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Non-steady and disparate chemical weathering pertinent to the failure of a landslide-induced dam in eastern Taiwan

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Rock weathering is crucial for regulating carbon fluxes among Earth's spheres. While silicate weathering is generally considered to be kinetically limited, pyrite-driven carbonate weathering and the oxidation of petrogenic organic carbon are governed by supply limitations that are further dependent on reactant mobility, availability, and reactivity. Consequently, weathering intensities vary dynamically from the outcrop to the catchment scale. The dynamics of these distinct mechanisms in topographically steep and deeply incised catchments remain largely unresolved. To address this, this study investigates the Matai'an River catchment in eastern Taiwan, delineating how the instantaneous supply of 320 million cubic meters of sediment from a catastrophic landslide and dam-breach event impacted chemical weathering and the carbon cycle. By integrating hydrochemical analyses of in-situ river water, sediment pore water, and laboratory incubations, we found that the massive initial influx of detritus material triggered intense sulfuric acid-driven carbonate weathering, which gradually transitioned to atmospheric carbonic acid-driven weathering over time. The yield combined with the decadal average of discharge reveal a daily aqueous carbon export of 15 to 20 tons through the river system. Although this range of rate aligns with natural and laboratory estimates and slightly exceeds pre-event background levels, it is remarkably an order of magnitude lower than the gaseous carbon dioxide released directly from the sediment surfaces. Such a disproportion between aqueous and gaseous carbon outputs highlights substantial spatial variability and a lack of synchronization in weathering reaction rates within the catchment. Transient weathering signals induced by massive sediment accumulation in banks only manifest synchronously in river hydrochemistry once solutes produced by weathering reactions migrate into the fluvial network. Ultimately, these findings highlight the critical role of pulsed geomorphic events, such as landslides, in comprehensively shaping the carbon budgets of active orogenic belts.