Public reporting of industrial minerals resources according to JORC 2012

The current edition of the JORC Code was published in 2012, and after a transition period the 2012 edition came into mandatory operation from 1 December 2013. There are some significant changes for the reporting of industrial mineral resources between JORC 2004 and 2012, which should be addressed by players in the industrial minerals arena.

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Recent interest in industrial minerals

Industrial minerals, such as graphite and spodumene, have recently become the focus of much attention for listed exploration and mining companies, partly due to developments in battery technologies related to the emerging electric vehicle market. Consequently, the race has been on to report larger tonnage exploration targets and resources, with certain projects being described, for example, as the "biggest" or "second biggest" in the world; perhaps hundreds of millions of tonnes that contain a certain percentage of a particular mineral. However, being the biggest doesn't necessarily mean the best. The author's intention is to highlight the need to report resources by market-related specification.

As noted in **IM**, "Without a market, an industrial mineral deposit is merely a geological curiosity." Too many industrial minerals explorers forget the significance of this, which is a bit like a geochemical anomaly in metals exploration that remains a geochemical anomaly and never becoming a mineable resource.

JORC 2012 – Reporting resources and reserves according to specifications

The fundamental difference between JORC 2004 and 2012 is contained in an all-important new paragraph in Clause 49, which requires that industrial mineral resources or reserves must be reported in terms of mineral specifications:

"For minerals that are defined by a specification, the mineral resource or ore reserve estimation must be reported in terms of the mineral or minerals on which the project is to be based and must include the specification of those minerals."

Further references to specifications are found in the JORC 2012 guidelines, of which excerpts are listed below:

"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."

"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."

It is significant to note that the word "specification" is referred to no less than four times in Clause 49, demonstrating its significance in reporting according to JORC 2012.

Examples of industrial mineral specifications

Industrial minerals which are commonly defined according to size and/or purity specifications include andalusite, chromite, graphite, kaolin, limestone, magnesite and vermiculite. Other minerals and clays, such as attapulgite and bentonite, may be specified according to final product sizing, but more importantly, specified according to performance in particular markets and applications such as oil well drilling, cat litter, metal casting and iron ore pelletising.

A quick glance at the price listings in **IM** highlights that different specifications and markets very likely command a range of prices. For example, crystalline graphite may range from $700/tonne (medium flake +100-80 mesh, minimum 85% C, FCL European port) to as much as $1,300/tonne (large flake +80 mesh, minimum 94% C, FCL European port). It is clear that such price variations could have a significant impact on the economics of an industrial minerals project.

Similarly, chromite varies significantly in price according to specification and markets; from $300/tonne for chemical grade to $500/tonne for refractory grade (FOB South Africa). The chromite price is generally directly related to specifications such as particle size, SiO_2 content and Cr/Fe ratio.

From the above examples it is obvious that when publicly reporting an industrial mineral resource, it is insufficient to simply report a tonnage and the contained percentage of the mineral. Not only is this contrary to JORC 2012 requirements but it could be misleading to investors. Let us take the case of a hypothetical graphite resource reported as 200m tonnes at 10% graphite. Essentially, all this tells us is that the resource contains 10% in-situ flake graphite, but it tells us nothing about, i) the size range of graphite flakes, ii) the likely purity of extracted graphite flakes, iii) impurities such as sulphides that may impact on mineral extraction, nor, iv) possible markets.

The same would apply to a vermiculite deposit, where flake size and exfoliation characteristics are required to be reported. In the case of clay, such as bentonite, simply reporting a tonnage based on purity measurement (e.g. cation exchange capacity or

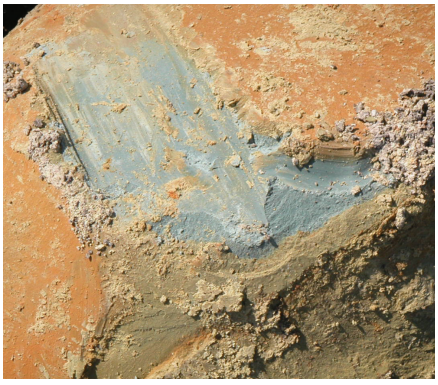


Figure 1: Turkish bentonite, illustrating oxidised yellow rind around remnant blue bentonite core. The yellow bentonite has improved drilling product performance.

