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Do Regional Naming Variations in the Central Asian Sand Seas Reflect Fe Mineralogy? Linking Geochemistry, Morphology, and Remote Sensing

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In drylands, iron availability significantly limits plant productivity. The lack of iron in drylands is caused by competitive oxidative interactions with other micro- (e.g. Cu, Zn, Mn) and major nutrients (P, formation of iron phosphates) and pH-controlled low mobility. Understanding the unique relationship between arid zone mineralogy, Fe cycling, and plant productivity has become increasingly urgent as global warming and its effects (i.e., desertification) change human habitation and agricultural practices. Landscape-scale understanding is especially important.

Our study is situated in the arid Turan basin where the Central Asian sand seas of Karakum and Kyzylkum accumulated. These sand seas cover an extensive area (over 600,000 km^2) in three countries (Turkmenistan, Uzbekistan, and Kazakhstan) and are mostly ($\sim$95%) stabilized. Dune stabilization in Karakum (black sands) and Kyzylkum (red sands) is driven by the presence of plants or other flora (e.g., moss and lichen) on the sand surface. The Amu Darya River divides Karakum (south) from Kyzylkum (north). If it were not for the boundary of the river, these would likely be one large sand sea. Nonetheless, we suspect that north/south regional naming differences in the area may arise from a combination of differences in iron mineralogy and vegetative cover.

Ongoing research to understand and map the aeolian dune forms of the area shows mostly vegetated sand morphologies, dominated by vegetated linear dunes (VLDs). Preliminary results of satellite-based vegetation cover analysis show 17% areal vegetation cover and large areas covered by biogenic crust. It is possible that Karakum might be called Kara (black) because of the Karaharshang (moss tortula desertorum), a black moss that covers these dunes. In addition, many ferrous, Fe(II) iron-bearing minerals are dominated by black phases (e.g., magnetite), while ferric, Fe(III) iron-bearing minerals are often red-colored (e.g., hematite). Thus we suspect that Karakum may be dominated by ferrous iron-bearing minerals, while Kyzylkum contains ferric iron-bearing minerals. Ferric iron is highly insoluble, and we therefore expect lower plant productivity where ferric iron-bearing minerals dominate.

To test for spectral changes with mineralogy, we measured diffuse reflectance on seven representative samples (4 Karakum, 3 Kyzylkum) on an Agilent Technologies Cary UV-Vis-NIR Spectrophotometer with an integrating sphere attachment. Spectra of the Kyzylkum sands showed an average slope between the yellow (580 nm) and red-edge (750 nm) wavelengths 37.14% steeper than that observed for the Karakum sand samples. These preliminary findings suggest that local names may reflect spectral differences related both to iron mineralogy and possibly associated vegetative cover. In our ongoing work, we will collect detailed mineralogy by X-ray diffraction and optical microscopy to confirm the role of iron mineralogy in these preliminary results. We will also map mineralogy, vegetative cover, and dune morphology by remote sensing and compare these maps; associating landscape-scale plant productivity with mineralogy in the region.