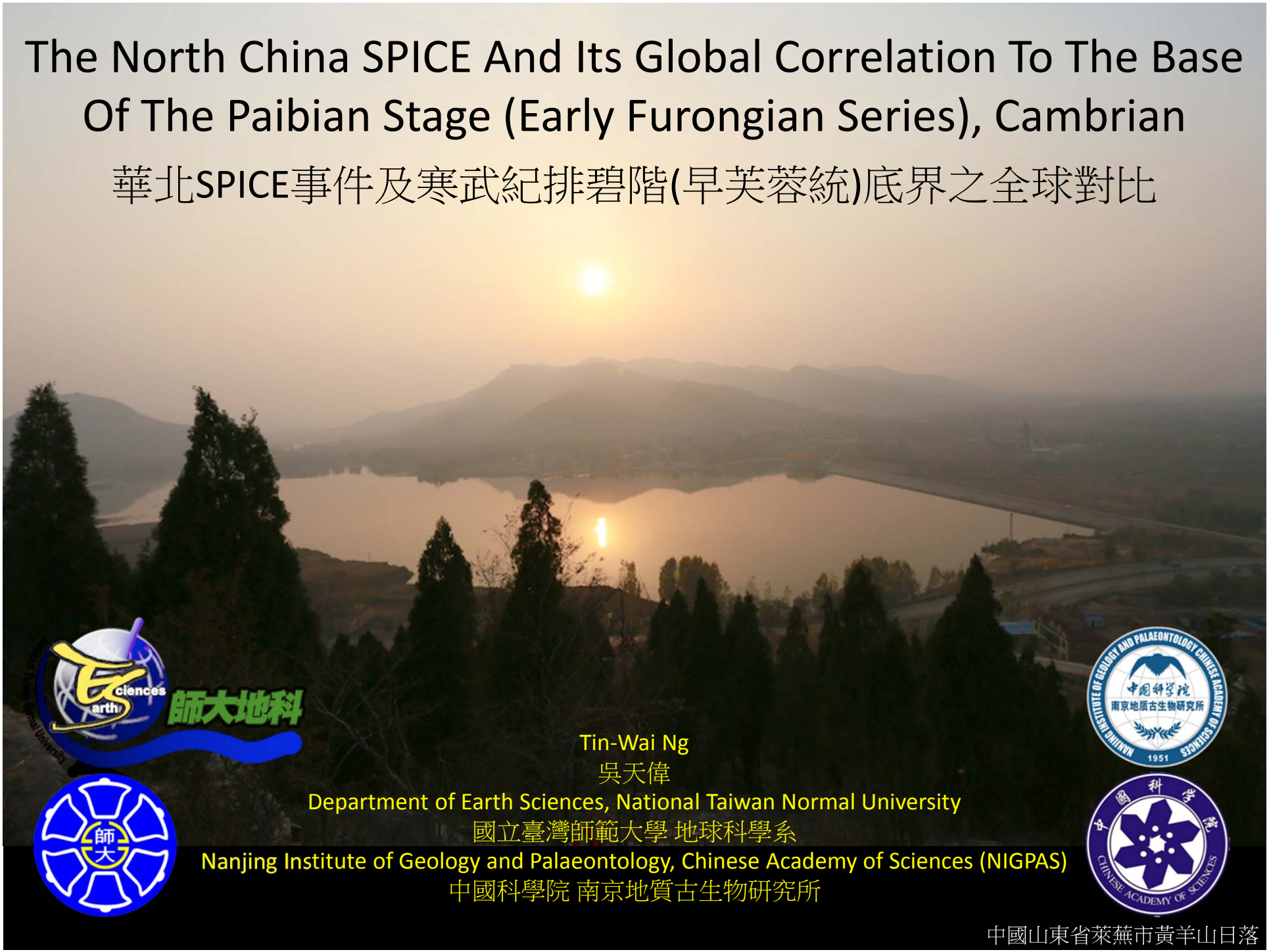
The North China SPICE And Its Global Correlation To The Base Of The Paibian Stage (Early Furongian Series), Cambrian

華北SPICE事件及寒武紀排碧階(早芙蓉統)底界之全球對比



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前身為 中央研究院地質研究所 及前中央地質調查所等機構之古生物室(組)

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古無脊椎動物學和古植物學研究

http://www.nigpas.cas.cn/gkjj/lsyg/

中央大學沿革簡表

http://www.ncu.edu.tw/ch/about_08.html

Outline 大綱

Problems of Cambrian Stratigraphy

What is SPICE?

“Upper” Cambrian of North China

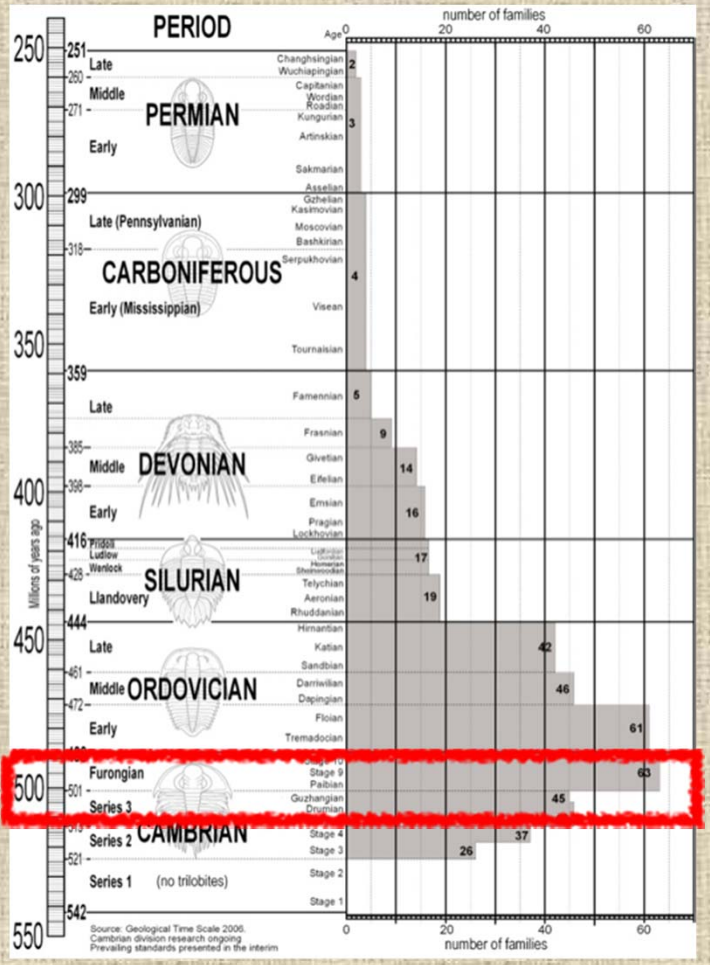
Shuangqiao (SQ), Tangshan, Hebei

河北省唐山市雙橋(村)剖面

Huangyangshan (HYS), Laiwu, Shandong

山東省萊蕪市黃羊山剖面

Other Projects



Cambrian Stratigraphy 寒武紀地層

Traditional “lower”, “middle”, and “upper” division

Trilobite-based biostratigraphy mainly

International Subcommission on Cambrian Stratigraphy - 4 series (統) and 10 stages (階)

