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Application of decision tree algorithm for identification of rock forming minerals using energy dispersive spectrometry

Efe Akkaş (1), H.Evren Çubukçu (1), and Harun Artuner (2)

(1) Hacettepe University, Institute of Natural & Applied Science, Department of Geological Engineering, Ankara, Turkey (akkasefe@hacettepe.edu.tr), (2) Hacettepe University, Institute of Natural & Applied Science, Department of Computer Engineering, Ankara, Turkey (artuner@hacettepe.edu.tr)

Rapid and automated mineral identification is compulsory in certain applications concerning natural rocks. Among all microscopic and spectrometric methods, energy dispersive X-ray spectrometers (EDS) integrated with scanning electron microscopes produce rapid information with reliable chemical data. Although obtaining elemental data with EDS analyses is fast and easy by the help of improving technology, it is rather challenging to perform accurate and rapid identification considering the large quantity of minerals in a rock sample with varying dimensions ranging between nanometer to centimeter. Furthermore, the physical properties of the specimen (roughness, thickness, electrical conductivity, position in the instrument etc.) and the incident electron beam (accelerating voltage, beam current, spot size etc.) control the produced characteristic X-ray, which in turn affect the elemental analyses. In order to minimize the effects of these physical constraints and develop an automated mineral identification system, a rule induction paradigm has been applied to energy dispersive spectral data. Decision tree classifiers divide training data sets into subclasses using generated rules or decisions and thereby it produces classification or recognition associated with these data sets.

A number of thinsections prepared from rock samples with suitable mineralogy have been investigated and a preliminary 12 distinct mineral groups (olivine, orthopyroxene, clinopyroxene, apatite, amphibole, plagioclase, K- feldspar, zircon, magnetite, titanomagnetite, biotite, quartz), comprised mostly of silicates and oxides, have been selected. Energy dispersive spectral data for each group, consisting of 240 reference and 200 test analyses, have been acquired under various, non-standard, physical and electrical conditions. The reference X-Ray data have been used to assign the spectral distribution of elements to the specified mineral groups. Consequently, the test data have been analyzed using C5.0 Decision Tree algorithm. The predictions of the decision tree classifier, namely the matching of the test data with the appropriate mineral group, yield an overall accuracy of >90%. Besides, the algorithm successfully discriminated some mineral (groups) despite their similar elemental composition such as orthopyroxene ((Mg,Fe)2[SiO6]) and olivine ((Mg,Fe)2[SiO4]). Furthermore, the effects of various operating conditions have been insignificant for the classifier.

These results demonstrate that decision tree algorithm stands as an accurate, rapid and automated method for mineral classification/identification. Hence, decision tree algorithm would be a promising component of an expert system focused on real-time, automated mineral identification using energy dispersive spectrometers without being affected from the operating conditions.

Keywords: mineral identification, energy dispersive spectrometry, decision tree algorithm.