Plume-type ophiolites in Japan, Russia and Mongolia: peculiarity and global importance

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Plume-type ophiolite [1] is characterized by abundant ultramafic lavas such as picrite, ferropicrite, komatiite and meimechite. This reflects high temperature of the source mantle plume that corresponds to the great depth of initial melting and high melting degree at shallow depths. In this context, the plume-type ophiolite is important to elucidate long-term evolution and dynamics of the earth’s mantle.

The plume-type ophiolites are fragments of ancient oceanic large igneous provinces (LIPs) or oceanic plateaus that were accreted to the continent by plate convergence. Their most typical example is the komatiite-bearing mafic-ultramafic complex in the Gorgona Island, Colombia [12] that is thought to be a part of the Caribbean LIP. Fragments of the ancient oceanic LIPs are reported from the accretionary complexes of the circum-Pacific areas such as Japan [6-10] and eastern Russia [8]. Our recent study revealed that the plume-type ophiolite with ferropicrite is also present in the Paleozoic Hangay accretionary complex in Mongolia [2], the territory evolved from closure of the Paleo-Pacific ocean. Here I discuss some general and interesting problems concerning plume-type ophiolites.

1. Are they really ophiolite?

If the Penrose-type complete stratigraphy is indispensable for identifying an ophiolite, then most plume-type ophiolites drop out from the category, because majority of the plume-type ophiolites consists solely of volcanic rocks. However, if an ophiolite is defined as an on-land fragment of ancient oceanic lithosphere, then all plume-type ophiolites satisfy this criterion. Some plume-type ophiolites accompany plutonic rocks of Alaskan-type affinity (Primorye [9] and Mikabu?) and highly depleted mantle peridotite (Sorachi-Kamuikotan-Horokanai [8]).

2. Are they different from continental LIPs?

It should be pointed out that the continental LIPs are chemically very diverse. For example, the dry and OIB-like magmas of the Ethiopian LIP are in strong contrast to the wet and arc-like magmas (with Nb negative anomaly) of the Siberian LIP. Wide geochemical variation also exists among and within the present oceanic plateaus from Shatsky to Kerguelen. However, the plume-type ophiolite magmas so far reported from Japan, NE Russia and Mongolia are devoid of arc signatures except for post-accretion, high-Mg andesite sills [2].

3. How is their global importance?

The ferropicritic magma can hardly be made from the earth’s magnesian, peridotic upper mantle material. It is generally thought that the recycled, iron-rich ferrobasaltic or ferrogabbroic rocks are necessary to produce those iron-rich ultramafic magmas [6]. However, ferropicrite and komatiite are common rocks on the surface of Mars (Gusev area [5] and Meridiani area [4, 13]) and Mercury [11]. The recycled crust model is applied for the Martian rocks [3], but long-term mantle circulation as in Earth is not plausible for these small planets, which cooled down quickly. Introduction of iron metal from the core into the superplume, or melting of primitive, metal-rich chondritic mantle material may be other choices. Primitive chondrite-melting model is preferable in view of abundant ferropicrites in the small planets. Common occurrence of ferropicrites in the earth’s plume-type ophiolites and its formation down to Cenozoic time suggest that the primitive chondritic material is still present in the lower mantle. However, Ti-rich and Cr-Mn-poor nature of Earth’s ferropicrite may suggest contribution of the recycled oceanic crust. Thus the plume-type ophiolites have universal petrogenetic importance.