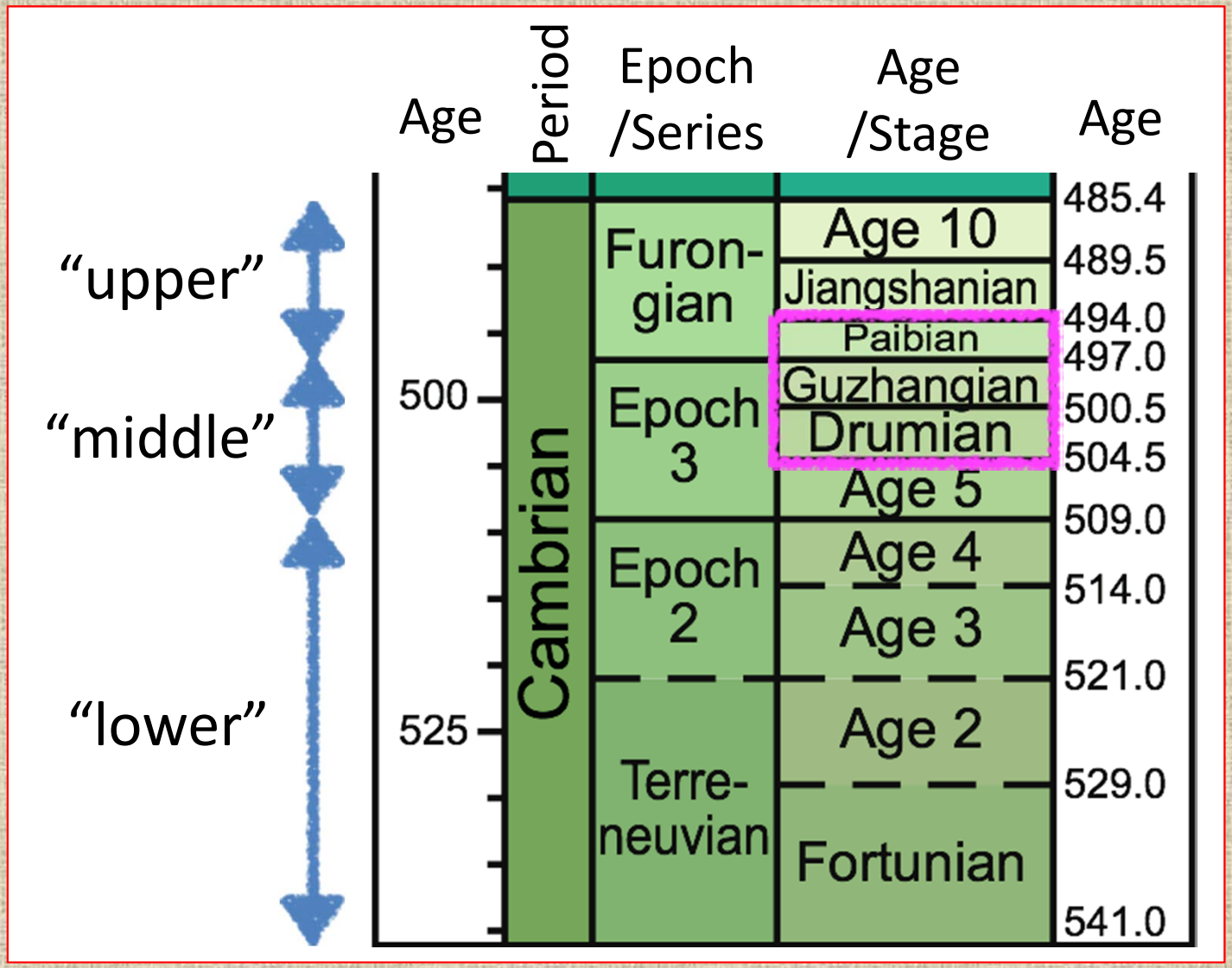
Global Stratotype Section and Point (GSSP)

- “Golden Spike”

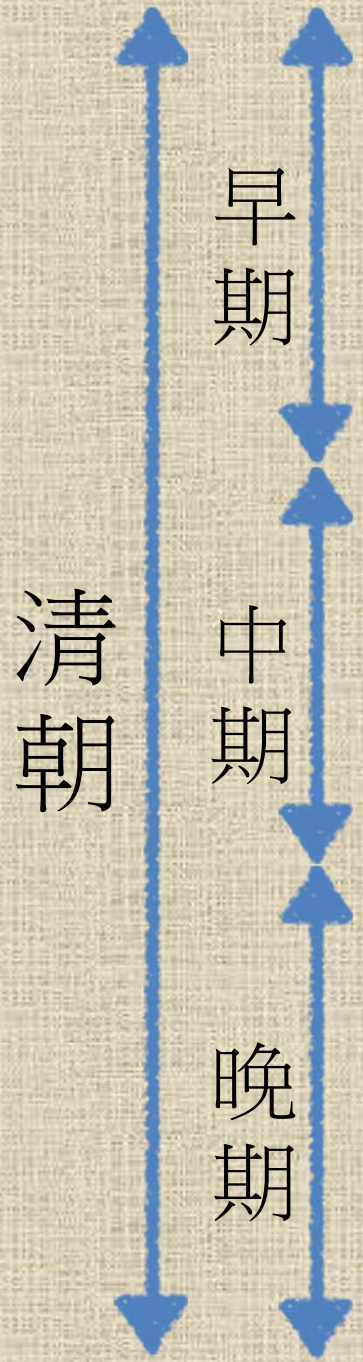
全球界線層型剖面和點位

- 金釘子

Cambrian Stratigraphy



http://www.nhm2.uio.no/norges/GTS_2012.pdf

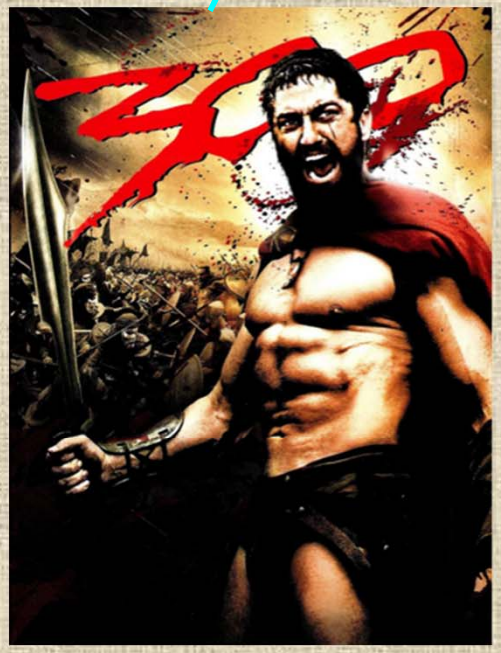


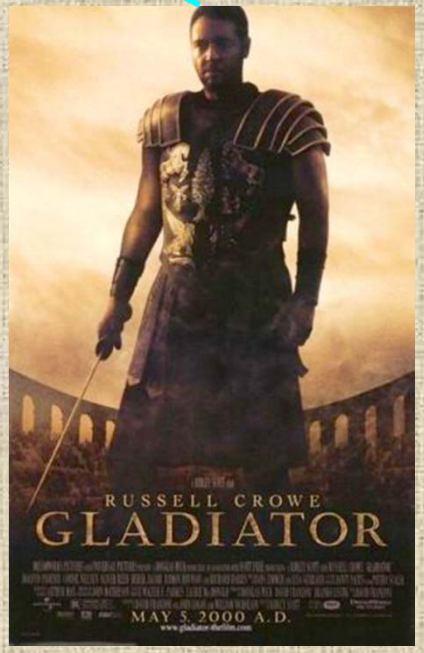
太祖 （清太宗追尊）	努爾哈赤	1616年2月17日－1626年9月30日	天命
太宗	皇太極	1626年10月20日－1643年9月21日	天聰 崇德
成宗 （清世祖追尊，後廢）	多爾袞	－	－
世祖	福臨	1643年4月8日－1661年2月5日	順治
聖祖	玄燁	1661年2月5日－1722年12月20日	康熙
世宗	胤禛	1722年12月27日－1735年10月8日	雍正
高宗	弘曆	1735年10月8日－1796年2月9日	乾隆
仁宗	顒琰	1796年2月9日－1820年9月2日	嘉慶
宣宗	旻寧	1820年10月3日－1850年2月25日	道光
文宗	奕詝	1850年3月9日－1861年8月22日	咸豐
穆宗	載淳	1861年8月22日－1875年1月12日	祺祥 同治
德宗	載湉	1875年1月12日－1908年11月14日	光緒
	溥儁[註 41]	1899年	保慶
	溥儀	1908年12月2日－1912年2月12日	宣統

