CONSTRAINTS ON THE STELLAR PRECURSORS OF THE SOLAR SYSTEM: A QUANTITATIVE COMPARISON OF NUCLEOSYNTHETIC ISOTOPE ANOMALIES AND NRLEE EJECTA. K.R. Bermingham[1] and B.S. Meyer[2], [1]Department of Earth and Planetary Sciences, Rutgers University USA (katherine.bermingham@rutgers.edu), [2]Physics and Astronomy, Clemson University USA.

Introduction: The combination of stellar precursors inherited by the protoplanetary disk defined the Solar System's composition and may have determined the potential for life to develop on its planetary bodies. The identity of the Solar System's stellar precursors, however, remains under investigation. Partial constraints have been inferred from nucleosynthetic isotope anomalies (i.e., µ-part per million-scale deviations from a terrestrial standard) observed in meteorites (e.g., μ^{48}Ca, μ^{46}Ti, μ^{50}Ti, μ^{54}Cr [1]). Nucleosynthetic isotope anomalies are the result of the heterogeneous distribution of isotopically anomalous presolar stardust (i.e., presolar carriers) in the disk (for review see [2]). Nucleosynthetic isotope anomalies in bulk meteorite samples may correlate if the isotopes are housed in presolar carriers that originate from a common nucleosynthesis site. Consequently, nucleosynthetic isotope anomalies provide direct evidence of the Solar System's stellar precursors.

Correlated nucleosynthetic isotope anomalies in bulk meteorite samples (e.g., ^{50}Ti *vs.* ^{54}Cr) underpin the noncarbonaceous (NC)-carbonaceous chondrite (CC) isotopic dichotomy [1]. The NC-CC isotopic dichotomy has been interpreted as a record of spatial and/or temporal disk processes, and it has been widely used to reconstruct the accretion location and movement of parent bodies in the disk [2]. It is challenging, however, to accurately use the NC-CC isotopic dichotomy to reconstruct the architecture of the disk if the identity and stellar origin of presolar carriers, and their mode of heterogeneous distribution in the disk, are unclear.

The exact nucleosynthetic sites from which the Solar System's ^{48}Ca, ^{46}Ti, ^{50}Ti, ^{54}Cr budget originated, and their presolar carriers, are debated. Production in SNII (^{46}Ti, ^{50}Ti, ^{54}Cr) [3], SNIa (^{48}Ca, ^{50}Ti, ^{54}Cr) [4], and electron-capture supernovae (^{48}Ca, ^{50}Ti, ^{54}Cr) [5] have been proposed. Currently, thermonuclear electron-capture supernova (tECSN) is favored [6].

This contribution investigates if a single type of stellar site (likely a tECSN) was responsible for the production of presolar carriers that underpin the correlated nucleosynthetic isotope anomalies measured in ^{48}Ca, ^{46}Ti, ^{50}Ti, ^{54}Cr, the backbone of the NC-CC isotopic dichotomy.

NRLEEs: Correlated bulk sample isotopic anomalies in ^{50}Ti, ^{54}Cr, and, especially, ^{48}Ca, in a variety of planetary materials suggest the predominance of dust in the early Solar System from rare astrophysical events that ejected neutron-rich, low-entropy matter [7]. The exact nature of these events is unclear. Due to the variety of plausible sites [4-6], here they are referred to generically as NRLEEs (Neutron-rich, Low-Entropy matter Ejectors). For details on NRLEE nucleosynthesis, see [8].

Neutron-rich, Low-Entropy matter Ejectors events are relatively rare supernovae [6]. Nevertheless, recent quantitative evaluation of the nature of NRLEE ejecta and their Galactic Chemical Evolution (GCE) from synthesis to incorporation into the disk indicates that these sporadic events can provide enough matter to generate the observed ppm-scale nucleosynthetic isotope anomalies measured in meteorites [8].

Methods: The relations between correlated nucleosynthetic isotope anomalies in meteorites and NRLEE ejecta were quantitatively assessed.

The molecular cloud composition resulting from the GCE model was a mixture of the gas and various dust ensembles [8]. The NRLEE component of that mix was then taken to vary to generate possible isotopic anomalies in resulting Solar System materials. Sample-derived within-element and interelement isotopic data (^{48}Ca, ^{46}Ti, ^{50}Ti, ^{54}Cr) were then contrasted with these calculated compositions.

High-precision isotope data of bulk meteorite samples and bulk calcium aluminum-rich inclusions were compiled from published literature. The correlations between parent body compositions confirmed and extend prior work (e.g., μ^{46}Ti *vs.* μ^{50}Ti [9], μ^{48}Ca *vs.* μ^{50}Ti [10], μ^{48}Ca *vs.* μ^{46}Ti [present study], and μ^{54}Cr *vs.* μ^{50}Ti [1]. All isotope data were measured using either thermal ionization mass spectrometry or multi-collector inductively coupled plasma mass spectrometry. These methods require isotopic data to be internally normalized, using an assumed fixed isotopic ratio, to correct for instrumental mass-dependent isotopic fractionation. This assumption of a fixed isotopic ratio, however, can obscure the identity of the anomalous isotopes (e.g., [11]). Following [1,9,10], here the anomalous isotopes are identified as ^{48}Ca, ^{46}Ti, ^{50}Ti, and ^{54}Cr, however, ongoing work is assessing how compositional variability in the normalizing ratios affects bulk sample compositions.

