

## ELEMENTAL ABUNDANCE ENHANCEMENTS OF LARGE FE-RICH GRADUAL EVENTS

W. F. Dietrich and **C. Lopate**

The Laboratory for Astrophysics and Space Research, The Enrico Fermi Institute, The University of Chicago, Chicago IL 60637, USA.

lopate@ulysses.uchicago.edu

We report on a study of the largest of the gradual (CME driven) solar energetic particle events, as measured with the University of Chicago instrument on the IMP-8 satellite during solar cycles 21 and 22, in order to categorize these largest events. Our selection criterion for studying events is when the CNO flux exceeds  $10^{-5} (\text{cm}^2 \text{ sec ster MeV/nucleon})^{-1}$  for CNO above  $\sim 25$  MeV/nucleon. Of these large gradual events the Fe/O ratio varies, as has been seen before, from  $\sim 0.04$  to  $\geq 2$ , while the  ${}^3\text{He}/{}^4\text{He} \leq 0.01$ . The subset of gradual events whose Fe/O ratio is enhanced ( $\geq 1$ ) is of great interest, both from a theoretical and practical point of view, and we have attempted to categorize these events. The enhanced-Fe gradual events can be divided into three broad subgroups. The first subgroup is a set of events for which the spectra of the heavy ions (e.g. Ca, S, Fe) is harder, and extends to higher energy, than that of the lighter ions (C and O), thus the Fe/O enhancement can be explained purely as a spectral effect. The second subgroup of events have very hard spectra for heavy elements from C through Ni, and the spectral shape is similar in all species. When we compare the abundances of the heavy ions in this subset of gradual events to an average abundance of heavy ions observed in all gradual events we see an increasing enhancement as an exponential function of charge. The final subset of Fe-enhanced gradual events looks very similar to the second subset, except that the C is relatively depleted and the Ne is additionally enhanced. This third subset shows abundance variations remarkably similar to those observed in some  ${}^3\text{He}$ -rich impulsive events.