中国IGCP全国委员会2021年学术研讨会

IGCP739项目：中生代-古近纪极热事件

2021年度项目学术报告

汇报人：胡修棉

南京大学地球科学与工程学院

2021 年 11 月14日 在线汇报

报告提纲

一、IGCP739概况

二、项目工作情况

三、代表性学术成果

Klages et al., 2020, Nature

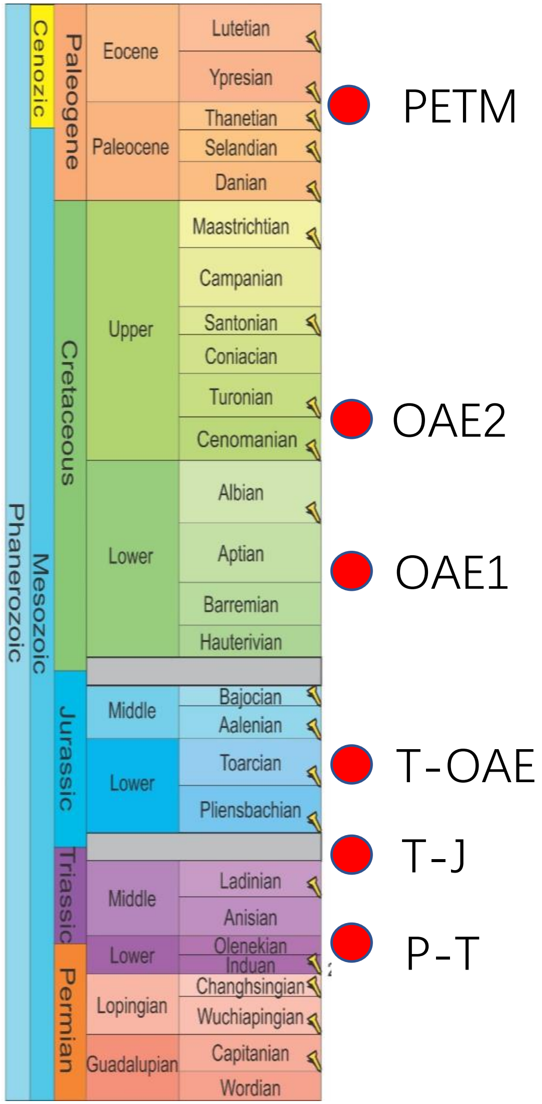
一、 IGCP739项目概况

极热事件：地质历史中短时期、快速增温事件

hyperthermal	age (Ma)	approximate onset duration (kyr)	approximate total duration of warmth/$\delta^{13}C$ excursion (kyr)	magnitude of marine neg. $\delta^{13}C$ (‰) excursion (if present)	low-latitude SST warming (ΔK)	ocean anoxia/ euxinia	approximate pCO_2 change (from pre event to peak) in ppm	approximate surface ocean acidification (pH units)	extinction intensity (% marine species)
Palaeocene–Eocene Thermal Maximum	55.9	0.1–3	170	3–4	3–4	Y	800–2200	0.3	1–20
OAE 2	~93	*~100*	1322	—	1.5–2	Y	370–500	—	20
OAE 1a	~120	1–100	1145	3–4	2–4	Y	1000–2000	—	22
early Toarcian OAE	~183	~150	300	5–6	*2–5*	Y	350–1200	—	15–20
End-Triassic	201.6	~85	1200	~1.5	*3–4*	Y	1120–2240	—	80
					terrestrial	Y	2000–4400		
Permian–Triassic	251.9	10–20	>5000	5–6	10–12	Y	1400–4200	0.4	95
							2800–7000		

Foster et al., 2018

- 在千年–10万年尺度内CO_2大量释放，造成全球快速变暖；
- 多数事件持续0.1-2 Myr, P-T事件例外 (5 Myr); 启动时几乎都以碳同位素负偏为特征
- 溶解氧含量急剧降低，大洋广泛缺氧; 大洋酸化，PH降低约0.3–0.4 个单位;
- 水文循环增强; 大陆风化作用增强;
- 生物集群灭绝



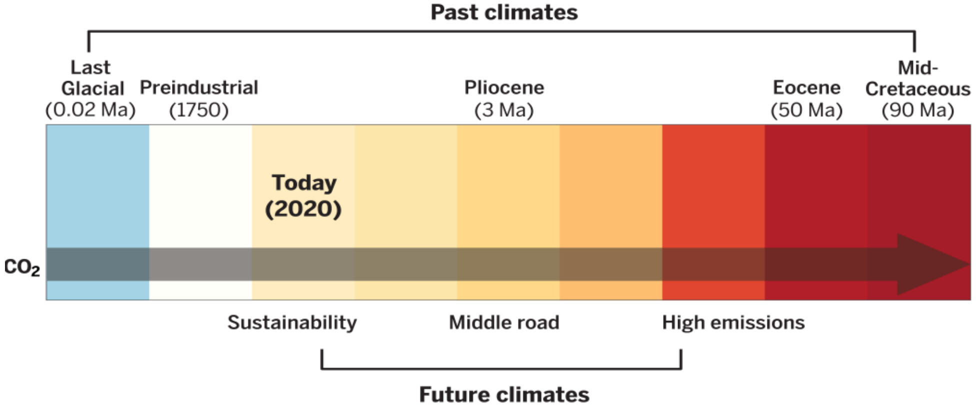
极热事件是研究现今和预测未来气候的重要参照，但是目前的研究中还存在很大分歧

23 温室效应会使地球温度达到多高

REVIEW SUMMARY

CLIMATE CHANGE

Past climates inform our future

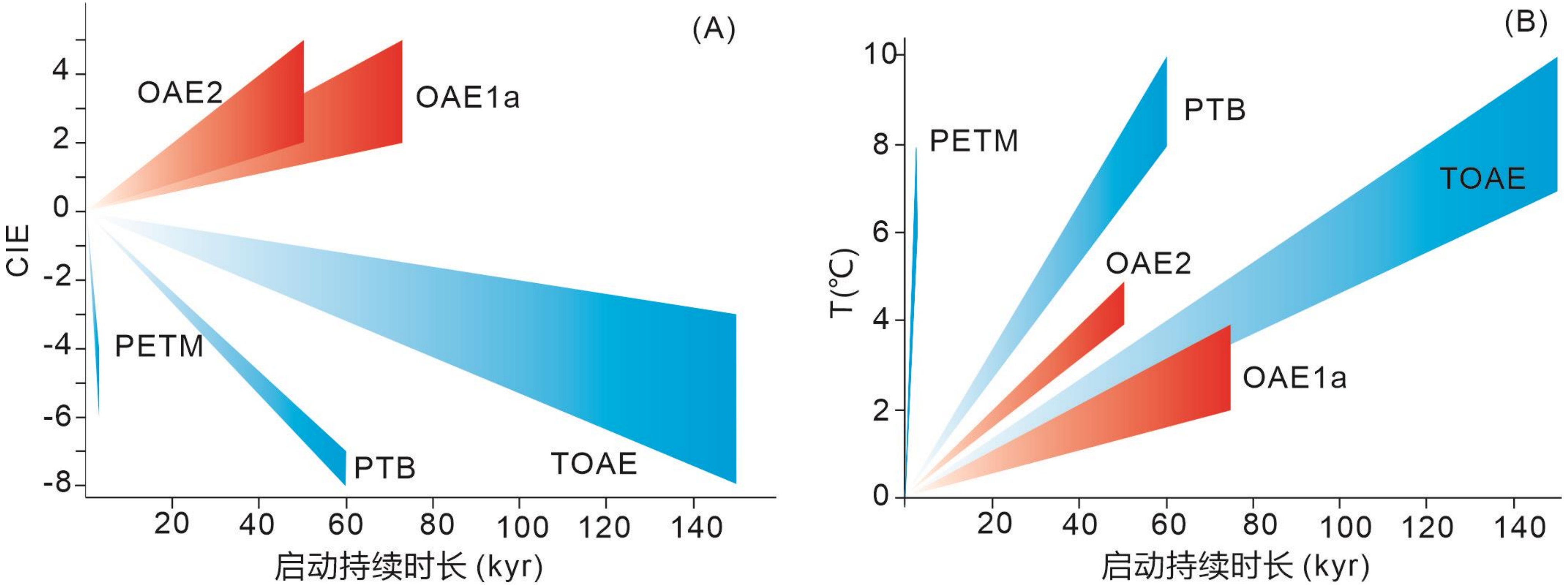


Tierney et al., 2020, Science

Geological or geochemical proxy evidence for	Future & "Anthropocene"	Deglacial Transition	Oligocene – Pliocene	PETM	End Cretaceous	OAEs	Triassic/Jurassic	Permian/Triassic
pCO_2 change	↑	↑	↑	↑	↑	↑	↑	↑
pH change	↓	↓	↓	↓	?	?	?	?
Saturation Change	↓	↓	-	↓	↓	?	?	?
Temperature Change	↑	↑	↑	↑	↑	↑	↑	↑
Carbon Release		X	X					
Ocean Acidification Score	/3	2	1	3	1	1.5	2	1.5

Honisch et al., 2012, Science

缺少不同时期极热事件的整合对比



五次极热事件启动阶段碳同位素偏移幅度与偏移速率**(a)**、增温幅度与增温速率**(b)**的对比

- 单个极热事件在不同古地理背景下表现各异
- 不同极热事件的环境演化过程与生态响应有显著差别

胡修棉等，中国科学 地球科学，2020

项目负责人

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40.75 · PhD

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Ying Cui
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美国蒙特克莱尔州立大学

2020年10月提出申请

The Mesozoic-Palaeogene hyperthermal events: lessons for understanding the Anthropocene global warming

中生代-古近纪极热事件：对人类世全球升温的启示

10月10日给国际同行发信，5天内收到来自欧、亚、北美、南美23个国家**60**余位学者支持，

反映了该主题在国际地学界的广泛关注度！

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18	17	Gerald Dickens	jerry@rice.edu		Professor	Ireland	Trinity College Dublin
19	18	Ricardo Ferreira Louro Silva	ricardo.silva@tcd.ie		Research Fellow	Ireland	›artment of Geology, School of Natural Sciences, Trinity College Dublin, The University of Dublin, Irelar
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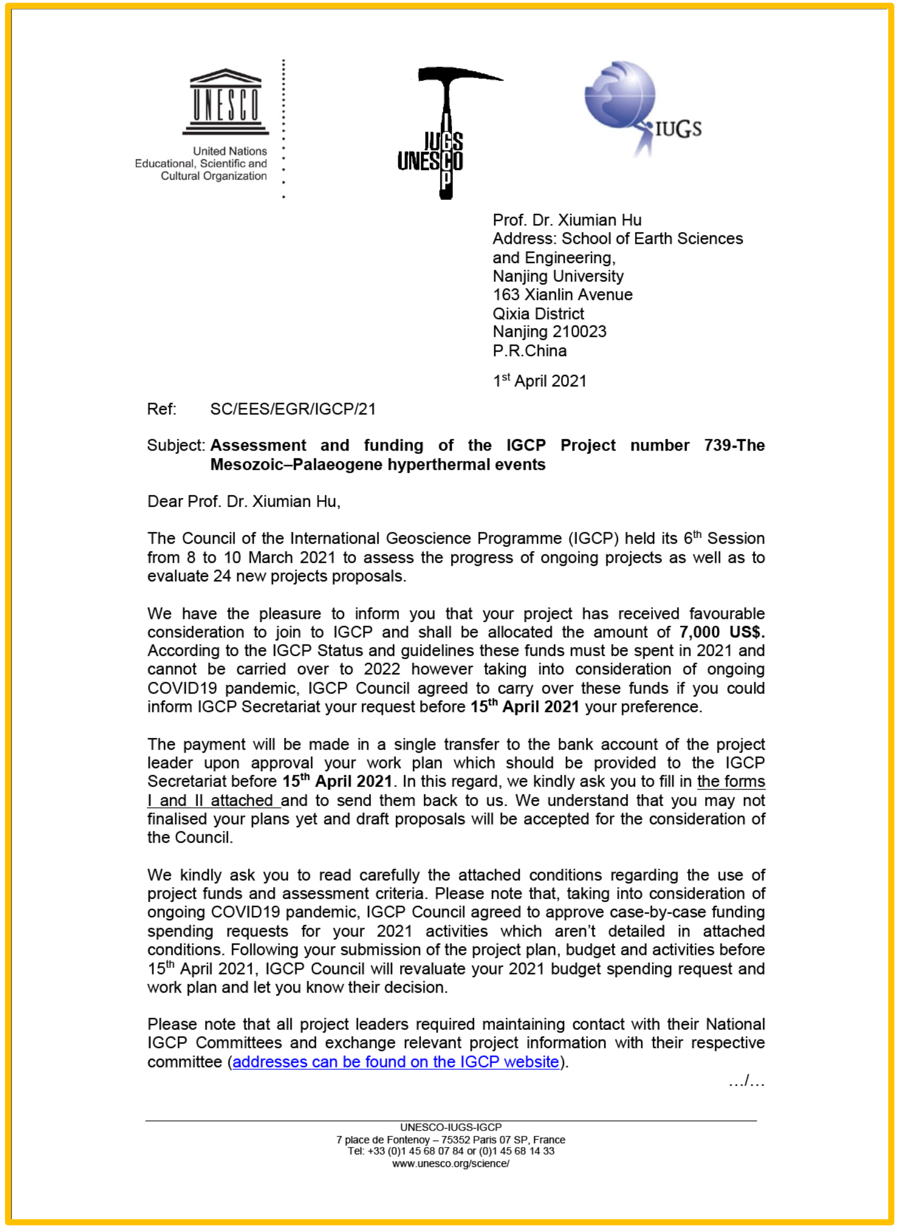
26	25	Hisao Ando	hisao.ando.sci@vc.ibaraki.ac.jp	male	Professor	Japan	Department of Earth Sciences, Faculty of Science, Ibaraki University,Japan
							Faculty and Graduate School of Education, Chiba University

执行年限：2021-2025年

研究对象：P/T界线事件、卡尼期洪泛事件、T/J界线事件、J-K 、OAEs、PETM、EEOC等

研究目标：极热事件期间全球环境演化过程与生物响应



United Nations Educational, Scientific and Cultural Organization

IUGS UNESCO IGCP

IUGS

Prof. Dr. Xiumian Hu
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P.R.China

1st April 2021

Ref: SC/EES/EGR/IGCP/21

Subject: **Assessment and funding of the IGCP Project number 739-The Mesozoic–Palaeogene hyperthermal events**

Dear Prof. Dr. Xiumian Hu,

The Council of the International Geoscience Programme (IGCP) held its 6th Session from 8 to 10 March 2021 to assess the progress of ongoing projects as well as to evaluate 24 new projects proposals.

We have the pleasure to inform you that your project has received favourable consideration to join to IGCP and shall be allocated the amount of **7,000 US$.** According to the IGCP Status and guidelines these funds must be spent in 2021 and cannot be carried over to 2022 however taking into consideration of ongoing COVID19 pandemic, IGCP Council agreed to carry over these funds if you could inform IGCP Secretariat your request before **15th April 2021** your preference.

The payment will be made in a single transfer to the bank account of the project leader upon approval your work plan which should be provided to the IGCP Secretariat before **15th April 2021**. In this regard, we kindly ask you to fill in the forms I and II attached and to send them back to us. We understand that you may not finalised your plans yet and draft proposals will be accepted for the consideration of the Council.

We kindly ask you to read carefully the attached conditions regarding the use of project funds and assessment criteria. Please note that, taking into consideration of ongoing COVID19 pandemic, IGCP Council agreed to approve case-by-case funding spending requests for your 2021 activities which aren't detailed in attached conditions. Following your submission of the project plan, budget and activities before 15th April 2021, IGCP Council will revaluate your 2021 budget spending request and work plan and let you know their decision.

Please note that all project leaders required maintaining contact with their National IGCP Committees and exchange relevant project information with their respective committee (addresses can be found on the IGCP website).

.../...

