



Magmatic evolution of the Karakoram Batholith, Trans-Himalaya, NW India: Geochemical insights for arc dynamics and crustal growth

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ABSTRACT

The Karakoram Terrane (KT), a continental block along the southern margin of the Asian Plate, originated within the *peri*-Gondwanan Cimmerian assemblage. It rifted from the Gondwana during the Permian, opened the Neo-Tethys Ocean, and accreted to southern Asia by the Early Jurassic. To constrain its tectono-magmatic evolution, we present whole-rock geochemical data from the Karakoram Batholith (KB), a major granitoid complex of the Trans-Himalaya, NW India. The KB is dominated by porphyritic granites containing abundant diorite enclaves, reflecting magma mingling between coeval mafic and felsic melts. Geochemically, KB granites and diorites exhibit calc-alkaline metaluminous characteristics typical of I-type granitoids, analogous to subduction-zone settings. KB granites have whole-rock $\epsilon_{\text{Nd}}(t = 110 \text{ Ma})$ values from -6.9 to -8.8 with Nd depleted mantle model ages (T_{DM}) from 1650 to 1857 Ma. Similarly, KB diorites have whole-rock $\epsilon_{\text{Nd}}(t = 110 \text{ Ma})$ values from -4.5 to -6.3 with T_{DM} from 1800 to 1953 Ma. These results are analogous to those of the Middle Cretaceous KB diorites (-8.2 to -7.3, and 1380 to 1650 Ma; respectively). These features indicate that during the Jurassic-Cretaceous, northward subduction of the Neo-Tethys oceanic plate beneath the southern margin of the KT established an Andean-type tectonic setting. This emplaced extensive KB magmatism derived from mixed sources, including the mantle wedge and upper crustal rocks of the KT.

1. Introduction

Continental arcs that develop along ocean-continent convergent margins are commonly referred to as Andean or Cordilleran-type systems (Gan et al., 2023). In contrast to intra-oceanic arcs, continental arcs display greater compositional and structural complexity. This complexity arises from the extensive interaction between mantle-derived magmas and older continental crust, in addition to the influence of slab-derived fluids and melts (Wilson, 1989). Progressive crustal thickening, assimilation, and magma mixing drive arc maturation over time (Zheng, 2019). As a result, continental arc magmatism provides a record of chemical exchange occurring between the subducting slab and the mantle wedge (Rudnick and Gao, 2003). This process provides crucial insights into the growth and evolution of continental crust in subduction environments (Hawkesworth et al., 2019).

The Himalayan region preserves a long-lived history of the Neo-Tethyan origin, subduction, accretion, and associated magmatic activity (Upadhyay et al., 1999). Multiple magmatic phases across the orogen

and adjoining terranes document the progressive reorganization of this convergent margin (Stampfli and Borel, 2002). Within this framework, the Ladakh Himalayan segment records signatures of both subduction processes and fore-arc to back-arc tectonics (Jain, 2014). Understanding the spatial and temporal evolution of these magmatic arcs is therefore fundamental to constrain the formation and modification of Himalayan orogenic belts.

The Karakoram Terrane (KT) was originally part of the *peri*-Gondwanan Cimmerian assemblage (Searle, 2011). It rifted from Gondwana during the Permian, which led to the opening of the Neo-Tethys Ocean (Groppo et al., 2019). By the Early Jurassic, it accreted to the southern margin of Asia (Saktura et al., 2023). Northern KT exposures are predominantly composed of Carboniferous-Cretaceous metasedimentary rocks (Pundir et al., 2020a). In contrast, the southern region is characterized by the Karakoram Batholith (KB), which consists of a suite of Late Jurassic to Late Cretaceous granitoids (~160–62 Ma), along with Murgo volcanics and the Miocene Nubra-Siachen leucogranites (Pundir et al., 2020a; Saktura et al., 2023). This terrane extends westward across the

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