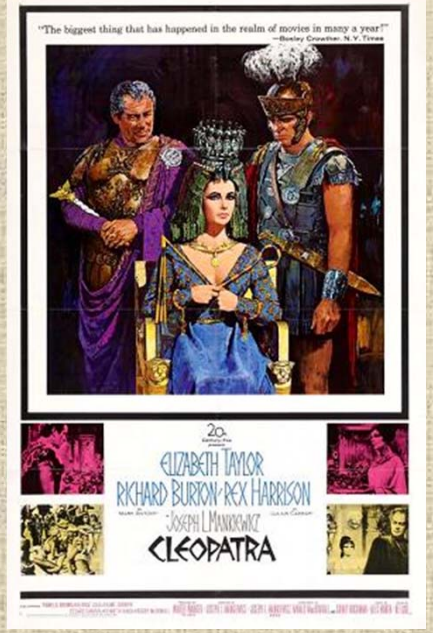
BC

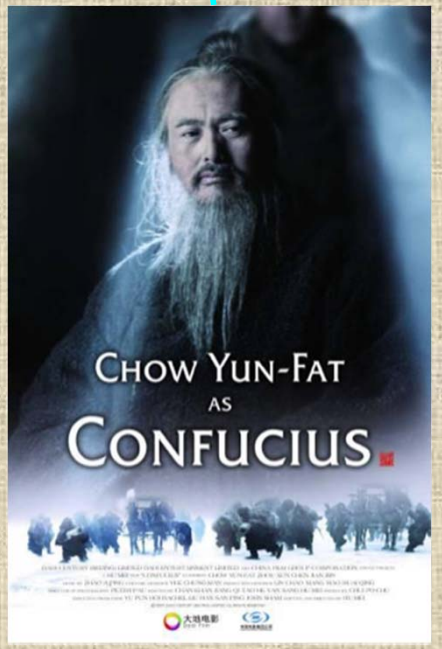
-1100		(阿基里斯)	特洛伊戰爭(赫克托)	希伯來王國			(周公)		
-1000		古希臘聯邦	埃及後王國	新亞述帝國		後吠陀時期	西周		
-900		(荷馬史詩問世)					(詩經問世)		
-800		(奧林匹克運動會)					東周		
-700	古羅馬王政時期			(尼尼微城建大圖書館)新巴比倫帝國		列國時期	春秋		
-600					(大流士)	佛士時期			
-500	(蘇格拉底)馬其	頓王國(300壯士)	埃及晚王國	(空中花園)	古波斯帝國	(釋迦牟尼)	(孔子)戰國	老子、墨子、孫子	
-400	(柏拉圖、亞里斯多德)	亞歷山大帝國	(亞歷山大帝國書館)				(屈原、商鞅)		
-300	(阿基米得、迦太	基戰爭、漢尼拔)	托密勒王朝	遠古高科技(碳鋅電池)	帕提亞帝國	孔雀王朝	秦(楚漢相爭)	萬里長城、阿房宮	
-200	羅馬共和時期			(楔形文字消失，希臘文字取代)			(衛青、霍去病)西漢	張騫通西域	
-100	(凱薩大帝)	馬其頓戰爭	(埃及豔后)			異伽王朝	(王昭君)		
0	(奧古斯都-屋大維)		(安東尼、耶穌)	貴霜帝國(大月氏支族)			東漢(竇固、班超)		
100	(龐貝城遭火山埋)(電影神鬼戰士年代背景)						(董卓、袁紹)		

AD









Index Fossil 標準/指準/指標化石

Common and abundant

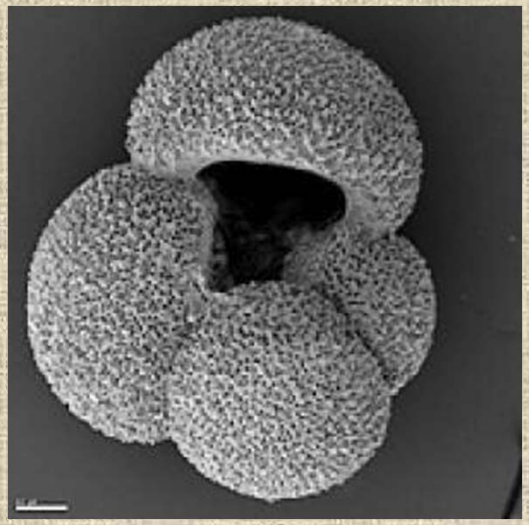
Broad distribution (∴ planktic mostly)

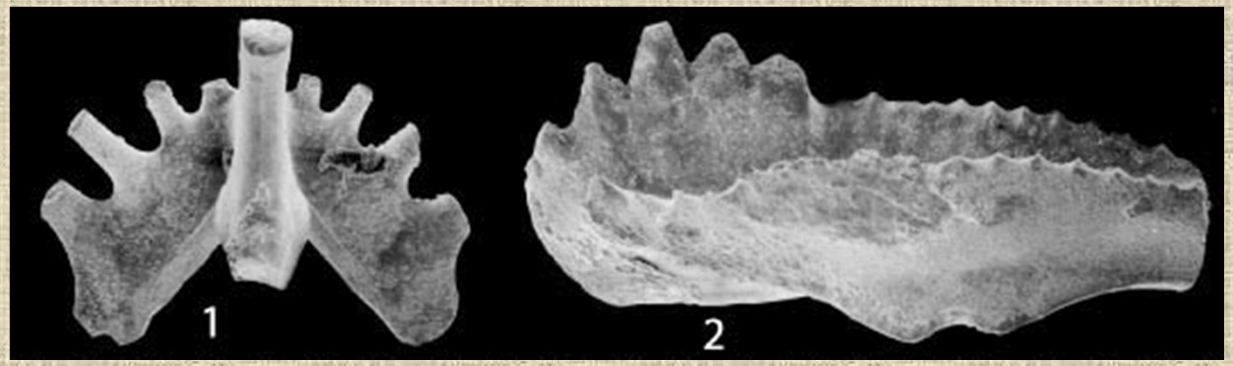
Easy-to-identify to species-level

Short lived

Rapidly evolving

Example: ammonites, planktic foraminifera, conodonts, etc.





Global boundary Stratotype Section and Point (GSSP) 全球界線層型剖面和點位

Conducted by the International Commission on Stratigraphy (ICS), a part of the International Union of Geological Sciences (IUGS)

Internationally agreed reference point on a stratigraphic section

Defines the lower boundary of a stage

Usually defined by FAD of a fossil species (primary marker)

Secondary markers (other fossils, chemical, geomagnetic reversal, etc.)

Global correlation

Independent of facies

Outcrop accessible to research and free to access

Cambrian Trilobite Biostratigraphic Utility?

