Petrogenesis of Apollo 16 Impact Melts. C.R. Neal[1] and A. L. Fagan[1], [1]Dept of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame, IN, 46556, USA (neal.1@nd.edu;abacasto@nd.edu).

Introduction: The Apollo 16 (A16) samples are dominated by impact melts and impact melt breccias [1-2]. The most recent study [2] of a large number of A16 impact melts examined the composition via Instrumental Neutron Activation Analysis (INAA); a principle drawback to INA analyses is the lack of Mg, Al, K, & Ti [2]. Although we examine some of the same samples, we employ a new technique via a combination of whole-rock (WR), individual crystal chemistry, and textural analyses to explore the petrogenesis of the A16 impact melts. This study examines 18 impact melt rocks from different stations of the A16 site (Table 1). The samples span the range of compositional groups defined by [2] including 2M, 2Mo, 3, and U; 8 of the samples were not examined by [2]. A16 impact melts in this study are predominantly igneous textured and composed of plagioclase laths of varying length with interstitial pyroxene, olivine, +/- ilmenite.

Methods: *Mineral Chemistry:* Chemical composition analyses of ilmenite, pyroxene, olivine, and plagioclase phases have been determined with a JEOL JXA-8200 electron microprobe (EMP) at Washington University in St. Louis. A 5 µm spot size and a 30-s on-peak counting times were used. Trace element data were collected via Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) using a New Wave UP-213 laser ablation system coupled with a ThermoFinnigan Element2 ICP-MS at the University of Notre Dame. Trace element analyses used a repetition rate of 5 Hz, spot size 15-65 µm (depending on crystal size), and power range of 85-100% to maximize the corresponding fluence of ~16-20 J/cm^2. Plagioclases and pyroxenes were analyzed using Ca and NIST SRM 612 glass as internal and external standards, respectively. Ilmenite and olivine crystals were analyzed using the NIST SRM 610 glass and Ti and Mn abundances for internal standards, respectively.

Whole Rock Chemistry: Whole rock analyses are being performed on 15 samples (Table 1); when possible, these WR aliquots were selected directly adjacent to the location of the thin-section to better tie together the WR data with the individual mineral analyses. Major elements are being determined via solution mode using a Perkin Elmer ICP-Optical Emission Spectrometry at the Center for Environmental Science and Technology (CEST) at the University of Notre Dame. Four basaltic standard reference materials (BIR-1, BCR-2, BHVO-1, BHVO-2) will be analyzed as unknowns and a calibration curve will be created using 6 solutions of known concentrations. Trace element abundances are being determined via solution-mode ICP-MS using the standard addition method (see [3]).

Textural Analyses. Crystal size distributions (CSDs) are used as a complement to compositional analyses and to quantitatively investigate igneous processes (e.g. [4-5]). Plagioclase CSDs are being collected from thin sections (Table 1). The method used for CSD construction is that reported in [6].

Parent	T.S. #	Symbol	WR #	Parent	T.S. #	Symbol	WR #
60235	5	◆	14	65795	2	●	14
	17	◆		67095	35	▲	122
60335	13	▲	143		36	▲	
	63	▲			127	▲	
	149	▲		67559	1	●	23
60615	8	■	18		28	●	
60618	3	●		67747	1	■	19
	4	●		67948	14	◆	0
60635	2	★ or ✳	19	68415	130	●	
62295	66	■	184		133	●	
	190	■		68416	6	▲	121
63545	6	●	18		70	▲	
63549			34		126	▲	
64455	38	■		*60639 Basalt*	*2*	×	*see*
64817	3	▲	18		*50*	✳	
65055	15	▲	48		*52*	+	
	51	▲					

Table 1. Summary of samples used in this study with the coordinating symbols for figures in this abstract. Sample 60639 is a basalt examined in a concurrent study [7].

Petrologic Models: Using the trace element data in conjunction with appropriate partition coefficients, parental melt compositions are calculated (i.e. target material) for these impact melts using a method similar to [8] for plagioclase in ferroan anorthosites. Such models can determine the crystallization sequence for these impact melts as well as show the prevalence of various modes of melt evolution (i.e. fractional crystallization, equilibrium crystallization or assimilation with fractional crystallization). By looking at trace element contents across different crystals, the evolution of the impact melt as it crystallized can be traced.

Results: Preliminary olivine results indicate that most olivines cluster around Fo$_{0.8}$ (Fig 1a). However, 62295, 65795, and all station 8 samples do not follow this trend. 62295 has the highest Fo while 65795 and the station 8 samples have Fo and trace elements similar to basaltic sample 60639. Ilmenites vary by a few weight percent in TiO$_2$ and are predominantly less than the FeO abundance for the 60639 basalts (Fig 1b). Most pyroxenes are augites or pigeonites with a few enstatites (Fig 1c); nearly all of the impact melt pyroxenes are more Mg-rich than pyroxenes from 60639.

Plagioclases appear to have different trace element trends depending on the station number. In addition, some plagioclase crystals display a –Eu anomly in their REE pattern, which is discussed in [7]. Petrologic modelling and WR analyses are ongoing.

Discussion: Although petrogenetic models and WR data will be needed to confirm, the mineral chemistry suggests that the impact melts from the different stations reflect unique target materials. In particular, Station 8 impact melt compositions suggest the target materials contained a basalt similar to that found as clasts in 60639. Further trace element data are needed to confirm this. In addition, impact melts from the lunar module station originated from a source with lower light and mid-REE compared to those from the other sites, based on the plagioclase trace elements (Fig 1d).

