PARTIAL MELTING OF CARBONACEOUS CHONDRITES II: CONSTRAINTS ON THE ORIGINS OF BASALTIC ACHONDRITES. J.H. Jones#, D.W. Mittlefehldt+ and A.J.G. Jurewicz+. #SN2, NASA Johnson Space Center, Houston, TX 77058; +C23, Lockheed Engineering and Sciences Company, 2400 NASA Road 1, Houston, TX 77058.

In an accompanying abstract [1] we present data on the compositions of partial melts of Allende (CV) and anhydrous Murchison (CM). Temperatures ranged from 1200 to 1150°C and f_{O_2} varied from IW-1 to IW+2 (from near the f_{O_2} inferred for eucrites [2] to that for angrites [3], respectively). At low f_{O_2} (IW-1) our partial melts greatly resemble eucrites and are clearly of eucritic affinity. We find that, with increasing f_{O_2} and the concomitant destabilization of Fe-metal, we produce melts that are more FeO-rich and are critically silica undersaturated. The increase in the activity of FeO also appears to stabilize hercynitic spinel, which has a high alumina content; and increasing the amount of modal spinel raises the Ca/Al ratio of partial melts significantly. Thus, our melts at high f_{O_2} (>IW) have striking similarities to the angrites. For reference, a summary of our 1200°C experiments on Allende is given in Figure 1. In light of these results, we wish to explore some of the implications of our experiments for the petrogenesis of eucrites and angrites.

Angrites. The origin of angrites has been controversial. The similarity of the fassaitic pyroxenes in angrites and Allende CAI's has even led to the suggestion that angrites are primitive materials that represent nebular condensates or slightly processed condensates [4]. We find, however, that those features that are uniquely angritic (i.e., calcic olivines, high Ca/Al ratios and silica undersaturation) can be explained by simple partial melting of CV-like material. Our 1200°C partial melts at (IW+2) have Ca/Al ratios similar to that of the LEW86010 angrite, and the olivines in equilibrium with these melts have ~0.8 wt.% CaO, similar to the olivines of the LEW87051 angrite. In addition, our "angritic" melts of Allende are critically silica undersaturated and are nepheline-normative. Most of these distinguishing features can be related, either directly or indirectly, to the increased activity of FeO, relative to eucrites. We suggest that the simplest explanation for the origin of angrites is that of partial melting of chondritic material at somewhat oxidizing conditions [(IW+1)±1]. However, we emphasize that, even if angrites as a class can be produced by this mechanism, the origin of AdoR remains obscure.

We reiterate that our choices of temperature and f_{O_2} for our "angrite" experiments were not random, but were dictated by previous estimates of the intrinsic f_{O_2}'s of AdoR [5] and LEW86010 [3] and by the experimentally-determined liquidus temperature of LEW86010 [6].

One significant difference between our experimental melts and those of natural angrites is Mg#. Our melts have lower Mg# than LEW86010 and this may indicate a more complex petrogenesis than the one suggested here.

Eucrites. Our "eucrite" partial melts, produced at low f_{O_2}, are clearly of eucritic affinity and scatter about the eucrite peritectic point [2]. At low f_{O_2} the Allende solidus is 1150±10°C. Consequently, the eucrite liquidus temperatures of 1195-~1150°C determined by Stolper [2] are all permissible temperatures for partial melts of Allende. Note that there is no automatic guarantee that this should be true. If, for example, eucrites were all evolved liquids, they could have been generated in a system whose solidus was >1200°C and then fractionated to their present compositions. As this is apparently not the case for Allende and Murchison compositions, partial melting remains a viable model for the formation of at least some eucrites [2]. Some of our partial melts, particularly those of Murchison, are compositionally quite similar to eucrites.

Our experiments indicate that bulk composition is an important parameter for chondrite partial melting. Enhanced concentrations of Ca and Al in Allende cause partial melting to proceed from the peritectic along the plagioclase-olivine cotectic, rather than along the olivine-pyroxene reaction boundary. This is the same direction of movement as the peritectic point with pressure

[7]. Therefore, some eucrite compositions, which have been interpreted as having formed at high pressure (0.5-1 kbar) [7], could also have been formed at low pressure on a planetoid enriched in Ca and Al. Partial melts of Murchison, however, move along the olivine-pyroxene reaction boundary when they leave the peritectic point, as has been typically envisaged [e.g., 2]. Clearly, bulk composition can play a role in the petrogenesis of eucritic liquids.

Eucrites and Angrites. An interesting observation is that, even though eucrites and angrites are compositionally very different, they have extremely similar oxygen isotopic signatures [8,9] and indistinguishable initial Sr isotopic ratios [10,11]. This indicates that both eucrites and angrites were generated on isotopically similar parent bodies.

In fact, because the reaction C-CO-CO_2 is pressure sensitive, it is theoretically possible to generate eucritic and angritic magmas on the same parent body. If graphite reactions control f_{O_2} on a carbonaceous chondrite parent body, f_{O_2} will increase with depth [12]. We estimate that, to achieve f_{O_2}'s greater than IW, pressures of ~>200 bars are required [13]. This corresponds to the center of an asteroid of ~80 km radius. At shallower levels on the same body, but where graphite is still stable and the f_{O_2} is lower, partial melting could produce eucrites. Thus, it should be possible to find both eucritic and angritic lithologies on the same planetoid.

Does our present collection of eucrites and angrites come from the same parent body? Probably not. Angrite fragments are not found in polymict eucrites or howardites and FeO/MnO ratios of angrites and eucrites are not similar [14]. However, angrite fragments are found in polymict ureilites [4]. If these fragments are not foreign, it may be that angritic magmatism has occurred on the ureilite parent body.

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Figure 1