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Climate of the Past Discussions

Interactive comment on "Modeling the consequences on late Triassic environment of intense pulse-like degassing during the Central Atlantic Magmatic Province using the GEOCLIM model" *by* G. Paris et al.

Anonymous Referee #1

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General comments

It is increasingly argued that CO2 degassing related to the emplacement of the extensive Central Atlantic Magmatic Province may have played a prominent role in triggering the end-Triassic biosphere crisis and associated extinctions. A precise cause-effect relationship between CAMP magmatism and environmental events at the Triassic-Jurassic transition interval is however still poorly constrained. This modeling excercise attempts to clarify whether volcanically derived CO2 could have driven carbon cycle perturbations, expressed as reduced carbonate production and δ13C excursions in

end-Triassic sedimentary records.

Principal results emphasize that a succession of CO2 degassing pulses could have been a plausible mechanism responsible for the Rhaetian carbonate production crisis. Only by assuming release of isotopically light CO2, CAMP volcanism could also be directly responsible for the pronounced end-Triassic negative δ13C excursion, recognized in sedimentary organic matter as well as carbonates.

The strong point of the modeling exercises is the realization that eruption rates modulated by pulses of intense volcanism have the potential to introduce considerable quantities of CO2 into the atmosphere over rapid time periods. The speculated release of isotopically light volcanogenic CO2 is particularly interesting, because of a similar concept proposed to explain the prominent end-Permian negative δ13C excursion (Sobolev et al., 2011).

On the other hand, the question may arise as to what extent model results match up-to-date observational constraints. Particularly δ13C modeling could benefit from being re-thought in the context of high-resolution δ13Corg data now available from the marine 'key' section at St. Audrie's Bay, England (Ruhl et al., 2010; see also Whiteside et al., 2010).

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- Ruhl, M., Deenen, M.H.L., Abels, H.A., Bonis, N.R., Krijgsman, W., Kürschner, W.M., 2010. Astronomical constraints on the duration of the early Jurassic Hettangian stage and recovery rates following the end-Triassic mass extinction (St. Audrie's Bay/ East Quantoxhead, UK). EPSL, 295: 262–276.

- Whiteside, J.H., Olsen, P.E., Eglinton, T., Brookfield, M.E., Sambrotto, R.N., 2010. Compound-specific carbon isotopes from Earth's largest flood basalt eruptions directly linked to the end-Triassic mass extinction. PNAS, 107: 6721–6725.

Specific comments

Following previous studies at St. Audrie's Bay, latest Triassic-Early Jurassic δ13Corg trends in Europe and North America are commonly considered to show (1) a relatively sharp 'initial' negative excursion followed by (2) a positive trend, and (3) an extended 'main' negative excursion. Although difficult to match with the original data from New York Canyon, this isotopic pattern is idealized in Fig.1. According to various authorities, estimates of the duration of the 'initial' excursion vary between "less than 200 ky and 500 ky".

The high-resolution δ13Corg record has confirmed the reality of a pronounced 'initial' excursion of about 5‰ coinciding with the end-Triassic extinction interval. On the other hand, the concept of a second 'main' excursion seems to be unjustified: a declining δ13C trend followed by the appearance of Jurassic ammonites reflects the onset of continuously low δ13Corg values throughout the Hettangian and early Sinemurian. Hence, rather than an 'excursion', this trend may reflect a shift to new long-term steady state values succeeding early Hettangian CAMP volcanic activity. Modeling attempts should therefore more explicitly focus on the 'initial' excursion.

Recognition of orbitally forced δ13Corg oscillations at St Audrie's Bay now enables calibration of the isotopic trends at high (20 ky) precision. Ruhl et al. consider the end-Triassic mass extinction interval and coinciding 'initial' δ13C excursion to be represented by 1–2 precession cycles (20–40 ky). This duration is typically an order of magnitude shorter than that of the modeled carbon-cycle perturbations. It seems relevant, therefore, to calibrate input parameters in harmony with these new age interpretations.

Technical corrections

- Although correctly defined as CO2 partial pressure, throughout the study the term pCO2 is used to denote CO2 concentrations or mixing ratios (expressed in ppm or

ppmv), rather than pressure. This is confusing and should be avoided.

- In general, the English is understandable but still may need some improvement. The authors may want to seek advice from a native English-speaking colleague who is familiar with their research area, and who is willing to check the manuscript.

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