Resource Estimation for the Aurukun Bauxite Deposit
Aurukun Bauxite Deposit - Resource

- Location
- Background
- Geology
- Density
- Modelling
- Resource Estimation
- Conclusions
Location: Far North Queensland
Introduction

The Weipa bauxite deposits

- occur along and inland from the western coast of Cape York.
- Are confined to the lateritic unit known as the Weipa Plateau – modified Cretaceous regression surface
- Stretch 350km by 40 km
- Is incised by rivers and alluvial fans

* Adapted from Taylor et.al 2008
Introduction – Aurukun Deposit

Aurukun Bauxite Deposits
- South East Rim of the Weipa Bauxite Deposit
- 40 km south east of Weipa

* Adapted from EOI Aurukun Project 2012
History

- During the 1950s and 1960s, the Aurukun bauxite resource area was explored through three different Authorities to Prospect from 1957 to 1968.

- The resource was subject to an exploration program run by the State during 2004 and 2005.

- During 2008, Chalco updated the resource prepared in compliance with the JORC Code, as reported in Qld QDEX system, CR-68138_1:

  Total mineral resources (Measured, Indicated, Inferred) of 357Mt @51.4% $\text{Al}_2\text{O}_3$, 11.2% $\text{SiO}_2$
Current Status

- The Aurukun bauxite deposit was held by Chalco Australia Pty Ltd (Chalco) until it withdrew from the agreement with the Queensland government in 2010 and was put up for tender in 2012.

- April 2013 the government of Queensland finalised a shortlist of five bidders for tender:
  - Aluminium Corporation of China Limited (CHALCO),
  - Australian Indigenous Resources Pty Ltd,
  - Cape Alumina Consortium,
  - Glencore International AG,
  - Rio Tinto Aluminium Limited
Geology – Bauxite Deposits

- Laterite deposits are typically laterally extensive relatively thin ore bodies, and as such present specific issues related to the lateral changes in thickness and elevation of the various horizontal layers within the deposit.
- These deposits display horizontal dimensions orders of magnitude greater than the vertical dimension.
- Traditionally a 2 dimensional gridded model would be utilised.
- The objective was to develop a 3D block model for the Aurukun Bauxite Deposit that retained the vertical and lateral variation inherent in deposits of the type.
### Regional Geology

<table>
<thead>
<tr>
<th>Age</th>
<th>Basin</th>
<th>Group</th>
<th>Formation</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td></td>
<td></td>
<td></td>
<td>Quartzose gravels, sands and minor muds</td>
</tr>
<tr>
<td>Neogene</td>
<td>Karumba Basin</td>
<td></td>
<td></td>
<td>Limestone, sandstone, siltstone (mainly offshore)</td>
</tr>
<tr>
<td>Paleogene</td>
<td></td>
<td><strong>Bauxite Development</strong></td>
<td>Bulimba Formation</td>
<td>Quartzose sandstone, siltstone, coal claystone</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Carpentaria Basin</td>
<td>Rolling Downs Group</td>
<td>Normanton Formation</td>
<td>Glauconitic sandstone with carbonaceous phases</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Early formations with in the Rolling Downs Group</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coen Inlier</td>
<td></td>
<td>Bulimba Formation</td>
<td>Proterozoic metamorphics and Palaeozoic granites and volcanics</td>
</tr>
</tbody>
</table>

Bauxite Development is dominantly upon the Bulimba Formation.

* Adapted from Taylor et.al 2008
Aurukun Bauxite Deposit is a chemical weathering product = Lateritisation;

In tropical regions with suitable bedrock, the ferruginous zone is replaced by an aluminous zone and bauxite develops;

Similarly if lateritisation occurs over an ultramafic there is potential for nickel laterites form.
## Bauxite Profile

<table>
<thead>
<tr>
<th>Bauxite Profile</th>
<th>Description</th>
<th>Photograph</th>
</tr>
</thead>
</table>
| **Zone 1**      | Topsoil - Grey, dry fines  
                 Fine dark nodules |            |
| **Zone 2/3**    | Reworked bauxite  
                 Higher fines and lower recoveries |            |
| **Zone 4**      | High Boehmite-gibbsite  
                 Higher hematite  
                 Dry & reddish (rusty)  
                 Range of pisolite/nodule sizes |            |
| **Zone 5**      | High Gibbsite, low Boehmte  
                 0 - 7 % Boehmite  
                 Moist & red-brown  
                 Very uniform, smaller pisolites |            |
| **Zone 6** – transition to kaolinite |             |            |
| **Zone 7**      | Iron-stained kaolinite  
                 If sampled, then zone 7,  
                 If not sampled but drilled,  
                 Then zone 8 |            |
| **Zone 8**      | Weakly mottled to pallid  
                 Kaolinite |            |
Bulk Density

- Density values obtained from pitting were previously used.
- Densities were updated with sonic drill results through the full bauxite profile over much wider proportion of the deposit.
Sonic Sampling “core sausage”

Retrieving the “core sausage”
Individual sausages are divided into quarters, each quarter represents \( \frac{1}{4} \) of a metre.
Profile Composition of bauxite with depth

Typical Mineralogical composition of bauxite profile with depth.

