REACTIVITY AND ELECTROSTATIC PROPERTIES OF ASTRONOMICAL SILICATE NANOPARTICLE ANALOGUES PRODUCED BY PULSED LASER IRRADIATION OF OLIVINE SINGLE CRYSTALS. M. Campione, M. Murri. Dept. of Earth and Environmental Sciences, University of Milano - Bicocca, I-20126 Milano, Italy (marcello.campione@unimib.it, mara.murri@unimib.it).

Introduction: With the terms "astronomical silicates" we indicate dust particles with size ranging from just below 1 nm to 1 µm, whose remote sensed optical fingerprint points to a general olivine [$(Mg,Fe)_2SiO_4$] structure. Silicate dust particles occur in various astrophysical environments and experience substantial processing in the interstellar medium, due to events such as grain-grain collisions, irradiation and shocks. The structure and chemical evolution together with the origin of these grains are still poorly understood and intensively debated [1,2].

Within this framework, the aim of this study is the simulation of space weathering processes on olivine single crystals by using them as targets in liquid phase pulsed laser ablation (LP-PLA) experiments and the analysis of the electrostatic properties and reactivity to acids and bases of the so-obtained colloidal solutions of the ablated nanoproducts.

Materials and Methods: Target samples were olivine single crystals from the São Miguel island (Azores) with 87% forsteritic [Mg_2SiO_4] composition. Inclusions of plagioclase [$NaAlSi_3O_8$-$CaAl_2Si_2O_8$] and ilmenite [$FeTiO_3$] were also present, as resulting from Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray spectroscopy (EDX) analyses. Reference colloidal solutions for the interpretation of optical spectra were prepared by dispersing in deionized water mesoporous silica [SiO_2] nanoparticles, brucite [$Mg(OH)_2$] nanoparticles, aluminum hydroxide [$Al(OH)_3$] nanoparticles, chrysotile [$Mg_3Si_2O_5(OH)_4$] nanotubes, and synthetic forsterite nanoparticles.

Olivine single crystals were fixed at the bottom of a polystyrene box filled with deionized water (type 1) to immerge the crystal completely, with the liquid level at ca. 3 mm above it. LP-PLA experiments were then performed with a Nd:YAG laser by focusing the beam with a singlet lens onto the surface of the target.

Laser pulses generate a plasma plume at the crystal/liquid interface. The rapid cooling induced by the confining liquid layer brings about the condensation of the chemical vapor it contains with production of a colloidal solution of nanoparticles. These solutions were analyzed by dynamic light scattering techniques to infer the particle size distribution and their surface electrostatic properties (ζ-potential). Optical absorption spectroscopy in the range 200-1100 nm (6.20-1.13 eV) was carried out to monitor the behavior of the LP-PLA synthesized and reference colloidal solutions as a function of the addition of known aliquots of sulfuric acid and sodium hydroxide solutions.

Results and Conclusions: The size distribution of LP-PLA synthesized nanoparticles is typically multimodal due to aggregation phenomena. Aggregation is consistent with the measured ζ-potential, which is negative with a relatively low absolute value, within the range 30-50 mV. Nonetheless, a recurrent mode is centered at about 2 nm (hydrodynamic diameter), consistently with the estimated size distribution by transmission electron microscopy analysis (average nanoparticles diameter around 3-5 nm). The optical signal of the colloidal solutions of such "Very Small Grains" [3] is centered at 215 nm. This feature is very similar to the "B2 band" reported in several studies on silica glass [4]. The "B2 band is often ascribed to oxygen vacancies, but its nature is still far to be fully understood. This band follows a clear trend as a function of pH due to a combined effect of modulation of the ζ-potential and then modification of the light scattering as a consequence of a change of the aggregation state of the nanoparticles, and of the reaction of basic [$Mg(OH)_2$] and amphoteric [$Al(OH)_3$] hydroxides.

The optical response of the astronomical silicate analog obtained by LP-PLA of olivine points to a relevant role played by Al-rich inclusions. These inclusions likely contribute after the laser-shock processing to the formation of $Al(OH)_3$ which is responsible for the appearance of an isosbestic point in the sequence of optical spectra collected at increasing amounts of basic solution.

The investigation of the surface reactivity and electrostatic properties of very small grains might find important applications in the possibility to differentiate and separate grains of different origin and in the comprehension of the cosmic evolution of dust particles.

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