LOCAL AND REGIONAL LUNAR REGOLITH CHARACTERISTICS AT REINER GAMMA FORMATION. P. C. Pinet[1], V.V. Shevchenko [2], S. Chevrel [1], Y. Daydou [1] ([1] OMP/UMR5562, 14 Av. E. Belin, Toulouse, 31400 France; Patrick.Pinet@cnes.fr; [2] Sternberg Astronomical Institute, Moscow, 119899, Russia).

I. Introduction and Background.

Following the Reiner Gamma region telescopic exploration described earlier (Pinet et al., 1992; 1995; Shevchenko et al., 1993), a detailed remote sensing survey of the region of Oceanus Procellarum surrounding the Reiner Gamma Formation (RGF) has been carried out by means of Clementine spectroimaging data with the purpose of establishing the regional distribution of the chronology index and weight percent of iron content in the lunar soils (Pinet et al., 1997). Since the previous studies (e.g., Bell and Hawke, 1981; 1987; Shevchenko et al., 1993) suggest that the surface reflectance variations observed at Reiner gamma region might be ascribed to a not yet fully well understood combination of both optical and compositional effects occurring in the regional mare regolith, our first objective has been to assess their relative contributions. Recently, a quantitative reliable method has been proposed (Lucey et al., 1995) which can be applied to the Clementine spectral dataset. It shows that, based on the examination of a suite of Apollo lunar soil samples, one can empirically separate both effects (soil maturity, iron content) in the lunar soil spectral properties in a rather simple way. Such an approach has been implemented on the present Reiner Gamma mosaic (Pinet et al., 1997) and a systematic analysis of the spatial distribution of the spectral features in the image has been then performed, based on the examination of soil maturity variations r , for a given iron composition q considered as a class. From the examination of the characteristics of the associated spectra, their location in the (r ,q) (soil maturity, iron content) plot and in the statistical cloud, produced by a principal component analysis done on the data, we select 4 extreme spectral types shown on figure 1.

II.Regional distribution by Spectral Mixture Analysis.

Spectral mixture analysis has gained wide acceptance in the past years and is used to separate the spectral components of lunar soils, mixed at the pixel scale, into percentages of distinct endmembers (e.g., Adams et al., 1986; Pinet et al., 1993, Head et al., 1993). However, the use of simple linear mixing models is hampered by the arbitrary selection of endmembers relevant to the geological problem under investigation. Different alternative approaches have been proposed (e.g., Boardman, 1993; Tompkins, 1997; Merényi et al., 1996). Following previous works (Johnson et al., 1994; Pinet et al., 1995; 1996; Martin et al., 1997), we have developed a methodology which combines principal component analysis and iterative linear mixture modelling and it has been applied to the Reiner Gamma region.

We identify at once 3 basic endmembers relevant for modelling the observed spectral variations in the vicinity of Reiner Gamma Formation. These are MB (mare background), SWS (south west swirl), and RGS (Reiner Gamma soil) and are derived from the previous identification of extreme spectral types (cf. § I, fig. 1). Any attempt involving only 2 endmembers among these 3 is unsuccessful while this ternary combination models 73 % of the pixels population and well handles the regional context. Are discarded in this first stage, 2 mare units (bottom of the image and upper right corner), the Reiner crater and its vicinity, the local areas of the mare regolith modified by small impact craters and related ejecta. The second iteration aims at describing this left over variability associated to the unmodelled mare units and regolith modified by impact craters and thus considers a simple binary combination of MB with a new endmember named MHB, detected in the previous analysis (cf. § I) and associated to Marius Hills volcanic complex.

The fractional abundance images respectively associated to RGS, MB, SWS and MHB endmembers provide with a valuable information in terms of spatial distribution. The RGS contribution appears to be restricted to the Reiner Gamma formation and the northeastern elongated high-albedo pattern, located north-east of RGF. The MB contribution is very homogeneous in the regional mare area, with however, local variations mainly seen around and south-west of RGF, and additional localized patches associated for instance with Reiner crater. These variations result from a variable mixing between MB and SWS, with respective proportions typically ranging between 60-80% and 40-20%. One immediate significant result is that this spectral mixture analysis reveals the existence of a diffuse triangle-shaped unit surrounding the Reiner-Gamma formation in its immediate vicinity. It corresponds very exactly to the enigmatic medium-albedo unit, detected from its low 0.40/0.56 micron ratio (Bell and Hawke, 1981) and referred to as 'red halo' unit in the literature. The SWS contribution, needed to describe the modified spectral signature of the mare in the 'red halo' area, appears quite prevailing in a few patches south of RGF (fig. 1) where the endmember was picked up. Finally, the MHB contribution correlates very conspicuously with the south part of the Marius Hills volcanic complex. Interestingly, local contributions are detected in association with Reiner crater ejecta and with the dark mare unit south of Reiner Gamma formation.

III. Interpretation.

The results above evidence that three components in terms of surface material are present in the Reiner Gamma region. The first two components exhibit spectral characteristics consistent with a prevailing contribution of mature mare soils for the surroundings (MB) and of immature mare crater-like soils (RGS) at RGF. The third intermediate-albedo component (SWS) has general characteristics of a mature mare soil, but with a redder continuum slope. It is in basic agreement with more elusive observations (Bell and Hawke, 1981;

1987) and the present work provides with a clear regional distribution.

Building upon experimental results produced by laboratory spectroscopic analyses of sieved size separates of lunar soils from Luna-16, Luna-20 and Luna-24 sites (Pieters et al., 1993; Starukhina and Skuratov, 1996), it is shown that one can explain the reported observation by a mechanism which would remove the finest fraction in the soil (particle diameter less than 45 micron) at RGF and redistribute it in the vicinity with a lateral variable proportion and local accumulations. This mechanism would be responsible for the disruption at RGF of the optical characteristics of mature soils, caused by the natural space-weathering effects. Indeed, the RGS-type spectral characteristics appear very close to those of the Luna-24 spectrum corresponding to separates with size ranging between 45 and 94 micron, i.e. the size range for which the spectral contrast is maximum, while the SWS-type characteristics are quite consistent with an accumulation of the finest fraction which dominates the optical properties of the mare soil and is responsible for the spectrum reddening.

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Figure 1 : extreme spectral types