membership for reporting purposes, notify the societies and subject themselves to a peer review prior to the publication of the work. This peer review entails confirming that they are members of the societies in the category they claim and have the necessary qualification and experience to undertake this assignment as a CP. However it does not mitigate against the individual producing work that is substandard. Should the individual complete substandard work and a complaint is laid, they will be subject to the disciplinary process.

Issues regarding the rewrite are discussed at a monthly meeting of the SAMREC Working Group (WG) chaired by Ken Lomberg (ken.lomberg@coffey.com) held on the last Thursday of each month at the Military Museum in Saxonwold. All interested parties are invited to participate. This is also provides an opportunity for the industry to highlight aspects that may need to be reviewed or improved upon. We would like to encourage all interested parties to submit any issues relevant to the re-write of the SAMREC Code via the SAIMM (sam@saimm.co.za) by 30 June 2014. The intention is to complete a draft for public comment by the end of Q3 2014.

Once a draft has been finalised it will be issued for comment prior to being ratified by the SAMREC. SAMVAL Committee (SSC). It is also the intention of the SAMREC WG to prepare a companion volume which would include the practical application of the code and assist to provide a bench mark for all the industry practices. This is likely to be a volume that is produced after launch of the code as the proceedings of a SAMREC conference.

Ken Lomberg

industrial minerals

Industrial Minerals – Reporting Resources according to Clause 49 of JORC 2012

The current edition of The Australasian Joint Ore Reserves Committee (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 between JORC 2004 and 2012 for the reporting of industrial mineral resources, which should be addressed by players in the industrial minerals space.

Industrial Minerals Definition

Industrial minerals are essentially minerals and rocks mined and processed for the value of their non-metallurgical properties, hence for the benefits they impart to the products and processes in which they are used. 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, density, insulating properties, mineralogy, particle shape, particle size distribution, thermal resistance, rheology, whiteness and oil or water absorption.

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 tonnage exploration targets and resources, with certain projects being described, for example, as *the biggest* or *second biggest* in the world, *world class* or *highest grade* and 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 specification (Scogings, 2014a, 2014b, 2014c) as such headline claims run the risk of being seen as misleading by investors and regulators.

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. Similarly, as noted by Border and Butt (2014) concerning the modifying factors for industrial minerals "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".

JORC 2012 – Reporting Resources and Reserves according to Specifications

The fundamental difference between JORC 2004 (Clause 44) and 2012 (Clause 49) is contained in an all-important new paragraph, which requires that Industrial Mineral Resources or Reserves must be reported in terms of mineral specifications when:

'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 noteworthy 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, Barytes, Chromite, Feldspar, Graphite, Limestone, Magnesite, Silica, Vermiculite, Wollastonite and Zircon. Other minerals and clays such as Attapulgite, Bentonite and Kaolin may be specified according to final product sizing and purity, but more importantly according to performance in particular markets and applications as diverse as civil engineering, oil well drilling, cat litter, metal casting, iron ore pelletising, paint, paper and plastics.

Bentonite waterproofing membrane inside a tunnel has to meet permeability specifications.

Greensand' used to make metal-casting moulds, in which silica sand is bonded by bentonite.

A quick glance at the Price Listing pages in Industrial Minerals Magazine (April 2014) highlights that different specifications and markets command a range of prices (Table 1). For example barytes for use as a weighting agent in drill muds varies between US$ 110 and US$150 per tonne FOB Chennai according to SG. High brightness, high purity barytes for paint applications commands even higher prices, up to US$400 per short ton.

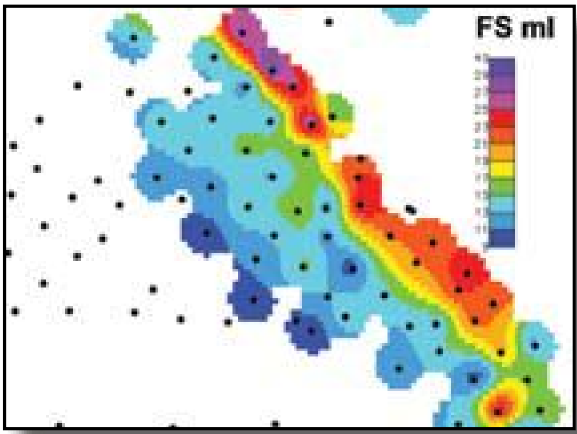
Similarly chromite sand varies significantly in price according to specification and markets, from US$230 per tonne for chemical grade to US$500 per tonne for refractory grade FOB South Africa. The chromite price is generally directly related to specifications such as particle size, SiO_2 and Cr_2O_3 content and Cr/Fe ratio and is driven by overall market conditions.

