Characterising asteroidal and cometary material on the Moon and its value for future resource utilisation

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Summary

Throughout solar system history thousands of asteroids and comets have struck the Moon, resulting in the heavily cratered surface we see today. There is growing evidence that some fraction of these bodies survive impact with the lunar surface (e.g. Yue et al., 2013; Svetsov and Shuvalov, 2015; Wieczorek et al, 2012). This is of interest for two reasons. Firstly, if impactor material can be recovered from the Moon it will yield valuable information about the composition of asteroids and comets passing through the inner solar system (e.g. Joy et al., 2016). Secondly, the remains of impacted asteroids and comets may provide local sources of raw materials which are naturally scarce on the Moon (e.g., depending on the composition of the impactor, native metals, carbon, nitrogen, organic molecules, and hydrated materials), but which will be very useful in the context of future human activities on the Moon (see, e.g., Crawford, 2015). This project will investigate both aspects, but with a particular emphasis on the latter.

The project will consist of three main parts:

(1) Use of the iSALE shock physics impact code (www.isale-code.de) to assess the survivability of asteroidal and cometary materials upon collision with the lunar surface as a function of impactor composition, velocity, and impact angle (e.g. Potter and Collins, 2013). These results will be used to estimate the fraction of impacts that are likely to retain a sufficient amount of impactor material to be useful as a potential resource, and to determine the likely locations of such material in and around the resulting impact crater.

(2) Assess the most appropriate remote sensing techniques that may be used to search for the presence of surviving impactor material on the lunar surface, and to make use of existing remote sensing datasets to search for such materials in the most promising localities.

(3) Use these results to make recommendations for future lunar missions designed to make in situ investigations of surviving asteroid and cometary material on the Moon and to identify specific landing sites where such materials may be expected to occur on the present surface.

Outline of proposed research

Year 1: Compile literature review of previous studies of survival of impactors on planetary surfaces. Become familiar with iSALE impact code and initiate impact computations for a range of impactor compositions, targets, and impact angles.

Year 2: Continue impact simulations and assess survivability of impactor material. Submit paper for publication outlining key results. Based on the likely type and locations of surviving impactor material, assess the most appropriate remote sensing datasets that may be used to identify it. As appropriate, make comparisons with other planetary bodies (e.g. inferred carbonaceous impactor material on Vesta; McCord et al., 2012). Initiate search for surviving impact material at most promising locations on the lunar surface.

Years 3-3.5: Conclude search of the lunar surface for surviving impactor material and assess the range of masses and compositions that might realistically be available for future resource utilisation. If necessary, use observational results to refine computer models. Submit paper for publication describing key results and making recommendations for future lunar missions. Write-up and submit PhD thesis.

Student Prerequisites

Applicants should have a first or upper-second class degree in planetary science or a related subject. Some knowledge of lunar geology and experience in computer modelling would be an advantage.

References

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