INVESTIGATING PROTOPLANETARY CARBON RESERVOIRS AND MOLECULAR INHERITANCE ALONG A GALACTIC GRADIENT.

R.L. Smith[1,2], G.A. Blake[3], A.C.A. Boogert[4], K.M. Pontoppidan[5], and A.C. Lockwood[6]. [1]NC Museum of Natural Sciences, [2]Appalachian State University. rachel.smith@naturalsciences.org. [3]California Institute of Technology. [4]SOFIA/USRA, NASA Ames. [5]Space Telescope Science Institute. [6]King Abdullah University of Science and Technology.

Introduction: High-resolution observations of CO gas toward young stellar objcts (YSOs) enable valuable comparisons between forming protoplanetry systems and solar system material, as well as robust evaluation of early protoplanetry chemical reservoirs [1-7]. Precise isotopic observations of carbon and oxygen in the gas-phase have largely targeted low-mass YSOs in our local solar neighborhood [1,2]. Yet, precise investigations of YSOs ranging in size, luminosity, and Galactic location have mulitple advantages, including the parameterization of variations in distribution and evolution of molecules that are key in prebiotic chemical pathways, and the buidling of a more comprehensive understanding of evolving planetary reservoirs in the Galaxy. The present study uses high-resolution observations of CO gas toward a large suite of massive YSOs where $^{12}C/^{13}C$ has also been measured in CO_2 ice [8], thereby enabling a robust study of carbon inheritance between these key molecular reservoirs observed along a single line-of-sight.

Observations and Methods: Using the NIRSPEC spectrograph on the Keck telesceope at high spectral resolution (R=25,000), we have obtained fundamental ($\upsilon = 1 - 0$) and first overtone ($\upsilon = 2 - 0$) CO rovibrational near-infrared absorption spectra toward 14 massive YSOs and, for comparison, 2 background YSOs (tracing foreground cloud material). Spectra were reduced using a customized IDL pipeline. Doppler broadening, gas temperatures, and total molecular column densities were determined with curve-of-growth and rotational analyses. A subset of preliminary results has been reported [6,7].

Results: Our set of 14 massive YSOs range in Galactocentric radius (R_{GC}) from 4.5 to 9.7 kpc, and in luminosity from 1×10^3 to 4.7×10^5 L_{Sun}. For comparison, we have observed two background YSOs at ~ 8 kpc, L_{Sun} ~ 40 and below. Results thus far show lower $[^{12}C^{16}O]/[^{13}C^{16}O]_{Gas}$ than $[^{12}CO_2][^{13}CO_2]_{Ice}$ at 6.1 and 9.4 R_{GC}, suggesting that CO_2 may not originate from CO reservoirs as previously assumed [9]. Cold $[^{12}C^{16}O]/[^{13}C^{16}O]_{Gas}$ from the massive YSOs follow the general expected $^{12}C/^{13}C$ Galactic trend, in stark contrast to the heterogeneity seen in $[^{12}CO]/[^{13}CO]_{Gas}$ toward low-mass YSOs at R_{GC} ~ 8 kpc [3,4].

Conclusions: New observations of precise $[^{12}C^{16}O]/[^{13}C^{16}O]_{Gas}$ toward massive YSOs suggest that CO_2 may not originte from CO. As compared to low-mass YSOs, less dispersion in $[^{12}C^{16}O]/[^{13}C^{16}O]_{Gas}$ observed toward the massive YSOs suggests that massive YSOs may follow evolutionary paths distinct from their low-mass counterparts. Massive YSOs should be considered valuable targets in the evaluation of protoplanetary chemical pathways and key prebiotic molecular reservoirs.

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