Characterising coal dust to assess the potential health risks

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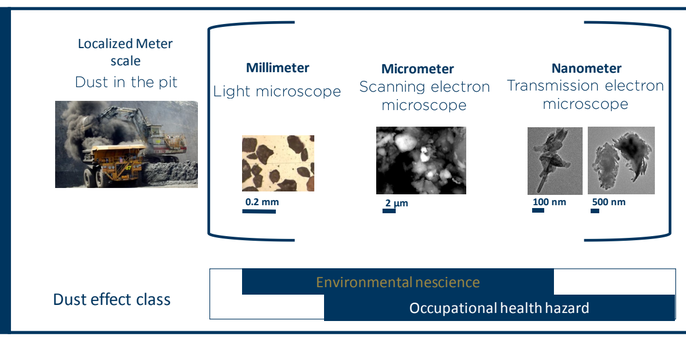
1. Introduction

- Dust in the mining environment occurs on various size scales.
- Dust coming from mines potentially exposes individuals in close proximity to harmful metals, which may react with lung tissue if inhaled causing damage and scaring[1].
- Current monitoring controls only look at the intensity of exposure over a given period. This assumes that every dust has equal toxicity[2]. For the mining environment, the inherent risk of different dusts needs to be characterised in order to aid in mitigation controls for preventable respiratory diseases.
- Several physicochemical characteristics of Earth materials are known to affect the bioaccessibility of potentially toxic features of dust when inhaled, such as particle size, encapsulation, mineralogy[3] and surface area[4].
- In this study we are focusing on coal dust and the physicochemical attributes which play a role in its toxicity.

1.1 Overarching aim & study objective



The overarching aim is o develop a risk characterisation protocol for inhalable coal dust that takes into account the most influential physicochemical characteristics of coal dust towards pulmonary toxicity.

The study objective is to characterise and quantify the individual physicochemical parameters of the coal dust for variable generation using a combination of elemental analysis, mineralogy, microscopy and spectroscopy tools.

2. Approach

Stage 1– sample selection:

Various coal samples were screened to determine inherently different coal samples, figure 1 shows the visual representation of the various coal samples chosen. Table 1 gives more detail to the sample names.

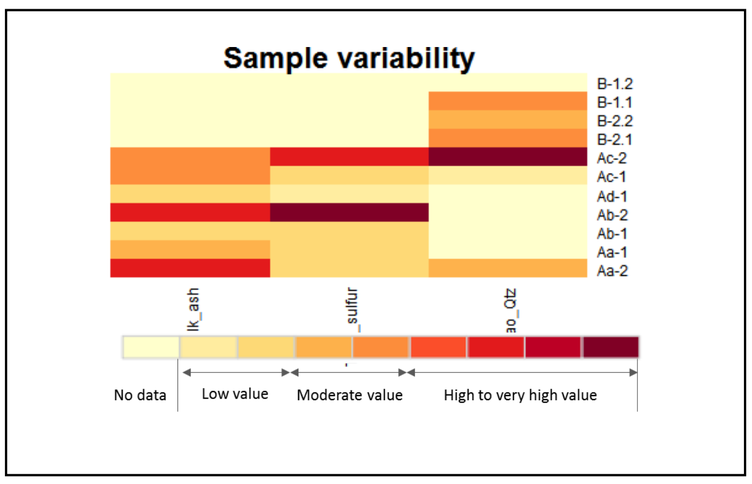


Figure 1: The heatmap above is a qualitative representation of the three metrics (bulk ash, total sulfur and the ratio of quartz to kaolinite) which were used to define a range to compare where the coal samples were inherently unique.

Table 1: A breakdown of the sample names listed on the Y-axis of the heatmap in figure 1.

Sample Descriptions	
Group	A = South Africa
Sub-group	a—Witbank colliery 1 b – Witbank colliery 2 c - Waterberg colliery 1 d—Witbank colliery 3
Sample type	1—ultrafine/slurry 2– Discard

Stage 2– characterisation of coal dust physicochemical characteristics:

the physicochemical characteristics know to induce an inflammatory response where quantified using a set of tools. The results displayed will show the comparison of two samples of the set

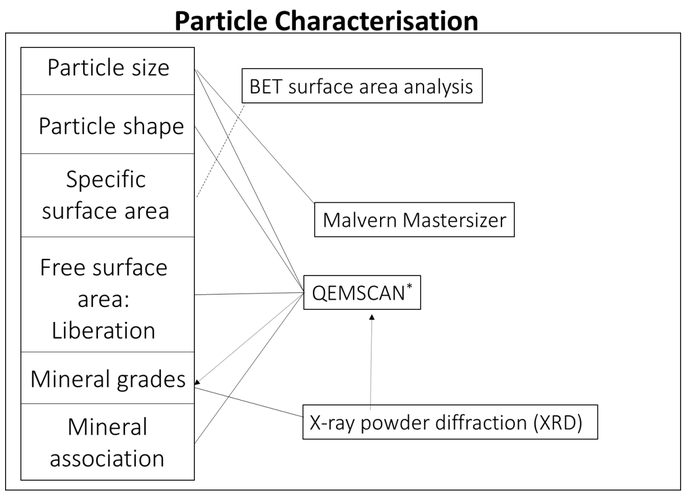


Figure 3: The synthesis of physicochemical characteristics currently being investigated. The boxes represent the tools used to identify these characteristics.

