Identification of Basaltic Clasts in Lunar Meteorites: In Search of South Pole-Aitken Basin Material

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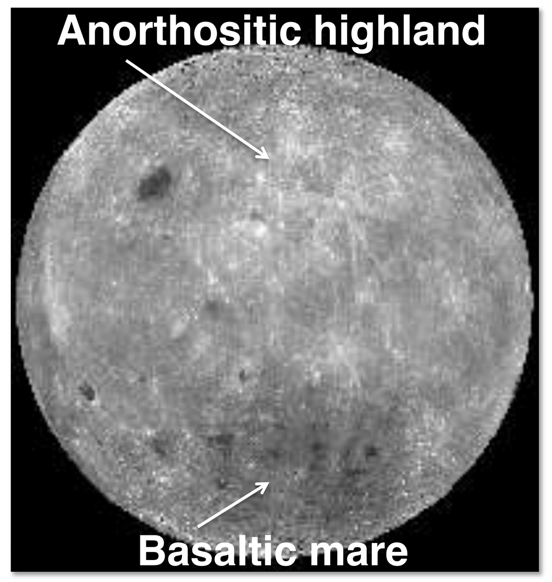
Introduction

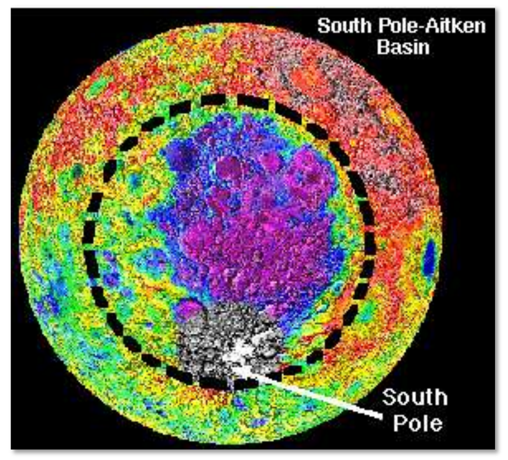


Lunar and Planetary Institute

The Hawaiian Islands are composed of basaltic rock.


The United States Geological Survey

The surface of the Moon is dominated by light-colored anorthositic highlands and dark-colored basaltic maria. On the far side of the Moon in the Southern Hemisphere, there is a large, dark, basaltic region: the South Pole-Aitken Basin (SPA). The SPA Basin, which was formed by meteorite impact, is the largest (250 km), deepest (8-12 km), and oldest (~4Ga) basin on the Moon. Due to its great depth, the SPA Basin may expose the lower crust and even the mantle of the Moon. If this is true, study of this crust and mantle would increase understanding of the evolution of the Moon, Earth, and other planetary bodies in the Solar System.



Lunar and Planetary Institute

Since the Apollo missions did not reach the far side of the Moon, samples of the South-Pole Aitken Basin must be obtained from lunar meteorites that originated in the Basin. Lunar meteorites are lunar rocks, ejected by the impact of a meteorite into the Moon. These lunar meteorites eventually landed on the Earth's surface after orbiting for a few to tens of thousands of years. The 65 lunar meteorites that have been found on Earth are random samples of the Moon's crust for which the location of origin is unknown[1]. The Smithsonian Institution's Antarctic Meteorite Collection has a thin section of every lunar meteorite collected during an Antarctic Search for Meteorites (ANSMET) field season. Due to the size of the Basin and the extent of the collection, it is our hypothesis that the Antarctic Meteorite Collection could have at least one lunar meteorite that originated from the South Pole-Aitken Basin.


Lunar meteorite ALHA 81005
The Lunar Meteorite Compendium

Materials and Methods

In order to determine if the origination location of a meteorite is the South-Pole Aitken Basin, the meteorite must have similarities to lunar rocks currently in the Basin. Spacecraft data shows that the SPA Basin has intermediate levels of Thorium (Th) [2]. Additionally, clasts within SPA Basin originated meteorites should be at least ~3.7 Ga. Basaltic clasts must be identified in the meteorites as they contain the minerals required for radiometric age dating and Th analysis.

