A MULTISPECTRAL ANALYSIS OF THE FLAMSTEED REGION OF OCEANUS PROCELLARUM.

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Introduction: According to Pieters et al. (1980) [1], the Flamsteed area of Oceanus Procellarum is representative of basalts that have yet to be sampled. They studied the area in detail using telescopic data to identify seven distinct mare flows. This diversity makes the Flamsteed region an ideal candidate for Clementine multispectral studies. The region studied here is far smaller than that covered by Pieters et al. (1980) [1], but the higher spatial resolution of the Clementine data will allow us to make a fresh interpretation of the nature of our restricted area before expanding to encompass the surrounding regions. The primary aim of this work is to use Clementine UVVIS data to analyse flows on a smaller scale and determine the stratigraphy of the mare, using impact craters as probes to measure the thickness of mare lavas wherever possible.

Data reduction: We used the Clementine UVVIS data to produce a multispectral image of the Flamsteed area from 0.60° N to 16.06° S and 308.34° E to 317.12° E. The data were processed at a resolution of 200m/pixel using the ISIS software program (available through the USGS), and the photometric coefficients tabulated in Blewett et al. (1997) [2]. In addition to the multispectral image, a ‘true colour’ image, FeO map (using the algorithms of [2]), and a TiO₂ map (using the algorithms of [3]) were generated. In conjunction with a 750nm Clementine mosaic and Lunar Orbiter photographs, these images formed the dataset used for this analysis. For more details on the data reduction procedure used, please contact the authors.

Mapping the flows: The area studied here lies in the south-eastern portion of Oceanus Procellarum, and covers approximately 134, 500 sq. km, extending from the mare-highland boundary (to the south) up to and including the Flamsteed P ring. The number of spectrally distinct flows in the area is striking in the multispectral image alone (Figure 1). From a preliminary analysis we have identified at least 5 flows in the multispectral image alone (Figure 1). Sunshine and Pieters (1990) [4] found three distinct flows within the Flamsteed P ring using high resolution CCD images from a ground based telescope. We find evidence for only two - a younger high-Ti flow (flow A in Figure 1) overlying an older lower-Ti flow (flow C in Figure 1). However, we have not yet reduced the data for the most eastern part of the ring, and it is possible that further flow(s) can be found in our missing section.

The low-Ti flows at some of the mare highland contacts to the south are exceptionally bright in the 750/415nm channel of the multispectral image (flow E in Figure 1). These areas correlate with intermediate FeO and TiO₂ content (the TiO₂ map is shown in Figure 2), and seem to be the oldest flows that are visible on the surface, probably extending over a large area beneath the later flows.

The extent of each flow so far identified is shown in Figure 1. Boundaries were defined according to multispectral and albedo properties. Detailed studies of the TiO₂ map (Figure 2) and maturity data (taken through observations of crater densities from the Orbiter frames, and an optical maturity image produced using the algorithm of Lucey et al. (1998) [5]), will improve this map. Work is continuing in an attempt to delineate clearer flow boundaries.

Stratigraphy of the region: The primary aim of this work is to determine the thickness of the mare flows as one moves out from the highland boundary into Oceanus Procellarum. First order indications of thickness can be obtained by searching for highland outcrops within the maria. The Flamsteed area shows many such outcrops (see Figure 1), and the lavas must be quite thin close to these.

A more absolute idea of basalt thickness can be obtained by calculating the depths of craters which have dug through the lavas to expose highland material below. These craters can be identified from multispectral images and 5-point spectra. Previous work has suggested that a cyan colour in the multispectral frame represents highland material [6,7] and that yellows and greens are freshly excavated basalts [8]. However, we have recently found that a cyan colour can also result from a freshly excavated high-Ti basalt. In order to differentiate between the high-Ti and highland signature it is necessary to look at the FeO and TiO₂ frames, and plot 5-point spectra to look for the absorption at 0.95µm that is characteristic of pyroxenes in the basalts.

These observations have shown there to be candidate craters in the Flamsteed region which have excavated highland material, an example of which is...
shown in Figure 3. The example crater displays a basaltic signature with a clear 0.95\(\mu\)m absorption in its south wall and ejecta, while the absorption in the north wall and ejecta is far weaker. The northern deposits are also relatively low in TiO\(_2\) and FeO, and probably represent a mix of basaltic and highland material. The crater is 8 km in diameter, so will have excavated to a depth of around 800m (using the depth:diameter ratio of 1:10 given by Croft (1980) [9]); this is therefore an upper limit to the thickness of the basalts at the crater’s northern edge.

In addition, there are several areas where craters close together excavate spectrally distinct materials. These may indicate boundaries of subsurface mare flows, and will allow for a more detailed stratigraphic picture to be constructed.

**Future work:** We intend to map the lava flow and crater distribution across the Flamsteed region, using craters to deduce depths to the highland-mare contact where possible. Flamsteed will then be combined with adjoining areas of Oceanus Procellarum, gradually developing a complete picture of the stratigraphy and basalt thickness across the basin. This work will form part of a continuing project in which we aim to study maria across the whole Moon, providing a global perspective of lunar volcanic history.

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