Chemie der Erde 77 (2017) 587–595

Contents lists available at ScienceDirect

Chemie der Erde

journal homepage: www.elsevier.com/locate/chemer

Compositional variability of spinel-group minerals from the shergol serpentinized peridotites along indus suture zone, ladakh himalaya (India): constraints on tectonomagmatic history

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ARTICLE INFO

Keywords:
Ladakh himalaya
Shergol peridotites
Cr-spinel chemistry
Melt-rock interaction

ABSTRACT

The Shergol ophiolitic peridotites along ISZ, Ladakh Himalaya are serpentinized to various degrees and are harzburgite in composition. Electron microprobe analyses of spinels from Shergol Serpentinized Peridotites (SSPs) were carried out in order to evaluate their compositional variation with alteration. Chemical discontinuity was observed from core to rim in analyzed spinel grains with Cr-rich cores rimmed by Cr-poor compositions. From unaltered cores to rims it was observed that Cr^{3+}# and Fe^{3+}# increases while Mg^{2+}# decreases due to $Mg^{2+} - Fe^{2+}$ and Al^{3+} (Cr^{3+}) $- Fe^{3+}$ exchange with surrounding silicates during alteration. These peridotites contain Al-rich spinels forming subhedral to anhedral grains with lobate and corroded grain boundaries; altered to ferritchromite or magnetite along cracks and boundaries by later metamorphism episode. The unaltered Cr-spinel cores are identified as Al-rich and are characterized by lower values of Cr^{3+}# (0.34–0.40), high Al^{3+}# (0.58–0.68) and Mg^{2+}# (0.52–0.70). Mineral chemistry of these Al-rich Cr-spinels suggest that host peridotites have an affinity to abyssal and alpine-type peridotites. High TiO_2 concentration of magmatic Cr-spinel cores are in agreement with MORB melt-residual peridotite interaction. Presence of unaltered magmatic Cr-spinel cores suggest that they do not have re-equilibrated completely with metamorphic spinel rims and surrounding silicates. Cr-spinel core compositions of SSPs suggest an ophiolitic origin derivation by low degrees of melting of a less-moderate depleted peridotite in a mid-ocean ridge tectonic setting. Based on textural and chemical observations the alteration conditions of studied spinel-group minerals match those of transitional greenschist-amphibolite facies metamorphism consistent with estimated metamorphic equilibration temperature of ~ 500–600 °C.

1. Introduction

The mineral chemistry of chromite or chromian spinel (Cr-spinel) is important in reflecting parent magma chemistry, degrees of partial melting, melting behavior of the mantle and variation in fO_2 (Dick and Bullen, 1984; Arai, 1994; Zhou et al., 1996; Barnes, 2000; Hellebrand et al., 2002; Farahat, 2008; Aswad et al., 2011). It also plays an important role in classifying mantle derived peridotites in terms of geotectonic setting (Arai, 1992, 2011; Zhou et al., 1997; Arai et al., 2006) and is recognized as a sensitive mineral for deducing the physico-chemical parameters such as temperature, pressure, fO_2 etc. during magma crystallization (Roeder and Reynold, 1991; Zhou and Kerrich, 1992). Primary mineral compositions, particularly that of spinels of upper mantle peridotites, are a key to constrain the extent of partial melting, fluid phase enrichment, and mantle-melt interaction processes subsequent to melt extraction (Bonatti and Michael, 1989; Zhou et al., 1996, 2005; Hellebrand et al., 2001; Farahat, 2008; Choi et al., 2008; Aswad et al., 2011). In peridotites the primary Cr-spinel is resistant against alteration and metamorphism and partly preserved to give primary petrological characteristics (Matsumoto et al., 1997; Farahat, 2008).

The primary composition of spinel-group minerals, particularly of Cr-spinel, is susceptible to chemical modifications related to sub-solidus equilibration during metamorphism and hydrothermal processes (Kimball, 1990; Barnes, 2000; Farahat, 2008). Hydrothermal fluids ingress along cracks and around grain boundaries of primary Cr-spinel grains and produce Fe-enriched spinel (ferritchromite) and magnetite rims surrounding unaltered Cr-spinel core compositions (Barnes, 2000;

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http://dx.doi.org/10.1016/j.chemer.2017.10.003
Received 1 May 2017; Received in revised form 10 October 2017; Accepted 10 October 2017