SP-1312

Extract of SMART-1 section

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3.2 SMART-1

Introduction

SMART-1 (the first Small Mission for Advanced Research and Technology) was designed mainly to demonstrate innovative and key technologies for future deep-space science missions, with emphasis on Solar Electric Primary Propulsion (SEPP). SMART-1 was launched by Ariane-5 on 27 September 2003. After a 13.5-month cruise using solar electric propulsion, it attained lunar capture orbit in November 2004, and lunar science orbit in March 2005. The in-orbit operations phase of SMART-1 was terminated on 3 September 2006 when the spacecraft made a targeted impact of the Moon, at the Lake of Excellence. SMART-1 achievements include:

— First mission leaving the Earth using solar power alone
— First ESA mission reaching the Moon and first European views of lunar poles
— First European demonstration of a wide range of new technologies: Li-Ion modular battery, deep-space communications in X- and Ka-bands, and autonomous positioning for navigation
— First lunar demonstration of an infrared spectrometer and of a Swept Charge Detector Lunar X-ray fluorescence spectrometer
— First ESA mission with opportunity for lunar science, elemental geochemistry, surface mineralogy mapping, surface geology and precursor studies for exploration
— First controlled-impact landing on the Moon with a real-time observation campaign.

SMART-1 instruments

SMART-1 carried seven instruments to perform 10 investigations. Part of the payload monitored the electric propulsion and spacecraft environment during the cruise, and tested novel spacecraft and instrument technologies:

— SPEDE, characterising the spacecraft and its environment, together with EPDP, a suite of sensors monitoring secondary thrust-ions, charging and deposition effects;
— KaTE, X/Ka-band deep-space communication experiment, and radio science investigation (RSIS).

The remote-sensing instruments for imaging and spectrometry were highly miniaturised:

— D-CIXS, a compact X-ray spectrometer, performed lunar mapping measurements by fluorescence of the major rock-forming elements (Mg, Si, Al, O, Fe) of lunar geochemistry;
— XSM, X-ray solar monitor observed variations of the Sun owing to activity and flares, and served in the calibration of the D-CIXS;
— SIR, a miniaturised quasi-monolithic point-spectrometer, the first near-IR lunar spectrometer, surveyed the distribution of the main minerals in the lunar crust;
— AMIE, a miniature camera based on 3-D integrated electronics, imaged the Moon in four spectral bands defined by thin-film filters, and supported three guest investigations: Laser-Link, a demonstration of acquisition of a deep-space laser-link from the ESA Optical Ground Station at Tenerife; OBAN, the demonstration

For further information, see http://sci.esa.int/smart-1/

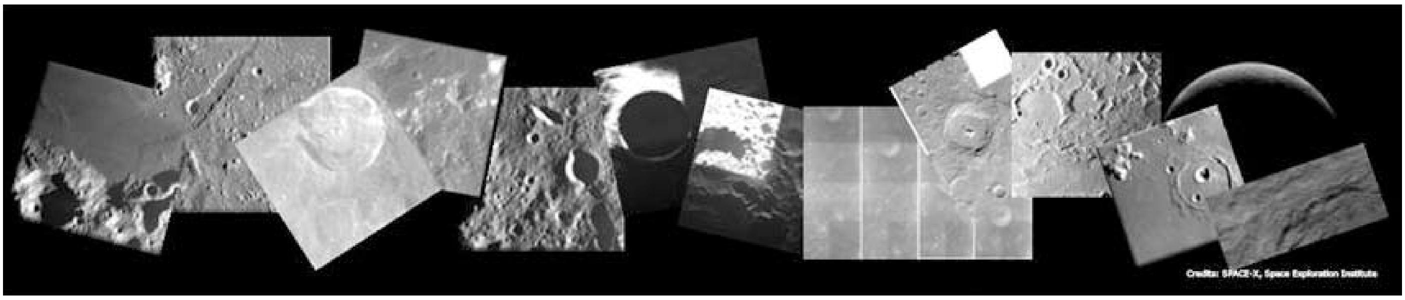

Figure 3.2.1. Gallery of SMART-1 images. They illustrate the volcanic, cratering, tectonic and weathering processes that have shaped the lunar landscape during its history.

of an autonomous navigation tool; and RSIS for the in-orbit measurement of lunar libration.

SMART-1 was operated from the Mission Operations Centre (MOC) at ESOC. The Science and Technology Coordination (STOC) effort was located at ESTEC. The scientific activities have been coordinated within the Science and Technology Working Team (STWT) chaired by the Project Scientist (B.H. Foing). In synergy with the technology objectives, the science objectives for the lunar investigations included studies of the origin of the Earth-Moon system, accretional processes that led to the formation of planets, the chemical composition and evolution of the Moon, geophysical processes (volcanism, tectonics, cratering, erosion, deposition of ices and volatiles) for comparative planetology, and high-resolution mapping for future exploration (Fig 3.2.1).

SMART-1 lunar results

D-CIXS produced measurements of the lunar surface in X-ray fluorescence (XRF), giving elemental abundances of Mg, Al and Si (and Fe plus others, even calcium when solar activity permitted) across the whole Moon. The South Pole-Aitken Basin and large lunar impact basins have been covered. Bulk crustal composition has a bearing on theories of the origin and evolution of the Moon.

