SMART-1 IMPACT GROUND-BASED CAMPAIGN

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Introduction: SMART-1 was launched in 2003 and was orbiting the Moon on a 5 hours period until impact on 3 September 2006. A slight thrusting manoeuver was operated in June to fine tune the exact time and location of impact. SMART-1 (285 kg) impacted at 5h42:22 UT at Lake of Excellence in grazing incidence with a velocity of 2 km/s and kinetic energy 600 MJ. We called the community to make predictions of impact magnitude, cloud ejecta dynamics and exospheric effects. We also organized a ground based observation campaign to perform coordinated measurements of the impact. Results from the coordinated multi-site campaign will be discussed.

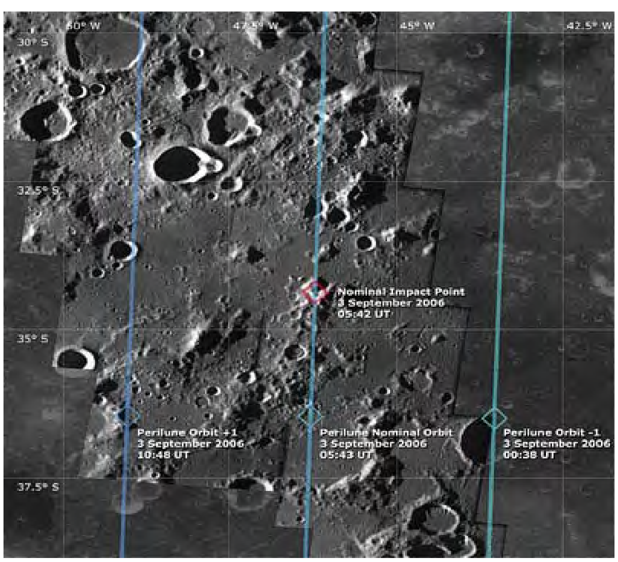

Fig.1 : Orbital track over the impact site imaged 10 days before with the SMART-1 AMIE camera

Predicted effects and proposed observations:

The science interest for SMART-1 impact observations are to study impact physics, lunar science and spacecraft related effects. The thermal and dynamic evolution of the thermal flash and ejecta right after impact can constrain the understanding of impact processes such as dust acceleration, gravity controlled excavation, and strength related effects. The monitoring of spacecraft volatiles released after impact can help to simulate and to understand processes occurring on volatile rich natural impactors. One should also monitor the speed and dynamics of ejecta and dust clouds that could be followed in the Earthshine or in sunlight, other transient changes, and the characteristics of impact crater and deposited ejecta. Among the relevant observations are infrared imaging of thermal flash and visible/infrared imaging of the dynamics of ejected clouds, measurements of motions, plumes and curtains of ejected mass, images of ejecta reaching sunlight and investigation of the mineralogy of ejecta. In particular the infrared range from 2 – 20 microns allows to constrain the present lunar minerals (pyroxene, olivine), complementary to SMART-1 diagnostics (AMIE camera colour ratio with 0.95 micron pyroxene band, and SIR 0.9 -2.5 micron spectrometry). The spectral energy distribution can provide quantitative characteristics such as mineralogical composition, porosity, crystallinity, size distribution and space weathering.

For the thermal flash bolometric magnitudes between 7–16 (during the first second) in the infrared, depending on efficiency (0.5-0.001), were predicted. In addition to thermal effects, we expected the emission from volatile elements onboard (hydrazine N_2H_4 decomposing in ammonia NH_3 and H compounds, detectable in Paschen and Brackett or even Balmer if the excitation temperature is sufficient). For the Hiten impact (300 kg, 2.7 km/s, 1 kg hydrazine) a flash signature detected in the K band was ascribed to Brackett g emission. Other probe signatures may be detectable (Al melting at 600 deg C, graphite). A crater size of 5-10 m was expected.

The volume of material ejected (predicted to be 10 m^3) will be essentially made of dust with dominant size around 15 microns (normalized per area) and the effective area of ejecta could be 25 km^2. This can lead to obscuration of the underground soil in the first minute after impact, and partial obscuration later. The ejecta can be also traced in Earth shine reflected light giving a level of V=14.5 per $arcsec^2$ accessible to large telescopes (1500 photon per second for a 2 m class telescope). Small telescopes are able to image the Earthshine on the Moon, even with a modest resolution of 1.5 arcsec. They would be able to detect the excess brightness of the effective area of elongated ejecta with excess magnitude 13-14.

