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Influence of the local controlling factors over the Early Triassic paired carbon isotopes fluctuations

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Context and localization

Important and recurrent perturbations of the carbon isotope signals are recorded in the aftermath of the end-Permian mass extinction (PTB, ~252 Ma) and during the entire Early Triassic. These perturbations are most notably represented by a globally recognized negative-positive isotopic couplet observed at the Smithian/Spathian boundary (SSB) and in a lesser extent by a positive excursion at the Dienerian/Smithian boundary (DSB), within both carbonate and organic matter (OM) reservoirs (Fig. 1). These fluctuations are usually linked to global paleoenvironmental variations related to the Siberian Traps degassing (e.g., Romano *et al.*, 2013).

Here, we propose an original study of the paired carbon isotope record of the Hot Springs (HS) section (southeasternmost Idaho, USA, Fig. 1), which is part of the Early Triassic Northern Sonoma Foreland Basin (SFB).

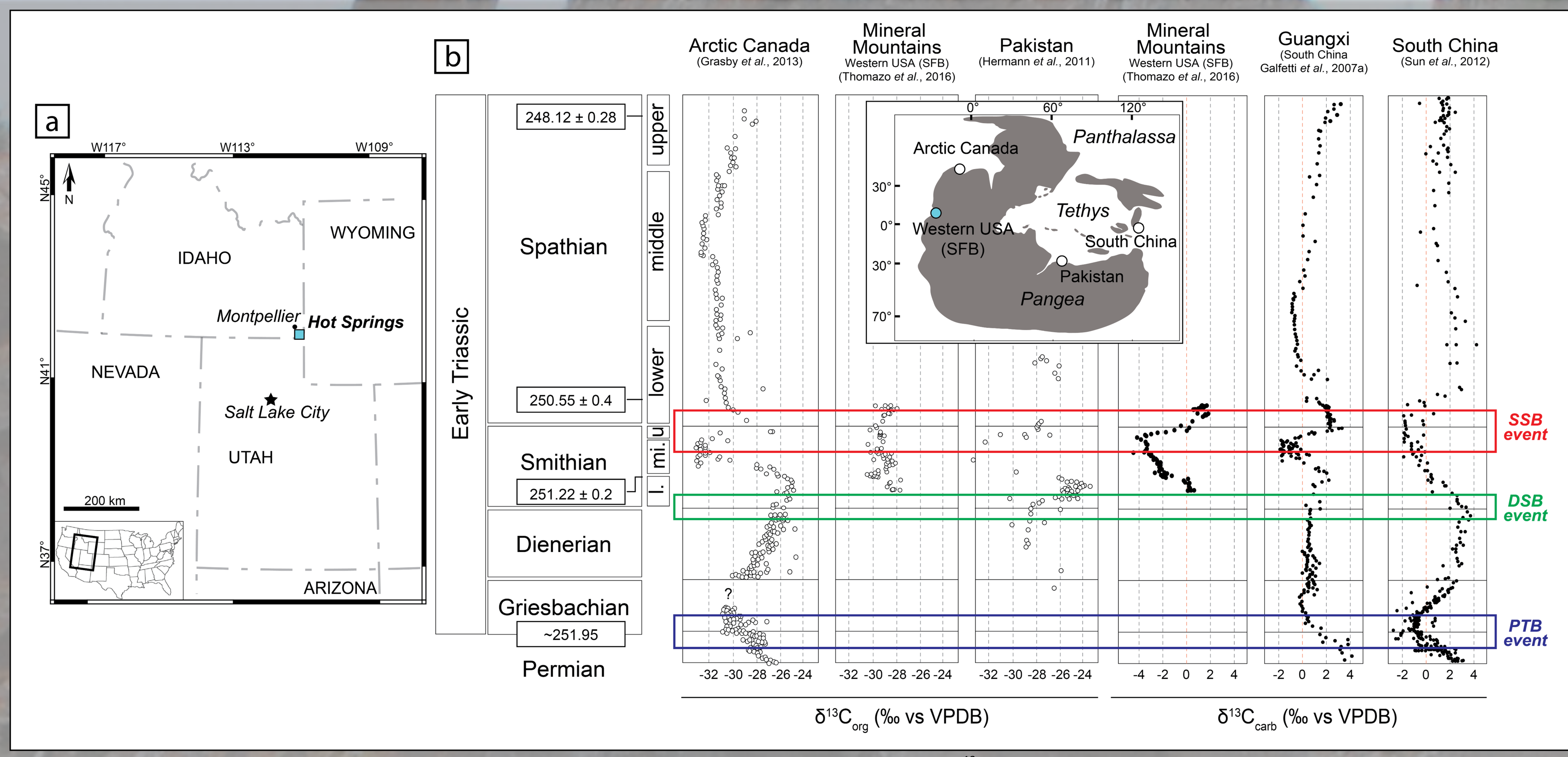


Figure 1: a) Map of the studied area and location of the Hot Springs section; b) Worldwide Early Triassic variations of the $\delta^{13}C$ signal for both carbonate and OM reservoirs.

