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Real -Time Mining: Sensors for materials characterization

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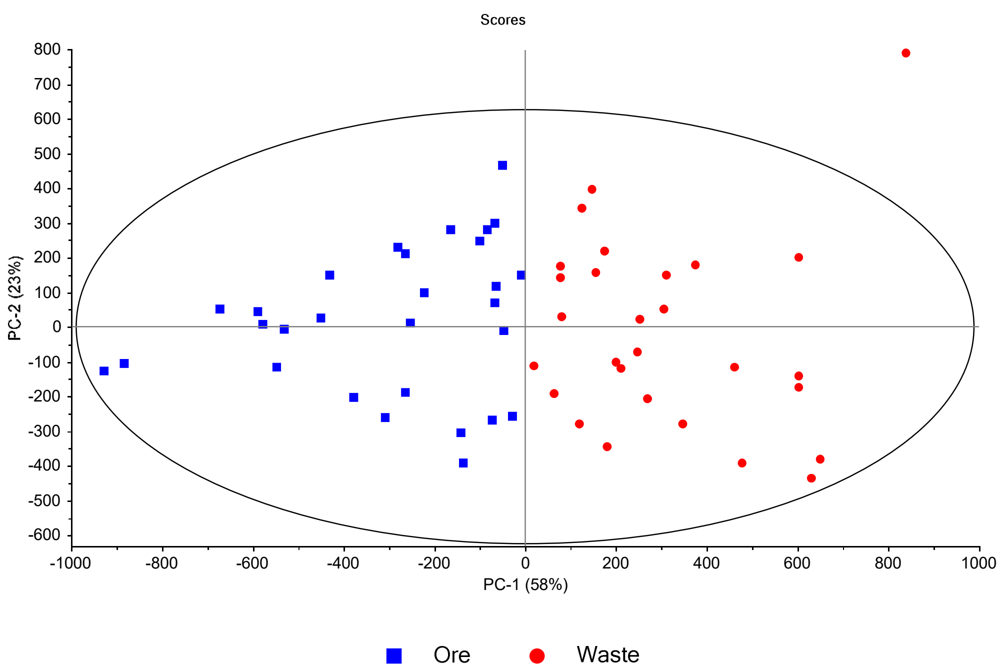
Sensors are being used as laboratory and in-situ techniques for characterization and definition of raw material properties. However, application of sensor technologies for underground mining resource extraction is very limited and highly dependent on the geological and operational environment. In our study the potential of RGB imaging, Fourier-Transform Infrared Spectroscopy (FTIR) spectroscopy and Hyperspectral imaging for the characterization of polymetallic sulphide minerals in a test case of the Reiche Zeche underground mine was investigated.

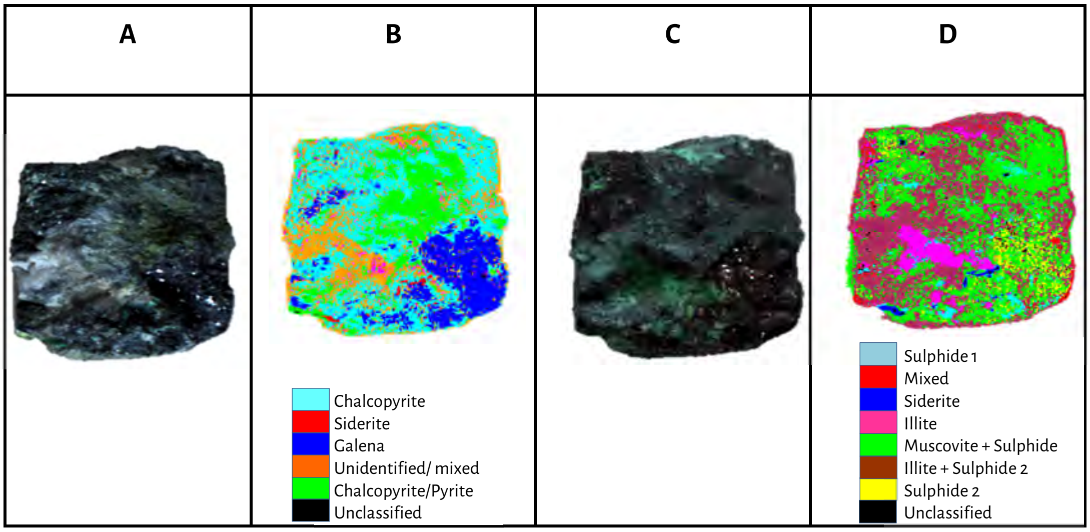
- In our previous work we have demonstrated the use of RGB imaging for ~4m long mine face mineral mapping. In this study the application was extended to map ~ 22m long mine face, to define an ore geometry and to generate quantitative fragmentation analysis results. The mine face images were georeferenced, mosaicked and a mineral map was produced using a supervised image classification technique. The overall classification accuracy shows the potential of the technique for the delineation of sulphide ores in an underground mine. RGB images acquired at muck pile sites were used to generate quantitative fragmentation analysis result. The analysis performed using the RGB images provided satisfactory quantitative results (grain size distribution curve). Taking in to account the blasting parameters, the result can further be used for development of models that better predict fragmentation in the test case.
- Our previous study has indicated the use of FTIR technology for discrimination of ore-waste using powder samples. In this study, the application was extended using whole rock samples. Due to the heterogeneous nature of rock samples multiple FTIR measurements were acquired at different spots of the rock surface. The FTIR data combined with Partial Least Square - Discriminant Analysis (PLS-DA) technique was used to assess the use of the technique for whole rock application. A series of calibration models were developed for ore and waste materials separately. The models were validated using independent dataset. The classification result obtained from whole rock application is remarkable. However compared to the powder samples application, the classification model accuracy is lower. This is likely due to the heterogeneous nature of the rock materials and the rough surface of the rock materials. Therefore for better classification accuracy an improved way of heterogeneity assimilation should be taken in to account. In general, the result obtained from the whole rock application is promising and with proper model calibration and

heterogeneity accommodation the application can be extended for automation of ore-waste discrimination process.

- Hyperspectral images were acquired over VNIR and SWIR spectral regions using rock chips and drill core samples. Thus the application of both VNIR and SWIR data were investigated separately. The spectrally distinct endmembers were collected. The endmembers were used to produce a mineral map using a Spectral Angle Mapper (SAM) classifier. The identified minerals using the VNIR data include: the sulphides (e.g chalcopyrite), hematite, goethite and siderites. Whereas, the identified minerals using the SWIR data include: muscovite, gypsum, montmorillonite, illite, siderite, quartz and mineral mixtures. The mineral identification results were validated using X-ray Diffraction (XRD) and Electron Micro Probe Analyser (EMPA) data. The sulphide minerals show no features in SWIR data. This result is expected since sulphide minerals are SWIR inactive. However, the featureless nature of the minerals in the SWIR spectra was used as characteristic value to map ore versus waste materials. Thus the technique is promising for ore-waste discrimination. The VNIR data show a great potential to detect and identify among the sulphide minerals. However, it needs careful analysis and validation since the sulphides do not show any particular absorption features. Thus, automation of the mineral identification process might be challenging due to lack of particular absorption features of the sulphide minerals and the matrix effect owing to the mineral mixtures. However, the variation in the spectra can be accommodated by considering a training library with wider range of mineral mixtures simulated based on the mineral composition of the test case materials.



FTIR data ore-waste discrimination using whole rock samples.



(A) False color image of VNIR data (B) Classified image of the VNIR data (C) False color image of SWIR data (B) Classified image of the SWIR data.