The SMART-1 impact observation campaign involved a core of participating telescopes, including: the South African Large Telescope (SALT), the Calar Alto observatory in Andalucia, Spain, the ESA Optical Ground Station (OGS) at Tenerife, Spain, the TNG telescope in La Palma, Canary Islands, Spain, the CEA Cariri observatory in Brazil, the Argentina National Telescope, the Florida Tech Robotic telescopes at Melbourne FL and Kitt Peak, MSFC lunar meteor robotic telescopes, Houston 1m, Big Bear Solar Observatory, MDM telescopes at Kitt Peak, NASA IRTF, the Canada-France-Hawaii Telescope, the Japanese Subaru Auxiliary telescopes on Hawaii, the ODIN space observatory. We acknowledge also support from Nottingham University, and the USGS.

Five radio telescopes were involved in the SMART-1 observations, coordinated by the Joint Institute for VLBI (Very Long Baseline Interferometry) in Europe (JIVE): the Medicina (INAF) 32- metre antenna in Italy, the Fortaleza (ROEN) 14-metre antenna in Brazil, the German-Chilean TIGO (BKG) 6-metre antenna in Chile, the Mount Pleasant Observatory of the University of Tasmania (Australia) and the Australia Telescope Compact Array (CSIRO).

References:

Burchell and Cole (2006), see SMART-1 website

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Links: http://sci.esa.int/smart-1/ ,
SMART-1 scitech website http://sci.esa.int/
ESA public site:
http://www.esa.int/SPECIALS/SMART-1/index.html

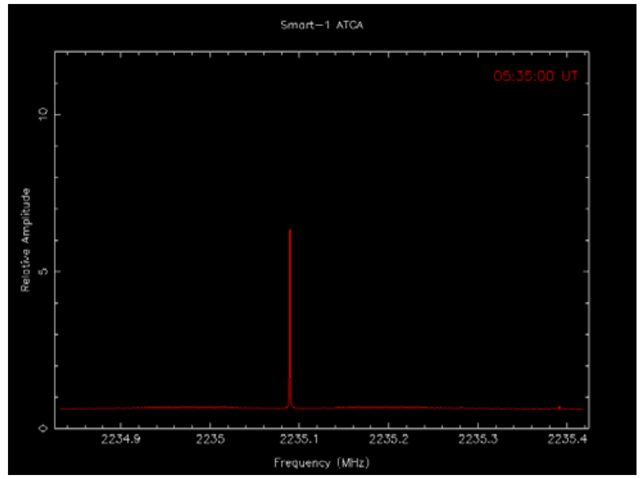

Fig.2 SMART-1 radio swan song just before impact.

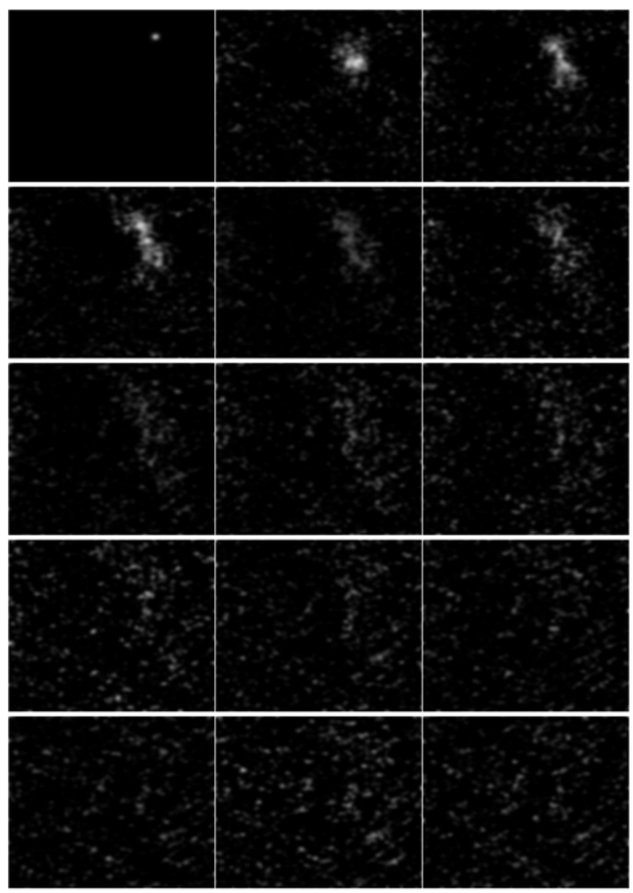

Fig.3 Time series of SMART-01 impact flash and ejected debris observed from CFHT (Veillet et al)