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The Lower Mantle Minerals in Ophiolite-hosted Diamond

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Ophiolites are fragments of ancient ocean lithosphere emplaced on continental margins, in island arcs or in accretionary prisms, and have long been studied to better understand the evolution of ocean basins and collision of tectonic plates, the processes of mountain building and the occurrence of valuable ore bodies, such as podiform chromitites (Dilek and Furnes, 2011). Because these bodies contain both upper mantle and crustal rocks of extensional origin, their magmas have traditionally been thought to form at shallow partial melting levels above spreading axes in the open ocean or above subduction zones. The podiform chromitites are currently interpreted as magmatic deposits formed during melt-rock reaction in MOR or suprasubduction zone (SSZ) environments (Zhou et al., 1994; Arai, 1997). However, discoveries of in-situ diamonds and other ultrahigh pressure (UHP) minerals, highly reduced phases and native elements, along with many crustal minerals in ophiolites and chromitites of southern Tibet and northern Ural, Russia, strongly suggest that these bodies formed at mantle depths of 150-300 km or greater, perhaps near the mantle transition zone (Bai et al., 2003; Yang et al., 2007; 2014, 2015; Xu et al., 2009, 2015; Dobrzhinetskaya et al., 2009, 2014; Yamamoto et al., 2009; Trumbull et al., 2009; Robinson et al., 2015).

Recently, diamond, moissanite and other unusual minerals were also reported from the podiform chromitite in the Hegenshan ophiolite of Inner Mongolia and the Sartohai ophiolite of Xinjiang (Tian et al., 2015; Huang et al., 2015). Both are Late Paleozoic (360-400 Ma) in age and occur along the Central Asian Orogenic Belt (CAOB), which is a huge complex extending E-W for over 4000 km and marks the boundary between the Siberian Block to the north and North China Block to the south. Here we report the first discovery of Ca-silicate perovskite as mineral inclusions in diamond from podiform chromitite in the Hegenshan ophiolite of Inner Mongolia and the Sartohai ophiolite of Xinjiang.

The mineral inclusions were identified in the foil #4070 by using FIB and TEM analyses at the GFZ, Germany. Ca-silicate perovskite in diamond from the Sartohai chromitite occurs as a 60 nm granular euhedral grain, associated with an equal size alloy. Both occur at the margin of a large graphite inclusion in diamond. EDS shows one is NiMnCo alloy (Ni 68.01, Mn 25.71, Co 6.27), the other is an oxide, with Si= 47.02at%, Ca= 42.19at% and Mn=10.78at%. The calculated mineral formula of the oxide is $Ca_{0.8}Mn_{0.2}SiO_3$, Mn-bearing Ca-silacate perovskite. The electron diffraction patterns can be indexed based on an orthorhombic symmetry of Ca-silicate perovskite and cubic structure of the alloy.

Ca-silicate perovskite (foil #4069) in diamond from Hegenshan chromitite occurs as a 50 nm grain within a large inclusion containing both Ni-Mn-Co alloy and Nd-Se-Cu-S phase. By EDS the chemical composition of the perovskite is Ca=48.3at%, Si=37.7at% and Mn=14.1at% plus oxygen. TEM diffraction data show that the Hegenshan inclusion has d-spacings and angles between adjacent lattice planes consistent with Ca-silicate perovskite with an orthorhombic structure (Li et al., 2006). Comparing to the research by others (Komabayashi et al., 2007), the formational P-T should be T＞1600℃, P＞20 GPa.

$CaSiO_3$ perovskite (CaPv) is an important mineral in both transition zone and lower mantle. It's modal mineral proportions are supposed to be about 5 and 25vol% in pyrolitic mantle and subducted mid- oceanic ridge basalt (MORB) materials, respectively, under the lower mantle conditions (e.g., Mao et al., 1989; Hirose etal.,2005).

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References

Arai, S. 1997. Origin of podiform chromitites. Journal of Asian Earth Sciences, 15(2-3), 303-310.

Bai, W.J., Yang, J.S., Fang, Q.S., Yan, B.G. and Shi, R.D. 2003. An unusual mantle mineral group in ophiolites of Tibet. Chinese Geology, 30(2), 144-150 (in Chinese with English abstract).

Dilek, Y. and Furnes, H. 2011. Ophiolite genesis and global tectonics: Geochemical and tectonic fingerprinting of ancient oceanic lithosphere. Geological Society of America Bulletin, 123, 387-411.

Hirose, K., Takafuji, N., Sata, N., Ohishi, Y., 2005. Phase transition and density of subducted MORB crust in the lower mantle. Earth Planet. Sci. Lett. 237, 239-251.

