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¡Cuba! New Chemical and physical denudation rates define source-to-sink mass transport and anthropogenic impacts on nutrient loads for the largest Caribbean nation

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Measurements of chemical and physical rates of landscape change in the tropics are rare. To address this data gap, a joint US/Cuban science team has worked together for two years sampling across the island of Cuba. Here, we report long-term cosmogenic erosion rates inferred from river sand paired with rates of chemical denudation estimated from river water solute loads. Together, these data define source-to-sink mass transport in 45 drainage basins in western and central Cuba and allow us to speculate on the role of agriculture on nutrient and sediment fluxes.

Rates of erosion determined from in situ ¹⁰Be concentrations range from <2 to ~80 m/My, are more varied in central than western Cuba, and do not correlate with chemical denudation rates. Comparison of cosmogenic erosion rates and sediment loads measured during the peak of industrial agriculture (1970s) suggests a modest increase in sediment yield likely reflecting intensive cultivation. Chemical denudation rates (n = 45) range from 42 to 302 tons/(km² yr) in central Cuba and from 11 to 125 tons/(km² yr) in western Cuba. Chemical denudation rates and total dissolved solids are several times higher in central Cuba than western Cuba. River water is dominated by Mg, Ca, Na, K, and Si in both areas.

Although cosmogenic erosion rates are often interpreted as total landscape denudation, we find in some Cuban drainage basins that ¹⁰Be-based erosion rates underestimate total landscape denudation. Considerable discordance (12-60X) between erosion rates and chemical denudation rates in five central Cuban basins suggests that significant mass loss by solution is not reflected by cosmogenic-based erosion rates. In 2 of these basins, erosion rates calculated from duplicate measurements of ¹⁰Be (1.4 & 2.5 m/My) and ²⁶Al (1.7 & 2.9 m/My) were ~50X lower than chemical denudation rates (89 & 108 m/My). Both ²⁶Al and ¹⁰Be concentrations indicate long term, near-surface (>>100 ky) quartz residence; stream water geochemical data are consistent with the

presence of evaporite deposits. We suspect that rapid chemical denudation enriches basin sediment in quartz, which lingers at or near the surface in these low slope (0.5°) basins.

Despite centuries of agriculture, the impact on Cuban river biogeochemistry is limited. Although river water in many central Cuban rivers has high levels of *E. coli* bacteria, likely sourced from livestock, concentrations of nitrate are far lower than other areas where intensive agriculture is practiced, such as the Mississippi River Basin. This suggests the benefits of Cuba's shift to conservation agriculture after 1990 and provides a model for more sustainable agriculture worldwide.