KREEP BASALT INTRUSION AGE: U-Th-Pb systematics of Imbrium consortium samples

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The Imbrium consortium samples 15405 and 15445 (J. A. Wood; Consortium leader) have been analyzed for U, Th, and Pb concentrations and Pb isotopic composition. A special analytical method which allows us to obtain isotopic data on a sub-nanogram Pb level has been developed and, hence, only sub-milligram sized samples were required for the U, Th, and Pb analyses of mineral separates and whole-rock samples of 15405 and 15445. Pb blanks ranged from 0.03 nanograms to 0.07 nanograms for a 100 microgram olivine sample to 1 milligram whole-rock samples.

A coarse-grained quartz-monzodiorite clast (sample no. 15405,88) separated from 15405 [1] (collected from a boulder at Station 6a, Apollo 15 mission) contains the highest U (17.39 ppm) and Th (85.81 ppm) concentrations of any lunar sample yet analyzed, including granitic breccia 12013 which contains 10.8 ppm U and 34.3 ppm Th in a lighter colored fraction [2]. On the other hand, the matrix (15405,59), a fine grained vesicular igneous-textured rock of KREEP basalt composition, contains 3.93 ppm U and 16.17 ppm Th which are typical for KREEP-rich basalts.

The quartz-monzodiorite clast contains 20.0 ppm Pb and is quite radiogenic (observed $^{206}Pb/^{204}Pb$ = 700), whereas the matrix contains 10.0 ppm Pb and is not as radiogenic (observed $^{206}Pb/^{204}Pb$ = 200). In view of the possibility of Pb contamination prior to analysis, as is discussed later, the actual $^{206}Pb/^{204}Pb$ ratios may be much higher.

The U-Pb data of 15405,59 and 88 are plotted on Wetherill's U-Pb evolution diagram in fig. 1. Shown for comparison are data from some Apollo 11, 12, and 15 basalts; granitic breccia 12013; breccia 15418 (Sta. 7, near Sta. 6a) and rock 12035.

A tie-line between the U-Pb data of 15405 intersects concordia at 4.2 b.y. and 1.9 b.y. (solid line, fig. 1). The 15405 data plot quite differently from most lunar samples yet analyzed, and appear not to fall on the "cataclysm" line (broken line, fig. 1) suggested by Tera and Wasserburg [3] even if significant pre-analysis Pb contamination in 15405,59 is considered. Although the matrix is considered to be of impact origin [1], the data are still different from those of impact-melt basalts 14310 and 14053. The lower intercept age of the tie-line in fig. 1 agrees with the "third event" age suggested from the U-Pb data of Apollo 14 soils [4]. The upper intercept probably does not have any strict age significance, although this age is close to the KREEP basalt age of ~4.3 b.y. obtained from a Rb-Sr whole-rock isochron [5]. It is unlikely that the KREEP basalts were extruded ~3.9 b.y. ago and the boulder containing 15405 was created at some later time [1], i.e. 1.9 b.y., but rather the KREEP basalts intruded the Imbrium Basin earlier than 4.1 b.y. ago.

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All Pb's in olivine and plagioclase-rich matrix separates and a whole-rock split of an olivine-spinel bearing white clast (15445,106) from sample 15445 are unusually non-radiogenic showing 20 - 24 in $^{206}Pb/^{204}Pb$ ratios. Pb concentrations in the olivine, matrix, and whole-rock samples of the clast are 17 ppm, 33 ppm, and 66 ppm, respectively, whilst U concentrations are 0.05 ppm, 0.25 ppm, and 0.16 ppm and Th concentration are 0.26 ppm, 1.18 ppm, and 0.88 ppm. The large amount of non-radiogenic Pb in these samples cannot be accounted for by our laboratory contamination but may be accounted for by contamination due to sample handling prior to our analysis.

A matrix sample of 15445 (15445,122) also has a high Pb concentration and a $^{206}Pb/^{204}Pb$ ratio of 27. The amount of pre-analysis contamination required to obtain $^{206}Pb/^{204}Pb$ ratios of <30 is very large, approximately 50 μgm/gram of sample. But if the data are real we cannot, as yet, account for the non-radiogenic Pb in these samples.

