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Exoplanet Habitability: Effects of Planetesimal Carbon Chemistry

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We explore the effects of reported differences in C/O values for exoplanet host stars on the composition of planetesimals formed beyond the snow line in these systems. Since the value of C/O in a planet forming nebula has a strong effect on amount of oxygen available for water ice in an oxidizing nebula, exoplanet systems for host stars with C/O greater than the solar value may have planetesimals with very little or no water ice. We have estimated the composition of volatile and refractory material in extrasolar planetesimals using a set of stars with a wide range of measured C/O abundances (Johnson et al. ApJ. 757(2), 192, 2012). The volatile ice content of planetesimals in these systems varies significantly with C/O, controlled primarily by the availability of O for H_2O ice condensation. Systems with C/O less than the solar value (C/O = 0.55) should have very water ice rich planetesimals, while water ice mass fraction decreases rapidly with increasing C/O until only ices of CO and CO_2 are left in significant proportions. If a significant fraction of C is in the form of refractory CHON particles, C and O are removed from the gas phase and the condensates for super-solar C/O values will be water-poor mixtures of silicates and metal, carbon, and carbon-bearing volatile ices, depending on temperature. For very carbon-rich systems, oxidizing conditions cannot be sustained beyond about C/O=1, due to the oxygen sequestered in solid silicates, oxides and CHON, for refractory C fractions within the Pollack et al. range of 0.4 – 0.7 (ApJ. 421, 615, 1994). These results have implications for assessing the habitability of exoplanets since they constrain the amount of water available beyond the snow line for dynamical delivery to inner planets, depending on the host star's C/O in the circumstellar nebula. Thus one the key chemical ingredients for habitability may be in short supply in carbon-rich, oxygen-poor systems even if planets exist in the 'habitable zone'. TVJ acknowledges government support at JPL/Caltech, under a contract with NASA. NM acknowledges support from Yale University. JIL was supported by the JWST Project through NASA. O.M. acknowledges support from CNES.