SUB-SOLAR Δ^{17}O VALUES IN PARENT CLOUD CORE INFALL MODELS. J. R. Lyons[1] and J.-E. Lee[2], [1]School of Earth & Space Exploration, ASU, jimlyons@asu.edu, [2]Astronomy & Space Science, School of Space Research, Kyung Hee University, Korea.

Introduction: Recent oxygen isotope measurements of grossite-rich CAIs with low initial ^{26}Al/^{27}Al ratio from CH chondrites exhibit Δ^{17}O values as low as -40 ‰ [1]. Assuming that CAIs with low initial ^{26}Al/^{27}Al predate CAIs with the canonical ^{26}Al/^{27}Al 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 $t_r = \dfrac{R^2}{a c_s H}$ for heliocentric distance R, sound speed c_s, and vertical scale height H. For CO self-shielding in the disk surface, only α ~ 0.1 yields timescales short enough to explain the low ^{26}Al/^{27}Al CAI data. The UV-active surface can, indeed, have α 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 β 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 ^{17}O and ^{18}O-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, β, varies greatly with G_0, with no solution for G_0 = 1 and G_0 = 10^3, to β = 0.9 for G_0 = 100 and G_0 = 10^5.

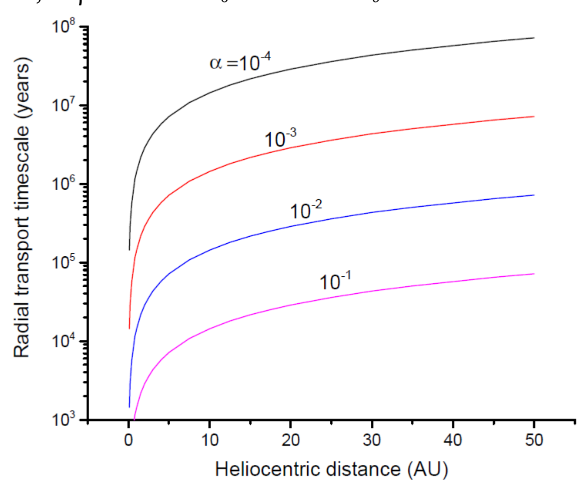

Figure 1. Radial transport timescales in an accretion disk, assuming a turbulent viscosity parameter, α. (Figure from [7]).

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.

References: [1] Krot A. N. et al. (2019) LPSC 50th, abstract #1230. [2] Pignatale F. C. et al. (2018) *ApJ Lett.*, 867, L23. [3] Yurimoto H. and Kuramoto K. (2004) *Science*, 305, 1763. [4] Lee J.-E. et al. (2008) *Meteor. & Planet. Sci.*, 43, 1351. [5] Simon J. et al. (2019) *Ap. J.*, *884*, L29. [6] Lyons J. and Young E. (2005) *Nature*, 435, 317. [7] Krot A. N. et al. (submitted).

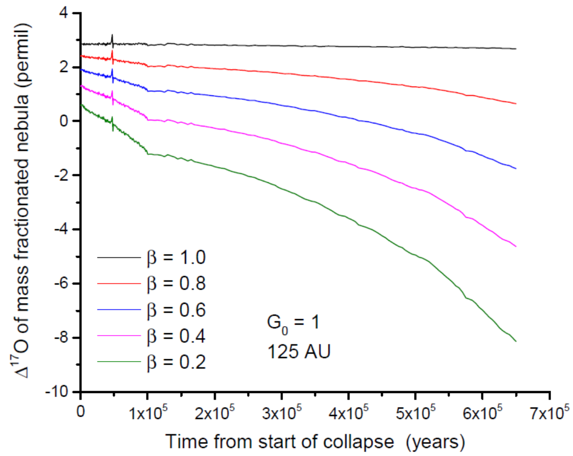

Figure 2a. $\Delta^{17}O$ for dust/gas fractionated material at the inner boundary of a cloud core infall model. β is the fraction of H_2O remaining with the gas at the inner boundary. G_0 = 1, which corresponds to the ISM FUV field. The CH CAIs require $\Delta^{17}O \sim 12$‰ or less at a few x 10^4 years.

