

GSA annual meeting, 2015, Baltimore

Environmental context for the terminal Ediacaran biomineralization of animals:

***Integrated bio-chemo-chrono-stratigraphy of the Gaojiashan
Member, Dengying Formation, South China***

Huan Cui & Alan J. Kaufman, Shuhai Xiao
(University of Maryland) (Virginia Tech)

Other collaborators:

**Sara Peek (USGS), Hansheng Cao (JLU), Xiao Min & Yaoping Cai
(NWU), Zakri Siegel, Xiao-Ming Liu (UNC), Yongbo Peng (LSU),
James D. Schiffbauer (Missouri), Aaron J. Martin (IPICYT)**

**Grants from: NASA Exobiology, NSF, NSFC,
AAPG Grants-In-Aid Program, Explorers Club Washington Group**

One-page Preview

Background:

The earliest animals (i.e. *Cloudina*) that evolved with **skeletons** emerged in the terminal Ediacaran.

Motivation:

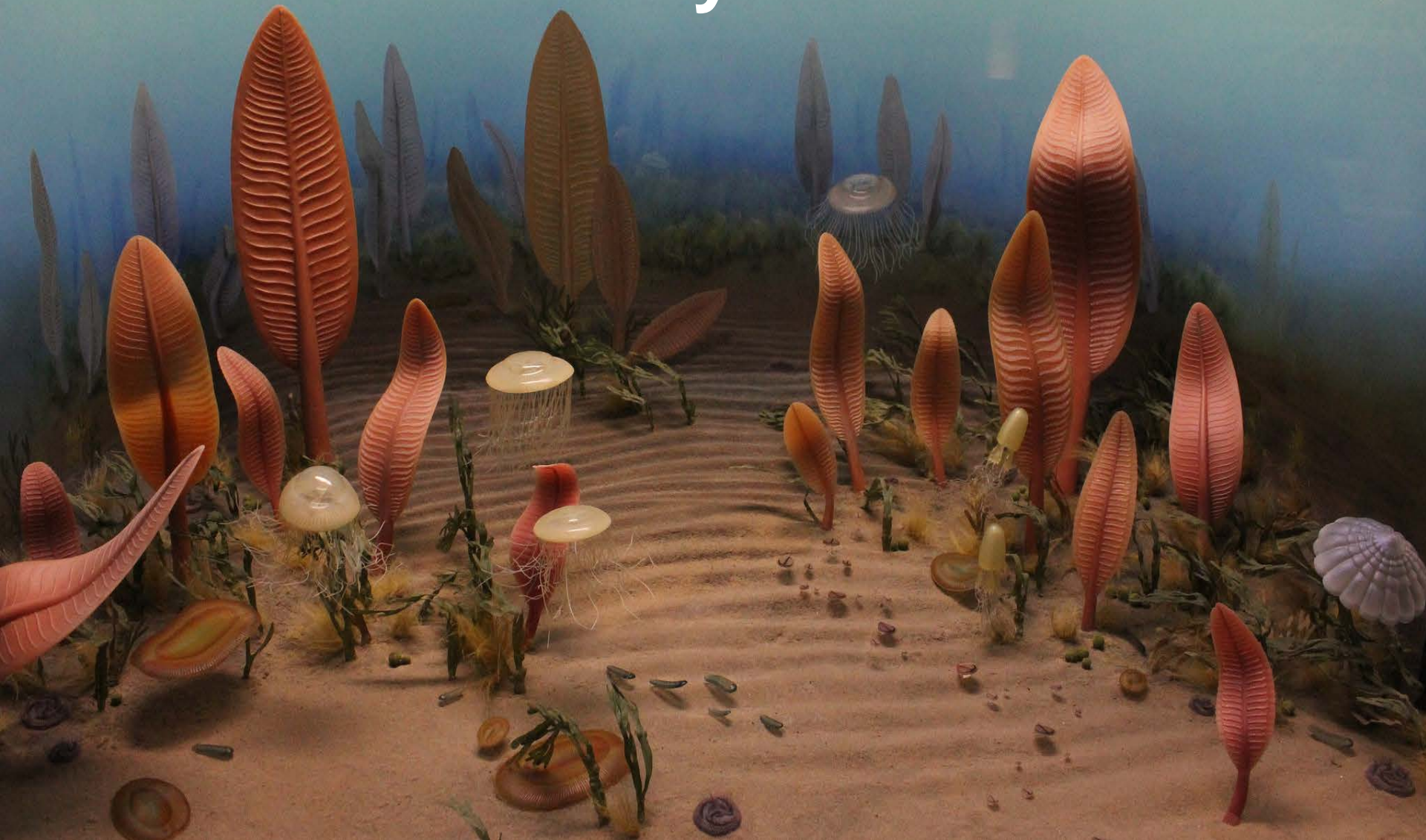
What is the **environmental driver** for this animal biomineralization event?

My study:

Based on chemostratigraphy, I discovered coupled **C-S-Ca-Sr anomalies** coinciding with the first appearance of *Cloudina* fossils.

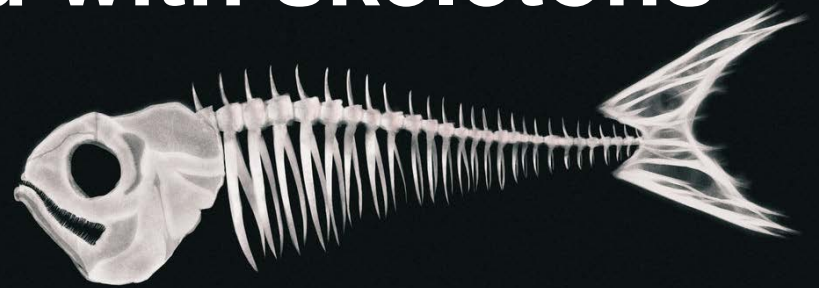
Enhanced Ca concentration in seawater may promote calcareous biomineralization.