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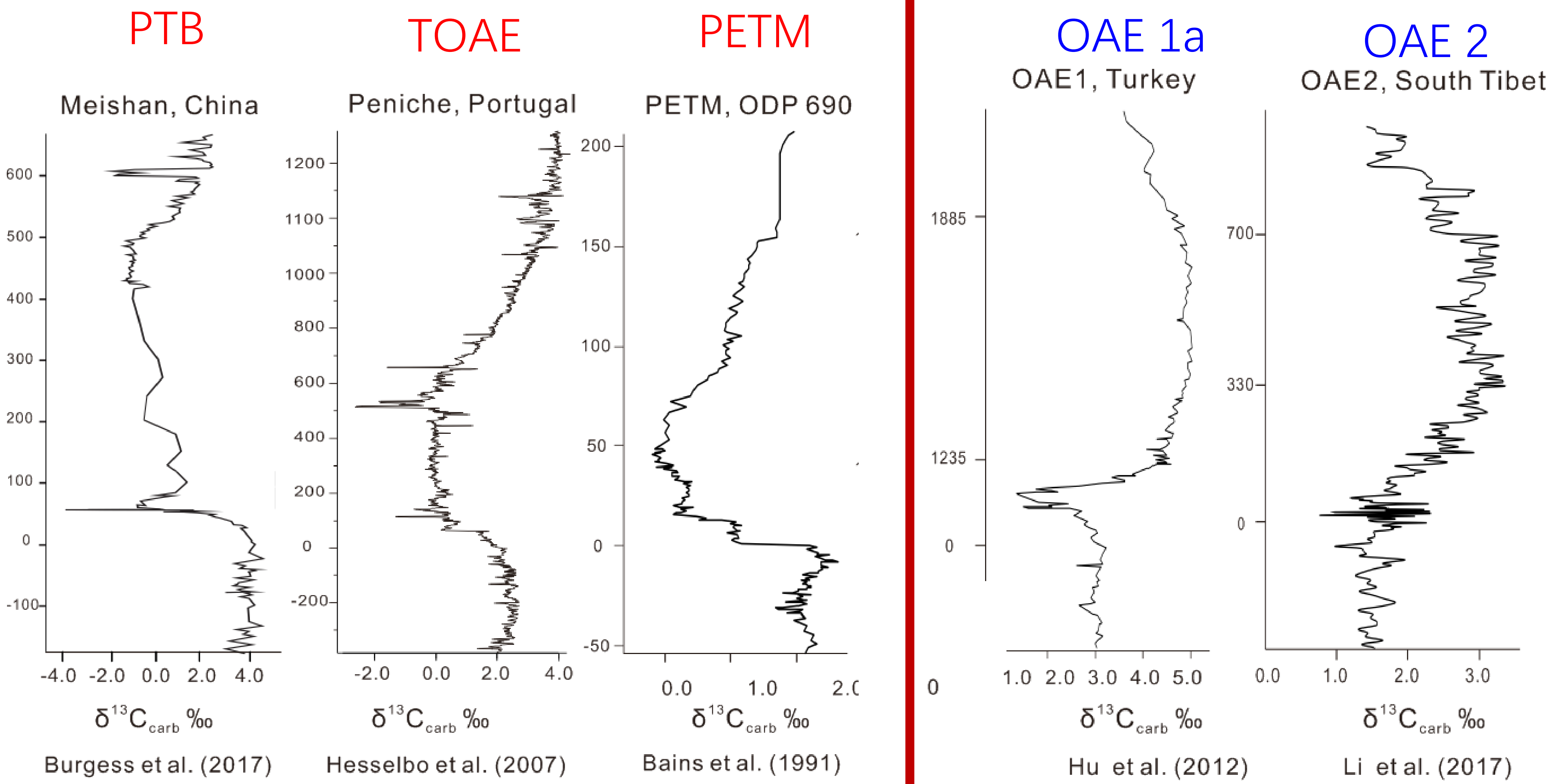
研究内容一：碳循环扰动的特征、持续时限，温室气体排放的来源、质量和速率

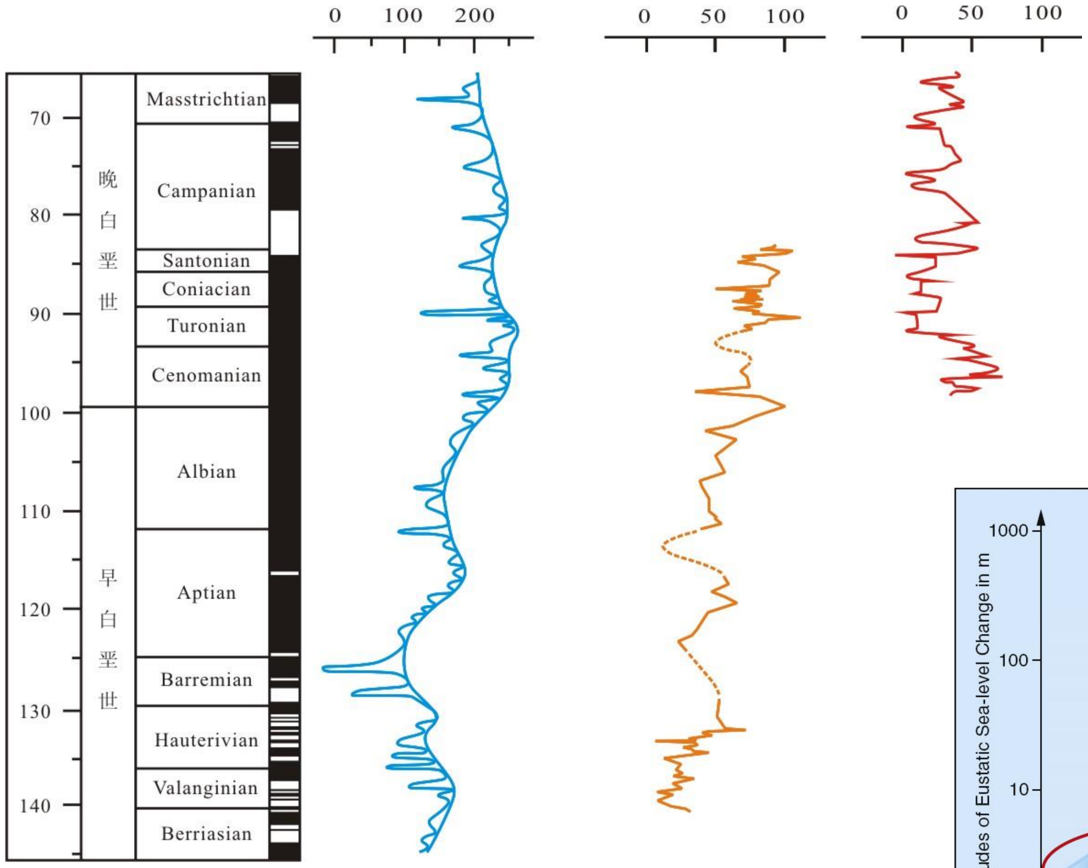


NCHE: CIE 负偏

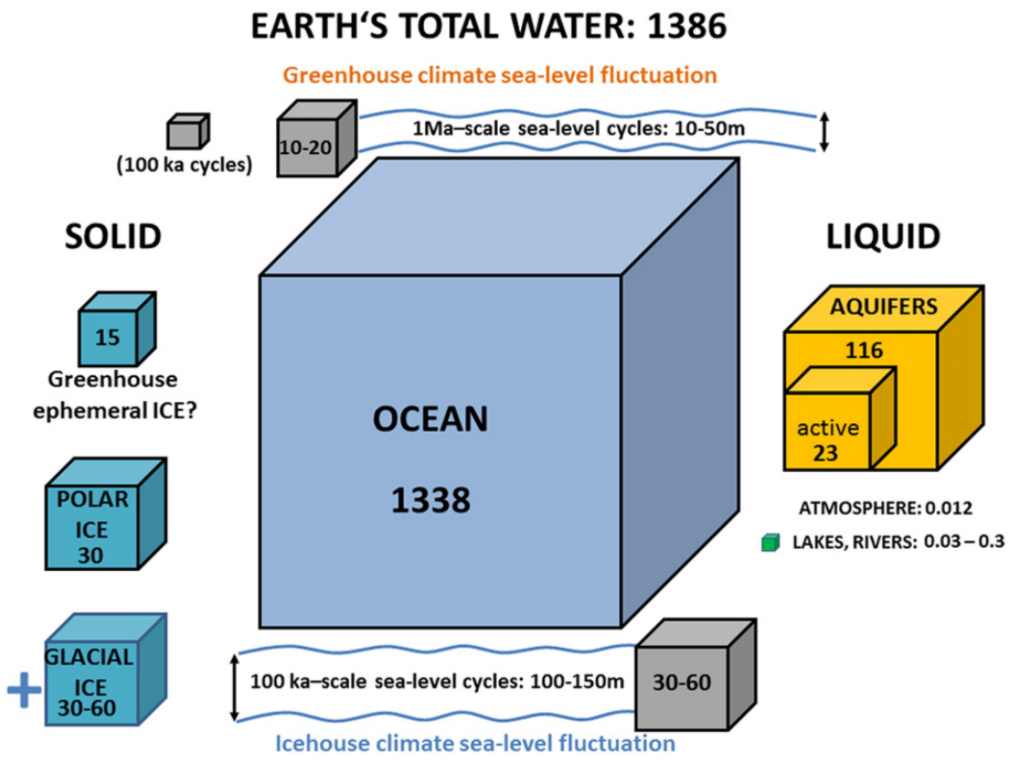
PCHE: CIE 正偏

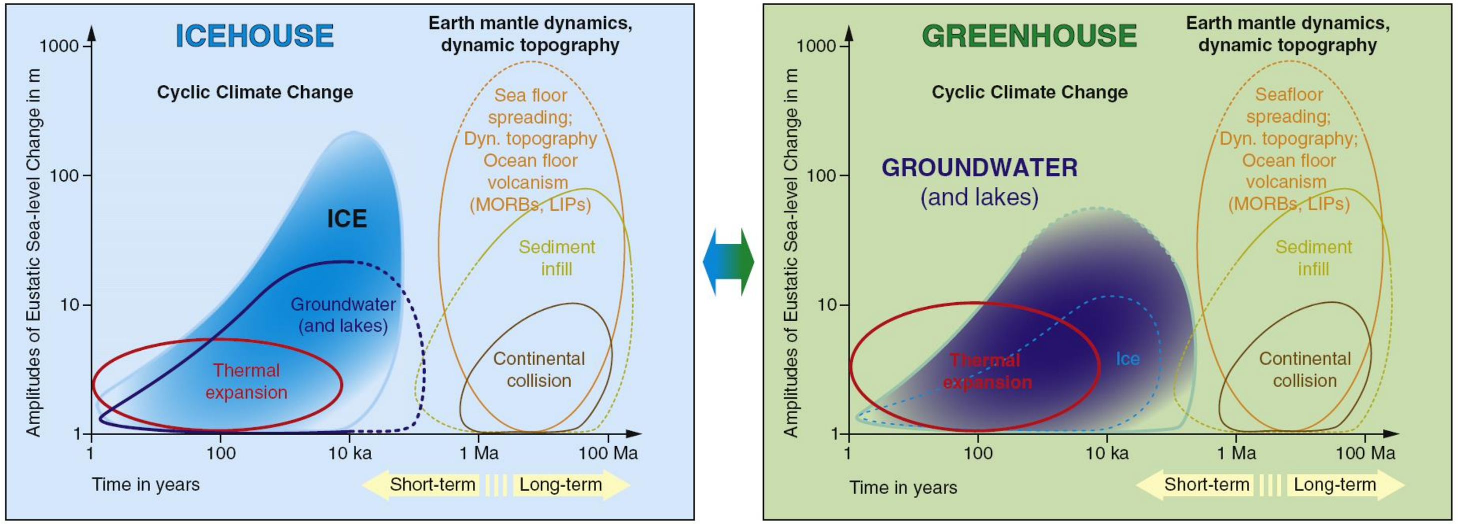
胡修棉等，中国科学 地球科学，2020

研究内容二：温度与海平面变化的幅度与速率



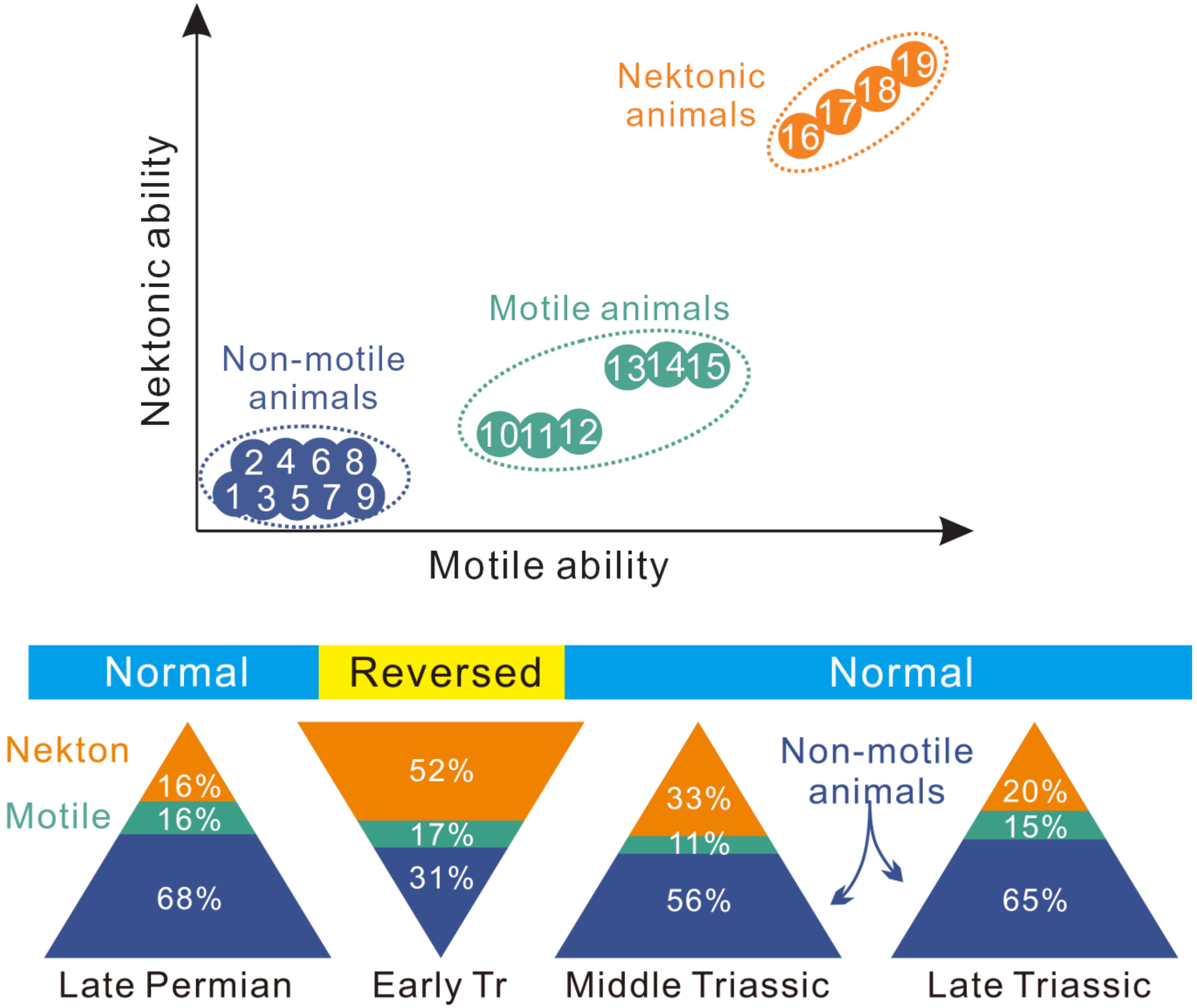
Haq, 1987 Science; Miller et al., 2005 Science



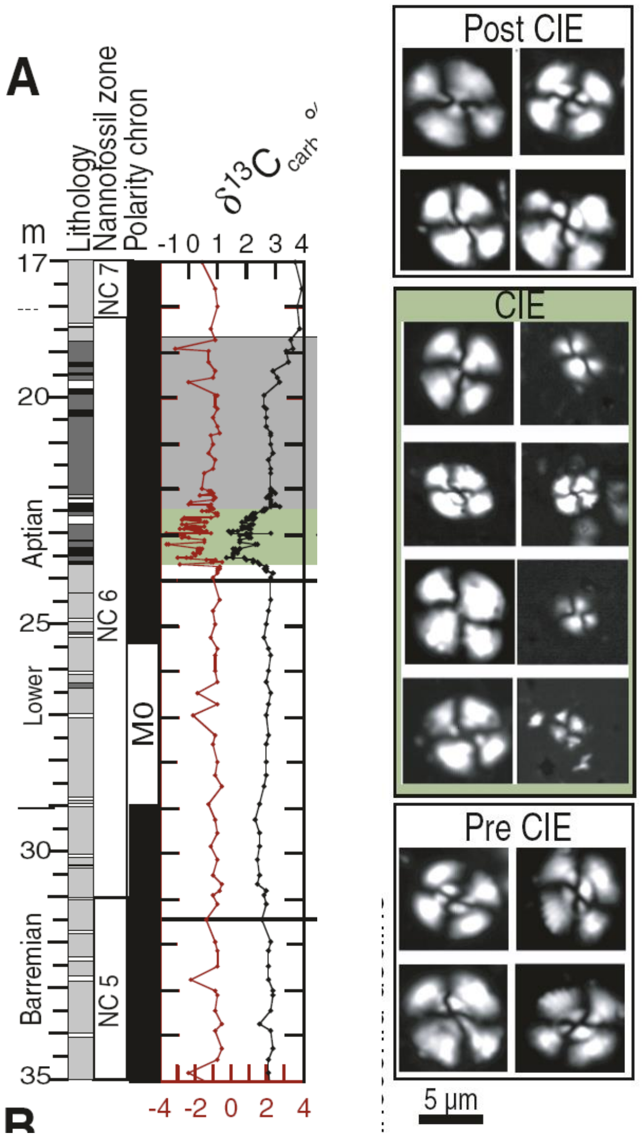


Sames, 2016, PPP

研究内容三：生物、生态系统和海洋化学条件对极热事件的响应



Song et al., 2018, Sci. Adv.



