Tectonics in the Median Tectonic Line and surrounding areas, southwest Japan during the Late Cretaceous to Paleogene periods

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The Median Tectonic Line (MTL) in Southwest Japan, a major east–west trending arc-parallel fault, has been defined as the boundary fault between the Cretaceous Sambagawa metamorphic rocks and the Ryoke granitic and metamorphic rocks, which are unconformably covered by the Upper Cretaceous Izumi Group. It has been well known that the MTL has been reactivated as a major dextral fault in the Quaternary period (e.g. Okada, 1973), and a huge inland earthquake occurred at the western extension of the MTL in Kumamoto city in April, 2016. However, the development of the MTL since Late Cretaceous, in particular, that during the Paleogene period, has been little known. We have recently conducted very detailed fieldwork and microstructural studies of the fault rocks, and dated some of the fault gouges along the MTL and branch faults in western Shikoku.

It has been well known that the proto-MTL was initiated as the southern marginal shear zone in the Ryoke metamorphic belt in Late Cretaceous, which is characterized by a sinistral strike-slip sense of shear (Hara et al., 1980). Kubota and Takeshita (2008) have found that there are two major phases for the reactivation of the MTL during the Paleogene period: the Ichinokawa and pre-Tobe phases. While the Ichinokawa phase is defined by large-scale, top-to-the-north normal faulting, the pre-Tobe phase is represented by large-scale, high-angle right-stepping *en échelon* faults almost parallel to the MTL in the Upper Cretaceous Izumi Group. We also found that left-handed *en échelon* folds have developed along the right-stepping faults, which contain 25–60 m wide cataclasite and fault gouge. All the map-scale *en échelon* faults, folds and microstructures (e.g., composite planar structures) in the fault rocks suggest that they were formed by sinistral-reverse faulting with top-to-the-SW kinematics. Furthermore, based on the new K-Ar age dating of authigenic illite from the fault gouge along the MTL and right-stepping faults, it can be concluded that the MTL was activated in two discrete stages at approximately 59 (Ichinokawa phase) and 47–46 Ma (pre-Tobe phase).

It is interesting note that geologic structures related to both movement phases of the MTL were also recorded in those in the Sambagawa metamorphic rocks. Yagi and Takeshita (2004) and El-Fakharani and Takeshita (2008) reported that normal faulting with a top to N to NW kinematics is very intense in the limited areas, in particular, those proximity to the MTL (e.g. Niihama area). These normal faulting activities in the Sambagawa metamorphic rocks are well correlated that along the MTL at the Ichinokawa phase. Further, the formation of WNW-ESE trending *en échelon* folds is pervasive in the Sambagawa metamorphic rocks in central Shikoku including the Oboke antiform, and occur in the areas more than 20 km apart from the MTL. This folding becomes very intense with a fold wavelength less than 100 m in proximity to the MTL (El-Fakharani and Takeshita, 2008), indicating a sinistral transpression along the MTL, which perhaps occurred at pre-Tobe phase. In fact, we obtained a fission-track resetting age of 47.2 ±3.8 Ma for zircon grains in psammitic schist collected from the Oboke antiform (Takeshita et al., 2011), which is coeval with the age of the pre-Tobe phase.

Currently, we inferred that large-scale normal faulting along the MTL at the Ichinokawa phase may have been caused by a buoyant subduction of the Izanagi-Pacific ridge recently inferred by Whittaker et al. (2007) and Seton et al. (2015), while the extensive sinistral transpression along the MTL at the pre-Tobe

phase may be related to the 50 Ma event as proposed by Müller et al. (2016).

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