Ediacara-type soft-body animals



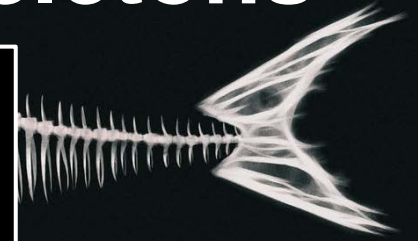
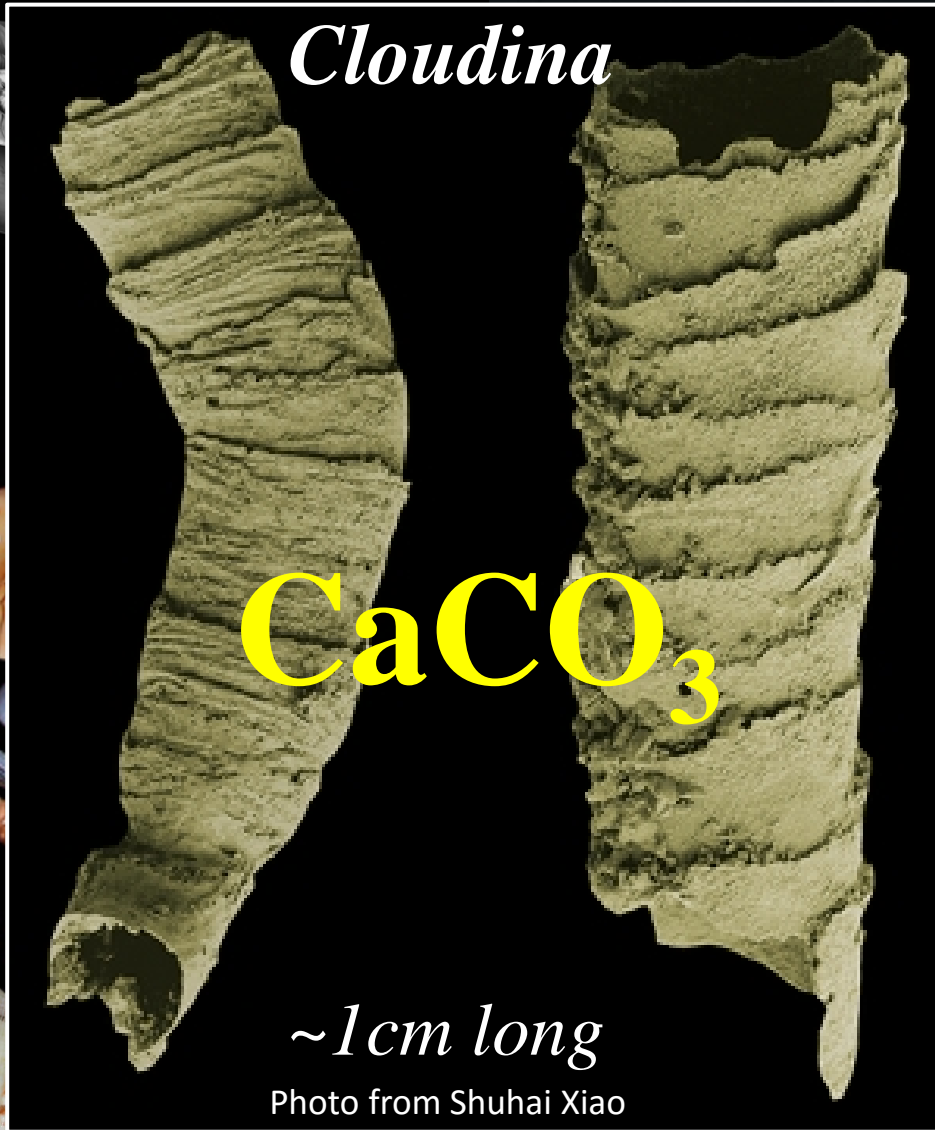
Photos taken in Smithsonian

Animals evolved with skeletons



(Photo from
internet)

Animals evolved with skeletons



(Photo from internet)

The Earth's earliest animal evolved with skeletons



Significance of the Terminal Ediacaran Dengying Formation

Postdates the Shuram Excursion,
The last >10 millions years of the
Ediacaran Period

(Condon et al., 2005 *Science*; An et al., 2015 *PreCam Res*)

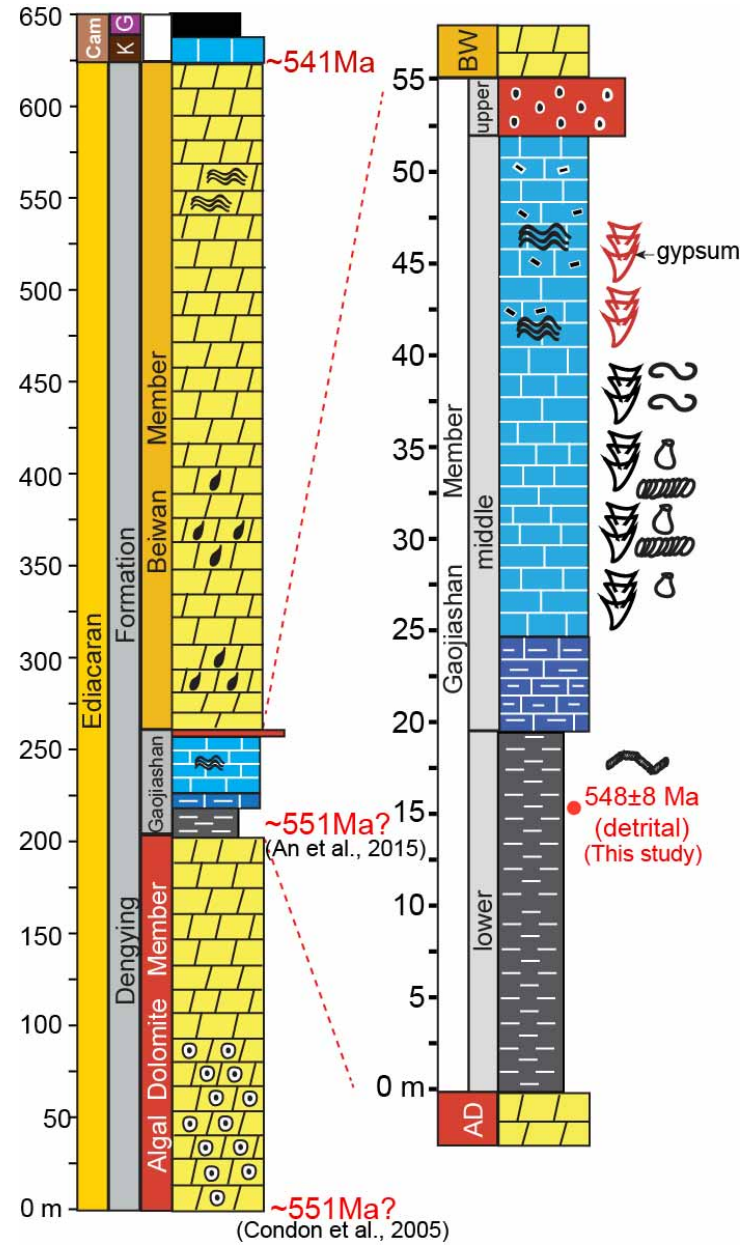
Gaojiashan Mb. \approx Shibantan Mb.

