THE MARTIAN GAS-ANALYTIC PACKAGE FOR THE LANDING PLATFORM EXPERIMENTS OF THE EXOMARS 2018. M.V. Gerasimov[1], A.G. Sapgir[1], M.A. Zaitsev[1], S.A. Aseev[1], I.I. Vinogradov[1], C. Szopa[2], P. Coll[3], M. Cabane[2], D. Coscia[2], F. Goesmann[4], P. Wurz[5], D. Lasi[5], and M. Tulej[5], [1]Space Research Institute of the RAS, 84/32 Profsoyuznaya, 117997, Moscow, Russia, (mgerasim@mx.iki.rssi.ru), [2]LATMOS, Univ. Pierre et Marie Curie, Univ. Versailles Saint-Quentin & CNRS, 75005 Paris, France, [3]LISA, Univ. Paris-Est Créteil, Univ. Denis Diderot & CNRS 94010 Créteil, France [4]Max Planck Ins. for Solar System Res., Katlenburg-Lindau, Germany, [5] Physikalisches Institut, University of Bern, Sidlerstrasse 5, CH-3012, Bern, Switzerland

Introduction: The Martian Gas-Analytic Package (MGAP) is an assemblage of instruments designed to investigate dynamics of atmospheric major and trace species and surface-atmosphere interaction. MGAP is planned to be delivered to the martian surface as a part of the Russian scientific payload on the Landing Platform of the ExoMars mission. The Landing Platform is designed to deliver the European ExoMars rover and to act as a surface station after release of the rover. The rover is focused mainly to explore the past or present habitability of Mars by exploring carbon chemistry and search for organic compounds at different geologic units and subsurface. The station has limited possibilities for life search, but is appropriate for atmosphere monitoring and investigation of surface-atmosphere interaction as well as seismology.

Scientific Goals of the MGAP:
The main scientific goal of the MGAP is to investigate the dynamics of atmospheric gases at the martian surface and their interaction with the soil. Experiments will include:

- measurements of diurnal and seasonal variations of water vapor and other volatiles concentration in the soil at depths accessible to the manipulator;
- measurements of diurnal and seasonal variations of major and trace components of the martian atmosphere near the surface;
- measurements of isotopic ratios of the main volatile elements: H, O, C, S, Cl, in different reservoirs;
- measurements of elemental composition and isotopic ratios of noble gases in the atmosphere;
- investigation of reactivity of martian soil.

MGAP Instruments and Subsystems: MGAP consist of four main instruments and two subsystems. The instruments are the Thermal Analyzer for Mars (TAM), the Gas Chromatograph for Mars (GCM), the Neutral Gas Mass-Spectrometer (NGMS), and the Martian Tunable Diode Laser Absorption Spectrometer (MTDLAS). Subsystems are a soil sample transfer system (SSTS), an atmospheric gases sampling system (AGSS), and an enrichment trap system (ETS).

The Thermal Analyzer for Mars (TAM) instrument. The TAM provides thermal analysis of solid soil samples. The TAM also provides sampling of both solid soil portions and atmospheric gases. Solid soil samples are loaded into ovens for pyrolysis and thermal analysis using SSTS. TAM experiments are performed using fine-grained solid material. There are two multiuse ovens in the TAM. Targeted temperature of heating of ovens is ~1000°C. One oven is used for analysis of volatiles in the martian samples, and the second has a possibility to perform chemical reactions between martian solid samples and probing gases. Manipulator drilling and sampling system sieves fine-grain material from the drilling debris or from the regolith and delivers it to the ovens. The drilling system is aimed to drill stony objects to a depth about 10 cm. The TAM houses AGSS for sampling of atmospheric gases. It consists of a pump and a gas volume. The sampling is performed via a tube which end is located at the end of the manipulator for the possibility to sample gases at heights varying from several centimeters to about 2 m above the surface. Pumped gases can pass the enrichment trap system before analysis. The ETS produces enriched concentration of trace gas components using their accumulation on different adsorbents with a focused release for analysis.

