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RESEARCH ARTICLE

Supra-subduction Zone Arc Magmatism along the Indus Suture Zone (ISZ), Western Ladakh: Implications from Clinopyroxene Chemistry of the Thasgam Ophiolitic Slice

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ABSTRACT

In Western Ladakh, a dismembered ophiolitic slice is exposed at the Thasgam Village, Kargil District, along the Indus Suture Zone (ISZ). This study presents the clinopyroxene mineral chemistry of gabbros from the Thasgam ophiolitic slice. These gabbros are massive, essentially composed of plagioclase and clinopyroxene with minor amounts of orthopyroxene, hornblende and opaques. The clinopyroxenes are very low in TiO_2 (0.18 to 0.31 wt.%) and Al_2O_3 (1.74 to 2.51 wt.%), while rich in CaO (21.23 to 24.47 wt.%) and MgO (15.5 to 16.4 wt.%), and show diopside compositional affinity in the Wo-En-Fs ternary diagram. These low-Ti clinopyroxenes are inferred to be tholeiitic in nature with a subduction-related island arc affinity.

Keywords*:* Western Ladakh, Island Arc, Thasgam Ophiolitic Slice, Gabbro, Clinopyroxene

INTRODUCTION

Supra-subduction zone (SSZ) ophiolites are significant in unravelling the source composition and extent of fluid/melt interaction in the mantle wedge and, thereby, the tectonic history of the subduction complex (Dilek and Furnes, 2019). Clinopyroxene is an important crystallizing mineral phase in mafic-ultramafic rocks and preserves crucial information about the parental mantle source composition (Batki et al., 2018; Li et al., 2020). Its compositional variation depends on the tectonic setting of the host magma related to the ophiolite sequences (Nisbet and Pearce, 1977; Beccaluva et al., 1989; Nayak and Pal, 2021). It has been demonstrated that the clinopyroxene mineral chemistry can be used as a proxy for determining thermo-barometry, petrogenesis, and tectonic setting of ophiolites (Nisbet and Pearve, 1977; Leterrier et al., 1982; Beccaluva et al., 1989; Yaliniz and Goncuoglu, 2000; Moazzen and Oberhansli, 2008; Ovung et al., 2018; Barnes et al., 2020; Vind et al., 2021; Khare et al., 2022). In low-grade metamorphosed rocks, the magmatic signatures of clinopyroxenes are well preserved and usually remain unchanged (Fodor and Thiede, 1977; Beccaluva et al., 1989). High-Ti clinopyroxenes generally occur in the mid-ocean ridge, back-arc basin, and Fe-depleted magmatic environments (Nisbet and Pearce, 1977; Beccaluva et al., 1989), while low-Ti clinopyroxenes are associated with the intra-oceanic island arc magmatism above subduction zones (Beccaluva et al., 1989). In clinopyroxenes, Al and Ti concentration generally increases from tholeiitic to per-alkaline magmatic affinities (Le Bas, 1962). In addition, clinopyroxene exhibits systematic and subtle chemical differences related to crust-mantle processes, melt-peridotite interaction, host magma composition, and tectonic affinity (Leterrier et al., 1982; Beccaluva et al., 1989; Putirka et al., 1996; Yogodzinski and Keleman, 2007; Chen et al., 2018; Vind et al., 2021).

In the Ladakh Himalaya, Late Jurassic to Early Cretaceous ophiolites are exposed along the Indus Suture Zone (ISZ), representing remnants of the eastern portion of the Neo-Tethys Ocean (Ahmad et al., 2008; Bhat et al., 2019a, 2019b; Buckman et al., 2018). Although, extensive whole-rock geochemical data is available on the ophiolitic rocks of the western Ladakh viz., Dras, Thasgam, Suru Valley, Shergol ophiolitic slices (Bhat et al., 2019a, 2019b, 2019c, 2021, 2023) however, limited studies are available on the mineral chemistry to understand the petrogenesis and tectonic affinity of the host ophiolitic rocks. In western Ladakh, the Thasgam ophiolitic gabbro offers distinct insights into the geodynamic evolution of SSZ magmatism. The main objective of the present study is to decipher the petrogenesis of Thasgam ophiolitic gabbros based on their clinopyroxene mineral chemistry. Further, the integration of clinopyroxene mineral chemistry with the available published data of other Neo-Tethyan ophiolites such as Nidar, Shergol, and Dras ophiolitic rocks of Ladakh Himalaya provides robust indicators for understanding melt evolution, mantle heterogeneity, and tectonic settings.

STUDY AREA

In Ladakh Himalaya (Fig. 1a), the ophiolites are highly dismembered, similar to other Tethyan ophiolites (Moores et al., 2000), and are emplaced as discrete thrusted blocks over the Dras arc complex (Radhakrishna et al., 1984; Reuber, 1989; Robertson, 2000). These ophiolitic slices are represented by Dras ophiolitic slice (Radhakrishna et al., 1984; Bhat et al., 2019a); Suru Valley ophiolitic slice (Bhat et al., 2019b); Shergol ophiolitic slice (Bhat et al., 2019c); Spongtang ophiolite complex (Buckman et al., 2018), and Nidar ophiolitic complex (Ahmad et al., 2008; Nayak and Pal, 2021).