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Olivine fabric evolution in a hydrated ductile shear zone at the Moho Transition Zone, Oman Ophiolite

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ABSTRACT

The Fizh massif, Oman Ophiolite, contains a ductile shear zone at the Moho Transition Zone. The dunites in the shear zone are classified based on microstructures into coarse granular texture, medium-grained texture, mylonite, and ultramylonites toward a gabbro contact. The average grain size of olivine decreases toward the shear zone, which contains a zone of high strain (∼15 m wide). The proportion of hydrous minerals (amphibole and chlorite) in the shear zone show an increase toward the gabbro contact, suggesting that water infiltrated the shear zone from the gabbro contact. Equilibrium temperatures indicate a higher deformation temperature (∼900 °C) outside of the high strain zone compared with inside this zone (∼750 °C). Under these geochemical and temperature conditions, the temporal evolution of olivine crystal-preferred orientations (CPO) indicates the following continuous deformation scenario. First, deformation by dislocation creep under higher temperatures resulted in slip by D-type {0*kl*}[100] and then weak E-type (001)[100] slip. Next, deformation by dislocation creep under lower temperatures and higher stress conditions produced a C-type (100)[001] CPO. Finally, superplastic deformation by grain boundary sliding resulted in a random CPO.

1. Introduction

The crystal-preferred orientation (CPO) of olivine has been classified into five types (A–E) based on the role of stress and water content in CPO development (Jung and Karato, 2001; Katayama et al., 2004; Jung et al., 2006; Katayama and Karato, 2006; Karato, 2008; Fig. 1). The five CPO types are assumed to represent different dominant slip systems: (010)[100] for A-type, (010)[001] for B-type, (100)[001] for C-type, {0*kl*}[100] for D-type, and (001)[100] for E-type.

B-type CPOs have attracted great attention because their seismic properties are different to those of the other CPO types and may explain the seismic anisotropies observed in the mantle wedge, such as at NE Japan, Kamchatka, and Tonga (e.g., Jung and Karato, 2001; Nakajima and Hasegawa, 2004; Mizukami et al., 2004; Katayama and Karato, 2006; Tasaka et al., 2008). In contrast, the other CPO types are relatively poorly understood, especially the C- and E-types.

E-type CPOs are common in nature (e.g., Tommasi et al., 2000; Mehl et al., 2003; Sawaguchi, 2004; Michibayashi and Mainprice,

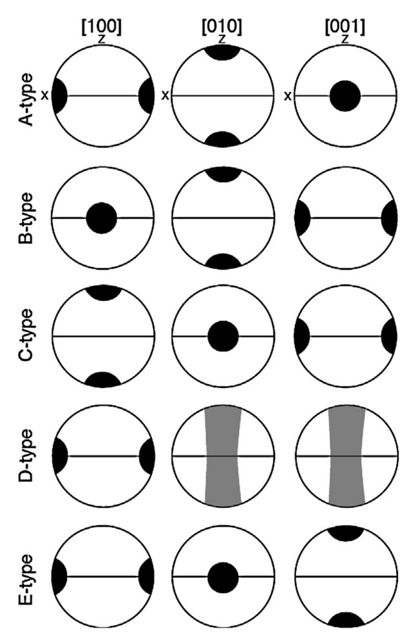

Fig. 1. Schematic olivine fabric types proposed by Jung and Karato (2001) and Katayama et al. (2004).

