**Alteration phases in Ca-Al rich inclusion xenoliths: evidence for nebular processes?**

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Ca-Al rich inclusions (CAIs) from chondritic meteorites are the first solar system rocks [1]. They formed at high temperature in reducing conditions at the inner edge of the protoplanetary disk. Secondary phases in CAIs are usually attributed to late Fe-Na metasomatism on asteroidal bodies [2]. However, the distribution of FeO minerals of some CAIs suggests a nebular origin [3], which would imply oxdizing conditions not expected from thermodynamics.

E101.1 is a well characterized compact type A CAI from the reduced CV3 Efremovka dominated by melilite ($Åk_{25}$ in average), associated with spinel, perovskite, fassaite and Fe,Ni metal. E101.1 contains sinuous fragments dominated by diopsidic pyroxene, which enclose FeO-rich minerals absent from the rest of the CAI [3]. O, Si and Mg isotopes indicate that these pyroxenes did not form by cristallization from the main E101.1 melt but formed by condensation, and can be considered as xenoliths [4]. Here, we conduct a detailed mineralogical study of the alteration phases in E101.1 xenoliths in order to determine if they could predate the capture of the xenoliths and be of nebular origin.

Mid-infrared spectroscopy indicates the presence of amorphous melt pockets spatially associated with the xenoliths. This is the first time that glass is reported in a CAI. Its chemistry is consistent with a mix between the xenoliths and the main E101.1 host. It is however not clear if this is a residual melt associated with the trapping of the xenoliths or a late impact melt. The FeO-rich phases have been charaterized by electron microprobe (EPMA) as kirschteinite ($Ca(Fe,Mg)SiO_4$) and Fe-åkermanite ($Ca_2(Mg,Fe)Si_2O_7$), associated with wollastonite. This mineral association is unusual and suggests formation in conditions different from the usual parent body Fe-Na metasomatism, possibly in nebular conditions. EPMA mapping shows that Fe and Na are spatially associated with the xenoliths. Fe is mostly contained by kirschteinite and Na is associated with nepheline at the boundary between xenoliths and the host. Fe and Na in the glass are found to originate from kirschteinite and nepheline, respectively. Fe and Na are abundant in the xenoliths, rare in the host CAI and nearly absent toward its edges and no Fe, nor Na are found in fractures. This distribution is again in favor of a nebular alteration.

Although our results favor a nebular origin, an asteroidal origin cannot be ruled out. Transmission electron microscopy is in progress to better constrain the formation of the FeO-rich phases.

**References:** [1] Connelly J.N. et al. 2012. *Science* 338, 651-655 ; [2] Brearley A.J. 2014. *Treatise on Geochemistry* vol.1, 309-334 ; [3] El Goresy A. et al. 2002. *GCA* 66: 1459-1491 ; [4] Aléon J. et al. *submitted to GCA*