Public reporting of industrial minerals resources according to JORC 2012
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Introduction
The current edition of the Australasian Joint Ore Reserves Committee Code (JORC Code) was published in 2012 and after a transition period, came into mandatory operation from 1 December 2013.

The 2012 edition has made some significant changes to the requirements regarding the reporting of industrial mineral resources that should be addressed by players in the industrial minerals space.

Although the definition of industrial minerals is far from straightforward, a commonly used definition is ‘any rock, mineral or other naturally occurring substance of economic value, exclusive of metallic ores, mineral fuels and gemstones: one of the non-metallics’ (Bates, 1975). Essentially they are minerals and rocks mined and processed for the value of their non-metallurgical properties.

Industrial minerals are commonly classified according to their end uses, where there are a diverse (and sometimes bewildering) number of specifications, for example chemical purity, mineralogy, particle size distribution, whiteness, density, water absorption, thermal resistance, rheology and insulating properties.

This extreme diversity of products and markets can make it difficult for explorers to select appropriate tests and specifications for industrial minerals deposits.

Recent interest in industrial minerals
Industrial minerals such as phosphates, potash, graphite and spodumene have recently become the focus of much attention for listed exploration companies, particularly the latter two due to developments in battery technologies related to the emerging electric vehicle and green energy market.

Consequently the race has been on to report larger industrial mineral exploration targets and resources, sometimes being described for example as ‘the biggest or second biggest in the world’, or ‘world-class’ with perhaps hundreds of millions of tonnes containing a certain percentage of a particular mineral. However, being the biggest doesn’t necessarily mean being the best and the author’s intention is to highlight the need to report resources by market-related specifications, as such headline claims run the risk of being seen as misleading by investors and regulators.

Caution should be exercised to ensure that headline and details in public reports reflect the state of knowledge and the viability of successfully developing a resource or reserve, having taken account of all relevant ‘modifying factors’. In this regard, attention is drawn to CIM (2003) guidelines page 37, where the issue of market size and technical barriers to entry is addressed:

‘Market considerations incorporate not only the requirement for detailed market analyses and/or contracts of sale, necessarily signify that extraction facilities are in place or operative, or that all necessary approvals or sales contracts have been received. It does signify that there are reasonable grounds to expect that such approvals or contracts will eventuate within the anticipated time frame required by the mine plans. There must be reasonable grounds to expect that all necessary government approvals will be received’.

The Code goes on to advise that ‘The Competent Person should highlight and discuss any material unresolved matter that is dependent on a third party on which extraction is contingent. If there is doubt about what should be reported, it is better to err on the side of providing too much information rather than too little’.

This article is based on the author’s paper ‘Reporting and Converting Resources to Reserves – how confident are we?’, published in the recently released Monograph 30 – Mineral Resource and Ore Reserve Estimation – the AusIMM Guide to Good Practice (Chapter 9 – Classification and Reporting).

References
but also recognition that markets for many industrial minerals are relatively small, may have a high degree of producer concentration, or may have very high technical barriers to entry, thus imposing limits or constraints on achievable market volumes’.

As noted on the website of *Industrial Minerals Magazine*, ‘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 the geochemical anomaly in metals exploration that remains a geochemical anomaly and never becomes a mineable resource.

**JORC 2012 – reporting industrial mineral Resources and Reserves according to specifications**

The fundamental difference between JORC 2004 (Clause 44) and JORC 2012 (Clause 49) 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 from Clause 49 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 noteworthy that the word ‘specification’ is referred to no less than four times in Clause 49, demonstrating its significance in public reporting according to JORC 2012.

**Examples of industrial mineral specifications**

Industrial Minerals that are commonly defined according to size and/or purity specifications include andalusite, barite, chromite, feldspar, graphite, kaolin, limestone, magnesite, phosphates, potash, silica, vermiculite, wollastonite and zircon. Other minerals and clays such as attapulgite and bentonite may be specified according to final product sizing, but more importantly 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 Listing’ pages in *Industrial Minerals Magazine* (March 2014, p 72-75) highlights that different specifications and markets command a range of prices (Table 1). 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 (Table 2). The chromite price is generally directly related to specifications such as particle size, SiO₂ content and Cr/Fe ratio.

