The JORC Code 2012 (Clause 49)

Its significance for economic industrial mineral deposits

MGEI 7th ANNUAL CONVENTION
Indonesia’s Mineral and Coal Resources: Discovery to Inventory
Balikpapan

Andrew Scogings, PhD Geology
Principal Consultant, CSA Global Pty Ltd
Setting the scene
Presentation outline

• What are industrial minerals?
• The JORC Code 2012 Clause 49 (mineral specifications)
• Bentonite market examples and specifications
• Bentonite Resource example
• Graphite Resource example
• Conclusions.

JORC 2012 Clause 49
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Density

General perspective of the industrial minerals space
What are industrial minerals?

- Minerals and Rocks mined and processed for the value of their non-metallurgical properties
- Natural or synthetic
- Natural: Clays, sand, stone aggregate, talc, limestone, gypsum, feldspar, mica, chromite, graphite
- Synthetic: Calcium carbonate, soda ash, graphite.
Where are industrial minerals used?

Numerous everyday items. Incorporated in the final product, or used in the manufacturing process:

- **Glass & Ceramics** - Clay, Silica, Limestone, Feldspar, Zircon, Soda Ash, Talc
- **Paint & Plastic** - Talc, GGC, Kaolin, Mica
- **Wine, Beer, Fruit Juice** - Diatomite, Perlite, Bentonite
- **Table Salt** - Halite
- **Metal Casting** - Silica Sand, Bentonite
- **Cement** - Limestone
- **Batteries** - Graphite
- **Oil Drilling** – Barite, Bentonite.
How important are markets?

- “Without a market, an Industrial Mineral deposit is merely a geological curiosity”
- “Without a potential market, there can be no resource; without a good knowledge of the planned market (volume, price and competition), there is no reserve”

Border and Butt (2014).
The JORC Code 2012
Clause 49

REPORTING OF INDUSTRIAL MINERALS EXPLORATION RESULTS, MINERAL RESOURCES AND ORE RESERVES

44. Industrial minerals are covered by the JORC Code if they meet the criteria set out in Clauses 5 and 6 of the Code. For the purpose of the JORC Code, industrial minerals can be considered to cover commodities such as kaolin, phosphate, limestone, talc, etc.

When reporting information and estimates for industrial minerals, the key principles and purpose of the JORC Code apply and should be borne in mind. Assays may not always be relevant, and other quality criteria may be more applicable. If criteria such as deleterious minerals or physical properties are of more relevance than the composition of the bulk mineral itself, then they should be reported accordingly.

The factors underpinning the estimation of Mineral Resources and Ore Reserves for industrial minerals are the same as those for other deposit types covered by the JORC Code. It may be necessary, prior to the reporting of a Mineral Resource or Ore Reserve, to take particular account of certain key characteristics or qualities such as likely product specifications, proximity to markets and general product marketability.

For some industrial minerals, it is common practice to report the saleable product rather than the ‘as-mined’ product, which is traditionally regarded as the Ore Reserve. JORC’s preference is that, if the saleable product is reported, it should be in conjunction with, not instead of, reporting of the Ore Reserve. However, it is recognised that commercial sensitivities may not always permit this preferred style of reporting. It is important that, in all situations where the saleable product is reported, a clarifying statement is included to ensure that the reader is fully informed as to what is being reported.

Some industrial mineral deposits may be capable of yielding products suitable for more than one application and/or specification. If considered material by the reporting company, such multiple products should be quantified either separately or as a percentage of the bulk deposit.

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Reporting of Industrial Minerals Exploration Results, Mineral Resources and Ore Reserves

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Some industrial mineral specifications

- Industrial minerals are classified according to market specifications, which may include:
  - mineralogy
  - purity
  - particle size distribution
  - colour
  - density
  - thermal resistance, etc.
# JORC Code (2012) – Clause 49

Graphite price related to specifications (purity and flake size)

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<tr>
<th>Graphite type</th>
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<th>Particle size</th>
<th>Description</th>
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Bentonite market examples
Bentonite – what is it?

