Goldschmidt 2022 Abstract
https://doi.org/10.46427/gold2022.10144

New constraints on early Paleozoic carbon cycle balance and climate change from modelling

MRS. CHLOÉ MARKUSSEN MARCILLY[1], PIERRE MAFFRE[2], GUILLAUME LE HIR[3], ALEXANDRE POHL[2,4], FRÉDÉRIC FLUTEAU[3], YVES GODDERIS[5], YANNICK DONNADIEU[6], THEA HATLEN HEIMDAL[1] AND TROND H. TORSVIK[1,7]

[1]Centre for Earth Evolution and Dynamics CEED, University of Oslo
[2]University of California
[3]Université de Paris
[4]Université Bourgogne Franche- Comté
[5]CNRS - Université Paul Sabatier
[6]CEREGE, Aix Marseille University
[7]University of Witwatersrand

Presenting Author: c.f.m.marcilly@geo.uio.no

The Ordovician long-term global cooling trend is a key feature of the early Paleozoic climate. The striking feature of this climatic transition is its magnitude, with tropical SSTs dropping by ~10°C, from ca. 40°C to 30°C. However, the cause(s) of the long-term Ordovician cooling trend still remains poorly understood and many hypotheses have been proposed to explain it, ranging from continental drift, to early land-plant colonization, silicate weathering, and variations in volcanic outgassing rates. Here, we present new simulations of the atmospheric concentration of CO_2 (pCO_2) and surface temperatures using a spatially resolved climate-carbon cycle Earth system model. The model, GEOCLIM, is fed with refined continental reconstructions and new estimates of solid Earth degassing. The model accounts for the competing impacts of continental weathering and volcanic outgassing on pCO_2 and climate. This allows us to quantify the magnitude and temporal trend in global cooling resulting from these competing mechanisms and evaluate their relative contributions. First, the impact of continental drift (paleogeography) alone is investigated, by calculating its imprint on continental weathering rates throughout the Ordovician under a constant pCO_2. Then, the sensitivity of the Earth's climate to paleogeography and carbon degassing changes is investigated by coupling the climate and carbon cycle in the GEOCLIM model.

Based on our experiments we show that, although early Ordovician high temperatures can be replicated within error margins, our new constraints cannot explain the intense cooling over the Mid to Late Ordovician, even if a progressive enhancement in Earth surface weatherability is taken into account.

By using GEOCLIM in an inverse modelling approach, we calculate that the theoretical degassing necessary to reach proxy-derived temperatures for the Early Ordovician is significantly higher compared to modern values. Further, in order to simulate the following Ordovician cooling trend, the solid Earth degassing must be reduced to modern day values in only 30 Myrs. If accepting the veracity of the high early Ordovician temperatures, alternative sources, but also sinks, of carbon must be considered to explain the climatic shift over this period.