PARENT MAGMAS OF SNC HARZBURGITES: PHASE EQUILIBRIA MODELING

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The clan of SNC meteorites includes two igneous harzburgites - ALHA77005 and LEW88516, both having similar textures and mineralogy [1,2]. A distinctive feature of these rocks is the presence of large (up to few mm) low-Ca pyroxene oikocrysts (hereafter *Opx*) enclosing olivine (*Ol*) and chromite (*Chr*). Mineral assemblage in non-poikilitic areas is represented by maskelynite, *Ol, Opx*, high-Ca pyroxenes (*Aug*), *Chr*, ilmenite, and minor phosphates (±sulfides). *Ol* in ALH is almost uniform in composition (Fo_{70-73}) [2-4], whereas olivines in LEW are more iron-rich ranging from Fo_{64} to Fo_{70} [1,4]. Pyroxene compositions display similar relations. Based on the textural and mineralogical data, the SNC harzburgites have been interpreted to be igneous cumulates solidified from primary magma mixtures of cumulus crystals (*Ol*+*Chr*±*Opx*) with intercumulus liquid [2,4]. Despite some doubts that the intercumulus minerals were crystallized as a closed system [5], few attempts have been done to estimate the parent magma compositions (***PMC***) for ALH using its bulk rock and mineral compositions [2,5], as well for LEW using the components from magmatic inclusions [1]. These attempts, however, did not result in an unambiguous solution, mainly because of the lack of constraints following from phase equilibria. Knowledge of the phase equilibria for the natural cumulates could allow one to estimate more correctly the range of trapped liquid compositions, and finally to make it narrower the range of parent magmas to be searched.

Calculating phase equilibria for SNC harzburgites. To accomplish the goal, we used the METEOMOD program designed for the calculations of melting-crystallization relationships in iron-rich meteoritic igneous systems [6]. The basic block of METEOMOD is a set of empirically calibrated equations, which describe equilibria between silicate melt and minerals such as *Ol*, *Opx, Aug,* and *Pl* in terms of temperature, f_{O2}, and liquid compositions. The program calculates crystallization sequences step by step, as the total amount of crystals is increased. The accuracy of the calculations for temperature is of ±10-15°C, with the contents of major end-members in the minerals calculated within ±1-2 mol% [6].

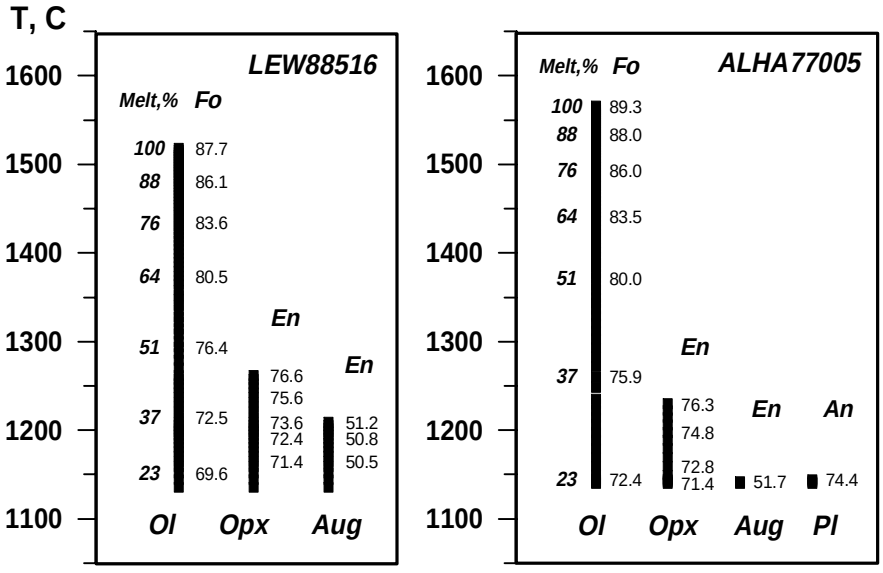

Fig.1. Modeled crystallization sequences

Using METEOMOD we calculated the course of equilibrium crystallization for 2 melts corresponding to the bulk compositions of ALH [2] and LEW [4]. These calculations were carried out at 1 atm, with the crystal increment of 1%, at *WM* buffer, and in the range of melting $100<F<20$ wt%. Results of the modeling are shown in Fig.1. Compositions for some of the residual melts are listed in the Table.

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These compositions can be used to estimate the ***PMC*** for ALH and LEW, if average compositions of their cumulus minerals were similar to those which should be in equilibrium with the trapped melt. The main problem of accurate defining the ***PMC*** along the calculated liquid lines of descent is the search for additional constraints following from primary cumulus mineral-melt equilibria.

These constraints may include proportions or/and compositions of initial cumulus minerals.

