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Serpentinites in the Ophiolite Belts of Kazakhstan: A Proxy for the Chemical Transformationof the Paleozoic Mantle

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Serpentinites in the Ophiolite Belts of Kazakhstan: A Proxy for the Chemical Transformation of the Paleozoic Mantle

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This study presents a comparative petrographic, mineralogical, and geochemical analysis of serpentinized ultramafic mantle rocks from three geologically significant Paleozoic regions: the Kempirsai massif (Southern Urals), the Char Ophiolite Belt (Eastern Kazakhstan), and the North Balkhash ophiolite zone. These complexes serve as critical indicators of the tectonic and chemical evolution of the Central Asian Orogenic Belt (CAOB) and the Uralian orogen. Petrographic observations reveal varying degrees of fluid-assisted alteration, ranging from partially preserved relict textures to complete serpentinization dominated by lizardite and antigorite minerals. In the Char and North Balkhash samples, olivine alteration is characterized by well-developed mesh textures, with advanced alteration stages exhibiting fibrous, bladed, and massive serpentinite fabrics that define a planar foliation. In contrast, samples from the Kempirsai (Aktobe) region are dominated by vein-related structures and better-preserved relict olivine along with Cr-spinel.

The mineralogy and bulk chemistry reflect distinct geodynamic environments. The Kempirsai massif, which hosts world-class podiform chromite deposits in dunite-harzburgite lithologies (MgO 38–42 wt. % and FeO 5–7 wt. %), is a characteristic of a supra-subduction zone (SSZ) mantle wedge. The North Balkhash zone similarly indicates high-degree melt extraction in a forearc setting (MgO 34–39 wt.% and FeO 6–9 wt.%). Conversely, the Char Ophiolite Belt preserves a complex history of plume-ridge interaction, where depleted mantle residues were subsequently re-fertilized by plume-derived melts, resulting in slightly distinct MgO (29–36 wt. %) and FeO (4–7 wt.%) content. High Cr (2400–4600 ppm) and Ni (1300–2300 ppm) contents across all three locations confirm their common mantle affinity. By integrating textural analysis with mineral and geochemical data, this research elucidates the diverse processes —including subduction-related depletion and plume-induced enrichment—that shaped the Paleozoic mantle lithosphere in Central Asia. The findings emphasize serpentinization as a primary driver of structural and chemical transformation during the closure of ancient oceanic basins.