Gaojiashan Member
in Southern Shaanxi province:

Gaojiashan Biota,
including *Cloudina*

Shibantan Member
in Three Gorges area:

Ediacara fossils preserved in
marine limestone



Significance of the Terminal Ediacaran **Dengying Formation**

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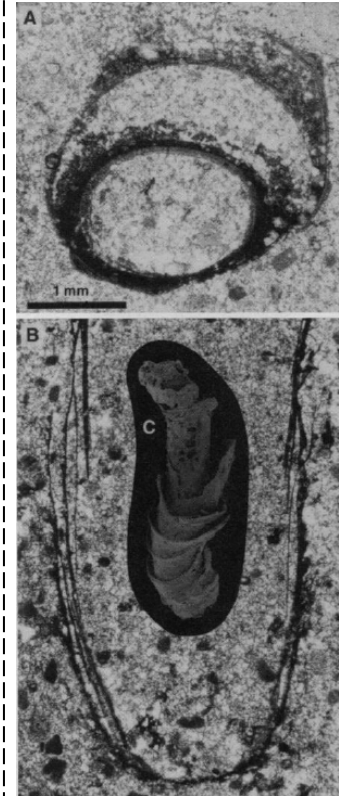
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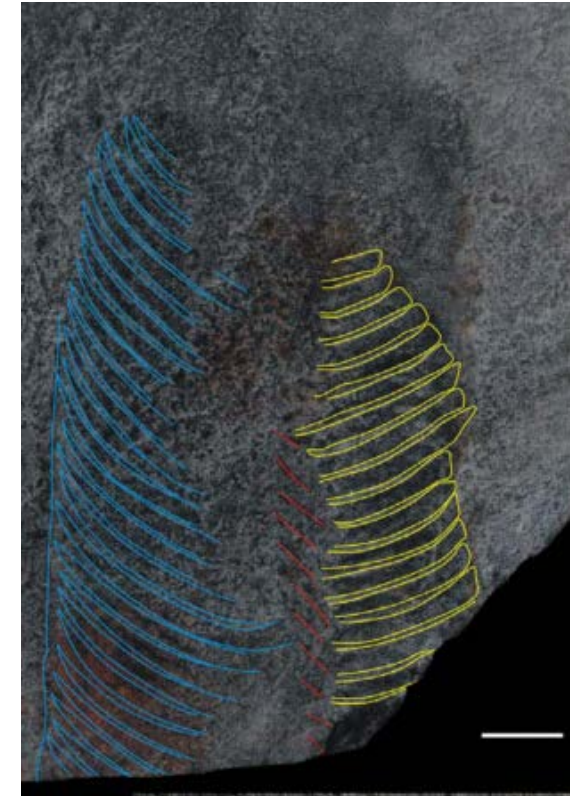
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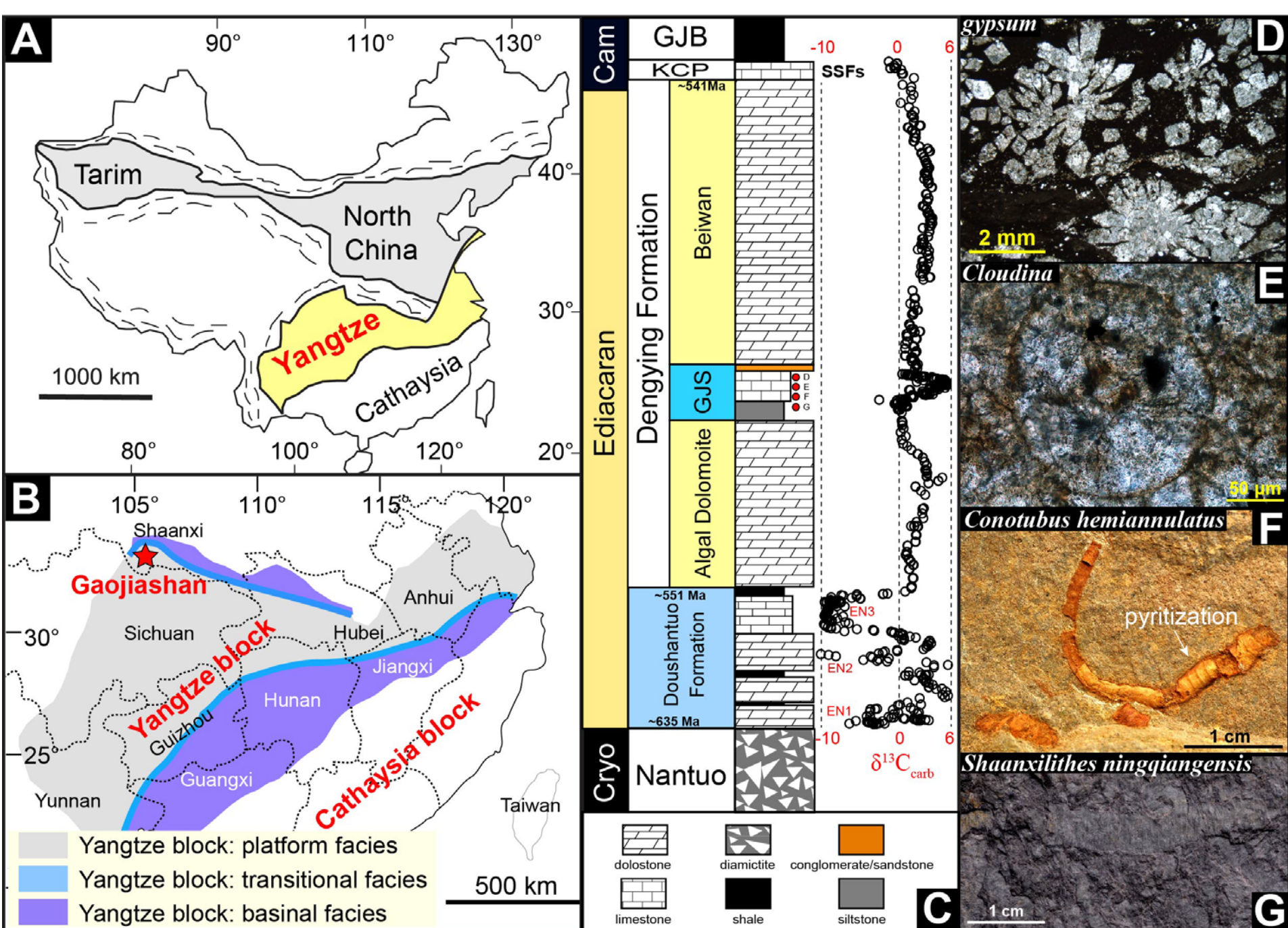
Cloudina in
Gaojiashan



