LAVA FLOWS IN MARE NUBIUM AND MARE COGNITUM: A GEOLOGICAL HISTORY BASED ON ANALYSIS OF MULTISPECTRAL DATA. R. Bugiolacchi[1], Paul D. Spudis[2], John E. Guest[1].[1]Department of Earth Sciences, University College London, Gower Street, London, WC1E 6BT, United Kingdom (*r.bugiolacchi@ucl.ac.uk)*, [2]Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723-6099, USA.

Introduction: A geological map of the Nubium/Cognitum Maria region (0˚-30˚W, 0˚-30˚S) is produced together with new compositional and morphological data derived from Clementine [1,2] multispectral images. Most of the exposed maria unit flows are identified, outlined, and classified according to their titanium and iron weight percentage content [3,4] and their estimated age [5,6]. Minerals with spectral absorption bands centred near 1μm are also revealed by use of filter ratios (750/950 nm) [3], and help identify late extrusive materials, fresh impact ejecta, and newly exposed regolith. Compositional variations in the ejecta blankets of several craters are used to estimate the maximum mare thickness at the time of impact.

Results: Our results place the Nubium/Cognitum basalts in the low-Ti category (1-5 wt% TiO_2), with nearly 80% of the data in the range of 3-5 wt%.

Multispectral Clementine data indicate that the majority (~90%) of the mare terrain has an iron content between 18 and 22%wt. In particular, Fe variances tend to concentrate towards two compositional poles of ~20%wt and ~15%wt.

Regional crater counting gives a frequency of 5.6×10^{-2} km^{-2} for craters larger than 500 m in diameter, translating to an inferred mean age of 3320 (±83) Ma for the majority of the exposed lava flows. Ages range between 2300 (±100) Ma and 3400 (±108) Ma.

We find a possible correlation between age of flow units and apparent titanium content, with younger basalts becoming progressively Ti-richer (from 2-3 to 4-5 wt% Ti).

We are in agreement with previous studies on maria thickness variations [7]: a possible thickening of the basalt layers in the centre of the Nubium basin (~17°W 23°S), the northern eastern region (~10°W 20°S), and the northern border (~18°W 17°S). We are also reporting two areas of mare thickening in Mare Cognitum: one just north of Dorney D (26°W 12°S) and another near the middle of the basin (23°W 10°S).

Three major periods of basaltic activity characterised the infill of the basins. Each of these periods were themselves punctuated by discreet phases of widespread magma eruptions: three during both the Early Imbrian Epoch (~3.5-3.3 Ga) and the Early Eratosthenian Period (~3.3-3.1 Ga), and finally, two in the Late Eratosthenian Period (up to 2.2 Ga). The freshest lavas can be found off the eastern border of the Fra Mauro peninsula and covering most of the central western Nubium basin.

Conclusions: Nine potential mare units are mapped and classified, each with its characteristic mineral composition (Fe and Ti abundances) and age (Fig. 1). Ejecta from larger craters are also used to estimate the probable period of impact and, in some cases, calculate the maximum depth of the maria by exploiting their comparative iron content readings.

A correlation between flow composition and age is noted. Titanium content appears to relate to the time of eruption, with a progressively higher presence in younger units. Iron displays a weaker, but similar, trend.

The exposed lava fields in the region suggest three distinct periods of effusion, each lasting around 300 Ma. The oldest exposed flows date back to the Early Imbrian Epoch (~3.5-3.3 Ga), with present titanium content between 2-3 %. A shorter, but more extended effusive period followed, with basalts covering most of the region's lower topography (Early Eratosthenian Period, ~3.3-3.1 Ga, 3-4% Ti). The last massive outpouring of lava continued until the Late Eratosthenian Period and we have dated the freshest units at around 2.3 ± 0.1 Ga with titanium content of 4-5 %.

Lesser volcanic activity probably continued for at least 1.0 Ga, but was characterised by a more limited rate of effusion and concentrating around fissures and local crustal weaknesses.

Further research will be carried out on other lunar basins to look for a possible planet-wide correlation of magma composition with age.

References:

[1] Nozette, S. et al. (1994) *Science*, 266, 1835-1839. [2] McEwen A. S. et al. (1997) *Adv. Sp. Res.,* 1523-1533. [3] Lucy P. G. et al. (2000a) *JGR,* 105, 20,297-20,305. [4] Lucey P. G. et al. (1995) *Science,* 268, 1150-1153. [5] Hiesinger H. et al. (2000) *JGR*, 105, 29,239-29,275. [6] Shultz P. H. and Spudis P. D. (1983) *Nature*, 302, 233-236. [7] De Hon R. A. (1977) *LPSC VIII*, 633-641.

Figure 1. Geological map of the Nubium/Cognitum Mare region.