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Origin and tectonic architecture of the Dargai ophiolitic peridotites and chromitites: A geochemical perspective on platinum-group elements

Tehseen Zafar [a,b,c,**], Abiola Oyebamiji [c], Irfan Maqbool Bhat [d], Zaheen Ullah [e,f], Hafiz Ur Rehman [g], Umar Farooq Jadoon [b], Mohamed Zaki Khedr [h,i], Fatemeh Nouri [j], Fatemeh Sepidbar [k], Shuguang Song [b], Cheng-Biao Leng [l], Muhammad Farhan [m,*], Zahid Hussain [n], Mabrouk Sami [a]

[a] Geosciences Department, College of Science, United Arab Emirates University, Al Ain, United Arab Emirates
[b] School of Earth and Space Sciences, Peking University, Beijing, China
[c] Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, China
[d] Centre for Disaster Risk Reduction, Islamic University of Science and Technology, Kashmir 192122 J&K, India
[e] Xinjiang Research Center for Mineral Resources, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences, Urumqi 830011, China
[f] Centre for Earth and Space Sciences, University of Swat, Swat 19120, Pakistan
[g] Department of Earth and Environmental Sciences, Kagoshima University, Kagoshima, Japan
[h] Department of Geology, College of Science, Taibah University, Madinah, Saudi Arabia
[i] Department of Geology, Faculty of Science, Kafrelsheikh University, 33516 Kafrelsheikh, Egypt
[j] Department of Mining Engineering, Faculty of Engineering, University of Kurdistan, Sanandaj, Iran
[k] Department of Geology, Faculty of Science, Ferdowsi University of Mashhad, Mashhad, Iran
[l] State Key Laboratory of Nuclear Resources and Environment, East China University of Technology, Nanchang, China
[m] Department of Marine Sciences, Zhejiang University, Zhoushan, China
[n] College of Oceanography, Hohai University, Nanjing, China

A B S T R A C T

The Dargai ophiolites in northern Pakistan are characterized by extensive peridotite and chromitite exposures, however, their geochemical evolution remains debated. Here we investigate the mineral chemistry and platinum-group elements (PGEs) of the Dargai ophiolitic peridotites and associated chromitites to elucidate their genesis and tectonic evolution. Olivine, pyroxenes, and spinel compositions suggest a forearc setting, with Dargai peridotites representing refractory mantle residues formed through two stages of melting. Initial low-degree melting produced less depleted peridotites and high-Al chromitites with mid-ocean ridge affinity, followed by high-degree melting resulting in the formation of high-Cr chromitites and highly depleted peridotites in a supra-subduction zone. The depletion of Palladium and Platinum in high-Cr chromitites suggests that they were formed from sulfur-undersaturated melts, while enrichment in high-Al chromitites reflects that they were formed from sulfur-saturated parental melts. Melt impregnation after partial melting influenced the geochemical signatures, revealing interactions between peridotite and infiltrating melts. The geochemical evolution, combined with melt modeling, suggests the formation of MORB-like melts during proto-forearc spreading and the formation of boninitic melts during mature arc formation, explaining the co-occurrence of high-Al and high-Cr chromitites.

1. Introduction

Ophiolites are important to understand mantle evolution and tectono-magmatic events (Uysal et al., 2012; Khedr et al., 2023; Ullah et al., 2025a, b). Tectonically, ophiolites represent sections of oceanic crust and upper mantle that have been emplaced onto continental boundaries. Ophiolites exhibit notable variations in geochemical characteristics thus providing evidence of various tectonic environments, ranging from rift–drift phases to the initiation and final stage of plate tectonic subduction (Furnes et al., 2014, and references therein).

Understanding the geochemistry and mineralogy of ophiolitic peridotites is crucial for gaining insights into: (1) the melt–mantle interface, (2) how melt is extracted from the mantle, (3) the compositionally heterogeneous nature of the mantle, and (4) how extensive the mantle can be depleted (Aldanmaz et al., 2009; Uysal et al., 2012; Dilek and Furnes, 2014; Saccani et al., 2017; Gamal El Dien, 2021). Specifically, geochemical analyses of major, minor, and trace elements, provide evidence regarding the multi-stage tectonic environments in which

* Corresponding author.
** Corresponding author at: Geosciences Department, College of Science, United Arab Emirates University, Al Ain, United Arab Emirates.
E-mail addresses: zafar@vip.gyig.ac.cn (T. Zafar), farhangeol@gmail.com (M. Farhan).

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