Clay derived from volcanic ash. Exchangeable cations Na, Ca, Mg

Sandstone

Tuff

Bentonite 2m

www.csaglobal.com
Bentonite – what is it?

Bentonite generally mined opencast
Bentonite – what is it?

Bentonite and rhyolite
Bentonite features

- Montmorillonite plus impurities such as quartz, feldspar, calcite, zeolite
- Absorbs water
- Swells when wet
- High surface area
- Natural ‘glue’ or binder
- May retain structural water to >600°C.
Bentonite markets

Iron ore pellets (water absorption, green strength)
Bentonite markets

Foundry sand (strength, thermal durability)
Bentonite markets

Greensand mould

Metal casting
Bentonite markets

Geosynthetic clay lining of a basement (free swell, permeability)
Bentonite markets

Geosynthetic clay lining of a tunnel (free swell, permeability)
Bentonite markets

Cat litter (clump strength, odour absorption, colour)
Bentonite markets

Drilling mud (viscosity, fluid loss and barrel yield)
Bentonite markets

Edible oil purification (decolourising ability)

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Bentonite markets

Specification examples

- Drill grade 1  12-15 ml Fluid Loss
- Drill grade 2  15-18 ml Fluid Loss
- Geosynthetic liner  <18 ml Fluid Loss, >24 ml Free Swell
- Iron ore pellets 1  >700% Water Plate
- Iron ore pellets 2  600-699% Water Plate

- Note that none of these specifications stipulate CEC, or purity of the clay. However some markets such as paper may require high CEC
Bentonite markets

Bentonite test methods - examples

- Free Swell: 25 ml, 32 ml
- Viscosity & Fluid Loss
- Foundry Sand Strength
- Clump Strength

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Bentonite markets

Test methods – Thermal durability

TGA

Sample R12-0576

Temperature (°C)

Weight (%)

695.38°C
98.26%

Residue
94.91%
(16.91mg)

Deriv. Weight Change(%/°C)

0.04

0.03

0.02

0.01

0.00

-0.01

0 200 400 600 800 1000

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Sample testing conclusions – The JORC Code 2012 Clause 49

- Assays may not always be relevant, and other quality criteria may be more applicable.
- If criteria such as deleterious minerals or physical properties are of more relevance than the composition of the bulk mineral itself, then they should be reported accordingly.
Bentonite resource example
Bentonite resource

Cross section

2 metres thick
Bentonite resource

Cation Exchange Capacity (meq) | Depth to Bentonite (m)

Drill collars (30m spacing)
Bentonite resource

Moisture (%)

Depth to Bentonite (m)

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Hypothetical Resource estimate based on CEC (~purity)

- 175,000 tonnes of bentonite at 25% moisture
- CEC = 80 meq/100g

- But this doesn’t tell us what we can potentially use the clay for.....therefore this is not a mineral resource according to Clause 49
Bentonite resource

pH

Depth to Bentonite (m)
Bentonite resource

Free Swell (mL/2g)  
Depth to Bentonite (m)
Bentonite resource

Unoxidised (blue) bentonite at depth

Yellow bentonite  Blue bentonite
Bentonite resource

Oxidised (yellow) or unoxidised (blue) bentonite

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Hypothetical resource estimate based on other parameters

- 175,000 tonnes of bentonite at 25% moisture
- CEC = 80 meq/100g
- Very high thermal durability and good bond strengths indicate that 100% can be used for foundry
- By the addition of soda ash and polymers, 75% can be used for drilling mud and geosynthetic clay liners
- None of the bentonite can be used for edible oil purification, paper manufacture or high yield drilling mud
- There are local and export opportunities
- This is a Mineral Resource in terms of Clause 49.
Some industrial mineral deposits may be capable of yielding products suitable for more than one application and/or specification.

