This abstract reports progress in a petrologic study of impact melt rocks that occur in the following Apollo 16 breccias: dimict breccias 61015, 64475 and 64476; unique dimict breccia 64435; feldspathic fragmental breccias 67455, 67055, 67975 and 67016; shocked polymict breccias 64477 and 68115; and fragment-laden melt rock 67475. (Sample classification used herein is consistent with [1].) The aim of this study is to obtain data bearing on the nature of the relationships among the most common types of Apollo 16 breccias and the subsurface geology at the Apollo 16 site.

Anorthositic fragment-laden melt rock is a major clast type in most of the feldspathic fragmental breccias, and it also forms the melt-rock component in the unique dimict breccia 64435 (in all the other dimict breccias, the melt-rock component is very high alumina (VHA) basalt). It is a relatively abundant clast type in 64477 and a minor clast type in 67975, 68115 and 61015. The melt rock is composed of abundant fragments and laths of plagioclase (An84-97) and minor fragments of pyroxene and olivine cemented together by minute amounts of interstitial pyroxene. Defocused-beam microprobe analyses of clast-poor areas are reported in Table 1; additional data for 67455 and 67475 are given in [2]. The two data sets are in good agreement.

Mafic fragment-laden melt rock is the major type of melt-rock clast in 67975 and 67055 and a minor type of clast in 67016. These melt rocks are all similar in texture. They contain about 10-40 volume percent glassy groundmass, abundant mineral fragments, and sparse lithic fragments. In 67975, fragments within the groundmass are, in order of abundance: plagioclase (An71-97, with two distinct clusters: An93-96 and An83-87); low-Ca pyroxene (En82-85Wo25-29); high-Ca pyroxene (En34-40Wo34-43); and olivine (Fo69-66). These fragments are generally homogeneous. Minor fragments of Mg-Al spinel, chromite, ilmenite, silica minerals, Fe metal, granulated anorthosite, and norite (consisting of devitrified maskelynite and shocked pyroxene) are also found. This melt rock forms rinds on large lithic and mineral clasts and on clasts of anorthositic fragment-laden melt rock, as well as monolithologic clasts. In 67055, the clasts of mafic melt rock have similar textures, except that the mineral fragments they contain are predominantly plagioclase (An59-97) and olivine (Fo58-77). Despite the textural similarities, the bulk compositions of the melt fractions are different in each of the three samples studied (Table 1). Very high alumina (VHA)-basalt melt rock forms the melt-rock lithology in dimict breccias and also is found in polymict breccia 64435, within a clast of dimict breccia. This type of melt rock is clast poor and has basaltic texture, with locally variable grain size. Bulk compositions are much the same in all samples studied (Table 1; also see [3]).

Discussion. The compositional (Table 1) and textural similarities indicate that the anorthositic fragment-laden melt rocks in the various samples probably represent a single lithology. Furthermore, the REE patterns for a clast of such melt rock from 67455 [4] and for the 64435 melt rock [5] are the same. This type of melt rock is a major clast type in the feldspathic fragmental breccias, which are generally felt to represent North Ray Crater subsurface material. It is also a major lithology in 64435, which is probably South Ray Crater ejecta [6-8]. These data indicate that anorthositic fragment-laden melt rock, though apparently most abundant in the North Ray Crater subsurface, is present also in the South Ray Crater subsurface.

The mafic fragment-laden melt rock differs in the various breccias studied (Table 1). That in 67975 is most similar in major-element chemistry to Apollo 16 poikilitic melt rocks, e.g. 62235 ("low-K Fra Mauro" bulk composition [10]). The mafic melt rock in 67055, except for its higher TiO2...
content, is very like VHA-basalt melt rock in bulk composition. The mafic melt rock in 67016 is unlike any other major type of melt rock; it contains amounts of SiO₂, Al₂O₃, and FeO appropriate for VHA basalt but contains larger amounts of TiO₂ and CaO and smaller amounts of MgO.

Spatial relationships may help clarify possible genetic relationships between the melt rocks discussed herein. In 68115, a rounded clast of anorthositic melt rock occurs within a large clast of VHA-basalt melt rock. In 61015, as well, a small rounded clast of anorthositic melt rock has been found within VHA-basalt melt rock. In 67975, mafic fragment-laden melt rock of low-K Fra Mauro bulk composition forms rinds on clasts of anorthositic fragment-laden melt rock. These relationships suggest that the anorthositic melt rock is the oldest of the melt rocks studied, but, in the absence of isotopic data, it cannot be determined how much older. (In fact, even where there are isotopic data, use of the data to ascertain age relationships is difficult because it is generally not possible to determine whether the measured ages represent the date of impact melting or the age of the precursor rocks [6].)

The data presented herein indicate that many of the major types of melt rocks found at the Apollo 16 site are present in the subsurface at both North Ray and South Ray Craters, though apparently in greatly different abundances in the two areas. Thus, hypotheses that invoke widely separated source terranes (such as Imbrium and Nectaris) for the deposits in the two areas are unlikely. The South Ray area is clearly in Cayley Formation; either the North Ray area is also in Cayley Formation or, if it is in Descartes Formation, the two formations are derived from closely related source terranes.


Table 1. Average compositions of melt rocks obtained by electron-microprobe defocused-beam analyses (15-30 μm spot size). Analyzed areas are free of obviously clastic material.

<table>
<thead>
<tr>
<th>Anorthositic fragment-laden melt rocks</th>
<th>Mafic fragment-laden melt rocks</th>
<th>VHA melt rocks</th>
</tr>
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<tbody>
<tr>
<td>64435 64755 67975 64477 68115 67975 67016 67055 64475 61015 64476 67475</td>
<td>45.1 44.8 44.7 46.5 47.6 45.5 48.7 17.3 23.1 22.2 21.5 21.8</td>
<td>47.5 46.9</td>
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<tr>
<td>SiO₂ 67455 64477 68115 67975</td>
<td>0.19 0.16 0.07 0.32 1.48 1.95 1.44</td>
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<tr>
<td>TiO₂ 67475 67975 67016 67055</td>
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<tr>
<td>Al₂O₃ 67975 67016 67055</td>
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<td>11.0 10.3</td>
</tr>
<tr>
<td>FeO 64475 61015</td>
<td>0.07 0.12</td>
<td>12.3 12.9</td>
</tr>
<tr>
<td>MgO 64476 67475</td>
<td>17.3 23.1 22.2</td>
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<tr>
<td>CaO 67975 67016 67055</td>
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</tr>
<tr>
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<td>0.03 0.03</td>
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<tr>
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<td>100.22 100.24</td>
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<tr>
<td>P₂O₅ 67016 67055</td>
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<tr>
<td>S 67475 67975</td>
<td>99.22 100.03</td>
<td>0.03 0.03</td>
</tr>
</tbody>
</table>

No. of analyses 21 13 3 4 12 7 3 11 6