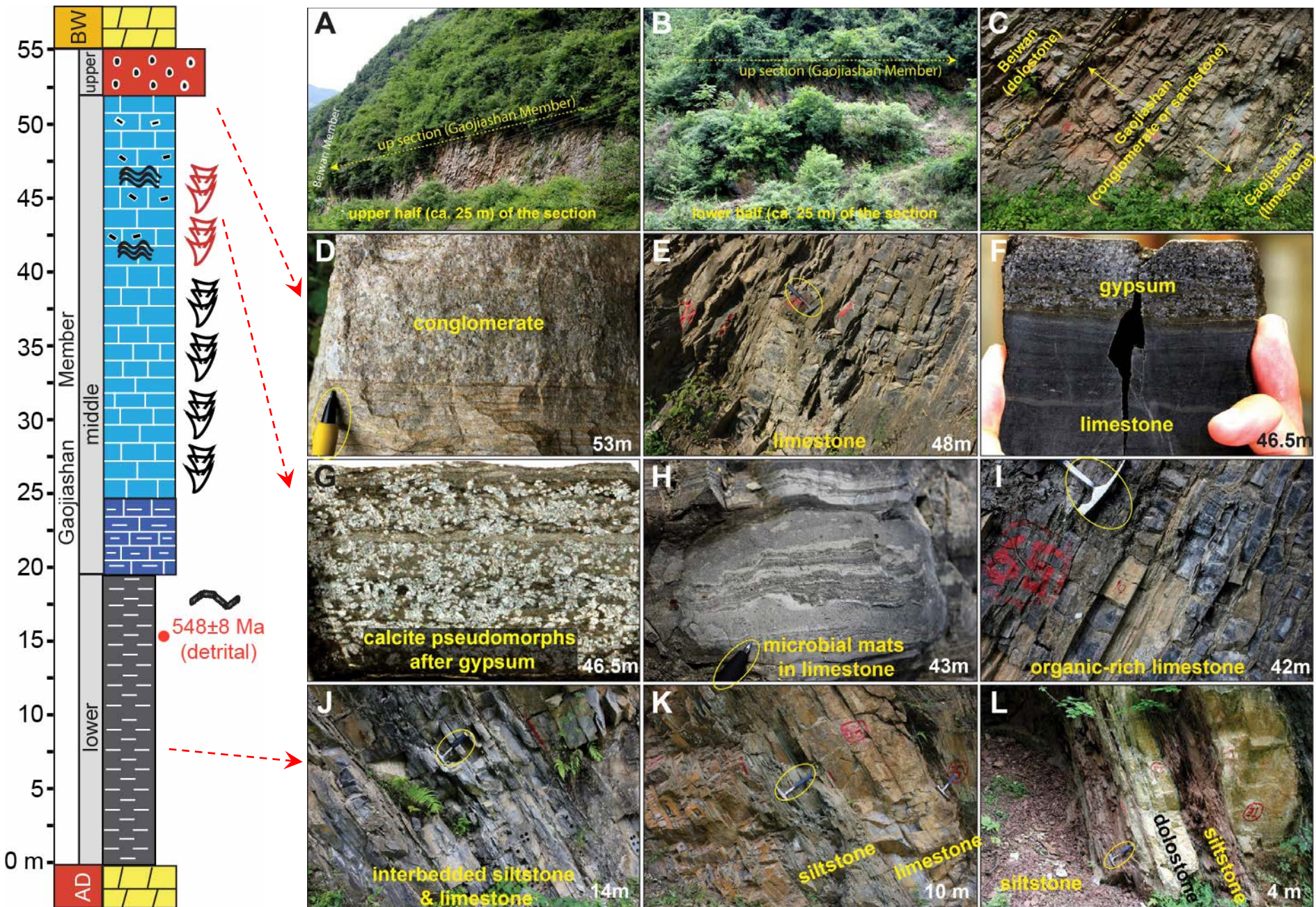
Ediacara fossil
in Shibantan



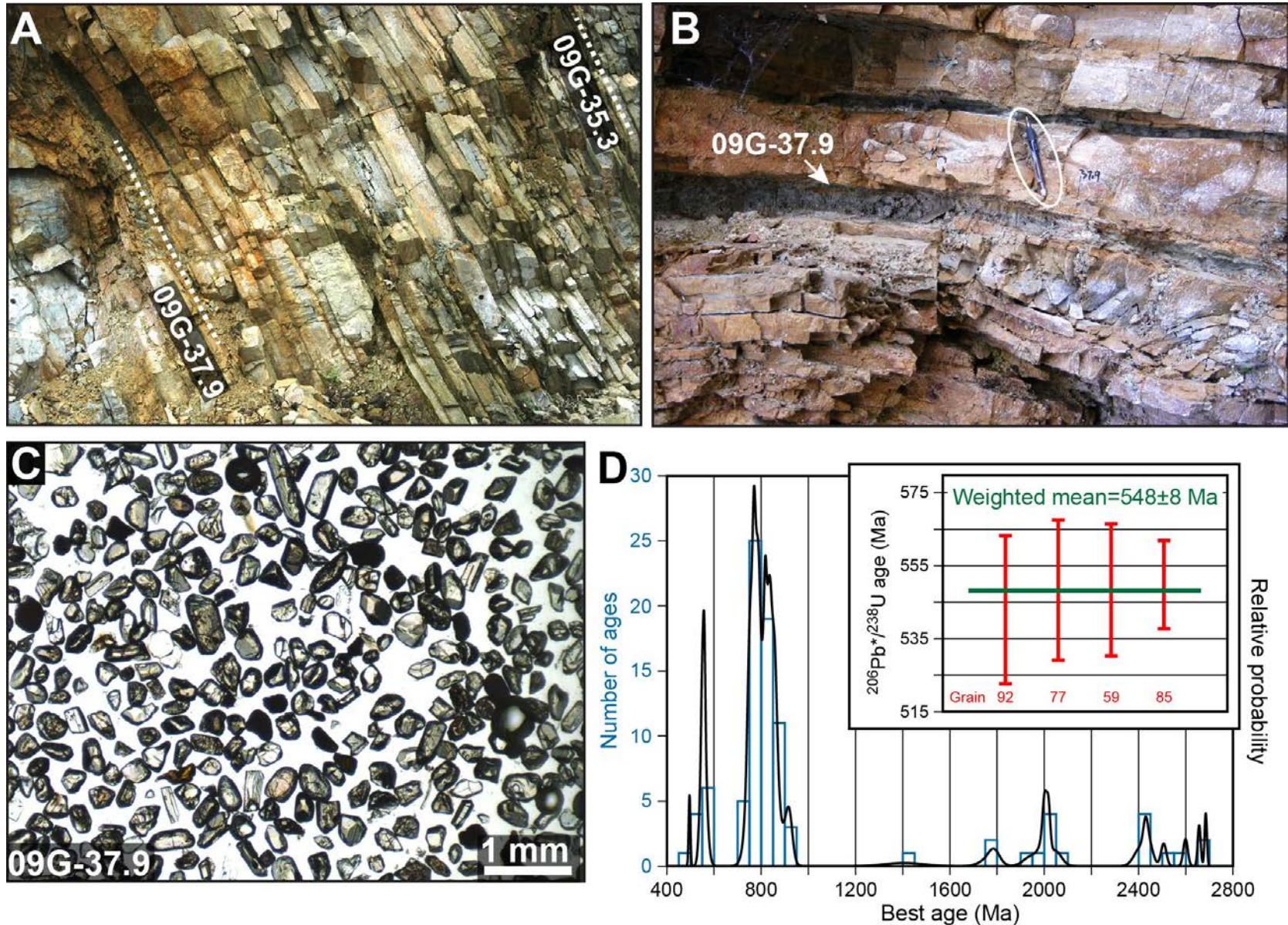
Bengtson and Zhao, 1992, *Science*
Chen et al., 2014, *Scientific Reports*



Field observations of the Gaojiashan Member



LA-ICP-MS Detrital zircons in lower Gaojiashan Member Analyzed in Arizona LaserChron Center