If considered material by the reporting company, such multiple products should be quantified either separately or as a percentage of the bulk deposit.
Graphite example
Graphite resource example

- 20 Mt at 10% graphitic carbon
- Contains 2 Mt of *in situ* flake graphite
- However this tells us nothing about:
  - Flake size distribution
  - Flake purity
  - How much graphite can be liberated from the rock
  - Impurities that may impact on mineral processing
  - How much market share we can get (total natural graphite produced in 2014 = 1.2 Mt).
Graphite production & markets

<table>
<thead>
<tr>
<th>Country</th>
<th>2014 Production</th>
</tr>
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<tbody>
<tr>
<td>China</td>
<td>825,000</td>
</tr>
<tr>
<td>Brazil</td>
<td>95,000</td>
</tr>
<tr>
<td>North Korea</td>
<td>70,000</td>
</tr>
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<td>Canada</td>
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<tr>
<td>Mexico</td>
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</tr>
<tr>
<td>Russia</td>
<td>14,000</td>
</tr>
<tr>
<td>Ukraine</td>
<td>12,000</td>
</tr>
<tr>
<td>Norway</td>
<td>8,000</td>
</tr>
<tr>
<td>Zimbabwe</td>
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<tr>
<td>Madagascar</td>
<td>5,000</td>
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<tr>
<td>Sri Lanka</td>
<td>4,000</td>
</tr>
<tr>
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</tr>
<tr>
<td>Germany</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1,126,000 t</strong></td>
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Graphite production by market:
- **Refractories**: 36%
- **Batteries**: 11%
- **Metallurgy**: 25%
- **Lubricants**: 10%
- **Parts and components**: 10%
- **Others**: 8%
### Graphite refractory markets

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<th>Product</th>
<th>Flake Graphite quality (Carbon content)</th>
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<td>Magnesia / Dolomite Carbon bricks</td>
<td>90 to 95%</td>
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<td>Alumina Magnesia Carbon bricks</td>
<td>92 to 94%</td>
<td>&lt; 100 mesh</td>
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<tr>
<td>Isostatically pressed parts for steel making</td>
<td>90 to 99%</td>
<td>&lt; 100 to &gt;50 mesh</td>
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<td>Graphite-containing crucibles</td>
<td>85 to 96%</td>
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<td>Unshaped refractories. Carbon bonded mixes</td>
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Product marketability conclusions – The JORC Code 2012 Clause 49

• *It may be necessary, prior to the reporting of a Mineral Resource or Ore Reserve, to take particular account of certain key characteristics or qualities such as likely product specifications, proximity to markets and general product marketability.*
Graphite geology

Graphite deposits – mostly in graphite schist opencast
Graphite geology

Graphite deposits – sometimes in graphite schist underground
Not all graphite can be recovered
Graphite resource

Graphite mineral resource – ‘High’ and ‘Low’ grade zones

High grade
>5% TGC

Low grade
>2% TGC
Graphite resource

‘Low Grade Zone’ >2% cut-off

‘High Grade Zone’ >5% cut-off

1 mm

Biotite

Thin graphite flakes

NRD14-067 22.3

1 mm

Thick graphite flakes

NRD14-067 30.1
Graphite resource

Oxide Zone - Jarosite, Clay, Opaline silica

Graphite

Jarosite

NRD14-067 9.5

Opaline silica / clay

200 µm

Split graphite

NRD14-067 16.2
Graphite resource

Transitional Zone - Kaolinised sillimanite, pyrite

Sillimanite & clay

Split graphite

1 mm

100 μm

Pyrite

NRD14-067 39.3

NRD14-067 39.3
Graphite resource

Fresh Zone – Fe sulphides, unaltered sillimanite

NRD14-141D 74.6

Pyrite

Unaltered Sillimanite

NRD14-141D 79.9
Conclusions
Conclusions

The JORC Code 2012 (Clause 49)

- Clause 49 of the JORC Code 2012 states that industrial mineral resources must be reported by specification.
- If multiple products are possible within a deposit, such products should be identified and quantified.
- Specific market-related testing is likely to be required when reporting an industrial mineral resource.
- It is not sufficient to rely just on assays, as commonly used in metals resource reporting.
- Proximity to markets, and general product marketability, should be considered in terms of ‘eventual economic extraction’.
Thank you

The support of MGEI, CSA Global, IMX Resources, Kibaran Resources and AMCOL is gratefully acknowledged