ESTIMATED IMPACT AGE FOR A COLD SPOT CRATER IN LUNAR MARE FECUNDITATIS

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We will present evidence that a lunar cold spot crater, with a diameter(D) ≈ 255 meters(m), was formed by an impact 57 to 78 years ago. Cold spots (Bandfield J. L. et al, 2014, [1]) are a family of very young- looking lunar craters, that are characterized by having a surface, surrounding the impact, with nighttime average temperature at least 2k less than the background, rock free, regolith temperature. This property seems common to all new and small impacts (100m ≈ ≤ D ≤ ≈1.5km) , but so ephemeral that the total number of them is only about 4,000 [1]. For instance, we see in Figure 1 that only three cold spots with D ≥ 250m, remain in an area close to 30,000 km^2. In contrast, the total number of craters, of the general population, of similar areas and size is estimated to be near 30,000 (Hartmann W. K., 1995,[2]). Hence, the above considerations strongly suggest that these three cold spots are the most recent impacts in this region, and in what follows we investigate their age more closely.

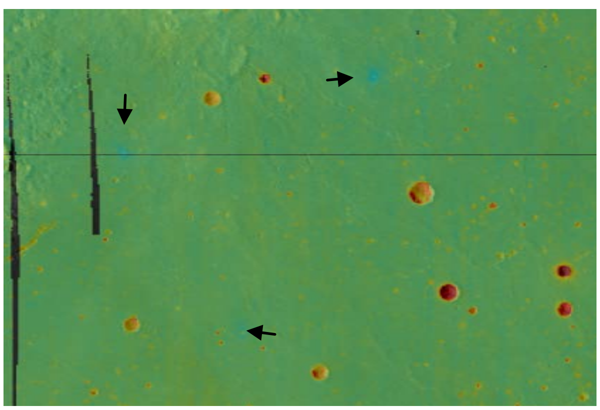

Figure 1: The Arrows Point To The Three Cold Spots With D ≥ 250m.

One of the ways for looking for signs of ageing in a crater is by inspecting its ejecta to find new impacts, that occurred after its formation. For the craters that concern us here (D ≈ 250m), without enough displaced material, we find that the smaller new craters, which can be resolved with the LROC (Lunar Reconnaissance Orbiter Camera), are mixed with the already existing craters of similar diameters, and thus it is not easy to differentiate them (see Figure 2). Fortunately, a procedure has been followed, based on the recognition of the perturbative effect of a new impact on the ejecta blanket, around a fresh crater. These alterations, visible on small angle solar incidence photos, usually appear as scars, with spider-like patterns (Figure 3) and symmetrical shapes that break the original strike radial symmetry. Moreover, by observing the corresponding (LROC) images, at a large angle of solar incidence, and covering the same location, we are able to identify the actual, inconspicuous, new impact crater which was responsible for the more clearly distinguishable and magnified scar event .

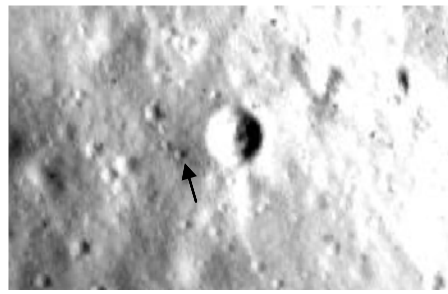

Figure 2: New Formed Crater(Arrow), At Latitude: 2.452,Longitude:45.437;(2.452/45.437).Source: LROC Large Solar Incidence Image, Near A Cold Spot With Similar Coordinates, In Mare Fecunditatis.

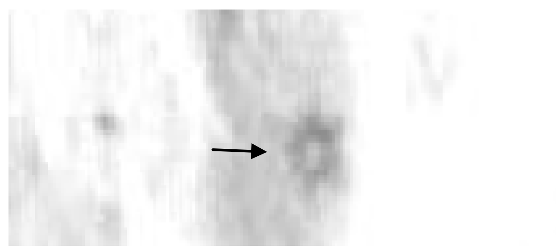

Figure 3: Spider-Like Mark Associated With The New Crater Of Figure 2. LROC Small Solar Incidence.

