Latest Sandbian–Earliest Katian (Late Ordovician) "Guttenberg" Positive $\delta^{13}C$ Excursion (GICE) Spans ca. 1.2 Myr (3 Long-Eccentricity Cycles) in Asia

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HIGHLIGHTS

"Guttenberg" positive carbon-isotope excursion (GICE) is a marker for the Katian GSSP, and a valuable global correlation tool for Late Ordovician.

GICE is a ~250-kyr event in N. America. But, it is a broad excursion spanning up to 100 m and 1.2 Myr in Asia.

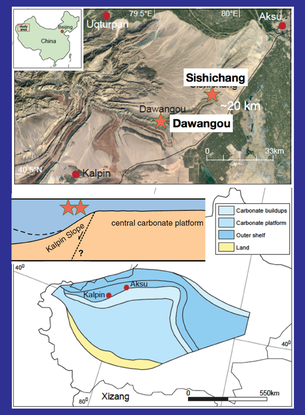
We enhanced the $\delta^{13}C$ records and applied cyclostratigraphy analysis to the thickest (ca. 100 m) GICE in Asia — Dawangou section of Tarim — and of a second section ca. 25 km away.

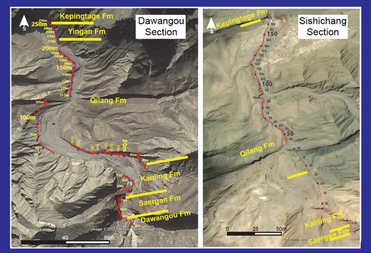
The Tarim GICE consists of three main 405-kyr secondary modulations (*G1*, *G2*, and *G3*).

Modulation peaks in $\delta^{13}C$ are in the clay-rich intervals, which $\delta^{18}O$ suggests are warmer climates.

The second of those modulations, *G2*, in the "Asian GICE" may correspond to the N. American assignment of GICE.

Tarim Sections





Sampling:

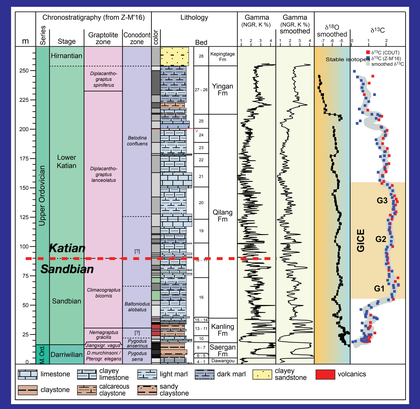
Natural gamma ray = 25-cm spacing

A portable radiation spectrometer (RS-230)

Stable isotopes: $\delta^{13}C_{carb}$ and $\delta^{18}O$

Merger of this study; Zhang & Munnecke (2016 - Paleo-3); and Liu et al. (2019, Global and Planetary Change)

Dawangou Stratigraphy



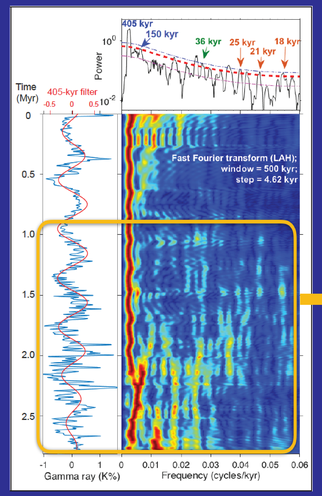
Natural gamma log *(and with a 5-pt Hanning smoothing)*

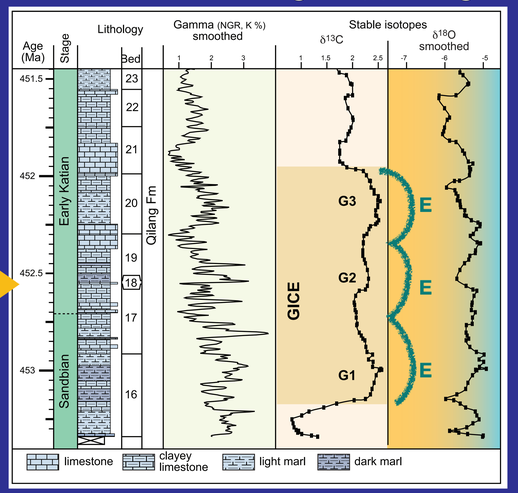
Merged stable isotopes = highest-temporal resolution of any GICE record?

GICE at Tarim: 100-m-thick plateau of highest values *(G1-G2-G3 had been previously suggested by Zhang & Munnecke (2016), but not in this detail).*

[Diagram prepared with *TimeScale Creator* visualization software (*www.timescalecreator.org*)]

Time scale from Long-Ecc (E) Tuning

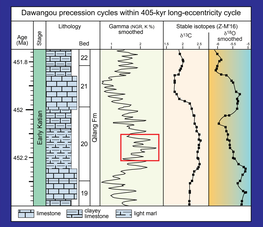


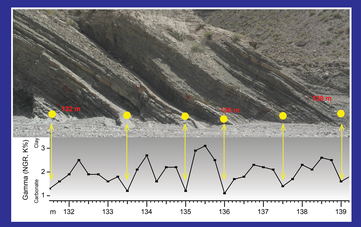


$\delta^{13}C$ variations are modulated by long-Eccentricity cycles (405-kyr). Implies that Total duration = 2.8 Myr; **GICE interval = 1.2 Myr span.** Anchor date — base Katian @ 452.75 Ma *(Goldman et al., 2020 in GTS2020)*

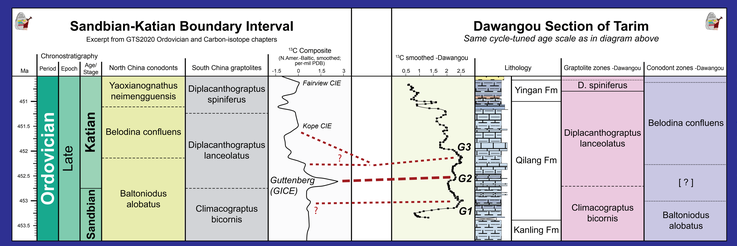
GICE has 3 secondary positive excursions (405-kyr each). Clay-enriched intervals represent warmer regional climate during peaks in the long-Eccentricity cycles of $\delta^{13}C$. Precession cycles are superimposed, but seem minor in the isotope signals.

Detail of periodic variations in natural gamma (= precession cycles of ca. 20 kyr)





Possible correlation of the brief N. American GICE to the long Asian (Tarim) GICE



Reference scales from GTS2020:

Age-model for biozones:

Daniel Goldman, Pete Sadler and Stephen Leslie

Stable isotope curve of $\delta^{13}C_{carb}$:

Smoothed version from Brad Cramer and Ian Jarvis; who based early Katian on Stig Bergström et al. (2010, Palaeo-3) and late Sandbian on Bauert et al. (2014; Eston. J. Earth Sci.)

Age model for $\delta^{13}C$ in GTS2020 is not tuned to cycles => Kope CIE might be older, therefore correlate to Tarim *G3*? Latest Sandbian might have a "SAICE", which might correlate to Tarim *G1*?