OXYGEN ISOTOPIC HETEROGENEITY IN THE SOLAR SYSTEM INHERITED FROM THE PROTOSOLAR MOLECULAR CLOUD

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The Sun is ^{16}O-enriched (Δ^{17}O = –28.4±3.6‰) relative to the terrestrial planets, asteroids and chondrules (–7‰ < Δ^{17}O < 3‰) [1]. Ca,Al-rich inclusions (CAIs) and amoeboid olivine aggregates (AOAs) are the only solids formed in the Solar System (SS) with Δ^{17}O approaching the solar value. Ultraviolet CO self-shielding [2] resulting in formation of ^{16}O-rich CO and ^{17,18}O-enriched H_2O is the currently favored mechanism invoked to explain the observed range of Δ^{17}O among extraterrestrial materials [3–5]. However, the location of the CO self-shielding is not known: this process is suggested to have occurred either in the protosolar molecular cloud [2,3] or in the outer protoplanetary disk [4]. In the latter case, the self-shielding effects in CO and H_2O are estimated to have been transferred to the inner SS within several hundred thousand years [4]. CAIs are the oldest SS solids dated [5] and are thought to have formed near the protoSun. Here we show that grossite-rich CAIs with the predominantly low (<5×10^{-6}) initial ^{26}Al/^{27}Al ratio from CH3.0 chondrites have uniform Δ^{17}O, but exhibit a large range of Δ^{17}O between individual CAIs (–40‰ to –5‰), providing a strong evidence for large variations in Δ^{17}O of the nebular gas in the CH CAI-forming region. In contrast, CAIs with the canonical initial ^{26}Al/^{27}Al ratio of ~5×10^{-5} from the CR2, CM2, and CO3.0 chondrites have a very limited range of Δ^{17}O, –24±2‰ [7–9]. Because CAIs with the low initial ^{26}Al/^{27}Al are thought to have predated the canonical CAIs and formed within first 10,000–20,000 years of the SS evolution [10], these observations suggest isotopic heterogeneity of the major O-bearing species (CO, H_2O, and silicates) in the early SS was inherited from the protosolar molecular cloud.

References: [1] McKeegan K. D. et al. (2011) *Science* **332**:1528. [2] Thiemens M. H. & Heidenreich J. (1983) *Science* **219**:1073. [3] Clayton R. N. (2002) *Nature* **415**:860. [4] Yurimoto H. & Kuramoto K. (2004) *Science* **305**:1763. [5] Lyons J. R. & Young E. D. (2005) *Nature* **435**:317. [6] Connelly J. N. et al. (2012) *Science* **338**, 651. [7] Makide K. et al. (2009) *GCA* **73**:5018. [8] Kööp L. et al. (2016) *GCA* **184**:151. [9] Ushikubo T. et al. (2017) *GCA* **201**:103. [10] Pignatale F. C. et al. (2018) *ApJL* **867**:L23.