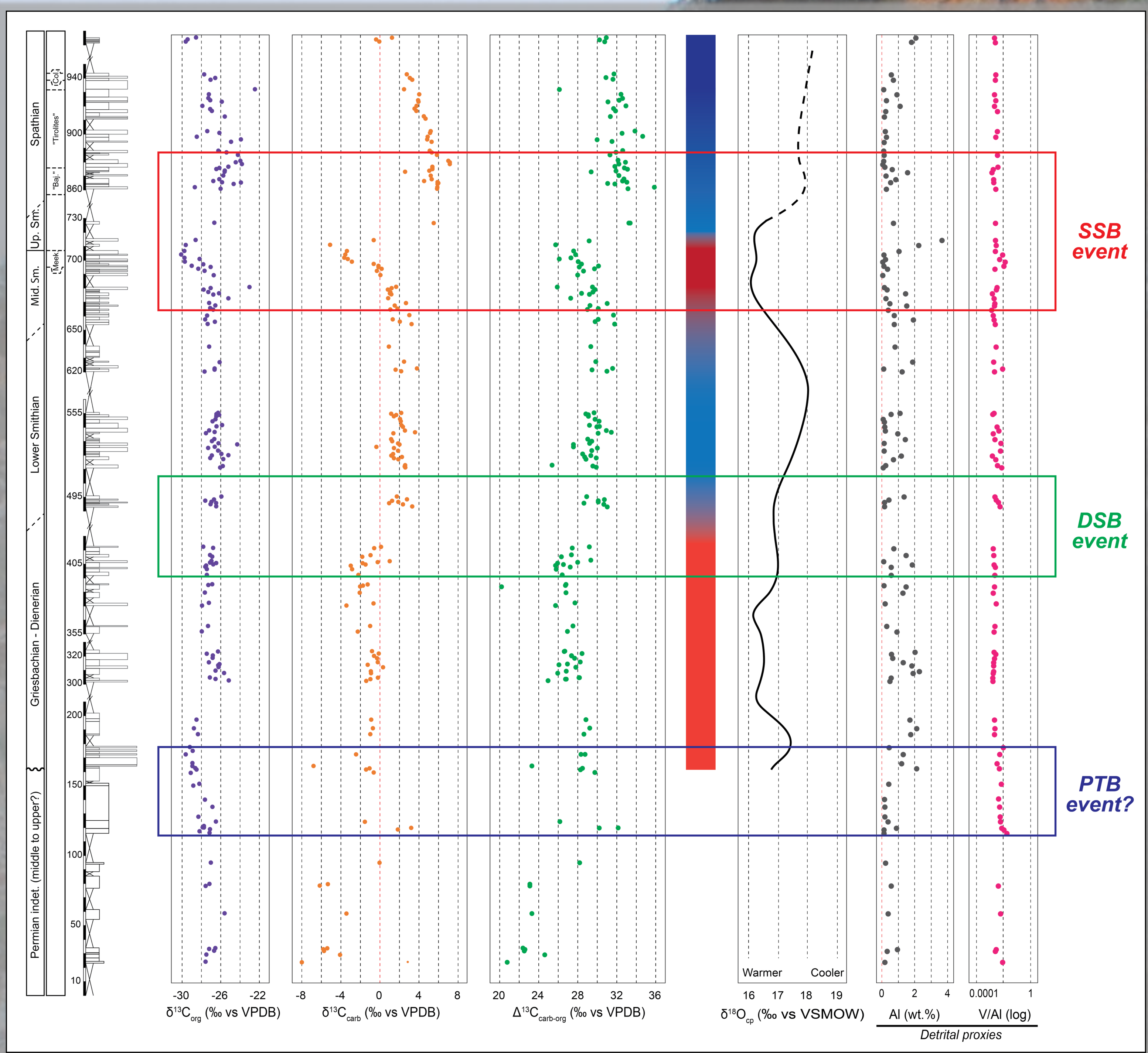


Figure 2: Main geochemical signals in the Hot Springs section with $\delta^{13}C_{org}$, $\delta^{13}C_{org}$, net isotopic effect $\Delta^{13}C$, and fluctuations of detrital trace and major elements Al and V/Al ratio. $\delta^{18}O_{cp}$ and paleotemperatures trends from Romano *et al.* (2013). Ammonoid biozones: Meek., Meekoceras; "Baj.", ~Bajarunia; Col., Columbites.

Main results

Sedimentology

- HS section spans a continuous interval from the Griesbachian-Dienerian up to the lower Spathian;
- Facies associations represent shallow marine environments;
- A transgressive trend is present, with the maximum flooding occurring during the Upper Smithian (*Meekoceras* ammonoid biozone).