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 mislead investors.

Let us take the case of a hypothetical flake graphite resource reported as 200 Mt at ten per cent graphite. Essentially all this tells us that the resource contains ten per cent, or 20 Mt of in-situ flake graphite, but it tells us nothing about:

1. the size range of graphite flakes
2. the likely purity of extracted graphite flakes
3. impurities such as sulfides that may impact on mineral extraction
4. possible markets, which may be relatively limited compared with the reported resource.

The same would apply to a vermiculite deposit, where flake size and exfoliation or expansion 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 (CEC) or 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 (Figure 1).

Industrial mineral performance or size classification can be affected by the drilling method used, something that is not always recognised by industrial minerals explorers. For example, drilling bentonite by auger may improve rheological properties due to the shearing effect imparted by the auger flights. This is akin to extruding the clay through a die plate, a method sometimes used to improve rheological properties. Similarly, reverse cycle (RC) drilling will very likely result in reduced flake size of minerals such as graphite and vermiculite, or in changed aspect ratio of acicular wollastonite, resulting from comminution by the hammer action of the drill bit. Based on the author’s experience, RC drilling may reduce the average size and population distribution of mineral flakes significantly compared with diamond core drilling (DD) as illustrated in Figure 2.

Appropriate quality tests (assays)

Responsibility falls on the Competent Person to ensure that exploration samples are tested for appropriate parameters in addition to basic tests for mineral content. As noted in JORC 2012 Clause 49 guidelines:

‘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.’

Therefore, 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 or commercial laboratory 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.

Other test methods may be obtained from institutions such as the British Geological Survey (e.g., Mitchell, 1993).

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

Figure 1. Turkish bentonite in hand specimen, illustrating oxidised yellow rind around remnant blue core. The yellow bentonite has higher viscosity in drilling applications. (Source: AMCOL Mineral Madencilik A S.)
• moisture in-situ and ‘as tested’
• purity – montmorillonite versus inert minerals (CEC)
• Ca, Mg and Na exchangeable cations
• XRF (chemistry)
• XRD (mineralogy)
• swelling in water
• pH
• grit.

However, these measures don’t necessarily indicate how the clay might perform in various applications; therefore a range of tests may be required to determine market opportunities:

• weight gain in water (iron ore pelletising)
• viscosity and fluid loss (drilling mud)
• thermo gravimetric analysis (metal casting) – refer to Figure 3
• green, dry and wet tensile strength (metal casting)
• clump strength (cat litter)
• acid activation (edible oil purification)
• lees formation (fining of wine)
• toxin adsorption (animal feed).

**Conclusion**

Clause 49 of JORC 2012 is a welcome and timely improvement to Clause 44 of JORC 2004.

When publicly reporting industrial mineral resource or reserve estimations according to JORC 2012, (effective since December 2013):

• It is no longer sufficient to simply report a resource of contained industrial mineral.
• The resource estimation must include the specification of those minerals, if those minerals are defined by a specification.
• If multiple products are possible from a deposit, these 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.
• The drilling method used should be appropriate for the mineralisation style. Be aware of the possible effects of drilling methods such as RC, rotary air blast and auger compared with core air drilling or bulk samples.
• Specific market-related testing and/or metallurgical (mineral processing) testwork are 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 such as commonly used in metals exploration.
• Commercial laboratories may not be equipped to test minerals to industry specifications. In this case test procedures could be developed either in-house or in conjunction with a commercial lab. Samples may alternatively be submitted to an existing industrial minerals producer or potential customer, for example a greensand foundry in the case of bentonite.

• Proximity to markets and general product marketability should be taken into account.

**References**


