Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.23728

A field-based estimate of Precambrian metamorphic CO_2 degassing

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Rock metamorphism is an often-neglected source of exogenic CO_2 within the long-term (geologic) carbon cycle. On the modern Earth, metamorphic carbon release may be comparable in magnitude to volcanic outgassing (a few Tmol C per year). However, characterization of metamorphic decarbonation prior to the Cambrian period is almost nonexistent. And yet, combined petrologic and carbon cycle modeling suggests that metamorphism may have played an outsized role in the Precambrian carbon cycle (Stewart & Penman 2024). This is primarily due to the abundance of dolomitic mixed carbonate-silicate sediments (Cantine *et al.* 2020) that have a higher decarbonation potential when metamorphosed; this effect could be further enhanced by hotter metamorphic pressure-temperature conditions on the earlier earth (*e.g.,* Brown 2006; Holder *et al.* 2019).

Models predict up to 2.5 times greater metamorphic C outgassing in the mid to late Proterozoic, contributing to evidently warm conditions in the 'boring billion' of earth history (~1.8 to 0.8 Ga). However intriguing, this prediction is not based on direct observation of decarbonation in the rock record. We therefore present preliminary results of a field test for enhanced metamorphic decarbonation during metamorphism of the Central Metasedimentary Belt in Ontario, Canada.

The Central Metasedimentary Belt was metamorphosed between ~1.3 and ~0.9 Ga during Grenville orogenesis and assembly of the supercontinent Rodinia. We focus on rocks from the Mazinaw and Elzevir domains which were subject to both regional and localized contact metamorphism. Thermodynamic modeling, detailed petrography, and stable carbon/oxygen isotopes are used to track metamorphic carbon mobility.

Preliminary results indicate substantial decarbonation ranging from ~ 30% to ~ 60% carbon loss, depending upon metamorphic grade and bulk composition. However, mineral assemblages indicate surprisingly high activity of CO_2 ($aCO_2 > 0.5$), suggesting minimal infiltration by water-bearing fluid. This relatively closed-system devolatilization may be expected to suppress carbon loss compared to model predictions, thus additional field constraints are critically important. Future work will explore fluid composition and both carbonate and organic carbon mobilization on the regional scale. Ultimately a net flux to the surface environment will be estimated and considered in terms of the Precambrian carbon cycle, climate state, and planetary habitability.