Geol. Mag. **142** (4), 2005, pp. 377–398. © 2005 Cambridge University Press
doi:10.1017/S0016756805000543 *Printed in the United Kingdom*

Late Cambrian ptychaspidid trilobites from western Utah: implications for trilobite systematics and biostratigraphy

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University of Oklahoma, Norman, Oklahoma 73072, USA

Jonathan Adrain
University of Iowa

Steve Westrop
University of Oklahoma

"Much previous work on Late Cambrian trilobites has emphasized biostratigraphic utility and the recognition of geographically widespread species."

"Data from new silicified collections indicate that this approach is difficult to justify because many putative 'index species' actually represent a plexus of closely related species whose biostratigraphic significance has yet to be determined."

Cambrian Carbon Isotope Chemostratigraphy
寒武紀碳同位素化學地層

Available online at www.sciencedirect.com
ScienceDirect
Palaeoworld
ELSEVIER
Palaeoworld 15 (2006) 217–222
www.elsevier.com/locate/palwor

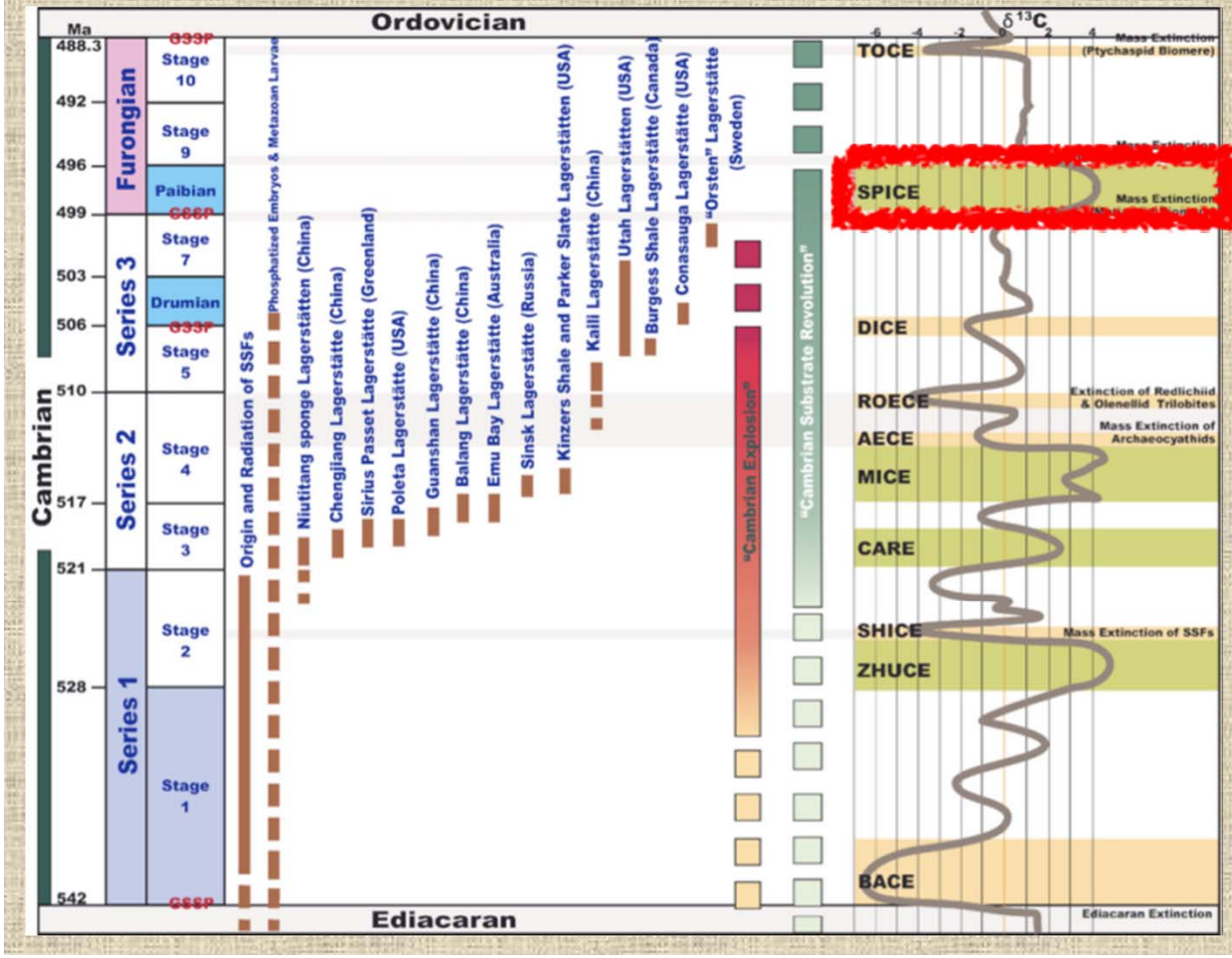
Research paper

Advances in Cambrian stratigraphy and paleontology: Integrating correlation techniques, paleobiology, taphonomy and paleoenvironmental reconstruction

Mao-Yan Zhu [a,*], Loren E. Babcock [b], Shan-Chi Peng [a]

[a] State Key Laboratory of Geology and Palaeontology, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
[b] School of Earth Sciences, The Ohio State University, Columbus, OH 43210, USA

Received 10 October 2006; received in revised form 15 October 2006; accepted 16 October 2006



朱茂炎
M.-Y. Zhu
NIGPAS

Loren Babcock
Ohio State Univ.
& Lund University

彭善池
S.-C. Peng
NIGPAS

What is SPICE?

Steptoean Positive Carbon Isotope Excursion (SPICE)

Discovered independently at Caltech (Ripperdan and Kirschvink), Oxford (Brasier), and UCLA (Saltzman and Runnegar)

Early 1990s

One of the most widespread oceanic isotopic event

Occurs at both high and low paleolatitudes

Bruce Runnegar
UCLA

Matt Saltzman
Ohio State University

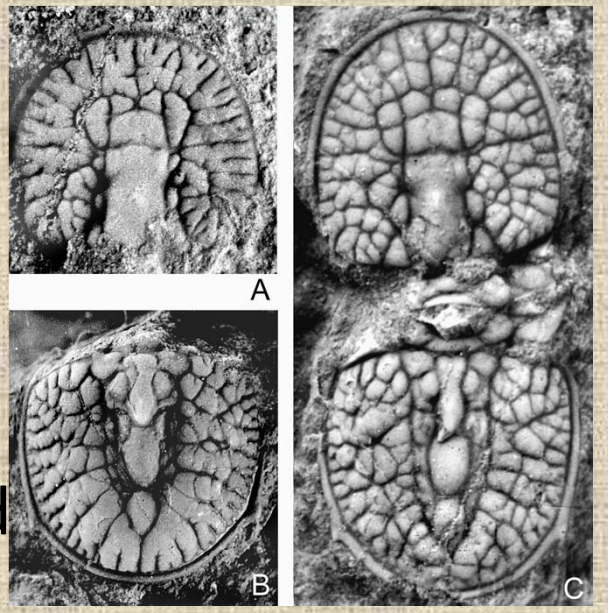
Runnegar et al., 2010: http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_181333.htm

What is SPICE?

