**15220**
Reference Soil
465.7 grams

**Introduction**
15220 is similar to the other soils collected at station 2 (15091, 15101, 15200 etc.). It was collected from the rim of a small crater (thought to be the secondary crater produced by the nearby boulder). The station was selected to sample Apennine Front material exposed by St. George Crater. In this area, the lunar surface was free of small rocks, except for the boulder.

**Modal content of soil 15221.**

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aginates</td>
<td>37.6%</td>
</tr>
<tr>
<td>Mare basalt</td>
<td>2.8</td>
</tr>
<tr>
<td>KREEP basalt</td>
<td>1.8</td>
</tr>
<tr>
<td>Breccia</td>
<td>15</td>
</tr>
<tr>
<td>Anorthosite</td>
<td>1.3</td>
</tr>
<tr>
<td>Norite</td>
<td></td>
</tr>
<tr>
<td>Gabbro</td>
<td>0.4</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>12.2</td>
</tr>
<tr>
<td>Pyroxene</td>
<td>14.2</td>
</tr>
<tr>
<td>Olivine</td>
<td>2.8</td>
</tr>
<tr>
<td>Ilmenite</td>
<td>0.4</td>
</tr>
<tr>
<td>Glass other</td>
<td>10.1</td>
</tr>
</tbody>
</table>

**Figure 1:** 15221 was collected from the flank of St. George Crater at station 2, on the Apennine Front.

**Figure 2:** Chemical composition of 15221 compared with other Apollo soil samples.

**Figure 3:** Carbon content and maturity index for 15221 and other Apollo soils.
15221 was selected as a reference soil for the Lunar Highland Initiative (Labotka et al. 1981).

**Petrography**

15221 is a mature lunar soil with maturity index (\(1/\text{FeO} = 63\)) (Morris 1978) and agglutinate count 37% (Basu et al. 1981; Simon et al. 1981). King et al. (1972), Engelhardt et al. (1972) and McKay et al. (unpublished) determined the grain size distribution (figure 4). The average grain size is very fine (54 microns).

Labotka et al. (1981) and Basu et al. (1980) presented the modal mineralogy and as a function of grain size. Labotka et al. (1981) also determined the composition of mineral grains (olivine, pyroxene and plagioclase) and compared results for different grain sizes. They found numerous orthopyroxene grains with high Mg/Fe ratios (figure 5). These are similar in composition to the orthopyroxene found in KREEP basalt (Meyer 1977).

Powell et al. (1973), Helmke et al. (1973), Ryder and Sherman (1989) reported on coarse-fine particles. Simon et al. (1987) studied two ferroan anorthosite particles and Laul et al. (1987) analyzed one fragments of impact melt rock (table 2).

**Chemistry**

The chemical composition of all of the soils collected at station 2, Apollo 15 are all very similar, probably because they were collected close to one another. Laul and Papike (1980) determined the chemical composition of grain size fractions finding little variation with the possible exception that there may be enhanced REE in the finest fraction (figure 6).

Moore et al. (1973) reported 115 ppm C, consistent with high maturity (figure 3).

Walker and Papike (1981) used chemical mixing model techniques to calculate that 15221 is 19 – 29% mare basalt, 16 – 23% KREEP, and 7.6 – 14.8% green glass.

**Cosmogenic isotopes and exposure ages**

Rancitelli et al. (1972) reported the cosmic-ray-induced activity of \(^{22}\text{Na} = 72 \text{ dpm/kg}, \, ^{26}\text{Al} = 169 \text{ dpm/kg}, \, ^{40}\text{Sc} = 1.9 \text{ dpm/kg}, \, ^{48}\text{V} = 6 \text{ dpm/kg}, \, ^{56}\text{Co} = 5 \text{ dpm/kg} \) etc. Stoenner et al. (1972) determined \(^{37}\text{Ar}, \, ^{39}\text{Ar} \) and \(^{3}\text{H} \).

