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Geochemical and isotopic constraints on the genesis of the Permian ferropicritic rocks from the Mino–Tamba belt, SW Japan

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Abstract

The Permian ferropicrite and picritic ferrobasalt occur in the Jurassic accretionary complexes of the Mino–Tamba belt as dikes intruded into the basaltic volcanic rocks. They are characterized by high MgO (11–27 wt.%), FeO* (16–20 wt.%) and HFSE (Nb = 24–86 ppm and Zr = 103–399 ppm) contents. Mineralogical and petrolographical evidences indicate that their unusual iron-rich nature is apparently magmatic in origin. The incompatible element contents and ratios indicate that the picritic ferrobasalt has close genetic kinship with the previously reported HFSE-rich, but iron-poor picrites, and that they were produced by the low degrees of partial melting of HFSE-enriched source material at high pressures (4–5 GPa). On the other hand, the ferropicrite may have been produced by the same degree of partial melting at a lower pressure, and subsequent olivine accumulation. The Sr and Nd isotopic signatures ($^{87}Sr/^{86}Sr_{(i)} = 0.70266$ to 0.70329 and $\varepsilon Nd_{(i)} = +5.7$ to $+7.7$) of these picritic and ferropicritic rocks are nearly constant and are equivalent to those of HIMU rocks, which require involvement of subducted oceanic crust material into their source region. Nevertheless, the ferropicritic melt cannot have been generated from the iron-poor picrite melt by crystal fractionation. Compared to the compositions of the melts obtained by some melting experiments, production of the unusual ferropicritic melts requires addition of an unreasonable amount of recycled basaltic component into the source mantle peridotite or partial melting at extremely high pressures. A possible source material for the ferropicrite is the mixture of the recycled Fe- and Ti-rich basalt (and/or gabbro) and mantle peridotite. Such a ferrobasalt occurs in the present ocean floor and also in some peridotite massifs as Fe- and Ti-rich eclogite bodies. The ferropicritic magma may have been derived from the Permian, deep mantle plume in an oceanic setting. The occurrence of the ferropicritic rocks and the HFSE-rich, iron-poor picrite in the Mino–Tamba belt implies that the greenstone–limestone–chert complexes in the Mino–Tamba belt may be fragments of an oceanic plateau formed by the Permian superplume activities in paleo-Pacific ocean and subsequently accreted to a continental margin through subduction process in the Jurassic time.

Keywords: Ferropicrite; HIMU magma; Recycled oceanic crust; Permian mantle plume; Mino–Tamba belt; Sr and Nd isotopes

1. Introduction

A ferropicrite is characterized by high-Mg and -Fe (typically FeO* > 14 wt.%) content, and was first recognized in the Early Proterozoic Pechenga Group, NW Russia by Hanski and Smolkin (1989). Francis et al.

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(1999) suggested that the occurrences of the iron-rich picritic and komatiitic rocks reflect the high iron content of the Precambrian mantle relative to the present one. Recently, however, Phanerozoic ferropicrites are discovered in some large igneous provinces (LIPs), and it is suggested that the occurrence of ferropicrite is restricted to the LIPs regardless of geologic age, and that the ferropicrite is generated by partial melting of mantle plume consisted of a basalt–peridotite mixture (Gibson et al., 2000; Gibson, 2002).