*Quantitative Evaluation of Materials by Scanning Electron Microscopy

3. Preliminary results

The data represented will be based on sample Aa-1 and Aa-2.

Mineral grades

Particle size

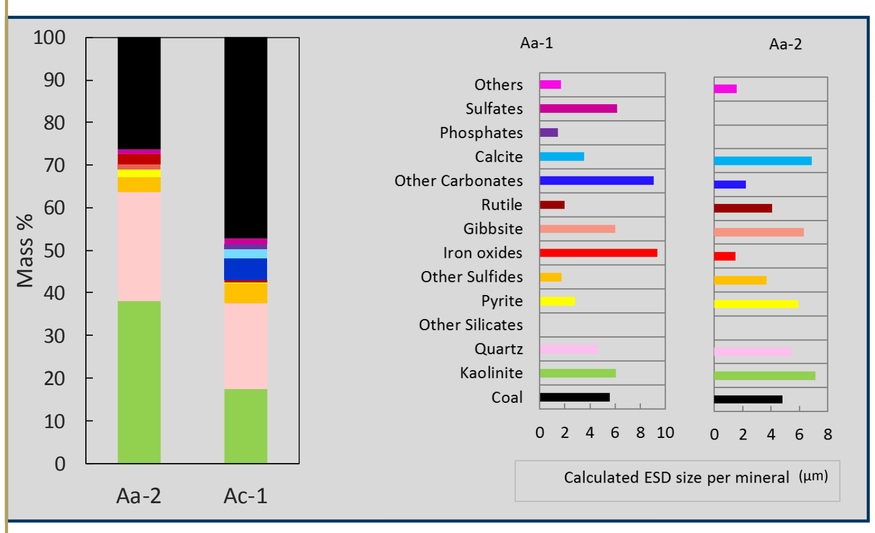
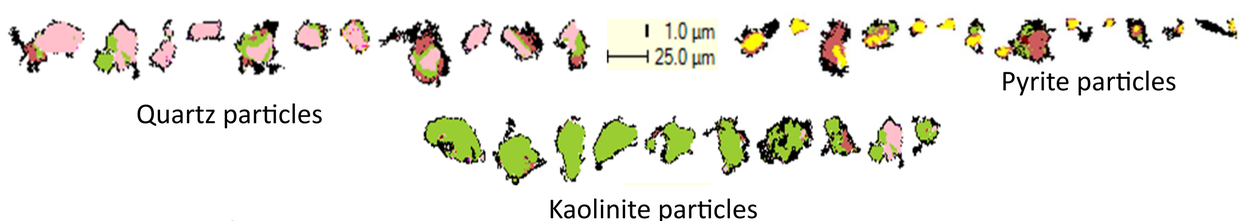


Figure 4: The mineral grades on the right hand side shows the mineral matter analyzed by XRD. Coal content was calculated using the Parr formula.

The graphs on the left hand side represent particle size from QEMSCAN, as equivalent spherical diameter calculated.



