AUGER SPECTROSCOPY ANALYSIS OF SUBMICRON-SIZED SILICATE GRAINS IN CHONDRITES: INSIGHT INTO THEIR AQUEOUS AND THERMAL ALTERATION HISTORY.

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Introduction: Auger Electron Spectroscopy is widely used in material science and allows qualitative and quantitative elemental measurements of solid materials with a lateral spatial resolution of ~10 nm and an excitation depth in the sample of about 5 nm. While Auger spectroscopy has had only limited applications in Geochemistry and Cosmochemistry, Stadermann et al. [1] showed that this technique is well-suited for the analysis of small grains, and can be used to obtain both qualitative and quantitative elemental information of presolar silicates and oxides. To date, the elemental compositions of close to 450 O-rich presolar grains have been determined using Auger spectroscopy [2]. Previous studies have shown some variations in the elemental composition of presolar silicates (e.g. Fe content) between different meteorites or in distinct fine-grained areas (matrix and chondrule rims) within individual meteorites that might reflect the degree of secondary processing (aqueous alteration and thermal metamorphism) experienced by the meteorite [3, 4]. However, the significance of these observations has been limited due to the low number of presolar silicate grains identified within each fine-grained region. Here we report on a comparison of the elemental compositions of 147 presolar silicates and over 800 non-presolar submicron silicate grains from the CO3.0 chondrite, LaPaz Icefield 031117 (LAP 031117).

Sample and Experimental Methods: We obtained a polished thin-section of the CO3.0 carbonaceous chondrite LAP 031117 from the meteorite curatorial facility at NASA Johnson Space Center. Presolar grains were identified with NanoSIMS 50 raster imaging of ^{12,13}C and ^{16,17,18}O isotopes in 10 x 10 μm^2 fine-grained areas in LAP 031117 [4]. We used the PHI 700 Auger Nanoprobe to determine the elemental composition of the presolar grains identified, as well as non-presolar (solar) silicate grains selected randomly within the NanoSIMS presputtered areas. Prior to acquiring Auger spectra, the areas of interest were sputter cleaned by scanning a widely defocused 2 kV, 1 μm Ar^+ ion beam over a broad area (~2 mm^2) of the sample surface in order to remove atmospheric surface contamination. All Auger electron energy spectra were then acquired at a primary beam accelerating voltage of 10 kV and a current of 0.25 nA over the energy range of 30–1730 eV. Quantitative elemental compositions were derived from the Auger spectra based on the experimentally derived sensitivity factors from a variety of olivine and pyroxene standards [1].

Results and Discussion: Because, on the parent-body asteroid, both presolar and non-presolar silicate grains within the same fine-grained areas should have experienced similar degrees of alteration, the effect of such processes should result in similar variations in their elemental compositions. The elemental compositions of submicron presolar and non-presolar silicate grains in different matrix regions (areas 1, 2 and 10) and a fine-grained rim (FGR, area 6) in LAP 031117 do not show any significant differences in their average elemental compositions; the median Fe contents of presolar and non-presolar ferromagnesian silicates are also similar in the matrix and FGRs (~15 at.%). All areas also exhibit a large range of Fe/Si and Mg/Si ratios (Fe/Si up to ~4 and Mg/Si up to ~2). Despite the clear identification of aqueous alteration in area 6 (e.g., presence of phyllosilicates [4]), the elemental compositions of submicron silicate grains in this area do not show any significant (or systematic) differences compared with grains in unaltered matrix areas (e.g., area 1). One exception is matrix area 5 where presolar silicate grains exhibit significantly higher Fe contents than in other areas (the median Fe content is about two times higher), and TEM analysis also indicated higher Fe contents in submicron non-presolar silicate grains (~30 at.%) and a higher proportion of magnetite grains [5]. These observations are consistent with the presence of a large Fe-rich vein, of likely terrestrial origin, in area 5, providing evidence that presolar silicates in this area might have been affected by terrestrial weathering in the Antarctic ice. We will acquire Auger data in additional fine-grained regions in LAP 031117 and compare these data with mineralogical information from the transmission electron microscopy study of several FIB sections in the same fine-grained regions.

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