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Unusual mineral inclusions in the Luobusa chromitite: Evidence of ultra-deep origin and recycled crustal materials

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Podiform chromitites in Luobusa ophiolite, southern Tibet, yield a wide variety of unusual minerals, including UHP minerals (micro-diamond, coesite, moissanite), highly reduced minerals (native elements, carbide, nitride, alloys), and crustal minerals (quartz, corundum, sillimanite, kyanite, zircon etc.). We reported unusual silicate lamellae (coesite, clinopyroxene and MgSiO3 phase) exsolved from chromite using TEM analysis (Yamamoto et al., 2009), and unusual ancient crustal zircon separates from chromitites using LA-ICPMS and Laser-Raman analysis (Yamamoto et al., 2013). To deduce long history of mantle convection, micro-inclusions preserved in refractory minerals can provide potential mineralogical and geochemical evidence.

Coesite as an exsolution in chromite is diagnostic UHP evidence and clinopyroxene exsolution in chromite is possible evidence of former CF-type high-pressure polymorph of chromite (>380 km deep). Silicate exsolutions in chromites are restricted in the nodular- and massive-type chromites, and disseminated-type chromites have no exsolutions. Petrographically, nodular-type chromites with abundant silicate-exsolutions are gradually modified into disseminated-type chromites in their morphology. The characteristic of the disseminated-type chromite, such as their interstitial distribution, euhedral to subhedral morphology and absence of silicate-exsolutions, suggest their formation under the low-pressure magmatic conditions.

We have measured the U?Pb age of zircon grains separated from podiform chromitites. Spot analyses with LA-ICPMS, assisted by CL images gave a wide age range, from the Cretaceous to the Late Archean (ca. 100-2700 Ma). Most of the ages are much older than those of the chromitite and ophiolite formation. Laser Raman analyses revealed that the zircons contain crustal mineral inclusions, such as quartz and K-feldspar, but lack mantle minerals (e.g., olivine, pyroxene, and chromite), suggesting that they had a crustal origin. From these results, we conclude that ancient crustal zircons in chromitites are xenocrysts that originated from continental materials that were brought into the upper mantle by ancient subduction processes, such as sediment subduction and subduction erosion.

We conclude that the podiform chromitites at the Luobusa retain evidence of their multi-stage development from ultrahigh-pressure environment to low-pressure magmatic processes, and tiny inclusions shielded by refractory minerals, such as chromite, diamond and zircon, record their prolonged history from the shallow crustal levels to the deep-mantle environments.