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Physical erosion rates in the Mackenzie river basin: Testing the steady state approach

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The steady state concept of weathering is a working hypothesis that states that the mass of bedrock being eroded during a given time period equals the mass of solid and dissolved products removed from the river basin. This also applies to particular elements.

The main problem of using this mass budget in order to relate physical and chemical erosion rates at the scale of a drainage basin is knowledge of the bedrock composition.

We report here data from dissolved and suspended loads of the Mackenzie river basin and its main tributaries, Northern Canada. Weathering intensities for the most soluble elements are calculated and compared to the composition of the bedrock mainly constituted of phanerozoic shales. The dissolved load is corrected from the contribution of carbonates, widespread in the basin, to isolate the dissolution of silicate weathering [1].

Source rock composition is constrained by the use of U-series isotopes. As shown by Vigier et al. [2], characteristic times of erosion in the Mackenzie system are much lower than the half-life of ^{230}Th, allowing us to deduce initial ^{238}U/^{232}Th ratios. Based on the correlation between ^{238}U/^{232}Th and the weathering intensities of most of the soluble elements in river suspended sediments, we deduced the composition of the bedrock and then solved the steady state equation for physical erosion rates. The steady state equation is solved for Rb, U, K, Mg and Ba.

The number calculated for the Mackenzie river at mouth is about 200 mg/l of sediments. This value is in agreement with the value of the long-term sediment record in the Mackenzie river. Conversely, the tributaries of the Mackenzie river show predicted rates larger than measured ones. We will discuss the reason for this discrepancy that we attribute either to the release of glacial sediments or the recent man-induced warming of the permafrost regions.

References

[1] Millot et al. (2003) *GCA*, vol. **67**, N° 7.
[2] Vigier et al. (2001) *EPSL*, **193**.

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Chemical response of aeolian weathering products to climate change in N-Africa following termination of the African Humid Period

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The increasing desertification of NE-Africa and Arabia since the Middle Holocene provides an ideal laboratory to examine the chemical consequences of varying chemical and physical weathering processes. We report a combined Sr-Nd and trace element study of the <2 micron clay fraction separated from sediment Core 905 (~1600 m water depth) off shore from Somalia in the NW Arabian Sea. Samples were obtained from the present day back to ~ 9 ka. The age model for the core is based on > 30 AMS ^{14}C dates and correlation of a high-resolution δ^{18}O record (0.5 cm sampling) to Oman stalagmite records (Neff et al. 2001). Deposition rates reach 30 cm/ka.

Based on the Sr-Nd-isotope records of the clay fraction we establish that there is no provenance change in aeolian dust supply, i.e. no change in Nd isotope ratios. The clay fraction throughout the Holocene is dominated by palygorskite. Hence the clay fraction can be used to monitor changes in weathering processes. Marked variation in Sr-isotope ratios are used to deduce the Holocene weathering history of NE Africa. The Early Holocene (10-6 ka) was generally more humid than today (African humid period – AHP). The sediment record records a dramatic change towards more radiogenic ^{87}Sr/^{86}Sr ratios associated with the onset of dryer conditions between 6 and 3.8 ka BP. Increased ^{87}Sr/^{86}Sr is associated with coherent variations in many trace element ratios. For example there are good positive correlations with Rb/Sr, Ba/Nb, Lu/Hf, Pb/U, Th/U and Ba/La. These relationships indicate that during wetter periods chemical weathering broke down feldspar and mica removing radiogenic Sr and LIL elements from the protolith. The net effect of increased chemical weathering was also to concentrate minor phases such as zircon in the residue resulting in lower Lu/Hf and ^{87}Sr/^{86}Sr.

References

[1] Neff, U., S. J. Burns, et al. (2001), Strong coherence between solar variability and the monsoon in Oman between 9 and 6 kyr ago, *Nature* **411,** 290-293.