

NUMERICAL MODEL OF A GENETIC LINK BETWEEN ACAPULCO AND Y791493 PRIMITIVE ACHONDRITES. I: PHASE EQUILIBRIA AND MAJOR ELEMENT CONSTRAINTS

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Abstract. The Y791493 lodranite can have been produced by partial melting of Acapulco precursor material, followed by removal of ~85% of the liquid (formed by ~6% melting of the precursor) and addition of ~3 wt.% metal. The residuum may then have been further heated and melted to produce 7-10% interstitial liquid, which crystallized *in situ* without further loss.

The acapulcoite-lodranite group of meteorites appear to have been formed in the same parent body [1], which experienced a range of degrees of partial melting. Acapulcoites represent precursor material, and lodranites are residua after partial melting [e.g., 1,2]. To quantify this process, we numerically modeled the relationship between the two members of this group that have been best characterized chemically and mineralogically: Acapulco itself [4], and the lodranite Y791493 [5]. The Meteorite Melting Model computer program of [3] was used to calculate the relationship.

Since Acapulco was assumed to be the precursor material in the system modeled, a series of 1-atm equilibrium melting calculations were carried out for degrees of melting >5 mol.%, at 0.5 mol.% increments, and for values of fO_2 between 1.5 to 2.5 log units below the iron-wüstite (IW) buffer, to estimate the equilibrium fO_2 value in the system. The bulk metal content of Acapulco and the Fo content of its olivine (Table 1, column ACA) were found to agree best with the model at $\log(fO_2) = IW-2.4$. The sequence of mineral assemblages left in the residue as melting proceeds was found to be: Ol+Met+Opx+Pl±Cpx (T=1122°C; 6.1 wt.% melt) → Ol+Met+Opx (T=1140°C; 8.1% melt) → Ol+Met (T=1346°C; 22.6% melt) → Met (T=1686°C; 88.8% melt).

The simplest way to produce a lodranite from an acapulcoite would be to completely segregate partial melt from a residue. We found that the removal of 6.1 wt.% of Al,Na-rich partial melt formed at 1122°C (Table 1, column M_{part}) leaves a residue whose bulk chemistry and mineralogy (Table 1, column R_{part}) are both quite similar to those of the Y791493 lodranite (Table 1, column Y93), except that the latter is depleted in Al and Na compared to the model residue. The discrepancy in these elements could be reconciled if a small amount of the partial melt (~15% of the melt) was retained within the residue. The composition of the crystal-melt mixture left as a residue (Table 1, column R_{cont}) is close to that of Y791493 lodranite (Table 1, column Y93), with the model residuum showing a minor depletion in Fe and enrichment in SiO_2 . A final adjustment between the compositions of 'model lodranite' (to produce column $mLod$, Table 1) and Y791493 lodranite could be made by assuming the addition of ~3 wt.% metal (recalculated to 3.5 wt.% FeO) to the crystal-melt mixture R_{cont} .

While bulk mineralogies of the 'model lodranite' and Y791493 are in very good agreement with one other, additional melting of the 'model lodranite' at temperatures above 1122°C seems to be required in order to reproduce the compositions of Y791493 Ol and Opx. The degree of further partial melting required depends upon the criterion chosen to estimate it. Such a criterion should take into consideration the strong relationship between total metal content, compositions of silicates and the melting degree. Our calculations have revealed the Fe/Mn ratio in olivine seems to be the most sensitive indicator to monitor variations of the parameters listed above. This ratio is found to increase from 15.1 to 41.0 as melting degree increases from 5 wt.% to 85.6%, when olivine dissolves. If the Fe/Mn ratio of mean Y791493 olivine is the criterion (Table 1), then the final phase assemblage in the 'model lodranite' source region (Table 1, column R_{mLod}) before it starts to cool should contain ~10 wt.% melt (Table 1, column M_{mLod}) and slightly more Ol and less Opx

than is now in Y791493. If the modal abundance or $Mg/(Mg+Fe)$ of Y791493 orthopyroxene are used to estimate the final degree of melting in the 'model lodranite' source region, this could vary from ~1 wt.% (no additional melting compared to $mLod$ phase composition) to ~7 %. The effect of crystallization of this melt, retained in the source region as an interstitial liquid, would be to decrease Ol content by ~2 wt.% and add ~4.5% Opx, 3.5% Cpx, and 3% Pl to the mineral assemblage R_{mLod} , improving the agreement in mineralogical composition between the model and Y791493. For this reason, Fe/Mn in olivine seems the preferable criterion to use in modelling.

References: [1] McCoy T.J. et al. (1993) *LPSC XXIV*, 945. [2] Takeda H. et al. (1992) *Proc. Japan Acad. Sci.* **68B**, 115. [3] Ariskin A.A. and Petaev M.I. (1994) *this volume*. [4] Palme H. et al. (1981) *GCA* **45**, 727. [5] Nagahara H. and Ozawa K. (1986) *Mem. Natl. Inst. Polar Res.* **41**, 181.

Table 1. Chemical, mineral and phase compositions of primitive achondrites and modeled melting products (normalized to 100 wt.%)

Comp	Acapulco	Equilibrium melting			'Model'	Equilibrium melting		Y791493
	bulk [4]	of <i>ACA</i> at 1122°C			lodranite	of <i>mLod</i> at 1340°C		bulk [5]
	<i>ACA</i> [§]	<i>M_{part}</i> [#]	<i>R_{part}</i> [#]	<i>R_{cont}</i> [#]	<i>mLod</i>	<i>M_{mLod}</i>	<i>R_{mLod}</i>	<i>Y93</i> [§]
SiO ₂	38.58	48.48	37.93	38.03	36.75	60.81	34.02	35.94
TiO ₂	0.07	0.71	0.03	0.03	0.03	0.21	0.01	0.05
Al ₂ O ₃	2.11	24.37	0.66	0.89	0.86	7.52	0.10	0.93
FeO*	26.33	2.75	28.07	27.83	30.27	8.22	32.77	30.43
MnO	0.40	0.18	0.41	0.41	0.40	0.42	0.40	0.43
MgO	29.46	3.68	31.13	31.13	29.83	9.59	32.13	30.41
CaO	1.98	7.31	1.63	1.63	1.63	10.96	0.57	1.58
Na ₂ O	0.88	12.52	0.12	0.12	0.23	2.26	>0.01	0.22
Phase Assemblages								
Melt, wt.%		6.1		~1	~1	10.2		
Ol, wt.%	25.6		38.5	40.6	39.3		46.8	40-42
<i>Fo</i>	88.1		87.9	87.9	87.9		87.8	87-91
<i>Fe/Mn</i>	19.6		16.6	16.6	16.6		20.2	20.4
Opx, wt.%	35.8		33.3	35.1	34		20.3	34-37
<i>En</i>	86.2		84.5	84.5	84.5		84.3	85-86
Pl, wt.%	9.4		1.5	1.6	1.5			1-5
Met, wt.%	19.1		20.6	21.7	24.1		22.7	17-22

[§] Mineral modes and chemical compositions are recalculated on a chromite, troilite and phosphate-free basis

[#] *R* and *M* denote Residues and partial Melt compositions (for subscripts see text) : $R_{cont} = R_{part} + 0.92\% M_{part}$;

$mLod = R_{cont} + 3 \text{ wt.}\% \text{ Fe}^\circ$

*All Fe as FeO