Impact of soil and landslide erosion processes on coupled sulfide oxidation and carbonate weathering

AARON BUFE[1], ROBERT EMBERSON[1], NIELS HOVIUS[1], JEREMY K. CAVES RUGENSTEIN[3], AND HIMA J. HASSENRUCK-GUDIPATI[4]

[1]GFZ German Research Center for Geosciences, Telegrafenberg, 14473 Potsdam, Germany
[2]Department of Earth Sciences, ETH Zürich, 8092, Zurich, Switzerland
[3]Jackson School of Geosciences, University of Texas at Austin, Austin, Texas, 78712, USA

Chemical weathering of silicate rocks strongly modulates Earth's carbon cycle by removing atmospheric CO2 via reaction with carbonic acid. Recent work has suggested that coupled sulfide oxidation and carbonate weathering, which releases CO2, may be a sufficiently important process to also modulate the long-term carbon cycle. Landslide erosion in active mountain ranges may be critical to this process by increasing weathering rates and, more importantly, by also increasing the relative contribution of minor, highly soluble (labile) carbonate and sulfide phases to the total weathering flux. However, it remains unclear to what extent high concentrations of labile phases in weathering products from landslide-prone catchments, in comparison with soil-erosion-dominated areas, reflect differences in the processes of landslide and soil erosion. The apparent difference could be due, instead, to generally higher erosion rates in landslide-prone regions or short-lived, transient increases in dissolved fluxes after major landslide events.

To investigate how landslide and soil erosion impact chemical weathering, we take advantage of a transition from low relief, soil covered hillslopes to high relief landslide-prone hillslopes across the southern tip of Taiwan. An analysis of water chemistry, landslide volumes, topographic data, and erosion rates in catchments across this transition suggest that in both soil and landslide erosion-dominated areas greater erosion rates increase coupled carbonate and sulfide weathering and reduce silicate weathering. The reduction of silicate weathering is hypothesized to occur because acidity is consumed in weathering readily available and rapidly dissolving carbonate phases at the expense of slower silicate weathering reactions. This effect is significantly more pronounced in the landslide-dominated north. We postulate that, in rapidly eroding mountain ranges, the effect of CO2 removal via silicate weathering is dampened and potentially reversed due to both enhanced sulfide-carbonate weathering and reduced silicate weathering.