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Strong and weak mineral acid-mediated chemical weathering pathways in the Central Himalayas: Its role on the chemical weathering and CO2 consumption rates

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The feedback of chemical weathering controlled by mineral acids on the concentration of atmospheric carbon dioxide plays an important role in the carbon cycle and therefore in global climate change. Previous studies in the Himalayas have produced a rich body of information on the role of weak carbonic acid (H_2CO_3) in chemical weathering, however, the role of H_2SO_4 and HNO_3 on the chemical weathering and CO_2 consumption rates of glacierized Himalayan catchments is under-explored but is critically important for constraining the cumulative impact of these mineral acids on inorganic CO_2 balance over a geological time scale. In this study, river water samples were collected from the snout of the Chorabari glacier (30°46’20.58’’ N; 79°2’59.381’’ E) during the entire ablation season of the year 2019. The samples were measured for cations and anions and dissolved silica concentrations. The sum of the equivalent ratio of all cations (Na^+, K^+, Ca^{2+}, and Mg^{2+}) produced from the silicate and carbonate to HCO_3^- (total cation $_{silicate+carbonate}$ / HCO_3^-) ranges from 1.08 to 3.26 suggesting there are significant excess cations that need to be balanced by other weathering agents. The equivalent ratio of total cation $_{silicate+carbonate}$ / HCO_3^- $+SO_4^{2-}$ + NO_3^- shows that the slope of the trend line is close to 1. The good positive correlation coefficient (R^2=0.6) suggests that the excess cations get balanced by (SO_4^{2-} + NO_3^-) H_2SO_4 and HNO_3 acids. We find carbonate weathering rate increases three times when all three weathering agents i.e., H_2CO_3, H_2SO_4, and HNO_3 (12.33 x 10^3 tons km^{-2} yr^{-1}) is considered compared to H_2CO_3-mediated reactions (4.19 x 10^3 tons km^{-2} yr^{-1}) whereas atmospheric CO_2 drawdown rate decreases twice for silicate weathering from 39.14 x 10^5 to 19.15 x 10^5 mol km^{-2} yr^{-1} and 1.5 times for carbonate weathering (from 6.01 x 10^5 to 3.94 x 10^5 mol km^{-2} yr^{-1}) when H_2SO_4 and HNO_3 along with H_2CO_3 are associated in chemical weathering reactions compared to H_2CO_3-mediated reactions alone. We show that the release of CO_2 to the atmosphere due to H_2SO_4 and HNO_3 acid-mediated chemical weathering can have a significant influence on inorganic CO2 balance over geological timescales.