Acta Geologica Sinica (English Edition), 2019, 93(supp.1): 163–164

IGCP-649 Project "Diamonds and Recycled Mantle"

YANG Jingsui*, ZHANG Cong, SHEN Tingting and QIU Tian

Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences, China

Citation: Yang et al., 2019. IGCP-649 Project "Diamonds and Recycled Mantle". *Acta Geologica Sinica* (English Edition), 93(supp. 1): 163-164

The IGCP-649 project "Diamonds and Recycled Mantle" is an International Geosciences Program sponsored by UNESCO and IUGS, supporting the scientific research on ultrahigh pressure and highly reduced minerals in ophiolitic peridotite and chromitite. Ophiolites are 5- to 10-km-thick fragments of ancient ocean lithosphere emplaced on continental margins, and provide 3-dimensional exposures to examine the internal structure, chemical makeup and the processes of formation of oceanic rocks (Dilek and Furnes, 2011). They are also essential for containing ore bodies, such as chromites, gold and platinum group minerals, and copper deposits as valuable commodities. Conventional models interpret ophiolites as manifestations of partial melting of the upper mantle at shallow depths (60-80 km). Podiform chromitites in ophioltes are thought as magmatic deposits formed due to melt-rock reactions beneath seafloor spreading centers (Zhou et al., 1994; Arai, 1997). However, our recent discoveries of in-situ diamonds and other ultrahigh pressure (UHP) minerals, highly reduced phases, native elements, and crustal minerals in ophiolitic peridotites–chromitites of southern Tibet, northern Russia and Burma, suggest that these bodies form at mantle depths of 150-300 km or perhaps deeper, near the mantle transition zone (Bai et al., 2003; Dobrzhinetskaya et al., 2009; Trumbull et al., 2009; Yang et al., 2007, 2015). These ophiolitic diamonds are distinctly different in their morphology, carbon isotopes and mineral inclusions from diamonds occurring in kimberlites and UHP metamorphic belts, indicating a new environment for diamond formation and carbon reservoir in the deep mantle. The widely accepted models for the formation of podiform chromitites propose their precipitation from melt-rock reactions between tholeiitic to boninitic magmas and their host peridotites, which commonly consist of depleted harzburgites in mantle wedges at 60-80 km at depth. These models infer that during melt-rock reactions both clinopyroxene and orthopyroxene are removed, leaving behind a residuum of dunite, enveloping the chromitite bodies (Zhou et al., 1994; Arai, 1997; Dilek and Morishita, 2009). Although interpreting some of the field observations and geochemical features in peridotites and associated chromitites adequately, these models do not provide a plausible explanation for the existence in these ultramafic rock suites of diamonds and other UHP minerals that clearly originated near the Transition Zone in the mantle. Relevant questions include: (1) Are diamonds ubiquitous in the mantle, or only exist in isolated mantle domains? (2) Where did the carbon for diamonds come from? (3) How did diamonds and other UHP minerals reach the surface? (4) How to reconcile the apparently conflicting partial melting and crystallization histories of peridotites and chromitites recorded in them? Answers to these questions require global studies, and would contribute significantly to our understanding of the mantle dynamics–recycling, and the operation of the Earth as a heat engine. Our project is designed to address these questions. The project undertook systematic sampling of peridotites-chromitites in different ophiolites with diverse ranges of ages and geochemical affinities, such as ophiolite in China, Cyprus, Cuba and New Caledonia， to document the extent of diamond occurrence in the mantle.

From 2015-2018, four IGCP-649 ophiolite workshops have been hold around the world for researchers working on ophiolites and chromitites to study and communicate with each other and also provide opportunities for geologists to investigate the composition and evolution of the deep oceanic mantle by studying ophiolites in different orogenic belts. The first workshop in 2015 was hold in Qilian Mountain of China to examine typical oceanic eclogite and associated Caledonia ophiolite; For the second workshop in 2016, we choose world famous Tethyan Troodos ophiolite in Cyprus to have a 4-day profile across the complete ophiolite sequence and examine the lithological and compositional variations within the Cretaceous oceanic crust (Yang et al., 2016); The third 2017 IGCP-649 workshop took place in Havana, the capital of Cuba and a UNESCO World Heritage Site, to investigate and discuss the origin of Cuba ophiolite, chromitites, and peri-Caribbean mantle dynamics during VII Cuba Earth Science Convention. The world -famous Mayarí-Baracoa ophiolite belt (MBOB) in northeastern Cuba is the best preserved oceanic lithosphere from the pre-Eocen Cuban orogeny. It is unique on some geological and structural characteristics, marking distinction with respect to other ophiolites of the island. The MBOB is fantastic as it hosts the most important chromitite deposits of Cuba with both metallurgical- and refractory-type (Yang et al., 2017).