Carbon isotopic signal (Fig. 2)

- Both carbonate and OM $\delta^{13}C$ records show the globally recognized couplet of isotopic excursions at the SSB;
- The DSB positive excursion is observed but only in the carbonate reservoir;
- Variations in the OM reservoir appears to be dampened compared to their carbonate counterpart.

Trace & Major elements (Fig. 2)

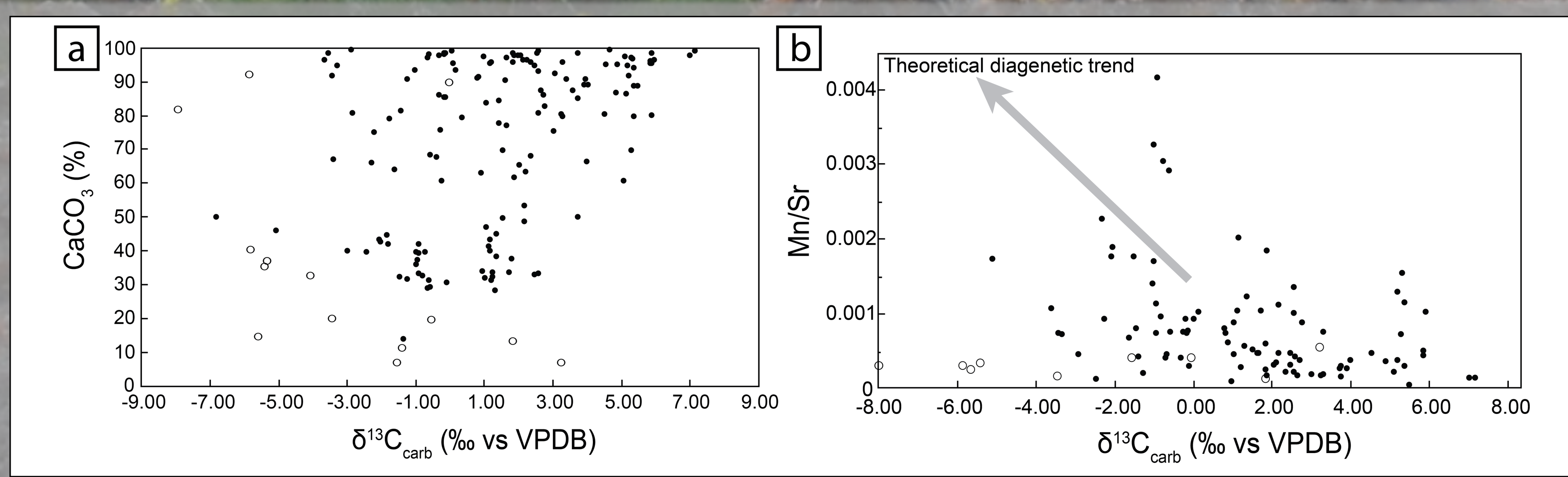
- Al concentrations do not show any significant variation, excepted for the Upper Smithian interval where a peak in Al concentrations is recorded;
- V shows an unexpected behavior and acts as a proxy for detritism due to its correlation to Al (r = 0.81***), rather than for paleoredox conditions (Tribovillard *et al.*, 2006).