Well-dated globally by cosmopolitan short-lived trilobite species and its onset is used in conjunction with the FAD of *Glyptagnostus reticulatus*

Systematic changes in $\Delta^{13}C$ throughout the event at widely separated sites

Imply CO_2 drawdown, global cooling, and a substantial increase in the amount of oxygen in the atmosphere



Glyptagnostus reticulatus

Runnegar et al., 2010: http://gsa.confex.com/gsa/2010AM/finalprogram/abstract_181333.htm

Paibian Stage and Furongian Series GSSP
排碧階及芙蓉統GSSP

Global Standard Stratotype-section and Point (GSSP) of the Furongian Series and Paibian Stage (Cambrian)

SHANCHI PENG, LOREN E. BABCOCK, RICHARD A. ROBISON, HUANLING LIN, MARGARET N. REES AND MATTHEW R. SALTZMAN

LETHAIA

Peng, S., Babcock, L.E., Robison, R.A., Lin, H., Rees, M.N. & Saltzman, M.R. 2004 12 01: Global Standard Stratotype-section and Point (GSSP) of the Furongian Series and Paibian Stage (Cambrian). *Lethaia*, Vol. 37, pp. 365–379. Oslo. ISSN 0024-1164.

The Global Standard Stratotype-section and Point (GSSP) of the Furongian Series (uppermost series of the Cambrian System) and the Paibian Stage (lowermost stage of the Furongian Series), has been recently defined and ratified by the International Union of Geological Sciences (IUGS). The boundary stratotype is 369 metres above the base of the Huaqiao Formation in the Paibi section, northwestern Hunan Province, China. This point coincides with the first appearance of the cosmopolitan agnostoid trilobite *Glyptagnostus reticulatus*, and occurs near the base of a large positive carbon isotopic excursion (SPICE excursion). □ *Cambrian, China, GSSP, Furongian, Paibian, trilobite.*

First Cambrian GSSP – Peng et al . 2004

Paibi, Hunan Province, China 湖南省花垣縣排碧鄉

Globally occurring agnostid (球接子) *Glyptagnostus reticulatus*

Steptoean Positive Carbon Isotope Excursion (SPICE)

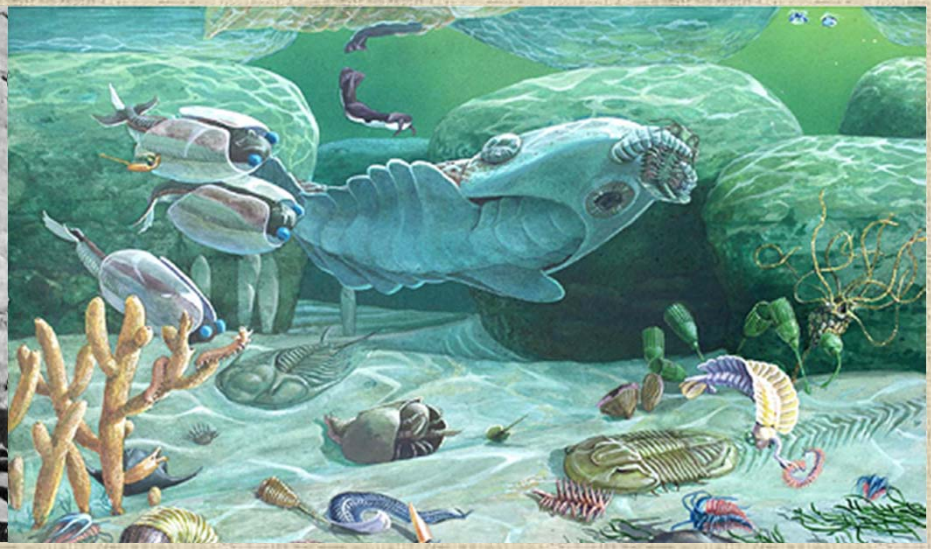
e.g. Brasier 1993; Montañez et al. 2000; Saltzman et al. 2000, 2004; Peng et al. 2004; Zhu et al. 2004, 2006; Ahlberg et al. 2009; Woods et al. 2011; Sial et al. 2013

“Upper” Cambrian Stratigraphy of North China

Blackwelder (1907) & Willis (1907) – basic framework of the systematic study on the Cambrian biostratigraphy of North China (Shandong)

Walcott (1905, 1907, 1913) Basic Cambrian paleontology

Charles Doolittle Walcott
1850-1927

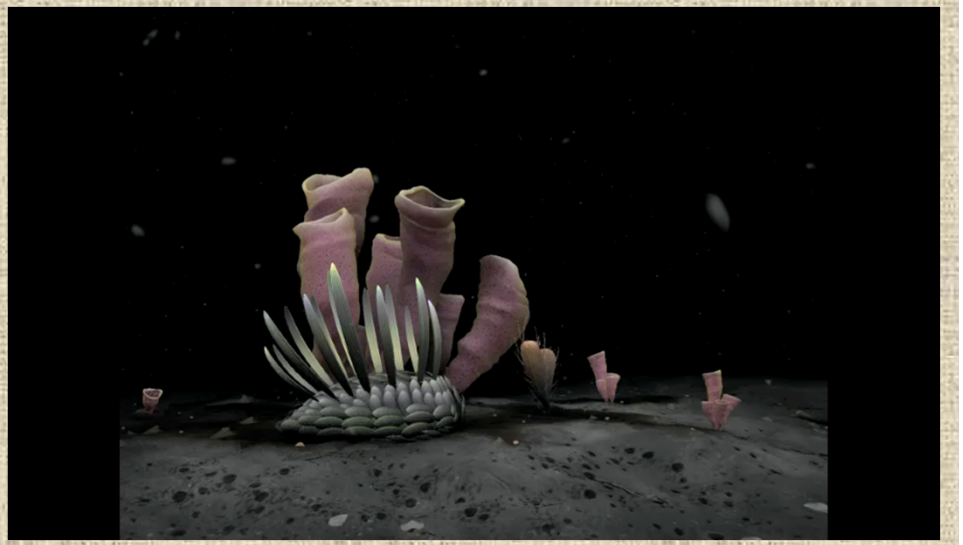


Burgess Shale 伯吉斯頁岩

Marrella spendens

Anomalocaris canadensis

Hallucigenia sparsa



Wiwaxia corrugata

3D Animations: http://burgess-shale.rom.on.ca/en/fossil-gallery/index.php

“Upper” Cambrian Stratigraphy of North China

Sun (孫雲鑄) (1930s) – Tangshan area: stratotype of Changshan Formation with local species-level biozonal scheme at Changshankou

孫雲鑄
Y. C. Sun
1895-1979

盧衍豪院士
Academician
Lu Y. H.
1913-2000

Lu (盧衍豪) (early 1950s) – Generic-level biozonal scheme for the entire North China craton

Lu and Zhu (朱兆玲) (late 1980s) – Revisited stratotype and decided to reassign new stratotype section near Tangshan due to poor condition of the original type section

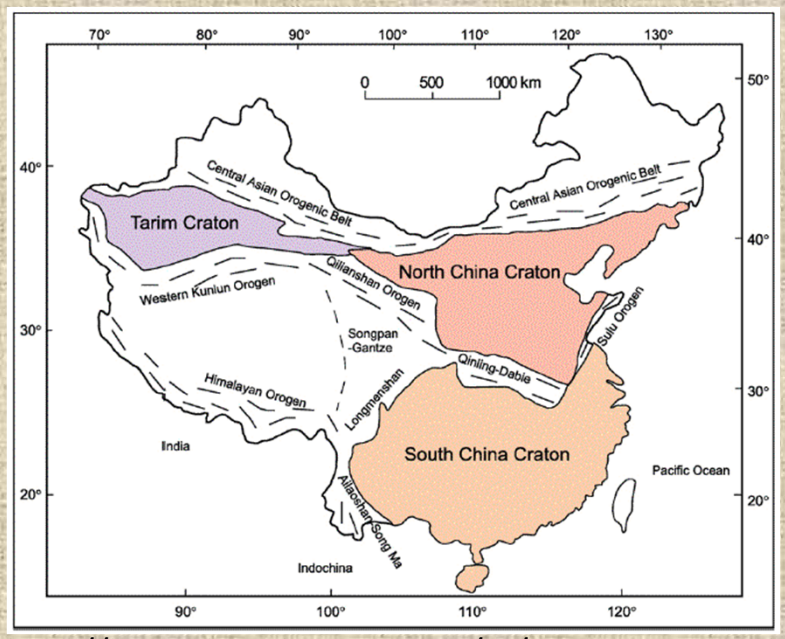
Qian (錢義元) (1980s - 1990s) – Studied trilobites from northeastern and north China

