LUNAR GLOBAL PETROLOGIC VARIATIONS. D. B. J. Bussey[1], P. D. Spudis[2], and J. J. Gillis[3], [1]European Sapce Agency/ESTEC, Code SCI-SO, 2200 AG Noordwijk, The Netherlands, (bbussey@estec.esa.nl), [2]Lunar and Planetary Institute, Houston TX 77058, USA, [3]Department of Earth and Planetary Sciences, Washington University, St. Louis MO 63130, USA.

Introduction. An initial attempt at producing petrologic province maps of the lunar highlands combined orbital and sample geochemical data in variation diagrams [1]. Three different variation diagrams were produced; Mg* (= 100 Mg/Mg+Fe) versus $(Th/Ti)_c$, Al versus Mg*/$(Th/Ti)_c$, and Fe versus $(Th/Ti)_c$. ($[Th/Ti]_c$ is the ratio of thorium to titanium, normalised to the chrondritic ratio for these elements). Later work [2] applied a ternary diagram approach to look at global lunar petrologic variations. This work used the Fe **-** $(Th/Ti)_c$ technique as this had the most spatial coverage with the available data and also appeared to be adequate at distinguishing between different rock types. In the ternary diagram, the apexes were assigned the average Fe and $(Th/Ti)_c$ values of ferroan anorthosite, mare basalt and KREEP rocks. Each apex was assigned a primary a colour whilst the center of the triangle was represented by grey. Each point on the lunar surface, covered by the Apollo geochemical instruments, was then assigned a colour depending on where in the ternary their composition placed them. The resultant petrologic classification map shows how the petrologic units vary spatially. The main results from this work were: (a) the highlands contain large areas of relatively pure ferroan anorthosite. (b) KREEP/ Mg suite rocks represent a small percentage of the upper lunar crust. (c) farside outcrops of KREEP/ Mg suite rocks are associated with areas of crustal thinning, particularly on the floor of South Pole Aitken basin. (d) the average composition of the highlands is richer in iron then ferroan anorthosite, which supports the magma ocean hypothesis of crystal formation. (e) regions of the eastern limb and farside highlands are relatively more mafic than average highlands. These areas have a high density of dark halo craters, supporting the idea that mare volcanism occurred in this region before the end of the heavy bombardment.

Global Coverage. This earlier work utilised the Apollo gamma and X-ray orbital datasets. These data provided limited coverage of the lunar surface (mostly confined to the equatorial latitudes). The gamma ray instrument covered approximately 19% of the lunar surface while the X-ray only covered 9%. With the Clementine and Lunar Prospector datasets we now have global maps of iron, titanium, and thorium [3,4,5,6]. Apart from global coverage, another important advantage of the new data sets is higher spatial resolution. The resolution of the Apollo instruments was 15 km for the X-ray and 100 km for the gamma ray [1]. The iron and titanium maps are derived from the full resolution Clementine UVVIS data, i.e. ~ 250 m/pix. The resolution of the thorium data, obtained by Lunar Prospector's neutron spectrometer, is currently approximately 150 km [5] (but will be available in the future with a spatial resolution of 60 km [7]). The other improvement provided by the recent lunar missions is the error associated with the data. The errors associated with the iron, titanium and thorium values obtained by Apollo were 10-25 wt.%. The error of the Clementine derived iron and titanium values is ~ 1%, whilst the thorium data have an error of approximately 1 ppm.

We intend to investigate the petrologic variations on the Moon at a global scale using the new Clementine and Lunar Prospector elemental maps for iron, titanium, and thorium. We shall use the technique described in Davis and Spudis (1987). An initial study has been undertaken that looks at some regions that were covered by the Apollo geochemistry data. Two mare regions, one in Imbrium and the other in Procellarum, match well with the results using the Apollo data. The highland terrain appears problematic. The calibration of the Th data [6] is based on the assumption of a constant background. This is a valid assumption where Th counts are well above background limits but as count rates decrease variations in Th concentration are more sensitive to background fluctuations. Eventually we will circumvent this problem by using the lower altitude (i.e., higher resolution) Prospector data and a calibration that is derived from deconvolution of the γ-ray spectra with proper attention to background variations.

The Th/Ti versus Fe technique provides more geologic information than can be extracted from solely using the elemental data because it quantitatively determines each pixel's composition in terms of the end member compositions: Ferroan anorthosite, mare basalt and KREEP rocks. Moreover, the digital map illustrates the extent, and lateral transition of one rock-type to another, thus allowing the sample data to be placed in a regional and global context.

Initial examination confirms earlier conclusions [2] that the Mg-suite is not a major contributor to at least the upper lunar crust. We summarise elsewhere in this volume evidence that Mg-suite rocks may be a significant contributor to the composition of the lower crust [8]. Study continues on the problem of the crustal fraction of the Mg-suite, needed to determine the Mg# of the bulk crust, an important constraint on lunar origin [9].

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