

COMPOSITION OF THE MOON AND MAJOR LUNAR DIFFERENTIATION PROCESSES

H. Wänke, H. Palme, H. Baddenhausen, G. Dreibus, E. Jagoutz, H. Kruse, B. Spettel and F. Teschke, Max-Planck-Institut für Chemie, Mainz, Germany

New data from our multielement analysis program (58 elements including all major and minor elements) on 18 samples of Apollo 16 and 17 confirm the element correlations observed previously^{1,2,3}). The two component model¹) for the bulk composition of the moon, as it was presented by us last year is based on the K/La ratio (Fig. 1). In this model the Chondritic Component (ChC) was not very well defined. As it was emphasized by Anders⁴) volatile elements like Mn, Na, K and to some extent also S and other elements are always observed in constant abundance ratios in chondrites, but with different depletion factors relative to the Fe, Mg-silicates. The volatile fraction of the chondritic component can be estimated from the FeO/MnO correlation (Fig. 2). An appropriate amount of FeS (assuming a C 1-chondritic Mn/S-ratio) has been added to the oxidized Fe to get the total iron content of the moon (10,4 %). Because of the low density of the moon the content of metallic iron must be close to zero. In this way a refined two component model is set up in which the ChC seems now better defined. The new calculations yield a somewhat lower value for the High Temperature Component (HTC, 60 % as compared to 69 % in the previous model). The calculated bulk composition of the moon has also slightly changed (Table 1).

The K/La correlation holds for the large concentration range observed for these two LIL-elements. The Na/Eu ratio covers the same two groups of elements, but the observed concentrations vary within a much smaller range. Nevertheless, the point for our model moon falls well within the field of the observed ratios (Fig. 3). As already observed by Laul et al.³) also Fe and Sc are at least weakly correlated (Fig. 4). However in this case our model moon is far off the observed concentrations and ratios. This seems to indicate a somewhat inhomogeneous accumulated moon with a higher concentration of HTC material towards the center. This conclusion is supported by similar considerations involving the refractory element vanadium (observed concentrations below our calculated value) and the element chromium belonging to the ChC (observed concentrations above the calculated value). The refractory siderophile elements highly enriched in the HTC (Ir, Re, Os) would also be preferentially concentrated in the interior of the moon and e.g. the chondritic Re/Ni ratio in lunar basalts⁵) is not in contradiction with a high fraction of HTC in the moon.

If the HTC fraction increases towards the center of the moon the heavier chondritic component must be enriched in layers beneath the crust. Hence,

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the low density crust would be compensated in order to satisfy the constraint given by the moment of inertia.

The high enrichment of U and Th in a lunar interior consisting of nearly 100 % HTC together with its high accretion temperature ($>1200^{\circ}\text{K}$) would produce the first partial melt in roughly 100 m.y. Uranium, Th and the other LIL-elements would concentrate in this melt and thus brought to the surface. The relative constancy of the LIL-element patterns in the two major lunar rock types (KREEP-basalts and gabbroic anorthosites) is assumed to reflect the fractionation due to the first partial melt. In a subsequent partial melting process mare basalts with different LIL-element patterns are produced. Fig. 5 shows the La/Hf ratio which is varying in mare basalts but constant in KREEP-basalts and gabbroic anorthosites. One can use the first (KREEP) fractionation pattern to calculate effective distribution coefficients for these elements, which are in turn used to calculate the LIL-element patterns in the partial melts producing the mare basalts. Fig. 6 and 7 show the results of such calculations for the rock 10044.

- 1) Wänke, H. et al.: Proc. IV Lunar Science Conf., Vol. 2, 1461-1481 (1973).
- 2) Duncan, A. R. et al.: *ibid.* 1097-1113.
- 3) Laul, J. C. and R. A. Schmitt: *ibid.* 1349-1367.
- 4) Anders, E.: Annual Rev. Astron. Astrophys., Vol. 9, 1-34 (1971).
- 5) Anders, E. et al.: Proc. II Lunar Science Conf., Vol. 2, 1021-1036 (1971).

Table 1:

MgO	15,4%	TiO ₂	1,0%	Na	2200ppm	Sc	71ppm	Eu	0,71ppm	W	1,2ppm
Al ₂ O ₃	20,2%	FeO	7,8%	K	220ppm	V	400ppm	Zr	58ppm	Ni	5600ppm
SiO ₂	30,4%	FeS	6,9%	Rb	0,86ppm	Sr	83ppm	Hf	2,1 ppm	Au	0,08ppm
CaO	15,9%			Mn	780ppm	La	3,0ppm	U	0,077ppm	Ir	5,6 ppm