Problems

Shallow water carbonate platform

Lack of agnostids

Endemic polymerid trilobite (多節類三葉蟲) faunas



http://home.hiroshima-u.ac.jp/er/ZR20_S_06.html

Neodrepanura 新蝙蝠蟲

Questions

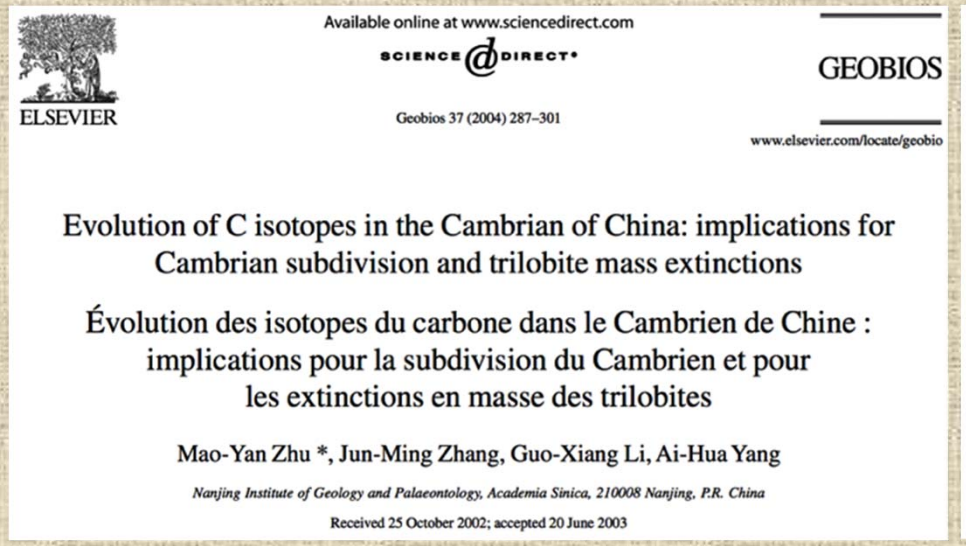
Good SPICE record in North China?

If so, any characteristics of SPICE in North China?

Is/are there any difference(s) from other Cambrian continents? why?

Any possible implications?

Previous North China SPICE Studies



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GEOBIOS
www.elsevier.com/locate/geobio

Evolution of C isotopes in the Cambrian of China: implications for Cambrian subdivision and trilobite mass extinctions

Évolution des isotopes du carbone dans le Cambrien de Chine : implications pour la subdivision du Cambrien et pour les extinctions en masse des trilobites

Mao-Yan Zhu *, Jun-Ming Zhang, Guo-Xiang Li, Ai-Hua Yang

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Received 25 October 2002; accepted 20 June 2003

Zhu (朱茂炎) et al., 2004

第 23 卷第 10 期　山东国土资源　2007 年 10 月

成果与方法

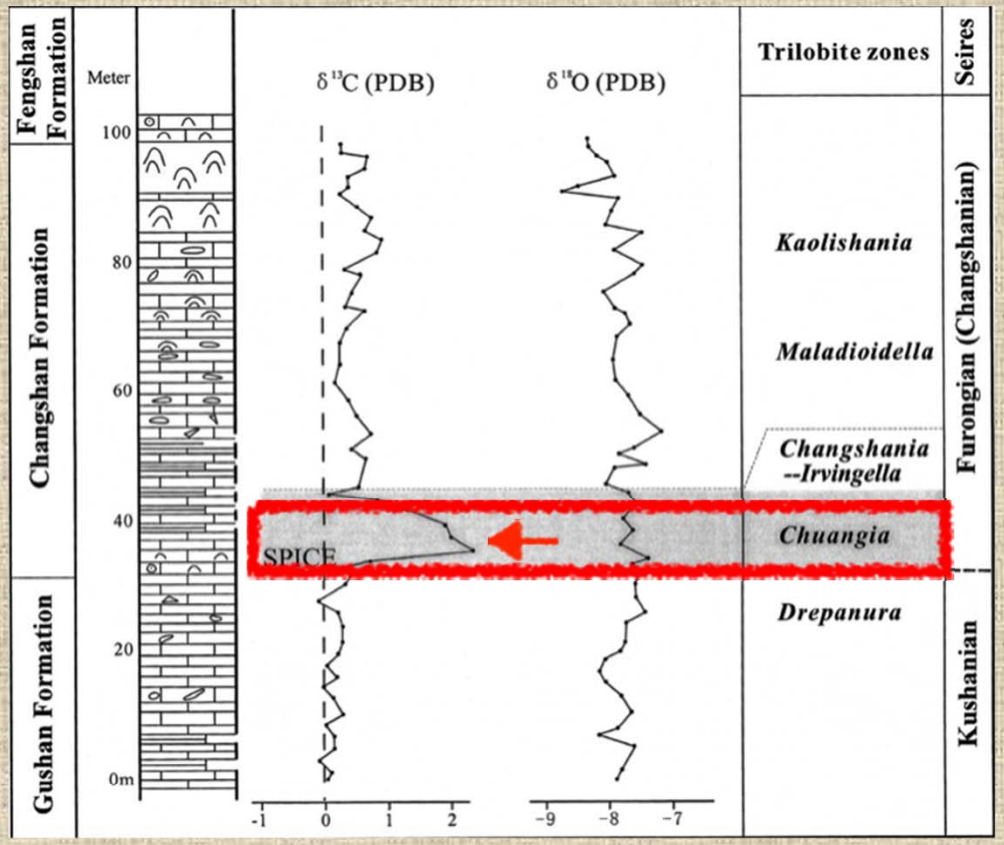
山东张夏-崮山地区华北寒武系标准剖面上寒武统研究新进展

杜圣贤[1],张瑞华[1],张贵丽[2],张俊波[1],陈雪梅[3]
(1.山东省地质科学实验研究院,山东 济南 250013;2.山东省地质调查院,山东 济南 250013;3.山东省化工地质勘察院,山东 济南 250013)