Results: From the GCE model, NRLEE dust makes up about 0.025 % of the total molecular cloud dust mass. **Figures 1a.** μ^{48}Ca *vs.* μ^{50}Ti, **1b.** μ^{46}Ti *vs.*

μ^{50}Ti, **1c.** μ^{54}Cr *vs.* μ^{50}Ti show the results of mixes between NRLEE and molecular cloud dust from the GCE model (black lines) along with meteorite data (red and blue symbols) that were compiled. The low end of the mixing line (black line) has a deficit of 585 ppm of NRLEE dust relative to the molecular cloud average while the upper end of each mixing line has an excess of 1170 ppm.

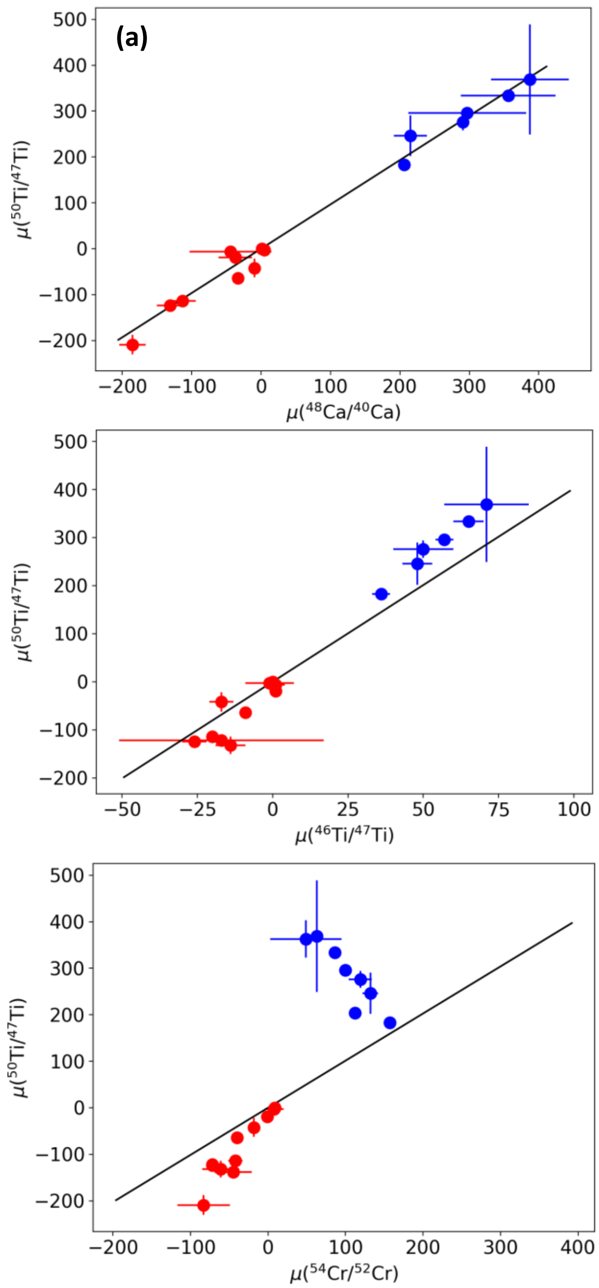

Fig. 1a. *μ^{48}Ca vs. μ^{50}Ti,* ***Fig. 1b.*** *μ^{46}Ti vs. μ^{50}Ti,* ***Fig. 1c.*** *μ^{54}Cr vs. μ^{50}Ti. Correlated isotopic anomalies in bulk meteorites (CC: blue symbols, NC: red symbols) compared to results of mixes of NRLEE and molecular cloud dust from the GCE model (black line). The most negative anomalies occur for mixes that have a 585 ppm deficit of NRLEE dust compared to the molecular cloud average. The most positive anomalies occur for mixes that have an 1170 ppm excess of NRLEE dust compared to the molecular cloud average.*

These proportions of NRLEE material mixed into the Solar System composition generates compositions on the order of magnitude of those measured in meteorite samples. Also, there is good agreement between the slopes of the correlated meteorite data and the predicted isotopic anomalies, excepting the CC group in μ^{54}Cr *vs.* μ^{50}Ti.

Discussion: The replication of the magnitude of nucleosynthetic isotope anomalies in bulk meteorite samples and most of their within-element and interelement correlations indicates that a single stellar source (i.e., NRLEE) for ^{48}Ca, ^{46}Ti, ^{50}Ti, ^{54}Cr presolar carriers is permissible. Explanations for the negative deviation of the CC group in μ^{54}Cr *vs.* μ^{50}Ti will be canvassed. This alleviates the requirement of multiple different stellar precursors contributing neutron-rich material to the Solar System (e.g., NRLEE, SNII, dust from low-mass stars).

A NRLEE event would produce presolar carriers with a range in isotopic compositions and variable enrichments in ^{48}Ca, ^{46}Ti, ^{50}Ti, and ^{54}Cr. These distributions could be reflected in the isotopic compositions measured in meteorite leachate studies and the number of components identified using independent component analysis [e.g., 12,13].

The spatial and temporal distribution of predicted presolar carriers in the disk and the development of the NC-CC isotopic dichotomy will be outlined.

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