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Microbial Pyrite Oxidation and Chemical Weathering to a Typhoon Precipitation and Discharge Event in Taiwan

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Microbially mediated pyrite oxidation is considered a crucial element of the global weathering engine. However, observations of bacterial pyrite oxidation in nature remain scarce due to limited field sampling, particularly during typhoon precipitation and discharge events. In this study, we present a time series of water chemistry at three-hour intervals from the Sinwulyu River, southeast Taiwan, across the typhoons Nesat (0-27th hours) and Haitung (30th-60th hours) in 2017. The cumulative precipitation for the two typhoons ranged from 18 to 78 mm and 59 to 227 mm in the catchment, resulting in discharge increases from 6 to 122 c.m.s. and 53 to 1,207 c.m.s. at the catchment's outlet. The Sinwulyu River drains a catchment underlain by metamorphosed passive-margin sediments that are rapidly exhuming. Integrating measurements of major ions, δD_{H2O}, $\delta^{18}O_{H2O}$, $\delta^{34}S_{SO4}$, $\delta^{18}O_{SO4}$, and simulations of discharge, we find dynamic changes in the source of solutes to the stream water across the typhoons. Our findings indicate that all chemical solutes experienced dilution by 30-80% during typhoon discharge. δD_{H2O} and $\delta^{18}O_{H2O}$ values were more negative with increasing discharge, suggesting that the discharge is driven by a combination of precipitation and groundwater injection into the river. $\delta^{34}S_{SO4}$ and $\delta^{18}O_{SO4}$ ranged from -3.9 ‰ to -7.1 ‰ and from -1.9 ‰ to -6.5 ‰, respectively, suggesting that the majority of riverine sulfate is sourced from oxidative weathering of pyrite. In addition to variations of the water chemistry, we also found substantial changes in the concentrations of sulphur-oxidizing bacteria, *Thiobacillus* and, *Sulfuricurvum* (anaerobic microorganisms) emerged as the dominant genera during typhoons. The peak concentration of *Thiobacillus* occurred at the first typhoon at the 27th hour (1.17×10^7 copies/L), while *Sulfuricurvum* peaked at the 48th hour during the second typhoon (2 hours before peak discharge) with a concentration of 2.32×10^8 copies/L, coinciding high ranges of sediment concentrations and representing 241 and 1,570 times the background level before typhoons, respectively. Both peak concentrations were sudden appearances, indicating that some pools of concentrated microorganisms were quickly depleted by typhoon precipitation/discharge. Notably, the highest abundance of *Sulfuricurvum* coincided with an increase in chemical solutes. As the discharge rose from 714 to 1,092 c.m.s. (45-48th hour), the concentration of *sulfuricurvum* increased around tenfold, coupled with an 8%, 7%, and 7% increase in the concentrations of SO_4^{-2},

Ca^{+2}, and Mg^{+2}, respectively. However, other chemical solutes maintained a similar concentration. These observations suggest the typhoon mobilized a specific reservoir of elevated pyrite oxidation for carbonate weathering under anaerobic conditions. Through discharge simulation, the high concentration of solute and *Sulfuricurvum* mobilized substantially at hourly precipitation rates of over 20 mm/hr. We propose that an ample amount of precipitation is essential to flush out the previously inaccessible pool with anaerobic bacterial pyrite oxidation and subsequent carbonate weathering in the stream.