A PETROGRAPHIC STUDY OF BASALT FRAGMENTS IN APOLLO REGOLITH SAMPLE 12003. J. F. Snape[1], I. A. Crawford[1], K. H. Joy[1,2,3], and R. Burgess[4], [1]The Centre for Planetary Sciences at UCL-Birkbeck, The Joint UCL-Birkbeck Research School of Earth Sciences, London, UK (j.snape@ucl.ac.uk), [2]The Center for Lunar Science and Exploration, The Lunar and Planetary Institute, USRA, Houston 77058, USA, [3]The NASA Lunar Science Institute, [4]SEAES , University of Manchester, Manchester, UK.

Introduction: Geologic mapping by [1,2] indicates that a large number of individual basaltic flows are located within the Oceanus Procellarum including some of the youngest mare basalts (~1.5 Ga) on the Moon. Given the location of the Apollo 12 landing site within the eastern region of this maria, and the potential for lateral transport of material across the lunar surface by impact processes [3, 4], it is possible that some of this young basaltic material may have been sampled by the mission. For this reason, further characterization of the Apollo 12 sample collection may provide new insights to the duration of lunar volcanism and the magmatic evolution of the Moon. To this end we have been allocated 10 small (2-4 mm) fines from the Apollo 12 regolith sample 12003,308. We divided each sample into two sub-splits (A and B), with the A split being used for geochemistry and petrography; the B split will be used for Ar-Ar radiometric dating. Of the ten samples being studied, seven basalt fragments are discussed here.

Methods: Our samples were analyzed with a JEOL JXA-8100 electron microprobe. BSE images, elemental maps and bulk clast composition analyses were obtained with an accompanying Oxford Instruments EDS probe and INCA software package. A more detailed description of these techniques is given in [5]. Individual mineral grain analyses were performed with an integrated WDS system.

Sample descriptions: We have grouped our samples into four petrographic types based on their textural characteristics, modal mineralogies and mineral chemistries.

Group 1: 12003,308_1A. This is a fine grained (0.01-0.50 mm) subophitic basalt (Fig. 1a), and consists predominantly of plagioclase lathes (An_{86-92}) and pyroxene ($Wo_{13-38}En_{0-55}Fs_{22-85}$) grains. The pyroxene within the sample exhibits prominent zoning (Figs. 1a, 2a). Compared with typical Apollo 12 basalts [6], the sample also has a large amount of silica (approximately ~6% by area). Aside from this, the basalt's modal mineralogy is most similar to that observed in Apollo 12 pigeonite and ilmenite basalts [6].

Group 2: 12003,308_2A;,308_4A; ,308_8A. These three ophitic basalts have a coarser grainsize than 12003,308_1A (0.20-0.80 mm) and contain less plagioclase (~19-25% by mode; An_{86-94}). The minerals in these samples also have more blocky, and less elongate appearance (Fig. 1b). Most of the pyroxene ($Wo_{9-40}En_{1-65}Fs_{17-85}$) is zoned. In some cases olivine (Fo_{35-74}) occurs around the edges of the pyroxene grains. The modal mineralogies of these samples are similar to those of Apollo 12 olivine basalts [6].

Group 3: 12003,308_3A. This sample has a coarser grained (0.25-0.75 mm) cumulate texture (Fig. 1c) consisting of equilibrated pyroxene ($Wo_{8-38}En_{43-62}Fs_{19-34}$), plagioclase ($An_{86-92}$) and olivine ($Fo_{55-64}$). Several large grains (0.05-0.10 mm in size) of Cr-spinel ($2Ti_{51-65}Al_{10-15}Cr_{25-35}$) also occur (Fig. 1). The relative mineral abundances (Fig. 1c) in this sample most similar to those observed in Apollo 12 olivine basalts [6].