The Search for Basaltic Clasts

Basalt is composed of the minerals:

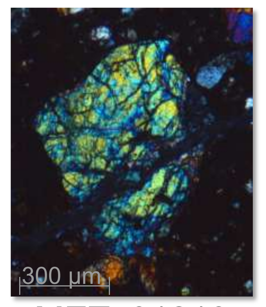
Plagioclase feldspar $(Ca,Na)(Al,Si)O_8$

LAP 04841

Pyroxene $(Ca,Fe,Mg)_2Si_2O_6$

QUE 94281

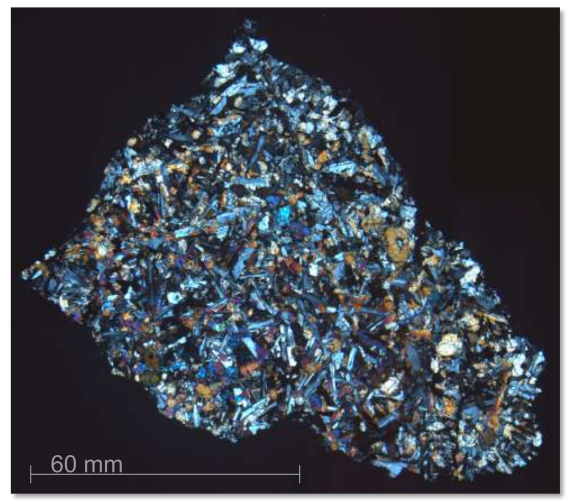
Olivine $(Mg, Fe)_2SiO_4$



MET 01210

Lunar Meteorite LAP 02436: Unbrecciated Basalt

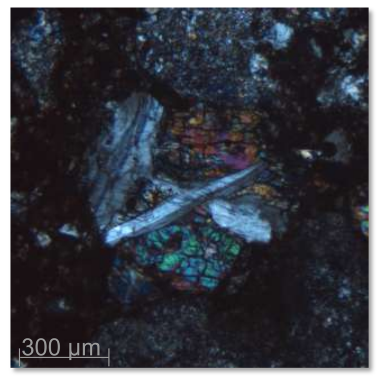
Plain Polarized Light



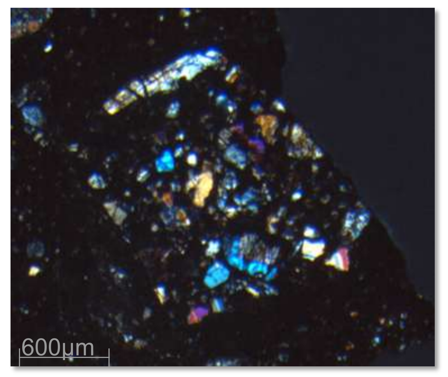
Cross Polarized Light

Potential Basaltic Clasts:

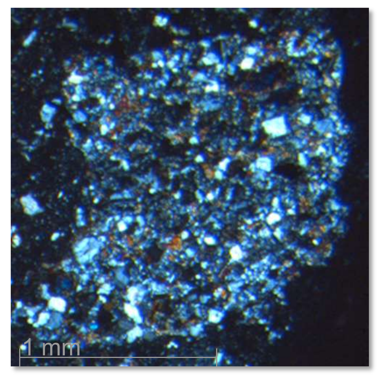
An Olympus BX61 Motorized Research Microscope was used to examine thin sections in search of basaltic clasts. The potential basaltic clasts were identified optically by the combination of plagioclase feldspar, pyroxene, and olivine.