Erba et al., 2010, Science

二、项目工作情况

部分中国工作组成员：

姓名	单位	职位
胡修棉	南京大学	教授
David Kemp	中国地质大学（武汉）	教授
陈曦	中国地质大学（北京）	副研究员
韩中	成都理工大学	副研究员
金鑫	成都理工大学	副研究员
李娟	南京大学	助理研究员
姚翰威	中国地质大学（北京）	博士后

80余位中国学者支持，分别来自南京大学、中国地质大学北京、中国地质大学武汉、成都理工大学等

野外工作：

中国西藏、鄂尔多斯

苏格兰

日本

西藏卧龙T-OAE

西藏岗巴OAE1a

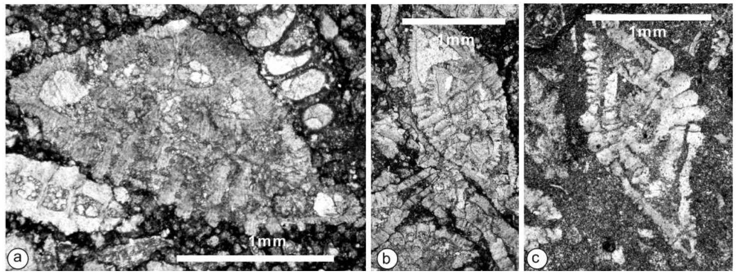
西藏申克扎PETM

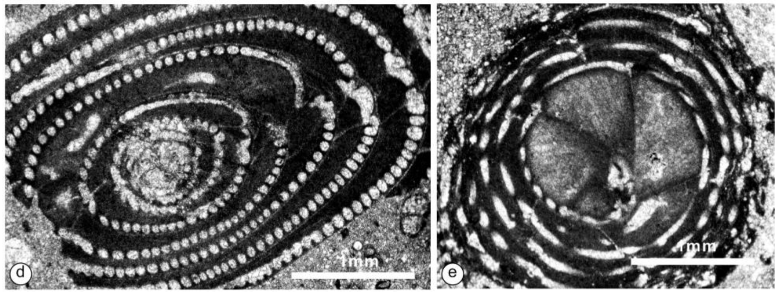
苏格兰T-OAE

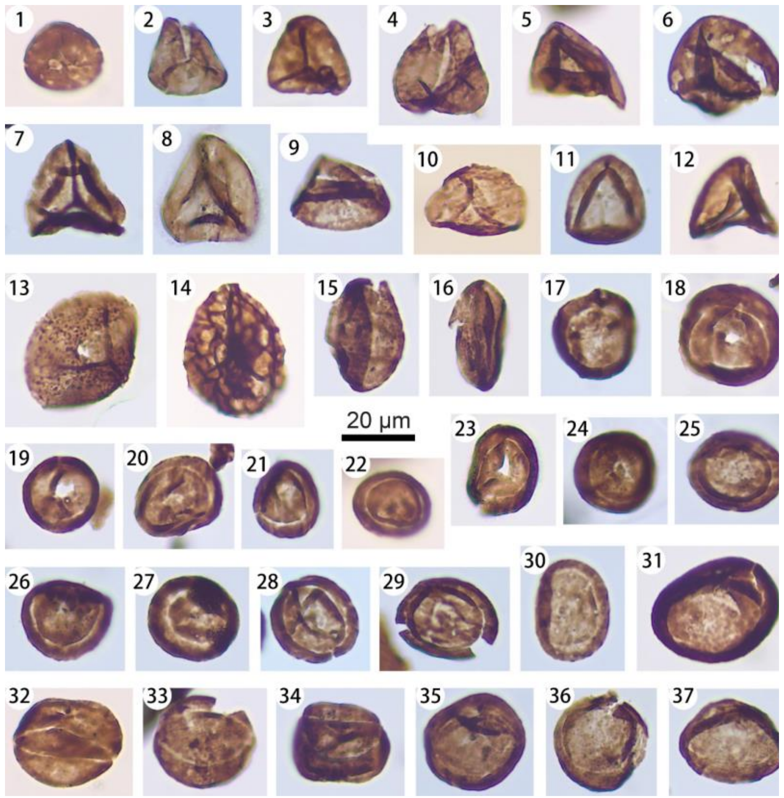
西藏定日OAE2

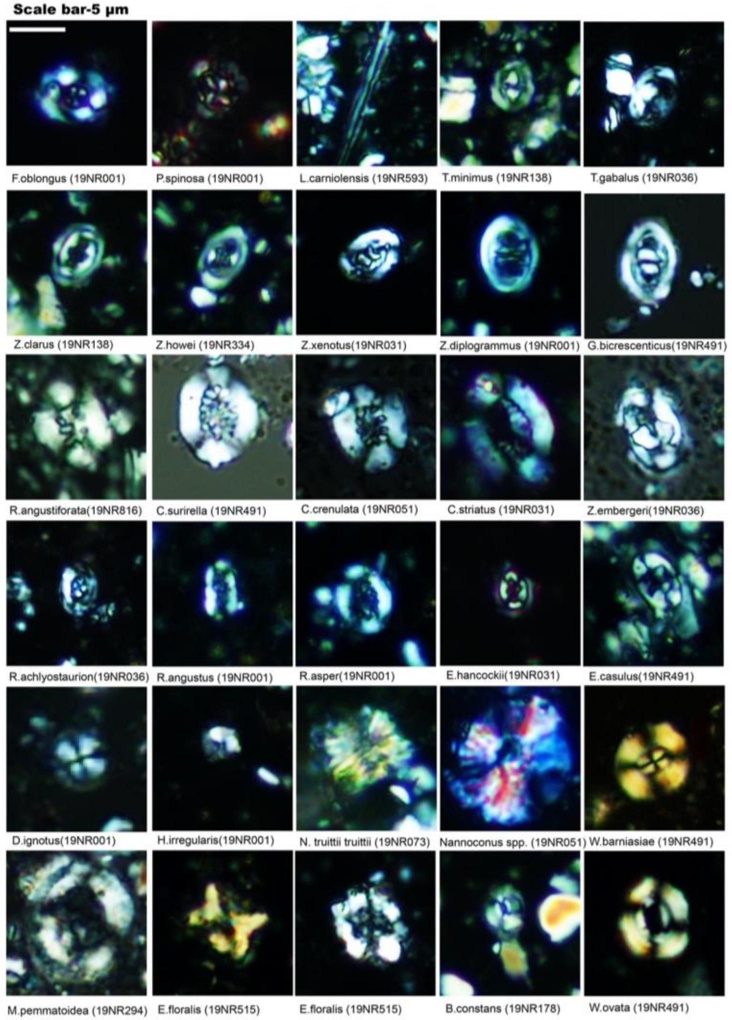
室内测试：各类分析测试1000余件

分析项目	数量（件）
主微量稀土	200
镁同位素	30
钡同位素	66
硫同位素	30
碳同位素	600
TOC	300
菊石鉴定	45
牙形石鉴定	8
珊瑚鉴定	5
孢粉鉴定	3
有孔虫鉴定	188
钙质超微	60
锆石定年	3







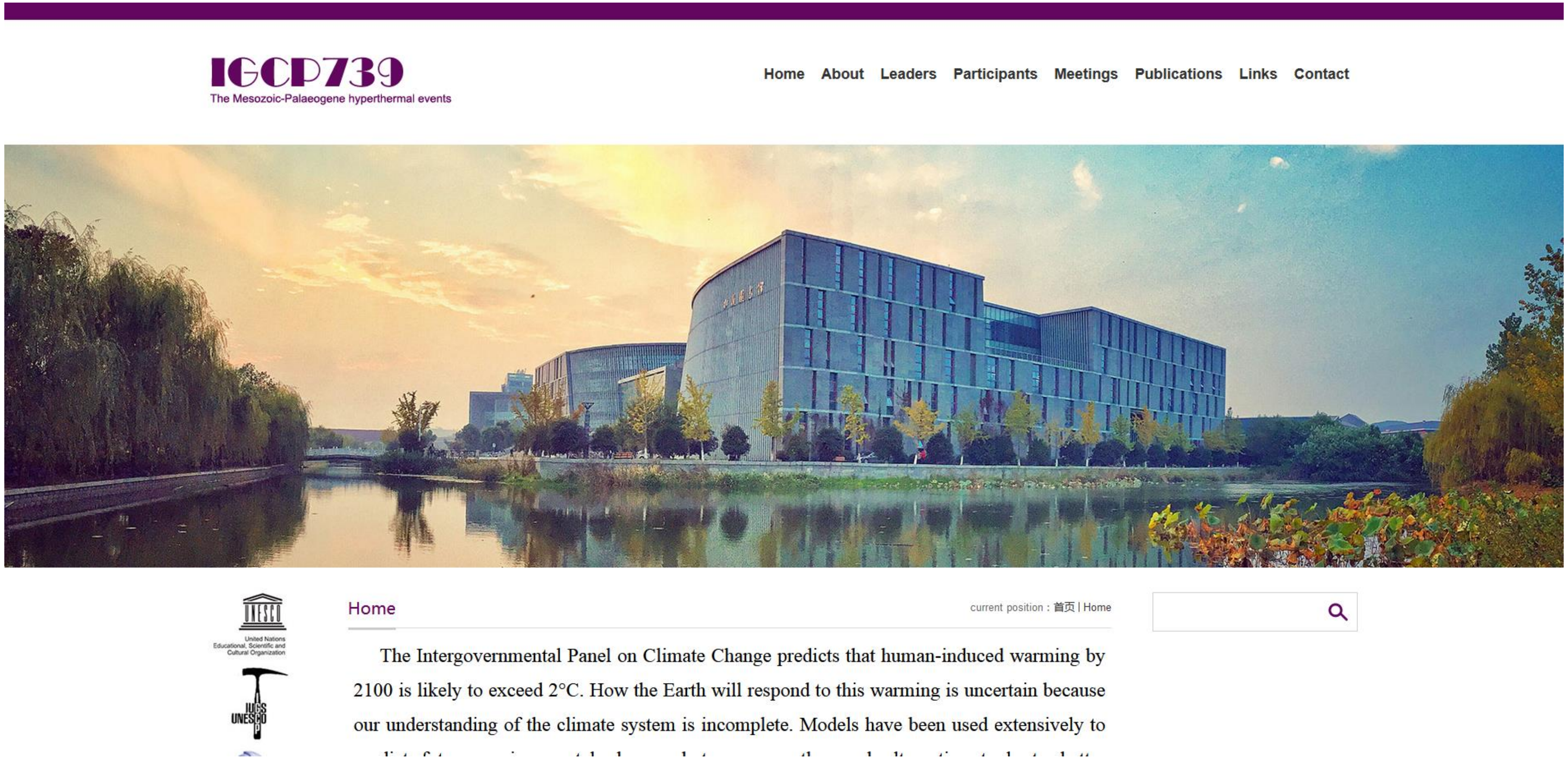


学术交流：

项目Leaders & Secretary工作讨论会（2021年4月）项目负责人及秘书

第一次学术年会（2021年11月）

IGCP739网站建设：https://webplus.nju.edu.cn/_s709/44923/list.psp



出版物

在Global and Planetary Change 组织专辑一期

主题：Paleoenvironmental changes across the Mesozoic-Paleogene hyperthermal events

Guest Editors:

Dr. Tianchan He, UoLeeds, UK

Prof. Dr. David Kemp, CUGB, China

Dr. Juan Li, NJU, China

Dr. Micha Ruhl, TCD, Ireland

组织了26篇论文的投稿

- **Proposed Time Schedule:**

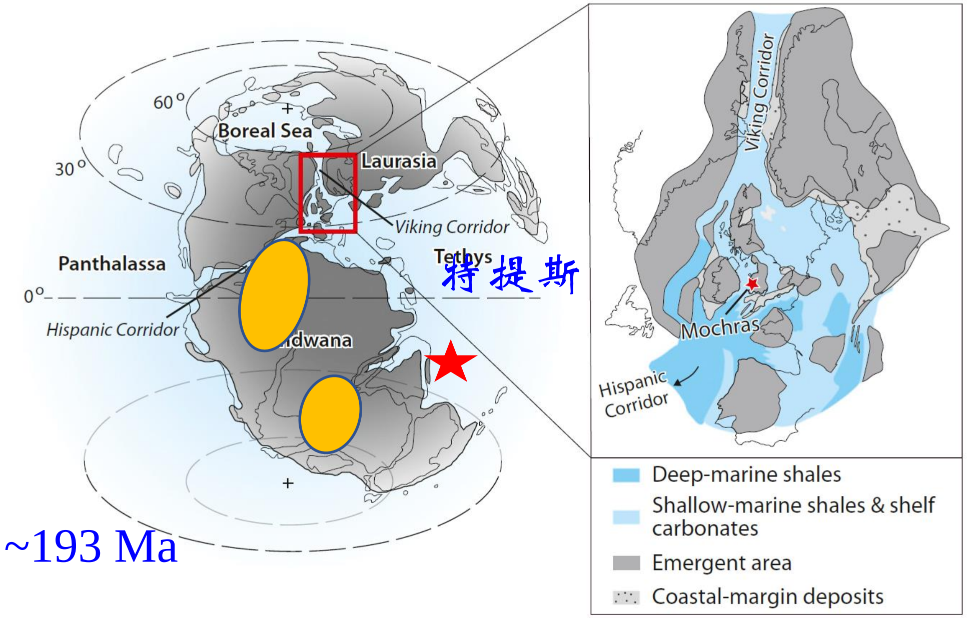
1. Initial submission starting date: **01/07/2021**
2. Deadline for initial submission: **30/11/2021**
3. Date of first-round review completion: **01/03/2022**
4. Date of all papers accepted for publication: **31/07/2022**

