$^{207}Pb/^{206}Pb$ AGES OF ZIRCON-CONTAINING ROCK FRAGMENTS INDICATE CONTINUOUS MAGMATISM IN THE LUNAR CRUST FROM 4350 TO 3900 MILLION YEARS;

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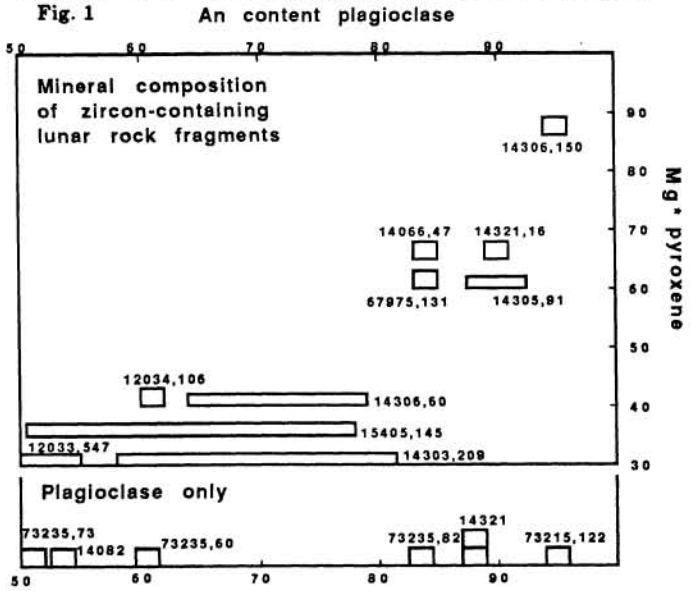
Zircons are found intergrown with other minerals in some igneous rock clasts within lunar breccias. The textures indicate that the ages determined for the zircons are also the ages of the rock fragments. The wide range of composition of attached plagioclase and pyroxene crystals show that lunar zircons formed in a wide variety of plutonic rock types (Fig. 1).

Fig. 1

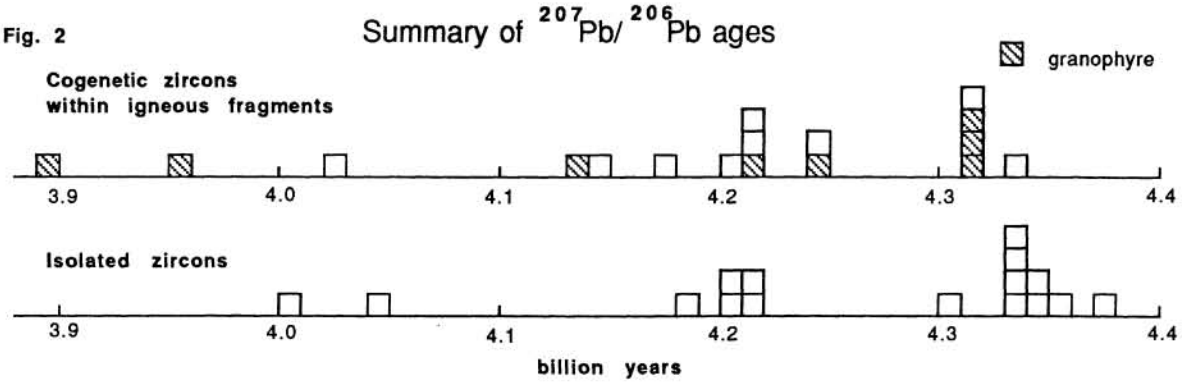


A sensitive high mass-resolution ion microprobe [1] has been used to date zircons located within texturally-pristine, lunar rock fragments in thin sections of lunar breccia [2]. Zircon data have been corrected for non-radiogenic Pb by using the observed $^{208}Pb/^{206}Pb$ for each analysed area to deduce its particular blend of high-*mu* initial Pb, as seen in cogenetic K-feldspar, and low-*mu* surface contamination from the meteoritic component of the breccia [3]. For most lunar zircons, the $^{207}Pb/^{206}Pb$ ratios from multiple spots are tightly grouped (within error expected by counting statistics). Our interpretation is that most individual zircons have not lost Pb during an early impact or thermal event (such as a cataclysm at about 4000 Ma). However, suites of zircons in some lunar granites do show redistribution of U/Pb by "young" events (Fig. 3).