Two of the three inspected cold spots in Figure 1 indeed display the spider-like features, mentioned before, that are associated, in their creation, with craters possessing D ≥ ≈ 4m. On the other hand, we did not find similar marks on the crater at the latitude 3.635 and longitude 48.929 degrees (cold spot 1), in an investigated area of about 1 km^2, surrounding it.

The above findings can be interpreted in terms of a probabilistic period for impacts, by using the following formula: $\bar{\Phi}(D) \approx 2.36\, D^{-3.82}$, (Ruiz et al, 2015,[3]) which approximately describes the rate of impacts, $\bar{\Phi}(D)$, per km^2, forming craters larger than D. This flux equation is consistent with observations of lunar flashes by Ortiz J. L. et al ,2006,[4], and Madiedo J. M. et al, 2013,[5]. For craters with D ≥ ≈ 4m, discussed above, we find that $\bar{\Phi}(4m) \approx (85\, years\_km^2)^{-1}$, thus suggesting that cold spot 1 was created within a period of 85 years. Nevertheless, it is older than 57 years, since it appears, bright, in a 1959 photo of the Rectified-Lunar-Atlas (also he is in Apollo 15-M-2008,(1971) and Lunar Orbiter l (1966), frame 1031, images). However, we cannot see it in a 1938 photo (Figures 4, 5a and 6a) of the Kuiper et al, Consolidated-Lunar-Atlas (Part 1,E3, high-resolution closeup), even though similar and dimmer objects are easily visible in the photo. For example, we see in Figure 6b that a LROC photo of the same location, with a similar solar incidence angle, shows a remarkable view of cold spot 1 (at the tip of the straight arrow in figure 6b), standing up among the other light sources in the proximity. Yet, the corresponding location for cold spot 1 in the 1938 image ((at the tip of the straight arrow in figure 6a) does not have a clear light source.

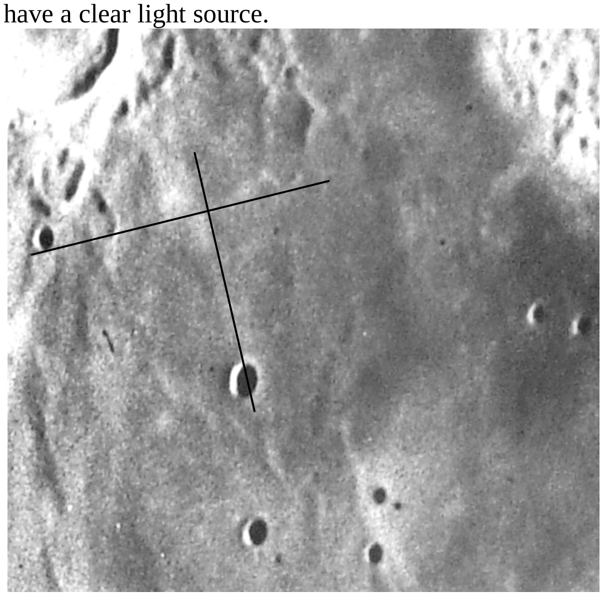

Figure 4:1938 Photo Of The Kuiper et al Consolidated Lunar Atlas (http://www.lpi.usra.edu/resources/cla/), In Mare Fecunditatis(E3). The Axis From Left To Right Was Determined By A Line Starting, At Left, Tangent To The Crater Taruntius B, With Coordinates 3.29/46.66, And Ending At The Center Of A Crater With Coordinates 3.79/50.48. The Origin Of Coordinates Is At 3.53/48.94.

Although, we understand the difficulties in interpreting lights and shadows in the moon, and that alternative explanations are possible, our interpretation is that the age of cold spot 1 is probably between 57 and 78 years.

