FORMATION OF CAIs BY PARTIAL MELTING AND ACCRETION DURING HEATING IN A GAS OF SOLAR COMPOSITION. G.P. Meeker, USGS, 903, Denver Federal Center, Denver, CO 80225.

A new model for the formation of USNM 5241, a type B1 CAI has been proposed [1]. The model provides an explanation for previously unrecognized large-scale major element zoning patterns in the melilite mantle of 5241. A second inclusion, EGG-6 [2], has now been discovered to contain the same chemical zoning patterns observed in 5241. The existence of two inclusions with identical large-scale chemical zoning supports an open system process of formation involving partial melting and accretion during heating in a gas of solar composition.

The melilite mantle zoning in both 5241 and EGG-6 is continuous, concentric, and totally independent of individual melilite crystals. The zoning can be divided into three regions (Fig. 1), an outer region rich in gehlenite (ge), a middle region with mottled chemical zoning patterns and some lath-like zones, and an inner region composed of concentric layers. The inner region can be divided into two major layers, both of which show a gradual increase in ge content toward the rim of the inclusion and an abrupt decrease in ge at the outer boundaries of the layers. A detailed description of these regions in 5241 is given in [1]. These zoning patterns suggest an accretion process for the formation of the melilite mantles and also suggest that the mantles formed during ambient *heating* rather than cooling as has traditionally been assumed.

The model involves the following stages of formation: 1) partial melting of a porous and permeable aggregate of grains with increasing temperature in a gas of solar composition, 2) continued partial melting accompanied by reaction of fassaite with the gas at ~1170°C to produce melilite ($Åk_{42}$) at exposed surfaces, 3) accretion of a melilite mantle which becomes more ge-rich with increasing temperature and 4) relatively rapid cooling with recrystallization. This report will consider the phase equlibria in the gas-solid [3] and liquid-solid [4, 5] systems as compared to the chemical and textural properties observed of 5241 and EGG-6. The REE patterns observed in the mantles of 5241 and EGG-6 are discussed in [6].

Diagrams of crystallization temperatures for the gas-solid [3] and liquid-solid systems [4] are combined in Figure 2. These diagrams show that temperatures compatible with partial melting of a CAI with type B composition (~1150° to ~1350°C) are also compatible with condensation of melilite of type B1 mantle compositions (~Ak_{42} to ~Ak_{12}) from a solar gas. This suggests that the two processes could occur simultaneously with reactions in isolated, partially-melted interior portions of a proto-inclusion governed by liquid-solid phase equilibria and reactions in the exposed, solid exterior portions governed by gas-solid phase equilibria. As mantle melilite accretes and grows outward, the grains become isolated from the gas and reside as stable or meta-stable phases within the mantle of the inclusion. Further reaction of these grains would be governed by constraints of the liquid-solid system rather than those of the gas-solid system. Figure 3 is a diagram of how this process might progress from T<1100 to T>1300°C.

The phases and textures found in the mantles of 5241 and EGG-6 are compatible with the accretion/partial melting model described above. In Fig. 2 note that spinel is not stable in the gas phase above ~1230°C. The mantles of both 5241 and EGG-6 are nearly devoid of spinel as seen in (Fig 1). Both hibonite and perovskite are stable in the gas phase above ~1230°C [3], but are not stable in a liquid-solid system of melilite mantle compositions [4,5] and therefore could react with melilite once incorporated into the mantle and isolated from the gas. Inclusions of fassaite and spinel in the mantle can be explained as relict grains that did not completely react with the gas before being isolated by the accreting melilite. The embayed textures of mantle fassaite described by [2] are compatible with reaction between fassaite and gas to produce melilite.

The formation process described above is compatible with most of the textural, isotopic and chemical features observed in type B CAIs and also defines a maximum temperature for the process of ~1350°C. Because the temperature never reaches the melting temperature of spinel and because pyroxene does not completely melt, both the spinel and portions of the fassaites must be relict phases. This provides a mechanism by which phases with different oxygen isotopic compositions can be part of the same inclusion without resorting to oxygen diffusion arguments. In addition, other chemical and isotopic anomalies found in CAIs can be explained by this process of partial melting and accretion because relict precursor material could be abundant and would be intermixed, on a fine scale, with newly formed material, primarily melilite, but also anorthite and fassaite. Finally, this model provides a window by which to view changing conditions in the early nebula (or other environment in which CAIs

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formed), because the compositional zoning patterns observed in the mantles of these inclusions are a direct response to, and preserve a record of changing ambient conditions.

