IMPACT SHOCK ORIGIN OF CARBON PHASES IN YAMATO 74123 UREILITE. A. Barbaro[1], F. Nestola[2,3], L. Pittarello[4], L. Ferrière[4], M. Murri[5], K. D. Litasov[6, 7], O. Christ[2], M. Alvaro[1], and M. C. Domeneghetti[1]; [1]Department of Earth and Environmental Sciences, University of Pavia, Pavia, Italy (anna.barbaro01@universitadipavia.it; chiara.domeneghetti@unipv.it); [2]Department of Geosciences, University of Padova, Padova, Italy (fabrizio.nestola@unipd.it); [3]Geoscience Institute, Goethe-University Frankfurt, Altenhöferalee 1, 60323 Frankfurt, Germany; [4]Natural History Museum Vienna, Department of Mineralogy and Petrography, Burgring 7, 1010 Vienna, Austria; [5]Department of Earth and Environmental Sciences, University of Milano-Bicocca, I-20126 Milano, Italy; [6]Vereshchagin Institute for High Pressure Physics RAS, Troitsk, Moscow, 108840, Russia; [7]Fersman Mineralogical Museum RAS, Moscow, 115162, Russia.

Introduction: The origin and history of carbon phases (up to ~8.5% wt.%) in ureilite meteorites are controversial and important for understanding their petrogenesis and the distribution of carbon in the early solar system. Ureilites are a major group of achondrites [1, 2], and consist of ultramafic rocks, mainly composed of olivine and pigeonite and minor interstitial carbon (mostly graphite and diamond) [3]. Recent studies on ureilites [4, 5] proposed that the coexistence of large monocrystalline diamonds and nanodiamonds together with nanographite in these meteorites could be explained by the transformation from graphite through the catalysis of Fe-Ni-C melts triggered by an impact event. Yamato 74123 (Y-74123) is an Antarctic ureilite found in February 1974 by the Japanese expedition on the Yamato mountains. This is the first work focusing in detail on the investigation of carbon phases in Y-74123 [6].

Aim: Our study aims at providing further evidence of shock origin for diamond in ureilites and, at the same time, at shedding light on the importance of the heterogeneous propagation and local scattering of the shock wave and the role of Ni-Fe bearing alloys in diamond crystal growth during impact event(s).
In order to obtain reliable data on the carbon-bearing aggregates (i.e., diamond, graphite, and other minor phases) from the Y-74123 ureilite, we used here the same experimental techniques previously adopted by [4, 5].

Methods: Our investigations were performed using a scanning electron microscope equipped with energy dispersive X-ray spectroscopy (SEM-EDS) in low vacuum mode, micro-X-ray diffraction (XRD), and micro-Raman spectroscopy (MRS). These techniques allow the characterization of the carbon phases and the estimation of the pressure (by textural features of silicates) and temperature (by graphite geothermometry [7, 8]) conditions experienced by Y-74123. In detail, the Full Width Half Maximum values of the G-band of graphite were used to apply the geothermometer by [7, 8] with the aim to calculate the temperature range recorded by graphite (T_{max}) in this meteorite.

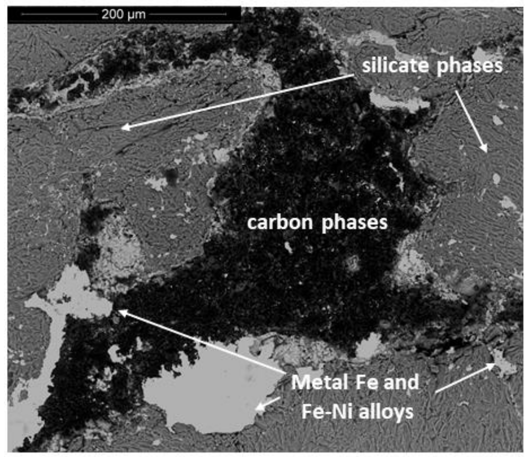

Figure 1. BSE image of a carbon aggregate from which the investigated carbon bearing subsample was removed. Also note the presence of silicate phases and metal Fe and Fe-Ni alloys (metal + troilite + oxide).

Results: Petrographic observations on silicate phases (such as undulate extinction, planar fractures, and locally, mosaicism in olivine) suggest that Y-74123 was shocked at pressure in the range of 15-20 GPa, corresponding to a shock level S4 [9, 10, 11]. Our SEM analysis of a non-carbon coated Y-74123 fragment confirmed the presence of silicate phases and interstitial carbon phases intergrown with Fe-Ni metals (Fig. 1).
XRD analysis revealed, in addition to olivine and pigeonite, the coexistence of nanodiamond and microdiamonds (up to about 10 μm in size) together with nanographite and troilite within the carbon-bearing areas. The average size of nanodiamonds and nanographite was estimated to 11-15 and 8 nm, respectively, using Scherrer equation [12].
MRS analysis, performed on the same subsample, showed that graphite in Y-74123 is disordered. Our calculations indicate a T_{max} between 1265 and 1365 °C.

Discussion: The coexistence of microdiamond nanodiamonds, and nanographite together with Fe-phases, as revealed by XRD, is similar to observatic reported by [4]. The apparent local differences in size the newly formed diamonds, i.e., nano- to micro-met in size, may result from a heterogeneous propagation a local scattering of the shock wave within a heterogenec sample [13]. The temperature range obtained using t geothermometer by [7, 8] is slightly higher than t temperature reported by [8] on the ureilitic fragment Almahata Sitta (AhS) #7 (990 °C). However, if account for the temperature uncertainties of this approa (i.e., ±120 °C [9]), our data agree with those obtain using the same approach on AhS fragments [5].

Conclusions: Combining our SEM, XRD, and MRS results together with the shock-deformation features observed in olivine, such as planar fractures and mosaicism, we suggest that diamond grains in Y-74123 were formed by a shock event (≥ 15 GPa) on the Ureilitic Parent Body. These results on Y-74123 are consistent with those obtained on the NWA 7983 ureilite [4] and further support the hypothesis that the simultaneous formation of nano- and microdiamonds is likely related to the catalytic effect of Fe-Ni melts and the heterogeneous propagation and local scattering of the shock wave, as already reported for Almahata Sitta ureilite fragments by [4]. The heterogeneous distribution of shock effects in ureilites can be mainly attributed to shock impedance contrast between contiguous phases [13].

In addition, since the XRD observation shows that graphite is nanometric in size, this supports the assumption that graphite was formed by shock. Thus, the temperature estimated here, between 1265 and 1365 °C, as obtained from graphite, represents the peak temperature experienced by the sample during the impact event.

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