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The Rise of Late Tertiary and Quaternary Erosion and Weathering Rates revisited (Ralph Alger Bagnold Medal Lecture)

Friedhelm von Blanckenburg
German Research Center for Geosciences GFZ Potsdam, Telegraphenberg, D-14473 Potsdam, fvb@gfz-potsdam.de

The analyses of both modern river loads and chemical and physical hillslope denudation show that rates of weathering and erosion are tightly interlinked. An increase in silicate weathering through increased mountain erosion should therefore lead to global cooling by increased drawdown of atmospheric CO_2. A five-fold increase of global sediment delivery was suggested for the last 5 Million years from a global compilation of sedimentation rates (1), and was also specifically suggested for the European Alps (2) and the India-Asia collisional area (3). While much research effort is currently being directed at explaining this increase, we should have been suspicious because this apparent increase in global erosion rate was not accompanied by a similar concomitant decrease in atmospheric CO_2 as recorded by ocean alkalinity proxies.

One possibility is that the increase in Neogene sedimentation rates is an artifact introduced by the discrepant time scale over which sedimentation is measured (4). The older the age, the longer the observational integration time will be, which in turn include longer periods of hiatus, and hence decreasing sedimentation rates with geologic time. An analysis of the records named above for time scale bias indeed suggests the possibility that erosion in these mountain belts might have been constant throughout the Neogene.

An independent test of this hypothesis is provided by marine records of the isotopes of Beryllium (5). Be-10 is a rare radioactive cosmogenic nuclide, is produced mostly in the atmosphere and introduced to the surface oceans with a flux that can be considered to be globally uniform when averaged over time scales exceeding those of climate cycles. Be-9, in contrast, is stable, and enters the oceans from the continents mainly by river particulates (which are dissolved to some extent in the water column and during early diagenesis), in the dissolved form, and in minor amounts from dust. Should the global erosion rates have increased, the isotope ratio of Be-10 to Be-9 would have decreased by roughly the same factor. Over the past 10 My, records of chemical marine deposits (Fe-Mn crusts and authigenic deep sea sediments) show no change in this ratio after correction for radioactive decay of Be-10. Therefore, these records support the hypothesis of constant global erosion and weathering fluxes.

If this hypothesis is true, neither Late Tertiary mountain building nor Quaternary cooling affected or was affected by a change in silicate weathering rates. Instead, a more continuous mechanism is suggested in that subtle ongoing hillslope rejuvenation in any soil-mantled hillslopes in kinetically-limited settings enable the feedback that stabilizes atmospheric CO_2 and climate levels through silicate weathering. In fact, in steep, active mountain belts an increase of relief and erosion rates to those that are in excess of conditions were soils are stable lead to a decrease, not an increase of weathering rate. But the aim here is not to discount active mountains as premier agents of CO_2 withdrawal. Silicate weathering may still take place within the adjacent sedimentary basins, and large carbon deposits could also be buried there in the organic form.

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