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Lunar zircons formed early in lunar history and have survived many impacts and associated thermal events. They give important information about the age of plutonic rocks from the original lunar crust [1,2]. However, most lunar zircons are found as loose individual mineral fragments in the soils and breccias and only a few zircons are found included in their original mineral assemblages or are found attached to other minerals. It is an important problem to establish the rock types that are parental to the many loose lunar zircons.

We have used reflected light microscopy to search lunar thin sections for zircons that are included in apparently pristine igneous rock fragments. Most of the zircon-containing rock fragments that we have found occur as small clasts in Apollo 14 breccia samples. Based on the apparent mineralogical mode (Table 1) and the composition of attached pyroxene and plagioclase (Figure 3), we have found that there are a wide variety of zircon-containing lunar rock fragments, ranging from "dunite" to norite to granophyre. Most lunar basalts do not contain zircons because the titanium-bearing minerals accept substitution of Zr preventing buildup of Zr concentration during crystallization. Ferroan anorthosites, do not contain zircon because of the extremely low Zr contents.

Lunar zircons are found in samples from the Apollo 12, 14, 15 and 17 (station 2) sites. They are varied in morphology, composition and age; preventing simple description. Many individual zircons are large (100-1000 microns) and rounded (resorbed?), and a few have euhedral shape. Many are birefringent, although some are metamict. They rarely contain mineral inclusions although a few lunar zircons have a "swiss-cheese" texture including plagioclase and pyroxene. Only one lunar zircon has been found to have an overgrowth [5]. Lunar zircons are generally more homogeneous than terrestrial zircons, although some are chemically zoned. The Zr/Hf ranges from 30 to 60 with a peak about 48. This is higher than the Zr/Hf of about 42-44 as determined for the lunar breccias by INAA on bulk rocks [3]. The lunar Hf anomaly, with respect to chondrites, remains unexplained.

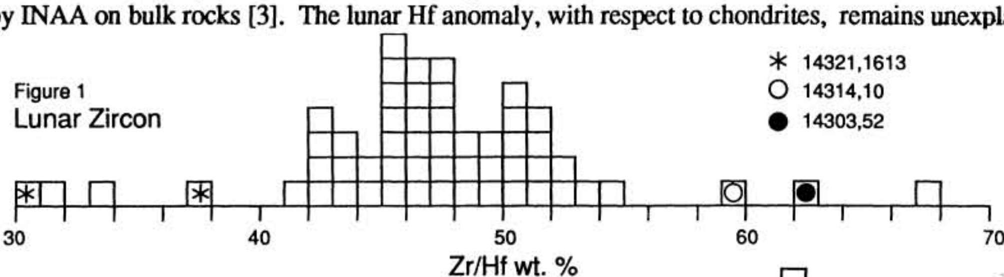

Figure 1
Lunar Zircon

Lunar zircons contain about 1 % xenotime YPO_4 substituting as a molecule for $ZrSiO_4$. Hf substitutes for Zr. The heavy REE substitute for Y. Electron probe analyses show that Yb ranges from 2500 to 100 ppm with the Y/Yb about 2 to 5. The REE patterns of two zircons from lunar granite 14321,1613 show a large positive Ce anomaly [4]. Zircons that are attached to Kspar have the highest trace-element contents.

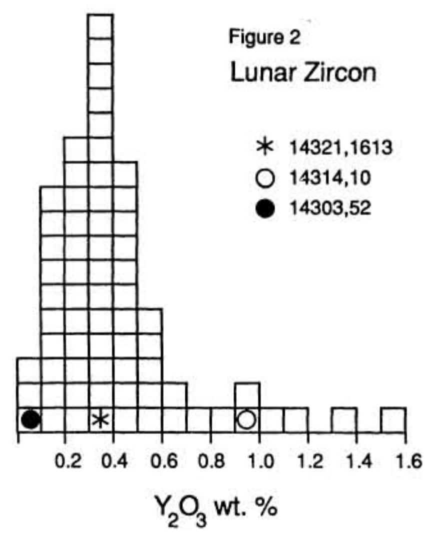

Figure 2
Lunar Zircon

No single clast has yet been found that we can assign as parental to the majority of lunar zircons. Zircons are found in most lunar granophyres; which is certainly one of the source rocks. Lunar norites are another source (Figure 3). Of the most unusual clasts, 14303,52 is a single large olivine (Fo_{63}) including two kinds of pyroxene ($En_{67}Fs_{26}Wo_4$ and $En_{43}Fs_{16}Wo_{41}$) as well as a large zircon (100 micron). This zircon has the lowest Y_2O_3 and highest Zr/Hf of lunar zircons studied (Figures 1 and 2). Another interesting clast, poikilitic norite 14314,10, was found to contain zirkelite as well as zircon. The zircon in this clast has a high trace element content and high Zr/Hf ratio.

The advent of precise and accurate ion microprobe techniques [7] allows us to use small zircon-containing lunar rock fragments to expand upon more standard techniques [6] in order to understand the chemical and isotopic differentiation of the lunar crust. Zircons could only have formed late in the sequence of crystallization of lunar magma when the Zr and Si activity were high enough for the zircon to precipitate. So far, no zircons have been found with an age greater than abut 4370 MY, which may be the time of the last differentiation of the hypothetical lunar magma ocean [1]. The wide spectrum of ages for lunar zircons [2] is further evidence that multiple igneous events occurred in the development of the lunar crust over the time span 4350 to 3900 MY.