中国国家工作组2021年度发表的部分论文列表

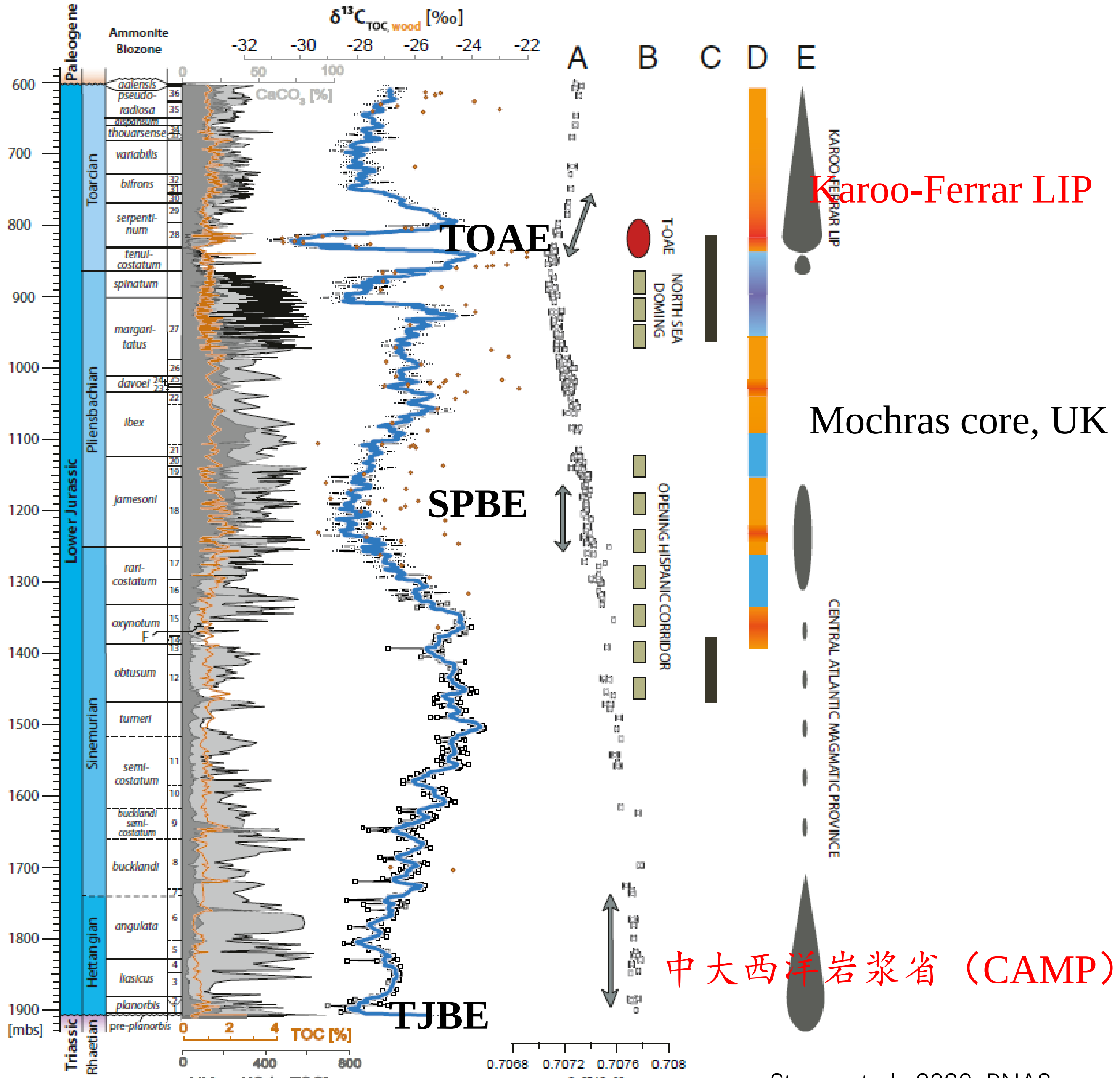
1. Han, Z., Hu, X., BouDagher-Fadel, M., Jenkyns, H.C., Franceschi, M., 2021. Early Jurassic carbon-isotope perturbations in a shallow water succession from the Tethys Himalaya, southern hemisphere. **Newsletters on Stratigraphy** 54, 461–481.
2. Han, Z., Hu, X., He, T., Newton, R.J., Jenkyns, H.C., Jamieson, R.A., Franceschi, M., 2021. Early Jurassic long-term oceanic sulfur-cycle perturbations in the Tibetan Himalaya. **Earth and Planetary Science Letters**. Accepted.
3. Jin, X., Baranyi, V., Caggiati, M., Franceschi, M., Wall, C. J., Liu, G., ... & Preto, N. (2021). Middle Triassic lake deepening in the Ordos Basin of North China linked with global sea-level rise. **Global and Planetary Change**, 103670.
4. Chen, W., Kemp, D.B., He, T., Huang, C., Jin, S., Xiong, Y., Newton, R.J., 2021. First record of the early Toarcian Oceanic Anoxic Event in the Hebrides Basin (UK) and implications for redox and weathering changes. **Global and Planetary Change** 207, 103685.
5. Li, J., Hu, X.M., Garzanti, E., BouDagher-Fadel, M., 2021. Climate-driven hydrological change and carbonate platform demise induced by the Paleocene–Eocene Thermal Maximum (southern Pyrenees). **Palaeogeography, Palaeoclimatology, Palaeoecology** 567,110250
6. Jiang, J.X.,Hu,X.M.,Li,J.,BouDagher-Fadel,M.,Garzanti,E.,2021.Discovery of the Paleocene-Eocene Thermal Maximum in shallow-marine sediments of the Xigaze forearc basin, Tibet: A record of enhanced extreme precipitation and siliciclastic sediment flux. **Palaeogeography, Palaeoclimatology, Palaeoecology** 562,110095.
7. Yao, H., Chen, X., Brunner, B., et al., 2021. Hydrocarbon seepage in the mid-Cretaceous greenhouse world: A new perspective from southern Tibet. **Global and Planetary Change** 208, 103683.
8. Yao H., Chen, X., Yin, R., et al., 2021. Mercury Evidence of Intense Volcanism Preceded Oceanic Anoxic Event 1d. **Geophysical Research Letters** 48, e2020GL091508.
9. Chen, X., Sageman, B., Yao, H., et al., 2021. Zinc isotope evidence for paleoenvironmental changes during Cretaceous Oceanic Anoxic Event 2. **Geology** 49, 412–416.
10. Liu X., Chen, X., Tostevin, R., et al., 2021. Post-depositional modification of carbonate ooids by sulfate-reducing bacteria: Evidence from the Lower–Middle Jurassic, Tethyan Himalayas of southern Tibet. **Sedimentary Geology** 426, 106027.
11. Guo, H., Chen, X., Yao, H et al., 2021. Lower Cretaceous clastic dykes in southern Tibet: Characteristics and palaeogeographic significance. **Geological Journal** 56, 1726-1739.
12. Xu, Y.W., Hu, X.M., Garzanti, E., BouDagher-Fadel, M., Sun, G.Y., Lai, W., 2021. Mid-Cretaceous thick carbonate accumulation in Northern Lhasa (Tibet): eustatic vs. tectonic control? **GSA Bulletin**, doi/10.1130/B35930.1.
13. 陈曦, 郭会芳, 姚翰威, 等. 2021. 白垩纪大洋缺氧事件OAE2期间碳循环扰动的过程与机制. **科学通报** 66, 1-12.
14. 李伟,胡修棉,Melinte-Dobrinescu M,.BouDagher-Fadel M.,2021.塔里木海齐姆根剖面早古近纪极热事件及其环境效应.**科学通报**,66,1067-1082.

三、代表性学术成果

1、侏罗纪极热期环境演化



植物碳同位素

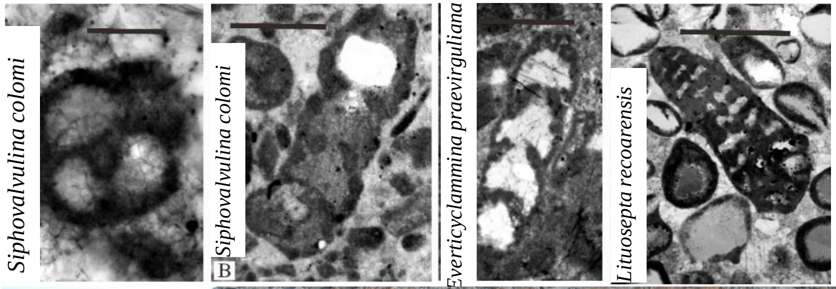


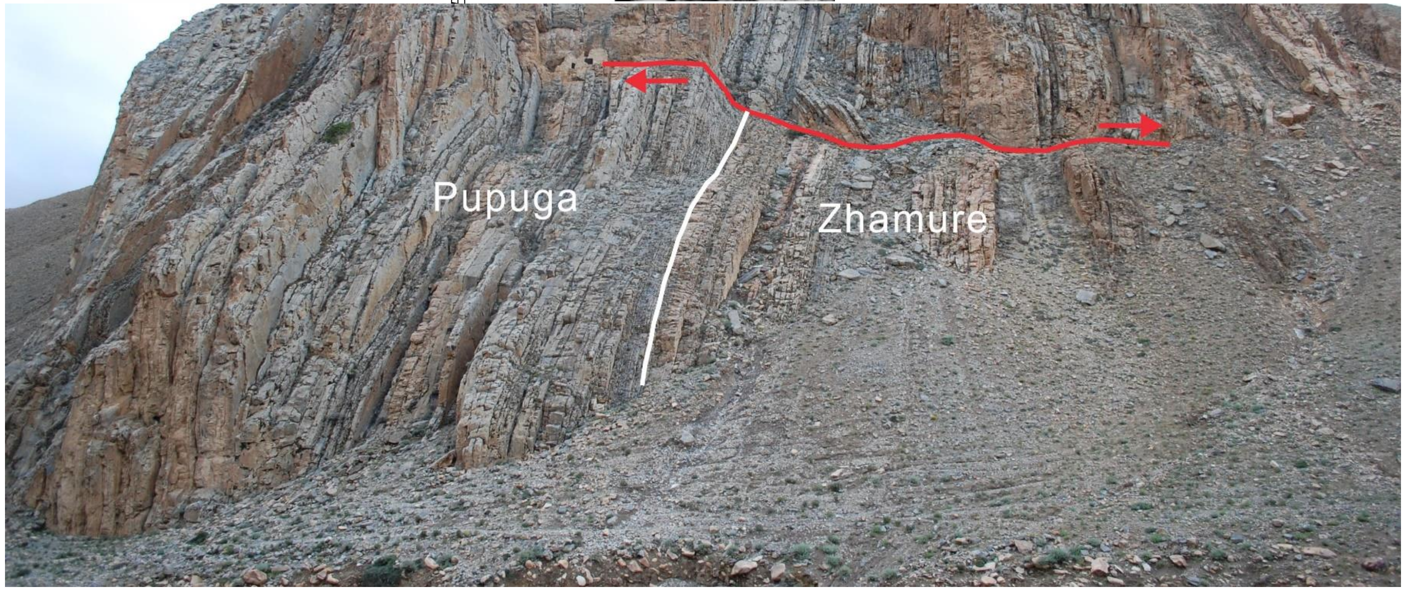
Storm et al., 2020, PNAS

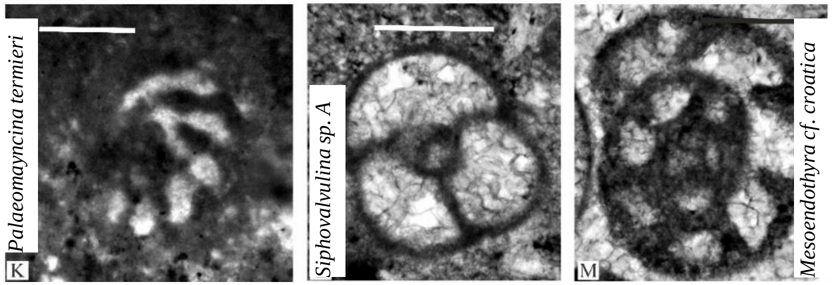
- 大西洋海道打开；
- CAMP 和 Karoo-Ferrar大火成岩省；
- 碳同位素频繁扰动和生物危机

问题：在特提斯域浅海环境有什么表现

早侏罗世全球变化——东特提斯碳-硫循环







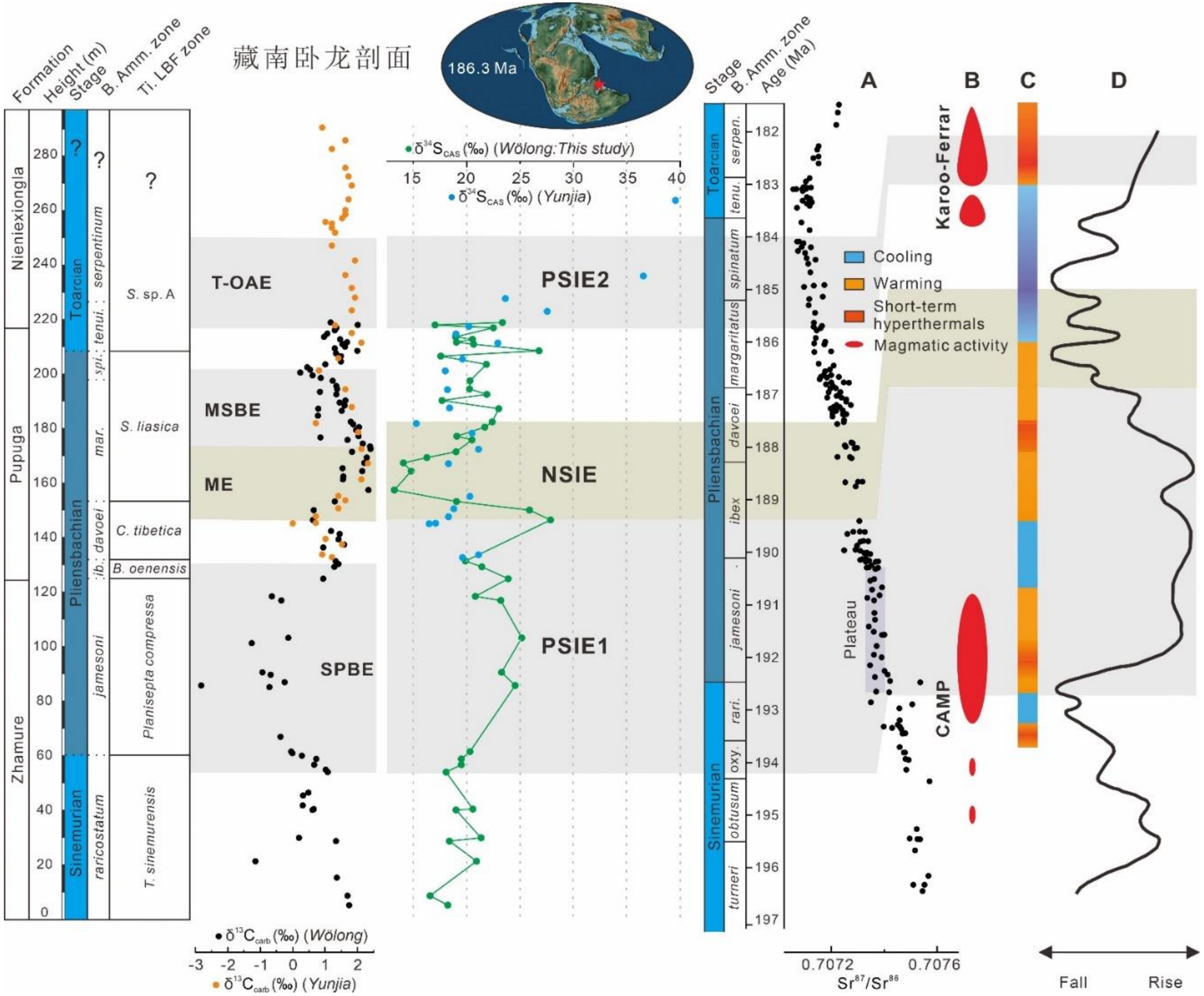
有孔虫标准化石

Stage	Ammonites	Wölong section		
	Tethyan	LBF	Biv.	Formation
Toar.	*Tenuicostatum*	*S.* sp. A		Nie.
	Emaciatum	*S. liasica*	*Lithiotis* Fauna	Pupuga
Pliensbachian	*Algovianum*			
	Lavinianum			
	Davoei	*C. tibetica*		
	Ibex	*B. oenensis*		
	Jamesoni	*Rectocyclammina* sp.		Zhamure
Sin.	*Raricostatum*	*T. sinemurensis*		

藏南特提斯喜马拉雅发育完整的早侏罗世Sinemurian-Toarcian地层。

Han et al, 2021, News. Strat.

东特提斯早侏罗世碳-硫同位素记录



频繁全球性碳-硫循环扰动件：

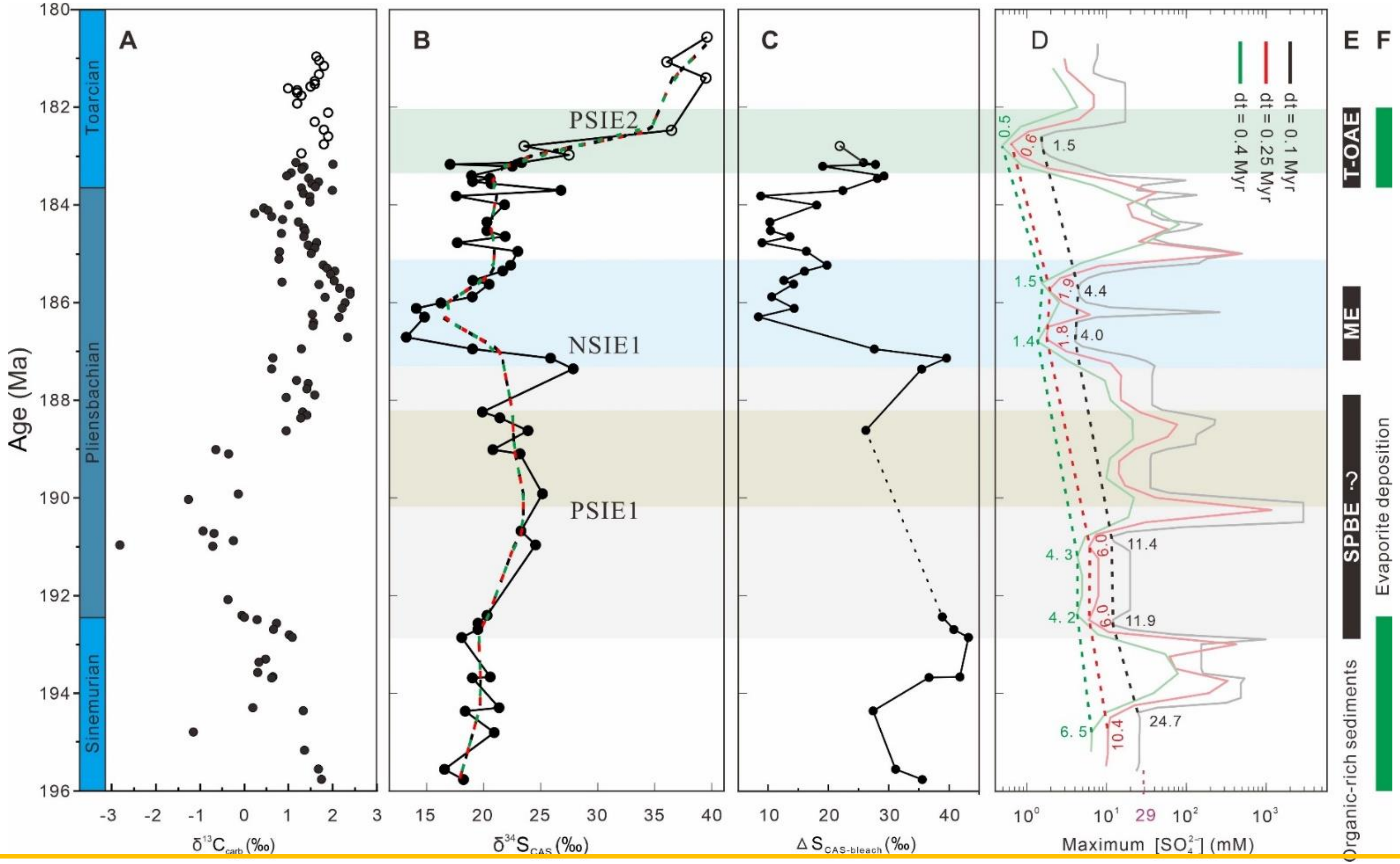
SPBE ：$\delta^{34}S_{CAS}$呈正偏移，总体对应$\delta^{13}C$负偏移，和CAMP晚期喷发相关；