[1] Ryder, G., 1975, Preprint Series No. 376, Cent. Astrophys. Cambridge.
[2] Tatsumoto, M., 1970, E.P.S.L., 9, 193.
[3] Tera, F. and Wasserburg, G. J., 1972, E.P.S.L., 14, 281.
[4] Tatsumoto, M. et al., 1972, Proc. Lunar Sci. Conf. 3rd, 1531.
[5] Nyquist, L. E. et al., 1972, Proc. Lunar Sci. Conf. 3rd, 1515.

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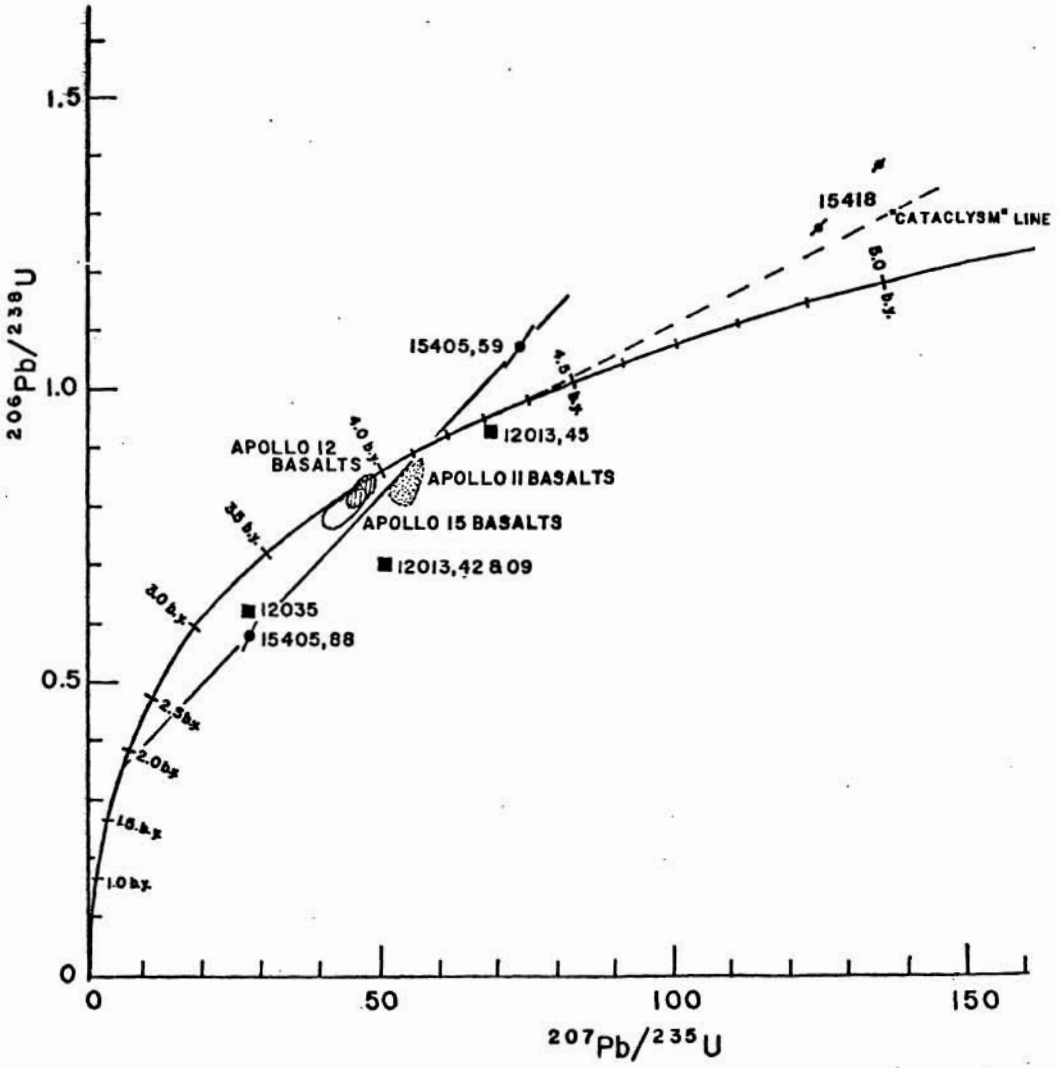

Fig. 1--U-Pb evolution diagram for samples 15405, 59 and 88. Shown for comparison are Apollo 11, 12 and 15 basalt fields; breccias 12013 and 15418 and rock 12035. The solid line is a tie-line between the 15405 samples and the broken line represents the "cataclysm" line.