THE MARE BASALT MAGMA SOURCE REGION AND MARE BASALT MAGMA GENESIS.

A.B. Binder, Institut für Mineralogie, Universität Münster, 4400 Münster, West Germany.

Analysis of major oxide, siderophile, and incompatible element data on the suite of mare basalt materials has led to the following comprehensive model of the mare basalt magma source region (MBMSR) and of mare basalt magma genesis:

1) The MBMSR lies between the crust-mantle boundary and a maximum depth of 200 km. The MBMSR consists of a relatively uniform peridotite containing 75-80% Ol (1). The shallow depth of- and the Ol dominated nature of the MBMSR is demonstrated by the fact that the members of the individual groups of pyroclastic glass magmas, which are thought to have been pristine partial melts of the MBMSR (1,2), lie along olivine control lines in the pseudo-quaternary phase diagrams (Fig. 1) and in other compositional plots. As discussed earlier (1,3), this Ol control of the magma compositions yields direct information about the depth and composition of the MBMSR.

2) The MBMSR consists of 2 or more density-graded rhythmic bands whose compositional variations, as determined following the discussion of Binder (1), are given in Table 1. The presence of 2 or more rhythmic bands in the MBMSR is deduced from the data of Delano and Livi (2) who show that the pyroclastic glass units fall into 2 distinct arrays, each of which consists of very low TiO_2 (VLT), low TiO_2 (LT), high TiO_2 (HT), and possibly very high TiO_2 (VHT) units. These density-graded bands are proposed to have formed as co-crystallizing Ol, Py, Pl, Ilm, and Chr settled out of a convecting magma (which was also parental to the crust) in which these crystals were suspended. Since the settling rates were governed by Stoke's law, the heavier minerals settled out more rapidly and therefore earlier than the lighter minerals. Thus the crystal assemblages deposited nearest the decending side of each convection cell were enriched in heavy (4.6 to 4.7 g/cm^3) Ilm and Chr with respect to lighter (3.4 to 3.5 g/cm^3) Ol and Py and very much lighter (2.7 g/cm^3) Pl. The reverse being the case for those units deposited near the ascending sides of the convection cells, Fig. 2. Thus each rhythmic band is density-graded horizontally and continuously from a VHT magma source region mineral assemblage to that of a VLT magma, as given in Table 1.

3) During the mare basalt epoch radiogenic induced remelting of various parts of the density-graded bands led to the formation of the initial magmas. As proposed earlier (1), the viscosity of the melting system appears to have limited the degree of partial melting which formed the magmas to 30±5%.

4) These ≈30% partial melts rose to the crust-mantle boundary where they pooled in magma storage chambers, Fig. 3 (1). The magmas remained in such chambers for different lengths of time, cooled to different degrees, and lost 0-30% Ol or 30% Ol plus 0-30% Py by fractional crystallization. Those magmas which remained in the chambers for very short times and lost no, or essentially no Ol before eruption were the parental magmas of the pyroclastic units. The magmas which lost significant amounts of Ol±Py were the parental magmas of basalts like the Apollo 11 and 17 HT-, the Apollo 12 and 15 LT-, and the Luna 16 and 24 basalts. As shown earlier (1), this fractional crystallization phase in the genesis of the magmas explains both the pattern of mare basalt magmas in the pseudo-quaternary phase diagrams (1,3) and the decrease in the siderophile element contents of the magmas as a function of their degree of fractionation.

5) The magma storage chambers, being located at the crust-mantle boundary, were located in the zone where urKREEP (4) formed during the initial differentiation of the moon, Fig. 3 (5). Due to the low melting point of KREEP compared to the initially high temperatures of the magmas, remanence of the

urKREEP layer or residual materials of the urKREEP layer (which underwent varying degrees of fractional melting early in lunar history) which formed part of the wall rocks of the magma chambers melted and mixed into the magmas. As model calculations show (e.g., Fig. 4) the mixing of up to 10% of urKREEP or the residuals of urKREEP into the magmas explains a) the wide variations in the absolute amounts of the incompatible elements in the mare basalt units, b) the various distribution patterns of the incompatible elements in the units, and c) the differences in the magnitude of the Eu anomaly in the units.

REFERENCES: (1) Binder A.B. (1980) Proc. Lunar Planet. Sci. Conf. 11th, p. 1-22. (2) Delano J.W. and Livi K. (1981) Geochim. Cosmochim. Acta, in press. (3) Binder A.B. (1976) Moon, 16, p. 115-150. (4) Warren P.H. and Wasson J.T. (1979) Rev. Geophys. Space Phys., 17, p. 73-88. (5) Binder A.B. (1974) Moon, 11, p. 53-76.

