ARE ALL LUNAR HIGHLAND PRISTINE ROCKS REALLY PRISTINE? A. T. Basilevsky[1,2] and G. Neukum[2], [1]Vernadsky Institute, RAS, 119991 Moscow, Russia atbas@geokhi.ru; [2]Freie Universitaet Berlin, D-12249 Berlin, Germany. gerhard.neukum@fu-berlin.de

Introduction: This paper has appeared as a result of attempts to resolve the well known controversy: If in the early history of the Moon there was a ***terminal cataclysm*** when within a short time period ~3.9 Ga ago a majority of now observed impact craters and basins of lunar highlands formed, or did they form over a longer time since the time of formation of the lunar crust till 3.9 Ga ago. One of the strongest arguments favoring the idea of a terminal cataclysm was advanced by G. Ryder [1]. He paid special attention to the fact that impact melts older than ~4.0 Ga (actually 4.2 Ga) are practically absent in the lunar sample collections and concluded that this rules out extensive basin formation during the earlier times. His logic was that formation of lunar basins should produce abundant impact melts and if the earlier basins were numerous, some of their melts should be among the collected samples. In the collections there are samples older than 4.2 Ga and these are ***pristine*** highland igneous rocks showing 4.2 -4.5 Ga ages of crystallization [2, 3] We explore a possibility if ***some of the alleged pristine highland rocks may indeed be remnants of impact melts from the large basin-forming impacts***.

Analysis of the problem: Pristine rocks of lunar highlands are distinguished on the basis of two criteria: 1) they have structures typical of igneous rocks; and 2) they are not polluted with meteoritic matter that is determined from the low contents of siderophile elements, of which the most indicative is considered to be iridium [e.g., 2]. The usual view of impact melts based on experience of their study in the majority of terrestrial impact craters implies poorly crystallized fine-grained rocks often with admixture of target rocks clasts. The majority of samples of lunar impact melts are indeed rocks of that sort. This is true, however, for the melts of not very large impact craters. Impact melts of the Sudbury astrobleme, which is the largest known terrestrial impact crater (D ~250 km) petrographically are normal medium- to coarse-grained igneous rocks: norites, quartz gabbro and granophyres [e.g., 4].

1) Lunar impact basins should contain very large pools of impact melt. The study [5] shows that as impact magnitude increases, the volume of created melt relative to that of the crater should grow. At the 20-30 km crater diameters the depth of melting should exceed the depth of excavation and this should progressively decrease a proportion of larger rock clasts (which effectively cool the melt) incorporated into the melt. At the sizes corresponding to the smallest basins incorporation of the clasts into the created melt pool should be insignificant and the melt pool, as it cools, should be able to evolve into a differentiated unit [5]. Recent numerical modeling by [6] demonstrated that impacts of large asteroid-like projectiles result in the formation of a central pool of impact melt (complete melting) of hundreds to more than a thousand kilometers in diameter and tens of kilometers thick. These should crystallize as normal large igneous massifs.

2) To consider a possibility if some lunar impact melts could have low contents of Ir and thus be classified as pristine rocks we compared Ir contents in 4 varieties of lunar materials (mare basalts, pristine highland monomict rocks, soils and regolith breccias and highland polymict breccias) with those in terrestrial impact melts: from 12 terrestrial impact craters the smallest of which was crater Aouelloul, D = 0.37 km and the largest, Sudbury, 250 km. The comparison showed that impact melts of the majority of the terrestrial craters considered have very variegated contents of Ir. The high contents are obviously due to admixture of meteoritic material, while the low contents may be due to low Ir contents in the projectiles responsible for these impacts: most achondrites and some iron meteorites have low iridium contents . The Sudbury impact melts, however, especially in the upper part of the body, have low Ir contents although the Sudbury projectile projectile had high siderophile contents [e.g., 7]. But Ni, Co and platinum group elements including Ir were extracted from the silicate melt into the sulfide melt which sank and formed ore deposits at the lower contact zone and in some dikes [e.g., 8] .

Conclusions: Some lunar highland "pristine" rocks having 4.2 to 4.5 Ga crystallization ages may indeed be not pristine but products of crystallization of large bodies of melt fomed by the basin-forming impacts. This suggests that the above mentioned argument of Ryder (2002) may not be valid and terminal lunar cataclysm might not be the case.

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