SUB-SOLAR Δ^{17}O VALUES IN PARENT CLOUD CORE INFALL MODELS. J. R. Lyons¹ and J.-E. Lee²,
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Introduction: Recent oxygen isotope measurements of grossite-rich CAIs with low initial 26Al/27Al ratio from CH chondrites exhibit Δ^{17}O values as low as -40% [1]. Assuming that CAIs with low initial 26Al/27Al predate CAIs with the canonical 26Al/27Al ratio (~5×10^-5), infall-disk models suggest that these very early CAIs may have formed ~20 Kyr – 30 Kyr after the initiation of collapse of the parent cloud core that formed the solar system [2]. This very short timescale is most consistent with inheritance of low Δ^{17}O values derived from CO self-shielding in the parent cloud [3], [4]. Here, we explore the dust/gas fractionation during the infall stage, and the implications for infall material entering the growing disk. Recently, measurements of Δ^{17}O layering in CAI spherules have been interpreted as evidence for inheritance of self-shielding effects from the parent cloud [5].

Transport timescales in accretion disk: A likely explanation for the very low Δ^{17}O values reported in [1] is rapid transport of self-shielded CO along the UV-active disk surface. Radial transport timescales in an accretion disk, such as that used for modeling CO self-shielding [6], are calculated as \( t_r = \frac{R^2}{ac_s H} \) for heliocentric distance \( R \), sound speed \( c_s \), and vertical scale height \( H \). For CO self-shielding in the disk surface, only \( \alpha \sim 0.1 \) yields timescales short enough to explain the low 26Al/27Al CAI data. The UV-active surface can, indeed, have \( \alpha \) as high as 0.1, so this is a seemingly plausible scenario. However, during the early stages of infall, the disk does not have an accretion disk structure, as assumed in [6], and implicit in Figure 1. We therefore consider delivery of self-shielded CO in the cloud core infall models.

Cloud core infall model: We use the cloud core model of Lee et al. [4], and explore the role of gas/dust fractionation in this model. Infall is modeled by densification of a Bonnor-Ebert sphere, followed by the start of gravitational collapse, which defines \( t = 0 \) in the model. We define \( \beta \) as the fraction of H_2O remaining in the infall gas at the inner boundary of 125 AU of the 1-D spherical model. Dust/gas fractionation is a material fractionation process that segregates CO gas with Δ^{17}O < < solar in the top of the growing disk from H_2O ice with Δ^{17}O >> solar. CO self-shielding and formation of H_2O from ^17O and ^18O-rich O atoms create the large isotopic difference in these two O reservoirs. The process of dust/gas fractionation requires a physical separation of the two reservoirs by, e.g., gravitational settling of ice-coated dust grains. The densification phase of the infall model affects the ability of FUV photons to penetrate the cloud core, and results in CO self-shielding signatures that vary greatly with the magnitude of the FUV radiation field incident on the cloud core [4].

Figure 2 a-f show the resulting Δ^{17}O values for dust/gas fractionation infall material at the inner boundary of the infall model. \( G_0 \) is a measure of the radiation field and is a multiplicative factor amplifying the local interstellar medium (ISM) FUV field. The required dust/gas fractionation factor, \( \beta \), varies greatly with \( G_0 \), with no solution for \( G_0 = 1 \) and \( G_0 = 10^3 \), to \( \beta = 0.9 \) for \( G_0 = 100 \) and \( G_0 = 10^5 \).

![Figure 1. Radial transport timescales in an accretion disk, assuming a turbulent viscosity parameter, \( \alpha \). (Figure from [7]).](https://example.com/figure1.png)

Conclusions: We find that for some radiation fields only a slight dust/gas fractionation is sufficient to explain the CH CAI Δ^{17}O data in [1]. A full evaluation of this requires coupling of our infall model into a growing disk model [2]. This is our next step.

Figure 2a. $\Delta^{17}\text{O}$ for dust/gas fractionated material at the inner boundary of a cloud core infall model. $\beta$ is the fraction of H$_2$O remaining with the gas at the inner boundary. $G_0 = 1$, which corresponds to the ISM FUV field. The CH CAIs require $\Delta^{17}\text{O} \sim 12\permil$ or less at a few $\times 10^4$ years.

Figure 2b. Same as 2a but for $G_0 = 10$.

Figure 2c. Same as 2a but for $G_0 = 100$.

Figure 2d. Same as 2a but for $G_0 = 1000$. No value of $\beta$ is consistent with the CH CAI data in [1].

Figure 2e. Same as 2a but for $G_0 = 1 \times 10^4$.

Figure 2f. Same as 2a but for $G_0 = 1 \times 10^5$. 