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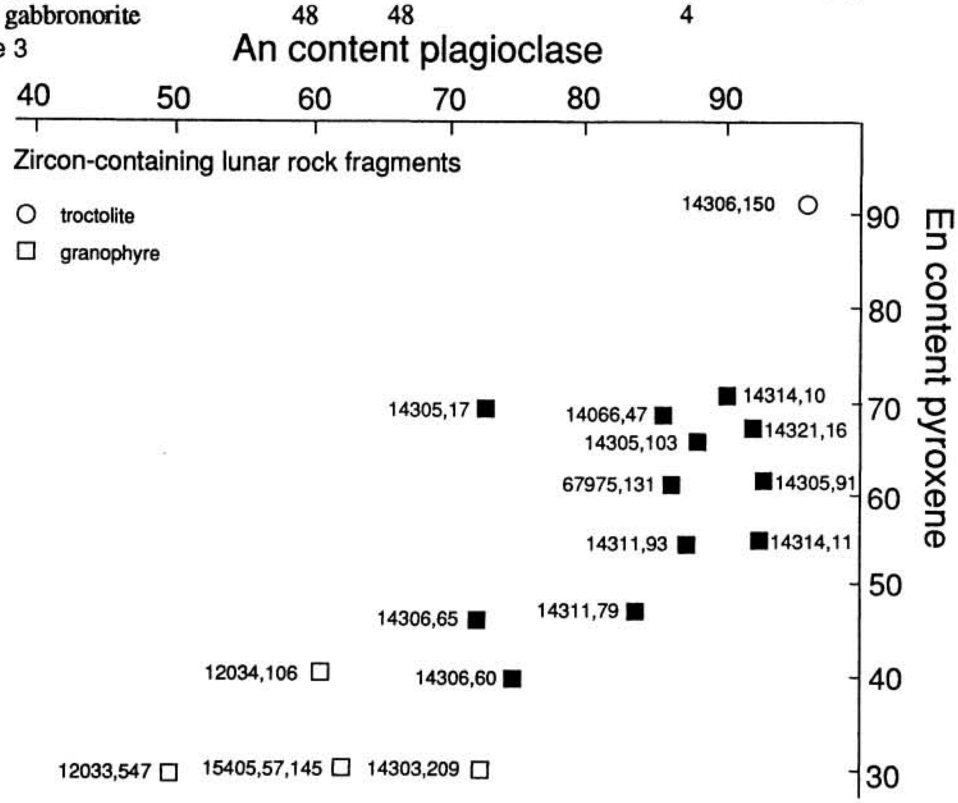
Table 1 Apparent mineralogical mode (*these fragments are all small, generally less than 1mm*).

	clast name	oliv.	pyrox.	plag.	ilm.	Kspar	zir.	other minerals
12033,547 (,507)	felsite	2		30	5	50	2	silica
12034,107	felsite		5	30		30	1	silica
14303,49 (,205)	granite, melted		4	12	3	8	2	silica, glass
14303,52	"dunite"	90	5				5	
14305,17	"anorthosite"		3	90			7	
14305,103	norite		45	45			10	
14306,60	sodic ferrogabbro		40	40	5	1	2	apatite
14306,65	plagioclase		10	80			10	
14306,150	troctolite	15		80			5	
14311,79	gabbro		33	50	5		2	apatite
14311,90	ilmenite ore		2		90	1	7	
14311,93	gabbro		35	55			2	apatite, troilite
14314,11	norite		49	49			2	
14314,10 (,9 ,8)	poikilitic norite	1	40	45	2	10	2	zirkelite, apatite
14321,16 (,17)	"anorthosite"		3	90			2	whitlockite
14321,1613	granite					50	1	silica, yttrobetafite
15405,57 (,145)	quartz monzodiorite		40	40	5	5	2	silica, apatite
67975,131	gabbronorite		48	48			4	

Figure 3



[1] Meyer C., Compston W. and Williams I.S. (1985) Lunar zircon and the closure age of the original lunar crust. *(abs.) Lunar Planet Sci. XVI, 557.* [2] Meyer C., Williams I.S. and Compston W. (1989) Pb/Pb ages of zircon-containing rock fragments indicate continuous magmatism in the lunar crust. *(abs.) Lunar Planet Sci. XX, 691.* [3] Hughes S.S and Schmitt R.A. (1985) Zr-Hf-Ta fractionation during lunar evolution. *Proc. Lunar Planet. Sci. Conf. 16th J. Geophys. Res. 91, D31.* [4] Hinton R.W. and Meyer C. (1991) Ion probe analysis of zircon and yttrobetafite in a lunar granite. *(abs.) (this conference)* [5] Smith J.M., Meyer C., Compston W. and Williams I.S. (1986) 73235,82 Pomegranate, A unique zircon. *(abs.) Lunar Planet Sci. XVII, 805.* [6] Shih et al (1991) Dating lunar granites. *(abs.) (this conference).* [7] Compston et al (1991) Initial Lunar Pb. GCA *(in press)*