We would like to point out ,conversely, that a confirmation of the absolute age for cold spot 1, or similar impacts, will be very important for determing a more refined impact rate at the scale of the LROC resolution. Furthermore, with knowledge of this more precise flux an iterational procedure will provide a very important accurate determination of $\bar{\Phi}(D)$ for larger diameters.

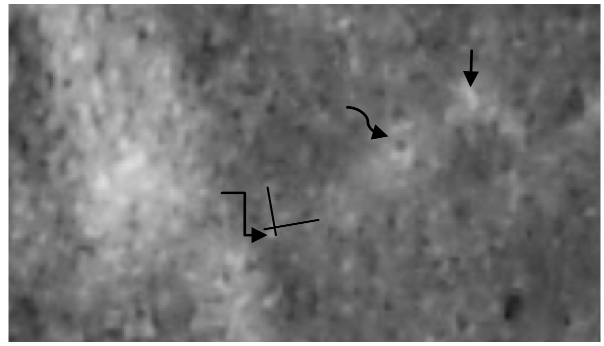

Figure 5a: The Tree Arrows Are Pointing To Objects In The 1938 Image That Are Identified In Figure 5b.

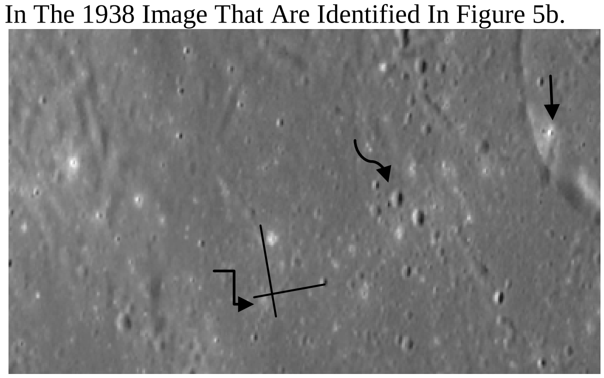

Figure 5b: LROC Image Of The region Of Figure 5a.

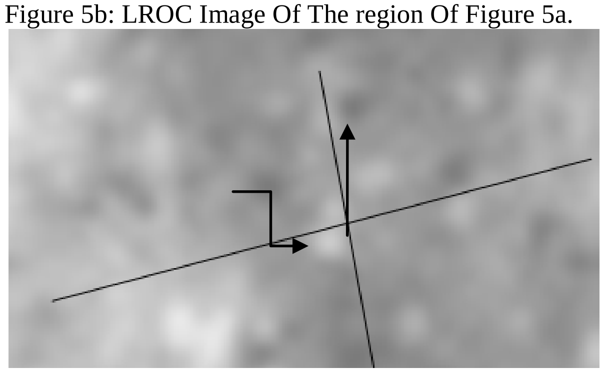

Figure 6a: Closeup Of Figure 5a

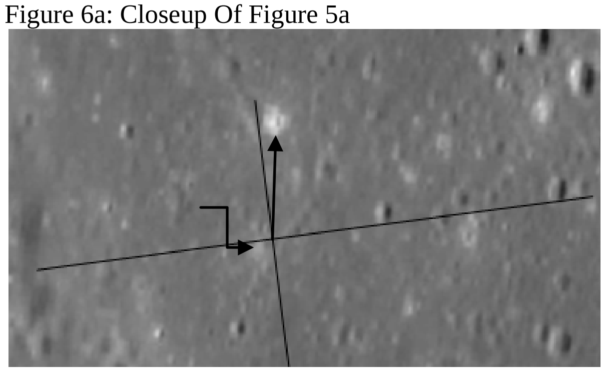

Figure 6b: Closeup Of Figure 5b

References:[1] Bandfield J. L. et al, (2014), Icarus, vol 231, [2] Hartmann W. K., (1995), Meteoritics, 30, p. 451. [3] Ruiz A. et al (2015) , 6th Planetary Crater Consortium Meeting,Abstract # 1503 [4] Ortiz J. L. et al (2006), Icarus, 184, 319, [5] Madiedo J. M. et al, (2013), MNRAS, 431, 2464.