EPSC Abstracts
Vol. 11, EPSC2017-971, 2017
European Planetary Science Congress 2017

Mapping Lunar Impact Flashes

A. C. Cook (1), D. Thorpe (1), and M. D. Menzies (1)
(1) Department of Physics, Aberystwyth University, Aberystwyth, Ceredigion. SY23 3BZ. UK. (atc@aber.ac.uk)

Abstract

Lunar Impact flashes are the result of the optical radiation of just under one percent of the kinetic energy released when meteoroids, travelling at tens of kilometres per second, strike the lunar surface. The locations of the impact sites of two photographic candidate impact flashes, are re-determined, and their apparent spatial extent given.

1. Introduction

Unless spacecraft images exist of the lunar surface, before and after a meteoroid strikes the Moon, and the images were taken under similar illumination angles, it is very difficult to identify which new crater has been formed amongst the already heavily cratered lunar surface [1]. This is furthermore hindered by Earth-based imagery being kilometre scale in resolution; whereas the resulting telescopic impact flash craters are on the scale of metres, i.e. a factor of a thousand times smaller. It is therefore essential to develop procedures which can narrow down the search space. We investigate a couple of historical observations of lunar flashes and simulate the visual appearance of the lunar terrain using the LDEM_64 digital elevation model [2], with solar illumination and shadow effects added for the given date and UT of each flash.

2. Lunar Flare from: 1953 Nov 15

On this date at 02:00 UT Doctor Leon Stuart, of Tulsa, OK, USA, photographed a long duration flare (Fig 1 Left) apparently on the lunar surface which moved with the image of the Moon when he moved the telescope [3]. He took a photographic plate, went inside to develop it, and when he came back outside to observe later it had gone. One attempt has been made previously to locate the impact crater in modern era spacecraft imagery [4], however the location of the candidate craters has been shown to be incorrect [5]. Using the topocentric libration (sub-observer point), and sub-solar point, a computer simulation was made to produce a virtual image of what the usual appearance surface of the Moon would have looked like (Fig 1 Centre). Using manually measured tie points, the image of the flash was affine transformed to the simulated view. From this we were able to determine the centre of figure of the flash lay at coordinates 4.29˚ N, 3.30˚ W, with an error of ±0.5 km, based upon our uncertainty of measuring the positions of the tie points. This is illustrated in Fig 1-Right where the flash has been overlaid upon the simulation. The flash is circular, has a diameter of 35 km, and the area is ~974 km^2.

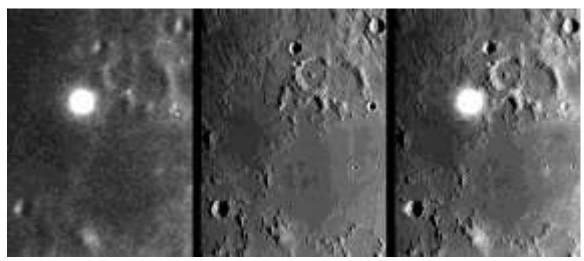

Figure 1 The Pallas area of the Moon where in 1953 Nov 15 Leon Stuart photographed a lunar flare. (Left) Copy of the photographic plate taken by Leon Stuart. (Centre) An ALVIS simulation of the surface appearance. (Right) The flash photograph overlaid on the simulation.

3. Lunar Flash from: 1985 May 23

On this date at 17:41 UT George Kolovos, was observing from a village in northern Greece (Nea Bafra, Serrai), capturing the Moon on 35 mm film. Without seeing it visually, he recorded a flash in the vicinity of Proclus C crater [6], however a later study [7,8] inferred that it may have come from a sun glint from a non-operational, rotating, US military DMSP F3 weather satellite, which was on a predicted track past the Moon. Subsequent correspondence suggested that sun-glint from solar panels (which are never perfectly optically flat) should have left a trail in the image [9]. As no trail was visible in the image another origin was suggested, namely a release of light from piezoelectric effect [9, 10], when rocks fracture under thermal stress during sunrise. Alternatively, it was speculated that the flash resulted from a meteoroid impact on the Moon [11].