An accretionary complex commonly consists of the rock sequence composed of mafic volcanics (greenstones), limestone, chert, sandstone and mudstone in younging order, forming the so-called “oceanic plate stratigraphy”, which were accreted to a continental margin or an island arc by the long-term subduction of an oceanic plate. Therefore, the investigation of the accreted greenstone provides us indispensable information on the ancient oceanic magmatism before Jurassic. The Mino–Tamba belt is one of the Jurassic accretionary complexes distributed in Japan (Fig. 1). Ichiyama and Ishiwatari (2005) studied the Permian HFSE-rich picrite from the Mino belt, and discussed the genetic relationships with other terrestrial HFSE-rich picrites. They suggested that the HFSE-rich picrites were generated by the partial melting of a mantle plume material containing previously subducted and recycled oceanic crust fragments at polybaric pressures, and that the Mino picrite was derived from the Permian oceanic superplume activity (see also a review by Ishiwatari and Ichiyama, 2004). Recently, we have also found ferropicritic rocks from the Mino–Tamba belt. These rocks have unusually high FeO* content (up to 20 wt.%), and contain iron-rich mineral phases such as aegirine and riebeckite. We believe that these rocks provide important constraint not only on the origin of the Mino–Tamba belt, but also on the Permian igneous activity of the whole earth. In this paper, we report the petrology, mineralogy and geochemistry of the ferropicritic rocks, and discuss their petrogenetic relationship with the Mino HFSE-rich picrite, and other continental and oceanic picrites and their geodynamic implications.

2. Geological outline and mode of occurrence

Geologic structure of the Inner Zone of southwestern Japan is essentially constructed by nappe piles. The Paleozoic–Mesozoic terranes of continental blocks (Hida and Oki), ophiolites (Oeyama and Yakuno), metamorphic belts (Unazuki, Renge, Suo and Ryoke) and accretionary complexes (Akiyoshi, Maizuru, Ultra-Tamba and Mino–Tamba) are tectonically overthrusted in order of increasing age as going upward in the nappe piles (Isozaki and Maruyama, 1991). Analogous structure is also seen in Primorye of Far East Russia, and it is interpreted that the Japanese and Russian nappe piles

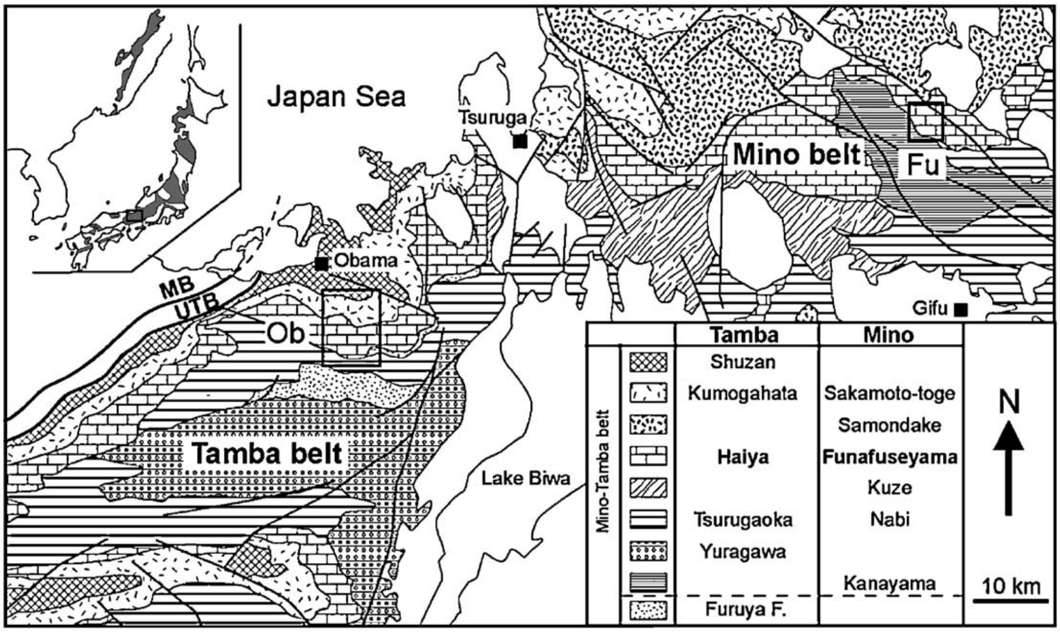

Fig. 1. Distribution of the Jurassic accretionary complexes (gray) in East Asia and geotectonic map of the Mino–Tamba belt in the Inner Zone of southwestern Japan (Nakae, 2000). Ob and Fu indicate the Obama (Tamba) and Funafuseyama (Mino) areas, respectively. UTB and MB indicate the Ultra-Tamba and Maizuru belts, respectively.