THE ELEMENTAL COMPOSITION OF EXTRATERRESTRIAL STONY DEEP SEA SPHERES; B.A. Bates and D.E. Brownlee, Dept. of Astronomy, FM20, Univ. of Washington, Seattle, Wash. 98195

"Cosmic " deep sea spheres (DSS) of the stony variety are usually submillimeter particles composed of olivine,magnetite and glass(1).They are believed to be extraterrestrial because of their elemental(2),and Sr isotopic abundances (3) and their content of the cosmogenic isotopes 53Mn (4),10Be and 26Al(5). The spheres are formed by the melting of submillimeter and larger objects during entry into the atmosphere at altitudes of 70 to 100 Km. Number density studies of DSS compared to meteoroid mass influx estimates suggest that most DSS are melt products of meteoroids smaller than 1 cm (6).

Unlike conventional meteorites, which are comparatively large and must have high strengths to survive atmospheric entry, DSS can be formed by any object which melts. In fact, the atmospheric processes which "destroy" most larger meteoroids create DSS. We therefore may find in the DSS suite a relatively unbiased sample of probably all objects in earth crossing orbits. The major source of millimeter meteoroids is known to be comets and it is expected that a significant fraction of the spheres should be melted samples of cometary material.

A study of the properties of the spheres unaffected by atmospheric entry may reveal some average properties of the earth crossing population of meteoroids. With this hope, a study of the chemical composition of a large number of stony DSS was undertaken. About 300 polished sections of 250um - 800um DSS collected 1000 km east of Hawaii were microprobed with a 30um defocused beam for the elements: Mg,Fe,Si,Al,Ca,Cr,Mn,Ni,P,Na, and S. Spot beam analyses were also performed which showed that the particles were homogeneous in composition at the 30um level.

The effect of the oceanic environment in which the DSS spend most of their lives is apparent. Dissolution of glass and Mg-rich cores of olivine grains around the perimeter of some spheres is seen. To avoid weathering effects, only the unetched cores of the DSS were microprobed. A study was undertaken to see if some unseen chemical weathering of the unetched cores had occurred. The cores of lightly etched DSS were compared to those of heavily etched ones. No chemical trend with etching "age" was seen.

The great majority of the spheres have elemental compositions which closely match chondritic abundances and indicate origin from a polymineralic parent because no single mineral matches chondritic composition. A minor fraction of these spheres have chondritic compositions with the exception that iron is considerably enhanced. These iron rich spheres may have been particles that contained a large metal or sulfide grain that oxidized during melting. Roughly 5% of the spheres have a clearly nonchondritic composition and appear to be melt products from precursors composed predominantly of a single mineral. The most conspicuous of these have very low aluminum contents and have stoichiometric ratios of Mg, Si and Fe that match olivine.

The elements in the chondritic composition particles can be grouped into three categories (A,B and C) based on their statistical occurrence in the large set of analysed spheres. The first group (A) consists of

Mg, Si, Al, Ti, Mn and Ca , elements that faithfully occur at chondritic values. In particular, abundance histograms of Mg/Si and Al/Si are strongly peaked at CI/CM values and are clearly distinct from the mean abundances of ordinary chondrites. For the other elements in this group there is not a clear cut difference between ordinary and CI/CM values. The Ca abundances are not as sharply peaked as the other group A elements. This can possibly be explained as due to the inhomogeneous distribution of Ca within the parent material. Ca is an element that is heterogeneously distributed within CI meteorites(7). The second group (B) elements, Na, P and S, are all volatile elements and are highly depleted compared to chondritic values. This, however, is not unexpected when the high temperature environment in which the spheres are formed is considered. In fact, we can use the Na depletion to put a lower limit of 1800 C on the maximum temperature the particles experienced(8). The third element group (C) is composed of Fe, Ni, and Cr and these elements are also slightly to extremely depleted in the spheres. It is hard to believe that volatilization of their oxides is solely responsible for their loss. A number of DSS contain imbedded in them a small Fe-Ni bead. The bead appears to be in the process of ejection from the sphere. The formation of the bead has been postulated and simulated in the laboratory (8,9) as being the result of intense reduction of silicate material during the initial pulse heating of carbon-rich (i.e. carbonaceous) material. This forms a metal bead melt within a silicate melt. After the carbon is consumed or vaporized, re-oxidation of the metal melt will occur. Ejection of the bead at any time will leave the DSS siderophile poor. Evaporation of the metal melt is likely as the vapor pressure of the metals Fe, Ni, and Cr is higher than that of their oxides. We postulate that Cr in the silicates is also reduced and is lost along with the Ni-Fe metal, either through ejection or evaporation. Consistent with this is that we see a slight positive correlation between Cr and Ni abundance. Cr-rich (compared to the abundance of Cr in Iron meteorites) metal DSS have been found (6) , possibly pointing to metal bead ejection as a source for some of these objects. However, the abundance of Cr in these Cr "rich" DSS is much less than that which we would predict from simple ejection of a bead with all of our "lost" Cr. The resolution of this problem is under study.

The results of this study are consistent with >85% of the spheres coming from parents with compositions like CI/CM chondrites. Only a small fraction of the spheres could have originated from ordinary chondrites. None of the spheres appear to have come from achondrites even though achondrites are reasonably common in falls (9%). Either these are unusually rare as small meteoroids or they are not stable in sediments or they do not produce spheres that can be collected magnetically.

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