



Extreme geochemical variability through the dunitic transition zone of the Oman ophiolite: Implications for melt/fluid-rock reactions at Moho level beneath oceanic spreading centers

Mathieu Rospabé^{a,*}, Mathieu Benoit^a, Georges Ceuleneer^a, Florent Hodel^{a,b},
Mary-Alix Kaczmarek^{a,c}

^a *Géosciences Environnement Toulouse (GET), Observatoire Midi Pyrénées, Université de Toulouse, CNRS, IRD, 14 avenue E. Belin, F-31400 Toulouse, France*

^b *Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo, 05508-900 São Paulo, Brazil*

^c *Institute of Earth Sciences, University of Lausanne, Géopolis, 1015 Lausanne, Switzerland*

Received 31 July 2017; accepted in revised form 8 May 2018;

Abstract

The Maqсад area in the Oman ophiolite exposes a >300 m thick dunitic mantle-crust transition zone (DTZ) that developed above a mantle diapir. The Maqсад DTZ is primarily made of “pure” dunites (olivine with scattered chromite and chromite seams) and “impregnated” dunites, which exhibit a significant lithological variability, including various kinds of clinopyroxene-, plagioclase-, orthopyroxene-, amphibole (hornblende/pargasite)-bearing dunites. These minerals are interstitial between olivine grains and their variable abundance and distribution suggest that they crystallized from a percolating melt. Generally studied through *in-situ* mineral characterization, the whole rock composition of dunites is poorly documented. This study reports on whole rock and minerals major and trace element contents on 79 pure to variably impregnated dunites collected systematically along cross sections from the base to the top of the DTZ. In spite of its high degree of depletion, the olivine matrix is selectively enriched in the most incompatible trace elements such as LREE, HFSE, Th, U, Rb and Ba. These data support the view that this enrichment has been acquired early in the magmatic evolution of the DTZ, during the dunitization process itself. The dissolution of orthopyroxene from mantle harzburgites enhanced by the involvement of hydrothermal fluids produced low amounts of melts enriched in silica and in some trace elements that re-equilibrated with the olivine matrix. This pristine signature of the DTZ dunite was eventually variably altered by percolation of melts with a Mid-Ocean Ridge Basalt (MORB) affinity but displaying a wide spectrum of composition attributable to evolution by fractional crystallization and hybridization with the silica enriched, hydrated melts. The olivine matrix has been partially or fully re-equilibrated with these melts, smoothing the early strong concave-upward REE pattern in dunite. The chemical variability in the interstitial minerals bears witness of the percolation of MORB, issued from the mantle decompression melting, variably hybridized with melt batches produced within the DTZ by melt-rock reaction and poorly homogenized before reaching the lower crust. Our results lead to the conclusion that pure and impregnated dunites are end-members that recorded different

* Corresponding author.

E-mail address: mathieu.rospace@get.omp.eu (M. Rospabé).

stages of the same initial igneous processes: pure dunites are residues left after extraction of a percolating melt while impregnated dunites correspond to a stage frozen before complete melt extraction. Therefore dunites trace elements contents allow deciphering the multi-stage processes that led to their formation at the mantle-crust transition zone.

© 2018 Elsevier Ltd. All rights reserved.

Keywords: Oman ophiolite; Dunitic mantle-crust transition zone; Trace elements; Melt-rock reactions; Melt percolation; Refertilization

1. INTRODUCTION

The boundary between the Earth mantle and the oceanic crust is underlined by a dunitic horizon in most ophiolites worldwide, regardless the tectonic setting in which they evolved (mid-ocean ridges vs. supra-subduction zone) (e.g. Moores and Vine, 1971; Prinzhofer et al., 1980; Boudier and Coleman, 1981; Quick, 1981; Jan and Howie, 1981; Kelemen et al., 1997a; Bédard and Hébert, 1998; Ceuleneer and le Sueur, 2008; Bouilhol et al., 2009). Since dunites are observed in present-day oceans in different tectonic settings, associated to mantle harzburgites and to troctolitic-gabbroic veins and sills like in the dunitic mantle-crust transition zone (DTZ) (e.g. Arai and Matsukage, 1996; Dick and Natland, 1996; Parkinson and Pearce, 1998; Savov et al., 2005; Godard et al., 2008), it is reasonable to suppose that ophiolitic DTZ formed prior to the intra-oceanic thrusting leading to obduction.