Of particular importance in today's industrial minerals arena, crystalline graphite may range from US$750 per tonne to as much as US$1300 per tonne. It is clear that such price variations could have a significant impact on the economics of a graphite project, especially considering the wide range of possible markets e.g. friction linings, lubricants, electrical, refractories and foundries.

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 flake graphite resource reported as 200 million tonnes at 10% graphitic carbon. Essentially all this tells us that the resource contains 20 million tonnes of in-situ flake graphite, but it conveys nothing specific to us about: 1) graphite flake size distribution, 2) the likely purity of extracted graphite flakes, or 3) markets, which may be limited relative to the size of the deposit.

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, reporting a tonnage simply based on purity measurements (e.g. Cation Exchange Capacity or XRD mineralogy) conveys little useful 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 manufacture, metal casting or oil well drilling. Bentonite quality may also be affected by depth of weathering, whereby 'blue' bentonite is oxidised to 'yellow' bentonite at shallow depths. Such oxidised clay may have improved performance for certain applications, despite having identical CEC and montmorillonite content.

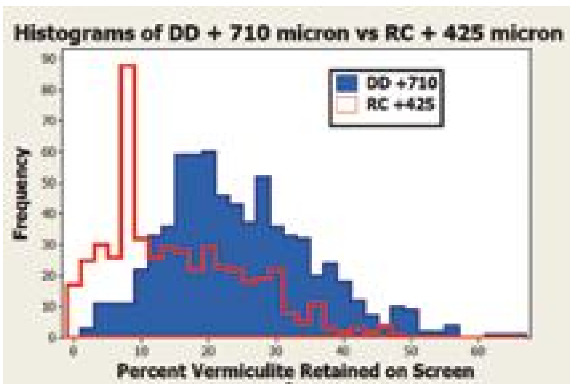
Turkish bentonite illustrating oxidised yellow rind around remnant blue bentonite core



Map of a bentonite deposit. Oxidised bentonite has high Free Swell >20 whereas unoxidised bentonite has Free Swell <10. Strike length 350m

Exploration Methods – Possible Impact on Specifications

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 for drilling products. Similarly, reverse cycle (RC) drilling will most likely result in reduced flake size of minerals such as graphite and vermiculite, or in reduced aspect ratio of acicular wollastonite, resulting from comminution by the hammer action of the drill bit. Based on the authors' experience, RC drilling may reduce the average size and population distribution of mineral flakes significantly compared with diamond core drilling (DD) as illustrated below



Histograms of two sample populations across a vermiculite deposit: DD mean value = 24.5%; RC = mean value of 15.5% vermiculite.

Table 1. Selected industrial mineral prices. (Industrial Minerals Magazine, April 2014.)

Barytes	**US$**
OCMA/API bulk lump, SG 4.2, FOB Chennai	135-150
OCMA/API bulk lump, SG 4.1, FOB Chennai	110-130
Paint Grade Chinese lump, CIF Gulf Coast	235-275
Paint Grade ground, 96-98% $BaSO_4$, ex-works USA ($/s. ton)	315-400
Chromite	
Chemical Grade, 46% Cr_2O_3 wet bulk, FOB South Africa	230-280
Refractory Grade, 46% Cr_2O_3 wet bulk, FOB South Africa	425-500
Foundry, +47% Cr_2O_3 dried 1 tonne big bags FOB South Africa	330-360
Foundry, 45.8% min Cr_2O_3 wet bulk, FOB South Africa	260-290
Graphite - Crystalline	
Fine, 90% C, -100 mesh	750-850
Medium, 94-97% C, +100-80 mesh	1050-1150
Large flake, 94-97% C, +80 mesh CIF	1250-1300
Magnesia - Fused	
Lump, FOB China 96% MgO	600-630
Lump, FOB China 97% MgO	890-1000
Lump, FOB China 98% MgO	1023-1100

Appropriate Quality Tests (Assays)

As per 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.'

