Geophysical Research Abstracts, Vol. 8, 07690, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07690

Statistically rigorous geochemical mapping of Mars

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New maps of the composition of the Martian surface have been produced by the Mars Odyssey Gamma-Ray Spectrometer Team. These maps of iron, silicon, hydrogen, thorium, potassium and chlorine were initially binned on a 2x2 deg grid, and then smoothed to reduce noise with a mean filter by varying amounts: The smoothing was over a 5-deg radius for K, 10-deg for H, and Th, and 15-deg for the others. Lastly the data were binned on a 5x5 grid. The typical instrument footprint is several hundreds of kilometers wide (depending on the gamma-ray line energy of the element). The subsurface composition of Mars needs to be known at a global scale to study the bulk composition of the planet, characterize the Martian crust, and therefore develop a better understanding of the mechanisms of Mars evolution.

Here we report first attempt to apply multivariate analysis on these data sets to systematically identify any information that are common to different maps. We seek to understand how all the chemical elements relate to each other, and to define and characterize possible geochemical units (classes) based on these 6 maps. If these units reveal unique compositions, then we have another tool to use in enhancing our understanding of Martian crustal evolution.

Different mathematical techniques have been used. K-means clustering was first applied to the 6 initial maps. We show that ten classes, which intriguingly overlap with known geologic units, can be identified. The same method has been applied with only

4 chemical elements (Fe, Si, Th, K) to reveal the effects on the classification of the two other elements (H, Cl) that may be mobile. This gives slightly different classes, which are nevertheless consistent with the first analysis. Another way of reducing the dimensionality of the initial information (6 dimensions) is to use principal component analysis to search for orthogonal highest variance directions in data space. New components are then defined as linear combination of the initial maps. The first component is dominated by H, Cl (mobile elements), K and Th; the second component is driven by Si, K, and to a less extent Cl, Th; the third component is controlled by Fe, and so on. Cluster analysis of the three first principal components leads to a comparable class definition as K-means clustering above.

Future work will include investigating the consistencies and discrepancies of these approaches so as to distill the geochemical information from analysis artifacts. We will also benchmark the output with the geological map of Mars, and with studies of the distribution of surficial materials. We will present the features that are common to all these methods, and those which are different, by quoting actual abundances measured in these units.