Geophysical Research Abstracts,
Vol. 11, EGU2009-5731, 2009
EGU General Assembly 2009

Mars: Mineralogy of mafic-rich regions and implications for the crust evolution

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Global mineral mapping provides critical context for understanding local-scale mineralogical variations, such as those that appear related to igneous lithologies in ancient terrains and for investigating the formation and subsequent differentiation of the planet. Here, our primary objective is to determine the modal mineralogy of selected mafic-bearing terrains of different ages ranging from $\tilde{4}$By (Noachian period) to 100My (Amazonian period) exposed on the surface of Mars. This analysis is conducted using the spectral modelling of the Observatoire pour la Minéralogie, lÉau, les Glaces, et lÁctivité (OMEGA) reflectance data. Our results indicate that the overall composition is consistent with two-pyroxene basalts: plagioclase (40-60% in volume) and high calcium pyroxene (20-40%, HCP) are the dominant minerals of the most regions, low calcium pyroxene (10-15%, LCP) and minor amounts of olivine are also present. The oldest terrains are characterized by the largest amount of LCP and the lowest concentration of plagioclase. The particle sizes are in the range of a few hundreds of micrometers, which is in good agreement with the thermal inertia of the Martian studied regions. In the region around the Nili Fossae, localized concentrations of olivine up to 40% with millimetre particle size similar to picritic basalts observed in situ by the Spirit rover in the Gusev crater are inferred. Chemical compositions are calculated for the first time from near-infrared spectra. They are quite consistent with Gusev rocks and Shergottite compositions but they appear to be significantly SiO2-poorer than Thermal Emission Spectrometer data.
A decreasing low calcium pyroxene abundance with the decreasing age of the studied regions is reported. This may be indicative of decreasing degree of partial melting as thermal flux decreases with time. We propose that the ancient Noachian-aged, LCP-rich terrains could have been formed from H2O-bearing melts. Then, dry, basaltic volcanism occurred leading to decreasing LCP abundance with time due to decreasing degree of partial melting.