Similarly the CIM (2003) guidelines to estimation of industrial minerals resources and reserves (pages 38 and 39) highlight the importance of physical properties as well as end products and markets:

'Critical elements to the Mineral Resource estimate for industrial minerals are: (i) the consideration of the physical and chemical properties of the subject mineral; (ii) the spatial relationship of these properties within the mineral occurrence; and (iii) the relationship of the physical and chemical properties of the mineral to the available market(s).'

'Customer specifications for industrial mineral products are frequently based solely on physical properties rather than, or in addition to, chemical characteristics. Sample testing should include those tests that will provide the physical characteristics and chemical analyses that relate to the specifications of the end product.'

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 bentonite rheology which are available from bodies like the American Petroleum Institute, while other physical and / or chemical test methods may be obtained from institutions such as the British Geological Survey (e.g. Mitchell, 1993).
- The question is often raised about how to test graphite, given that relatively expensive and time-consuming flotation procedures are usually required

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to separate graphite from gangue minerals. It is suggested that estimation of flake size and mineral relationships using petrographic examination of polished thin sections, or perhaps SEM methods such as QEMSCAN® could augment flotation data.

Taking bentonite as an example, this complex clay may be characterised or fingerprinted by a number of metrics such as purity, chemistry and exchangeable cations including:

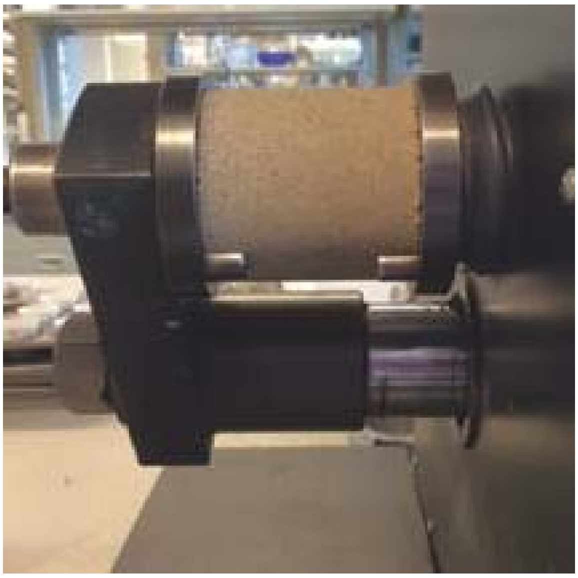
- in-situ moisture
- in-situ density
- pH
- grit content
- purity – montmorillonite vs inert minerals (cation exchange capacity)
- Ca, Mg and Na exchangeable cations (Ca or Na bentonite?)
- XRF (chemistry)
- XRD (mineralogy).

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 including:

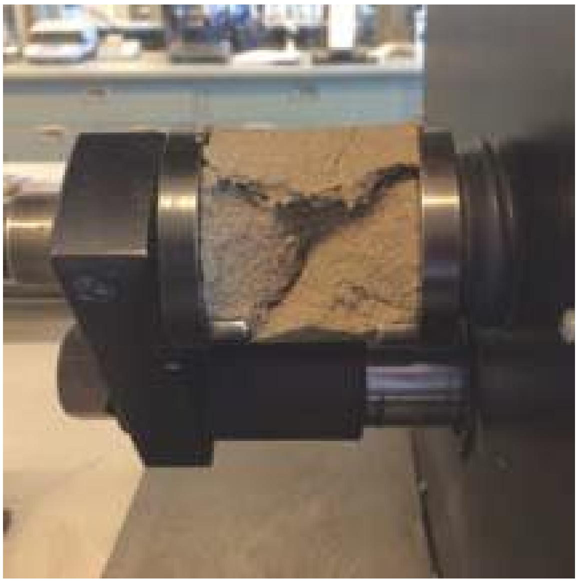
- plate water absorption (Iron Ore and Chromite Pelletising)
- bond strength (metal casting)
- thermogravimetric analysis (metal casting)
- rheology (drilling mud)
- fluid loss, free swell and permeability (geosynthetic clay liners and membranes)
- clump strength (cat litter)
- lees formation (wine fining)
- toxin adsorption (animal feed).