ALHA 81005 Clast A

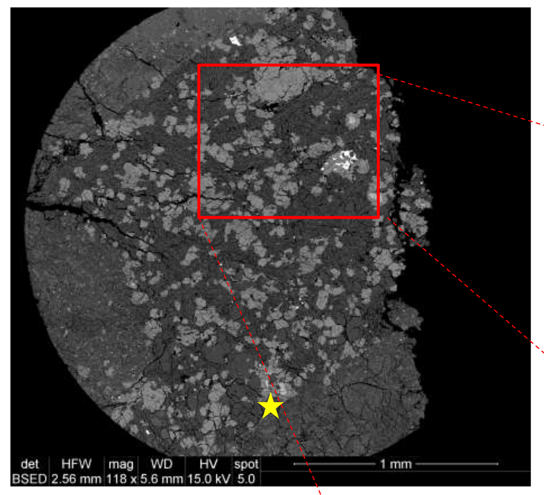


PCA 020007 Clast A

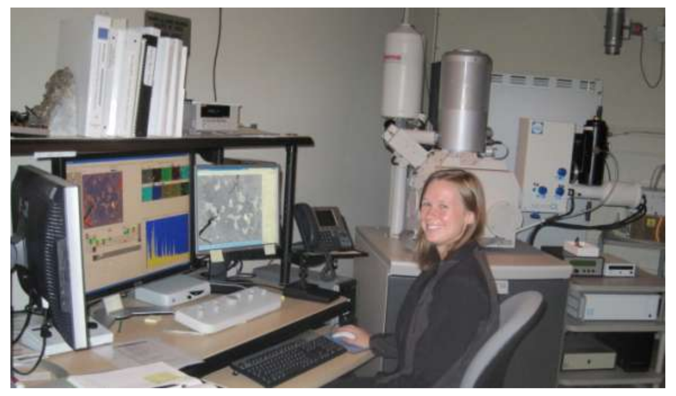


LAR 06638 Clast B

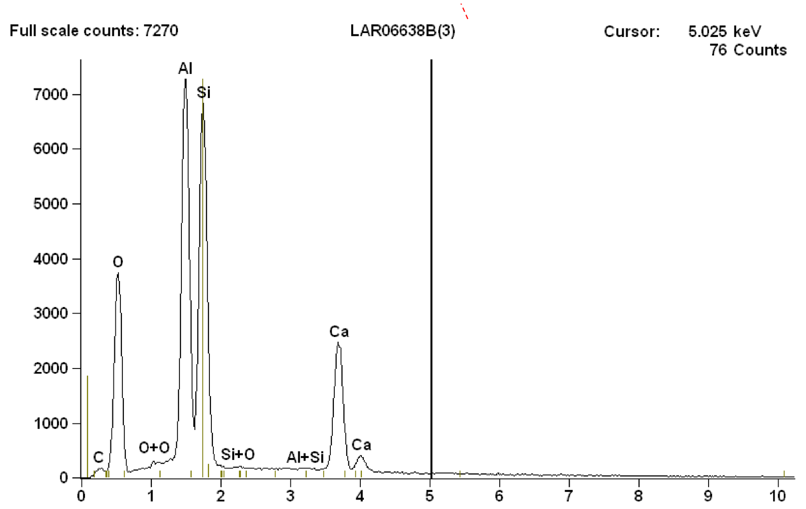
LAR 06638 Clast B



A FEI Nova NanoSEM 600 Variable Pressure Field Emission Scanning Electron Microscope (SEM) was used to closely examine potential basaltic clasts that were located with the Olympus BX61 microscope. The Energy Dispersive Spectrometer (EDS) of the SEM was used to obtain compositional data of individual minerals within clasts.



