GAS-ANALYTIC PACKAGE OF THE RUSSIAN "LUNAR-RESOURCE" MISSION. M.V. Gerasimov and the GAP team. Space Research Institute of the Russian Academy of Science, 84/32 Profsoyuznaya, 117997, Moscow, Russia, mgerasim@mx.iki.rssi.ru.

Introduction: The discovery of noticeable hydrogen concentration (believed to be in the form of water) in the polar regions was among the most exciting recent events in the exploration of the Moon. Concentration of water in polar regolith was estimated at a level of 4–6 wt.% [1,2]. Such high concentration of water in polar regolith on the Moon is probably a result of migration of water molecules from its hot low latitudes and accumulation in "cold traps" of the northern and southern polar regions. These depositions of volatiles on one hand contain important information on the evolution of the Moon and on the other hand their utilization can be a bases for the future human exploration. The question about diversity and source of the volatiles is still open.

Sources of lunar volatiles: Three main possible sources of the Lunar polar volatiles are:

Degassing of the interior. Endogenous source of volatiles is provided by degassing of heated interior of planetary bodies. In this case chemical composition of released gases reflects thermodynamic equilibrium of gases over typical magmas at temperatures around 1000°C and presents a complex mixture of gases built from main volatile elements (H, O, C, S, N, Cl, P). The composition of such gas mixtures is characterized by domination of H_2O, CO_2, and SO_2 over other H, C, and S containing components. CO/CO_2 ratio here is typically far below 0.1 level. Hydrocarbons are mainly aromatic hydrocarbons, alkanes, and cycloalkanes. Sulfur containing gases are mainly SO_2, H_2S, and S_x. Isotopic ratios of volatile elements should be the same as for the bulk Moon.

Interaction of solar wind protons with surface rocks. Energetic solar wind protons with the absence of an atmospheric shield can react with oxygen of surface rocks and produce water molecules as end product. Such a mechanism provides a source of mainly pure water on the Moon with solar hydrogen isotopes and Moon rocks oxygen isotopes.

Degassing of impacting meteorites and comets. Volatiles of impacting meteorites and comets are released into transient atmosphere. It was shown experimentally [3] that the forming gases are qualitatively similar for various rocky materials including meteorites of different classes and reflects equilibrium with magmas at temperatures over 3000K. Such gas mixtures have the following characteristics: the CO/CO_2 ratio is ≥1, sulfur containing gases are presented by SO_2, CS_2, H_2S, and COS in decreasing sequence, production of HCN, and noticeable release of water. There is also efficient production of light and heavy organic molecules. Isotopic composition of volatile elements reflects the projectile to target proportion.

Gas-analytic package (GAP) of the "Lunar-Resource" mission: It is very important to measure all the main and trace components as well as isotopic composition of volatile elements to give the full inventory of polar volatiles and to understand their real source and to evaluate their validity as a resource for the Moon exploration. The GAP as part of the scientific payload of the "Lunar-Resource" mission (planned launch in 2019) is aimed on comprehensive investigation of the inventory of volatiles in the regolith of polar regions. It uses pyrolysis-gas-chromatography-mass-spectrometry method and consists of three instruments: 1) Thermal Analyzer (TA-L); 2) Gas Chromatograph (GC-L) with Tunable Diode Laser Absorption Spectrometer (TDLAS) for isotopic measurements of H, O, and C in CO_2 and H_2O molecules; and 3) Neutral Gas Mass-Spectrometer (NGMS).

The TA-L instrument performs pyrolysis of a portion of lunar regolith delivered by the manipulator and/or drilling device. The heating of a regolith sample up to 1000°C results in release of volatile compounds which are transferred via a system of capillaries into the GC-L and the NGMS for chemical analysis. TA-L is equipped by two types of pyrolytic ovens: a carousel with 8 one-use high-temperature (up to 1000°C) pyrolytic cells (PC) and a multiuse low temperature (up to 250°C) desorption cell (DC). The DC is optimized to work with cryogenic regolith samples and to measure frozen and adsorbed components. The PCs are used to measure bound volatile components.

The gas chromatograph GC-L uses a complex system of capillaries, valves, and adsorption traps to collect, separate, and concentrate gases for analysis. The GC-L also has a TDLAS for precise measurement of isotopic composition of carbon, hydrogen, and oxygen in H_2O and CO_2 molecules. The GC-L has two capillary chromatographic columns (molsieve 5A Plot and PoraPlot Q) which can work in a serial or parallel mode depending on the valves configuration.

The mass spectrometer NGMS is a time-of-flight type mass spectrometer with a grid-less ion mirror (reflectron). The ions are generated from the neutral gas by electron impact ionisation. 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 task for the NGMS is to identify gas components and to measure isotopic composition of constituent volatile elements. NGMS can operate as a standalone instrument for sampling the tenuous lunar exosphere.

The GAP is able to detect concentrations of volatile species in the soil sample of about ~0.1 ppb by mass for hydrocarbons and ~1ppb by mass for permanent gases.

References: [1] Mitrofanov, I. G. et al. (2010) *Science* 330, 483-486. [2] Colaprete, A. et al. (2010) *Science* 330, 463-468. [3] Gerasimov, M.V. (2002) *Geological Society of America Special Paper 356*, 705-716.

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