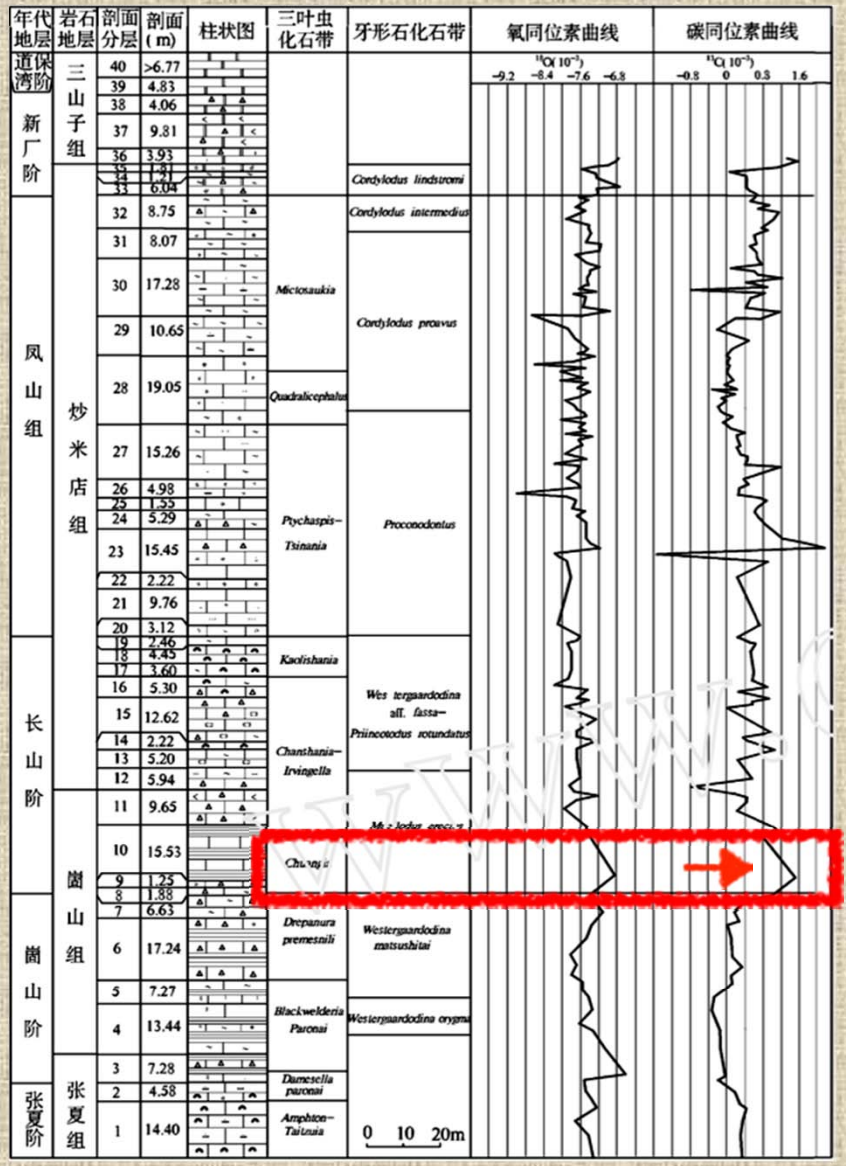
摘要:华北寒武系标准剖面分布在济南市长清区张夏镇和崮山镇,该剖面寒武纪地层发育,出露良好,三叶虫等古生物化石保存完好,笔者根据微体古生物牙形石的种属及其在地层中的分布序列,建立了上寒武统 6 个牙形石生物带,并根据牙形石 "*Cordylodus lindstromi*" 的首现,准确地确定了寒武系与奥陶系的界线;对寒武系长山阶的碳氧同位素曲线特征进行了分析,并把长山阶底部的碳同位素曲线与我国华南及哈萨克斯坦等国寒武系芙蓉统底部的碳同位素进行了对比,建立了华北寒武系与国内以及国外寒武系的对比关系。

关键词:华北;上寒武统;标准剖面;牙形石;张夏镇;崮山镇;山东
中图分类号:P534.41　　文献标识码:A

Du (杜聖賢) et al., 2007



Zhu (朱茂炎) et al., 2004, Fig. 4



Du (杜聖賢) et al., 2007, Fig. 2

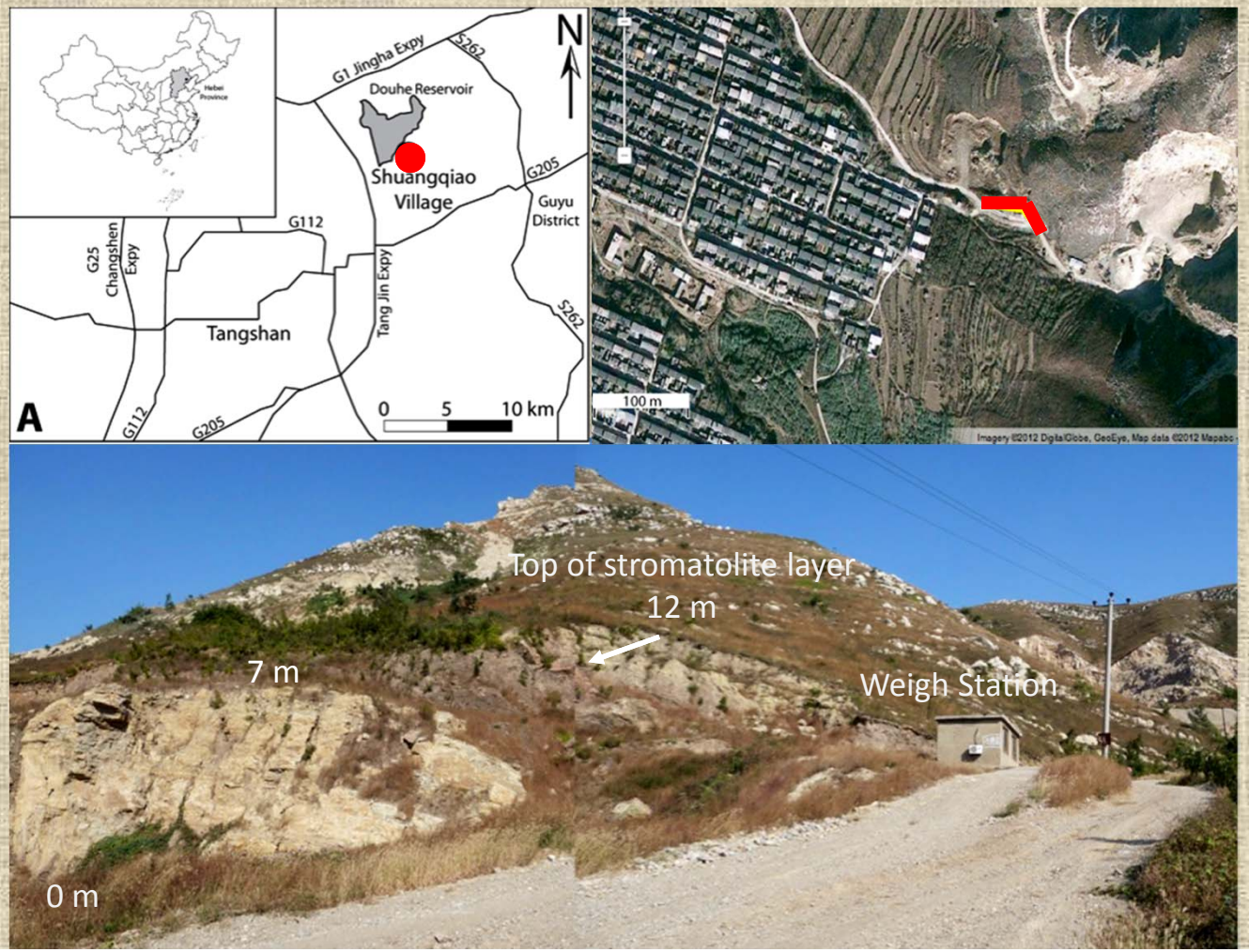
North China Trilobite Zones
華北三葉蟲生物帶

GLOBAL SERIES	GLOBAL STAGES	N. CHINA STAGES	Hebei Sun, 1935; 1937	Shandong Lu & Dong, 1952	Hebei Zhu & Wittke, 1989	E. North China Guo & Zhang, 1992	Liaoning Qian, 1994	North China Duan *et al.*, 2005
Furongian	Jiangshanian	Changshanian	*Kaolishania pustulosa*	*Kaolishania*	*Kaolishania pustulosa*	*Kaolishania granulosa*	*Kaolishania*	*Kaolishania*
			Changshania conica	*Chuangia-Changshania*	*Maladioidella splendens*	*Maladioidella Eochuangia*	*Shirakiella xiaoshiensis*	*Changshania*
					Changshania conica	*Changshania*	*Changshania -Irvingella*	
	Paibian		*Chuangia batia*		*Chuangia batia*	*Chuangia*	*Chuangia* (*C.*) *subquadrangulata*	*Chuangia*
						Prochuangia -Paracoosia	*Prochuangia mansuyi*	
							Luotuolingia	
Cambrian Series 3	Guzhangian	Kushanian	*Neodrepanura*	*Neodrepanura*	*Neodrepanura*	*Neodrepanura*	*Neodrepanura*	*Neodrepanura*