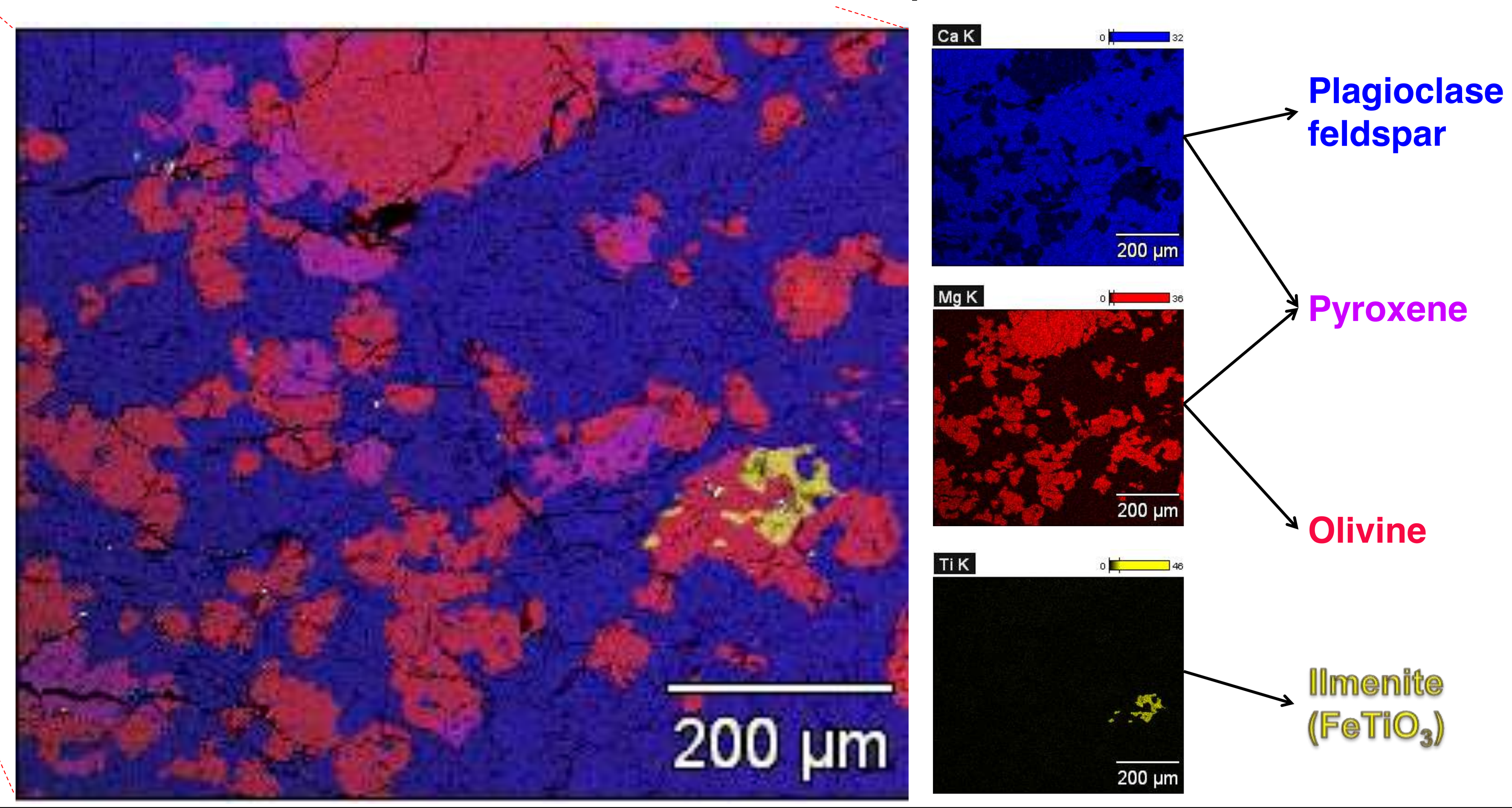
☆ EDS data of Clast B Point 3



Point 3 is plagioclase feldspar

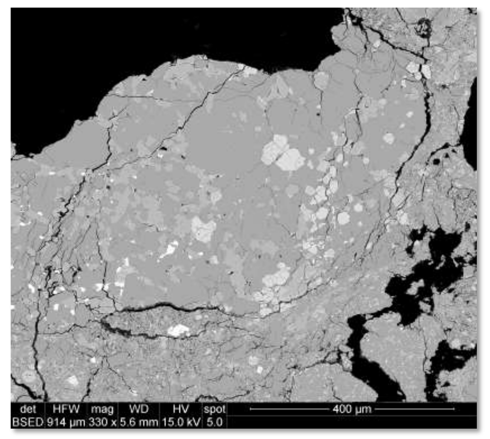
Element Line	*Weight %*	*Norm. Wt.%*	*Atom %*	*Formula*	*Compnd %*	*Norm. Compnd%*	*# Cations*
C K	---	---	---		---	---	---
O K	45.89S	45.89S	61.52		---	---	---
Al K	18.64	18.64	14.82	Al2O3	35.22	35.22	5.780
Si K	20.48	20.48	15.64	SiO2	43.81	43.81	6.101
Si L	---	---	---		---	---	---
Ca K	14.99	14.99	8.02	CaO	20.97	20.97	3.129
Ca L	---	---	---		---	---	---
Total	100.00	100.00	100.00		100.00	100.00	15.010

Clast B Elemental Map



A microprobe was used to perform Electron Microprobe Analysis in order to measure the elemental compositions of mineral phases within features of interest.