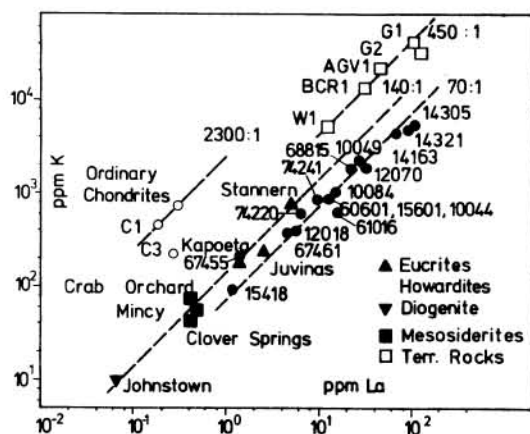


Fig. 1

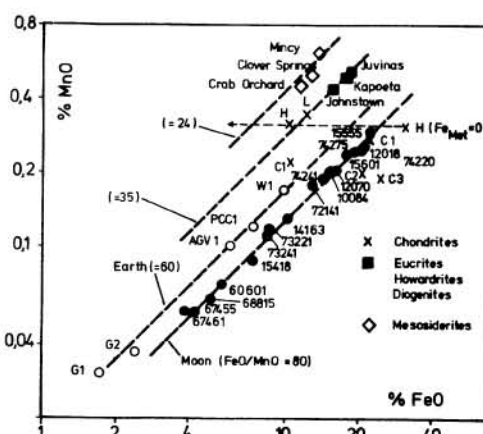


Fig. 2

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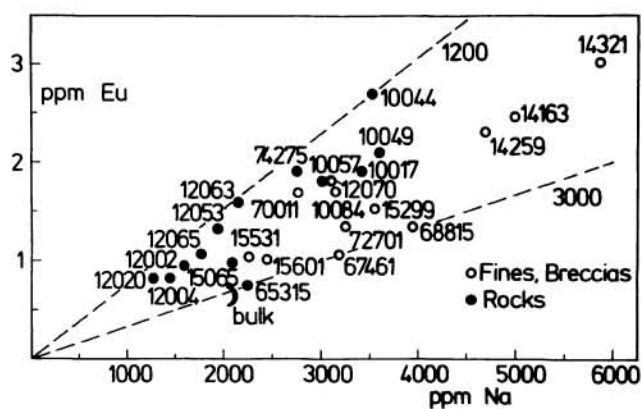


Fig. 3

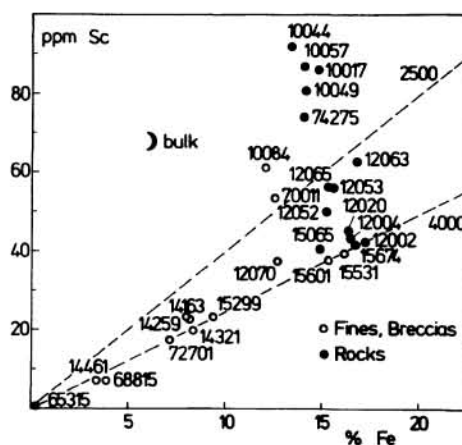


Fig. 4

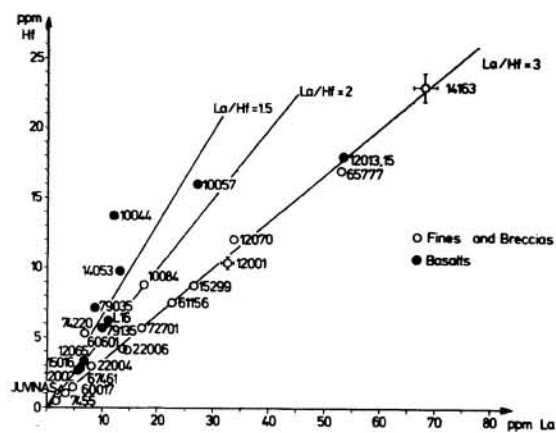


Fig. 5

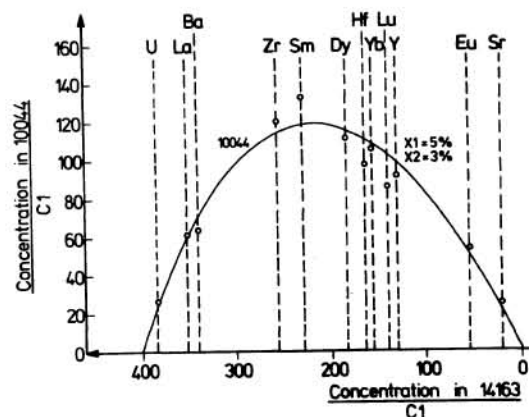


Fig. 6

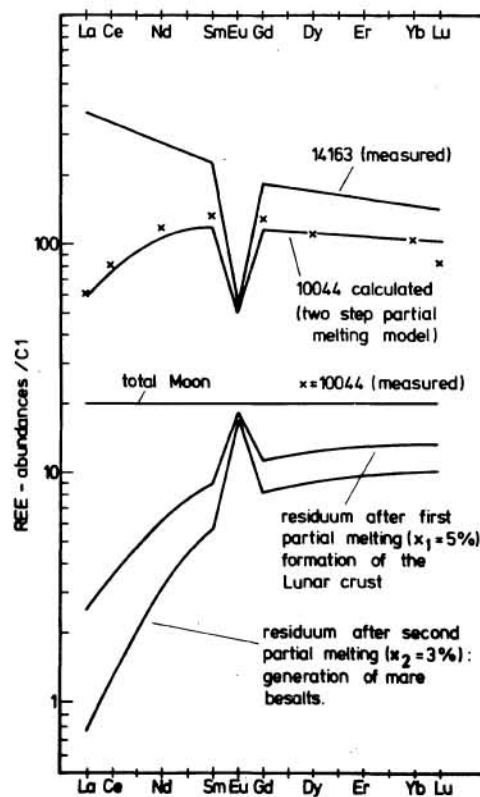


Fig. 7

 x_1, x_2 fraction of partial melting