Significance of the paired carbon isotopic signal

Net isotopic effect is represented by $\Delta^{13}C$ (=$\delta^{13}C_{carb}$—$\delta^{13}C_{org}$). Along the HS section, $\Delta^{13}C$ variations mirror that of both carbonate and OM $\delta^{13}C$ signals.

These variations may originate from:

- Diagenesis: Secondary modification of the signal may have altered the original signal. However, several tests argue against an important impact of secondary modification (Fig. 3).
- Biological fractionation variations: Evolutions of the biological fractionation may reflect variations of the temperatures, in relation to atmospheric pCO_2. However, a drop in $\Delta^{13}C$ is expected when temperatures (and thus $[CO_2]$) increase, which is the opposite of the observed behavior at HS (Fig. 2)
- Contamination by a locally brought secondary source: Local input of terrigenous highly negative OM (-22 to -32 ‰) might modify the positive isotopic excursions by "drawing" the signal towards more negative values (Fig. 4). This hypothesis is supported by regional evidence of such input and sustained detrital input to the basin.



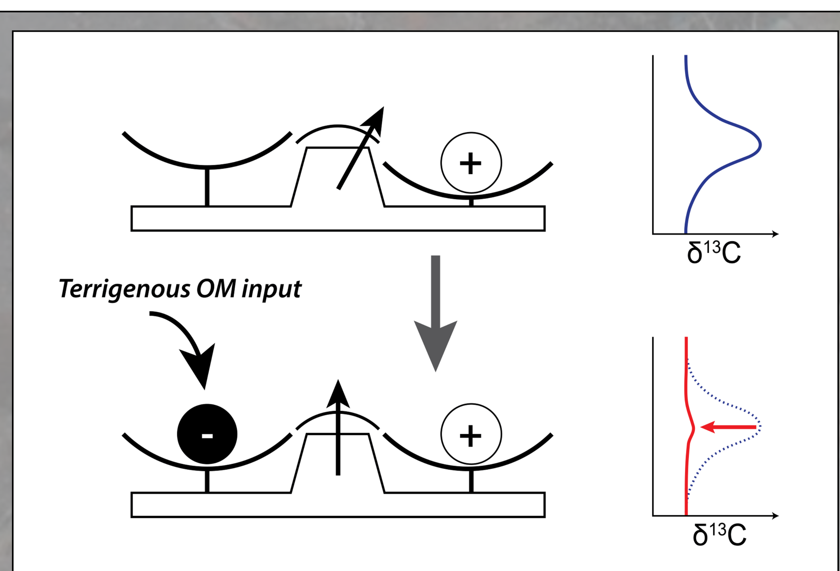


Figure 3 (top): Cross-plots for isotopic and elemental geochemical parameters; a) $\delta^{13}C_{carb}$ *vs* $CaCO_3$ content; b) $\delta^{13}C_{carb}$ *vs* Mn/Sr. $\delta^{13}C_{carb}$ does not follow any diagenetic trend and does not show any correlation.

Figure 4 (left): Schematic representation of the modification of the $\delta^{13}C_{org}$ signal due to contamination by terrigenous input. This highly negative OM (~-22 to -32 ‰) would therefore modify the positive excursion signal by "drawing" it toward more negative values..

Conclusion

The globally expected and recognized isotopic signal for the Early Triassic, and especially the couplet of negative and positive excursions at the SSB, is observed at HS. However, we argue that influences on the $\delta^{13}C$ signal that are neither of local diagenetic origin nor representative of the global exogenic carbon cycle, have probably largely contributed to the HS geochemical signature.

We therefore argue that this signal is unfit for accurate long-range correlations and paleoenvironmental interpretations regarding the global carbon cycle of the Early Triassic. In turn, $\delta^{13}C$ should better be used as a proxy to finely constrain and characterize fluctuating local paleoenvironmental conditions during deposition.

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