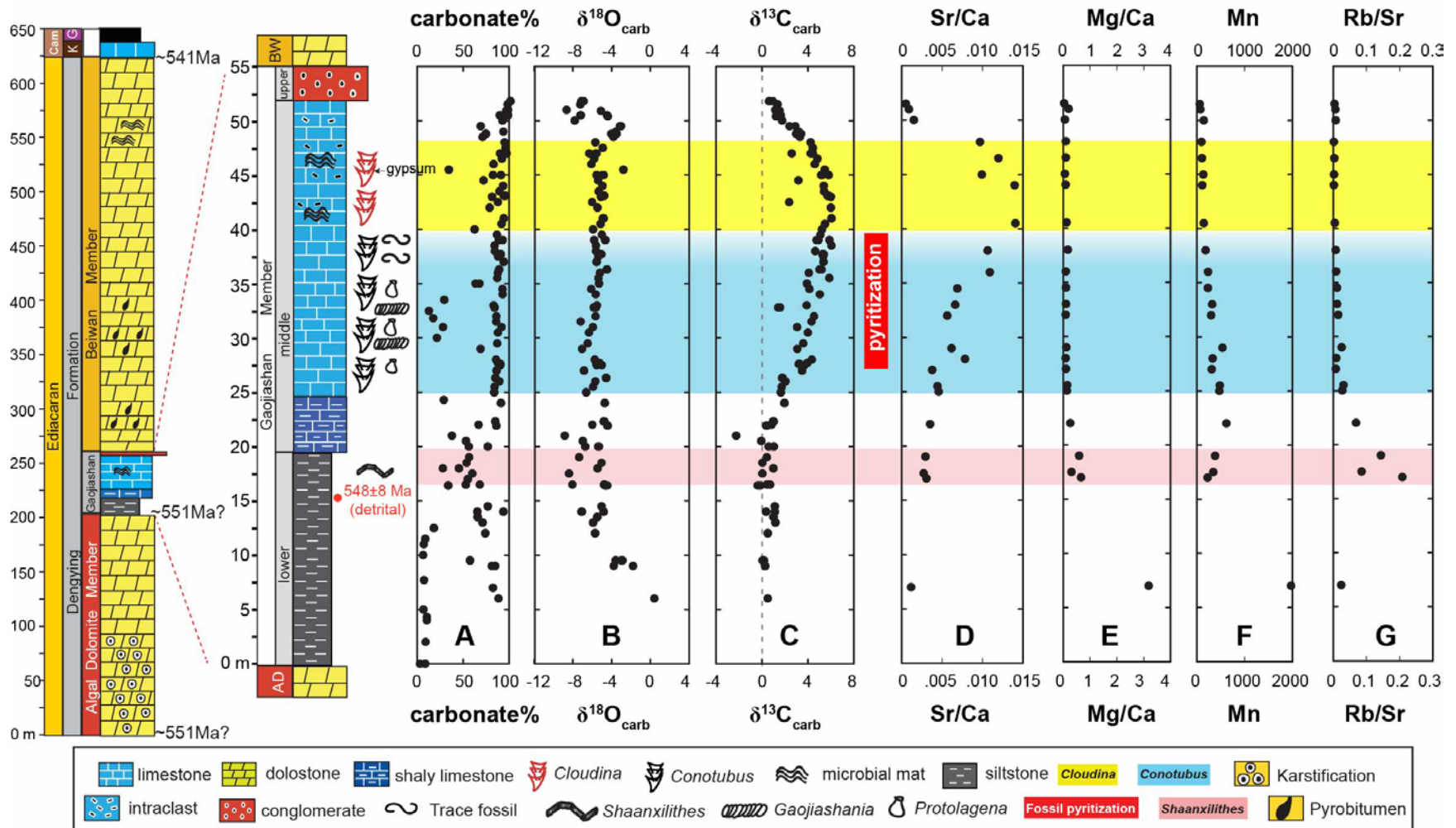


Cui et al., under review by *Geobiology*

Time-series Gaojiashan samples for chemostratigraphy

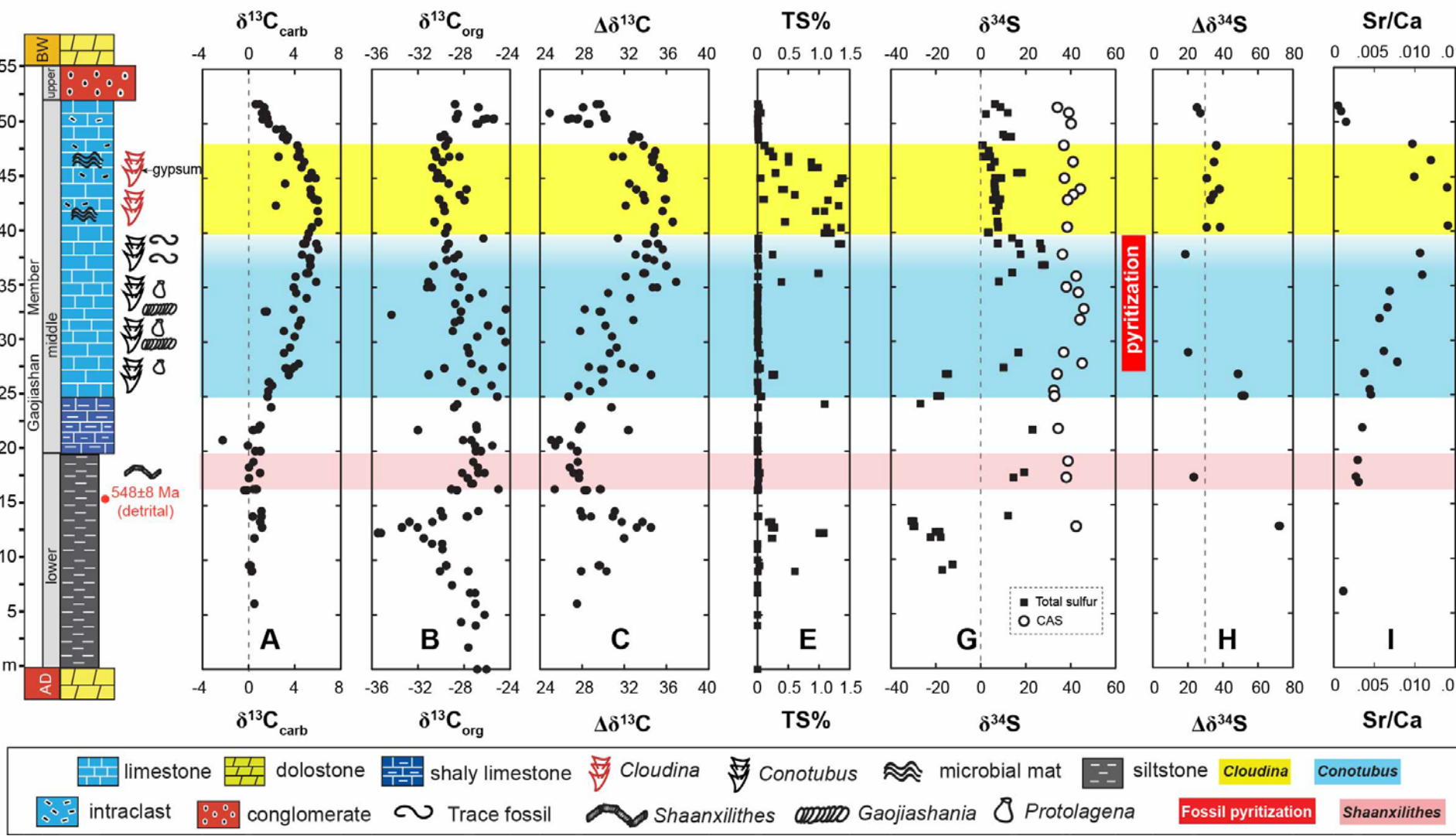


Diagenesis: Trace elemental concentration data of the terminal Ediacaran Gaojiashan Member

