Appendix of *The global imprint of shale weathering on molybdenum isotope ratios in river waters*

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Below, we provide the derivation and assumption of the river mass budget equations used to quantify the relative export of Mo compared to silicate (Section 4.2). Roughly, this method consist of combining the dissolved and solid Mo river fluxes following the river mass budget equations performed in Gaillardet et al. (1997):

$$F_{riv}^{Mo} = F_{diss}^{Mo} + F_{spm}^{Mo} \qquad A.1$$

with F_{riv}^{Mo}, F_{diss}^{Mo}, F_{spm}^{Mo} the total Mo riverine flux, the river dissolved Mo flux and the river solid Mo flux, respectively. However, these absolute fluxes are challenging to estimate, hence in the introduction of the elemental budget of an additional element (here sodium, Na):

$$F_{riv}^{Na} = F_{diss}^{Na} + F_{spm}^{Na} \qquad A.2$$

with F_{riv}^{Na}, F_{diss}^{Na}, F_{spm}^{Na} the total Na riverine flux, the river dissolved Na flux and the river solid Na flux, respectively. Then, introducing eq. A.2 in eq. A.1 turns the absolute fluxes into elemental ratios:

$$\left(\frac{Mo}{Na}\right)_{riv} = \frac{F_{riv}^{Mo}}{F_{riv}^{Na}} = \frac{F_{diss}^{Mo}}{F_{diss}^{Na}} + \frac{F_{spm}^{Mo}}{F_{spm}^{Na}} = \left(\frac{Mo}{Na^*}\right)_{diss} \times w^{Na} + \left(\frac{Mo}{Na}\right)_{spm} \times (1 - w^{Na}) \qquad A.3$$

with $\left(\frac{Mo}{Na}\right)_{riv}$ the total Mo/Na ratio exported by rivers, $\left(\frac{Mo}{Na^*}\right)_{diss}$ and $\left(\frac{Mo}{Na}\right)_{spm}$ the Mo/Na ratio of river dissolved and suspended particulate loads, respectively, and w^{Na} the fraction of Na exported as dissolved species:

$$w^{Na} = \frac{[Na^*]_{diss}}{[Na^*]_{diss} + [Na]_{spm} \times [spm]} \qquad A.4$$

With $[Na^*]_{diss}$ and $[Na]_{spm}$, the concentration of sodium in the river dissolved (in µg/L) and solid loads (in mg/kg), respectively; and $[spm]$ the concentration of suspended particulate matter (in g/L).

At steady-state, the parameter $\left(\frac{Mo}{Na}\right)_{riv}$ samples the Mo/Na ratio of the rock undergoing weathering. This steady-state hypothesis for silicate weathering has been demonstrated and discussed in Gaillardet et al. (1999a), Dellinger et al. (2015a), Dellinger et al. (2017) and Charbonnier et al. (2022).

Similarly, the δ^{98}Mo of the source materials (δ_{riv}^{Mo}) is quantified as the weighted sum of the dissolved and solid δ^{98}Mo fluxes:

$$\delta_{riv}^{Mo} = \delta_{diss}^{Mo} \times w^{Mo} + \delta_{spm}^{Mo} \times (1 - w^{Mo}) \qquad A.5$$

with δ_{diss}^{Mo} and δ_{spm}^{Mo} the Mo isotope composition of the river dissolved and suspended loads. In fig. 5, we compare the result of eqs. A. 3 vs. A. 5.

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