SAFE SHIPPING OF BAUXITE
AGENDA

1. Background Information
2. GBWG Members & Objectives
3. Peer Review Process
4. Bauxite General Information
5. Research Methodology and Tests
6. Criteria for Classification of Bauxites
7. Bauxite Proctor Fagerberg Test for TML
8. Bauxite Classification Process
9. GBWG Recommendations
10. Safely Shipping Bauxite
## Background Info

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Jan</td>
<td>Bulk Jupiter Incident</td>
</tr>
<tr>
<td></td>
<td>Early '15</td>
<td>P&amp;I Clubs issue alert regarding the carriage of bauxite</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
<td>CCC2 / IMO Correspondence Group (CG) on bauxite properties was established</td>
</tr>
<tr>
<td></td>
<td>Oct</td>
<td>IMO issues circular regarding the carriage of bauxite</td>
</tr>
<tr>
<td></td>
<td>Dec</td>
<td>Key bauxite players start discussions on their technical research findings</td>
</tr>
<tr>
<td>2016</td>
<td>Feb</td>
<td>Formation of an informal industry group (GBWG)</td>
</tr>
<tr>
<td></td>
<td>Jun</td>
<td>GBWG meetings</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
<td>CCC 3 - IMO acknowledgement of GBWG and new CG</td>
</tr>
<tr>
<td>2017</td>
<td>Mar</td>
<td>GBWG draft report finalized and submitted for peer review</td>
</tr>
<tr>
<td></td>
<td>Apr</td>
<td>GBWG report peer review</td>
</tr>
<tr>
<td></td>
<td>May</td>
<td>GBWG peer reviewed report submitted to CG</td>
</tr>
<tr>
<td></td>
<td>Jun</td>
<td>CG report to CCC 4</td>
</tr>
<tr>
<td></td>
<td>Sep</td>
<td>CCC 4 – CG Workshop &amp; Present GBWG findings to IMO</td>
</tr>
</tbody>
</table>
# GBWG Members

<table>
<thead>
<tr>
<th>Company</th>
<th>Company Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rio Tinto</td>
<td>Dr Tim Evans</td>
</tr>
<tr>
<td>Rio Tinto</td>
<td>Mr Owen Lofthouse</td>
</tr>
<tr>
<td>Alcoa</td>
<td>Mrs Heloisa Ruggeri</td>
</tr>
<tr>
<td>Alcoa</td>
<td>Mr Gustavo Correia</td>
</tr>
<tr>
<td>Mineração Rio do Norte - MRN</td>
<td>Mr Cacio da Silva</td>
</tr>
<tr>
<td>Winning</td>
<td>Mr Lu Jian</td>
</tr>
<tr>
<td>Rusal</td>
<td>Cpt Kevin Cribbin</td>
</tr>
<tr>
<td>Oldendorff</td>
<td>Cpt Paul Jeffrey</td>
</tr>
<tr>
<td>South32</td>
<td>Mr Irshad Omar</td>
</tr>
<tr>
<td>Deltares</td>
<td>Mr Johan Pennekamp</td>
</tr>
<tr>
<td>Russell Geotechnical Inovations - RGI</td>
<td>Mr Chris Russell</td>
</tr>
<tr>
<td>Geotechnical Consulting Group</td>
<td>Dr Chris Menkiti</td>
</tr>
<tr>
<td>Geotechnical Consulting Group</td>
<td>Dr David Hight</td>
</tr>
<tr>
<td>Marin</td>
<td>MSc. Johan H. de Jong</td>
</tr>
<tr>
<td>Pimenta De Avila Consultoria</td>
<td>Mr Joaquin Pimenta de Avila</td>
</tr>
<tr>
<td>Castello, Misorelli Corporate Affairs</td>
<td>Mr Robin Castello</td>
</tr>
</tbody>
</table>
GBWG Objectives

• Conduct research on the behaviour and characteristics of seaborne traded bauxites
• Determine science based, globally applicable criterion for the safe shipping of bauxites (Group A, Group C)
• Determine a global applicable TML test for Group A bauxites
• Have the research outcomes peer reviewed for submission to CCC4 (Sept 2017)
Peer Review Process

- Third-Party Peer Review
  - Imperial College
  - IAI

- Correspondence Group
  - CG Coordinator
  - Competent Authorities
    - Australia
    - Brazil
  - Other CG Members

- Global Bauxite Working Group
  - MRN
  - Rio Tinto
  - South32
  - Alcoa
  - Winning

- CCC4 (Sept/17)
Sources of Bauxite in the World

Bauxite is the primary aluminum ore for most of the world’s production of aluminum.

Investigated bauxites cover +90% of seaborne trade.

<table>
<thead>
<tr>
<th>Vessel Size</th>
<th>% By Tonnage</th>
<th>% By Voyage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handymax</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Panamax</td>
<td>80</td>
<td>75</td>
</tr>
<tr>
<td>Capesize</td>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>
Particle Size Distribution (PSD)
Research Methodology

- Laboratory Analysis & Testing
- Vessel Monitoring
- Cargo Observations
- Scale Model Testing
- Numerical Modeling
Research Tests Included

- **Cyclic Triaxial Tests**
  - Extreme case vessel motions
  - Saturated, Undrained (Worst Case)
  - Bauxites Resistance to Liquefaction
  - Identifies amount of straining

- **Hexapod Tests (1G)**
  - Sea state and worse case roll motions
  - High moisture contents but drained
  - Confining Pressure not scaled
  - Identifies any instability due to moisture

- **Dynamic Centrifuge Tests (50G)**
  - Worst case rolling motions
  - High moisture contents but drained
  - Confining Pressure scaled
  - Identifies any instability due to moisture
Criteria for Classification of Bauxite

Determine science based, globally applicable criterion for the safe shipping of bauxites (Group A, Group C)
Bauxite Proctor-Fagerberg Test

Determine a global applicable TML test for Group A bauxites

- Proposed Bauxite Proctor-Fagerberg Test (PFT) involves:
  - 150mm diameter “CBR” mould as per BS1377 and ASTM1883
  - Utilises standard D hammer based on compaction conditions measured in bauxite cargoes
  - Sample screening and reconstitution to provide a test top size limits but still representing the as shipped material

![Graph showing void ratio vs. gross moisture content](image)

- If OMC $S < 90\%$:
  - TML at 70% saturation
- If OMC $S > 90\%$:
  - TML at 80% saturation
Bauxite Classification Process

Determine Particle Size

% Passing
1mm ≤ 30%
2.5mm ≤ 40%
OR BOTH

Y

N

Proctor-Fagerberg Test

Saturation achieved 70% or more?

N

Y

Group C

Group A
GBWG Recommendations

- Proposed draft schedule for BAUXITE FINES Group A for consideration of inclusion in the IMSBC code
- Proposed modification to the existing schedule for BAUXITE Group C for consideration
- Proposed bauxite Proctor-Fagerberg Test methodology for consideration of inclusion in Appendix 2 of the IMSBC code.

- Consideration be given to the classification category of Group A “liable to liquefy” cargoes as other cargo instabilities due to moisture also need to be considered.
- Group A classification should be for cargoes which may have hazards arising from cargo instability due to moisture.
Improved Safety

• Compliance to proposed bauxites schedules will ensure bauxites are safely shipped into the future.
• Insights of the instabilities due to moisture occurring in bauxite offers improved safety in cases where bauxite cargo has been mis-declared.
• Better understanding by seafarers on the effect of a dense free slurry surface formation on the vessels behaviour.
From Cargo Instability to Capsize
Vessel Behaviour due to FSE
Thank you for your attention!