Group 4: 12003,308_5A; ,308_7A. These two basalts are also relatively coarsely grained (~0.25 mm crystal size). They are composed mostly of pyroxene (>80%; $Wo_{4-41}En_{43-65}Fs_{15-35}$) and olivine (~10%; Fo_{62-68}). Whilst plagioclase is much less abundant (<5%) in these samples, it has a wider compositional range (An_{77-93}) than the other 12003,308 basalts. Cr-spinel ($2Ti_{19-63}Al_{12-27}Cr_{26-51}$) grains are common within pyroxene phases of these samples. The modal mineralogies of these samples are unlike those observed in other Apollo 12 basalts [6].

Summary: Based on our results we have identified

	12003,308_1A	12003,308_2A	12003,308_3A	12003,308_4A	12003,308_5A	12003,308_7A	12003,308_8A
SiO_2	46.16 ± 0.26	44.20 ± 0.09	42.31 ± 0.08	44.99 ± 0.15	47.75 ± 0.07	48.53 ± 0.06	46.11 ± 0.16
TiO_2	4.72 ± 0.06	2.72 ± 0.08	1.10 ± 0.02	2.24 ± 0.04	2.64 ± 0.07	1.21 ± 0.02	1.62 ± 0.04
Al_2O_3	13.13 ± 0.04	10.11 ± 0.07	9.35 ± 0.14	7.13 ± 0.07	2.17 ± 0.03	3.90 ± 0.03	8.84 ± 0.07
Cr_2O_3	0.21 ± 0.01	0.66 ± 0.02	0.71 ± 0.02	0.67 ± 0.03	1.43 ± 0.03	1.41 ± 0.03	0.55 ± 0.03
FeO	19.39 ± 0.11	20.55 ± 0.13	21.98 ± 0.14	20.39 ± 0.15	18.48 ± 0.06	16.17 ± 0.08	18.09 ± 0.06
MnO	0.23 ± 0.03	0.27 ± 0.03	0.25 ± 0.02	0.28 ± 0.02	0.31 ± 0.02	0.27 ± 0.03	0.24 ± 0.03
MgO	4.25 ± 0.11	11.78 ± 0.08	17.23 ± 0.11	16.33 ± 0.09	20.80 ± 0.04	19.42 ± 0.05	15.92 ± 0.06
CaO	11.12 ± 0.13	9.04 ± 0.03	6.53 ± 0.06	7.47 ± 0.06	6.14 ± 0.03	8.78 ± 0.04	8.09 ± 0.04
Na_2O	0.43 ± 0.02	0.43 ± 0.01	0.41 ± 0.01	0.34 ± 0.02	0.24 ± 0.02	0.26 ± 0.01	0.38 ± 0.01
K_2O	0.09 ± 0.01	0.06 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	b.d.	b.d.	0.03 ± 0.01
P_2O_5	0.28 ± 0.02	0.18 ± 0.03	0.10 ± 0.02	0.14 ± 0.02	0.04 ± 0.02	0.05 ± 0.02	0.11 ± 0.03
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Mg#	28.10	50.56	58.30	58.83	66.75	68.17	61.08

Table 1: Normalized major element bulk compositions of the seven samples discussed here. The errors provided are 1σ standard deviations. These values have been corrected for differing phase densities using the method of [9].

four individual basaltic groups within the 12003,308 regolith. Of these groups, at least one appears to be unlike previously studied Apollo 12 basalts [6]. It seems likely that these groups crystallized from separate lava flows. We are currently performing more extensive analyses of these basalts, including the acquisition of trace element mineral chemistry and crystallization ages, in order to better understand their petrogenesis, cooling history and their relationship (if any) to other basalt hand specimens and fines [e.g. 7,8] collected at the Apollo 12 landing site.

