

Fe-Minerals Unlock Tropical Critical Zone Dynamics and Climate History

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The Earth's critical zone (CZ), the near-surface environment, plays a crucial role in determining the availability of life-sustaining resources. This is facilitated by water table circulation within the CZ, which drives organic and inorganic chemical exchanges, contributing to the dissolution of minerals and the precipitation of secondary minerals. In the tropical CZ, Fe-minerals and clays are dominant and ubiquitous, serving as key mineral products of the CZ. These minerals act as witnesses to the evolution of the critical zone, as they are direct products of the dissolution of parent rocks (igneous and sedimentary) and reflect paleo-environmental conditions (precipitation, temperature, redox state, organic content) that enabled their formation. Understanding the formation and evolution of the tropical CZ, including the natural accumulation of potentially toxic metals, past and present hydrology, landscape changes, and biodiversity adaptation in response to climate oscillations, represents a major challenge for ensuring Earth's habitability. Geochemical analysis of Fe-minerals and (U-Th)/He geochronology provide insights into the CZ's evolution over geological timescales (thousands to millions of years), revealing past climatic and geodynamic changes and their implications for biogeographic barriers. This approach has opened new avenues for interpreting these unconventional archives of critical zone processes across geological time.