Partitioning the denudation flux between silicate and carbonate physical erosion and chemical weathering in the Northern Apennines

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The Northern Apennines of Italy are a young orogen comprised of mixed siliciclastic and carbonate lithologies. Young orogens are typically characterized by marine sedimentary sequences that contain important volumes of carbonate, which can dominate chemical weathering, as carbonate weathers a factor of 3 times faster than silicates. However, most models that address the interplay between erosion and weathering have focused on silicate lithologies. Carbonate weathering is typically limited by the availability of acid rather than dissolution kinetics, and more tightly linked to soil and sub-surface CO₂ concentrations than silicate weathering. Therefore, it remains unclear if the same processes that control the partitioning of denudation between erosion and weathering in actively uplifting, silicate-rich lithologies are also active in orogens comprised of mixed carbonate-silicate lithologies. The partitioning of denudation between physical erosion and chemical weathering in mixed silicate-carbonate landscapes remains a fundamental knowledge gap that has implications for landscape development and the carbon cycle. Here we address two key questions: (1) how is the total denudation separated into carbonate and silicate fluxes, and (2) how is carbonate denudation partitioned into erosion and weathering in an active orogenic setting? We partition denudation fluxes from ¹⁰Be concentrations into carbonate and silicate chemical weathering and physical erosion fluxes, using major dissolved ions from water chemistry, the percent of carbonate sand from each catchment, and annual discharge measurements. Denudation fluxes in the Northern Apennines are dominated by physical erosion of both silicate and carbonate lithologies. Chemical weathering fluxes are 1-2 orders of magnitude lower than physical erosion fluxes and are dominated by carbonate dissolution. Despite a number of studies that have shown a strong positive correlation between denudation and chemical weathering fluxes, we find only a weakly positive correlation. Relative to a global dataset from silicate-rich orogenic settings, the Northern Apennines have similar denudation fluxes as the eastern side of the New Zealand Southern Alps. However, rivers from the Northern Apennines generally have higher total weathering fluxes relative to the Southern Alps, consistent with the exposure of a large volume of carbonate lithologies in the Northern Apennines.