RETURN TO THE MOON: NEXT STEPS. V. V. Shevchenko, Sternberg State Astronomical Institute, Moscow University. 119992 Moscow, 13 Universitetsky pr., Russia, vladislav_shevch@mail.ru

Introduction: After an interval of more than 30 years Russia is resuming its studies of the Moon by means of space robotic technique. It will look for water at the Moon's poles, identify the presence of the core, if any, and determine its size more correctly than before. "Roscosmos" (Federal Space Agency, Russia) planned lunar program, called Luna-Globe, is scheduled to start in 2012 (or recently) with unmanned exploration of mineral deposits, remote sensing, and inner structure of the Moon [1]. After that, the Russians plan to land onto the Moon an advanced heavy rover of the new generation. As to the manned lunar mission, Russia plans to launch it in 2025 with a subsequent establishing of a permanent lunar base within the years 2027 – 2032 [2].

Lunar Reconnaissance Orbiter/LEND: According to international agreement, robotic missions will be linked to space cooperation with NASA USA. The Lunar Exploration Neutron Detector (LEND) has been selected for the NASA Lunar Reconnaissance Orbiter (LRO) mission to determine hydrogen distribution through lunar subsurface of 1 – 2 meters depth with high sensitivity and high spatial resolution [3]. LEND is the Russian contributed instrument for NASA's Lunar Reconnaissance Orbiter [4], and its investigation team includes scientists from leading research centers for nuclear and planetary science both from Russia and from the United States. LEND is the natural next step in this series of investigations and is based on the available heritage of joint work for neutron mapping of Mars onboard Odyssey by GRS/HEND instrumentation [5]. The methods and procedures of LEND data processing and analysis are based on existing procedures that have been developed for analysis of HEND and the GRS data.

It is known that presence of hydrogen nuclei in lunar soil significantly influences on the epithermal neutron leakage flux allowing measurements of hydrogen content. For neutron detectors without imaging capabilities the surface footprint of such measurements is defined by the orbit's altitude and may be as large as 100 km in diameter, provided 50 km would be an averaged LRO altitude. That is why the collimator for epithermal neutrons is suggested for the LEND in terms to improve spatial resolution [6]. Due to efficient collimation of epithermal neutrons and high efficiency for their detection, LEND is able to provide estimation of hydrogen content with spatial resolution up to 5 km and detection limit better then 100 ppm in the vicinity of lunar poles.

In reality, the major targets of LEND observations are the permanently shadowed craters distributed around the poles. It were calculated detection limits of hydrogen for some known craters taking into account the presently available data for landscape around them from Clementine data and for the predictable LRO orbit – it is demonstrated that LEND will have sufficiently high sensitivity for detection of enhanced hydrogen (or deposits of water ice) at these spots.

To perform this analysis, two sets of lunar craters were selected for the northern and southern polar regions of the Moon (Fig. 1a, b) [7]. The center positions of southern cold traps lie above 83° S latitude belt. Their shadowed surfaces range from 30 up to 575 km^2. The northern cold traps have centers located above 81° N latitude belt, and their shadowed surfaces range from 30 up to 300 km^2. According to estimations LEND will be able to detect the presence of hydrogen ranging from 30 up to 150 ppm for the selected cold traps. The corresponding limit for detection of water ice is also presented (in weight %) for these candidate craters. It varies from 0.03 to 0.15 wt % of water in the regolith.