Average Zone SG

Zone 1 - Soil
  SG 3.0

Zone 2
  SG 2.7

Zone 3
  SG 5.3

Zone 4
  SG 2.4

Zone 5
  SG 2.6

Zone 6
  SG 1.77
Hard / Soft Boundaries

HARD BOUNDARIES - prevent assay data informing neighbouring domains, the domains are independent.

SOFT BOUNDARIES – permit assay data to inform neighbouring domains, the domains are related.

Aurukun Resource Model used a combination of soft and hard boundaries, determined by the Bauxite profile.
## Bauxite Profile

<table>
<thead>
<tr>
<th>ZONE</th>
<th>LITHOLOGY</th>
<th>RECOVERY</th>
<th>Ksi</th>
<th>Boehmite</th>
<th>Boundary Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Soil</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Reworked BX</td>
<td>Earthy</td>
<td>low</td>
<td></td>
<td>Hard</td>
</tr>
<tr>
<td>3</td>
<td>Reworked BX</td>
<td>Pisolitic</td>
<td>medium</td>
<td></td>
<td>Soft</td>
</tr>
<tr>
<td>4</td>
<td>In-situ BX</td>
<td>High Boehmite</td>
<td>high</td>
<td>high</td>
<td>Hard</td>
</tr>
<tr>
<td>5</td>
<td>In-situ BX</td>
<td>Low Boehmite</td>
<td>high</td>
<td>low</td>
<td>Soft</td>
</tr>
<tr>
<td>6</td>
<td>KAOLINITE</td>
<td></td>
<td>medium</td>
<td></td>
<td>Soft</td>
</tr>
<tr>
<td>7</td>
<td>KAOLINITE</td>
<td>Sampled</td>
<td>high</td>
<td></td>
<td>Hard</td>
</tr>
<tr>
<td>8</td>
<td>KAOLINITE</td>
<td>Unsampled</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The resource estimate was conducted in unfolded space.

This approach:

- Preserves the laterite profile characteristics (both horizontally and vertically) irrespective of thickness or orientation;
- Constrains informing samples for estimation into the zone(s) required and improves stationarity/domaining concerns; and
- Converts real RL to a relative position.
Block Models

- **Seam Model**
  - Cell has variable height following Layer B

- **Block Model**
  - Cell has fixed height but contains 22% layer A and 78% layer B
Unfolded Block Model

FOLDED

- Layer A
- Layer B
- Layer C

UNFOLDED

- Layer A
- Layer B
- Layer C
Folded Block Model

Folded Block Model

Unfolded Samples

Zone Description
1 soil
2 earthy reworked bx
3 pisolithic reworked bx
4 hi boehmite bx
5 low boehmite bx
6 kaolinitic bx
7 kaolinite
8 no sample
Resource Estimation - Sequence

1. Bauxite layers were generally above the economic cut-off, as such, the concentration of contaminants were considered more important to model;

2. Experimental variography was undertaken using unfolded data;

3. Modelled variograms were based on total silica, and confirmed as representative of all major elements in all layers;

4. To limit order relation issues a single modelled variogram is preferred;

5. Kriging neighbourhood analysis was carried out using the modelled silica variogram;

6. Estimation was conducted in unfolded space using ordinary kriging;

7. Relative block levels were re-set of original block levels thus re-folding the block model.
A number of selection criteria were used in consultation with the project engineers and owners to meet the JORC criteria for classification of the resource.

- Zone 1 (soil) & Zone 8 (unsampled Kaolinite) were excluded;
- Zone 2 to 7 were categorised in a two step process;
  - Vertical column selection using metallurgical and mining parameters.
  - Lateral resource categorisation based on estimation confidence parameters.
Resource Classification

The result is the vertical selection of intervals relating to reasonable prospects of economic extraction and classified as:

- **Mineable bauxite** – meets reactive silica, alumina recovery;
- **High silica bauxite** – meets alumina and recovery criteria but has high silica and is not internal waste within the mineable bauxite interval;
- **Thin bauxite** – meets the above criteria but is too thin.
Resource Classification

Only material classified as Mineable bauxite was subject to lateral classification which incorporated a number of outputs from the kriging run.

- number of informing samples;
- drill pattern density;
- average distance of informing samples;
- kriging variance for the silica estimation run.

Based on these parameters, "Mineable Bauxite" in high confidence areas were assigned as measured resource, low confidence areas were assigned as inferred resource and the remainder is as assigned as indicated resource.
Conclusions

- The resource estimation of the Aurukun lateritic deposits presented specific issues related to the lateral changes in thickness and elevation of the various zones within the deposit where the x and y dimensions are orders of magnitude greater than the z dimension.

- The solution was to do the resource estimation in “unfolded” space which maintains the zone layering irrespective of zone thickness or orientation. The block model estimation method was Ordinary Kriging done in unfolded space and then refolded.

- A number of selection criteria, developed in consultation with the project engineers and owners, were applied to the deposit to define resource categories.