Comparison and Integration of Fe, Ti And Th Abundances of the Lunar Surface at Global Scale from Clementine and Gamma-Ray Lunar Prospector Data

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Because of their complementarity, the comparison and the integration of the Clementine mineralogical spectral reflectance and the Lunar Prospector chemical data is crucial for understanding the lunar crust origin and evolution, the lunar volcanism and surface processes.

The objectives of this work, at a global scale on the Moon, are: 1) to test the consistency between the mineralogical Clementine spectral reflectance (CSR) data and the chemical Lunar Prospector gamma-ray spectrometer (GRS) data; 2) to characterize and define the spatial distribution of compositional units when integrating the three elements Fe, Ti and Th.

The comparison of FeO and TiO2 abundances between CSR and GRS shows at first order a general good agreement. However some significative differences are observed for some lunar regions such as the South Pole-Aitken (SPA) basin, where GRS lower concentrations of FeO than CSR and slightly GRS higher TiO2 concentrations than CSR may indicate that the SPA floor materials have a composition closer to LKFM (lower crust) than a composition intermediate (50-50%) between LKFM and the lunar mantle.

The investigation relies on a clustering method based on a principal component analysis (PCA) of the CSR FeO and TiO2 abundances (wt%) and the GRS Th abundances (ppm). It permits to statistically identify major cluster types in the PC space in relation with their spatial distribution. Homogeneous geological units are defined when integrating the three elements, which can be related to different rock types.

Highland regions display the lowest values of the three elements (Fe<5wt%; Ti<0.1wt%; Th<1.2ppm), typical of feldspathic rock and regolith samples. A branch in the PCA diagram represents units having relatively constant low Ti (<1wt%), low to intermediate Fe (6-10wt%) concentrations, and increasing Th concentrations, from 3.5 up to 7.7ppm. Most of these regions correspond to KREEP-rich (Th-rich) terrains which are thought to represent ejecta materials from the Imbrium impact. However, some regions, such as the Mairan-Gruithuisen domes and the Apennine Bench regions, could also be associated with materials corresponding to KREEP basalt volcanism.

Mare regions, which correspond to a large domain in the PCA diagram, are characterized by large variations in Ti (0.7-7wt%) relatively to Fe (12-15wt%) and Th (1.9-4.3ppm). The western maria of the near side display the higher concentrations of Th respectively to the eastern maria (one exception is Humorum).

A distinct cluster in the PC space corresponds to the South Pole-Aitken (SPA) basin with higher Fe and Th concentrations than the surrounding highlands (Fe: 10-11.5wt%; Ti: 0.2-0.6wt%; Th: 1.8-2.9ppm). These specific characteristics of the SPA basin, concerning Fe, Ti and Th, are also found in the Lacus Somniorum region, between Mare Serenitatis and Mare Frigoris. As we already proposed, the presence of higher concentrations of Fe and Th relative to the surrounding background suggests that the lower crust may be widely exposed in these regions.