Table 1

	Array I				Array II		
	VLT	LT	HT	VHT	VLT	LT	HT
Pl	6.1	5.7	5.0	4.1	8.0	7.3	6.1
Py	13.4	11.8	12.6	12.5	13.7	12.6	11.3
Ol	79.2	79.9	76.3	72.6	77.1	76.5	73.7
Ilm	0.2	1.2	5.7	9.4	0.3	2.0	7.5
Chr	1.1	1.2	1.4	1.6	1.0	1.2	1.4

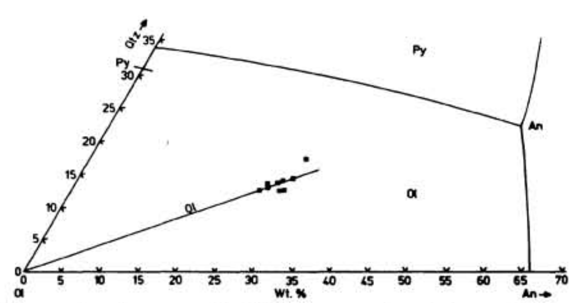

Fig. 1. Array I VLT pyroclastic glass units in the phase diagram for Qtz-An-Ol-Aug. Shown are the projections of the points onto the Qtz-An-Ol side of the tetrahedron.

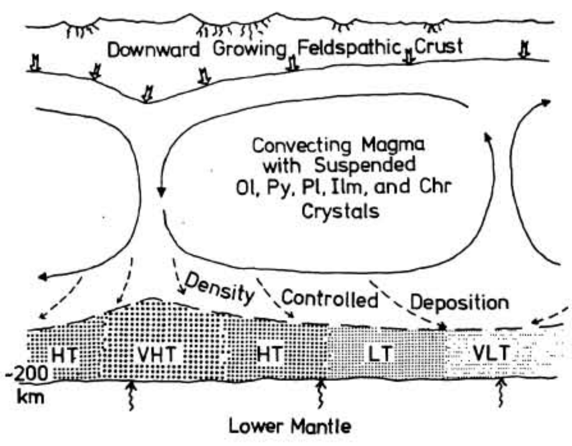

Fig. 2. Formation of the density-graded rhythmic bands of the MBMSR.

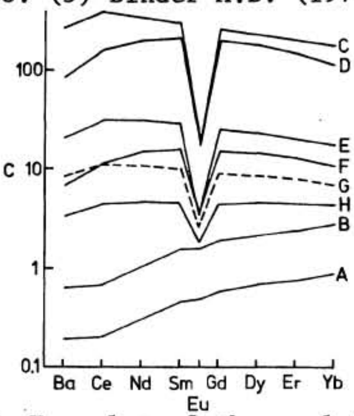

Fig. 4. Examples of the evolution of the Ba-REE concentrations (in arbitrary units) in the magmas. A-B, computed concentrations in the MBMSR and 30% partial melts. C-D, computed concentrations in urKREEP and 86% urKREEP residuals. E-H, concentrations produced by mixing 1-10% of C or D into B.

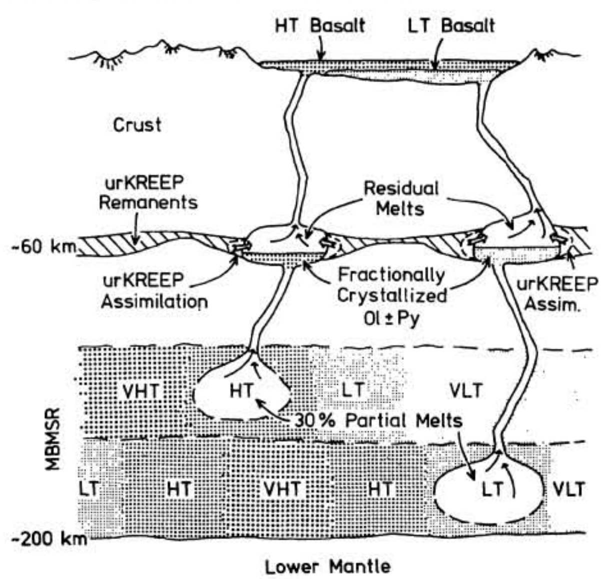

Fig. 3. Development of the mare basalt magmas.