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統計的ラマン分光法による採掘鉱物資源粒子の新規分類法
A Novel Approach for the Classification of Mineral Ore Particles by A Statistical Raman Spectroscopic Method

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[Introduction]

Mineral ores extracted by mining go through a milling process before ore dressing. An important factor in both milling and ore dressing operations is the determination of the particle size distribution of the materials being processed, commonly referred to as particle size analysis. An elemental analysis technique such as X-Ray fluorescence and destructive wet chemical analysis can determine the quantity of mineral species present in the ore, however, these chemical analysis methods do not allow the study of the composition of individual particles of different size and shape. The statistical Raman spectroscopic method is a novel approach which can resolve this problem. Using this method the Raman spectra of several hundred particles is determined after size and shape classification of each individual particle by automated particle image analysis. Raman spectroscopy can be used to acquire the spectra of any inorganic compounds such as metal oxides and nitrides which are Raman active. Many mineral resources are mined as inorganic compounds. Therefore, Raman spectroscopy can be used for the identification of the chemical composition of mineral ores. Using the statistical Raman spectroscopic method described herein, it is possible to calculate the particle size distribution and proportion by mass or volume of each chemical component or mineral species based on Raman spectroscopic information. This study will report and discuss the capability of the statistical Raman spectroscopic method using iron ore as a model material.

[Material and Method]

Iron ore samples were purchased from a vendor. These samples had been through the ore dressing process. Statistical Raman analysis was carried out using a Morphologi G3SE-ID instrument (Malvern Instruments, UK) equipped with a dry powder sample dispersion unit (SDU) and Raman module. The laser wavelength of Raman excitation was 785nm the laser power was less than 5mW and the irradiation time was 5 sec. The particle image measurements were made in diascopic mode with a total magnification 250x. Iron ore dry powder samples were dispersed using the SDU using a short duration pulse of compressed air. Measurements were made automatically using Standard Operating Procedures (SOPs) which define the software and hardware settings used. Measurement sample was dispersed on to glass plate as sample carrier which was minimized environmental exposure by the enclosed sample chamber unit. Particle identification by Raman analysis used the spectrum correlation coefficient approach.

[Results and Discussion]

A Total of 66,436 particles of iron ore were measured by image analysis. The circle equivalent diameter particle size distribution by volume (VCED) exhibited a monomodal distribution with size distribution percentiles as follows: 8.62μm (d10), 21.83μm (d50), 51.29μm (d90). A subset of 700 particles were selected and the Raman spectra were measured. Particles over 20 micron in size were selected randomly from the image analysis data and Raman spectra were acquired. The spectra enabled identification of 4 components (Fig.1). The relative proportion of each component by volume or number of particles is shown in Table 1. Component (A) comprised approximately 90% of the sample. This component exhibited a Raman spectrum typical of α-Fe_2O_3 [1]. It is assumed that components (B) and (C) are polymorphs based on the ratio of the intensities at 221cm^{-1} and 245cm^{-1}. Component (D) exhibited a spectrum typical of α-FeOOH and composed less than 3% of the sample. This result does show that the statistical Raman analysis approach can detect components present at quite low concentrations.

[Summary]

This report illustrated the application and capability of statistical Raman analysis for the characterization of mineral ores using a new approach based on combining chemical and particle size / shape information.

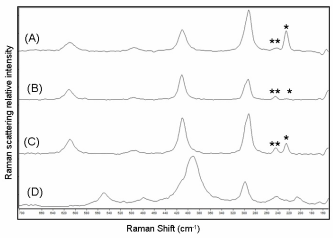

Fig 1. Raman Spectrums of iron ore.
(* : 221cm^{-1},** : 245cm^{-1})

Table 1.
Ratio of each component based on Raman spectrum

Component	Number (%)	Volume(%)
A	87.6	90.2
B	2.5	2.1
C	7.2	6.3
D	2.7	1.4