Preservation of geochemical characteristics in Permo-Triassic mudstones by metagenesis and low-grade metamorphism in the Tethys Himalaya, Central Nepal

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Pre-Himalayan tectonic history has been poorly addressed in previous models of the Himalayan Mountains and Tibetan Plateau crustal structures. With the opening of the Neo-Tethys Sea and convergence in the southern margin of the Asian continent, it is assumed that a large amount of continental and oceanic blocks, ophiolites, and arcs collided and accreted to the Asian margin until the Late Cretaceous period, prior to the Late Eocene [1]. It is also believed that a series of the collisions by such blocks until the Himalayan–Tibetan orogeny led to an increase in the crustal thickness of the Asian continent [2]. Recent studies of the individual geological blocks located in the suture zones and melange belt between the Indian and Asian continents reveal the individual tectonic and environmental histories of each geological unit [3, 4]. However, most of these blocks were affected by low-to-high grade metamorphic effects during the Himalayan–Tibetan orogeny. The estimation of the preservation of the geochemical signature in low-grade metamorphic rocks originating from the Paleozoic and Mesozoic geological units is still controversial, and the correlation and reconstruction of these blocks often encounter difficulties.

The present study of the geochemistry of the Permo-Triassic successions in the Tethyan Himalaya enabled us to test and estimate the preservation degree of geochemical signatures in Jomsom and Manang regions in the Central Nepal, using major, trace, and rare-earth elements (REE) in mudstones using X-ray fluorescence spectrometry (XRF) and inductively coupled plasma mass spectrometry (ICP-MS). Additionally, we used the excursion pattern of stable carbon isotope ratio (δ13C) from the Triassic carbonates.

A previous study suggests that the Paleozoic–Mesozoic sediments of the Manang region suffers from higher grade diagenesis and lower grade metagenesis (330–370 °C), because of mineral assemblage, vitrinite reflectance, crystalinity of metamorphic mica minerals, and paleomagnetism [5]. On the other hand, those in the Jomsom region are affected by the slightly lower thermal effects, though it reached into metagenesis (250-280°C; [6]).

In the Jomsom region, the geochemistry of the Triassic mudstones reveals high concentration of Al_2O_3 because of the dissolution of feldspars by intense weathering during the Early Triassic period. In addition, trace elemental geochemistry indicates Zr addition in the Triassic mudstones of Jomson because of the concentration of zircon grains derived from old sedimentary rocks by intense reworking during the Late Triassic period. The REE geochemistry suggests that all Triassic mudstones have a chondrite-normalized pattern similar to PAAS (Post Archaean Australian Shale), indicating their origin from continental-type rocks. Obvious changes in the Eu/Eu*, Th/Sc, and La/Sc ratios were detected from the Late Triassic mudstones, which implies that additional provenance rocks could occur in the hinterland, including more felsic or old sedimentary rocks.

The excursion pattern of the stable carbon isotope ratio from the Manang region is similar to that of the Jomsom region, though the individual value of δ13C in the Manang region suggests its clear shift to a lower value. When considering the geochemistry of major elements, the Lower Triassic sequence in both regions is commonly characterized by the high concentration of Al_2O_3. In the Manang region, the increase in the concentration of K_2O and decrease in that of CaO, MgO and MnO were observed; these effects seem to clearly increase in the finer sediments of the Triassic mudstones of the Jomson region. The difference in the concentrations of immobile trace elements, e.g., Zr and Th, is not clear in both regions, whereas the concentration of relatively mobile trace elements, e.g., Rb, Sr and Ba, shows distinct difference. The chondrite-normalized REE patterns of mudstones from both regions do not show any obvious difference.

The difference in the major and trace elemental chemistry of the Triassic mudstones between the Jomsom and Manang regions probably represents the difference in the diagenetic and metamorphic conditions. However, stable carbon isotope ratio is more sensitive, and the excursion pattern is likely preserved even in higher grade diagenesis. The signature of immobile elements is still preserved in higher grade diagenesis and lower grade metagenesis; chondrite-normalized REE pattern is also distinguishable. These elemental signatures are important for deciphering the complex tectonic history and correlating each geological block in the Himalayan–Tibetan orogenic belt.

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