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A multi-instrument *Exomars* study of meteoroid effects on the Martian environment

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ABSTRACT

Mars, like the Earth, encounters meteoroids of various sizes, composition and origin during its orbital trek around the Sun. Those meteoroids' mass and kinetic energy are incorporated into the Martian environment through: atmospheric ablation and deposition of meteoroid constituents in the upper atmosphere; efficient atmospheric braking leading to a meteorite on the surface; and hard impact, resulting in luminous flares (and/or plumes), seismic shaking and crater excavation [1]. These effects have been modelled theoretically but in situ measurements needed to test these models have hitherto been lacking. The Exomars instrument suite presents an excellent opportunity to carry out such observations and compare with similar processes detected at the Earth and Moon. The following investigations that we advocate promote synergism between the different instruments, require no hardware modification or space qualification of "soft" mission resources such as inflight software and provide maximum science for the effort.

Meteor activity at Mars would be punctuated by annually recurring showers and occasional outbursts with pronounced effects on the Martian atmosphere and surface [2, 3, 4, 5]. These, mostly cometary, meteoroids, have been delivering prebiotic material to Mars for the past 4.5 Gyr. As the present Martian atmosphere has similarities with that of the early Earth, the astrobiological relevance of meteor showers as exogenous sources of organics and water for both Earth and Mars is obvious. These events can now be predicted with sufficient reliability both at Mars [4] and the Earth (eg [6, 7]) to justify targeted observational campaigns. Relevant measurements include: dual-eye panoramic camera detection of visible meteors in the Martian sky using existing flight-qualified change-detection software to minimise data volume [8]; radio occultation height profiles of ionospheric electron density during the orbital phase of the mission [9] and of the total electron content (TEC) post-landing; and seismic detection of impact event clusters correlated with Mars' passage through low-speed meteoroid streams [10].

Decimetre-to-metre size craters are theoretically expected on the Martian surface due to the influx of specific meteoroid subpopulations, eg cm-sized M-type asteroidal fragments [11, 12]. Pit-like formations of this size have been observed by Opportunity although their origin, whether impact-related or otherwise, remains a mystery. Observing such pits would lead to estimates of their area density, and characterise the mechanisms that destroy them over time such as dust infilling. A combination of panoramic and hi-res camera observations is well suited to this task and will determine the present hazard from such meteoroids on surface activities.

Meteorites, particularly rare nickel-irons, have recently been identified on the Martian surface [13]. The area density and size distribution of those and other, more common, meteorite classes are sensitive to atmospheric density [14, 15] and can be used as proxies for past climate variations. Identification of such meteorites using imaging and spectroscopy during the landed part of the mission will provide a unique insight on the variation of the Martian environment with time. Apart from their role in fulfilling the mission goals of characterising the biological environment on Mars in preparation for robotic missions and human exploration, these investigations hold a significant potential for communicating to the public the excitement of exploring Mars and the sense of "being there". Public release of selected data products eg images of meteors and fireballs against the Martian sky are bound to have a positive impact on the public perception of European planetary exploration.

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