The fourth workshop was held from 4th July to 15th July, in Brisbane (Australia) and New Caledonia. The workshop was led by Prof. Jingsui Yang from Institute of Geology of CAGS, China and Prof. Jonathan Aitchison from School of Earth and Environment Sciences, The University of Queensland, Australia (Yang and Shen, 2018). After the workshop, attendees participated in a field trip to New Caledonia. New Caledonia is a French Overseas Territory, located in the southwest Pacific, about 1,200 km east of Queensland. New Caledonia consists of a principal island—Grande Terre, which is continental in origin, the Loyalty Islands, which are oceanic origin, a number of small, isolated islands that are geologically young, and several reefs. New Caledonia separated from Australia about 85 Ma ago, and

* Corresponding author. E-mail: yangjsui@163.com

http://www.geojournals.cn/dzxbcn/ch/index.aspx
https://onlinelibrary.wiley.com/journal/17556724

drifted to the northeast and reaching its present position about 55 Ma ago. During the Cenozoic, large parts of New Caledonia experienced a series of marine transgressions, and by the late Eocene nearly all of the island was covered by a thick (2000 km) sheet of peridotite that was slowly over-thrust during tectonic movement. The extensive dissected nappe of ultramafic rocks, the New Caledonia Peridotite Nappe, is one of the largest exposed ultramafic bodies on Earth, and once they extended across nearly all the of the Grande Terre as well as Pines Island and Belep islands. Although has been reduced by erosion, but it still covers 41% of the archipelago, and contributed to the considerable economic Ni, Co and Cr resources (Pirard et al., 2013). The famous blueschist to eclogite facies rocks, which crop out in the NE of the island are inferred to have experienced high-P metamorphism in response to the attempted subduction of the crustal basement terranes of New Caledonia beneath the Eocene oceanic island-arc subduction system (Clarke et al., 1997). During the field trip, various kinds of peridotite and serpentinite, chromitite, basalt, boninite, blueschist eclogite and rocks with fossils were investigated in detail and many samples were collected. Large amounts of peridotites and chromitites were collected for future mineral separation, petrological and geochemical studies.

Key words: IGCP-649, ophiolitic diamond, recycled mantle, chromitite

Acknowledgments: This work is granted by the International Union of Geological Sciences (IGCP 649), the research founding from Chinese Academy of Geological Sciences (Grant No. YYWF201702) and National Natural Science Foundation of China (Grant Nos. 41720104009, 41572051).

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)

Clarke, G., Aitchison, J.C., and Cluzel, D., 1997. Eclogites and blueschists of the Pam Peninsula, NE New Caledonia: a reappraisal. *Journal of Petrology*, 36: 843–876.

Dilek, Y., and Morishita, T., 2009. Melt migration and upper mantle evolution during incipient arc construction: Jurassic Eastern Mirdita ophiolite, Albania. *Island Arc*, 18: 551–554.

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.

Dobrzhinetskaya, L.F., Wirth, R., Yang, J.S., Hutcheon, I.D., Weber, P.K., and Green, II. H.W., 2009. High-presssure highly reduced nitrides and oxides from chromitite of a Tibetan ophiolite. *PNAS Early Edition*, 1–6.

Pirard, C., Hermann, J., and O'Neill, H.S.T.C., 2013. Petrology and geochemistry of the crust-mantle boundary in a nascent arc, Massif du Sud Ophiolite, New Caledonia, SW Pacific. *Journal of Petrology*, 54: 1759–1792.

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

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

Yang, J.S., Meng, F.C., Xu, X.Z., Robinson, T., Dilek, Y., Makeyev, A.B., Wirth, R., Wiedenbeck, M., and Cliff, J., 2015. Diamonds, native elements and metal alloys from chromitites of the Ray-Iz ophiolite of the Polar Urals, *Gondwana Research*, 27(2): 459–485.

Yang, J.S., Peaarce, J., and Dilek, Y., 2016. Probing the Troodos ophiolite: IGCP-649 workshop and field excursion held in Agros-Cyprus. *Acta Geologica Sinica*, 90(3): 1041–1044.

Yang, J.S., Qiu, T., and Angelica, I.L.C., 2017. Report on the Third IGCP-649 International workshop on the Mayari-Baracoa Ophiolites and Chromitites, Cuba. *Acta Geological Sinica*, 91(6): 2305–2309.

Yang J.S., and Shen T.T., 2018. IGCP-649 project held 2018 international workshop and field trip in Brisbane, Australia and New Caledonia. *Episodes*, 41(4): 259–265.

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.

About the first author (also corresponding author)

YANG Jingsui, male, born in 1950 in Zhejiang Province; PhD; graduated from Dalhousie University, Canada; Academician of China Academy of Sciences. He is interested in igneous petrology, petrotectonics; Tibetan Plateau and orogneic belts; ophiolite, high-ultrahigh pressure metamorphic rocks, volcanic rocks, mafic-ultramfic rocks and related mineral deposit, e.g., chromite deposit. Email: yangjsui@163.com; phone: 010-68997804.