MICROSCOPIC IMAGES OF SURFACE AND SUBSURFACE PARTS OF PLANETS USING TV MICROSCOPE MIKROTEL; P. Jakeš1, J. Boček2, R. Rieder3 and H. Wänke3, 1. Institute of Geochemistry, Faculty of Science, Charles University, Prague 2, Czech Republic, 2. Astronomy Institute, Czech Academy Sciences, Ondřejov u Prahy, Czech Republic, 3. Max-Planck Institute, Abt. Kosmochemie, Mainz, Germany

Microscopic images that has allowed major progress in the interpretation of geological processes acting upon the surface of the Earth, Moon and meteorite parent bodies were not used so far in the "in situ" exploration of planets e.g., Mars. Simple device - TV microscope with illumination, simple optics and digital readout is suggested to bridge the gap and to widen the scope of the planetary surface examination to submillimeter size particles.

Physical properties, chemical composition and "geological features" are sources of information in "field geology" of planetary surfaces. Geological features are observed through the human eye and represent visual interpretation of landforms, structures or mineralogical composition, morphology of particles etc., Geological features derive from igneous, sedimentary, metamorphic or impact processes that has taken part during the formation within the planet and consequently at its surface.

The images of large i.e., planetary features (in range of 10^3 meters to 10^4 meters) have been widely used to interpret the processes that acted upon the planet. Impact, volcanic, sedimentary and tectonic phenomena are easily identified using terrestrial or lunar analogs.

The smaller objects (less than meter) i.e., hand specimen sizes, mineral particles, have not been studied since the imaging systems sent to planets (e.g. Venus, Mars and in early days to the Moon) did not have resolution better than grain size or regolith particles of the surface. Only the Earth, Moon, asteroid belt (through meteorite samples) and Mars (through the analogy with SNC meteorites) were studied using smaller objects (samples). The understanding of their evolution has enormously increased.

In early planetary missions (e.g., Viking, Venera or Surveyor) the preference has been given to determination of chemical composition rather than to optical images (close-ups). Images were thought (probably based on Apollo sample imaging experience) to be of little value and the transmission of optical images byte-costly. Low resolution did not allow reading of the records of planetary processes on grain size scale and imaging of small scale features has been abandoned. The interpretation of chemical data without the images of analyzed area, however, appeared to be difficult. Petrologists, mineralogists and experimentalists have developed criteria that help to establish or define processes such as sequence of magmatic crystallization, characteristics of sedimentary processes, intensity of impact processes, or type of weathering, through the studies of particle morphologies, particle size distribution, etc. Number of such criteria relies on the observation of the rocks (soils, regoliths) through the eye powered by magnifying lenses, i.e., through hand held lens and microscope.

The images of the surface of planets with resolutions better than particle (grain) sizes could be an another tool to study planets (Jakeš, 1992; Jakeš and Wänke, 1993). The possibility that future planetary missions will carry the instruments complemented with autonomous decision making systems have led to the notion that such decisions could be made through the image analyses and in the geology - petrology - geochemistry oriented robotics missions the chemical data, rock textures, particle sizes and shapes (optical image analysis) should be one of the decision making (site selection) criteria. Thus the combination of chemical as well as morphological data that complement each other should be preferably used.

In order to obtain "mineralogical and morphologic" information "in situ" on planetary surfaces we have designed and constructed TV - microscope (Mikrotel) that allows to image remotely the area of several square centimeters and/or millimeters of rock or regolith surface.

The microscope (or hand-held lens equivalent) uses photosensitive device (e.g., CCD chip, TV camera) combined with the microscopic lenses, mirrors, internal light and/or fiber optics to image the area in visible and near visible wavelengths. The size of monitored area translated to magnification could be easily changed, varying the optics. The other modes of magnification, i.e., through dense CCD chips could be used as well. Microscope lenses with short working distance between the optic system and the "eye" (CCD) must be used. Magnification of 10 to 1000 times (using TV screen) were
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preliminary explored. The images could be digitized and saved to computer memory and later computer processed.

The multispectral images could be obtained using monochromatic sources (such as LED's with light of known wavelengths). Computer combination of images taken at different defined wavelengths can provide color images. UV illumination providing the "visible light" effects is added to detect "fluorescent phases" (e.g., quartz, zircon, etc.). The use of NIR or IR illumination enlarges the analytical capabilities. The use of the discrete light wavelengths computer grabbing of the images and the processing the images makes the Mikrotel into an identification tool. Independent illumination allows to use light of known spectral characteristics and sufficient intensity and allows also the use of camera in the unfavorable light conditions (or during the time that is otherwise unsuitable for observations i.e., night).

In the terrestrial laboratories the optical determination of mineral phases (rock constituents) usually precedes more sophisticated determinations of chemical compositions. Homogeneity of the analyzed sample, its alterations and "freshness" are studied in order to interpret chemical data.

Similar procedures i.e., analysis of the area that has been imaged and available to human eye observation should be used in planetary exploration (Jakeš 1992). The value of the chemical (and any other analysis) increases if the analyzed object is "visually" known. It is imperative of modern exploration geology and geochemistry that surfaces (rocks, regoliths) that are analyzed are imaged at least in a visible light spectrum.

NanoKhod Imaging system has been designed as a part of science package of NanoKhod (Rieder et al., 1995) that contains alpha proton, XRF and Moessbauer spectrometries and Microtel imaging system. The microscope images the area of the chemical analyses i.e., approximately 40 x 40 mm, and the area of substantial detail (4 x 4 mm) with the resolution better than 10 microns. In order to view the analyzed area and to identify mineral phases two magnification are necessary. Camera uses two chips, two fixed focus microscope lenses (f=1.6 mm and f=7.5 mm) with short working distance between the optic system and object (40mm) and short distance between the optic system and the "eye" (CCD) (both 3.4mm).

Electronics integration with relatively low resolution chip (160x160 pixels) for this camera are being built in the DLR Berlin (Harald Michaelis group). The size of the camera with two magnifications is 70 x 40 x 30 mm. Mass does not exceeds 150 gm. Power consumption is less than 1 W.

Soft penetrator microscope stratigraphy tool. The stratigraphy (sequence of layers) in the regolith that covers planetary surface provides a direct record of planetary evolution. Therefore the use of an microscope or an equivalent of hand-held lens imaging system in the drill holes will enable to study maturity of regolith, stratification, and stratigraphy. Linear, pencil like arrangement "side -looking" Microtel application that can be used being "pushed" into the regolith using the manipulator arm or landing gear as a supporting system.

Dust studies. One of the advantages of Microtel is the use of internal (calibrated) illumination. Movable arm and/or an instrument (NanoKhod) motion will unable to turn the microscope upside down, i.e. to face the microscope towards the sky. This will allow to employ the Microtel for the studies of settled dust on protective glass (motion of dust could be caused by motion of rover or through dust storm or even through the landing of lander and settling of the dust, monitoring the size and morphology of dust particles may provide extremely useful information. It will allow to study "dusty" environment and to record the dust particle shapes and sized during the extended periods of time.

The extension into NIR, important for the determination of mineral phases containing the volatiles, especially OH group, seems inevitable trend of evolution. First approximation to such an analytical tool is the use of different wavelength emitting diodes (e.g. Jakš and Wanke, 1993) or in more sophisticated application micro-imaging spectrometer using tunable spectrally selective illuminator proposed by (Chrien et al., 1994).