The first method, based on the modal mineralogy analysis, results in too large differences between the estimated *Ol* proportion for ALH (45.8 wt% [2,5] and 60.2% [4]). The problem of mafic mineral reequilibration during a post-cumulus process was also widely discussed in the literature. An alternative approach includes the use of chromite core compositions.

Table. Calculated mineral-melt compositions and phase proportions in terms of the temperature

Component, wt%	*LEW88516 (bulk)*		*ALHA77005 (bulk)*		
	1135.6°C	**1226.2°C**	**1140.3°C**	**1229.6°C**	**1336.5 °C**
SiO_2	50.45	51.03	50.16	51.53	47.66
TiO_2	1.07	0.67	1.94	1.30	0.99
Al_2O_3	12.68	7.35	12.88	9.33	6.98
FeO	14.17	17.99	13.10	16.32	21.10
MnO	0.36	0.47	0.34	0.43	0.53
MgO	5.93	9.33	6.32	9.19	13.51
CaO	10.58	10.60	10.97	9.14	7.16
Na_2O	2.28	1.23	2.15	1.43	1.07
K_2O	0.14	0.08	0.19	0.12	0.09
P_2O_5	2.33	1.25	1.96	1.22	0.91
Total	100.0	100.0	100.0	100.0	100.0
Mg/(Mg+Fe)	*0.427*	*0.480*	*0.462*	*0.501*	*0.533*
Ca/(Ca+Al)	*0.431*	*0.567*	*0.436*	*0.471*	*0.483*
Calculated proportions of melts and minerals, wt%					
Melt	21.0	39.1	21.2	34.1	45.5
Ol	54.4	53.9	64.6	65.6	54.5
Opx	15.4	7.0	12.1	0.3	-
Aug	9.2	-	0.9	-	-
Pl	-	-	1.1	-	-
Calculated mineral compositions, mol%					
Fo *(Ol)*	69.1	73.0	72.2	74.8	78.5
En-Wo *(Opx)*	69.3-6.6	74.8-3.5	71.4-6.7	76.3-3.1	-
En-Wo *(Aug)*	50.4-33.5	-	51.7-34.3	-	-
An *(Pl)*	-	-	74	-	-

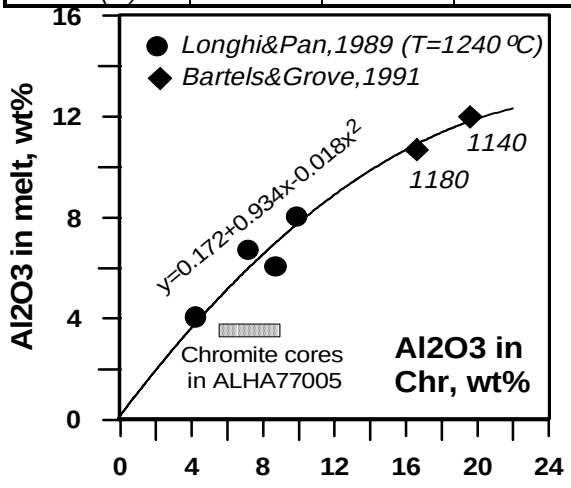

Fig. 2. Experimental Chromite and Glass compositions

Constraints from spinel compositions.

The chromite cores in SNC harzburgites were found to contain small amounts of Al_2O_3, mostly in the range of 6-9 wt.% [3,4,8]. Experimental data obtained in eucrite/SNC igneous systems indicate that such spinels could be crystallized only from the melts containing no more than 8 wt% Al_2O_3 [7,8]. In fact, there is a strong dependence between the observed spinel and experimental glass compositions (Fig. 2), which could be used to predict alumina content in the trapped melt (***PMC***?), if an average composition of chromite cores is known. For example, if the Chr cores in ALH contain in average of about 7.5% Al_2O_3, one can estimate the alumina content in its trapped melt to be of 7 wt.%. Such a melt corresponds to the temperature of 1340°C (see Table). More detail studies of Chr chemistry are necessary to estimate the ***PMC*** for LEW.

References. [1] Harvey et al. (1993) *GCA* 57, 4769-4783. [2] Lundberg et al. (1990) *GCA* 54, 2535-2547. [3] Ikeda Y. (1994) *Proc. NIPR Symp. Antarct. Meteorites* 7, 9-29. [4] Treiman et al. (1994) *Meteoritics* 29, 581-592. [5] McSween et al. (1988) *LPSC* 19, 766-767. [6] Ariskin et al. (1997) *Meteoritics and Planet. Sci.* 32 (in press). [7] Longhi J., Pan V. (1989) *PLPSC* 19, 451-464. [8] Bartels&Grove (1991) *PLPSC* 21, 351-365.