全自動粒子画像分析と統合されたラマン分光法を用いた100ミクロン以下細粒を有する地質粒子の新しい定量的分類法の提案

Proposal for novel quantitative classification method of below the hundred-micron particle in soils using a microscope Raman spectroscopy combined with an automated image analysis.

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Introduction

It is well known that importance of particle characterization on soil to investigate of geoscience. The characteristics of particle is including various information such as history of factual energy by distortion of ground, transportation process of material and chemical inside of ground and physical property reflects of soil mechanics. Particle morphology as physical properties and the chemical properties such as the elemental populations and crystal properties are important as primary attribute for characteristics of particle on soil investigation.

To investigate of morphological analysis as a volume-based analysis, especially a grain size, a sieving is well performed on greater than 4- phi (1/63, 63um) scaled range. However, finer than 4-phi are complicate to perform due to clogging and low flowabilities on samples. Therefore, investigation on this range are sedimentation analysis and manually optical microscope analysis (OM) as time consuming methods.Especially, OM analysis is the near impossibility of measuring a statistically significant number of several ten thousand number of particles as recommended in ISO 13322-1,2.

Recent advances in computer technology have allowed for the development of a new automated particle image analysis (APIA) approach. A principle of APIA is based on uses digital imaging technology to allow for the acquisition of 2D particle projection images of a statistically significant number of particles. This technique has allowed for the calculation of a wide range of size and shape with quantitative information. Recently, several studies reported to an automated particle image analysis (APIA) are well performed for soil particle analysis especially finer than hundred-micron particles[1][2].

Furthermore, existing a grain size analysis are nearly impossible to investigate with chemical analysis. This is because, the various chemical analysis can measure for chemical composition as a bulk information, however, it do not allow the study of the composition of individual particles of different morphology as integrated information. The statistical Raman spectroscopic (SRS) 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 APIA. Raman spectroscopy can be used to acquire the spectra of any inorganic compounds which are included in soils. Therefore, Raman spectroscopy can be used for the identification of the chemical composition of fine particle ranges. Using the SRS method described herein, it is possible to calculate the mass and/or volume with precise quantitative information of each chemical component species based on Raman spectroscopy. This study will report and discuss for capability of a novel quantitative classification flamework on below the hundred-micron particle in soils using model samples.

Material and Methods

Model samples were milled Normal Glass (NG) powder and Silica Sand(SS) samples used. Estimated chemical composition measuring were measured by EDXRF instruments (Epsilon 1, Malvern Panalytical Instruments, Netherlands) with a semi quantitative analysis based on a fundamental parameter method. Major elemental components on both were Si (NG=72%, SS=98%) and other alkali metals. SRS analysis was carried out using a Morphologi 4-ID instrument (Malvern Panalytical Instruments, UK) equipped with a dry powder sample dispersion unit (SDU) and Raman module. The laser wavelength of Raman excitation was 785nm with arbitrary intensity of laser power. 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.

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