Pliensbachian晚期(ME): $\delta^{34}S_{CAS}$呈弓形负偏移，总体对应$\delta^{13}C$正偏移，可能和当时全球变冷相关；

T-OAE：$\delta^{34}S_{CAS}$呈急剧大幅度正偏移，对应$\delta^{13}C$负偏移，和Karoo-Ferrar喷发相关

Han et al, 2021, EPSL

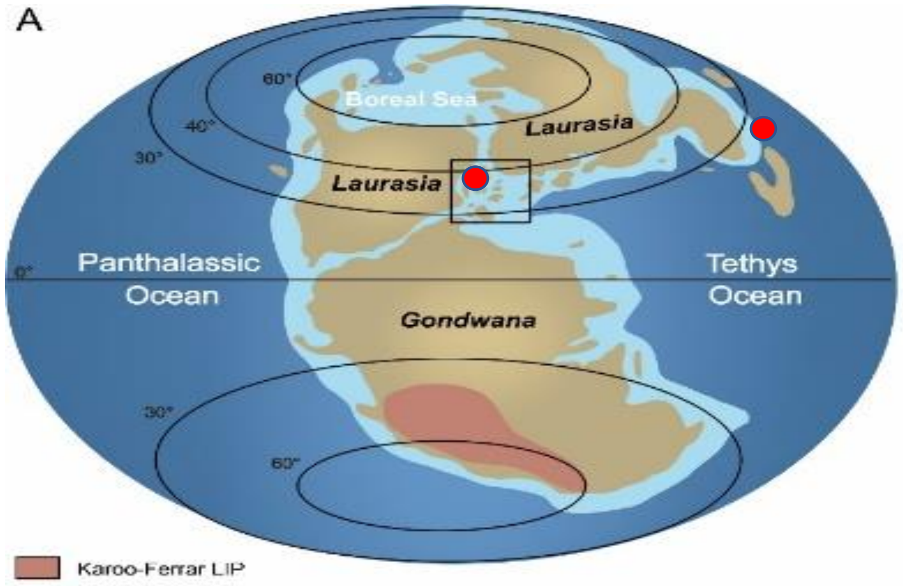
东特提斯早侏罗世硫循环



模型表明硫酸盐浓度持续降低，T-OAE时期达到最低值（0.5-1.5 mM），远低于现今大洋浓度 (29mM)；

硫酸盐浓度的降低可能和早侏罗世频繁的有机质和蒸发岩埋藏相关。

Han et al, 2021, EPSL



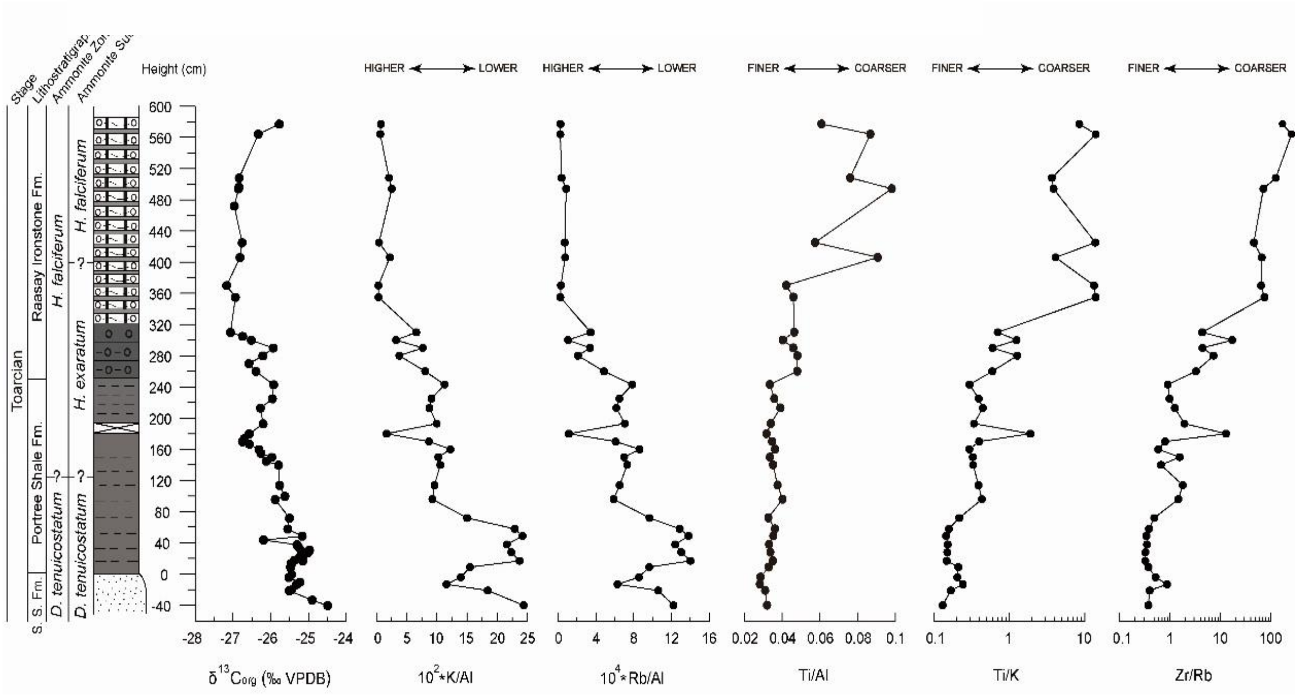
西特提斯T-OAE极热事件的特征：

元素地球化学研究表明海水为氧化状态

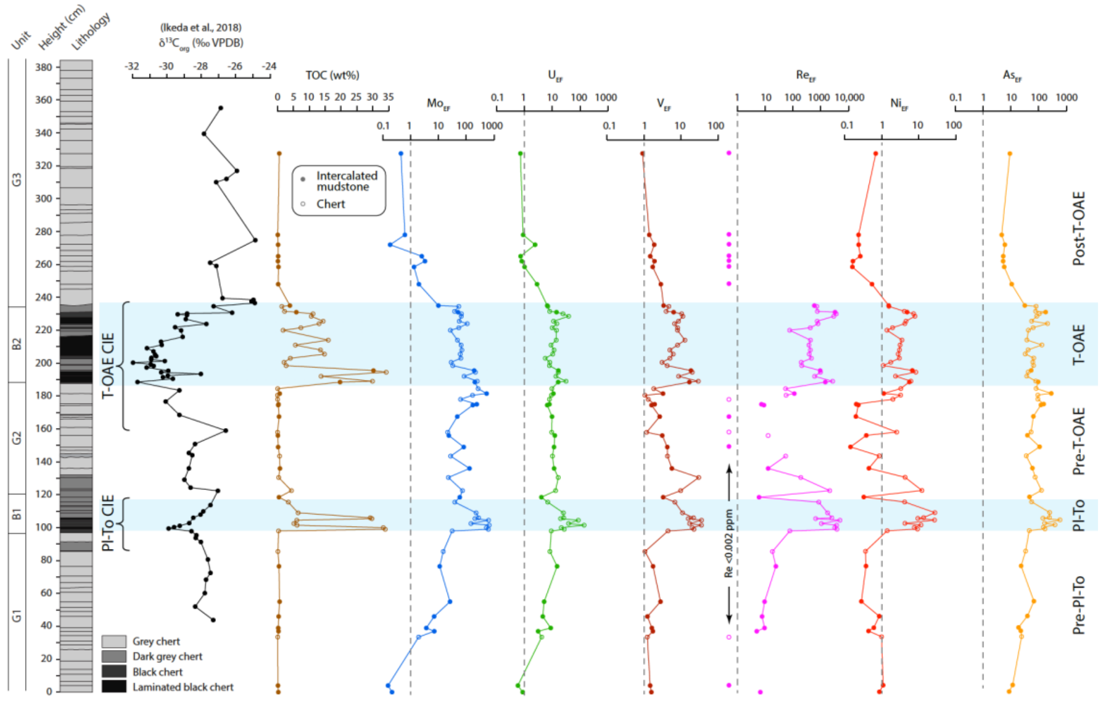
大陆风化增强，水文循环加强

太平洋T-OAE极热事件的特征：

缺氧，有机碳埋藏速率增加

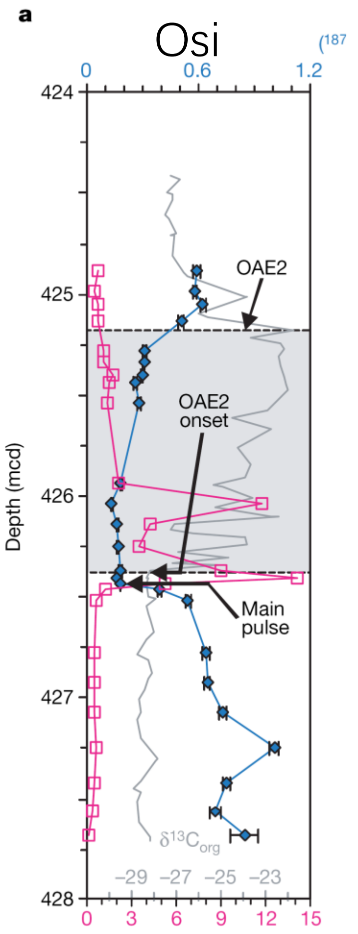


Chen et al., 2021 GPC



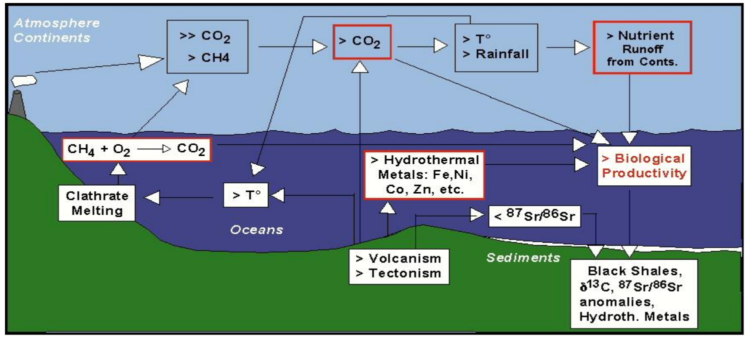
Kemp et al., in review GPC

2、白垩纪极热事件成因与环境演化



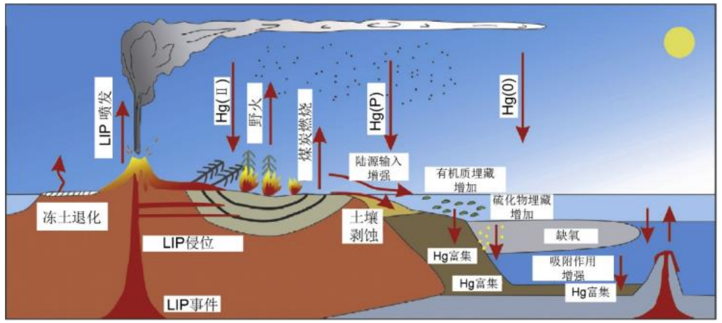
Turgeon and Creaser, 2008, Nature

2008年以前： LIP、甲烷与OAE



Erba, 2003, MM

2016年以后：Hg富集、LIP与OAE



Grasby et al., 2019 ESR

问题一：

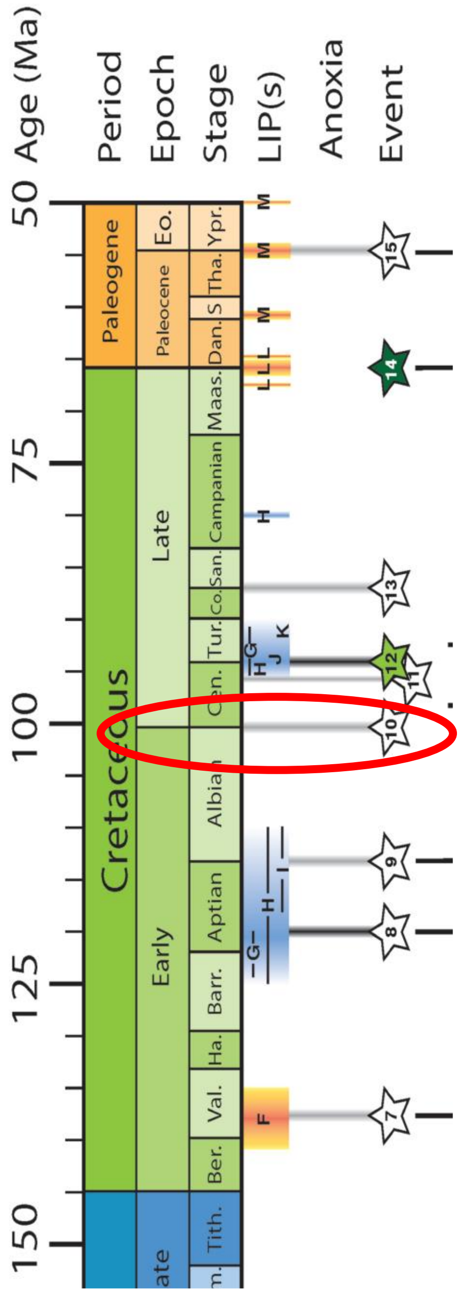
白垩纪极热事件，全部由大火成岩省岩浆作用引起吗？

最后的拼图：OAE1d与LIP

是否具有成因联系

其它指标对OAE之前的LIP

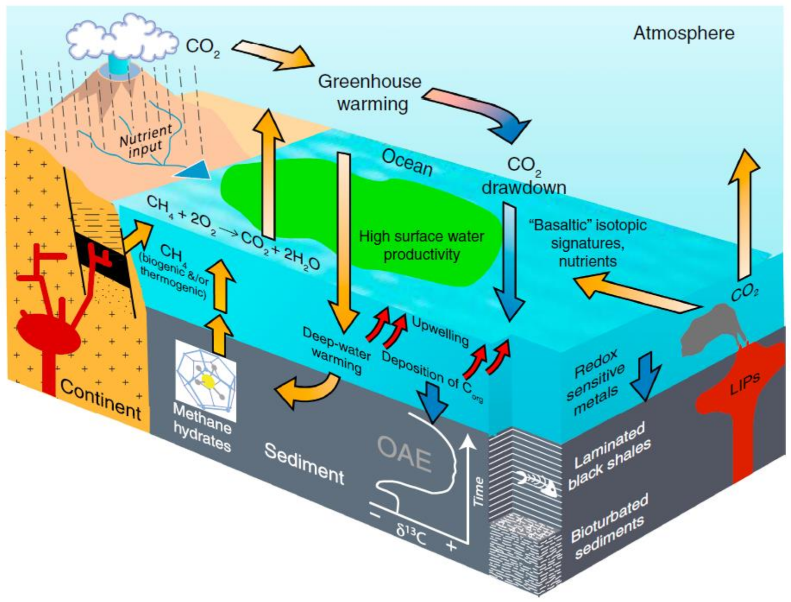
有什么响应



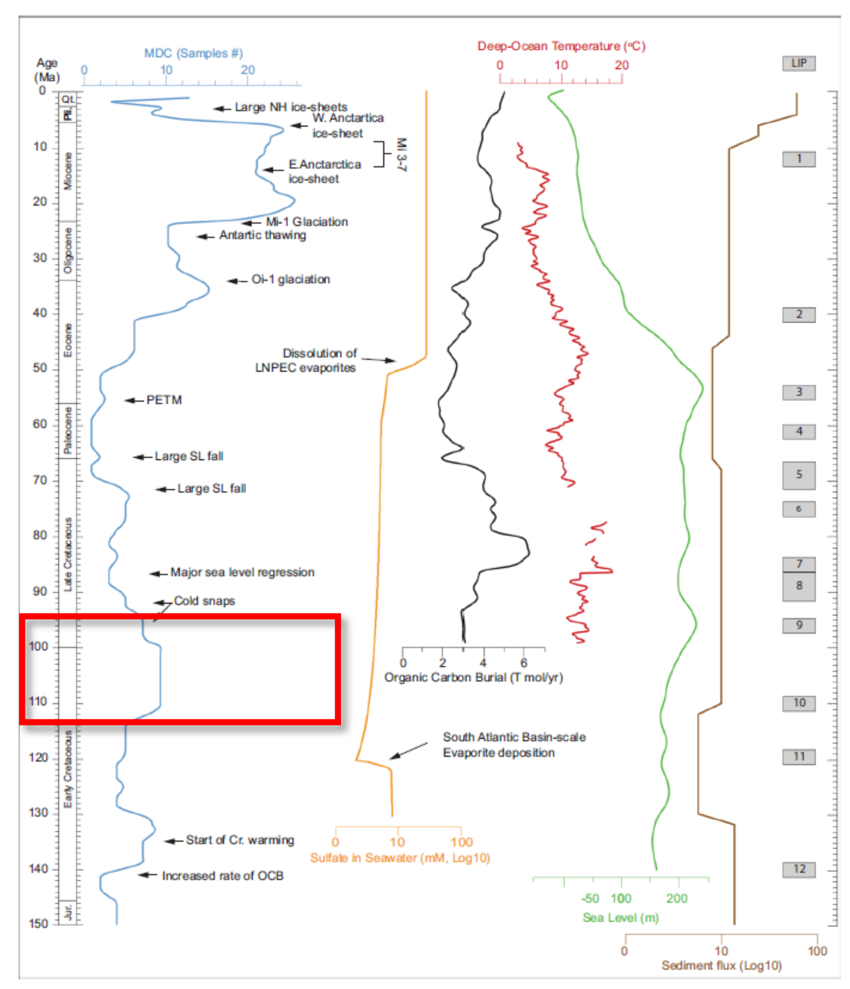
Percival et al., 2018, AJS

问题二：

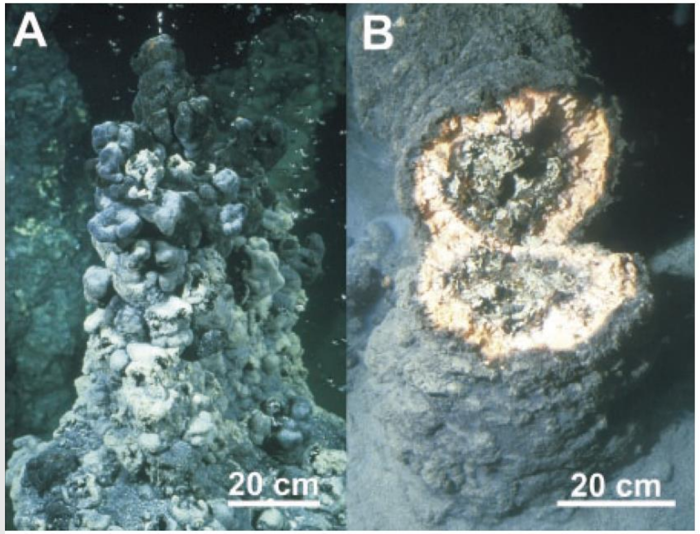
白垩纪中期全球广泛记录甲烷成因碳酸盐岩（MDC）。甲烷释放是极热事件的“因”还是“果”？