The wide spectrum of ages for zircon-containing lunar rock fragments (Fig. 2) is further evidence that multiple igneous events occurred within the lunar crust during the time interval 4350 to 3900 Ma. No zircons have been found older than 4371 +/- 8 Ma, which may be within the period of crystallization of the last differentiates from an early lunar magma ocean [5]. Individual zircons and zircon-containing rock fragments in the same lunar breccia often have widely varying ages consistent with a wide variety of sources. Highly precise Pb/Pb ages of zircons show that individual rock fragments have distinctly different ages even when they are from the same chemical grouping. Zircon data show that magmatism in the lunar crust may be better described as continuous rather than (episodically) serial [4].

It has been difficult to date lunar granites by techniques based on mineral separation [6-10]. However, many lunar granites contain zircons large enough to be dated by the ion microprobe. We have found that the felsites (12033, 14321), with characteristic bow-shaped REE patterns, have relatively young ages, whereas, lunar "granites", with included Fe-rich

Fig. 2



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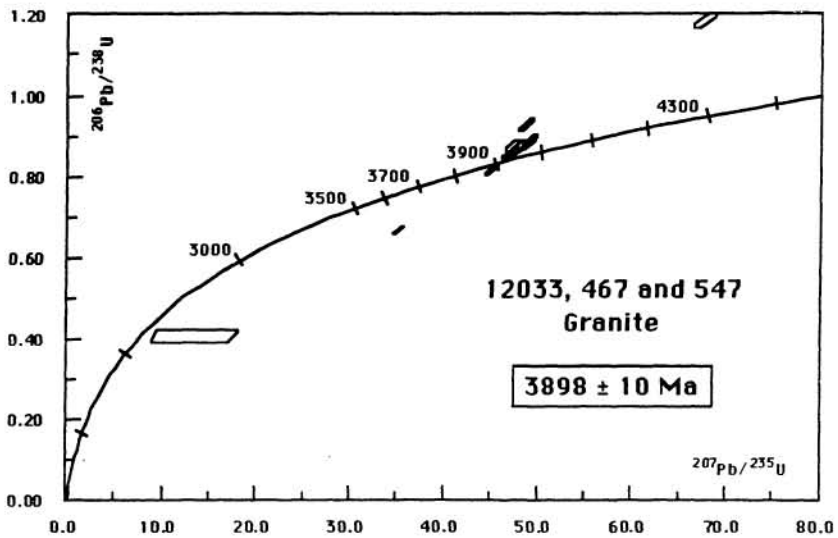
pyroxene and REE patterns characteristic of KREEP (14303, 15405), have relatively old ages [11]. Lunar granophyre thus formed over a wide range of lunar history (Fig. 2). "Young" lunar granophyre is not remelted or reset "old" granite, because both types of lunar granophyre have low ratios of initial Sr [7,10].

The U content of four zircons in two thin sections of 12033,507 range from 200 to 470 ppm. The central spot on one equant, euhedral zircon has 30% excess radiogenic Pb over U while an adjacent spot has 15% deficiency. One spot on an eroded microcrystalline zircon has lost about 60% of its radiogenic Pb (Fig. 3). Zircons in 12033 were strongly disturbed isotopically 760 +/- 200 Ma, in agreement with the "Age of the Crater Copernicus" (800 +/- 40 Ma) [15].

	$^{207}Pb/^{206}Pb$ Age (Ma +/- 1 sigma)		Reference
12033,507	3898 +- 10 (intercept)	granite	13
14066,47	4141 +- 5	mg alkali gabbronorite	2
14305,91	4211 +- 5	norite	2
14306,150	4245 +- 75 (disperse)	troctolite	2
14321,16	4028 +- 6	alkali anorthosite	2
14321,1027	3956 +- 21	graphic granite	2,10,12
67975,131	4339 +- 5	mg alkali gabbronorite	14
73217,52	4332 +- 3	needles in K glass	1
73235,60 A	4213 +- 5	granite	5
73235,60 B	4353 +- 4	individual zircon	5

Fig. 3



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