XRD mineralogy indicative of montmorillonite content) conveys no information as to possible market applications, if any. Individual bentonite deposits may have similar montmorillonite content, but perform entirely differently in markets as diverse as paper manufacturing, metal casting or oil well drilling. Bentonite quality may also be affected by depth of weathering, whereby "blue" bentonite is oxidised to a yellow colour at shallow depths and may have improved performance in drilling products, despite having identical CEC and montmorillonite content as other bentonite deposits (*Figure 1*).

Appropriate quality tests (assays)

The responsibility falls on the competent person to ensure that exploration samples are tested for appropriate parameters in addition to basic tests for mineral content.

- Individual or appropriate composite samples should be evaluated according to size, purity of extracted minerals and/or market performance specifications.
- It may be difficult to find a commercial lab that can run such tests, as most industrial minerals testing is done in-house by producers. Either a current producer may be approached to test the samples, or test methods will have to be developed internally.
- Some test methods are industry standards, such as bentonite slurry viscosity, and are available from bodies like the American Petroleum Institute.

For example, bentonite may be characterised by a number of metrics such as purity, chemistry and exchangeable cations:

- Moisture in-situ and "as tested"
- Purity – Montmorillonite vs Inert Minerals (Cation Exchange Capacity)
- Ca, Mg and Na Exchangeable Cations
- XRF (chemistry)
- XRD (mineralogy)
- Swelling in Water
- pH

However, these measures do not necessarily indicate how the clay might perform in various applications and so a range of tests may be required to determine market opportunities, including:

- Water absorption (iron ore and chromite pelletising).
- Viscosity and fluid loss (drilling mud).
- Thermal stability by TGA (metal casting) - refer to Figure 2.
- Green, dry and wet tensile strength (metal casting).
- Clump Strength (cat litter).
- Acid Activation (edible oil purification).
- Brightness (paper, detergents).

Reporting of industrial minerals exploration results, mineral resources and ore reserves (JORC 2012, Clause 49)

Industrial minerals are covered by the JORC Code if they meet the criteria set out in Clauses 6 and 7 of the Code. For the purpose of the JORC Code, industrial minerals can be considered to cover commodities such as kaolin, phosphate, limestone and talc.

For minerals that are defined by a specification, the mineral resource or ore reserve estimation must be reported in terms of the mineral, or minerals, on which the project is to be based, and must include the specification of those minerals.

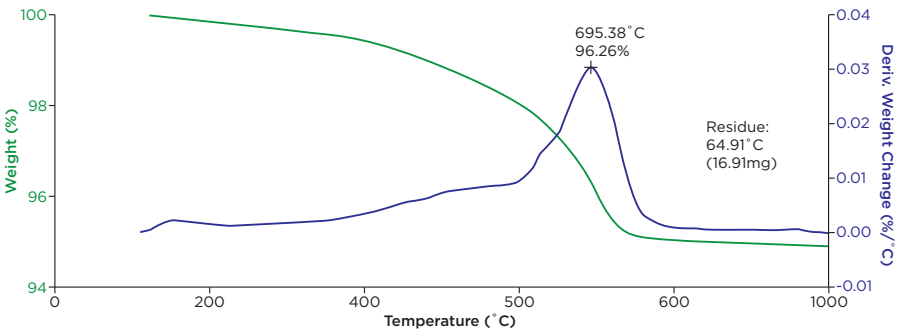
When reporting information and estimates for industrial minerals, the key principles and purpose of the JORC Code apply and should be borne in mind. Assays may not always be relevant, and other quality criteria may be more applicable. If criteria such as deleterious minerals or physical properties are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

Figure 2: TGA analysis of an Australian bentonite, indicating maximum dehydroxylation at 695°C - indicative of high thermal durability for metal casting applications.



Conclusions

When publicly reporting industrial minerals resources or reserve estimations according to JORC 2012:

- It is no longer sufficient to simply report a resource of contained industrial minerals.
- The estimation must include the specification of those minerals if those minerals are defined by a specification.
- If multiple products are possible from a deposit, such multiple products should be quantified either separately or as a percentage of the bulk deposit. A typical example could be a bentonite deposit that yields metal casting and drilling products from different parts of the deposit based on weathering domains.
- Proximity to markets and general product marketability should be taken into account.
- Specific market-related testing and/or process test work is very likely to be required for industrial minerals deposits. It is not good enough to rely solely on traditional mineralogical or chemical purity (assay grade) tests as commonly used in metals exploration.

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