Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10920

Mineral disequilibrium in the achondrite EC 002

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The recently reported oldest (^{26}Al-^{26}Mg age of 4565 Ma) alkali-undepleted andesitic achondrite, Erg Chech 002 (EC 002), has shown structures of mineral disequilibrium [1], whereas no reasonable explanation accounts for their presence. It seems there is a more complicated evolutional history of the parent body of EC002 than already reported. Here, we report our new analytical results of the minerals and mineral inclusions from EC002 and attempt to better understand its formation history.

Four orthopyroxene xenocrysts (2-4 mm in size) are present in our sample chips. The chemical compositions of the core areas of these xenocrysts are $En_{78.63-80.60}Fs_{16.13-16.97}Wo_{2.49-4.71}$, which are similar to the previously reported ones. Based on the back-scattered electron images, we identified two rims, namely, the inner and outer rims of the xenocrysts. The inner rims have compositions of $En_{53.24-56.07}Fs_{40.27-42.88}Wo_{2.68-5.86}$ and are chemically distinguishable from those of the outer rims ($En_{38.62-46.35}Fs_{19.61-26.87}Wo_{30.96-40.67}$). In the core area of the xenocrysts, we also detected mineral assemblage consisting of clinopyroxene (cpx), plagioclase, chromite, and quartz. It is worth noting that the chemical compositions of these hosted cpx minerals ($En_{48.86-50.23}Fs_{6.93-7.92}Wo_{41.85-43.44}$) are distinct from those of the groundmass cpx ($En_{35.97-40.02}Fs_{23.88-28.03}Wo_{35.97-40.02}$). Besides, we identified four types of chromites, i.e., the chromites in the core area of the xenocryst (C type), the ones in the boundary area between the xenocryst and the inner rim (R type), the ones in the groundmass (G type), and the ones occur as fine veins in the xenocrysts (V type). These chromites have large variations of Cr# (Cr# = 76–95). The TiO_2 contents of C and V types are less than 1 wt.%, whereas in G and R types range from 1 wt.% to 15 wt.%. In addition, correlations between Cr_2O_3 and V_2O_3 contents in C and V types are negative, but in G and R types are positive. Based on these analytical results, we preliminarily conclude that the xenocryst opx and groundmass minerals have probably not crystallized from the same magma system; and the two possible magma systems had different oxygen fugacity.

[1] Barrat et al. *PNAS*. 118 (2021).