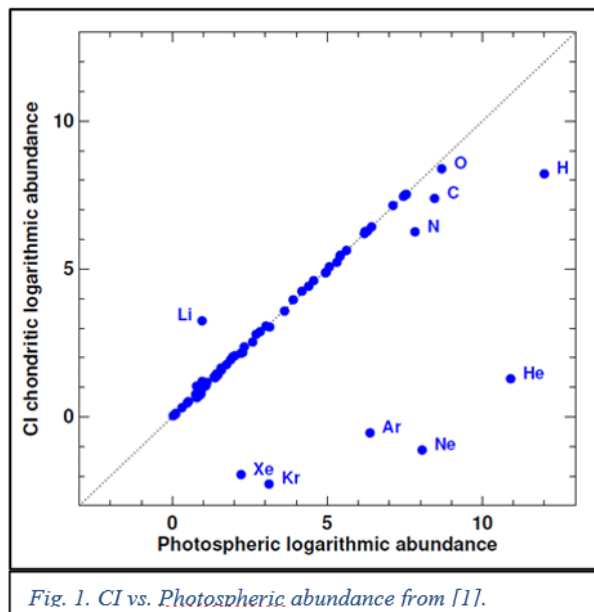


EVIDENCE CI CHONDRITE COMPOSITIONS ARE NOT SOLAR. A. J. G. Jurewicz¹, D. S. Burnett², A. M. Amarsi³, and ⁴N. Grevesse. ¹BCMS, ASU, Tempe AZ 85287-6004, ²D. S. Burnett, GPS, Caltech Pasadena CA 90025, ³Theoretical Astrophysics, Dept. Phys. & Astro., Uppsala Uni., Uppsala, Sweden, ⁴Centre Spatial de Liège, Université de Liège, Avenue Pré Aily, B-4031-Angleur-Liège, Belgium. (Amy.Jurewicz@asu.edu).

Introduction: CI chondrites are used to represent solar composition in models for good reason: except for fragile (Li) and highly volatile elements (H, He, C, N O, etc.), the composition of CI chondrites appears to mirror Photospheric data (Fig. 1). But chondrites are

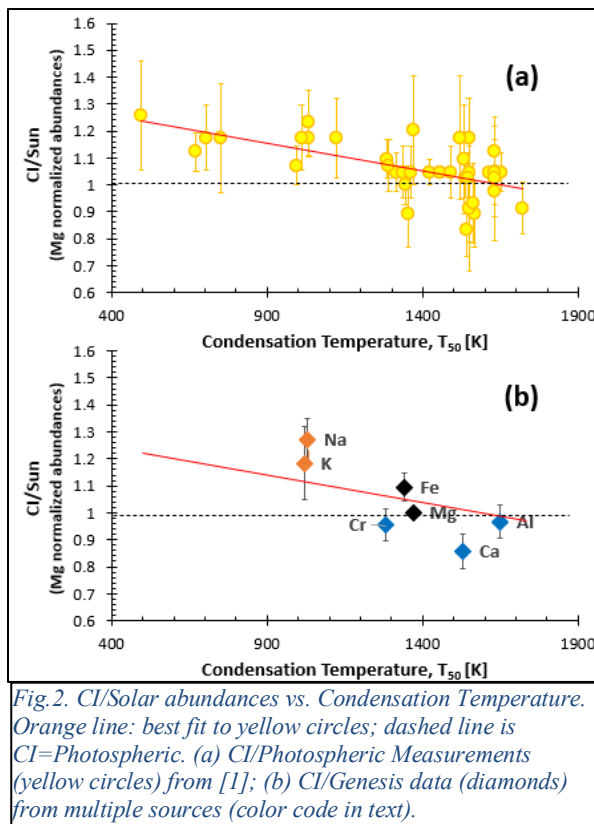


rocks and, therefore must have been subject to at least some processing of their components both during and after accretion. Processing requires chemical change, and at least a minor fractionation of elements.

Recently, a potential indicator of fractionation of the CI chondrite composition from solar Photospheric composition was published in [1]. Their data is in Fig. 2a, but the plot is modified to emphasize volatility, to change their normalization from Si to Mg, and shows data on a linear scale. As per [1], dex errors ≥ 0.1 ($\sim 30\%$ or more) were not included and the condensation temperature does not go below 400 K. Below 400 K are many true volatile elements that are clearly not representative of solar abundances in CI chondrites (Fig. 1).

The trend presented in Fig. 2a is interesting, but ambiguous because of the sizeable uncertainties, largely due to potential modeling systematics affecting the Photospheric abundances. Validation by an independent source is needed: for example, data from the Genesis Solar Wind Sample Return Mission as plotted in Fig. 2b.

Solar wind (SW) data are not exactly Photospheric, having gone through the processes of solar wind



formation. However, the elements in Fig. 2b have a first ionization potential (FIP) ≤ 9 eV, so they are not significantly fractionated from each other [2, Model 2]. Moreover, fractionation with respect to the Photosphere caused by solar wind formation is not likely to correlate with condensation temperature.