The Gas Chromatograph for Mars (GCM) instrument. The GCM separates complex mixtures of gases into molecular components with their subsequent measurements with the thermal conductivity detectors and MS analysis. GC is focused on separation of permanent and noble gases using two SS capillary columns: one with molecular sieves 5A and another with PoraPlot Q. Only light organic molecules (C_1 to C_7) can be measured by the GCM. The GCM instrument has two injection traps (IT), the first one collects gases for analysis on the column with molecular sieves 5A and the second collects gases for analysis on the column with PoraPlot Q. The GCM has a carrier gas transfer system with heated micro valve manifolds and transfer capillaries to send gases through the MGAP. The GCM electronics controls the main chronogram sequence for the MGAP experiments.

The Neutral Gas Mass-Spectrometer (NGMS) instrument. The NGMS is a time-of-flight type mass spectrometer (TOF-MS) with a grid-less ion mirror (reflectron). The ions are generated from the neutral gas inside ion source by electron impact ionization. The high cadence of recorded mass spectra allows the accumulation of mass spectra with a large dynamic range of up to 10^6 within 1s integration time. The source of gas being either from the output of the GCM instrument (GC-mode) or directly from the martian

atmosphere (atmosphere mode). The NGMS is built by the Physics Institute of the University of Bern. Measuring range of the NGMS is 1 – 1000 amu with a resolution ~1000, sensitivity for trace gas measurements – 1ppbv. The sensitivity can be increased by use of the ETS. The detection limit of the combined TAM/GCM/NGMS work exceeds the part per billion for any volatile component in the soil. The prototype of the NGMS is the same-name instrument of the Luna-Resource lander but equipped with a high-vacuum turbo-molecular-pump for work in martian atmosphere.

The Martian Tunable Diode Laser Absorption Spectrometer (MTDLAS) instrument. The MTDLAS is an autonomous instrument to monitor water vapor and methane in the atmosphere. The MTDLAS incorporates a separate optical cell of the MGAP which can be purged by gases from the GCM via transfer capillaries. The cell has optical windows on both sides to pass a beam of four lasers through it. The MTDLAS is capable to measure D/H and $^{17}O/^{16}O$, $^{18}O/^{16}O$, $^{13}C/^{12}C$ in water and carbon dioxide molecules. The accuracy of 1.0% to measure $H_2{}^{17,18}O$ and HDO will be available at water concentration over 400 ppm in the soil.

MTDLAS can operate in the following modes of work:

- active measurements in a Herriot multi-pass optical cell, co-axially combined with an ICOS (Integrated Cavity Output Spectroscopy) cell which are directly linked to the ambient atmosphere;
- active measurements in a closed optical capillary cell, which is linked to a pyrolytic cell of the MGAP, in a similar way as it was earlier developed for the Phobos-Grunt Lander mission;
- passive heterodyne measurements at the Solar occultation free atmosphere optical path, which is co-directional with the optical path of the FAST (Fourier spectrometer for Atmospheric Species and Temperature) experiment.

The Atmospheric Gases Analysis: MGAP will perform regular direct atmospheric sampling which will enable diurnal and seasonal variations measurement over the period of the two year mission. Most of the measurements will be performed using NGMS and some of them will involve GC separation for precise isotopic measurements. Specialized gas sampling experiments will be performed using enrichment traps to accumulate trace gases and to remove the major components (CO_2, N_2, Ar, etc.). Enriched trace gases can be analyzed using both GCMS and MTDLAS (water vapor). The noble gas enrichment experiment removes out chemically reactive gases to provide noble gas enriched samples for the MS for isotope and noble gas elemental ratio analysis. The gas sampling tube being mounted on the manipulator can provide sampling of gases from the close vicinity at the surface to investigate UV-induced decomposition of salts.

The Analysis of Soil Samples: Experiments with soil samples include:

1. Measurement of volatiles composition of the soil sample and
2. Probing of the soil interaction with labeled gases.

In sequence 1, several hundreds of cubic millimeters of a fine-grain soil sample are deposited into one of the ovens and heated with a programmed ramp from ambient to ~1000°C while the evolved gas continuously pass through the MTDLAS tube and is accumulated in the injection traps of the GC for later release and GCMS analysis. Small portions of the evolved gas is periodically sent into NGMS for on-line MS analysis. In sequence 2, labeled by isotopes gases are added to the sample in the oven and the sequence of analysis 1 is repeated.