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SHIFTING BIOGEOCHEMICAL DYNAMICS DURING THE LATE TRIASSIC AND EARLY JURASSIC: INSIGHT FROM STABLE CARBON AND NITROGEN RECORDS

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1. Introduction

The end-Triassic mass extinction was one of the largest mass extinctions of the Phanerozoic. The causes of the extinction and associated environmental changes have largely been hypothesized to be from the contemporaneous emplacement of the Central Atlantic magmatic province (CAMP), a large igneous province that injected climatically significant volatiles into the atmosphere during its geologically rapid emplacement (e.g. Marzoli et al., 2004).

The stable carbon isotope composition of marine carbonate ($\delta^{13}C_{carb}$) and organic carbon ($\delta^{13}C_{org}$) changed during the end-Triassic mass extinction and the emplacement of CAMP (e.g., Ward et al., 2001; Hesselbo et al., 2002; Palfy et al., 2001; Guex et al., 2004). Interpretations of the C isotope records across the Triassic-Jurassic boundary vary widely, particularly in terms of what these records tell us about CAMP and associated C cycle change. Hypotheses range from ocean acidification to changes in nutrient cycles, and are typically invoked as products of increased atmospheric CO_2 (e.g. Greene et al., 2012; van de Schootbrugge et al., 2007).

2. Levanto Section

Within the framework of our ongoing sedimentological, biostratigraphic, and geochemical analyses across the Triassic-Jurassic boundary in selected localities from Nevada (USA) and Morococha and Chachapoyas (Peru) (Ritterbush et al., 2014; 2015; Yager et al., In review), we discuss our stable carbon and nitrogen ($\delta^{15}N$) analyses from the Levanto section (Chachapoyas). The Late Triassic and Early Jurassic outcrop at the Levanto section as the Aramachay formation, part of the Pucara group (Rosas et al., 2007), consisting of carbonate-rich shales. U-Pb ash bed dating and ammonite biostratigraphy (Schaltegger et al., 2008 ; Schoene et al., 2010 ; Guex et al., 2012 ; Wotzlaw et al., 2014) from the Levanto section enable assessment of changes in isotope measurements through time and global correlation, respectively.

We will discuss changes in paired $\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ and $\delta^{15}N$ measurements from the Levanto section to evaluate possible changes in biogeochemical cycling across the end-Triassic extinction and emplacement of CAMP.

3. $\delta^{13}C$

$\delta^{13}C_{org}$ and $\delta^{13}C_{carb}$ both exhibit broad first order positive excursions. $\delta^{13}C_{org}$ is consistent near -30‰ for much of the Rhaetian, until an abrupt shift to -27.5‰, followed by a shift to -28.5‰ coincident with the end-Triassic mass extinction. A second positive shift follows, and then values slowly return to -30‰ until the top of the section.

$\delta^{13}C_{carb}$ is near -2‰ and shifts towards 1.5‰ during the entirety of the measured Rhaetian. $\delta^{13}C_{carb}$ shifts back towards -2‰ while $\delta^{13}C_{org}$ shifts back towards -30‰ during the Hettangian. These records are consistent with other measured sections from the Triassic-Jurassic (e.g. Hesselbo et al., 2002; Ward et al., 2001 Williford et al., 2007; Bachan et al., 2012).

4. $\delta^{15}N$

Our ~four million year record is the first high-resolution $\delta^{15}N$ study spanning much of the Rhaetian through much of the Hettangian. $\delta^{15}N$ values shift systematically through the Rhaetian at the Levanto section, from ~9‰(early – mid Rhaetian) to ~3‰ (late Rhaetian). Rhaetian values exhibit cyclicity within this trend, with a variability of about 3‰. We speculate these changes may be related to Milankovitch cycles. $\delta^{15}N$ values stabilize near 2.5‰ in association with the end-Triassic extinction and Triassic-Jurassic boundary, with very little variability seen through the Hettangian (< ±0.5 ‰). The shift from Milankovitch-driven cycling towards low variability and accompanying shift from more positive to low $\delta^{15}N$ values could be explained by several potential hypotheses related to the cycling of organic matter, paleo-redox, and nutrient dynamics leading up to the end-Triassic mass extinction. We will discuss possible scenarios (e.g. change in nutrient supply, water column oxygenation) leading to these changes and the plausibility of each in light of other data (e.g. C:N, %TOC) in an attempt to better understand changes in biogeochemical cycling prior to the end-Triassic mass extinction.

References

Bachan, A., van de Schootbrugge, B., Fiebig, J., McRoberts, C. A., Ciarapica, G., Payne, J. L., 2012, Carbon cycle dynamics following the end-Triassic mass extinction: Constraints from paired $\delta^{13}C_{carb}$ and $\delta^{13}C_{org}$ records: Geochemistry, Geophysics, Geosystems, v. 13, no. 9, Q09008, doi: 10.1029/2012GC004150.

