

COSMIC CLASS STRATOSPHERIC PARTICLES: TRACE ELEMENTS IN C? SAMPLES AND ZN DEPLETIONS

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Introduction: Minor and trace element abundances were measured by Synchrotron X-Ray Fluorescence (SXRF) on eight stratospheric particles: five "cosmic" (C) and three "possibly cosmic" (C?) in the Johnson Space Center (JSC) preliminary classification (table 1). The particles had typical dimensions of 10 μm , making the present set of particles smaller than most we have previously analyzed by SXRF [1]. Our main goals in the present study were to better define the constituents of the C and C? classes. One of the more interesting observations is that Zn concentrations in three of the chondritic particles are extremely low. One possibility is that these depletions result from partial heating of the particles.

Trace element analyses were performed as described previously (1), except that, because of the smaller particle size, the X-ray beam was collimated using a 10 μm pinhole. An 85 μm thick Al filter was placed over the detector to suppress pileup peaks during analyses for elements heavier than Fe. Elements lighter than Fe were detected in a second run without the Al filter. These data were corrected for self-absorption, but the light element analyses may reflect the composition of only an exterior portion of the particle.

C-type Particles: W7029B5 exhibits Ca, Ti, Cr, Mn, Ni, Cu, and Se abundances within a factor of 2 of CI. Only Zn of the detected elements is non-chondritic, with $\text{Zn/Fe} = 0.03 \times \text{CI}$.

W7027A1 exhibits an Fe/Ni ratio = 50, three times the CI ratio. The element/Fe ratios for Ti, Mn, Ni, Cu, Ga, Ge, and Se are all within a factor of 3 of the CI ratios, however Ca, Cr and Zn are substantially lower than CI (by factors of 0.01, 0.02, and 0.06, respectively).

U2015E8 and U2015E17 appear morphologically similar in the JSC catalog photographs, both being aggregates of spherical aggregates. Both particles appeared quite thin in optical microscope examination, and their low masses limited the number of elements detected during 30 minute filtered analyses. The elemental compositions of both particles are within a factor of 3 of CI for Ca, Ti, Cr, Mn, and Ni. Zn is depleted to $0.1 \times \text{CI}$ in U2015E8. A small, daughter fragment of U2015E17, analyzed separately, exhibited substantial enrichments over chondritic in K, Ca, Ti, Cu, and Zn.

U2015C27 was selected because of the absence of Ni in its JSC EDX spectrum. We measured the Fe/Ni ratio to be 460, dramatically inconsistent with the CI value of 17. The unfiltered spectrum shows a substantial Ca depletion, but Ti, Cr, and Mn are present in the normal CI ratios to Fe.

C?-type Particles: We examined three C? particles (U2015C26, W7017D6, and W7027E7) selected because they exhibited roughly chondritic Fe/Ni ratios in the JSC EDX spectra.

W7017D6 and W7027E7, exhibit trace element abundances within a factor of 2 of CI for Ti, Cr, Mn, Ni, Cu, Zn, Ge and Se, as shown in Figure 1. Br is enriched in both particles ($50\text{-}60 \times \text{CI}$), and Ca is low in W7027E7 ($\text{Ca/Fe} = 0.2 \times \text{CI}$). The chondritic nature of these two particles is strongly suggested by the trace element analyses.

U2015C26 along with U2015C27 (described above) is described as having the "same parent" (2), however, the minor/trace element abundances are quite distinct. The Fe/Ni ratio is 4.1 in U2015C26 (compared with 460 for U2015C27) and the particle exhibits Cu and Sr enrichments of more than a factor of $5 \times \text{CI}$ and a Ti depletion to $0.3 \times \text{CI}$.

Zinc: Zn was depleted by more than a factor of 10 in 3 of the particles which exhibited chondritic minor/trace element patterns in our analyses. We have previously identified one other stratospheric particle, U2022G2, exhibiting a similar Zn depletion but an otherwise chondritic minor/trace element abundance pattern (1). These low-Zn particles, now found on 4 different collectors, appear to be a persistent component of the stratospheric collection. Since Zn is quite volatile, with a loss temperature of 600°C in heating experiments on meteorites (3), the low Zn abundances in particles exhibiting otherwise chondritic trace element patterns may result from particle heating, as might occur on atmospheric entry, for example. Correlations between Zn content and other internal thermometers, such as the presence of charged particle tracks and low-temperature mineral phases, may help to determine whether or not these depletions are thermal in origin.

