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Chemical weathering in a mountainous watershed with rapid uplifting rates

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Chemical weathering plays a vital role in controlling long-termed climatic fluctuation and landscape development. In particular, silicate weathering regulates atmospheric carbon dioxide by transforming it into carbonic acid for the dissolution of silicate minerals. The rates of silicate weathering have been correlated to various factors, such as lithology, temperature, runoff, and erosion rate for major river systems, providing a basis to generalize the CO_2 drawdown on a geological time scale. For comparison, small river systems in rapidly uplifting orogenic belts are characterized by short transport path and residence time, and often associated with torrential runoff and sediment discharge. River channels are deeply incised, generating large quantities of fresh materials and mineral surface area readily for weathering processes. The patterns and reaction pathways of chemical weathering in such river systems and its impacts on the global solute export and long-termed climatic fluctuation remain largely unknown. In this study, we carried out periodic field sampling campaigns to sample various materials (river water, seeps, hot springs, suspended particulates, soils, and rocks) in a small river system in southern Taiwan where the uplift (> 1 cm/yr) is rapid. The analyses of major cations and anions yielded that calcium and sulfate were the major ions in river water. These data combined with isotopic compositions of sulfate indicated that pyrite oxidation generated sulfuric acid for the dissolution of carbonate minerals, and outcompeted silicate weathering for the production of solutes by different degrees in different tributaries. Partial pressures of CO_2 exceeded the atmospheric equilibrium saturation at some sites. These lines of evidence indicate that such a river system instead of a sink is prone to CO_2 emission. The sulfate concentration was neither correlated with the yield of suspended particulate, nor the concentration and isotopic composition of dissolved inorganic carbon, suggesting that multiple weathering pathways and mixing processes are needed to account for the solute budget.