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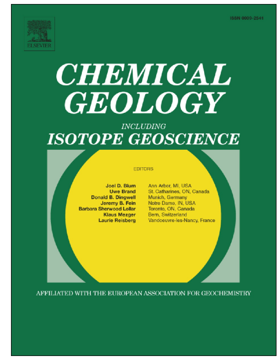

Temperature versus hydrologic controls of chemical weathering fluxes from United States forests

Peter A. Raymond

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Temperature versus hydrologic controls of chemical weathering fluxes from United States forests

Peter A. Raymond

Yale School of Forestry and Environmental Studies, New Haven CT, 06511

Stockholm University, Department of Environmental Science and Analytical Chemistry, Stockholm, Sweden, 106 91

Abstract

Chemical weathering is a dominant control on modern inland water chemistry and global element budgets over geologic time scales. Due to its central role in the earth's biogeochemistry it remains an intense area of interest. Understanding the controls on chemical weathering is difficult because it has many drivers with overlapping temporal and spatial signals. Of particular interest is the relationship between chemical weathering fluxes and global temperatures due to a negative feedback loop where warmer temperatures leads to more chemical weathering and its associated atmospheric CO_2 consumption (Berner et al., 1983). Recently it has been proposed that this negative feedback loop is indirect where the acceleration of the hydrologic cycle by increased global temperatures leads to higher chemical weathering and atmospheric CO_2 consumption (Maher and Chamberlain, 2014). Here, fluxes of all major cations and anions are calculated for 150 forested watersheds smaller than 500km^2 in order to explore controls on chemical weathering from United States forests. Relationships between watershed hydrology, ion ratios and pH are reported that explain a large amount of across site variation in bicarbonate fluxes. Furthermore, across all watersheds ~32% of the cation flux is not balanced by bicarbonate but by sulfate. Paired alkalinity, temperature and discharge data are used to determine a temperature sensitivity of chemical weathering across 51 forested watersheds with a minimum of 70 measurements. The temperature sensitivity of bicarbonate fluxes is absent at low flow conditions because long residence times leads to chemical equilibrium and transport limitation. As discharge increases and residence time decreases, the temperature sensitivity of chemical weathering is released from transport limitation. The temperature sensitivity then increases with discharge until it levels off at high discharges as the system becomes reaction limited. Records of daily discharge, watershed discharge to flux relationships, and the temperature sensitivity are then used to estimate how chemical fluxes would change with a 20% increase in discharge, and 10^o increase in temperature global change scenario. Not surprisingly it is found that increased discharge leads to higher weathering fluxes. Interestingly, wetter years have a higher temperature sensitivity due to a release of the temperature sensitivity from transport limitation. This coupled with the a strong direct temperature effect leads to an approximately equal response from temperature and increased discharge using this scenario of global change. Thus periods of time and regions that are subject to both warm and wet conditions may have a particularly strong control on weathering fluxes.

Highlights

-Bicarbonate fluxes from United States forests can be predicted using hydrology and ion ratios