The role of continental weathering in controlling atmospheric CO_2 levels at glacial-interglacial time scales

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There is a continuous transfer of carbon between the continental crust, the atmosphere and the ocean due to the chemical weathering of continental rocks. Atmospheric CO_2 is consumed and HCO_3^- produced by weathering processes. The rates at which these processes take place, and at which the produced HCO_3^- is transferred to the ocean by rivers set the global accumulation rate of carbonate in the sea-floor sediments (as illustrated in Figure 1).

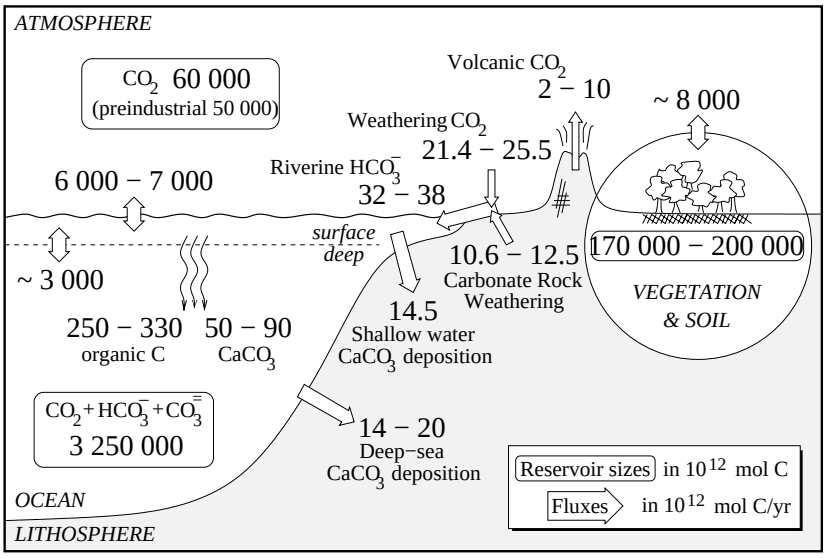

Figure 1: The global carbon cycle at present-day and at pre-industrial times.

In the first part of the presentation, it is discussed from a qualitative point of view how weathering processes may possibly influence atmospheric CO_2 levels at glacial-interglacial time scales. The effects of variations in either silicate or carbonate rock weathering are discussed and illustrated with results from theoretical sensitivity expertiments carried out with a model of the ocean carbon cycle.

In the second part of the presentation, two different types of reconstructions for the variations of weathering fluxes between glacial and interglacial times were discussed. The first type is based on the inversion of marine records ((Munhoven and François, 1994, 1996): $^{87}Sr/^{86}Sr$ and Ge/Si. The reconstruction based upon the $^{87}Sr/^{86}Sr$ record remains inconclusive; the one based on the Ge/Si record indicates that silicate weathering alone consumed at least twice as much, possibly even 3.5 times as much CO_2 at the LGM than at present-day. The second type of reconstruction calls upon empirical models of continental weathering (Gibbs and Kump, 1994; Munhoven, 1997, 1999; Ludwig et al., 1999), linking the CO_2 consumption and HCO_3^- production rates to the water drainage distribution using empirical bicarbonate flux-runoff relationships for different exposed rock types. A systematic analysis is carried out, using the two mod-

els of Gibbs and Kump (1994) and Amiotte Suchet and Probst (1995) (also used by Ludwig et al. (1999) in a similar study) under uniform boundary conditions and with a range of climatic forcings. It is shown that the two models respectively yield HCO_3^- production rates that were on average 9 ± 7 and $18 \pm 12\%$ higher at the LGM than at present. The increase due to shelf exposure is generally found to be 3–4 times larger than the decrease resulting from ice cover. Variations over land exposed at LGM and present-day remained within uncertainty range of the global net change. The shelf environment thus remains a critical unknown. The calculated CO_2 consumption rates are on average 6 ± 7 resp. $15 \pm 12\%$ higher at the LGM. The CO_2 consumption rate by silicate weathering was found to be at most 35% higher at the LGM, far less than the increase obtained by Munhoven and François (1996).

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