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**Modal Mineralogy of 15221**

*Simon et al. 1981*

**LITHIC FRAGMENTS**

- Mare basalt 3.1
- Highland Component
  - ANT 2.6
  - LMB 0.6
  - Feld. basalt 0.4
  - RNB/POIK 2.7

**FUSED SOIL COMPONENT**

- DMB 13.3
- Agglutinate 36.9

**MINERAL FRAG**

- Mafic 16.1
- Plag 13.1
- Opaque 0.1

**GLASS FRAG**

- Orange/black 0.4
- Yellow/Green 4.5
- Brown 0.3
- Clear 1.5

**MISC**

- Devitrified glass 4.1
- Others 0.3

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*Figure 4: Grain size distribution of 15220 (Graf 1993).*

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Lunar Sample Compendium
C Meyer 2010
Russ et al. (1972) determined the exposure to neutrons (produced by cosmic ray interaction with lunar material) by measuring the isotopic ratio of gadolinium in 15221 and as a function of depth in the drill core.

Bhandari et al. (1973) determined the density of solar-flare cosmic-ray tracks and give a surface irradiation age of 23 m.y.

**Processing**

15220 was returned in a sealed ALSRC (#1). It is a “reference soil”.

Figure 5: Composition of olivine and pyroxene in 15221 (Labotka et al. 1980).

Figure 6: Normalized rare-earth-element diagram for different grain size fractions of 15220 (Laul and Papike 1980).
Table 1. Chemical composition of 15221.

<table>
<thead>
<tr>
<th>Element</th>
<th>15221 (a)</th>
<th>15221 (b)</th>
<th>15221 (b)</th>
<th>Rancitelli (72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2 %</td>
<td>46</td>
<td>46.56</td>
<td>46.56</td>
<td>96 g</td>
</tr>
<tr>
<td>TiO2</td>
<td>1.1</td>
<td>1.43</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>Al2O3</td>
<td>18</td>
<td>17</td>
<td>17.54</td>
<td></td>
</tr>
<tr>
<td>FeO</td>
<td>11.3</td>
<td>11.7</td>
<td>11.32</td>
<td></td>
</tr>
<tr>
<td>MnO</td>
<td>0.15</td>
<td>(a)</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>MgO</td>
<td>10.7</td>
<td>(a)</td>
<td>10.69</td>
<td></td>
</tr>
<tr>
<td>CaO</td>
<td>13.3</td>
<td>(a)</td>
<td>11.87</td>
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<tr>
<td>Na2O</td>
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<td>0.41</td>
<td>0.45</td>
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</tr>
<tr>
<td>K2O</td>
<td>0.16</td>
<td>(a) 0.14</td>
<td>0.19</td>
<td>0.18</td>
</tr>
<tr>
<td>S%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Technique: (a) INAA, (b) "microchemical", (c) radiation counting

Table 2. Composition of coarse-fines.

<table>
<thead>
<tr>
<th>Element</th>
<th>15223 (ferroan anorthosite)</th>
<th>15221 (impact melt)</th>
<th>15221 (b)</th>
<th>Rancitelli (72)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO2 %</td>
<td>&lt; 0.1</td>
<td>&lt; 0.1</td>
<td>0.86</td>
<td>0.11</td>
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<tr>
<td>TiO2</td>
<td>32.1</td>
<td>31.4</td>
<td>17.5</td>
<td>19.2</td>
</tr>
<tr>
<td>Al2O3</td>
<td>2.3</td>
<td>1.43</td>
<td>6.65</td>
<td>6.7</td>
</tr>
<tr>
<td>FeO</td>
<td>1.03</td>
<td>0.023</td>
<td>0.088</td>
<td>0.099</td>
</tr>
<tr>
<td>MnO</td>
<td>1.5</td>
<td>1</td>
<td>10.6</td>
<td>9</td>
</tr>
<tr>
<td>MgO</td>
<td>17.7</td>
<td>17.1</td>
<td>11.3</td>
<td>12</td>
</tr>
<tr>
<td>CaO</td>
<td>0.28</td>
<td>0.25</td>
<td>0.61</td>
<td>0.6</td>
</tr>
<tr>
<td>K2O</td>
<td>0.012</td>
<td>0.007</td>
<td>0.16</td>
<td>0.088</td>
</tr>
<tr>
<td>S%</td>
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</tr>
<tr>
<td>sum</td>
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</table>

Technique: (a) INAA
References for 15221


Butler (1972) Lunar Sample Information Catalog: Apollo 15. MSC 03209


Powell B.N. (1972) Apollo 15 Coarse Fines (4-10mm): Sample classification, description and inventory. MSC 03228 Curator’s Office JSC


