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隕石の全岩組成データベースのクラスター解析
Cluster analyses on bulk elemental compositions of meteorites

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Meteorites are now determined to be precious samples from extraterrestrial bodies and thus identifications of the corresponding meteorite types of the targeted bodies of asteroid missions are among the major goals of asteroid missions. Besides such scientific importance, rapid identification of the surface materials during the reconnaissance phase is also critically important even for maneuvering a spacecraft. Modern spacecraft carry cameras/spectrometers in the visible to infrared wavelengths, which are powerful tools in identifying surface materials. However, irradiation by cosmic and solar wind irons as well as bombardment by interplanetary dust particles modify the surface of airless bodies through processes known as space weathering. Impact events also mix mateirals at the surface of the body. These processes may flatten or change the absorption characteristics of reflectance spectra. In this sense, elemental compositions, which can be obtained by X and gamma-ray spectrometers, may be useful for the above purpose. However, it has not been investigated extensively how well we can classify these planetary materials based on elemental composition alone. In this study, we perform principal component and cluster analyses on 12 major and minor elements of the bulk compositions of 500 meteorites reported in the NIPR database. Our unique approach, which includes using hierarchical cluster analysis, indicates that meteorites can be classified into about 10 groups purely by their bulk elemental compositions. We suggest that Si, Fe, Mg, Ca, and Na are the optimal set of elements, as this set has been used successfully to classify meteorites of the NIPR database with more than 94% accuracy. Principal components analysis indicates that elemental compositions of meteorites form 8 clusters in the 3 dimensional space of the components. The three major principal components (PC1, PC2, and PC3) are interpreted as degree of differentiations of the source body (i.e., primitive vs. differentiated), degree of thermal effects, and degree of chemical fractionation, respectively. Though the exact ranges of elements of each cluster suffer from the systematic intra-laboratory error, realized through comparing our results with those of another elemental composition database, our new method shows promise in the classification of the surface materials of a small body into a known group of meteorites, having a significant bearing in future reconnaissance.

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