Oceanic plateau accretion inferred from Late Paleozoic greenstones in the Jurassic Tamba accretionary complex, Southwest Japan

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Large Igneous Province (LIP) is an extensive region of igneous rocks resulting from flood basalt volcanism, which is related to large-scale mantle upwelling from the deeper part ('superplume' of Larson, 1991, *Geology*, **19**, 547-). Oceanic plateaus such as Ontong Java and Kerguelen cover large areas, have anomalously thick oceanic crust, and are inferred to have originated from superplumes (Coffin & Eldholm, 1994, *Rev. Geophys.*, **32**, 1-). Compared with the Jurassic-Cretaceous LIP, the Permo-Triassic LIP are less well documented, and they are known only as continental flood basalt provinces (Siberian Trap and Emeishan) and accreted oceanic plateaus (e.g. Kerr *et al*. 2000, *J. Petrol.*, **41**, 1041- ; Tatsumi *et al*. 2000, *Geology*, **28**, 580-).

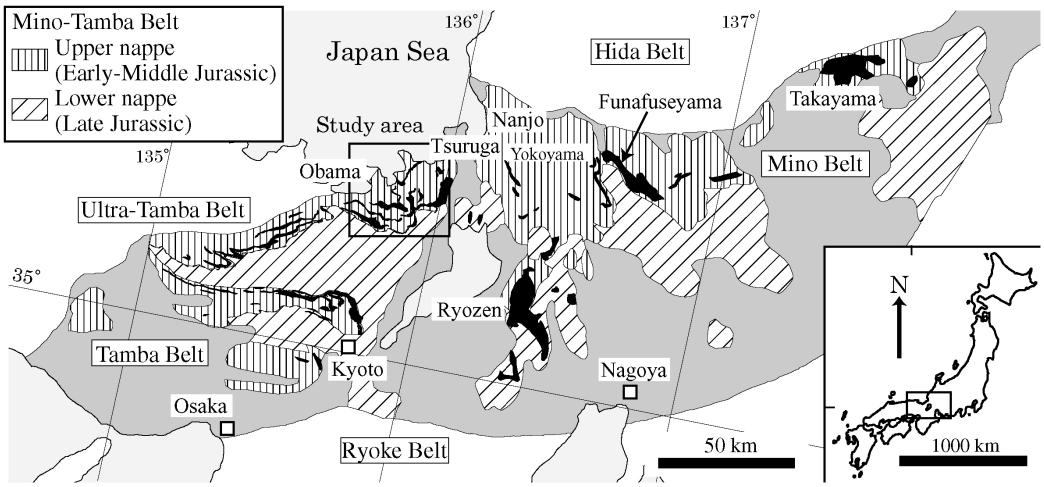

Fig. 1 Distribution of the Jurassic Mino-Tamba accretionary complex and major Permo-Carboniferous greenstone slabs (black) in Southwest Japan. Simplified from Nakae (2000, *Mem. Geol. Soc. Japan*, **55**, 73-), Ishiwatari and Nakae (2001, *108th Ann. Meet. Geol. Soc. Japan, Field Trip Guide Book*, 67-) and Wakita (1988, *Bull. Geol. Surv. Japan,* **39**, 675-).

Jurassic accretionary complexes are widely developed in Japan, Far East Russia and northeastern China. The Jurassic Tamba accretionary complex is divided into two nappes (Lower and Upper), which are further divided into five sub-nappes, each of which consists of Late Paleozoic greenstone (pillow basalt, dolerite and volcaniclastic rocks) and limestone, Permian to Jurassic chert, and Jurassic terrigenous clastic rocks (Nakae, 2000, *Mem. Geol. Soc. Japan*, **55**, 73-). The Upper nappe is characterized by occurrence of large greenstone bodies (Fig. 1). The mode of occurrence of the greenstone is divided into two types; "basal" and "mixed". The basal greenstone occurs as a large coherent slab associated with thick Permian chert and limestone beds, constituting the basal part of each sub-nappe. The basal greenstone bodies are distributed for more than 500 km length in an east-west direction (Fig. 1) and its geochemical features are relatively uniform. The mixed greenstone occurs as fragmented allochthonous greenstone blocks mixed with chert, limestone and sandstone in a Jurassic mudstone matrix. The Upper nappe contains both of the basal and mixed greenstones, whereas the Lower nappe includes only mixed greenstone. Geochemical compositions of the greenstones vary in accordance with their occurrences. The basal greenstone is predominantly

composed of homogenous tholeiitic basalt with E-MORB affinity, associated with minor HFSE-rich alkali basalt. In contrast, mixed greenstone is chemically diverse and includes tholeiitic basalt with N-MORB and oceanic tholeiite (OIT) and alkali basalt (OIA).