Bromine: Bromine, which has been observed to be enriched by factors of 1.3 to 40x CI in all chondritic particles measured to date, follows the same general pattern in the present set. The possibly related fragments, U2015C26 and U2015C27, exhibited grossly different Br contents, 50 and <4x CI, respectively. The Br enrichments in the two C? particles which abundance patterns suggest are chondritic, W7017D6 and W7027E7, were 60 and 50x CI, respectively. An intriguing observation is that the two volatile elements Br and Zn are decoupled, i.e., Br is enriched in Zn-depleted particles.

Conclusions: The Fe/Ni ratio, when coupled with major element abundances, appears to be a useful discriminator of cosmic particles. The C-type particle without detectable Ni in its JSC EDX spectrum exhibited a clearly non-chondritic minor/trace element abundance pattern, as have the previous low-Ni particles we have analyzed (1). Two of the C? particles having Fe/Ni peak height ratios similar to Allende in their JSC EDX spectra also exhibited chondritic minor/trace element abundance patterns, suggesting they are extraterrestrial. We have also identified a class of particles which have chondritic trace element contents, except for large depletions in the volatile element Zn. If the low Zn contents result from thermal devolatilization, it may eventually be possible to use the content of this volatile element as a particle thermometer.

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References: 1. Flynn, G.J. and Sutton, S.R., Proc. 20th Lunar Planet. Sci. Conf., 335-342 (1990). 2. Clanton, U.S., et al., Cosmic Dust Catalog, Vol. 5 No. 1, NASA Planet. Materials Pub. 70. (1984). 3. Ikramuddin, M. et al., Geochim. Cosmochim. Acta, 41, 1247 (1977).

Table 1: JSC Catalog Data for 8 Stratospheric Particles Analyzed

Particle	Type	Size (μm)	Major Elements in EDX Spectrum
U2015C27	C	10 x 11	Mg, Al, Si, Fe
U2015E8	C	8 x 12	Mg, Al, Si, Ca, Fe, Ni
U2015E17	C	9 x 17	Mg, Al, Si, Ca, Fe, Ni
W7027A1	C	11 x 14	Mg, Al, Si, S, Fe, Ni
W7029B5	C	12 x 12	Mg, Al, Si, S, Ca, Cr, Fe, Ni, Cu
U2015C26	C?	10 x 13	Mg, Al, Si, P, S, Ca, Cr, Fe, Ni
W7017D6	C?	8 x 7	Mg, Al, Si, S, Ca, Cr, Fe, Ni
W7027E7	C?	10 x 17	Mg, Al, Si, S, Fe, Ni

Figure 1: Trace Element Abundances for Three C? Particles

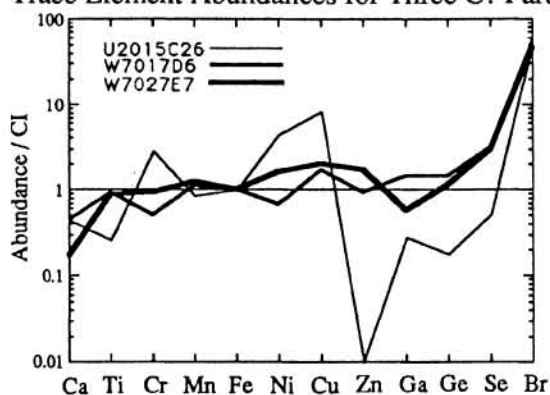


Figure 2: Trace Element Abundances in W7029B5

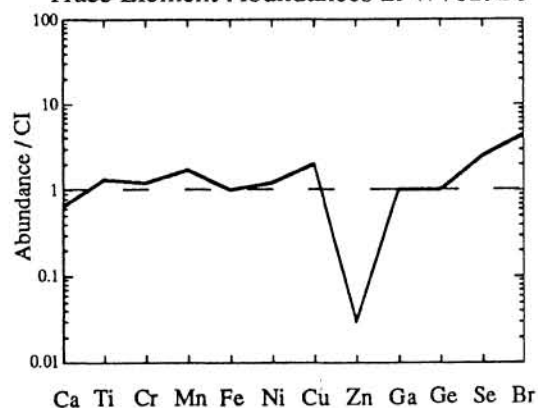


Figure 1: Trace element abundances in three C? particles U2015C26, W7017D6 and W7027E7. The latter two exhibit typical "chondritic" particle patterns while the first does not.

Figure 2: Trace element abundances for chondritic particle W7029B5 showing a large Zn depletion.