A residual origin for dunites after very high (>40%) degrees of partial melting of the mantle (Green and Ringwood, 1967) requires unrealistic thermal regimes, at least in the modern Earth and in oceanic spreading contexts (Herzberg et al., 1983). Alternatively, dunite may result from the accumulation of olivine grains issued from fractional crystallization from a melt sufficiently rich in Mg to remain during a significant time in the fractionation field of olivine alone (\pm spinel) (Bowen, 1915; O'Hara, 1965; Elthon, 1979). Finally, dunite may be replacive after interaction ("reactional melting") between melts and peridotite in dry (Bowen, 1927; Berger and Vannier, 1984) or hydrated systems (Bowen and Tuttle, 1949). The interaction between harzburgite and a melt undersaturated in silica accounts for the formation of dunite through the dissolution of pyroxenes, leading to the enrichment in silica of the melt with concomitant crystallization of olivine (Dick, 1977; Quick, 1981; Kelemen, 1990; Kelemen et al., 1992). Petrological evolutions across a densely sampled cross section along a 330 m thick DTZ of the Oman ophiolite revealed that the DTZ does essentially but not exclusively derive from melt-peridotite interaction, its shallowest part (topmost 50 m) showing fractional crystallization trends (Abily and Ceuleneer, 2013).

In the melt-rock reaction model, it was proposed that reactional melting and orthopyroxene consumption leads to high intergranular permeability enhancing the efficiency of melt extraction from the mantle (Ortoleva et al., 1987; Daines and Kohlstedt, 1994; Kelemen et al., 1995a; Kelemen et al., 1997b). In this way, the DTZ appears to be a reactive interface where melts are focused, transformed and potentially accumulated, then distributed beneath the mid-ocean ridge. Crystallization associated to melt

migration through the mantle-crust transition zone accounts for the wide diversity of lithological facies observed in the DTZ. Dunites evolve from "pure dunites", i.e. compacted at very high temperature when complete melt extraction occurred, to "impregnated dunites", highly refertilized before incipient cooling and that potentially leads in extreme cases to the formation of hybrid olivine-rich troctolites or plagioclase-bearing wehrlites (e.g. Arai and Matsukage, 1996; Abily and Ceuleneer, 2013; Sanfilippo and Tribuzio, 2013a). Although interstitial minerals in ophiolites or abyssal DTZ are regularly found in equilibrium with melts that fed the overlying crust (e.g. Drouin et al., 2009; Ghosh et al., 2014; Nicolle et al., 2016), the Oman ophiolite DTZ was also percolated by melts with more exotic compositions (Koga et al., 2001) that, for a part of them, may be attributable to hybridization with a hydrothermal fluid component (Rospabé et al., 2017). Especially the presence of orthopyroxene, amphibole, garnet and diopsides both interstitially between olivine grains and in inclusion in chromite calls for early, high temperature, hydration of the DTZ. In this frame, to define the origin of the DTZ has direct implications on melt generation, transfer and evolution from the mantle to the crust, as well as on the deep hydrothermal circulations that may influence both the chemical exchanges and the thermal structure of the oceanic lithosphere.

Most geochemists use the trace element contents of interstitial clinopyroxene and plagioclase (if any) scattered in dunites to build petrological scenario (e.g. Kelemen et al., 1995a; Nicolle et al., 2016; Akizawa et al., 2016a). However, it concerns actually the genesis of crystallization products from melt fractions that travelled through the dunites, which might be risky to extrapolate to the genesis of the dunitic matrix itself. Very few whole rock analysis or olivine trace element contents are available due to their very low content in olivine. The sporadic studies providing trace elements data on dunite show that re-equilibration processes occurred between the olivine matrix, selectively enriched in some trace elements, and the melts percolating interstitially between olivine grains (e.g. Godard et al., 2000; Gerbert-Gaillard, 2002; Sanfilippo et al., 2014, 2017).

To better constrain the processes leading to the formation of both pure and impregnated dunitic products constituting the DTZ as well as to their chemical signature, we combined major and trace elements in whole rock and in mineral phases for 79 samples of dunite from the Oman ophiolite mantle-crust transition zone. We show that the important chemical variability recorded by the dunites at Moho level is issued from a combination of harzburgite dunitization, re-equilibration associated to melt percolation, and refertilization from unmixed and contrasted

Download English Version:

<https://daneshyari.com/en/article/8910697>

Download Persian Version:

<https://daneshyari.com/article/8910697>

[Daneshyari.com](https://daneshyari.com)