HUANG Zhu, YANG Jingsui, Paul T. ROBINSON, ZHU Yongwang, XIONG Fahui, LIU Zhao and ZHANG Zhongming, XU Wei, 2015. The Discovery of Diamonds in Chromitites of the Hegenshan Ophioite, Inner Mongolia, China. Acta GeologiaSinica (Englis Edition), 89 (2): 341-350.

Jingsui Yang, Fancong Meng, Xiangzhen Xu, Paul T. Robinson, Yildirim Dilek, Alexander B. Makeyev, Richard Wirth, Michael Wiedenbeck, John Cliff. 2015, Diamonds, native elements and metal alloys from chromitites of the Ray-Iz ophiolite of the Polar Urals. Gondwana Research. 27, 459-485.

Komabayashi, T., Hirose, K., Sata, N., Ohishi, Y., Dubrovinsky, L.S., 2007. Phase transition in CaSiO3 perovskite. Earth Planet. Sci. Lett. 260, 564–569.

Larissa F. Dobrzhinetskaya, Richard Wirth, Jingsui Yang, Ian D. Hutcheon, Peter K. Weber, and Harry W. Green II. 2009. High -pressure highly reduced nitrides and oxides from chromitite of a Tibetan ophiolite, PANS, 106 (46), 19233-19238.

Larissa F. Dobrzhinetskaya, RichardWirth, Jingsui Yang, Harry W. Green, Ian D. Hutcheon, Peter K. Weber and Edward S. Grew, 2014. Qingsongite, natural cubic boron nitride: The first boron mineral from the Earth's mantle American Mineralogist, Volume 99, 764–772, 2014.

Li, L., Weidner, D.J., Brodholt, J., Alfè, D., Price, G.D., Caracas, R., Wentzcovitch, R., 2006. Phase stability of CaSiO3 perovskite at high pressure and temperature: insights from ab initio molecular dynamics. Phys. Earth Planet. Inter. 155, 260–268.

Mao, H.K., Chen, L.C., Hemley, R.J., Jephcoat, A.P., Wu, Y., 1989. Stability and equation of state of CaSiO3-perovskite to 134 GPa. J. Geophys. Res. 94, 17889-17894.

Paul T. Robinson, Robert B. Trumbull, Axel Schmitt, JingSui Yang, JianWei Li, MeiFu Zhou, Jörg Erzinger, Sarah Dare, Fahui Xiong. 2015, The origin and significance of crustal minerals in ophiolitic chromitites and peridotites[J]. Gondwana Research. 27, 486-506.

TIAN Ya-zhou, YANG Jing-sui, PAUL T. Robinson, XIONG Fa-hui, LI Yuan, ZHANG Zhong-ming, LIU Zhao, LIU Fei, NIU Xiao-lu. 2015. Diamond discovered from chromitites in the Sartohay ophiolite, Xinjiang Province, China. Acta Geologica Sinica, 89(2), 801-809.

Trumbull, R.B, Yang, J.S., Robinson, P.T., Di Pierro, S., Vennemann, T. and Wiedenbeck. 2009. The carbon isotope composition of natural SiC (moissanite) from the Earth's mantle: New discoveries from ophiolites. Lithos, 113, 612-620.

Xu, X.Z., Yang, J.S., Chen, S.Y., Fang, Q.S., Bai, W.J. and Ba, D.Z. 2009. Unusual mantle mineral group from chromitite orebody Cr-11 in Luobusa ophiolite of Yarlung-Zangbo suture zone, Tibet. Journal of Earth Science, 20, 284-302

XiangZhen Xu, JingSui Yang, Paul T. Robinson, FaHui Xiong, DengZhu Ba, GuoLin Guo. 2015, Origin of ultrahigh pressure and highly reduced minerals in podiform chromitites and associated mantle peridotites of the Luobusa ophiolite, Tibet. Gondwana Research. 27, 686-700.

Yamamoto, S., Komiya, T., Hirose, K. and Maruyama, S. 2009. Coesite and clinopyroxene exsolution lamellae in chromites: In -situ ultrahigh pressure evidence from podiform chromites in the Luobusa ophiolite, southern Tibet. Lithos, 109, 314-322.

Yang, J. S., Dobrzhinetskaya, L., Bai, W. J., Fang, Q. S., Robinson, P. T., Zhang, J. and Green, H. 2007a. Diamond- and coesite-bearing chromitites from the Luobusa ophiolite, Tibet. Geology, 35, 875-878.

Yang JingSui, Robinson Paul T, Dilek Y. 2014, Diamonds in ophiolites[J]. Elements, 10(2): 127-130.

Zhou, M. F., Robinson, P. T. and Bai, W. J. 1994. Formation of podiform chromitites by melt/rock interaction in the upper mantle. Mineralium Deposita, 28, 98-101.