Conversion tectonics from spreading to subduction: Paleostress field analysis of dike swarms of the V2 arc volcanism in the Oman Ophiolite

*Susumu Umino[1], Yuki Kusano[2], Atsushi Yamaji[3], Takahiro Fudai[1]

1. Department of Earth Sciences, Kanazawa University, 2. Geological Survey of Japan, AIST, 3. Division of Earth and Planetary Sciences, Kyoto University

Paleostress field of the V2 arc stage in the Oman Ophiolite was analyzed by the method of Yamaji and Sato (2011). Conjugate sets of the V2 arc dike swarms is in contrast to the subparallel V1 MORB sheeted dike complex, indicating conversion of tectonic stress field from spreading to subduction of oceanic plates that formed the ophiolite.

The world largest and best preserved Oman Ophiolite provides the entire geological records of intra-oceanic subduction zone formation and arc evolution. The fast-spread oceanic crust consisting of 98-96 Ma MORB-like basalt (V1) was followed by 96-94 Ma arc volcanism (V2) on a shallow dipping subduction zone [2-7]. The V2 arc volcanics are dominated by arc tholeiitic rocks, which are sporadically overlain by low-silica boninite. Progressive depletion of the source mantle by stepwise melt extraction from V1 through V2 stage is indicated by the decreasing Nb/Ta ratios for the younger volcanic rocks (V2 boninite < V2 tholeiite < V1)[4,5]. This strongly suggests the absence of convection in the mantle wedge due to forced subduction of buoyant hot lithosphere, consistent with the microplate rotation model including the spreading axis [6].

The tholeiitic lower V2 volcanics are widely distributed over 200 km in the northern Oman Mountains, however, the boninitic upper V2 rocks are locally distributed between wadis Hatta and Ahin, where boninitic and tholeiitic volcanic rocks are intimately associated with hypabyssal and plutonic equivalents, such as dikes, gabbronorite and gabbros [2-5,7]. In the north of Wadi Fizh, intense E-W-striking V2 dike swarms cross cut the N-S-striking V1-stage sheeted dikes and were fed from diorite-gabbro-gabbronorite-ultramafic cumulate complex, which intruded into the V1-stage layered gabbros, sheeted dikes and lavas. On the other hand, the V2 feeders in the south of Wadi Fizh are N-S to NW-SE dikes and low-angle sheets, the latter of which locally form intense sill swarms emanated from shallow ultramafic-mafic plutonic bodies.

The V2 dikes in the north form four dense clusters of dikes 3-4 km in width and 5 km apart N-S. They strike mostly in two directions of WNW-ESE and E-W, and less commonly in N-S directions, all of which are mutually intrusive. The most intense swarms consist of 100 % sheeted dikes that appear between the lower plutonic bodies and the upper V2 strata. The paleostress analysis [1] of the E-W dike swarms shows that most dikes intruded under a vertical to steeply dipping maximum compressive stress axis and high magmatic pressure exceeding the minimum compressive stress. This indicates intrusions along extensional shear fractures oblique to the minimum stress axis, as represented by the conjugate sets of dikes. Furthermore, each swarm of dikes is divided into a couple of group of dikes that are not reconciled with the same stress orientations, suggesting of some dike intrusions along pre-existing fractures striking

N-S.

It is worthy to note that some MORB-like dikes striking N-S cross cut E-W-striking dikes of the same MORB-like composition. This suggests that intrusion of MORB-like V1 magma persisted in the early stage of V2 arc volcanism, where both V1 and V2 magmas were simultaneously active.

[1] Yamaji and Sato 2011. J. Struct. Geol. 33, 1148–116 [2] Lippard et al. 1986. Geol. Soc. London Memoir, 11 , Blackwell Sci. Pub. [3] Umino et al. 1990. Malpas et al. (eds.), Ophiolites, Oceanic Crustal Analogues, 375 - 384 [4] Kusano et al. 2014. Geol. Soc. London Spec. Pub., 392, 177-193 [5] Kusano et al. 2017. Chemical Geol., 449, 206 –225 [6] Weiler 2000. Marine Geophysical Res., 21, 195 - 210 [7] Tsuchiya et al. 2012. Lithos, 156-159, 120 –138

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