Supplement of

Ideas and perspectives: Emerging contours of a dynamic exogenous kerogen cycle

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This supplementary document details how the reported kerogen oxidation fluxes ($F_{L-A}$) were calculated in Table 1 from the references that require conversion.

**S1 Bouchez et al. (2010)**

Kerogen oxidation flux reported from the Madeira floodplain: 
\[ 0.25 \frac{Mt C}{yr} = 2.5E + 11 \frac{SC}{yr} \]

Normalizing this flux to the catchment area (850,000 km$^2$) of the Madeira floodplain reported in Clark et al. (2017) delivers:
\[ F_{L-A} \geq 0.3 \frac{MgC}{km^2 yr} \]

As Bouchez et al. (2010) report the kerogen oxidation flux as a “lower bound”, greater than or equal to is used.

**S2 Clark et al. (2017)**

Revising Bouchez et al.’s (2010) figures, the kerogen oxidation flux reported from the Madeira floodplain: 
\[ 1 \frac{Mt C}{yr} = 1E + 12 \frac{SC}{yr} \]

Normalizing this flux to the catchment area (850,000 km$^2$) of the Madeira floodplain reported in Clark et al. (2017) delivers:
\[ F_{L-A} = 1.2 \frac{MgC}{km^2 yr} \]

**S3 Keller and Bacon (1998)**

Kerogen oxidation flux is reported as: 
\[ 0.35 \frac{mol C}{m^2 yr} \]

Converting this leads to: 
\[ F_{L-A} = 4.2 \frac{MgC}{km^2 yr} \]

**S4 Littke et al. (1991)**

Using scenarios S1B and S2B assuming weathering started after the last glacial period (10,000 yrs before present), Littke report organic matter weathering rates between 3.3 and 4.8 kgOM m$^{-3}$ yr$^{-1}$. Converting mass of organic matter to organic carbon using the conversion factor of 1.5 delivers a carbon flux emanating from 1 m$^3$ of shale of 2.2-3.2 kgC m$^{-3}$ yr$^{-1}$. Assuming a weathering depth of 5 m (Littke et al., 1991), this value is converted (by multiplication and unit conversion) to an aerial kerogen oxidation flux of 
\[ F_{L-A} = 11-16 \frac{MgC}{km^2 yr} \]
**S5 Rogieri Pelissari et al. (2021)**

Rogieri Pelissari et al. (2021) report volumetric CO$_2$ fluxes of 54,000 $\frac{\text{ml CO}_2}{\text{t yr}}$ emanating per unit mass of tar sandstone. Using the universal gas law (assuming 295 K temperature) and converting the units yields 27 $\frac{\text{g C}}{\text{t yr}}$ per unit mass of tar sandstone. Taking a density of 2000 kg/m$^3$ for tar sand sandstone:

$$27 \frac{\text{g C}}{\text{t yr}} * 2000 \frac{\text{kg}}{\text{m}^3} = 54 \frac{\text{g C}}{\text{m}^3 \text{yr}}$$

Assuming a conservative weathering depth of 1 m leads to a 54 $\frac{\text{g C}}{\text{m}^3 \text{yr}}$ aerial flux. Converting the units further:

$$F_{L-A} = 54 \frac{\text{Mg C}}{km^2 \text{yr}}$$

**S6 Chang and Berner (1998, 1999)**

The oxygen consumption rate of subaquatic bituminous coal is around $2 \times 10^{-12} \frac{\text{mol O}_2}{\text{m}^2 \text{s}}$, with surface area normalized to specific surface area of coal. See Chang and Berner (1998, 1999) for details on experimental setup. These authors report a CO$_2$ production rate which is 30-50% of the O$_2$ consumption rate. Multiplying these and converting moles to mass of carbon delivers:

$$0.72 - 1.2 \times 10^{-11} \frac{\text{g C}}{\text{m}^2 \text{s}}$$

Converting this to annual CO$_2$ release:

$$2.3 - 3.8 \times 10^{-4} \frac{\text{g C}}{\text{m}^2 \text{yr}}$$

Taking specific surface area of coal as 1 m$^2$/g (Chang and Berner, 1999) converts the above to coal mass normalized CO$_2$ release:

$$2.3 - 3.8 \times 10^{-4} \frac{\text{g C}}{\text{g Coal yr}}$$

Taking the density of bituminous coal as 1.4 t/m$^3$ converts to volumetric normalized CO$_2$ release by multiplication with the above:

$$320 - 530 \frac{\text{g C}}{\text{m}^3 \text{Coal yr}}$$

Assuming a conservative weathering depth of 1 m, and converting the units:

$$320 - 530 \frac{\text{Mg C}}{km^2 \text{yr}}$$
S7 Bertassoli Jr. et al. (2016)

Bertassoli Jr. et al. (2016) report volumetric CO$_2$ fluxes between 211 and 2645 m$^3$CO$_2$/t*day emanating per unit mass of shale. Using the universal gas law (assuming 295 K temperature) and converting the units yields 38-479 gC/t*yr per unit mass of shale. Taking a density of 2200 kg/m$^3$ for shale:

$$38 - 479 \frac{gC}{t*yr} \times 2200 \frac{kg}{m^3} = 84 - 1053 \frac{gC}{m^3*yr}$$

Assuming a conservative weathering depth of 1 m leads to a 54 gC/m$^2$*yr aerial flux. Converting the units further:

$$F_{L-A} = 84 - 1053 \frac{MgC}{km^2*yr}$$

S8 Ait-Langomazino et al. (1991)

Ait-Langomazino et al. (1991) report CO$_2$ release from bitumen from microbial cultures releasing between 3.4 and 6.4 wt. % carbon released per unit weight of bitumen. Converting this:

$$0.0093 - 0.0175 \frac{gC}{gBitumen}$$

Normalizing this per unit time, by dividing by 2400 hours (the duration of the incubation experiment):

$$0.03 - 0.06 \frac{gC}{gBitumen*yr}$$

Assuming 10 wt.% bitumen content in oil sand with a bulk density of 2000 kg/m$^3$ and a conservative weathering depth of 1 m:

$$F_{L-A} = 6800 - 13000 \frac{MgC}{km^2*yr}$$