ROCK FRAGMENTS HEIGHT/DIAMETER RATIO AS MEASURED ON THE LUNOKHOD AND APOLLO SURFACE PANORAMAS. N. E. Demidov$^{1,2}$ and A. T. Basilevsky$^3$, $^1$ Vernadsky Institute of Geochemistry and Analytical Chemistry, RAN, Kosygin Str. 19, Moscow 119991 Russia, nikdemidov@mail.ru, $^2$ Institute of Physicochemical and Biological Problems of Soil Science, RAN, Pushchino, Moscow region 142290 Russia.

Introduction: In this work we shortly describe results of measurements of height to diameter ratios ($h/d$) of rock fragments occurred on lunar surface (Figure 1). For that we used TV panoramas of Lunokhod 1 and 2 [1] and the Apollo surface panoramas [2].

![Figure 1. Examples of measurements of rock fragments height ($h$) and diameter ($d$). Fragment of TV panorama of Lunokhod 1.](image)

Parameter $h/d$ is an important property of the rock fragments both for general characteristic of lunar surface and for working out engineering models of the surface [e.g., 3]. The latter are necessary for reliable design of landing spacecraft and thus for successful landing. Despite obvious importance of this parameter, publications reporting its values are rare. We have found the $h/d$ values for lunar surface (0.2 to 1) in the mentioned engineering model of lunar surface [3] and in early report on Lunokhod 1 studies (0.2 to 0.9) [4]. There were given only ranges of $h/d$ values with no statistical characteristics such as mean value and standard deviation. Measurements of the latter characteristics is the goal of our work.

Data and method. As it was said above we have studied TV panoramas taken by Lunokhod 1 and 2 and the Apollo surface panoramas [1, 2]. In this work we measured $h$ and $d$ not in units of length, but in pixels that was enough to calculate the $h/d$ ratio, but we know from other sources that the measured rock fragments were between 10 cm and 1 m in diameter. For reliable measurements of $h$ we avoided to study rock fragments being too close to the camera because in this case the view is essentially “from above”. We also avoid to measure $h$ and $d$ of too distant rock fragments which dimensions in pixels were small. In this study we did not try to estimate how large is the buried part of the fragment. Such work was done by [5] using the Surveyor images for the boulders larger than 1-2 m by considering angles under which the boulder “profile” outlines meet the adjacent soil surface and making some assumptions.

We have studied significant part of available Lunokhod 1 and 2 panoramas and only some part of the Apollo surface panoramas. We plan to extend the study of the latter in the nearest future. For now 108 rock fragments were identified and measured in 58 panoramas of Lunochod-1, 116 rock fragments - in 33 panoramas of Lunochod-2 and 86 rock fragments - in Apollo 11 through 17 panoramas taken together.

Results. Table 1 shows the results of the $h/d$ ratio measurements:

<table>
<thead>
<tr>
<th></th>
<th>Lunokhod 1</th>
<th>Lunokhod 2</th>
<th>Apollo 11</th>
<th>Apollo 12</th>
<th>Apollo 14</th>
<th>Apollo 15</th>
<th>Apollo 16</th>
<th>Apollo 17</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>108</td>
<td>116</td>
<td>13</td>
<td>6</td>
<td>3</td>
<td>11</td>
<td>18</td>
<td>35</td>
<td>310</td>
</tr>
<tr>
<td>Mean $h/d$</td>
<td>0.64</td>
<td>0.60</td>
<td>0.58</td>
<td>0.66</td>
<td>0.49</td>
<td>0.58</td>
<td>0.54</td>
<td>0.52</td>
<td>0.60</td>
</tr>
<tr>
<td>Stand Dev</td>
<td>0.07</td>
<td>0.05</td>
<td>0.04</td>
<td>0.08</td>
<td>0.02</td>
<td>0.09</td>
<td>0.04</td>
<td>0.08</td>
<td>0.09</td>
</tr>
</tbody>
</table>

As it can be seen in the table for the most study sites the mean values of $h/d$ are close to 0.6 and the standard deviations vary from 0.04 to 0.09. Anomalous look results for Apollo 14: the mean value is 0.49 and standard deviation, 0.02. This is probably because of too small number of measurements (only 3) for this site.

Discussion: The studied rock fragments were formed by impact disruption of bedrock underlying
regolith as well as relatively large boulders which are locally included in regolith. Shape of rock fragments formed by impact disruption was studied in several works [see e.g., 6-8]. The disrupted targets were basalts and artificial materials with mechanical properties close to that of basalts and granites. Shape of rock fragments formed by impact disruption was studied in several works [see e.g., 6-8]. The disrupted targets were basalts and artificial materials with mechanical properties close to that of basalts and granites. It was found that if the fragment long axis is \(a\), intermediate axis is \(b\) and short axis is \(c\), then the mean value of \(c/a\) ratio is 0.4-0.5 and the mean value of \(b/a\) ratio is 0.6-0.7 with standard deviations 0.12-0.15.

It is naturally to expect that the rock fragments formed and excavated by impacts will rest on the lunar surface with the \(ab\) plane being close to horizontal position and the \(c\) axis being close to vertical. If so the observed on panoramas rock fragments should typically have the \(h/d\) ratios varying mostly from the \(c/a\) to \(b/a\) ratios, that is from 0.4-0.5 to 0.6-0.7. The mean values resulted from our measurements (0.49-0.66) are within this range. But if so this may mean that significant part of the studied rock fragments have almost no the buried by soil lower parts. This, in turn, may mean that rock fragments of decimeter size get destroyed on lunar surface by micrometeorite erosion on average faster than they are significantly buried by accumulation of soil material.

**Summary:** Measurements of height to diameter ratios (\(h/d\)) of the rock fragments of the decimeter size have been done using the Lunokhod 1 and 2 and the Apollo surface panoramas. Results of this study showed that the mean values of this parameter in the study sites are within 0.49 to 0.66, that is close to the ratios of short axis to intermediate and long axes for the fragments formed in impact disruption experiments. We plan to make measurements of rock fragments on larger number of the Apollo surface panoramas that should improve the reliability of the measurements. The measured \(h/d\) values will be used in engineering models of lunar surface for future lunar missions and for building testbeds for the perspective landers.

**References:**