Plagioclase CSDs, when compared with those from mare basalts, suggest the A16 impact melts underwent slower cooling as they have a gentler slope (longer "residence time") than those from the basalts. In addition, they have been used by [9] to propose a scheme that distinguishes pristine basalts from impact melts on the basis of plagioclase CSDs. This scheme showed that A12 basalt 12038 has a plagioclase CSD similar to impact melts [9]. In this study, application of this scheme shows 60235 has a plagioclase CSD similar to A12 mare basalts. This sample is currently under scrutiny, along with 12038, to explain these dischotomies.

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References: [1] Ryder & Norman (1980) *Cat. Of Apollo 16 Rocks, JSC 16904*. [2] Korotev, R.L. (1994) *GCA, 18*, 3931-3969. [3] Neal C.R. (2001) *JGR, 106*, 27865-27885. [4] Higgins M.D. (1996), *Bull. Volc. 58*, 194-204. [5] Cashman, KV & BD Marsh (1988) *Contrib. Min. Pet., 99*, 292-305. [6] Neal et al. (2011), *LPSC, 42*, abs #2668. [7] Fagan A.L. and Neal C.R. (2012) *this conference*. [8] Papike, J.J. et al. (1997) *GCA, 61*, 2343-2350. [9] Neal C.R. et al. (2012) *LPS 42* abstract# 2668.

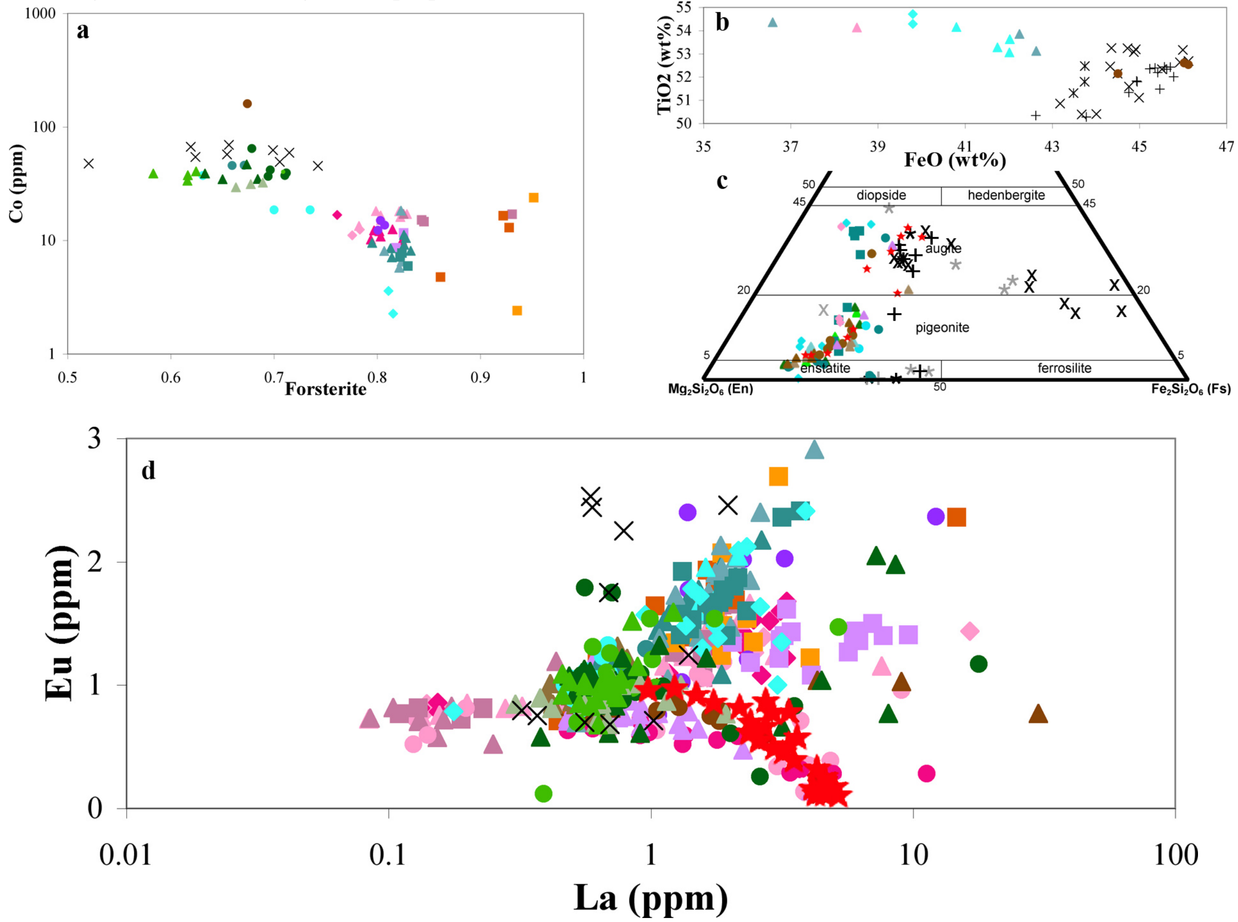

Fig 1. (a) Olivine major and trace elements may be used to distinguish between samples from different stations; (b) ilmenite major elements mostly separate those from impact melts from 60639 basaltic ilmenites; (c) quad plot shows that most pyroxenes are augite or pigeonite while most 60639 basalts are augite with some being more Fe-rich; pyroxenes from the breccia portions are shown in grey and those from basalt are black; (d) plagioclase trace elements show varying trends amongst impact melts and basalt. Symbols/colors as in Table 1.