Greene, S. E., Martindale, R. C., Ritterbush, K. A., Bottjer, D. J., Corsetti, F. A., Berelson, W. M., 2012, Recognizing ocean acidification in deep time: An evaluation of the evidence for acidification across the Triassic-Jurassic boundary: Earth-Science Reviews, v. 113, p. 72-93, doi: 10.1016/j.earscirev.2012.03.009.

Guex, J., Bartolini, A., Autudorei, V., Taylor. D. 2004. High-resolution ammonite and carbon isotope stratigraphy across the Triassic–Jurassic boundary at New York Canyon (Nevada). Earth and Planetary Science Letters, v. 225, p. 29–41.

Guex, J., Schoene, B., Bartolini, A., Spangenberg, J., Schaltegger, U., O'Dogherty, L., Taylor, D., Bucher, H., Atudorei, V., 2012, Geochronological constraints on post-extinction recovery of the ammonoids and carbon cycle perturbations during the Early Jurassic: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 346-347, p. 1-11, doi: 10.1016/j.palaeo.2012.04.030.

Hesselbo, S. P., Robinson, S. A., Surlyk, F., Piasecki, S., 2002, Terrestrial and marine extinction at the Triassic-Jurassic boundary synchronized with major carbon-cycle perturbation: a link to initiation of massive volcanism? Geology, v. 30, p. 251-254.

Marzoli, A., Bertrand, H., Knight, K. B., Cirilli, S., Buratti, N., Verati, C., Nomade, S., Renne, P. R., Youbi, N., Martini, R., Allenbach, K., Neuwerth, R., Rapaille, C., Zaninetti, L., Bellieni, G., 2004, Synchrony of the Central Atlantic magmatic province and the Triassic-Jurassic boundary climatic and biotic crisis: Geology, v. 32, no. 11, p. 973-976, doi: 10.1130/G20652.1.

Palfy, J., Demeny, A., Haas, J., Hetenyi, M., Orchard, M. J., Veto, I., 2001, Carbon isotope anomaly and other geochemical changes at the Triassic-Jurassic boundary from a marine section in Hungary: Geology, v. 29, no. 11, p. 1047-1050.

Ritterbush, K., Bottjer, D., Corsetti, F. & Rosas, S. 2014. New evidence on the role of siliceous sponges in ecology and sedimentary facies development in eastern Panthalassa following the Triassic/Jurassic mass extinction. Palaios, v. 29(12), p. 652-668.

Ritterbush, K., Rosas, S., Corsetti, F., Bottjer, D., West, J. 2015. Andean sponges reveal long-term benthic ecosystem shifts following the end-Triassic mass extinction. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 420, p. 193–209.

Rosas, S., Fontboté, L., Tankard, A. 2007. Tectonic evolution and paleogeography of the Mesozoic Pucará Basin, central Peru. Journal of South American Earth Sciences, v. 24, p. 1–24.

Schaltegger, U., Guex, J., Bartolini, A., Schoene, B., Ovtcharova., M., 2008. Precise U-Pb age constraints for end-Triassic mass extinction, its correlation to volcanism and Hettangian post-extinction recovery: Earth and Planetary Science Letters v. 267, p. 266-275, doi:10.1016/j.epsl.2007.11.031.

Schoene, B., Guex, J., Bartolini, A., Schaltegger, U., Blackburn, T.J., 2010, Correlating the end-Triassic mass extinction and flood basalt volcanism at the 100 ka level: Geology, v. 38, no. 5, p. 387–390, doi: 10.1130/G30683.1.

van de Schootbrugge, B., Tremolada, F., Bailey, T. R., Rosenthal, Y., Feist-Burkhardt, S., Brinkhuis, H., Pross, J., Kent, D. V., Falkowski, P. G., 2007, End-Triassic calcification crisis and blooms of organic-walled disaster species: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 244, p. 126-141, doi: 10.1016/j.palaeo.2006.06.026.

Ward, P.D., Haggart, J. W., Carter, E. S., Wilbur, D., Tipper, H. W., Evans, T., 2001, Sudden productivity collapse associated with the Triassic-Jurassic boundary mass extinction: Science, v. 292 p. 1148-1151.

Williford, K. H., Ward, P. D., Garrison, G. H., Buick, R., 2007, An extended organic carbon-isotope record across the Triassic-Jurassic boundary in the Queen Charolette Islands, British Columbia, Canada: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 244, p. 290-296, doi: 10.1016/j.palaeo.2006.06.032.

Wotzlaw, J.F., Guex, J., Bartolini, A., Gallet, Y., Krystyn, L., McRoberts, C.A., Taylor, D., Schoene, B., Schaltegger, U., 2014, Towards accurate numerical calibration of the Late Triassic: High precision U-Pb geochronology constraints on the duration of the Rhaetian: Geology, v. 42, p. 571-574, doi: 10.1130/G35612.1.

Yager, J., West, J., Corsetti, F., Berelson, W., Rollins, N., Rosas, S., Bottjer, D. In review. Duration and decoupling of carbon isotope excursions associated with the end-Triassic mass extinction and emplacement of the Central Atlantic Magmatic Province.