Petrology of the ultramafic rocks from the Waziristan Ophiolite, NW Pakistan

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Waziristan is the 2nd largest (~1800 km^2 in area) of the ophiolites exposed along the western plate boundary of the Indian Plate and involved in the India-Afghan collision (Figure 1). Spread across the border between the Waziristan Tribal Agency, Pakistan, and Khost Province, Afghanistan, the ophiolite body is probably an extension of the Khost ophiolite (Cassaingeau, 1979; Gnos et al., 1997). The ophiolite is one of the three major thrust sheets derived from the Neothyteys and emplaced onto the western passive-margin outer shelf of the Indian Plate in Pakistan. The Waziristan ophiolite (WO) is the uppermost thrust sheet, followed eastwards by the Kurram-Khaisora nappe derived from Triassic-Paleocene Outer Shelf, and westwards by the Kahi nappe derived from a Cretaceous oceanic fore-deep sequence (Robinson et al., 2000; Khan et al., 2003). The ophiolite was intially obducted at 90 Ma within an intraoceanic setting (Gnos et al., 1997), but emplacement onto the Indian-Plate shelf sequence is dated at Late Paleocene (Beck et al., 1995; 1996).

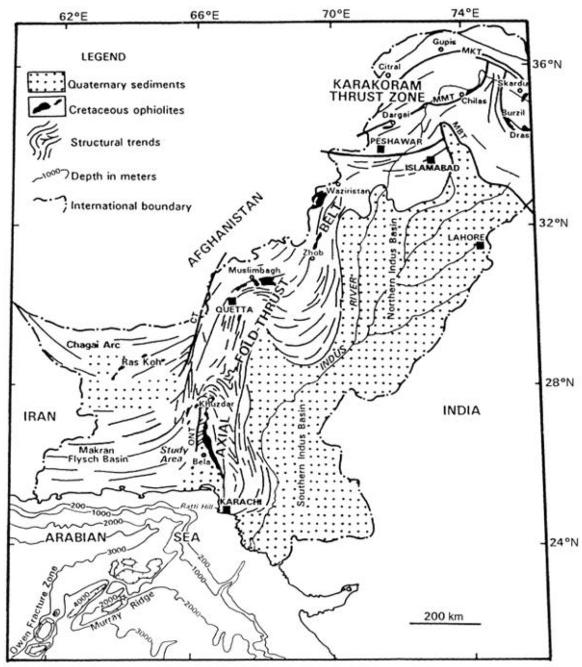

Figure 1. Simplified geological map of Pakistan showing Cretaceous ophiolites at the western-northwestern plate boundary of the Indian plate (Asrarullah and Abbas, 1979).

WO is internally divisible into three thrust sheets (nappe); these, from east to west (i.e., lower to upper), include, Vezhda Sar, Boya and Datta Khel nappes. Despite strong tectonic dismemberment, the WO, includes all the principal lithological elements of a type ophiolite, i.e., ultamfic rocks, gabbros, sheeted dykes, plagiogranite, pillowed basalts and pelagic sediments. This paper is restricted to the ultramafic rocks in terms of their petrology and mineralogy.

The Vezhda Sar nappe, which forms the eastern edge of the WO and is thrust over the outer shelf sediments of the Indian Plate, is composed entirely of pillow basalts. Ultramafic rocks in this nappe are restricted to exotic blocks dispersed in the pillow basalts. The Boya nappe, which forms the central part of the WO is strongly dismembered, giving the appearance of a typical mélange. Here, the ultramafic rocks are irregularly distributed as fault-bounded blocks within a larger mass of pillow basalt. However, an intact ophiolite section occurs in the basal part of the nappe at Mami Rogha. This sequence is composed of ultramafic rocks at the base, followed upwards by isotropic gabbros, and pillow basalts capped by pelagic sediments. In the Datta Khel nappe, the ophiolite sequence starts with gabbros at the base, and the ultramafic rocks occur only as fault-bounded blocks, irregularly distributed in the thrust sheet.

Ultramafic rocks in the ophiolites and oceanic crust are commonly of two types; granular- and layered peridotites, respectively occuring below and above the petrological Moho. The former, having annelaed under high temperature, are commonly refered to as the mantle (tectonized) peridotites, while the latter are considered to have crystallized as comulates from a basaltic magma in the ophiolite magma chamber. A great majority of the WO ultramafic rocks are characterized by a cumulus textures typical of the crustal untramafic rocks in ophiolites and oceanic crust. The mantle peridotites are either not exposed or not sampled. The ultramafic cumulates in the WO include wherlite (olivine, diopside with enstatite, magnetite and chrome spinel as accessories), harzburgite (olivine, enstatite, with minor accessroes of diopside and chrome spinel), and dunite (olivine with minor clinopyroxene); wherlite being the most common and dunite being the least. Chromitite forms lensoide bodies (up to 3 m thick), layers (cm scale), veins and stringers associated with dunites. It consists of chromite and olivine or secondary chlorite and serpentine.

Olivine and chrome spinels from the ultramafic rocks of the WO have been analyzed for mineral chemistry. Olivine in the silicate rocks is characterized by a high foresterite content, but with a narrow range, i.e., Fo 90-91. Orthopyrexene in the harzburgite is similarly magnesian (En 90-91).The peridotites locally contain swarms of pyroxenite dykes comprising enstatite ± olivine ± opaque oxide. The olivine in the chromitites is more magnesian (Fo 92 to 96) due probably to Mg – Fe exchange with chromite during subsolidus re-equilibution.

Chromite shows considerable variation in Cr# (100 Cr/(Cr + Al) and Mg # (Mg/ (Mg+Fe^{2+}). The Cr # ranges from 84 to 45 in chromitites and 74 to 21 in accessory chromite. Similarly, Mg # ranges from 44 to 55 in chromite in chromitites and 76 to 47, in accessory chromite. Several workers (i.e., Dick and Bullen, 1984, Jan and Windley, 1991) have suggested that large variations in chromite compsoition, especially in Cr #, may be suggestive of a complex origin.

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