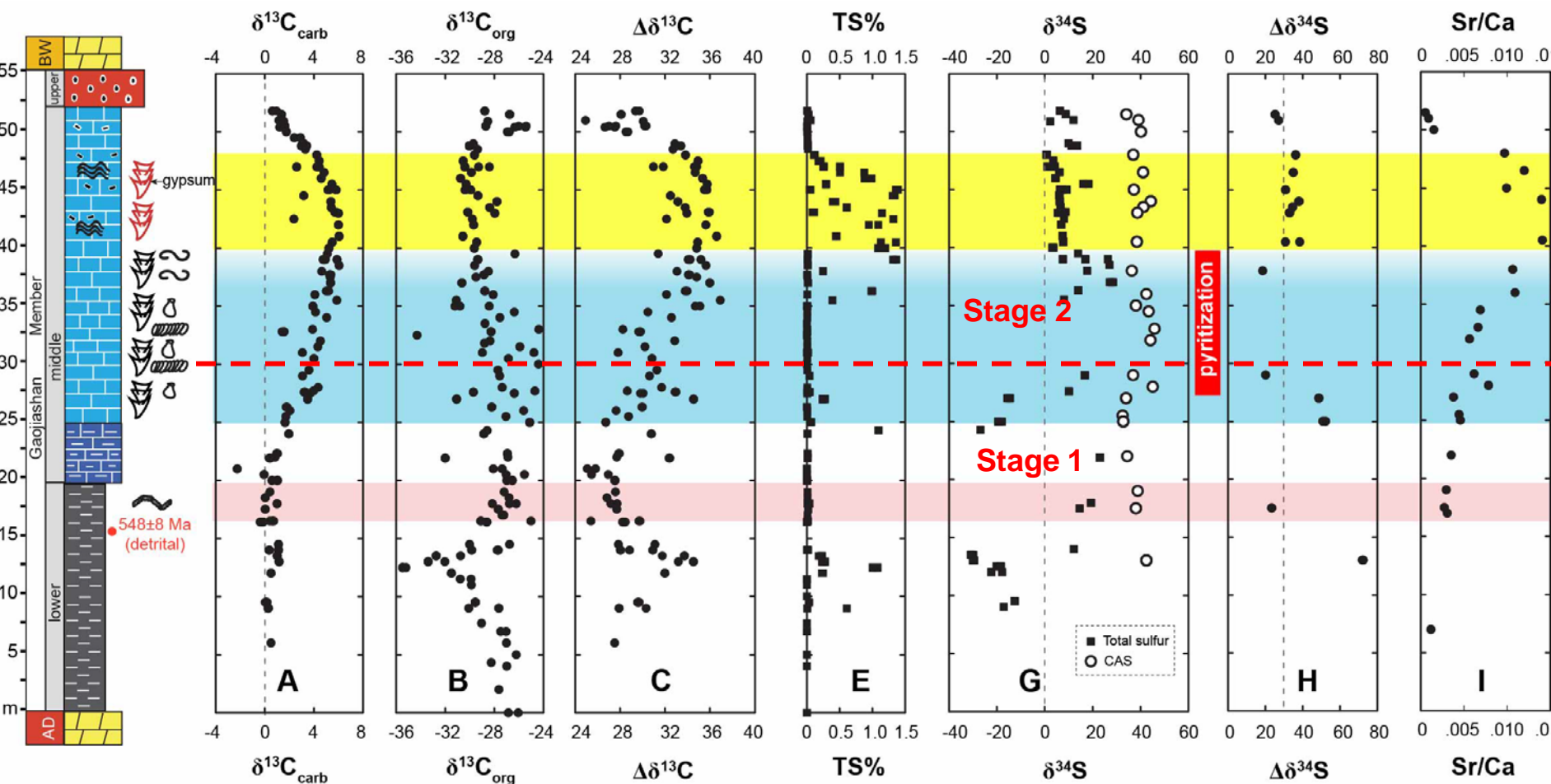


Limestone: very low [Mn], Rb/Sr and Mg/Ca, high [Sr], suggesting good preservation.

Paired C and S isotope data of the terminal Ediacaran Gaojiashan Member



Paired C and S isotope data of the terminal Ediacaran Gaojiashan Member

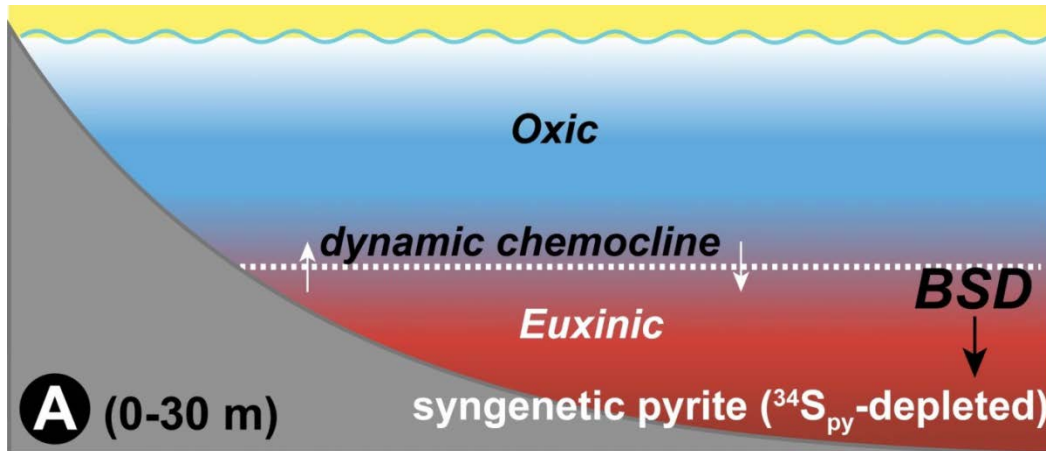
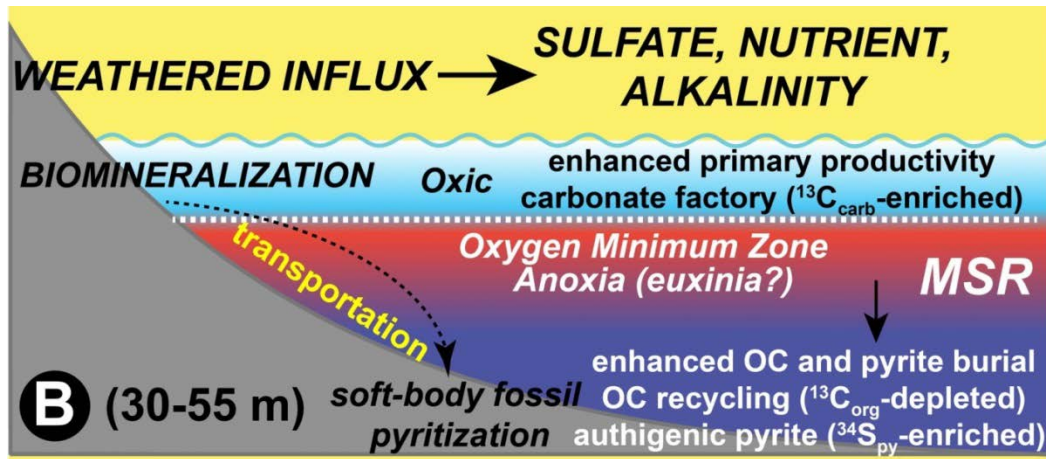