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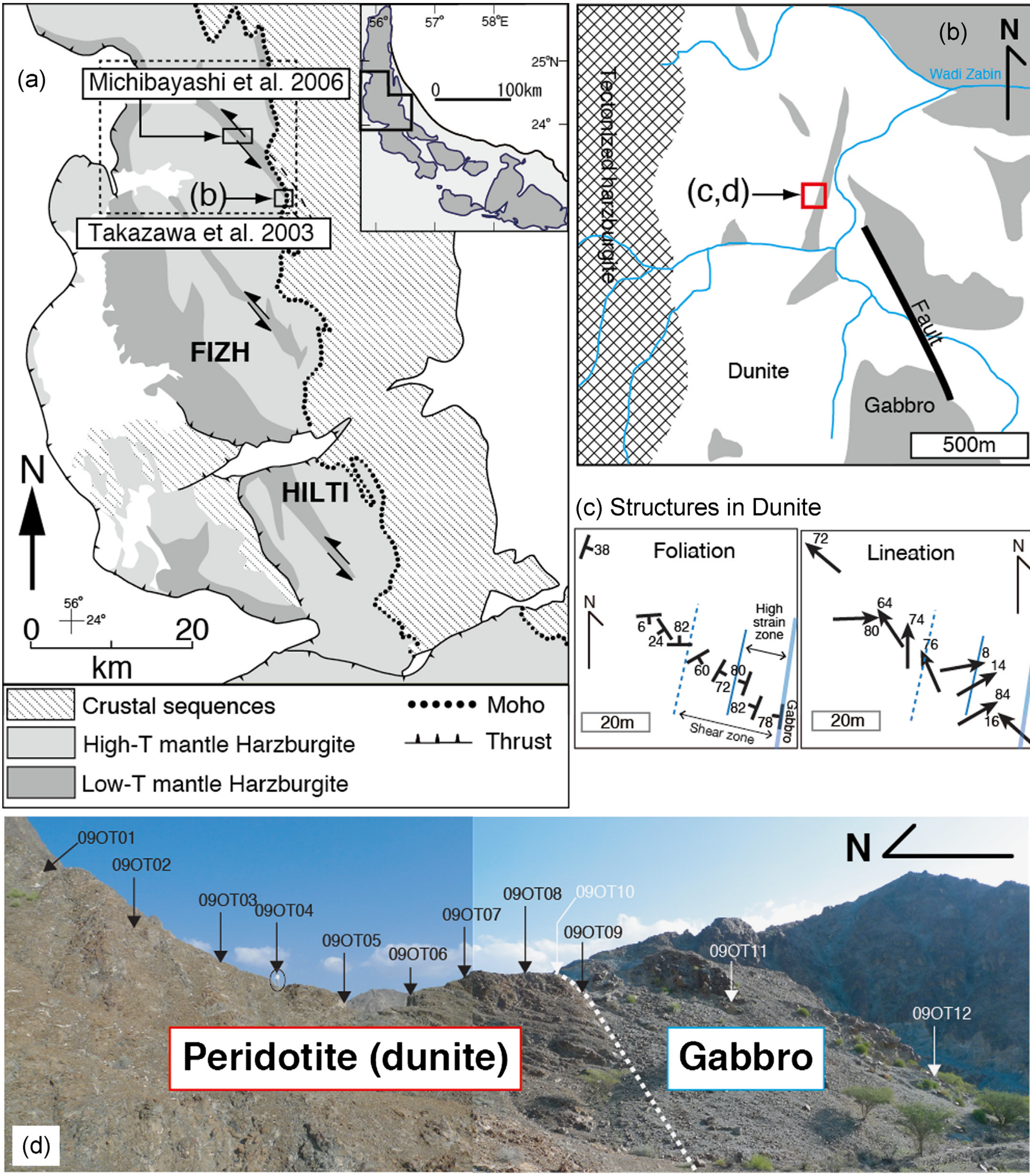

Fig. 2. (a) Locality map and generalized geology of the northern part of the Oman Ophiolite. Michibayashi et al. (2006) has studied the deeper section of the same shear zone (the small box). Takazawa et al. (2003) has studied a whole mantle section (broken box). (b) The locality of the shear zone is shown by the red box, where a ductile shear zone crosscuts the crust-mantle boundary. (c) Structures in Dunite. (d) A photograph for the outcrop of the shear zone. Sample numbers are shown with arrows that point the locations the samples have been taken. A male student (co-author, height: ca. 175 cm) is seen at the location of 09OT04.

2004; Skemer et al., 2010) and may form via (i) plastic flow under a low flow stress and intermediate water content (Katayama et al., 2004), (ii) mechanical weakening of a pre-existing mechanical anisotropy under low temperatures (Michibayashi and Mainprice, 2004), or (iii) high melt contents under high temperatures (Tommasi et al., 2006).

C-type CPOs are relatively rare in natural examples (Ben Ismaïl and Mainprice, 1998; Mainprice, 2007) and may form via