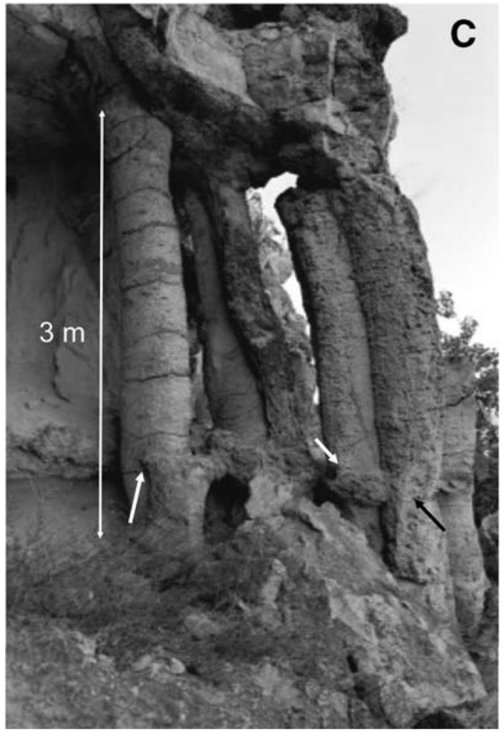


Robinson et al., 2017, Sedimentology



Oppo et al., 2020, Sci. Rep.





