NANOKHOD: A MINIATURE INSTRUMENT DEPLOYMENT DEVICE WITH INSTRUMENTATION FOR CHEMICAL, MINERALOGICAL AND GEOLOGICAL ANALYSIS OF PLANETARY SURFACES, FOR USE IN CONNECTION WITH FIXED PLANETARY SURFACE STATIONS

R.Rieder and H.Wänke, MPI für Chemie, Saarstr.23, D-55122 Mainz,
V.Gromov, A. Kemurdjian, V.Kucherenkov and P.Sologub, VNIITRANSMASH, 2 Zarechnaya, Russia-198323 St.Petersburg,
B.Andreichikov, A.Kalyushniy, B.Korchuganow and V.Linkin, IKI-RAN, Profsoyuznaya Str. 84/32, Russia-117810 Moscow,
E.Kankeleit, G.Klingelhöfer, J.Foh, P. Held, R. Teucher, Institute for Nuclear Physics, Technical University Darmstadt, D-64289 Darmstadt, Germany
O.Prilutzkii, E.Evlanov, V.Khromov and B.Zubkov, IKI-RAN, Profsoyuznaya Str. 84/32, Russia-117810 Moscow,
T.Economu, Univ. of Chicago, LASR, 933 E.56th Street, Chicago, IL 60637,
G.Neukum, H.Hoffmann, H.Michaelis, E.Ress and M.Langfeld, Institute for Planetary Exploration, DLR, Rudower Chaussee 5, D-12484 Berlin,
P. Jakes, Charles University, Albertov 6, 128 43 Praha 2, Czech Republic,
H.v.Hoerner and H.Henkel, v.Hoerner u. Sulger GmbH, Schlossplatz 8, D-68723 Schwetzingen.

Summary: For the in-situ characterization of planetary surfaces chemical as well as mineralogical and geological analysis is extremely important. Furthermore such investigations should be performed at different samples and/or locations, which means that either the instruments have to be placed at different sites or samples have to be delivered to the instruments. In this paper a instrument deployment device carrying a α-Proton-Backscattering, X-ray and Mössbauer spectrometer, a close-up camera and a thermal analyzer, is presented. The overall size is about 180 mm x 130 mm x 60 mm with a total weight of less than 1.5 kg, and a power consumption below 1 Watt. This instrument package could be used in missions to Mars, to the Moon or Asteroids as well.

The Nanokhod:

In connection with the planning of a network of surface stations by ESA we had started a development program for instrument deployment devices, based on principles that offer significant advantages over most other proposed versions: Instruments for geochemical and mineralogical analysis, such as Alpha backscattering -, X-ray- and Mössbauer-spectrometers, a close-up camera and a thermal analyser form an integral part of a self-propelled chassis. A tether links the deployment device to the lander, providing energy and a two-way data connection. Although this tether limits the range of operation to several tens of meters, it alleviates the need to carry power sources and the associated thermal shielding, thus permitting to obtain a very small size and mass.

The deployment device presented here is a version incorporating tracks on the side-bodies and a prismatic instrument box that can be rotated through 360°. The instrument box with a size of about 160 mm x 40 mm x 60 mm is divided in two parts each containing at least two instruments. The Nanokhod has a size of ca. 180 mm x 130mm x 60 mm and a mass of less than 1.5 kg, including instruments. It can easily be steered through flat terrain and perform precision docking maneuvres.

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The α-Proton-Backscattering and the X-ray fluorescence spectrometer:

Both instruments have a long standing space heritage, going back to the days of Surveyors V, VI and VII (1968/69) [1] and Phobos (1988) [2]. They will be used to determine the concentration of all major and some minor elements, including C, N and O, at levels above typically 1%, present in planetary surface rocks and soils. The α-Proton-Backscattering spectrometer will measure the backscattered α-particles, emitted from a radioactive source of Curium 244 (Rutherford Backscatter mode: RBS), and the Protons from A(α,p)B reactions (Proton mode). It consists of a ^{244}Cm source of about 50 mCi and a telescope of silicon detectors for the detection of α-particles and Protons. The X-ray spectrometer consists of a set of different radioactive sources (e.g. ^{55}Fe, ^{109}Cd, ^{244}Cm) to excite characteristic X-rays in the sample, and a high resolution X-ray detector system.

The Mössbauer spectrometer:

A miniaturized ^{57}Fe Mössbauer (MB) spectrometer has been developed for the in-situ exploration of the Martian surface [3,4,5]. By ^{57}Fe MB spectroscopy the oxidation state of the iron, its magnetic phases, and the mineralogical composition of iron containing samples can be determined. The main parts of the MB system are the electromechanical velocity transducer (double loudspeaker system), the γ- and X-ray detectors (silicon-PIN-diodes), the ^{57}Co MB-source, a multilayered radiation shield, and a γ- and x-ray window. Besides a more powerfull version to be installed on the Russian Mars Rover for the Mars98 mission also a low power consuming version (0.4 W) has been constructed for integration in the Nanokhod. For this the hybridization technique was required to reduce weight and dimensions.

The CCD-Camera (Microscope):

In the terrestrial environment the determination of mineral phases by optical devices (microscope), combined with the observation of textural relationships of phases and bulk mineral composition, usually precedes the use of sophisticated techniques as for instance elemental analysis etc. Just a simple hand-held lens is a very powerful tool for the examination of minerals and rocks. Therefore it is quite obvious to include some kind of a microscope in the payload of the Nanokhod [6]. The instrument is a miniature CCD camera, equipped with microscope optics. It has colour capability by LED- exposures. The field of view has a diameter of about 4 cm, and the specified resolution is in the order of 40 μm.

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