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Origin of Dicatomy in Laterites along Westcoast of India: A Thermodymamic Treatise of Mineral Paragnesis

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Laterite is a residual weathering product formed through the extreme leaching of precursor rocks, resulting in enrichment of iron (Fe) and aluminum (Al). Mineralogically, it is composed primarily of goethite, hematite, kaolinite, and gibbsite. Along the western coast of India, laterites are extensively developed in both high and low elevation areas. Those occurring at higher elevations are classified as high-level laterites, while those at lower elevations are termed low-level laterites. Approximately 50 laterite samples were collected from these regions for detailed mineralogical and geochemical characterization. These samples were analyzed using X-ray diffraction (XRD), X-ray fluorescence (XRF), and inductively coupled plasma mass spectrometry (ICP-MS) to determine their mineralogical and geochemical composition. Additionally, micro-XRF was employed to map elemental variations across polished sections of the samples. The chemical variations observed were modeled using Gibbs free energy minimization techniques to understand the thermodynamic controls on mineral formation and transformation.

Mineralogical analysis revealed that high-level and low-level laterites exhibit similar compositions, with the primary differences being the relative proportions of goethite and gibbsite. A key finding of this study is that laterites from very high elevations show significantly higher aluminum content, predominantly in the form of gibbsite. Raman spectroscopy was further utilized to identify and confirm mineral phases at specific spots within the samples. Based on the mineralogical composition, point chemistry, and Gibbs free energy minimization modeling, a possible transformation pathway from goethite to hematite under low-temperature conditions has been proposed. This pathway provides insights into the geochemical processes governing laterite formation.

This study also aims to incorporate a comprehensive understanding of the laterite formation mechanism through advanced geochemical and reactive transport modeling. These models help elucidate the interplay between chemical weathering, leaching, and mineral transformation processes over time. The findings contribute to a deeper understanding of laterite genesis and its implications for geochemical cycling in tropical and subtropical environments.