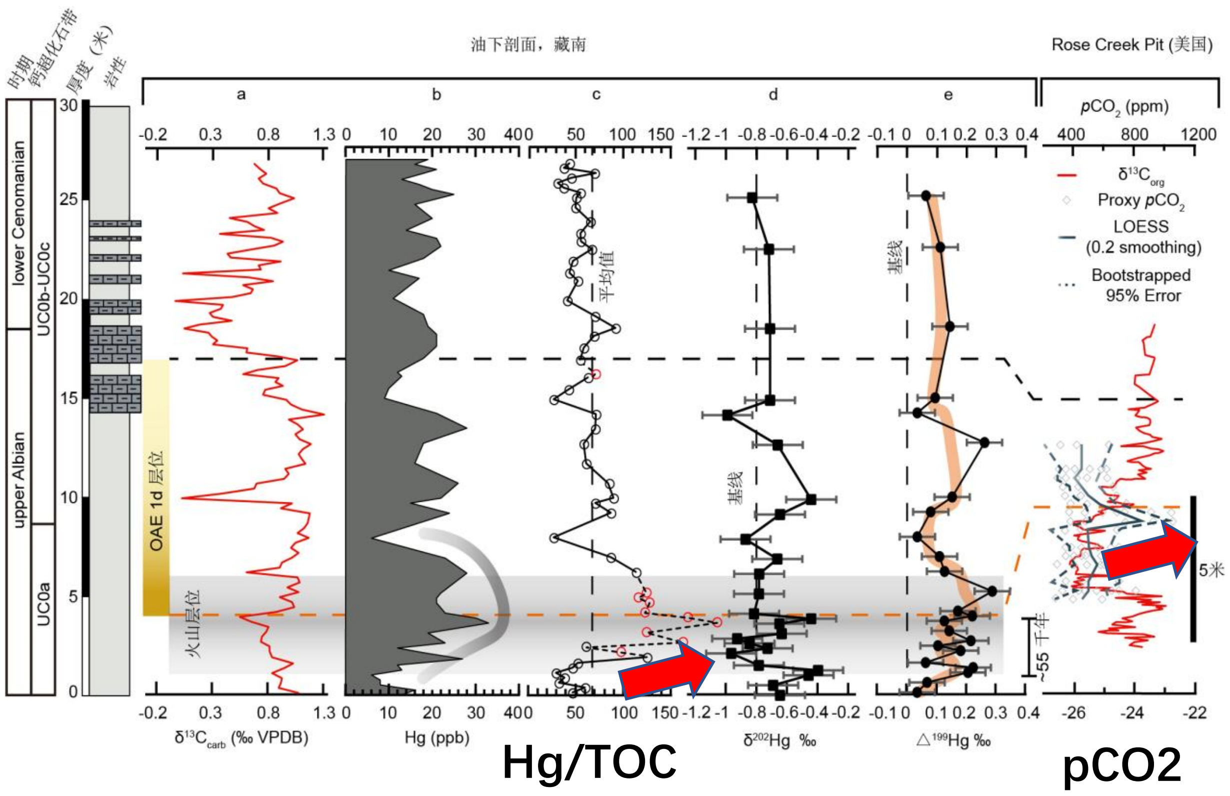
De Boever et al., 2006, SG

Hg的研究证实OAE1d与LIP是否具有成因联系

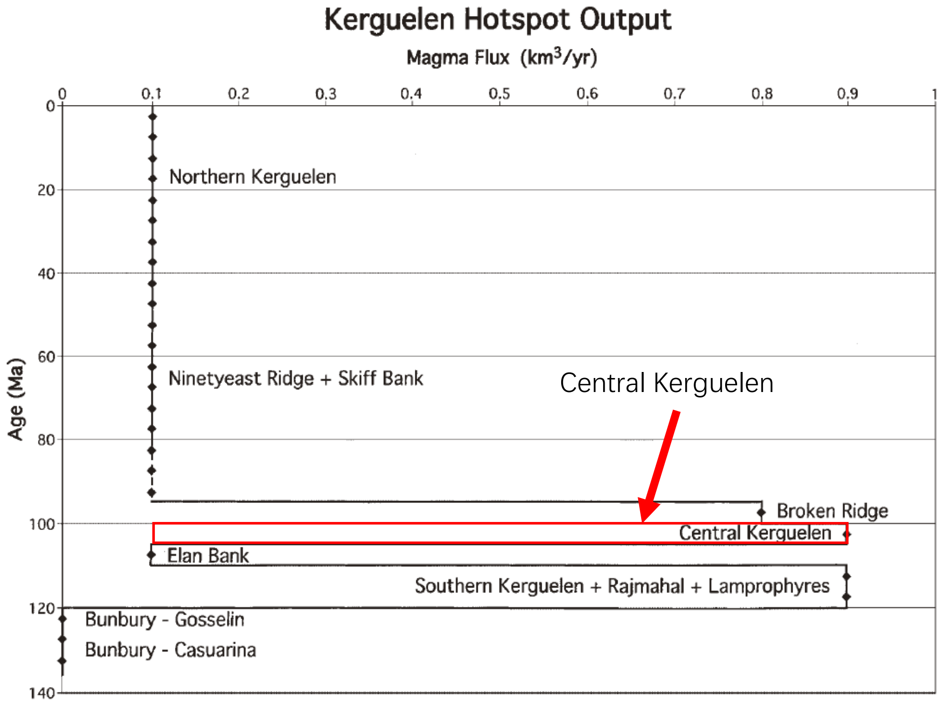
OAE1d前55kyr Hg快速上升，7倍富集

pCO2从400增加到800ppm

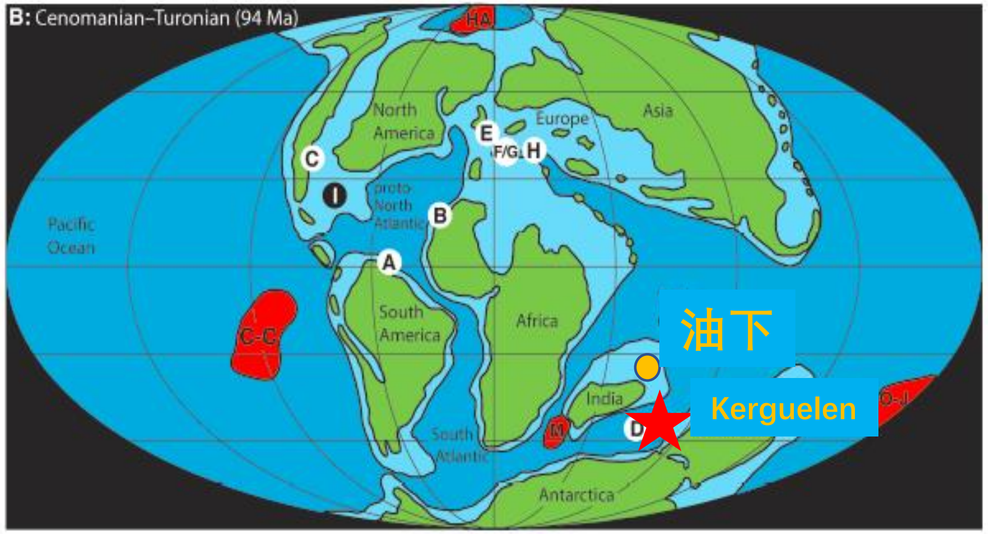
由中Kergulen LIP活动引起



Yao et al., 2021 GRL



Coffin et al., 2002, JP



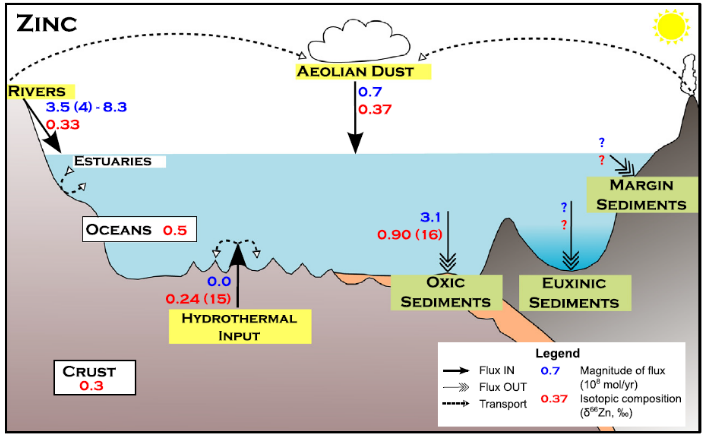
Zn同位素在OAE与LIP联系上有良好的示踪作用

OAE2前Zn同位素快速降低

水中Zn含量快速增加

Zn与Os同步变化

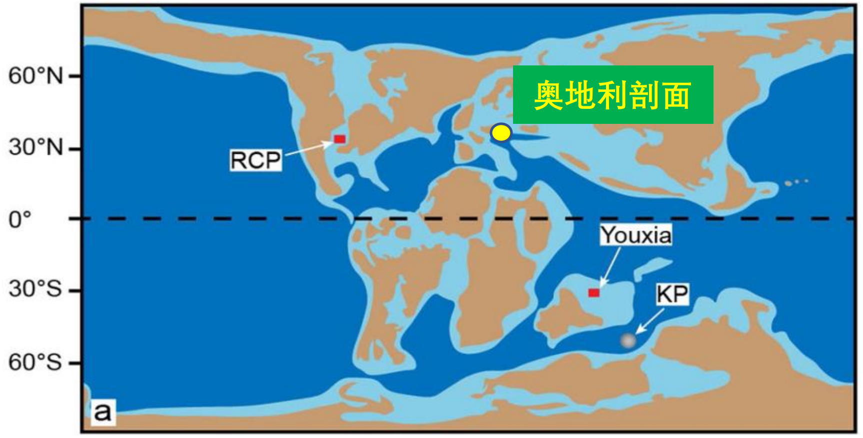
Zn与Hg同步变化

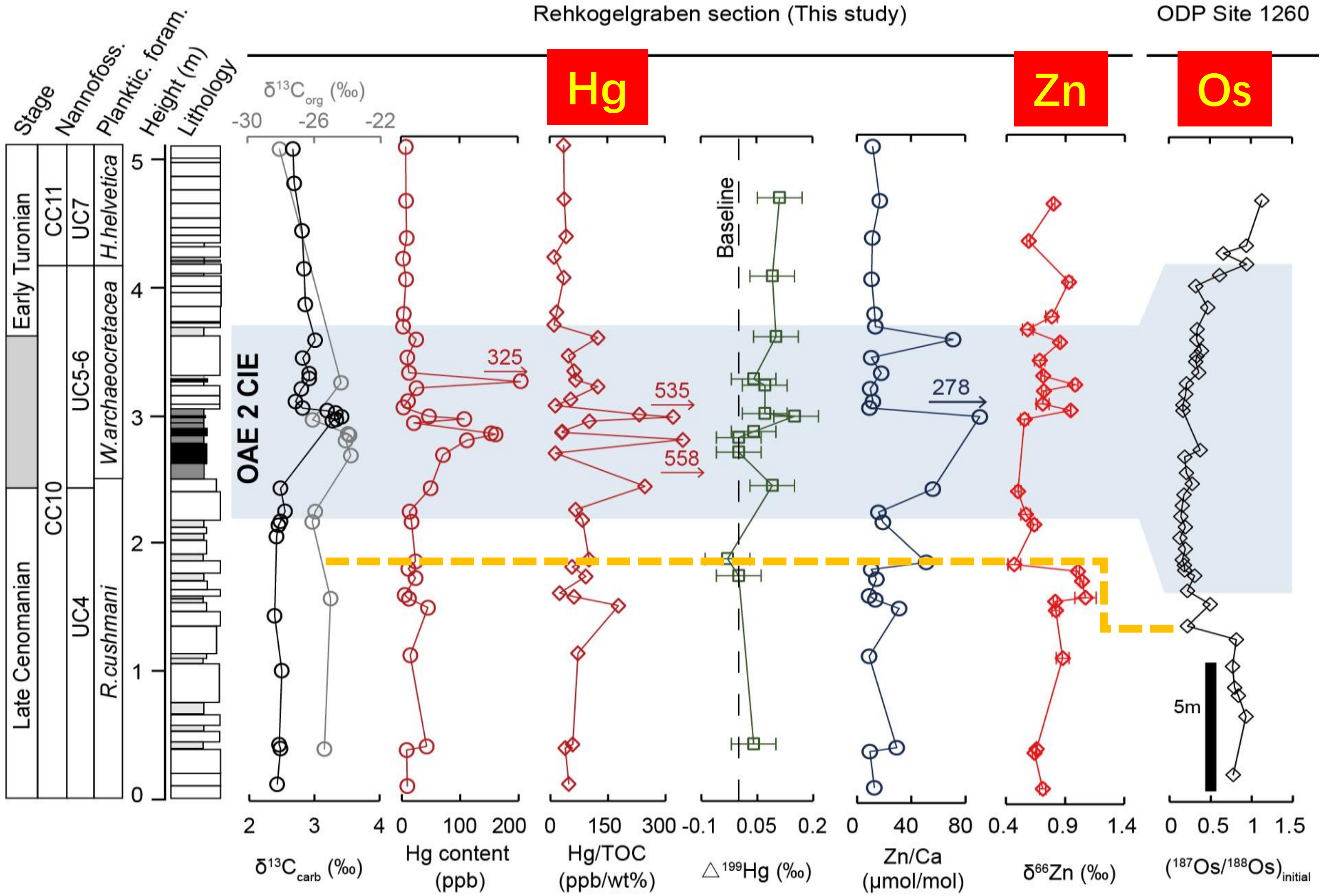


热液输入的Zn同位素0.24‰

正常碳酸盐0.90‰

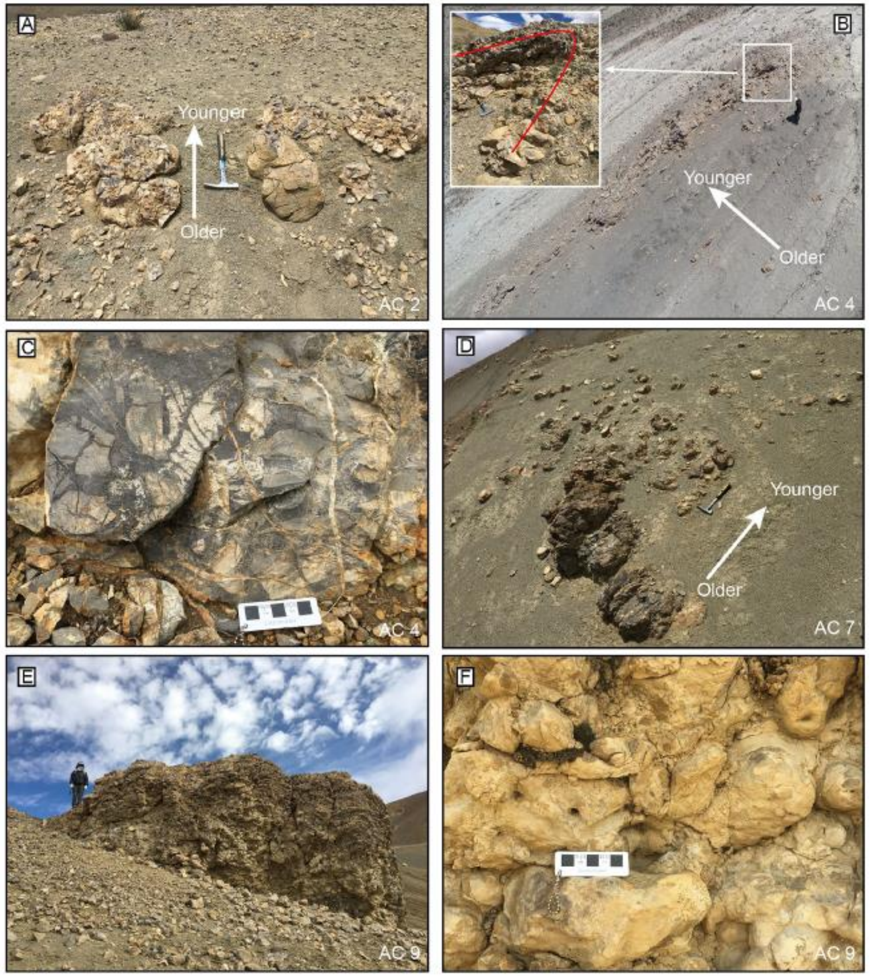
Little et al., 2014, GCA

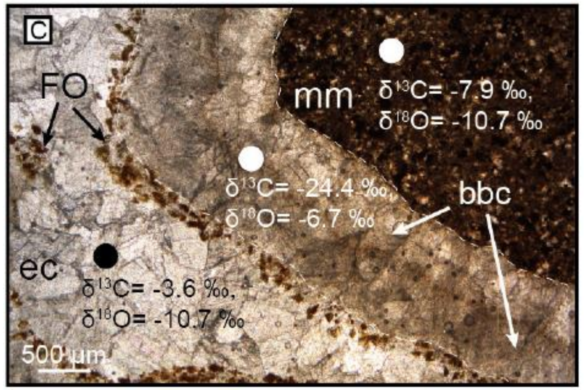


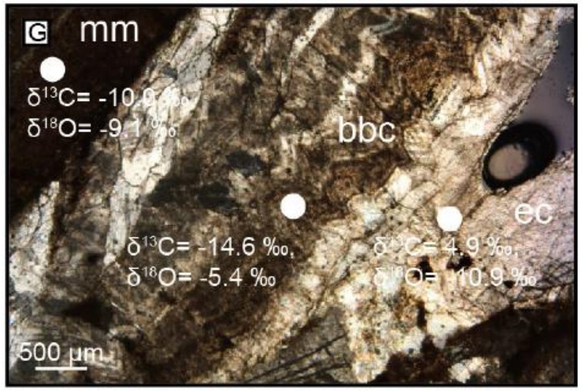


Yao et al., GPC, in preparation

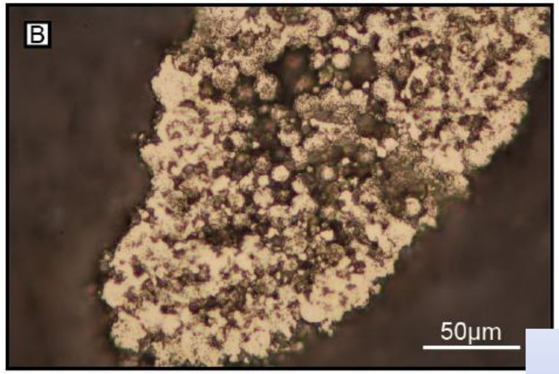
西藏白垩纪中期自生碳酸盐岩是甲烷渗漏成因





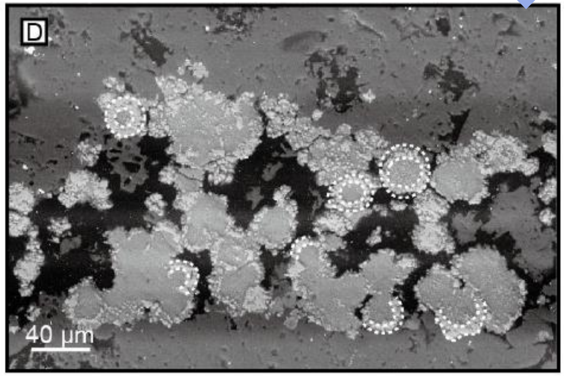


白垩纪中期（Albian-Turonian）9套自生碳酸盐岩具有典型的甲烷成因结构；黄铁矿生长过程指示了微生物厌氧氧化过程



草莓状

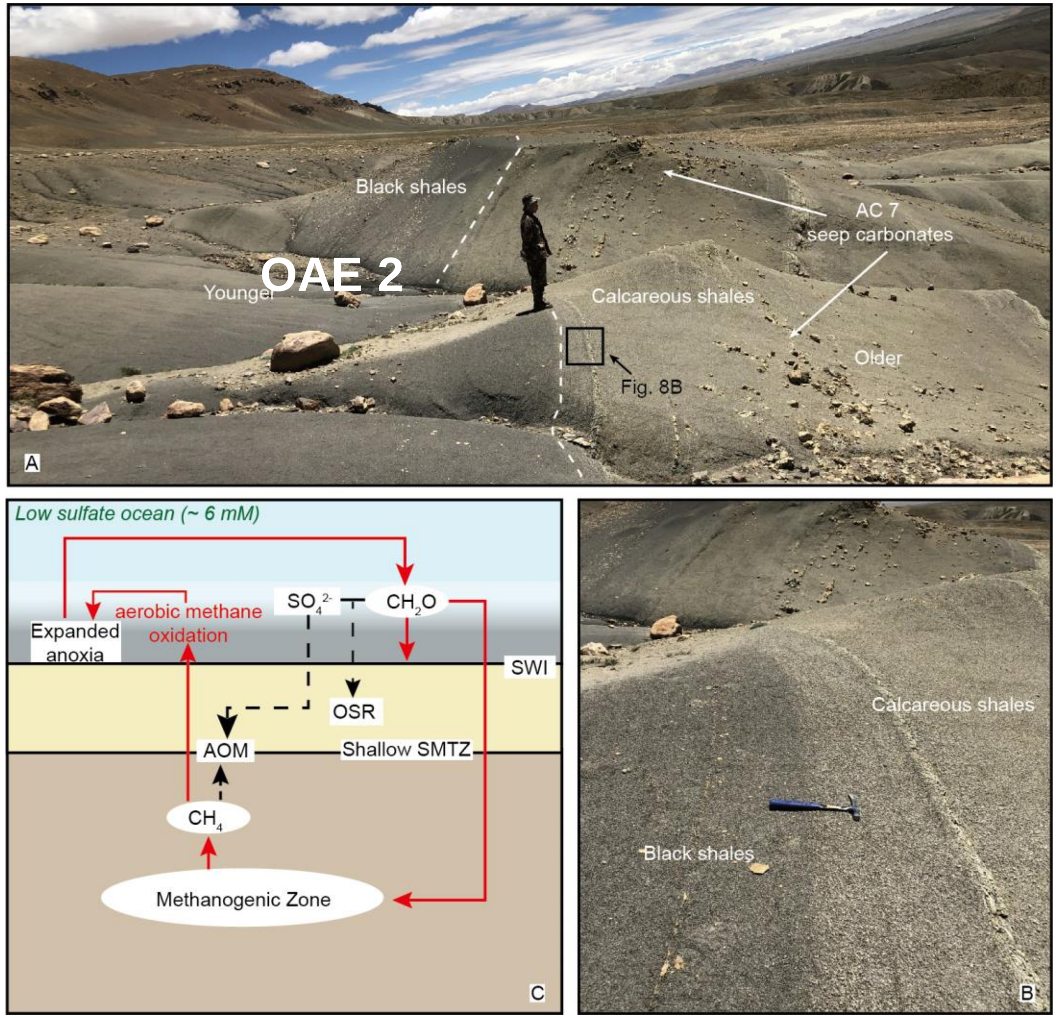
持续的生物厌氧氧化，消耗硫酸根，形成黄铁矿



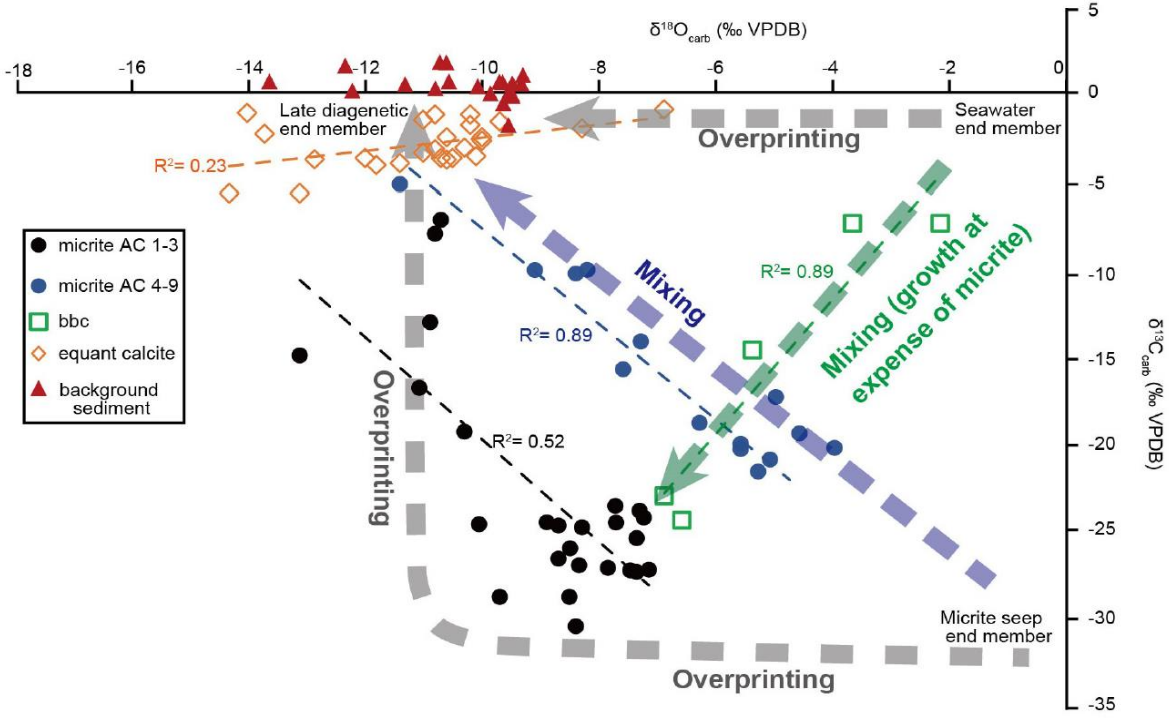
增生

Yao et al., 2021, GPC

甲烷渗漏很可能是全球低硫酸盐海洋、极热条件下有机质埋藏增加的“果”

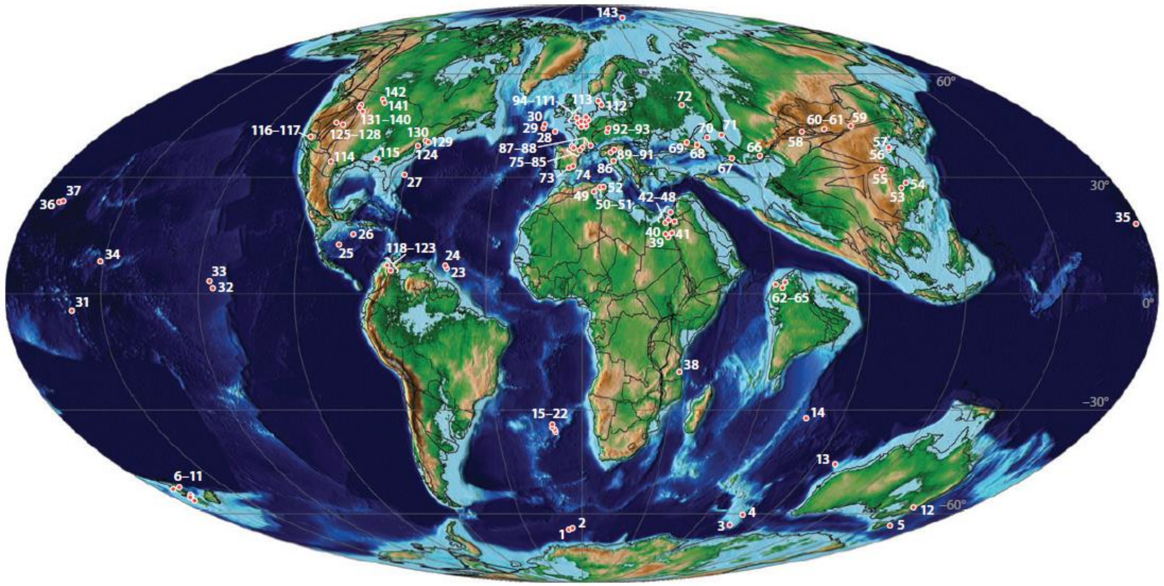


- 碳同位素结果显示三个端元混合的结果：1）海水（高 $\delta^{13}C$, 高 $\delta^{18}O$）；2）冷泉流体（低 $\delta^{13}C$, 高 $\delta^{18}O$）；3）成岩期流体（高 $\delta^{13}C$, 低 $\delta^{18}O$）；
- 全球海水低硫酸盐浓度导致水合物稳定带上移，有机质易于进入产甲烷带，在升温或海平面波动时甲烷大量释放。



Yao et al., 2021, GPC

3、古近纪极热气候、环境与生物响应



PETM研究点分布图（Francesca and Wing, 2011）

- ●PETM在东特提斯的研究相对薄弱；
- ●目前PETM的研究多集中于深水相和陆相背景，浅海PETM研究较少

深海

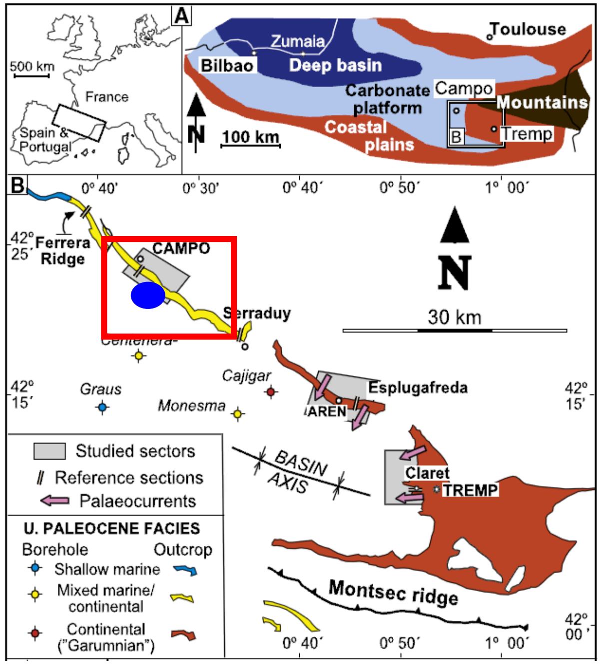
?