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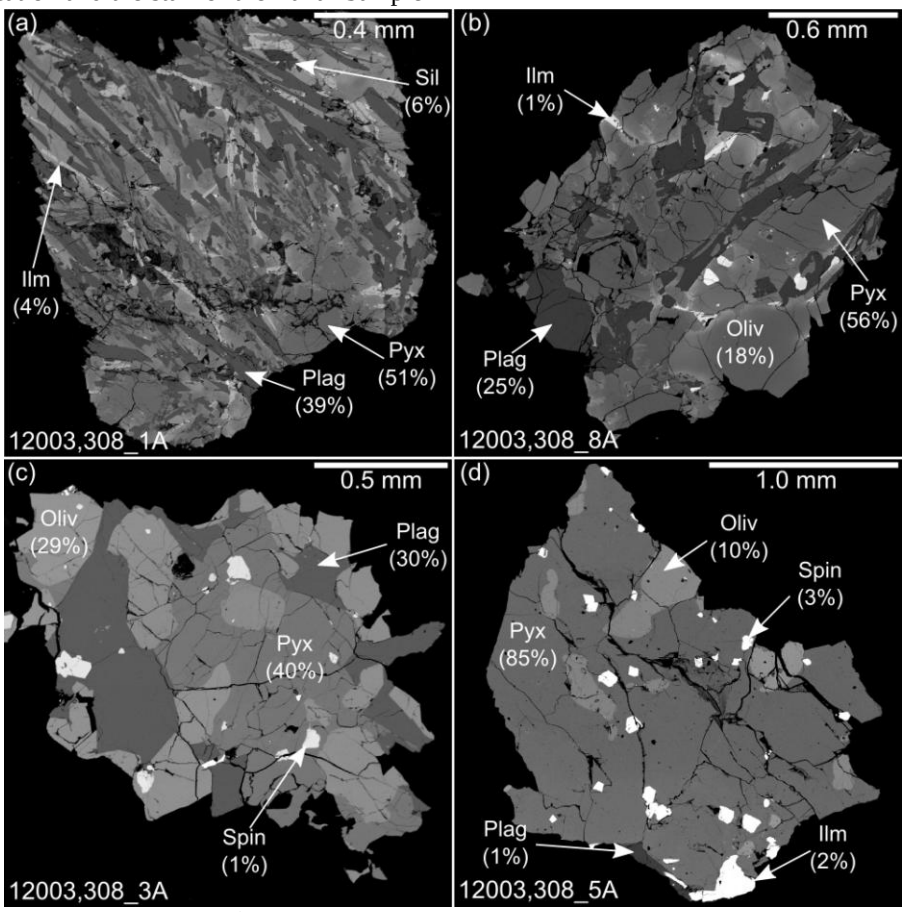

Figure 1: BSE images of samples (a) 12003,308_1A; (b) 12003,308_8A; (c) 12003,308_3A; (d) 12003,308_5A, illustrating the textures of the four groups identified.

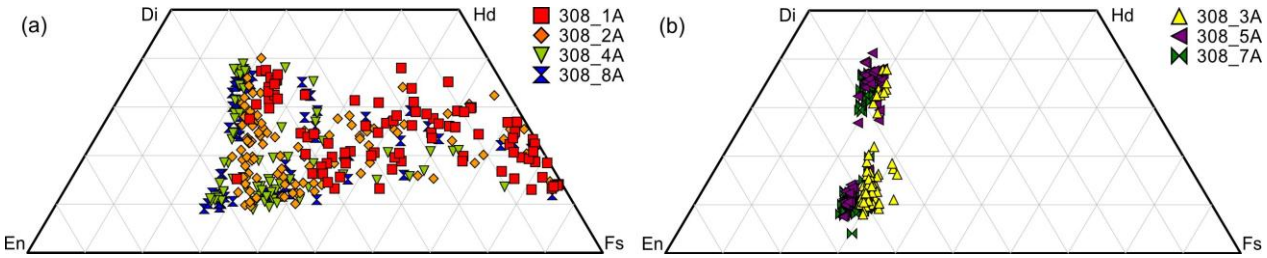

Figure 2: Pyroxene compositions of samples (a) 12003,308_1A; ,308_2A; ,308_4A; ,308_8A and (b) 12003,308_3A; ,308_5A; ,308_7A. Note the much more diverse compositions present in the Group 1 and 2 basalts, compared with the more equilibrated compositions of those in the Group 3 and 4 basalts.