Using a similar approach to the 1953 flash, we produced a simulated view of the lunar surface and used this to refine the location of the flash (Fig 2). We deduce that the flash is an ellipse of a = 17.5 km, b = 14.0 km, and an area of ~770 km^2, as seen from Earth. Although the flash is slightly irregular in shape, in view of the photographic image noise, we do not see strong evidence that it may have illuminated surrounding terrain in the image [6], nor been modified in shape by the surrounding topography [9]. Neither do we see the semi-major axis of the flash lying along the trajectory of the satellite [7,8], which was aligned approximately 30˚ clockwise from the terminator at this location. We estimate the location of the flash as 13.40˚ N, 43.11˚ E +/- 2.2 km in the image plane, based upon our tie point uncertainty.

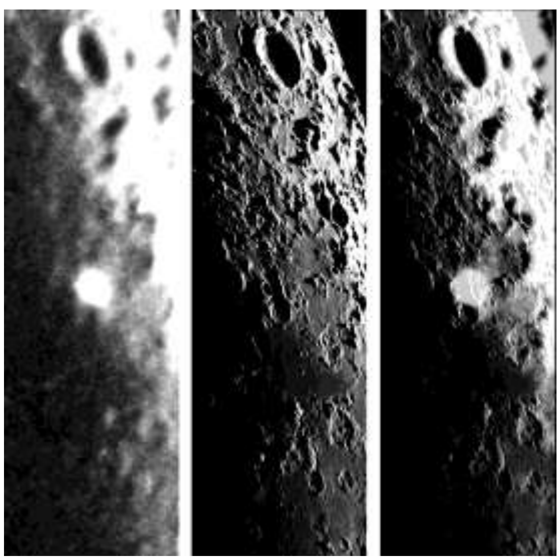

Figure 2: The 1985 May 23 observation of a flash on the Moon, by George Kolovos, Aristotle University of Thessaloniki, Greece. (Left) A scanned copy of the original image. (Centre) A computer simulation of the appearance of the lunar surface at the given date and time. (Right) Simulation with flash overlaid.

4. Discussion

The 1953 flare is widely regarded as the first known photographic record of an impact flash on the Moon and happened during the Leonid meteor shower. It was also seen visually by the observer concerned on a photographic ground glass screen. By contrast the 1985 flash is less certain as it was not seen visually. Both flashes are not too dissimilar in apparent size.

It is important to note that the positions of the flashes found by ourselves have a caveat, namely it is assumed that the geocentric centre of each observed flash is the actual centre of the impact. Studies have suggested that this may not always be the case, in that there are at least three examples where supposedly point-like impact flashes, as videoed from Earth, have appeared elongated [11]. It is also possible that the area of each flash is the result of photographic halation and not a true spatial area on the Moon

We will refine our studies using a higher resolution DTM and allow for terrestrial atmospheric effects such as distortion due to atmospheric convection cells, and refraction, with the aim of reducing the measurement errors further. We have also been experimenting with the use of Earth-based imagery taken under similar illumination and viewing conditions, in order to better match the appearances of these historical observations than the simulations can provide.

Acknowledgements

We would like to thank Jerry Stuart for supplying a scanned image of a copy of his father's photographic plate, and to George Kolovos for supplying some photographs of his recorded flash. Europlanet 2020 RI has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208 for the development of lunar impact flash detection software at Aberystwyth University.

References

[1] Speyer *et al. Nature*, 538, p215-218, 20. **[2]** Barker, M.K. *et al.*, *Icarus*, 273, p346-355, 2016. **[3]** Stuart, LH., *The Journal of the International Lunar Society*, 1, p6-8, 1957. **[4]** Buratti, B.J. and Johnson, L.L, *Icarus* 161, p192-197. **[5]** Haas, W.H., *The Strolling Astronomer*, 47, p46-55, 2005. **[6]** Kolovos, G. *et al.*, *Icarus*, 76, p525-532, 1988. **[7]** Maley, P.D., *Icarus*, 90, p326-327. **[8]** Rast, R.H., *Icarus*, 90, p328-329, 1991. **[9]** Kolovos, G. *et al.*, *Icarus*, 97, p142-144, 1992. **[10]** Zitto, R.R., *Icarus*, 92, p419-422, 1989.. **[11]** Madiedo, J.M. *et al.*, *Astronomy and Astrophysics*, A118, p1-9, 2015. **[12]** Menzies *et al.* (This conference). 2017.