The Dongcaohe ophiolite from the North Qilian Mountains, NW China: A fossil oceanic crust of the Proto-Tethys Ocean

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Abstract

The Dongcaohe ophiolite, a tectonic block with an areal extent of 3 km×6 km, is a Proto-Tethyan ophiolite in the North Qilian Mountains. It consists of an intrusive sequence and an extrusive sequence. The lower part of the intrusive sequence consists of modally cyclic layers of cumulate dunites, troctolites, anorthosites, anorthositic gabbros, and gabbros intruded by many small discordant dunite-troctolite layered bodies. This layered cumulates series grades upward into an isotropic gabbro series in the upper part, which consists of gabbros and gabbronorites. The intrusive sequence is overlain by the extrusive sequence of sheeted diabasic dikes and basaltic lavas. Order of mineral crystallization for the intrusive sequence is olivine±Cr-spinel, plagioclase, clinopyroxene, orthopyroxene, and Fe-Ti oxide minerals.

Twenty-two rock samples of the Dongcaohe ophiolite, including eleven layered cumulates, three isotropic gabbroic rocks, and eight volcanic rocks, were analyzed for their major, minor, and trace elements. Samples of four layered gabbro cumulates, three isotropic gabbros, and six volcanic rocks were further analyzed for their Nd-Sr isotopic compositions. Plots of the major elements against the Mg# show that chemical variation of the major elements from bottom to top of the intrusive sequence were controlled by fractionation of olivine, plagioclase, and pyroxenes. The modeled liquids of the gabbronorites are essentially the same as the extrusive rocks in composition, indicating that the magmas formed the extrusive rocks could be derived from a primary basaltic magma by fractionating the mineral assemblage of gabbronorite, or that the rocks of the extrusive and intrusive sequence were co-magmatic. The REE patterns and discriminating diagrams of trace elements of the volcanic rocks all indicate that the Dongcaohe ophiolite was formed most probably at mid-ocean ridge of a major ocean or a mature backarc basin.

Nd-Sr isotopic study shows that the age-corrected εNd(t) and $(^{87}Sr/^{86}Sr)_t$ of the Dongcaohe ophiolite range from 4.0 to 6.1 and from 0.7028 to 0.7066 respectively. These values fall within the compositional range of the modern Indian oceanic crust. The three gabbronorite samples are plotted on the mantle correlation line in the εNd(t) vs $(^{87}Sr/^{86}Sr)_t$ diagram, implying that effect of sea-floor metamorphism or post-emplacement geological processes on the gabbronorite is negligible. The present study indicates that the Proto-Tethyan asthenospheric domain, just as the Paleo-Tethyan, Neo-Tethyan, and modern Indian asthenospheric domains, was characterized by relatively low εNd(t) and relatively high $(^{87}Sr/^{86}Sr)_t$.