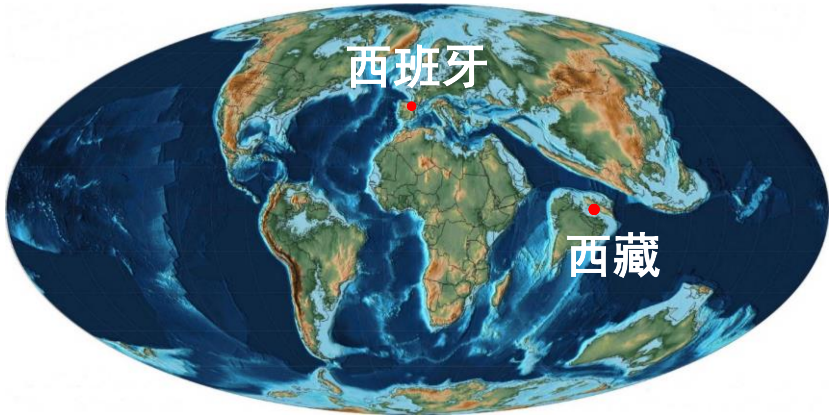
浅海

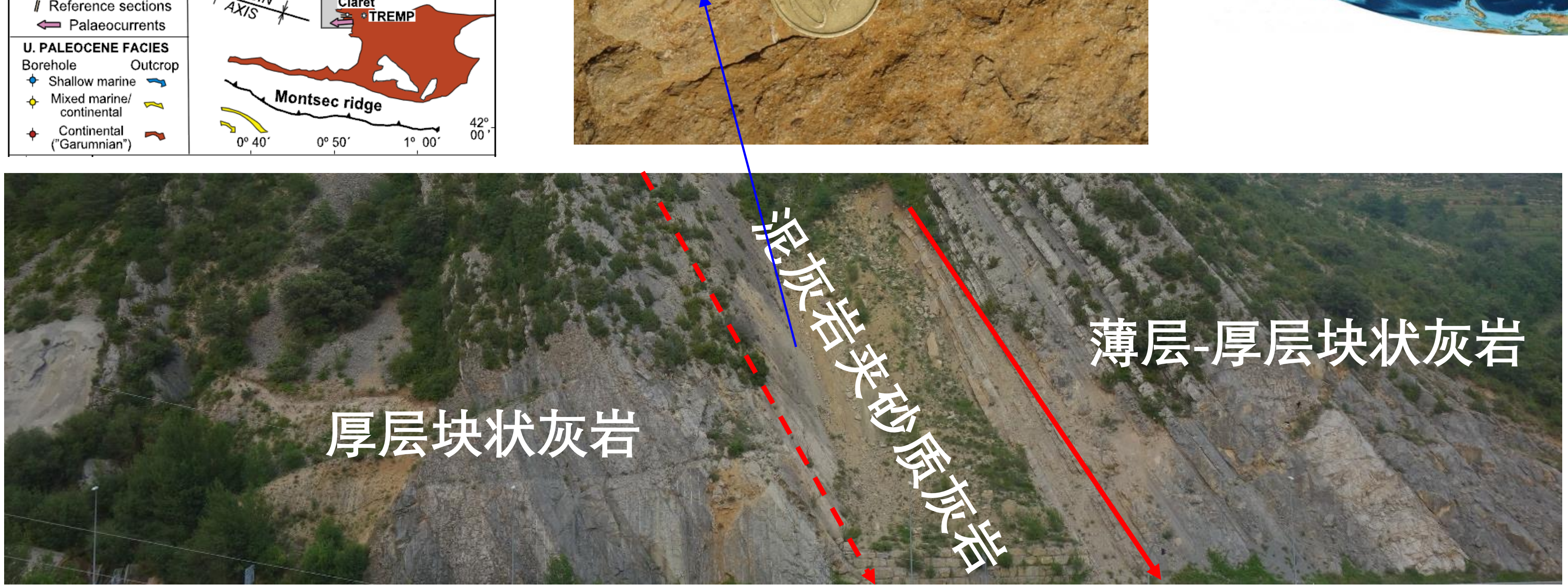
陆相 Bighorn 盆地

浅海地层、沉积环境、生物对PETM如何响应的呢？

① 西班牙Campo地区



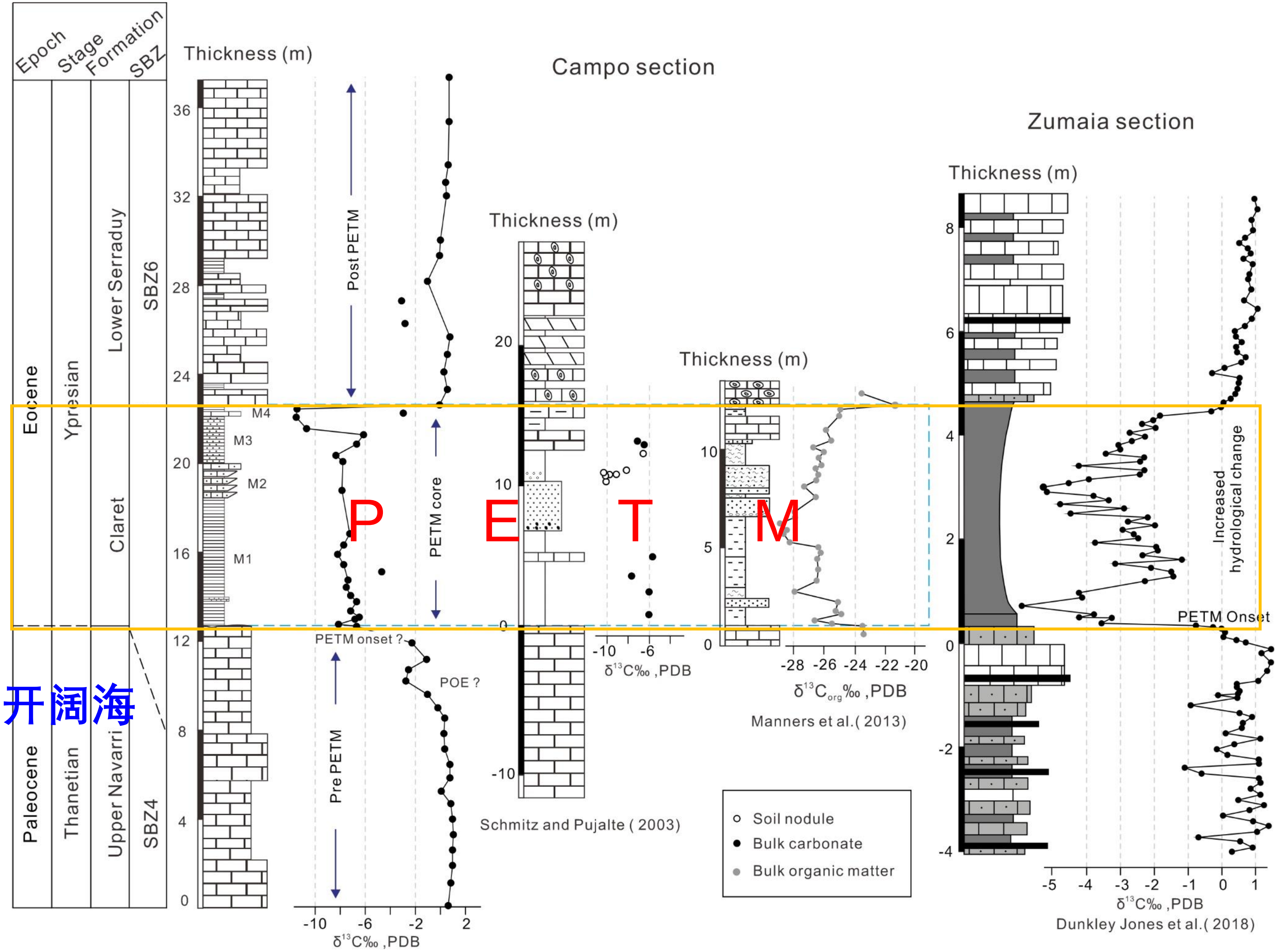




濶湖

潮坪

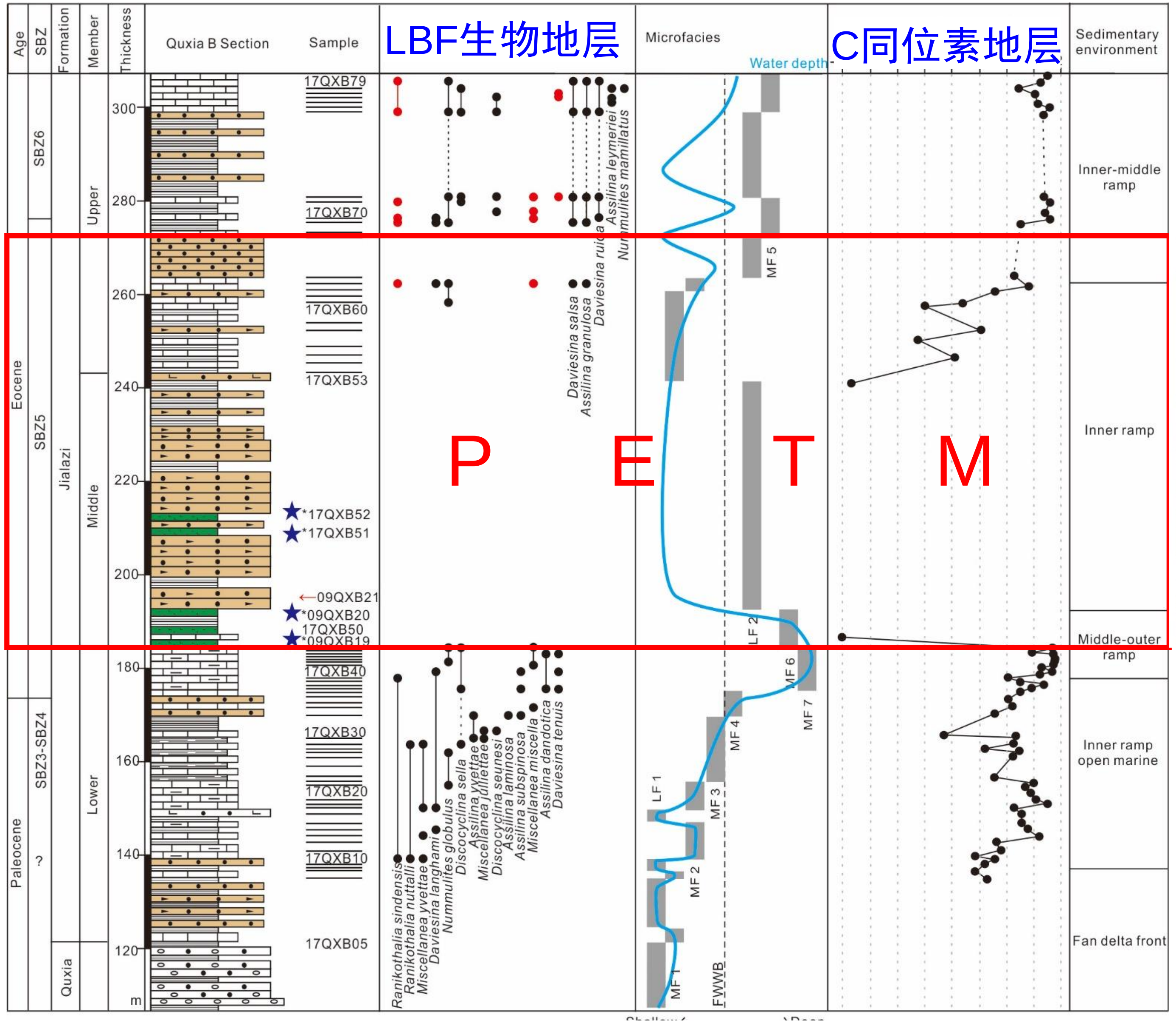
浅滩、开阔海



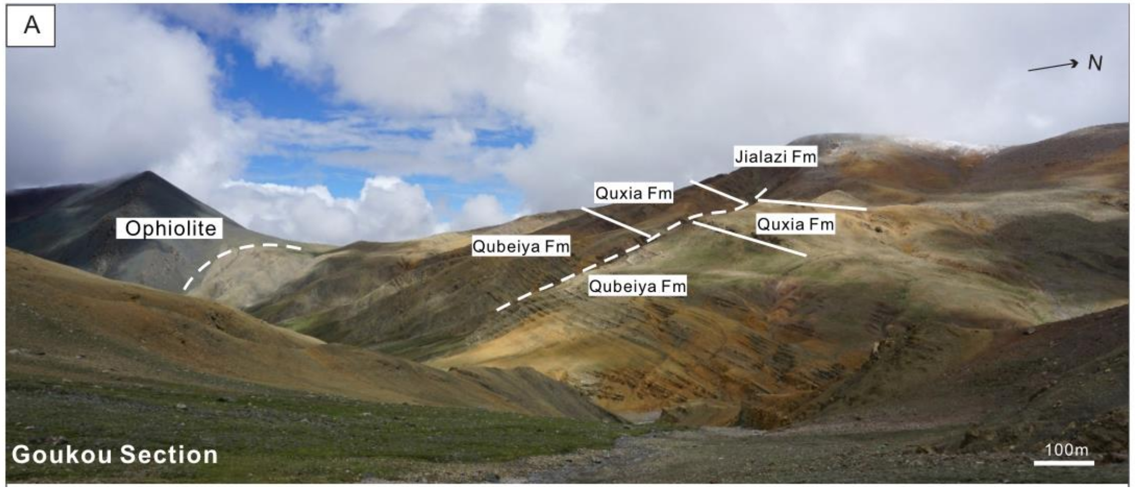
PETM水循环增强导致，陆源碎屑物质输入增加，碳酸盐岩地死亡

Li et al., 2021 Palaeo3

② 东特提斯日喀则弧前盆地PETM记录

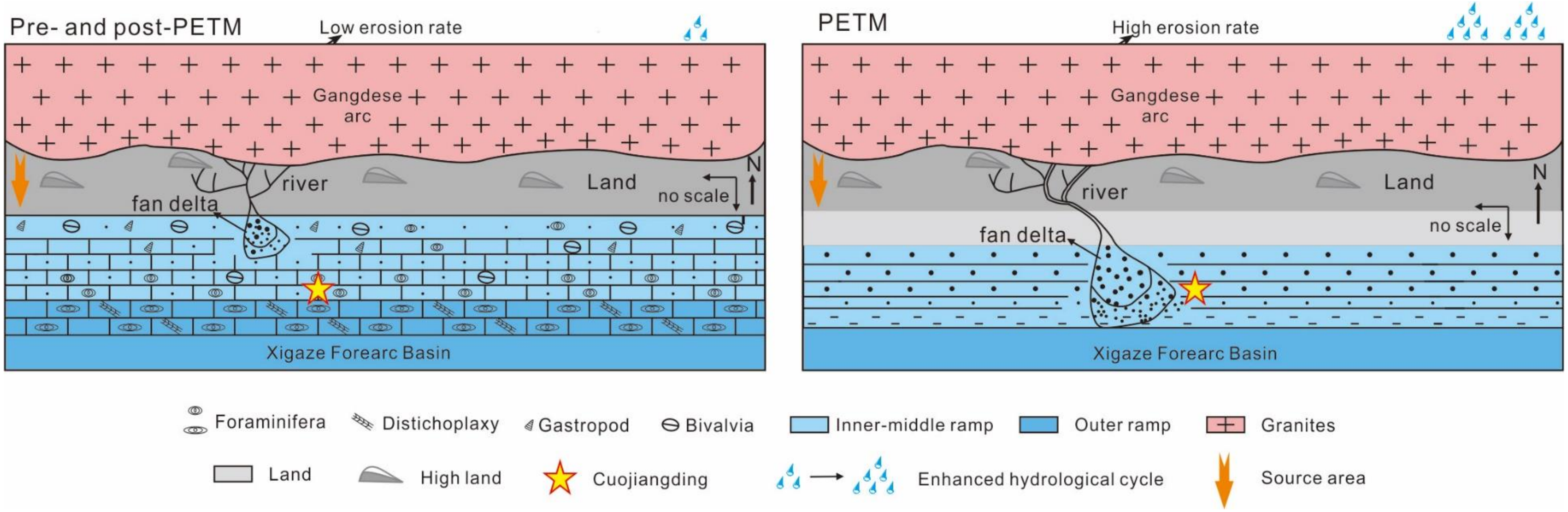


错江顶地区曲下剖面 加拉孜组



PETM期间陆源碎屑物质增加

生物大量灭绝，导致台地死亡



PETM事件期间出现**河流输入巨厚的碎屑岩**，是PETM水循环加剧的结果，导致碳酸盐台地死亡

Jiang et al., 2021 Palaeo 3

IGCP739中国工作组学术成果小结

1）侏罗纪东特提斯地区海洋碳-硫循环，受大火成岩省喷发及全球气候变化控制。

2）T-OAE期间全球海洋硫酸盐浓度仅相当于现今大洋的2-5%，全球水文循环加剧。

3）白垩纪极热事件由大火成岩省岩浆作用触发。

4）白垩纪中期低硫酸盐浓度海洋和富有机质沉积，导致甲烷水合物库增大。

5）PETM事件期间，全球水文循环加剧，造成浅海碳酸盐台地短暂消失。


谢 谢 大 家！
请 批 评 指 正 ！