ISOPACH MAPPING OF LUNAR BASALTS IN THE NORTHERN OCEANUS PROCELLARUM REGION, USING CLEMENTINE DATA.

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ABSTRACT.

Analysis of Clementine remote sensing data permits new observations and therefore results to be obtained of basalt flow stratigraphy and underlying morphology and thus the geological evolution of the Moon. In particular the northern section of Oceanus Procellarum contains numerous impact craters that have penetrated the basalt to different depths, providing natural probes for estimating the number and thickness of flows. These estimates when mapped allow an understanding of the underlying morphology.

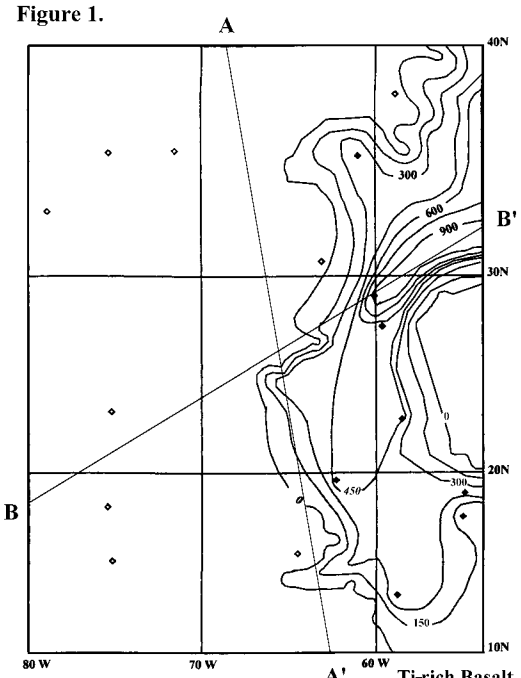
Previous work by De Hon in 1979 [3] used a photogeological technique to attempt construction of isopach maps for this and other regions. This is a revisit to construct isopach maps using Clementine derived images, that include the primary mosaic image (415, 750, and 950 nm bands) [7], [8], ratio image (750/415, 750/950, and 415/750) [7], [4], [8], and an iron image [7], [8]. All indicate that basalt flows in the northern Oceanus Procellarum region change in composition over time and that different layers can be correlated over large areas based on their composition. The western parts of the northern portion of the mare are bounded by anorthositic highlands covered by anorthositic regolith and contains widespread titanium-poor basalts. In contrast, in eastern Oceanus Procellarum, the larger craters expose at least two basalt flows of around one kilometre to 1.5 kilometres in thickness. Broadly, each titanium-rich surface unit is underlain by a titanium-poor unit that itself is underlain by anorthositic basement. A statistical sample of craters to 20 kilometers in diameter was used to derive the relative thickness of the basalt layer(s). Using the relationship that depth equals ten percent of the diameter for craters up to about 20 kilometres [2], [5]. In addition, hand drawn isopach diagram (Figs 1 and 2) and computer generated graphics, for the basalt layers provide area and volume estimates that are in reasonable agreement [7]. The titanium-rich basalts in the region are estimated to be as young as 1.1 billion years old [6], [9], while the titanium-poor basalts (Apollo 12 basalt samples) are estimated in age between 3.08 and 3.37 billion years [6]. In the northern Oceanus Procellarum [area 525,000 square kilometres), the volume of basalt exceeds 240,000 cubic kilometres [7]. The titanium rich surface layer is estimated to be 48,000 cu km and the titanium poor second basalt layer is about 193,000 cu kilometers [7].

Combined with topographic maps [1], [10], the interpretation of resulting isopach cross sections is that the Oceanus Procellarum basin formed and was later subjected to further impacts, into which the titanium poor basalts flowed filling these hollows and covering the region; the titanium poor basalt layer was later subjected to impact events that created hollows into which the titanium rich basalts flowed and covering much of the eastern Oceanus Procellarum. While another mechanism may have created these hollows – impact cratering seems the most likely cause.

These results in turn provide a new set of constraints that contribute to a growing understanding of the geological history of the Moon.

References: [1] Bowker D.E., and Hughes J.K., *Lunar Orbiter Photographic Atlas of the Moon*, (NASA Langley, Virginia USA, NASA SP-206). 1971. [2] Croft S.K., *Cratering flow field: Implications for the excavation and transient expansion stages of crater formation*. Proc. LPSC, 9th, P2347, 1980. [3] DE Hon R.A., *Thickness of the Western Mare Basalts*, Proc LPSC, 10th, P 2935-2955. [4] Eliason E.M. et al, *Digital image processing for a global multispectral map of the Moon from the Clementine UVVIS imaging instrument,* Lunar Planetary Science Conference, XXX (CD-ROM), Houston Texas, USA, abstract no. 1933, 1999. [5] Grieve R.A.F., *Impact Cratering,* "Nature" Journal Volume 291, p 16, 1981. [6] Heiken G.H., Vaniman D.T., French B.M., *The Lunar Source Book*, Cambridge University Press, 1991. [7] Jackson, N.W., *A Study of the basalts of Northern Oceanus Procellarum using Clementine Lunar Orbiter data,* 1st Australian Space Science Workshop, National Space Society of Australia, Sydney, Australia. 2001. [8]. Lucey, P G.; Blewett, D T.; Jolliff, B L., *Lunar iron and titanium abundance algorithms based on final processing of Clementine ultraviolet-visible images,* Jour. Geophys. Res. Volume: 105 Number: E8, Pages: 20,297-20,306, 2000 ISSN/ISBN: 0148-0227. [9] Spudis P.D., *Once and future Moon*, Smithsonian Institution, 1996. [10] US Geological Survey, Weir D. ed)"*Atlas of the Moon"; 1:5,000,000 Topographic Series, The Lunar Near Side, L 5M 0/0 R, 1992, MAP I-2276 (Sheet 1 of 2,* 1990). Projection is Conical Mercator (Polar Mercator) - map of study area in northern Oceanus Procellarum.

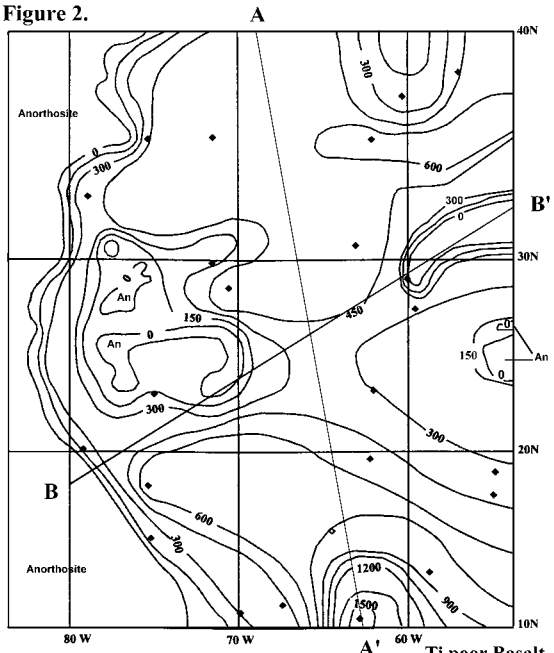
Figure 1.



Isopach interval = 150 metres

Ti-rich Basalt isopach map.

Figure 2.



Isopach interval = 150 metres

Ti-poor Basalt isopach map