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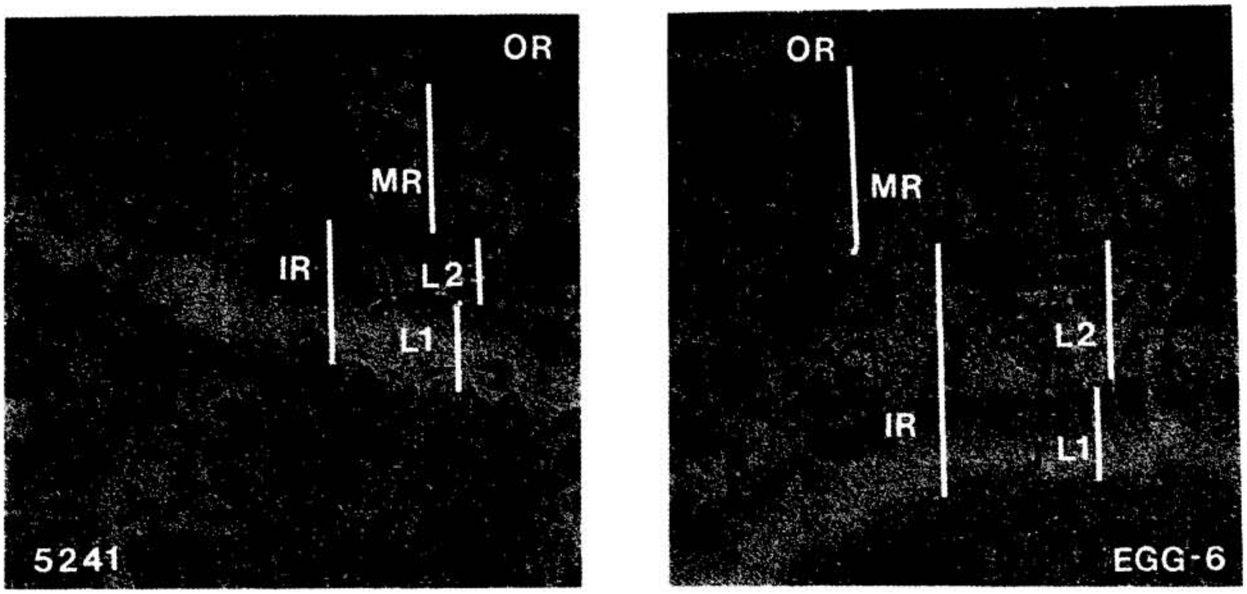

Fig. 1 a b

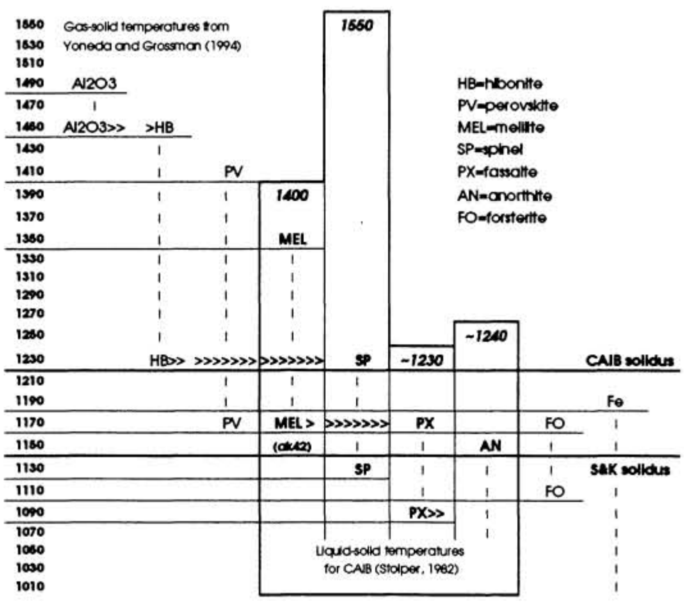

Fig.2

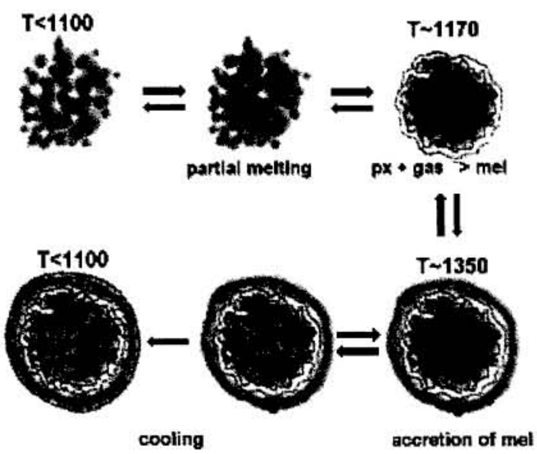

Fig.3

CAPTIONS: Fig.1. Digital Al concentration images of a) 5241 and b) EGG-6. Mantle regions are marked as follows: OR=outer region, MR=middle region, IR= inner region, L1=layer 1, L2=layer 2. Lighter regions = lower Al content. Fig. 2. Diagram of crystallization temperatures for gas-solid [3] and liquid-solid [4] systems (heavy outline). CAIB solidus [4], S&K solidus [7]. Fig. 3. Diagram of possible formation history for 5241 and EGG-6.