The Acadian metamorphic carbon flux and Devonian climate

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The magnitude of the flux of CO_2 from the solid Earth into the atmosphere as a result of metamorphic degassing processes has long remained one of the great uncertainties in our understanding of the geologic carbon cycle, and few observational constraints exist. We therfore present new observations and numerical modeling of metamorphic CO_2 evolution during Acadian orogenesis in New England, USA.

A total orogenic CO_2 flux is calculated as follows: (1) More than 100 closed-system and fluid-infiltrated pressure-temperature petrologic (pseudosection) models are calculated for a total of eight samples from the Wepawaug Schist, a metaclastic-metacarbonate sequence in Connecticut, USA. Only fluid-infiltrated calculations match observations, thus only these results are propagated through the rest of the model. (2) Diagrams are used to estimate the CO_2 lost across a range of metamorphic conditions, progressing to more than 50% CO_2 loss at amphibolite facies. (3) Using an existing field temperature gradient[1] and a heating rate deduced from high precision garnet geochronology[2] we calculate the fraction of CO_2 released over a spatial profile of the region through time and estimate an area-normalized CO_2 flux. Uncertainties are propagated via a 10,000 iteration Monte-Carlo simulation. (4) Finally, this estimate is multipled by the area of Acadian metamorphism for a total flux.

We calculate an area-normalized flux of 0.50×10^{12} to 1.7×10^{12} mol CO_2 km^{-2} Myr^{-1}. This is in good agreement with flux estimates from modern[3],[4] and ancient[5],[6] orogenic belts and is comparable in magnitude to the areal flux from mid-ocean ridge and arc volcanism[7]. The Acadian belt is estimated to have released a total of $\sim 0.74 \times 10^{19}$ to 2.5×10^{19} mol CO_2 at a rate of 0.50×10^{18} to 1.7×10^{18} mol CO_2 Myr^{-1}. Coincident global warming, transgression, and extinction[8] suggest that Acadian degassing may have perturbed climate in the Middle and Upper Devonian.

[1] Ague (2002) *Contrib Mineral Petrol* [2] Lancaster *et al.* (2008) *J Metamorph Geo* [3] Becker *et al.* (2008) *EPSL* [4] Chiodini *et al.* (2000) *J Geophys Res: Solid Earth* [5] Kerrick & Caldeira (1998) *Chem Geo* [6] Skelton (2011) *Geology* [7] Dasgupta & Hirschmann (2010) *EPSL* [8] Aboussalam & Becker (2011) *Paleogeogr, Paleoclimatol, & Paleoecol.*