Atmospheric CO_2 levels from 2.7 billion years ago using micrometeorite oxidation

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Earth's atmospheric CO_2 concentration during the Archean is poorly constrained. To counter the faint young Sun, atmospheric models of the Archean show that CO_2 levels must have been much higher than on the modern Earth, by a factor of ~10^2 to ~10^3 [1]. In addition to atmospheric models, Archean paleosols and other proxies have been studied to constrain atmospheric CO_2 levels. These studies estimate that the Archean CO_2 level was between ~10 to 2500 times modern (see Sec. 11.4.3 of [2] for discussion). Thus, the estimated atmospheric CO_2 level in the Archean spans ~3 orders of magnitude.

In this work, we find that oxidation of Fe-rich Archean micrometeorites could provide an additional constraint on atmospheric CO_2 levels. We develop a micrometeorite atmospheric entry model and compare our results with Archean micrometeorites [3]. The micrometeorites from [3] are from 2.7 Ga limestones in the Tumbiana Formation of northwest Australia. Our model shows that a CO_2-rich atmosphere can explain the observed iron oxidation from [3] in contrast to other models that claim oxidation by O_2 [4]. Furthermore, we find that the average fractional area of unoxidized Fe to oxidized Fe in sectioned micrometeorites should fall monotonically with increasing atmospheric CO_2 concentrations. Our model predicts an Archean CO_2 vol. mixing ratio of 64±58% (2σ) using data from [3]. Unfortunately, only two data points from [3] constrain the CO_2 estimate, which are the cause of the large uncertainty. However, if additional micrometeorites were collected, the uncertainty could be greatly reduced. [1] Krissansen-Totton et al. (2018) *PNAS*. [2] Catling, D. C., and Kasting, J. F. (2017). [3] Tomkins A. G. et al. (2016) *Nature* 7602, 235-238. [4] Rimmer P. B. et al. (2019) *Geochemical Perspective Letters* 38-42.