Supplement of Biogeosciences, 19, 359–373, 2022
https://doi.org/10.5194/bg-19-359-2022-supplement

Biogeosciences Open Access

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: $0.25\ \frac{MtC}{yr} = 2.5E + 11\frac{gC}{yr}$

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: $1\ \frac{MtC}{yr} = 1E + 12\frac{gC}{yr}$

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: $0.35\frac{molC}{m^2 yr}$

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 $\frac{kgOM}{m^3 yr}$. 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 $\frac{kgC}{m^3 yr}$. 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 $\frac{mlCO_2}{t*yr}$ emanating per unit mass of tar sandstone. Using the universal gas law (assuming 295 K temperature) and converting the units yields 27 $\frac{gC}{t*yr}$ per unit mass of tar sandstone. Taking a density of 2000 kg/m^3 for tar sand sandstone:

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

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

$$F_{L-A}=54\ \frac{MgC}{km^2yr}$$

S6 Chang and Berner (1998, 1999)

The oxygen consumption rate of subaquatic bituminous coal is around 2E-12 $\frac{molO_2}{m^2s}$, 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:

0.72-1.2E-11 $\frac{gC}{m^2s}$

Converting this to annual CO_2 release:

2.3-3.8E-4 $\frac{gC}{m^2yr}$

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:

2.3-3.8E-4 $\frac{gC}{gCoal*yr}$

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 $\frac{gC}{m^3Coal*yr}$

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

320-530 $\frac{MgC}{km^2*yr}$

S7 Bertassoli Jr. et al. (2016)

Bertassoli Jr. et al. (2016) report volumetric CO_2 fluxes between 211 and 2645 $\frac{mlCO_2}{t*day}$ emanating per unit mass of shale. Using the universal gas law (assuming 295 K temperature) and converting the units yields 38-479 $\frac{gC}{t*yr}$ per unit mass of shale. Taking a density of 2200 kg/m^3 for shale:

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

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

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

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/m3 and a conservative weathering depth of 1 m:

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