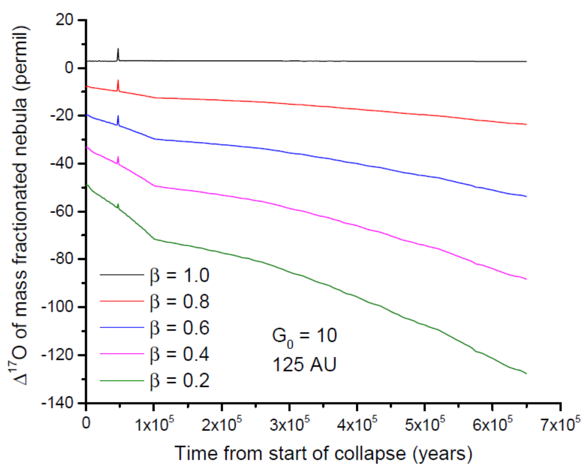

Figure 2b. Same as 2a but for G_0 = 10.

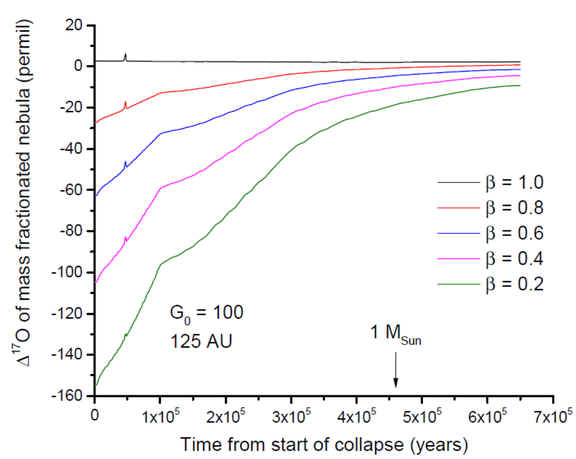

Figure 2c. Same as 2a but for G_0 = 100.

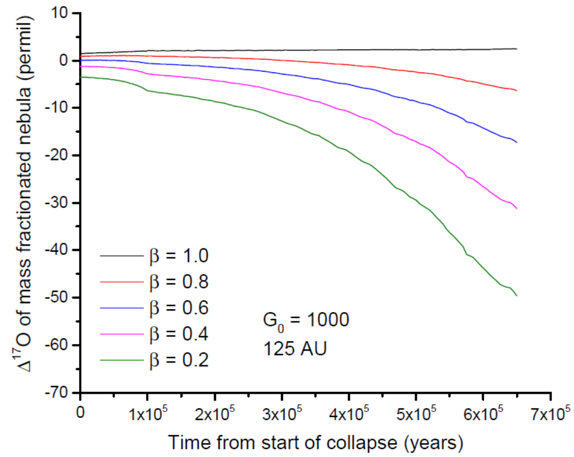

Figure 2d. Same as 2a but for G_0 = 1000. No value of β is consistent with the CH CAI data in [1].

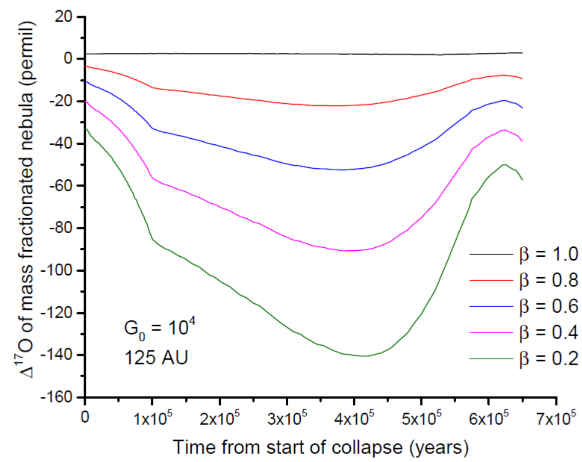

Figure 2e. Same as 2a but for $G_0 = 1\times10^4$.

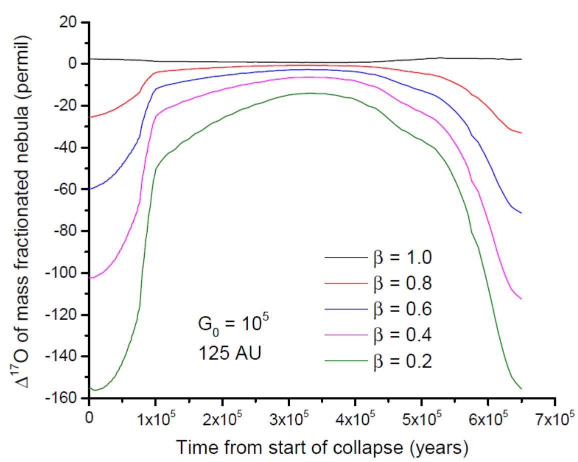

Figure 2f. Same as 2a but for $G_0 = 1\times10^5$.