Mineral association

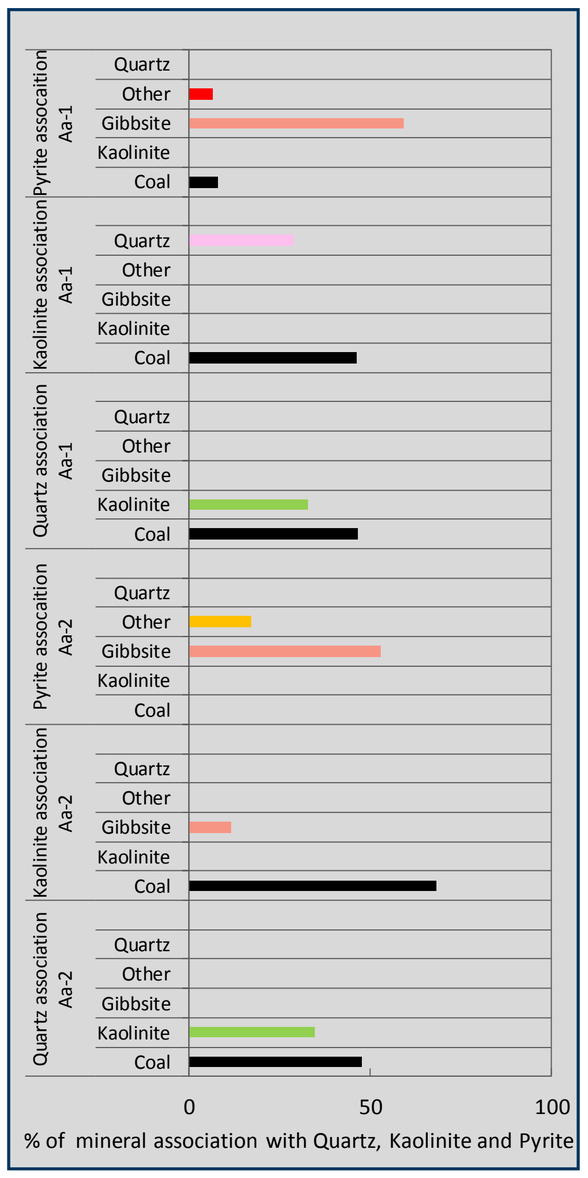


Figure 5: Represents the quartz, kaolinite and pyrite mineral associations from the QEMSCAN dataset.

Liberation

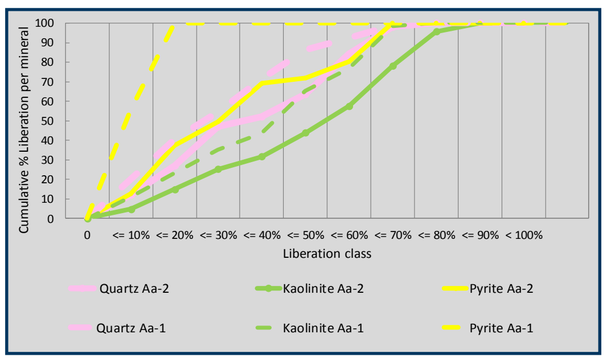
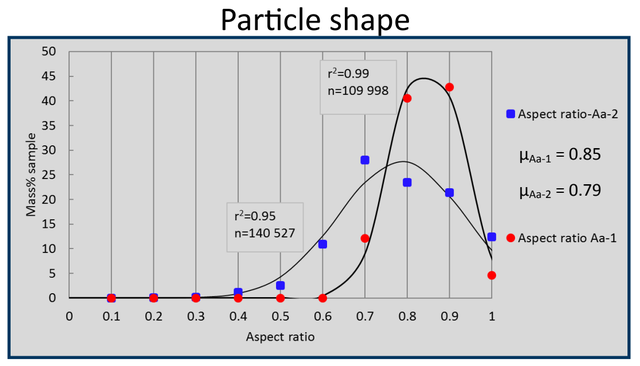


Figure 6: The cumulative liberation of quartz, kaolinite and pyrite is shown from the QEMSCAN dataset.

Particle shape



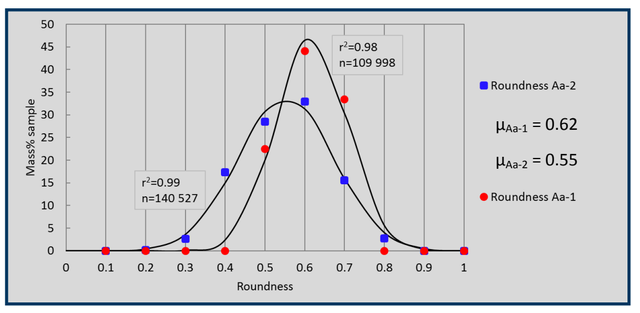


Figure 7: Aspect ratio and roundness from the QEMSCAN dataset

4. Findings, recommendations & next steps

- Particles reported in the dataset are composites of minerals. Data from mineral association and liberation class confirm this (liberation between <= 10 to <= 50%).
- The size distributions per mineral were found to be random. R^2 = 0.0157.
- Similar mean aspect ratio and roundness values reviled little difference in particle shape.
- Mineral grades of the two samples showed that quartz and kaolinite were dominant phases in both cases, however proportions of carbonate, sulfate and sulfide varied.
- Although the QEMSCAN is a powerful quantitive tool for assessing the physical characteristics of coal, further validation of the measurements needs to be conducted using complementary techniques.
- Specific surface area needs to be quantified by BET analysis for all of the samples to obtain a robust representation of surface area as the QEMSCAN offers a rudimentary measure of surface area for fine coal.
- The quantified physicochemical characteristics will aid in decoupling the responses seen in immunological test of the dust on lung cells .

References: 1- Schoonen et al., (2010) Geochimica et Cosmochimica Acta ; 2- Lelieveld et al., (2015) Nature ; 3-Plumlee et al., (2006) Reviews in Mineralogy and Geochemistry; 4– Tran et a.; (2000) Reviews in Mineralogy and Geochemistry.