

ESTIMATES OF P, Cl, Br AND I IN PRIMORDIAL PLANETARY BODIES. R.A. Schmitt, Dept. of Chemistry and The Radiation Center, Oregon State University, Corvallis, OR 97331

P in the primordial moon: From simple partial melting (p.m.) calculations, the approximate primordial P may be obtained if it is assumed that P behaves as a trace element similar to LIL trace elements like La. Since the ratio of La(high K KREEP)/La(avg. low K mare basalts) ~ 16 is close to the P (high K KREEP)/P(avg. low K mare basalts) ~ 9 , the above assumption is partially justified. The differences in ratios may reflect expected divergences in their relative \bar{D} values as fractional crystallization presumably proceeded to form the cumulates from which the mare basalts were later derived by p.m. and the presumed late stage cumulates from which KREEP was generated later by p.m. events. Also, some terrestrial studies (1) support this assumption. The avg. P in low K mare basalts is ~ 370 ppm or 0.34X chondrites. Assuming 20% p.m. of cumulates that were laid down after $\sim 90\%$ fractional crystallization from a lunar oceanic magma (which satisfies the La data for a similar oceanic magma and the cumulate hypothesis for a starting La of ~ 3 X in a primordial moon and ~ 15 - 18 X in the Apollo 12, 15 and 17 low K mare basalts) and assuming $\bar{D}_p(s/l) \sim 0.02$ (an estimate by F. Anderson to G.W. Reed), it is calculated that a P of ~ 0.4 X was present in the primordial moon which agrees with the P estimate of 0.5X chondrites by Ganapathy and Anders (2).

P in the primordial earth: Performing similar p.m. calculations after Gast (3) for the generation of alkali and MOR basalts, and using the avg. P values of ~ 2000 ppm and ~ 660 ppm in alkali and MOR basalts, respectively, it is found that a \bar{D}_p is ~ 0.1 and that ~ 250 ppm P or 0.23X chondrites satisfy the model. Such a "high" $\bar{D}_p \sim 0.1$ suggests a $\bar{D}_p(\text{garnet/liq}) \sim 0.3$ which is not too unreasonable in view of the large amounts (4%) of P_2O_5 observed (4) in some garnets. Since the estimated P content of ~ 0.23 X in the earth's mantle is considerable less than the estimated (2) P of ~ 2 X in the primordial earth, a large fraction of P must reside in the earth's metallic core since an appreciable degree of fractional crystallization of garnet with $\bar{D}_p \sim 0.3$ or slightly higher will only result in P enrichment in the crust. To reduce \bar{D}_p appreciably in the upper mantle via garnet crystallization would require $\bar{D}_p > 1$, provided little P were present in the core.

P in the EPB (eucrite parent body): From the observed avg. P in eucrites of ~ 400 ppm and an assumed avg. 10% p.m. of primordial EPB matter for the generation of eucrites, which satisfies the REE data, ~ 40 ppm P (~ 0.04 X chondrites) is estimated in the silicate source matter. This suggests that P has been severely depleted in the silicate fraction relative to chondrites and in turn, suggests an appreciable fraction of P resides in the metallic core of an EPB. This supports the hypothesis that the source material for the eucrites has been fractionated. Assuming a starting matter with P ~ 1 X, which melts and fractionates iron metal (13% as suggested by (5)) and which brings along P as phosphides and leaves P (0.04X) in the residual silicate phase, a $\bar{D}_p(\text{metal/liq})$ of ~ 24 and a P content of ~ 7 X in the metallic phase are obtained. Such a P content is consistent with the P content of ~ 9 - 2 X chondrites observed in iron meteorites.

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Cl, Br and I in the primordial moon: Assuming that the halogens have $\bar{D}(s/l) \sim 0.01$ and performing the same 20% p.m. exercise for the generation of the mare basalts from cumulates, which were derived after $\sim 90\%$ fractional crystallization of a lunar oceanic magma, the halogen contents were estimated for the primordial moon. In these calculations, the following selected halogen data for low K mare basalts from (6) were used: $Cl_r \sim 3$ ppm in Apollo 12 and 15 basalts; avg. $Br_{l+r} \sim 24$ ppb in Apollo 12, 15 and 17 basalts; and avg. $I \sim 0.06$ ppb in Apollo 15 and 17 basalts.

	<u>Estimates in Primordial Moon</u>	<u>G. & A. estimate (2)</u>
Cl	0.027X chondrites	0.0027X chondrites
Br	0.009X	0.0006X
I	0.0023X	0.0008X

If $\bar{D}_{Cl}(s/l) \sim 0.1$, $\bar{D}_{Br} \sim 0.14$ and $\bar{D}_I \sim 0.03$, the estimates by (2) are supported. However, in view of the large ionic radii for the halogen ions and the required charge compensation for balancing univalent negative ions, it seems unreasonable to expect such large D values of ~ 0.1 or even 0.03. If appreciable halogen loss has occurred via volatilization from mare flows, then our estimates are too low.

As indicated by Anders (7), these halogen calculations have questioned the oversimplification of their model (2); namely, that highly volatile elements such as the halogens are accreted by the moon as a late stage veneer and that these elements are wholly absent in the "unremelted silicate." As further indicated by Anders (7), dropping the condensate temperature to 460-500°K might provide an enhancement of some volatiles in the primordial moon.

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