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Silicate Weathering Rates Inferred from Sr Isotopes Systematics in the Mackenzie River Basin, Canada

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The Mackenzie river basin offers an opportunity of studying silicate weathering in a pristine environment under subarctic climatic conditions (Reeder et al., 1972) and to get some constraints on river geochemistry in post-glacial area. We have analyzed the dissolved, suspended and sandy load of the major tributaries of the Mackenzie river as well as some typical small rivers in the basin. The coupled use of Sr isotope and major elements ratios in the dissolved load allows us to infer the dominant role of lithology on river water chemistry and to estimate the silicate weathering component from other sources (Négrel et al., 1993; Gaillardet et al., 1999).

The Mackenzie river basin is characterized by two principal weathering environments. We observe a clear contrast between the highlands (Rocky and Mackenzie mountains) and the interior lowlands (Alberta plain). Rivers of the highlands, especially the headwaters in the Liard and the Athabasca rivers, are characterized by high strontium isotope ratios ($^{87}Sr/^{86}Sr$ ranges from 0.7130 to 0.7580 and from 0.7162 to 0.7368 respectively for the dissolved and the suspended load), although these rivers drain mainly through carbonates and dolomitic limestones. Similar to the headwaters in the major Himalayan rivers (Galy et al., 1999), very high Sr isotopic ratios ($^{87}Sr/^{86}Sr$ ranging from 0.730 to 0.740) are found to be associated with high Ca/Na ratios (20 to 30). In addition, the suspended phase of several rivers in the Rocky mountains exhibit a very radiogenic silicate component ($^{87}Sr/^{86}Sr$ up to 0.9). Therefore the high $^{87}Sr/^{86}Sr$ and Ca/Na ratios of the highland rivers can be explained by a simple mixing between highly radiogenic silicate and limestones.

Rivers in the lowlands, characterized by swamps and hence high dissolved organic carbon contents, have $^{87}Sr/^{86}Sr$ ranging from 0.7083 to 0.7136 in the dissolved load. These rivers reflect mainly black shales and carbonate weathering in terms of strontium isotopic ratios and major element ratios. Moreover these organic rich rivers have also high values of silicate weathering rates. These preliminary results seem to suggest that under the subarctic conditions of the Mackenzie basin, dissolved organic matter may be a key parameter in controlling the weathering processes and possibly silicate weathering rates.

Based on mixing equations with Sr isotopic and major element ratios, we calculate for each rivers the contribution of the dissolved load derived from silicate weathering for the calculation of CO_2 consumption and silicate weathering rates. We find that the average of CO_2 consumption rates are twice for the rivers in the lowlands than those in the highlands (91 and 48 x10^3 mol CO_2/km^2/year respectively). These results reinforce our hypothesis that in the subarctic environment of the Mackenzie river basin, dissolved organic matter is a dominant parameter in controlling silicate weathering rates especially in the lowlands.

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