RELEVANCE OF PHOBOS IN-SITU SCIENCE FOR UNDERSTANDING ASTEROIDS Stephan Ulamec[1*], Patrick Michel[2], Matthias Grott[3], Susanne Schröder[3], Heinz-Wilhelm Hübers[3], Yuichiro Cho[4], Naomi Murdoch[5], Pierre Vernazza[6], Olga Prieto-Ballesteros[7], Jens Biele[1], Tra-Mi Ho[8], Simon Tardivel[9], Till Hagelschuer[3], Jörg Knollenberg[3], Maximilian Hamm[3,10], Hirdy Miyamoto[4], Tomohiro Usui[11]. [1]DLR MUSC, Linder Höhe 1, 51147 Cologne, Germany, stephan.ulamec@dlr.de, [2]Université Côte d'Azur, Obs. de la Côte d'Azur, CNRS, Nice, France, [3]DLR, 12489 Berlin, Germany, [4]University of Tokyo, 113-0033 Tokyo, Japan, [5]ISAE-SUPAERO, 31055 Toulouse, France, [6] LAM, 13388 Marseille, France, [7]CAB-INTA-CSIC, 28850 Torrejón de Ardoz, Spain, 8 DLR, 28359 Bremen, Germany, [9]CNES, 31401 Toulouse, France, [10]Freie Universität Berlin, 12249, Berlin, Germany, [11]JAXA Sagamihara 252-5210, Japan

Introduction: The origin of the martian moons, Phobos and Deimos is under debate since a very long time. There exist arguments and counter arguments that they may be captured asteroids. Other models favor, e.g., a massive impact at Mars as their origin [1].

The Martian Moons eXploration (MMX) mission by the Japan Aerospace Exploration Agency, JAXA, is going to explore both Martian moons remotely, but also return samples from Phobos, and deliver a small Rover to its surface [2,3]. This rover, provided by CNES and DLR, with contributions from INTA and the University of Tokyo has a payload of four scientific instruments, analyzing the physical, dynamical and mineralogical properties of Phobos´ surface. Parallels to asteroids of a similar size are eminent and the results will help deciphering the origin of Phobos [4].

Figure 1: MMX Rover in deployed configuration [5]

MMX Rover design and payload: The rover, to be delivered to the surface of Phobos has a mass of about 25 kg and consists of a chassis, with the locomotion system, a Service Module (SEM) in the interior, accommodating e.g. electronics, batteries and most part of the payload and a solar generator. There are four science instruments on board, as listed in table 1: RAX, a Raman spectrometer to measure signatures of the mineralogical composition of the surface material, NavCam, a stereo pair of cameras looking ahead to investigate the terrain and also serve for navigation, miniRAD a radiometer measuring surface brightness temperatures, constraining surface roughness and minerology, and two WheelCams looking at the wheel-surface interaction, and thus investigating the properties and dynamics of the regolith. The cameras, will serve for both technological and scientific needs.

Figure 1 shows a drawing of the rover in fully deployed configuration [5].

Table 1: MMX Rover instruments [5]

	type	Mass [kg]	PI institute(s)
NavCams	Stereo navigation camera	0.35	LAM, Marseille
WheelCams	Wheel camera	0.35	ISAE-SUPAERO, Toulouse
RAX	Raman spectrometer	1.51	DLR, Berlin; INTA, Madrid, UVa, Valladolid and Univ.Tokyo
miniRAD	Radiometer	0.34	DLR, Berlin

Phobos and asteroids: The visible to near-infrared reflectance spectra of Phobos have similarities with those of D-type or T-type asteroids [6] that are thought to have volatile-rich, carbonaceous compositions and likely originated from near or beyond the Jovian orbit. This led to the (controversial) capture hypothesis for the origin of the Martian moons. If this was the case, the exploration of Phobos would allow conclusions about the delivery processes of volatiles (incl. water) from the outer Solar System to early terrestrial planets [3]. If Phobos originated from a giant impact on Mars, however, the investigation of its physical surface properties would still be relevant for our understanding of (actual) asteroids of the same size and mass, exposed to space weathering and continuous meteorite impacts, and for major improvements in our understanding and modeling of giant impacts.

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