A QUANTITATIVE, TIME-DEPENDENT MODEL OF OXYGEN ISOTOPES IN THE SOLAR NEBULA: STEP 1.

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Introduction: The remarkable discovery that oxygen isotopes in primitive meteorites were fractionated along a line of slope 1 rather than along the typical slope 0.52 terrestrial fractionation line occurred almost 40 years ago[1]. However, a satisfactory, quantitative explanation for this observation has yet to be found, though many different explanations have been proposed. The first of these explanations proposed that the observed line represented the final product produced by mixing molecular cloud dust with a nucleosynthetic component, rich in ^{16}O, possibly resulting from a nearby supernova explosion. Donald Clayton[2] suggested that Galactic Chemical Evolution would gradually change the oxygen isotopic composition of the interstellar grain population by steadily producing ^{16}O in supernovae, then producing the heavier isotopes as secondary products in lower mass stars. Thiemens and collaborators proposed a chemical mechanism that relied on the availability of additional active rotational and vibrational states in otherwise-symmetric molecules, such as CO_2, O_3 or SiO_2, containing two different oxygen isotopes[3,4] and a second, photochemical process that suggested that differential photochemical dissociation processes could fractionate oxygen[5]. This second line of research has been pursued by several groups[6,7], though none of the current models is quantitative.

Lightning as the processing agent: Based on experiments[8] done at GSFC that produced non-mass-dependently fractionated solid oxides from plasma, we have previously suggested[8] that dust processed via nebular lightning could explain the observed oxygen isotopic distribution in the solar system. Necessary conditions for nebular lightning have been previously discussed[10-12] and we will present preliminary work suggesting that lightning is a major component of protostellar nebulae.

We will also present preliminary results of the time dependent evolution of oxygen isotopes in nebular dust and the largest uncertainties that remain in the model.

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