Stage 2 (30–55 m): positive $\delta^{13}\text{C}_{\text{carb}}$ and Sr/Ca excursion, negative $\delta^{13}\text{C}_{\text{org}}$ excursion, Enrichment in pyrite, high $\delta^{34}\text{S}_{\text{pyrite}}$

Stage 1 (0–30 m): Fluctuated $\delta^{34}\text{S}_{\text{pyrite}}$ with very negative values and large $\Delta\delta^{34}\text{S}$

Biogeochemical Model

Data + Interpretation



Stage 2 (30–55m):

Positive $\delta^{13}\text{C}_{\text{carb}}$ excursion:

Higher primary productivity,
More organic C (OC) burial, Anoxia

Negative $\delta^{13}\text{C}_{\text{org}}$ excursion:

Enhanced organic C recycling

Positive Sr/Ca excursions:

enhanced weathering flux

Enrichment in pyrite:

Dominated by Microbial Sulfate
Reduction (MSR)

Stage 1 (0–30m):

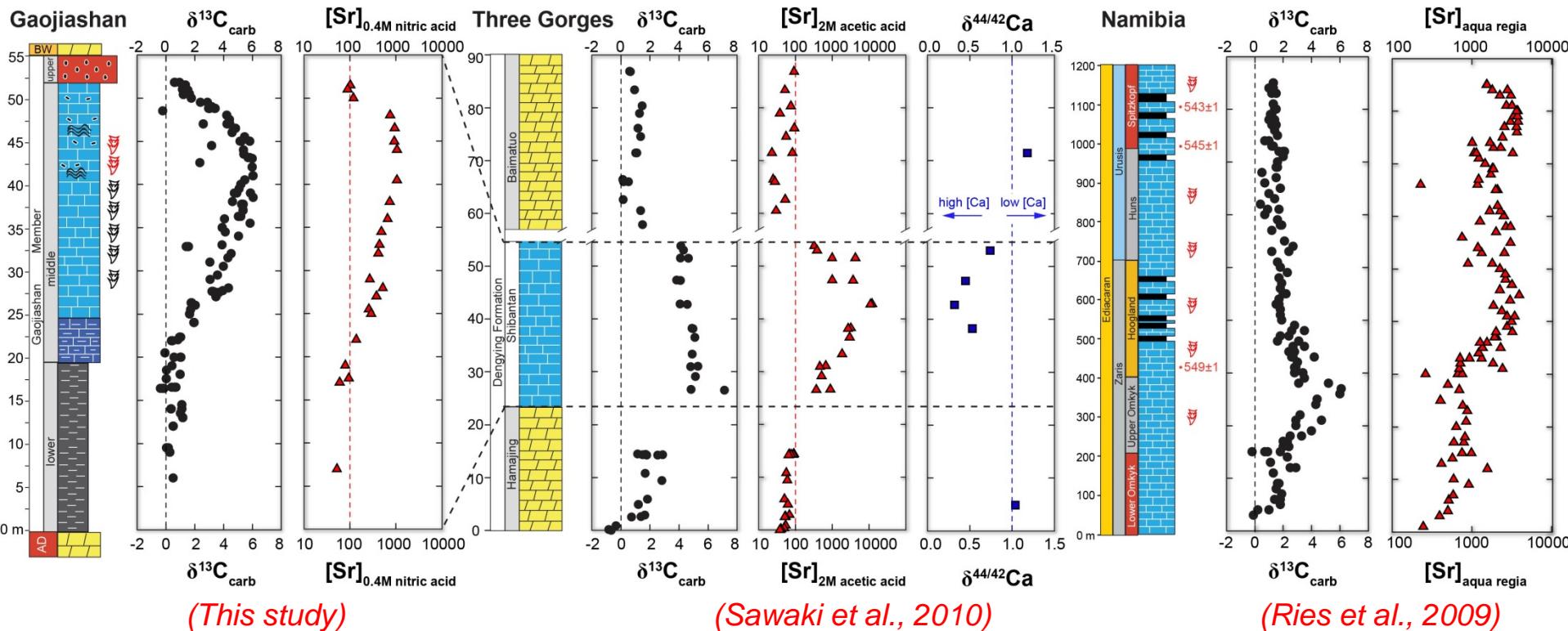
Very negative $\delta^{34}\text{S}_{\text{pyrite}}$

Large $\Delta\delta^{34}\text{S}_{\text{sulfate-pyrite}}$

Dominated by Bacterial S
disproportionation (BSD)

Redox: Oxic + euxinic

Enhanced Sr and Ca flux into the terminal Ediacaran ocean



High concentration of Sr in limestone intervals:
high Sr influx into the ocean due to enhanced chemical weathering

Negative $\delta^{44}\text{Ca}$ excursion:
high concentration of Ca ion, promoting CaCO_3 biomineralization

Cui et al., under review by Geobiology

Take-home Messages

**Integrated litho-bio-chemo-chrono-stratigraphy
of the terminal Ediacaran Gaojiashan Member.**

**$\delta^{13}\text{C}$ - $\delta^{34}\text{S}$ -[Sr]-[Ca] anomaly
coupled with animal biomineralization.**

Enhanced chemical weathering.

**High flux of Sr, Ca, and alkalinity may promote
animal biomineralization.**

Thank you!

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