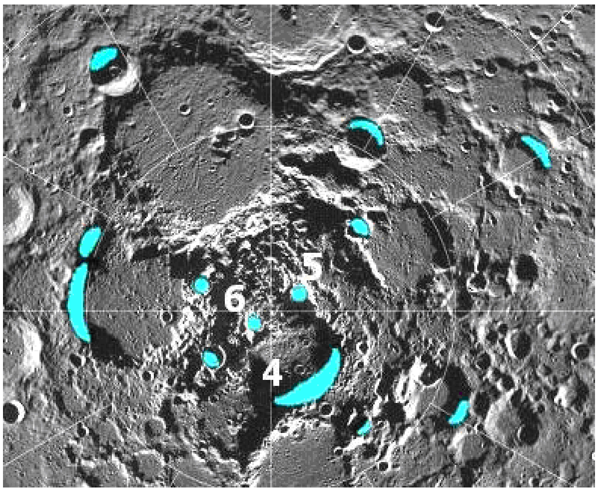

Fig. 1 a

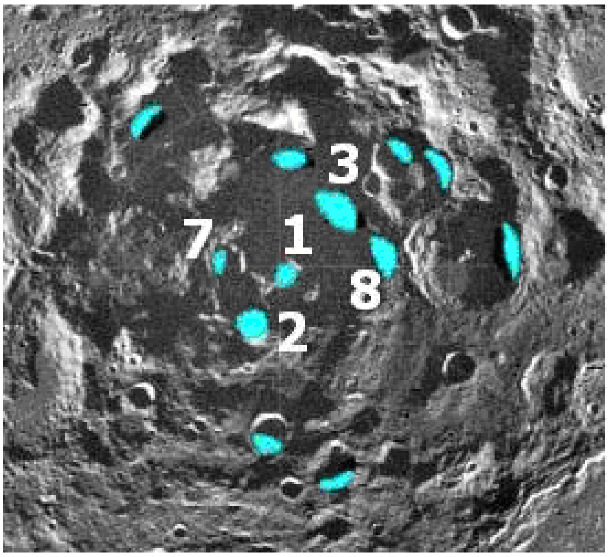

Fig. 1 b

LCROSS mission: the Lunar Crater Observation and Sensing Satellite (LCROSS) mission is a search for water on the Moon. The mission include confirming the presence or absence of water ice in a permanently shadowed crater at the Moon's South Pole. The identification of water is very important to the future of human activities on the Moon. LCROSS will excavate the permanently dark floor of one of the Moon's polar craters with two heavy impactors early in 2009 to test the theory that ancient ice lies buried there. The impact will eject material from the crater's surface to create a plume that specialized instruments will be able to analyze for the presence of water (ice and vapor), hydrocarbons and hydrated materials. The two main components of the LCROSS mission are the Shepherding Spacecraft and the Centaur upper stage rocket. The Shepherding Spacecraft and Centaur rocket are launched together with spacecraft the Lunar Reconnaissance Orbiter. All three are connected to each other for launch, but then the LRO separates one hour after launch. . The crash will be so big that we on Earth may be able to view the resulting plume of material it ejects with a good amateur telescope [8].

Luna-Globe Mission: According to international agreement, robotic missions will be linked to space cooperation with India, which will provide scientific equipment, the rover, a transfer rocket, and even a launching site for the Russian lunar flights. A joint lunar mission that India and Russia had agreed to undertake may pave the way for long-term, far-ranging collaboration between them in Moon exploration and tapping of its natural resources [9]. The Moon mission will be a cross between the two countries' phase-2 programmes for lunar research, Chandrayaan in India and Luna-Globe in Russia. In phase 1, India and Russia will proceed alone. One of the most intriguing riddles of contemporary Moon exploration is the presence or absence in the polar regions of so-called "cold traps" - craters whose bottoms are always shaded from the Sun. The Moon is known to have experienced many collisions with comets (Fig. 2).

Fig. 2

Their evaporation would produce a short-lived atmosphere of water vapor, which would then condense and settle at the bottom of such "cold traps." If there were many such collisions (the history of the solar system is known to have had periods of high cometary activity), then large amounts of water ice could have accumulated over millions of years. It is the search for water on the Moon that will be central to all the world's next space missions. The search for water in the polar lunar region will be one of the main goals of the Luna-Globe mission. In order to explore small traps a few kilometers in diameter from the orbit of an artificial lunar satellite, it was necessary to combine the neutron detector with telescopic devices accurate enough to match measurements with crater dimensions. These measurements will yield a map of hydrogen occurrence on the Moon's surface. The Russian instrument is sensitive enough to register a hydrogen presence when water content in the Moon's surface is as low as one-tenth of a percentage point by weight. Water ice in near-polar craters, if it exists, will be highlighted as bright specks showing high hydrogen content. Under Chandrayaan-I India, in the first half of 2008, will launch a space probe that will circle the Moon but will not land on its surface. Foreign input into Chandrayaan-I is limited to two research instruments built by the United States and Bulgaria. Russia's first Luna-Globe mission, scheduled for 2010, does not envisage landing any spacecraft on the Moon either. In the second stage, Russia plans to soft-land a 400-kg sophisticated moon rover, which will be carried to the moon aboard an Indian rocket. The Russian programme also provides for phase-3 and phase-4 missions to the Moon between 2012 and 2015. These may also become joint India-Russia projects if the agreement will be effective till 2017 and can be extended by mutual agreement. According to the plans of Russia's Lavochkin Spacecraft Design Bureau, in phase-4, the Luna-Globe programme is planned to look for mineral resources on the Moon.

Lunny Poligom: The next stage of exploration will be sampling lunar soil and transporting the samples back to the Earth. It will be followed by the Lunny

Poligon program, which will set up some infrastructure near the Moon's poles for a future habitable base to carry out a wide range of scientific and technological studies. The most suitable areas for such a base will be sites with discovered water. Because they are also areas always exposed to the Sun, they could use solar generators to produce electricity to obtain hydrogen fuel from ice for interplanetary ships and the needs of the base.

References: [1] Moon race – 2008 // http://en.rian.ri/12.01.2008. [2] Russia to lunch space base for mission to Moon, Mars after 2020 // http://en.rian.ri/12.01.2008. [3] Mitrofanov I.G. et al., LEAG-2005, Abstract #2035, 2005. [4] d'Uston C et al., Nature, v. 341, p. 598, 1989. [5] Boynton W.V. et al., Science, v. 297, p. 81-85, 2002. [6] Sanin A.B. et al., LEAG-2005, Abstract #2034, 2005. [7] Kozlova E.A., Shevchenko V.V.36 microsymposium of comparative planetology. Moscow, October 14-16, 2002. MS.053. [8] http://lcross.arc.nasa.gov. [9] Lunar mission to help long-term collaboration