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Clinopyroxenes still trapped in diamonds: high-energy synchrotron X-ray diffraction as a chemical probe

Nicola Casati (1), Fabrizio Nestola (2), Matteo Alvaro (2), Heribert Wilhelm (3), Annette Kleppe (3), Paolo Nimis (2), and Jeffrey W. Harris (4)

(1) Paul Scherrer Institut, Willigen, Switzerland (Nicola.Casati@psi.ch), (2) Università di Padova, Dipartimento di Geoscienze, Padova, Italy (fabrizio.nestola@unipd.it), (3) Diamond Light Source, Didcot, UK (heribert.wilhelm@diamond.ac.uk), (4) University of Glasgow, School of Geographical and Earth Sciences (Jeff.Harris@glasgow.ac.uk)

Clinopyroxenes are mainly Ca-Na-Fe-Mg-silicates constituting a significant portion of the Earth's upper mantle up to 20% of such shell of our planet. They could be found as typical mineral inclusions in diamonds being diopsidic and omphacitic in composition and, together with garnets, cover a key role in providing indications concerning the source rock in which the diamond crystallize. In detail, it is well known that eclogitic diamonds are characterized by clinopyroxenes with omphacitic compositions (about Ca0.5Na0.5Mg0.5Al0.5Si2O6) whereas peridotitic diamonds show clinopyroxenes very rich in the diopside end-member (CaMgSi2O6).
In order to get direct chemical composition on the inclusions, and therefore on the diamond origin source, it is obviously necessary to extract them breaking and/or polishing the diamond host. However, a non-destructive investigation of an inclusion still trapped in a diamond is useful and important for different reasons: (1) the inclusions could be under pressure and their crystal structure can be modified if the pressure is released by the extraction; (2) the residual pressure on the inclusion can provide information about the formation pressure of the diamond (e.g. Nestola et al. 2011 and references therein); (3) the morphology and growth relationships of the inclusion with the host diamond can provide indications about its protogenetic vs. syngenetic and/or epigenetic nature; and (4) preservation of the diamond surface growth features can maintain crucial information on late oxidation processes (Fedortchouk et al. 2011). However the available methods to measure the composition of the inclusions implies to destroy the sample. The aim of this work is to obtain chemical information on the inclusions still trapped in their diamond host and therefore to indicate the diamond origin without extracting the inclusions. The work was carried out by single crystal X-ray diffraction using a new experimental approach by high energy synchrotron radiation at I15 extreme-conditions beamline, Diamond Light Source Ltd. Such approach makes the absorption from the large diamond host nearly negligible (i.e. with a decrease in the mass attenuation coefficient of more than 75% with respect to a conventional laboratory X-ray source for single crystal diffraction) and allows to collect extremely high quality data on the inclusions. The details will be discussed.

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