Thick sequence of the Tamba basal greenstone with homogeneous E-MORB chemistry and the associated occurrences of HFSE-rich picritic rocks (Ishiwatari & Ichiyama, 2004, *Int. Geol. Rev.,* **46**, 316-; Ichiyama & Ishiwatari, 2005, *CMP,* **149**, 373-; Ichiyama *et al.* 2006, *Lithos*, in press) are consistent with main features of oceanic plateaus reviewed by Kerr *et al.* (2000). The Mino-Tamba basal greenstones shows distinctly higher Nb/Y and Zr/Y rations than Jurassic-Cretaceous oceanic plateau basalt although their Zr/Nb rations are similar. Geochemical features of Permo-Triassic accreted oceanic plateaus, including the Mino-Tamba belt, are commonly characterized by enrichment of incompatible elements than that of Jurassic-Cretaceous oceanic plateaus (Fig. 2a). This suggests that the Permo-Triassic plume activities are different from the Jurassic-Cretaceous ones. Kerguelen plateau have a lower Nb/La ratio because of the attribution of continental components (e.g. Mahoney et al. 1995, *Chem. Geol.*, **120**, 315-). High Na/La ratio of the Mino-Tamba basal greenstone thus suggests to be developed in oceanic basin far from continental crust (Fig. 2b).

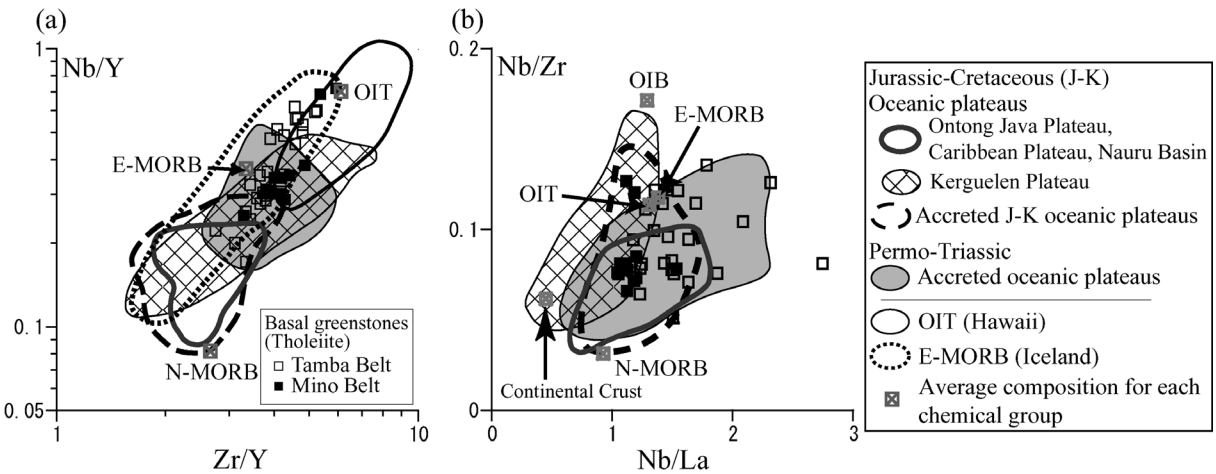

Fig. 2 Chemical comparison of tholeiitic basalts from accreted Permo-Triassic and Jurassic-Cretaceous oceanic plateau rocks on (a) Zr/Y-Nb/Y diagram and (b) Nb/La-Nb/Zr diagram. Data of continental crust is Weaver (1991, *EPSL*, **104**, 381-). Fields of E-MORB and OIT are after Maclennan *et al.* (2001, *EPSL*, **194**, 67-), Slater et al. (1998, *EPSL*, **164**, 151-), Rhodes (1996, *JGR*, **101**, 11729-) and Frey et al. (1991, *JGR*, **96**, 14347-). For data source of MORB, OIB, oceanic plateaus, accreted oceanic plateaus and basal greenstones from Mino-Tamba accretionary complex, see Koizumi and Ishiwatari (2006, *Island Arc,* **15** (1), in press).

The mode of occurrence of the greenstone is systematically related to the geochemical features. This may reflect difference in topographic relief and crustal thickness of the oceanic edifices when they accreted to the continental margin. The remnants of thick oceanic plateau crust tended to accrete to the continental margin as a large basal greenstone body with less destruction and deformation, whereas thin normal oceanic crust with small seamounts or oceanic islands accreted as mixed greenstone because of their smaller size, thinner crust and mechanical weakness. The distinction in mode of occurrence of greenstones between Upper nappe (with both basal and mixed types) and Lower nappe (only mixed type) may also reflect termination of plateau accretion, that is the change of accreting oceanic basement from thick plateau crust (Upper nappes) to thin oceanic crust (Lower nappe) through successive underplating. Thus, subduction and accretion of large oceanic plateaus have been responsible for building of a voluminous accretionary complex with abundant, thick greenstone slabs.