Microprobe data and SEM image from PCA 02007 Clast D

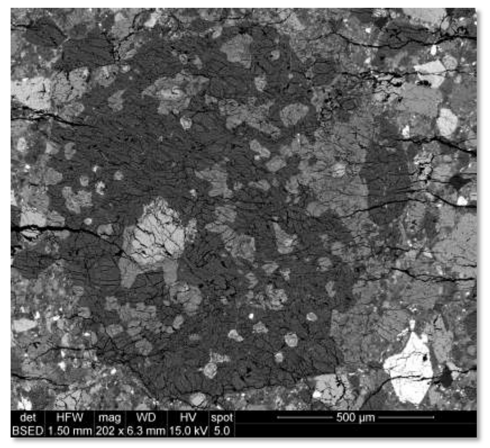


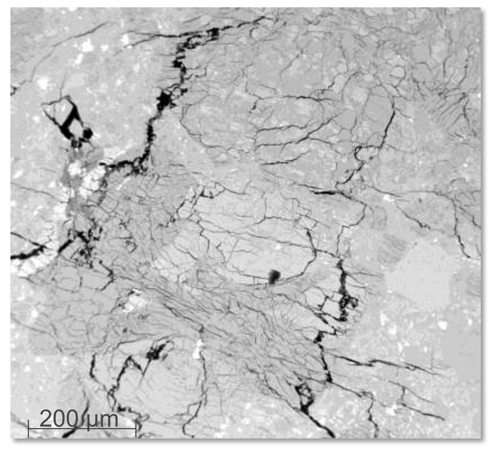
Comment	SiO2	Al2O3	FeO	MgO	MnO	TiO2	CaO	Na2O	Cr2O3	Total	Mineral
pca 02007_23	53.68	1.16	16.06	24.55	0.26	0.72	2.31	0.00	0.47	99.22	pyroxene
pca 02007_24	37.37	0.00	28.71	33.36	0.35	0.05	0.17	0.04	0.09	100.15	olivine
pca 02007_25	50.74	2.31	9.65	15.91	0.20	1.30	17.53	0.05	0.78	98.47	pyroxene
pca 02007_27	43.93	35.92	0.25	0.09	0.01	0.01	19.14	0.34	0.00	99.74	Plagioclase feldspar
pca 02007_28	44.26	36.41	0.20	0.06	0.00	0.02	19.20	0.32	0.00	100.50	Plagioclase feldspar

Results

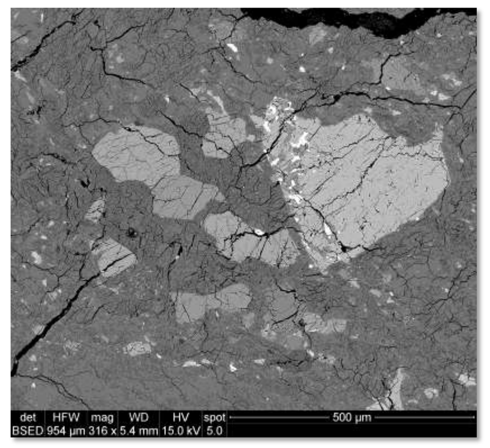
Basaltic clasts were found in lunar meteorites LAR 06638, ALHA 81005, PCA 02007, QUE 94269,7, GRA 06157, and MET 01210. In total, 17 basaltic clasts were found.

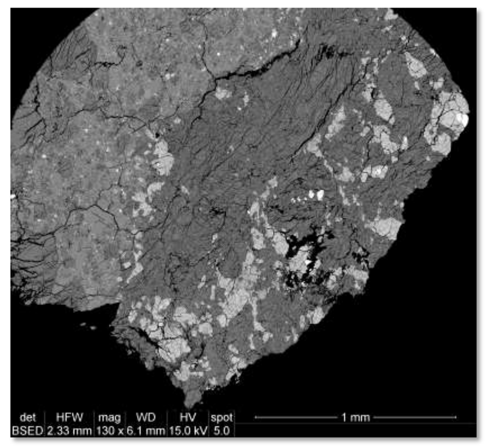
Lunar Meteorite	Basaltic Clasts
LAR 06638	4
ALHA 81005	3
PCA 02007	3
QUE 94269,7	3
GRA 06157	2
MET 01210	2


MET01210 Clast B



ALHA 81005 Clast A


GRA 06157 Clast C


QUE 94269,7 Clast E

Future Works

- Look for basaltic clasts in lunar meteorites that have not yet been examined.
- Identify Th-rich portions of lunar meteorites using the Smithsonian's Time of Flight Secondary Ion Mass Spectrometer.
- Micro-core the basaltic clasts found to have intermediate thorium levels.
- Perform ^{40}Ar-^{39}Ar radiometric dating on these cores to determine crystallization and disturbance age of the basaltic clasts.
- Using these results, determine if the lunar meteorites' place of origin is the South Pole-Aitken Basin.

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Literature Cited

[1] Korotev, Randy L. "Lunar Meteorites - Washington University in St. Louis." *Meteorite Information.* 22 June 2010. Web. 13 July 2010. <http://meteorites.wustl.edu/lunar/moon_meteorites.htm>. [2] Lucey et al 2006. Lucey Et Al. "Understanding the Lunar Surface and Space-Moon Interactions." *Reviews in Mineralogy and Geochemistry.* Vol 60 (January 2006): 83-219.