CONSTRAINTS IMPOSED BY ^{87}Rb-^{87}Sr ON LUNAR PROCESSES AND ON THE COMPOSITION OF THE LUNAR MANTLE.

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Rb-Sr dating of Apollo 16 and 17 rocks has resulted in an age of 3.9 BY for the brecciated anorthosites and of 3.83 B.Y. for the basaltic igneous rocks. These ages were obtained from internal isochrons. The initial ($^{87}Sr/^{86}Sr$) ratio of the brecciated anorthosite is rather high, but some of plagioclase in those breccias have conserved a lower initial strontium isotope ratio. These observations may be interpreted as indicating an impact metamorphic event at 3.9 B.Y. ago.

The ($^{87}Sr/^{86}Sr$) initial ratio of the basalts is very low, one Apollo 17 basalt has even an initial strontium isotope ratio smaller than BABI. The total rock strontium isotopic composition of all anorthosites and norites from the lunar highlands fall on, or very close to, 4.5 ± 0.2 B.Y. isochron. The total rock strontium isotopic compositions of all lunar basalts, except the high K Apollo 11 basalts, plot also in this isochron, notwithstanding that these rocks have widely differing Rb/Sr ratios. A really trivial consequence of this observation is that lunar soils should, and indeed do, plot on or close to, this isochron. Isotopic reequilibration occuring after the 4.5 ± 0.2 B.Y. is responsible for the minor deviations shown by the lunar soil points on our isochron plot.
The fact that the total rock strontium isotopic compositions of nearly all lunar rocks fall on this isochron of 4.5 ± 0.2 BY implies that no Rb/Sr fractionation has occured since then. Accepting the petrological estimate that the lunar basalts are the result of a 15 to 25% partial fusion of the lunar mantle, one may draw one of the following conclusions :

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1) The internal isochron age is the solidification age, which occured quite soon after partial fusion of the lunar mantle. The basaltic liquid rose to the surface without being contaminated. No fractional crystallization giving rise to different liquids after partial fusion occured. In this case, the lunar mantle should contain less than 0.2% plagioclase in order to prevent Rb/Sr fractionation and according to the Apollo 12 and 17 basalts, the lunar mantle should be heterogeneous. Further, one will have some problems in interpreting the initial ($^{87}Sr/^{86}Sr$) ratio as has been pointed out by Wasserburg ( ).

2) Same as point (1), but during their ascent to the surface, the basaltic liquids were contaminated (Tera et al). To preserve the 4.5 ± 0.2 B.Y. age, no Rb/Sr fractionation should occur subsequently. If this interpretation is correct, one should observe a linear mixing relationship for the samples of the same site. Except for the Apollo 14 basalts, no mixing relationships have been observed for the samples of the same site.

3) Partial melting and genesis of the basalts took place at 4.5 ± 0.2 B.Y. The internal isochron ages give the age of remelting and solidification. The remelting is presumably due to an external event such as for example a meteorite impact. This interpretation would mean a very much simpler thermal history than is suggested by points (1) and (2). The Rb-Sr internal isochrons for the basaltic achondrites indicate also the possibility of producing basalt during the early differentiation of a planet.

(1) WASSERBURG G.J. and PAPANASTASSIOU D.A. (1971) E.P.S.L. 13 97.

(2) TERA , EUGSTER, BURNETT, WASSERBURG (1970) Apollo 11 Lunar Sciences Conf. Geoch. Cosmch. Acta Vol.1 Pergamon Press.