Conclusions

- Clause 49 of JORC 2012 is a welcome and timely improvement to Clause 44 of JORC 2004.
- The CIM (2003) guidelines on reporting of industrial minerals resources and reserves are an invaluable reference for the CP reporting according to JORC 2012.
- It is no longer sufficient to simply report a resource of contained industrial mineral.
- 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.

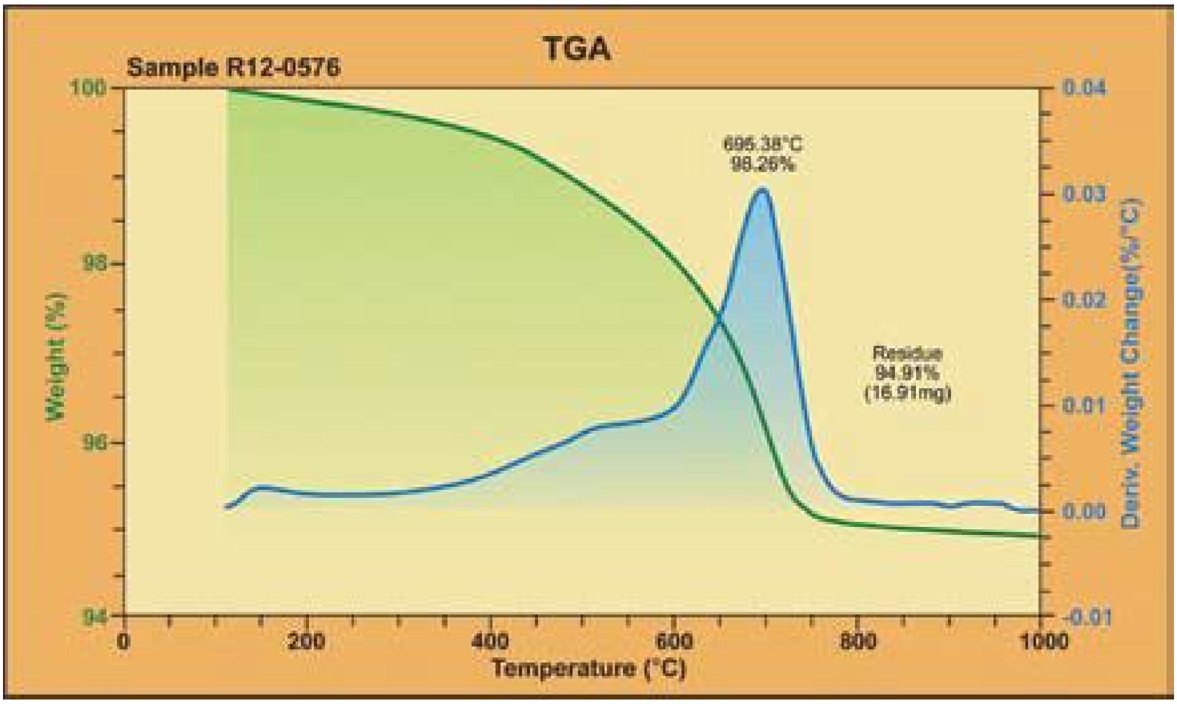


Bond strength testing of a laboratory-prepared 'greensand'.



An example could be a bentonite deposit that yields metal casting and drilling products from different parts of the deposit based on weathering domains.

- Specific market-related testing and / or metallurgical (mineral processing) testwork is required for industrial minerals deposits. It does not suffice to rely solely on traditional mineralogical or chemical purity (assay grade) tests 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.



Bentonite TGA: 695oC dehydroxylation peak indicates high thermal durability.

- Examination by petrographic, SEM or other methods is recommended to augment metallurgical testwork in the case of minerals such as chromite, graphite, wollastonite and other minerals where morphology is important.
- Proximity to markets and general product marketability must be taken into account, remembering that 'without a potential market, there can be no resource'.

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