The infrared spectrometer, SIR, had sufficient spectral resolution to separate the pyroxene and olivine signatures in lunar soils. SIR data are helping to refine compositional analyses from Clementine/Lunar Prospector data. IR spectrometry, with spatial resolution as high as 400 m, permitted units to be distinguished on central peaks, walls, rims and ejecta blankets of large impact craters, allowing stratigraphic studies of the crust. Observations of small craters showing a wide age range are aiding studies of the influence of space weathering on reflectance spectra.

The AMIE camera obtained more than 23 000 images of the Moon. AMIE included filters deposited on the CCD in white light + three filters for colour analyses, with bands at 750, 900 and 950 nm. The camera had a resolution of 40 m/pixel for a perilune of 400 km, and 80 m/pixel for a large part of the southern hemisphere. Imaging was obtained in survey mode to cover adjacent parts of the Moon, and in targeted mode for detailed studies of specific sites. AMIE images are being used in the study of impact crater physics, volcanic processes and tectonics. They give a geological context for SIR and D-CIXS data, and complementary colour or multi-phase angle data.

Repeated high-resolution images of the poles have been obtained (see Fig 3.2.2), mapping areas of ‘quasi-eternal light’ and ‘permanent shadow’, and sites important for future exploration.

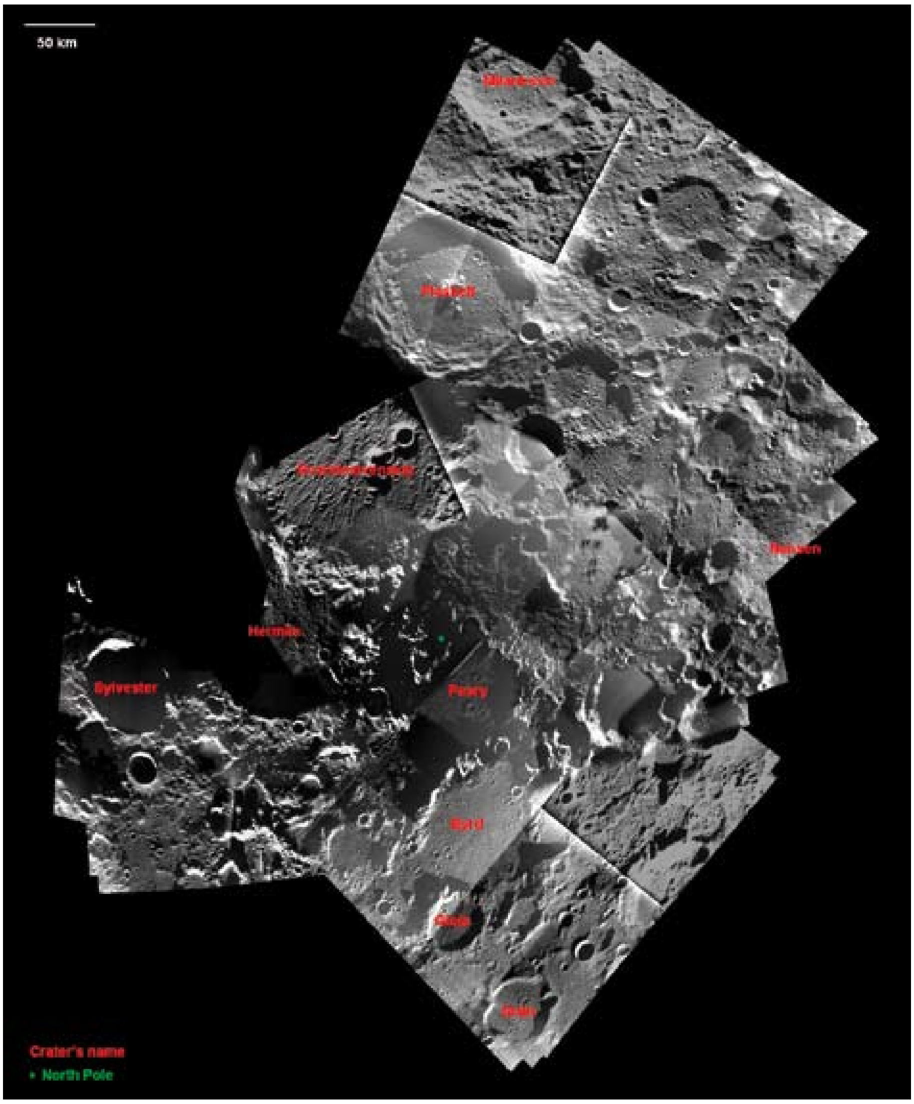

Figure 3.2.2. SMART-1 mosaics of the lunar North Pole. Some 30 individual images (each with a field of 300 km and medium resolution of 300 m/pixel) were obtained at different phases of the mission from May 2005 to February 2006. The SMART-1 spacecraft over-flew the north pole at a distance of 3000 km. The names of prominent craters are indicated. The lunar poles are interesting sites for bases because of their access to sunlit rims, resources, permanent shadows and possible volatiles.

SMART-1 data are archived according to the Planetary Data System Standards. There will be an inter-calibration and integration of the SMART-1 data between the instruments and with existing data from previous missions such as Clementine and Lunar Prospector. The SMART-1 team is cooperating with the teams from upcoming missions (Japan's Selene-Kaguya, India's Chandrayaan-1, China's Chang'E-1, and the US Lunar Reconnaissance Orbiter/LCROSS impactor) and is studying data on sites for future landers and rovers.

As of Jan 2008, more than 40 refereed papers and 210 proceedings papers have been published on the mission and its technology, science and exploration results.