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The contribution of weathering of the main Alpine rivers on the global carbon cycle

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Abstract

On geological time-scales the carbon fluxes from the solid Earth to the atmosphere mainly result from volcanism and metamorphic-decarbonation processes, whereas the carbon fluxes from atmosphere to solid Earth mainly depend on weathering of silicates and carbonates, biogenic precipitation and removal of $CaCO_3$ in the oceans and volcanic gases – seawater interactions. Quantifying each contribution is critical. In this work, we estimate the atmospheric CO_2 uptake by weathering in the Alps, using results of the study of the dissolved loads transported by 33 main Alpine rivers. The chemical composition of river water in unpolluted areas is a good indicator of surface weathering processes (Garrels and Mackenzie, 1971; Drever, 1982; Meybeck, 1984; Tardy, 1986; Berner and Berner, 1987; Probst et al., 1994). The dissolved load of streams originates from atmospheric input, pollution, evaporite dissolution, and weathering of carbonate and silicate rocks, and the application of mass balance calculations allows quantification of the different contributions. In this work, we applied the MEGA (Major Element Geochemical Approach) geochemical code (Amiotte Suchet, 1995; Amiotte Suchet and Probst, 1996) to the chemical compositions of the selected rivers in order to quantify the atmospheric CO_2 consumed by weathering in Alpine region. The drainage basins of the main Alpine rivers were sampled near the basin outlets during dry and flood seasons. The application of the MEGA geochemical consisted in several steps. First, we subtracted the rain contribution in river waters knowing the X/Cl (X = Na, K, Mg, Ca) ratios of the rain. Next, we considered that all (Na+K) came from silicate weathering. The average molar ratio Rsil = (Na+K)/(Ca+Mg) for rivers draining silicate terrains was estimated from unpolluted French stream waters draining small monolithological basins (Meybeck, 1986; 1987). For the purpose, we prepared a simplified geo-lithological map of Alps according to the lithological classification of Meybeck (1986, 1987). Then for each basin we computed Rsil weighted average considering the surface and the mean precipitation for the surface area of each lithology. Lastly, we estimated the (Ca+Mg) originating from carbonate weathering as the remaining cations after silicate correction. Depending on time-scales of the phenomena (shorter than about 1 million year i.e. correlated to the short term carbon cycle, or longer than about 1 million years i.e. correlated to the long-term carbon cycle), we considered different equations for the quantification of the atmospheric CO_2 consumed by weathering (Huh, 2010). The results show the net predominance of carbonate weathering on fixing atmospheric CO_2 and that, considering the long-term carbon cycle, the amount of atmospheric CO_2 uptake by weathering is about one order of magnitude lower than considering the short-term carbon cycle. Moreover, considering the short-term carbon cycle, the mean CO_2 consumed by Alpine basins is of the same order of magnitude of the mean CO_2 consumed by weathering by the 60 largest rivers of the world estimated by Gaillardet et al. (1999).

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