DEVOLATILIZED-ALLENDE PARTIAL MELTS AS AN ANALOG FOR PRIMITIVE ANGRITE MAGMAS. A. J. G. Jurewicz[1] , J. H. Jones[2], D. W. Mittlefehldt[2], and J. Longhi[3], [1]JPL, m/s 183-800A, 4800 Oak Grove Dr., Pasadena CA 91108, (Amy.J.Jurewicz@jpl.nasa.gov), [2]SR, NASA/JSC, Houston TX 77058 [3]LDEO, Palisades NY 10964.

Introduction: We have shown that partial melts of devolatilized Allende chondrite (CV3) have bulk compositions generally similar to those of angrites [1]. Here we show that the recently described D'Orbigny and Sahara 99555 angrites [2] are virtually identical in major-element composition to specific Allende experimental melts from [1]. This observation has petrogenetic significance for the origins of the angrite clan.

Angrites – Provenance and General Phase Equilibria: Angrites are critically-silica-undersaturated basalts with unusual mineralogy - Ca-rich olivine, kirschsteinite, fassaitic pyroxene and Na-free plagioclase. Some are vesicular and so clearly came from low pressure environments, presumably near the surfaces of small bodies. They are ancient rocks that have experienced no brecciation and little thermal metamorphism, so their petrogenesis may shed light on environmental conditions, parental materials, and processes that occurred very early in the history of the solar system.

The Sr-isotopic evolution diagram for several angrites suggests a CV-like parent body [3]. It has been shown experimentally [1] that angritic melts can be produced from devolatilized CV chondrites (Allende was used). Angritic melts were produced when Allende was partially melted at one bar total pressure under oxygen fugacities greater than the iron-wüstite (IW) buffer, when most of the Fe in the rock was oxidized. Not all chondrites produced silica undersaturated melts under these conditions [4], so partial-melting experiments constrained the angrite parent body composition to a subset of bulk compositions that included CV-like materials. But, although the partial melts of Allende had angrite-like characteristics, they did not precisely match any known angrite [1].

Longhi [5] produced a phase diagram for angrite petrogenesis by estimating liquidus boundaries and mineral solid solutions in the CMAS+Fe system. He calculated phase equilibria for different FeO contents (through oxidation/reduction at constant total Fe content) for melts of CM (Murchison) and CV (Allende) chondrites, and inferred that the compositions of angrites known at that time could not be matched by melting these chondrites, or through fractional crystallization of primitive melts, unless an additional high-temperature (CAI) component was added.

Since [5], two new angrites, D'Orbigny and Sahara 99555, have been described and the angrite clan is now better understood. In particular, it has been shown that olivine xenocrysts are a nearly ubiquitous feature of angrites [6]. D'Orbigny and Sahara 99555 are the only angrites that seem to be nearly xenocryst free, and therefore may represent real melt compositions [6]. Here we extend the comparison of the calculated and experimental phase equilibria of CV and CM chondrites to natural angrites [1, 5] to include D'Orbigny and Sahara 99555.

D'Orbigny: D'Orbigny is an unusual, vesicular angrite containing glass [2, 7]. D'Orbigny has disequilibrium textures, including extreme mineral zoning, but there are no shock features [2]. D'Orbigny has "xenocrystic" olivines – as defined by anomalous Fe/Mg distribution coefficients and Cr and Ca partition coefficients – but these are rare [6], and there is no evidence of later thermal metamorphism [2].

We show (Table 1) that D'Orbigny looks very much like our devolatilized-Allende melts produced at IW+1 and IW+2, 1200°C [1]. Direct comparison of the IW+2 glass and bulk D'Orbigny indicates that Si, Al, Fe, Ca, and Mg differ by less than 5% and that Ti is within 15%. Considering there is no a priori expectation that the angrite parent body is exactly equivalent to CV chondrites, this is an excellent match.

Sahara 99555: Sahara 99555 is considered to be essentially identical in composition to D'Orbigny, with the slight differences observed plausibly arising from sampling problems [2]. The match of Sahara 99555 to the primary melts of devolatilized Allende is not quite as close. Sahara 99555 lies within 5% of the IW+2 Allende melt for Si, Al, Fe, and Ca but differs by $\geq$15% for Ti, Mg. The difference between the D'Orbigny match and that of Sahara 99555 is mostly in the Mg# which, again, may reflect sampling issues.

Conclusions: The angrite parent body was compositionally similar to a devolatilized CV chondrite in terms of its major elements. In contrast to [5], no additional high-temperature material is required to produce an analog for D'Orbigny or Sahara 99555.

The fact that the Allende melts make good analogs for D'Orbigny and Sahara 99555, but do not exactly replicate those angites, has interesting implications for the bulk composition of the angrite parent body. First, we note that CV chondrites have the highest refractory element to Si ratios observed among well-characterized chondrite groups [8]; our observations suggest that the angrite parent body does not extend this range for the major elements. Second, we note that there are real differences in the minor element contents. The angrite parent body has a higher Mn content than CV chondrites. Yet, it is extremely depleted in Na, with a Na/Sm ratio an order of magnitude lower than observed for any other solar system material [9].

This fractionation of Mn vs. Na is difficult to understand in the context of solar nebula models, as Mn and Na are both moderately volatile elements. Typically, chondrites show depletions in both of these relative to CI chondrites [10]. Although fractionation of volatile elements can occur during melting, there is evidence that these unusual compositional characteristics reflect that of the angrite parent body rather than later magmatism. Lead isotopic studies have shown that the angrite parent body has had a much lower Pb/U ratio than other solar system materials since formation [11]. So, the angrite parent body was CV-like but had some unique traits.

References: [1] Jurewicz A. J. G. et al. (1993) *GCA, 57,* 2123-2139. [2] Mittlefelhdt D. W. et al. (2002) *MAPS, 37*, 345-69. [3] Nyquist L. E. et al. (2003) *LPS XXXIV,* Abstract #1388. [4] Jurewicz A. J. G. et al. (1995) *GCA, 59,* 391-408. [5] Longhi J. (1999) *GCA, 63,* 573-585. [6] Mikouchi T. and McKay G.A. (2003) 66 *Met. Soc.* Abstract #5220. [7] Kurat et al (2001) *LPS XXXI.* #1753. [8] Lodders and Fegley (1998) *The Planetary Scientist's Companion*, Oxford Univ. Press. [9] Mittlefehldt and Lindstrom (1990) GCA 54, 3209. [10] Wasson and Kallemeyn (1988) Phil. Trans. R. Soc. Lond. A325, 535. [11] Lugmair and Galer (1992) GCA 56, 1673.

Table 1: Comparison of natural compositions and experimental melts of Allende at 1200°C, in wt.%. D'Orbigny and Sahara 99555 are higher in Mn and lower in Na than the Allende partial melts. IW+2 and IW+1 refer to 2- and 1- orders of magnitude more oxygen present then at the iron-wüstite buffer.

	Allende at IW+2 [1]	D'Orbigny [2]	Sahara 99555 [2]	Allende at IW+1 [1]
SiO_2	37.7	38.4	38.6	40.1
TiO_2	0.76	0.89	0.91	0.83
Al_2O_3	12.0	12.4	12.5	13.1
FeO*	24.7	24.7	23.1	22.7
MgO	6.4	6.5	7.0	6.1
CaO	14.4	15.0	15.1	15.0

* All Fe as FeO.

Figure 1. Projection of compositions in CMAS system, after [5]: (a) from olivine [Ol]; (b) from wollastonite [Wo]. Allende 1200 IW+2 clusters with D'Orbigny and Sahara 99555, within the range of the other angrites, in An+Ol and Ol fields.