS FINES

Clay to Fines ratio is not constant

<table>
<thead>
<tr>
<th></th>
<th>Clay</th>
<th>CWR</th>
<th>CFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>D10</td>
<td>24</td>
<td>0.15</td>
<td>0.34</td>
</tr>
<tr>
<td>D50</td>
<td>48</td>
<td>0.29</td>
<td>0.55</td>
</tr>
<tr>
<td>D90</td>
<td>86</td>
<td>0.52</td>
<td>0.88</td>
</tr>
</tbody>
</table>

![Graph showing the clay to fines ratio over depth](image-url)

- Pond A, 2015
- Pond A, 2009
- Pond B, 2009
- Pond B, 2015
CONSOLIDATION IN ACTIVE PONDS

General increase in F/F+W with time for some cases, but not all

Consistent increase in CWR with time, but larger scatter in results

Note: Time comparisons are difficult because the material is fluid and the material present at time 0 is not the same as time N. Trends and statistical comparison of average pond compositions are the best way to draw conclusions.
VARIABILITY IN PROCESS TIME SCALE

Dredge depth kept constant as operator tried to provide constant feed.

Small changes observed in mineral but large changes in CWR which correlated to changes in measured yield stress.
CONCLUSIONS

- FFT is highly variable and changes rapidly at a scale and frequency that impacts treatment processes.
- Clay to Fines ratios are not constant within a pond.
- Measuring Clay content can show the segregation not captured by measuring only Fines.
- Clay to Water Ratio correlates with FFT yield stress.
- Important to measure basic FFT characteristics in research/process development:
  - Bitumen, Solids & Water by Dean stark (or equivalent)
  - Particle Size Distribution
  - Clay content by Methylene Blue Index
  - Water Chemistry (at least pH and Major cations/anions)