Details of Genesis Data: The Genesis data in Fig. 2b were determined by several workers using secondary ion mass spectrometry (SIMS). All diamond markers are Genesis bulk solar wind data: brown are from diamond-like carbon (DLC) on silicon (DoS) collectors; black were measured in both DoS and silicon collectors (and had the same values within analytical error); and blue diamonds were measured in silicon collectors. Error bars are $\pm 1\sigma$. All data are calibrated except Al. *The Al value is based on a nominal implant value, so the marker (with error bar) may shift when calibration is complete.* Calibration is in progress by Rutherford Backscattering of Al in a carbon (DLC) matrix. The calibrated 2nd implant will then be intercalibrated with the standard used by [4].

SW Mg and SW Fe were measured in both silicon and DoS collectors. The results agreed, proving that the measured SW was pristine. Bulk SW Mg in DLC are from [6]; and are consistent with data from silicon [4]. SW Fe fluences in both silicon and DoS collectors are from D. S. Burnett [5]. Note that Fe was not measured by [4]. It was expected to diffuse in silicon, exchanging with the surface during SW collection.

Although bulk SW in silicon collectors shows radiation-enhanced segregation, the SW Fe fluence gives the same value within analytical error in both Si and DLC, so Fe was not gained or lost. This result is in contrast with that for Na [7], [8].

SW Na is problematic because the abundance from silicon [4,8] is in stark contrast to that from DLC (DoS collectors [7], [8]). In fact, the difference is ~50%. This work uses Na data from [7] for multiple reasons detailed in [8]. But the primary reason was that, unlike depth profiles from DLC, neither [4] or [7] were able to obtain bulk SW Na SIMS back-side depth profiles in silicon that reached to the collection surface. Na could have diffused during the analysis (in silicon only); but, shortened back-side depth profiles are also a feature of radiation-enhanced diffusion in which material is exchanged with the collection surface.

Discussion:

Both Genesis and Photospheric data indicate a weak fractionation when compared to CI chondrite abundances. Although Genesis data is bulk SW which has undergone some fractionation, the elements presented herein are low FIP elements are unlikely to have been significantly fractionated relative to each other. Photospheric data are completely independent of the Genesis SW data, so the trend in Fig. 2ab is likely real. Both figures suggest that CI chondrites are enriched in volatile elements including Na and K, and, perhaps, slightly depleted in the refractories Ca and Al relative to the Photosphere. This trend may reflect either the environment of CI chondrite formation or the sequence of dust formation and/or the preferential accretion of early-formed dust into the Sun. Further discussion and interpretation can be found in [1].

Note: enrichment and depletion of elements are relative. If both Genesis- and Photospheric data were renormalized to, say, Si, then the fractionation trend would stay the same, but the CI/Sun = 1 value in Fig. 2 would shift position from Mg to Si.

SW K and Na (brown in Fig. 2b) appear to anchor the Genesis trend (i.e., if we only looked at Genesis data, we might have said that only K and Na are enriched in CI). Thus, more elements need to be added to the Genesis data base. A variety of additional

elements can plausibly be measured in Genesis materials by Genesis PIs (e.g., S is in progress; P and Mn are likely candidates; reconnaissance is being done to see if SW Si can be measured in DLC if surface silicon is removed). And, just like Fe, Mg, and Na, precisely determining all elements in two collectors would ensure that the measured solar wind is pristine.

Finally, FIP is unlikely to be a significant effect for elements with first ionization potentials $\leq 9\text{eV}$, but Genesis data in Fig. 2b are from bulk solar wind and FIP effects on solar wind abundances appear to be primarily from fractionation in solar loops [2]. So, data from the high-speed Genesis SW sample (from Coronal Holes) might be more appropriate. Moreover, we still cannot be positive that FIP is the only factor in fractionation. Thus, besides measuring more elements in the bulk SW, more elements in the SW regimes collected by the Genesis Mission (SW from the high speed, low speed and coronal mass ejection collectors) should be measured.

Summary: The plot of CI vs. Photospheric abundances (Fig. 1) is used to justify using CI chondrites as a baseline for abundances of non-volatile elements in the solar system. The plot is great on a log scale. Moreover, abundances from CI chondrites are precise and easy for multiple workers to adopt. However, recent work by [1] suggests that there are measurable differences between CI and Photospheric abundances (Fig. 2a) on a smaller scale. Currently available Genesis data are both independent of the Photospheric measurements and consistent with the deviation of CI abundances from Photospheric abundances (Fig. 2b). More measurements of Genesis elemental abundances are still needed. Many more elements are feasible, and we hope and expect additional results in the near future. But, it is now clear (see Fig 2a and b) that CI composition does not represent the composition of solar matter.

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