Ng et al. in press *Lethaia* Fig. 1

Shuangqiao, Tangshan, Hebei
河北省唐山市雙橋(村)剖面

Type locality of the Changshan Formation 長山組/層 & Changshanian Stage (華北)長山階



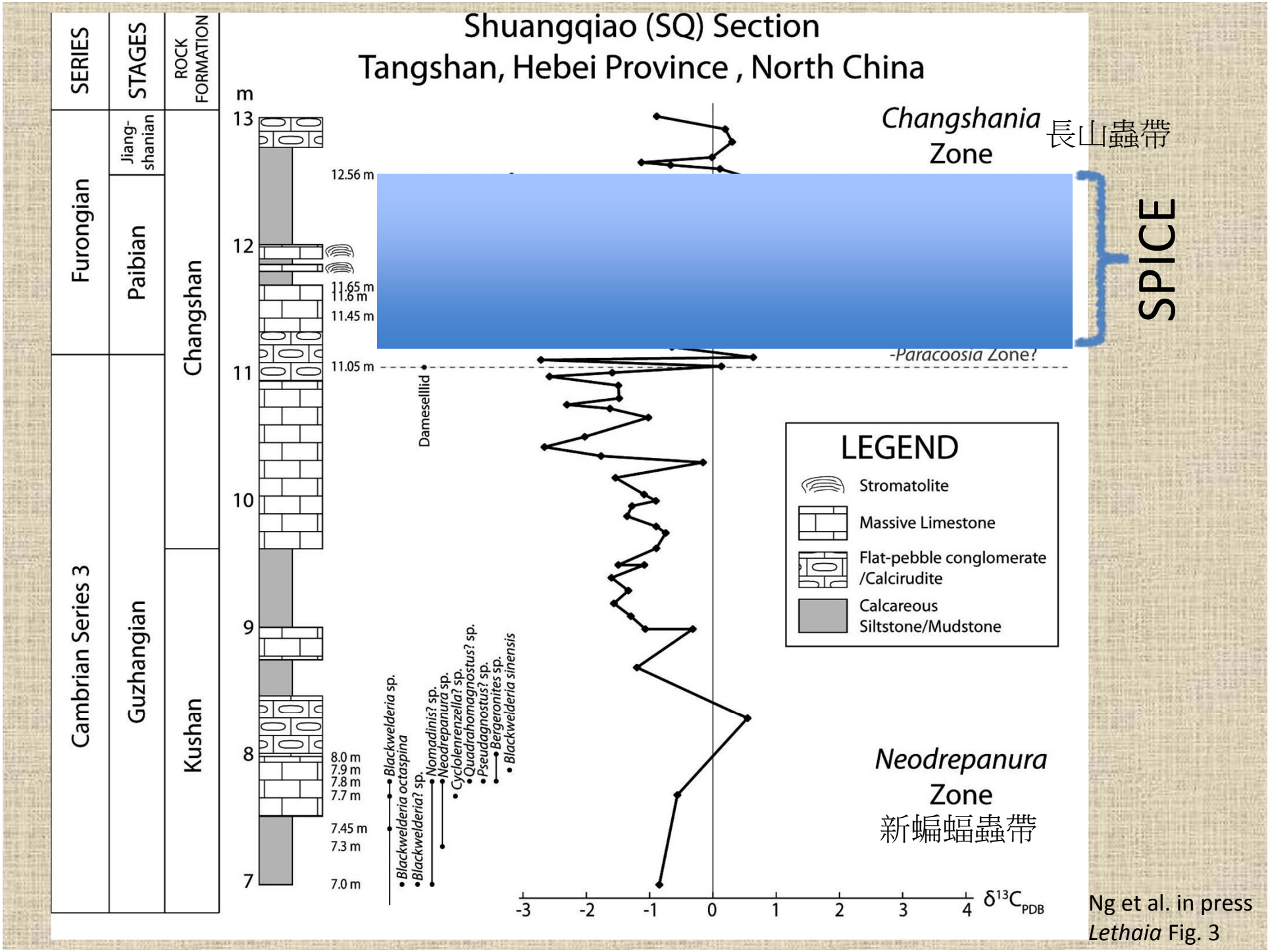
Modified from Ng et al. in press *Lethaia* Fig. 2


Top of stromatolite layer

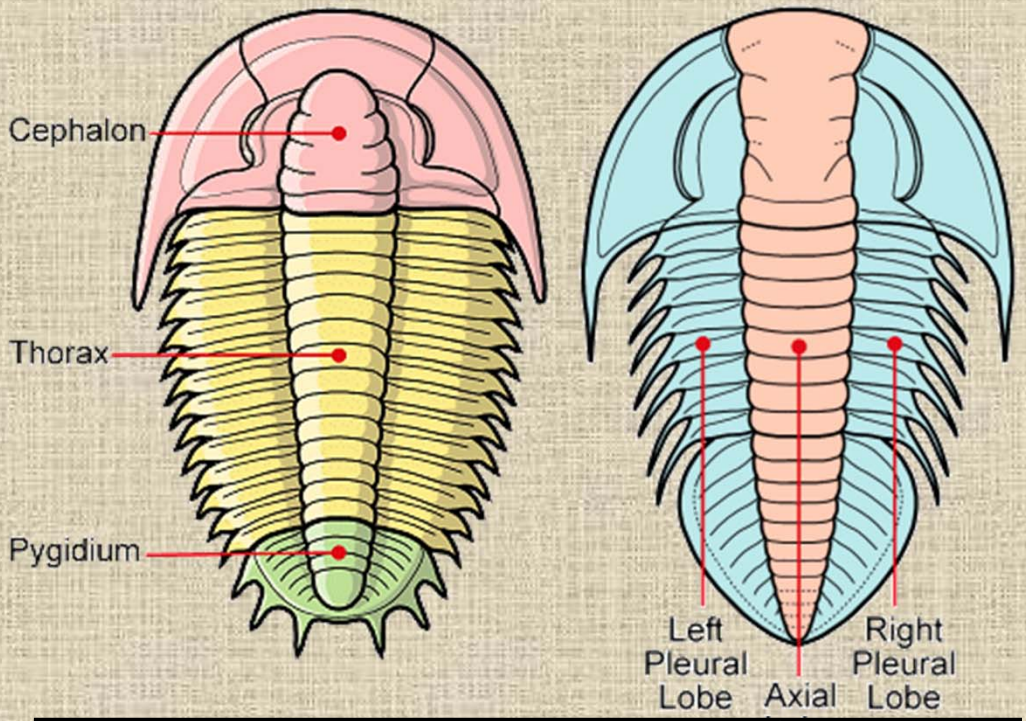

Stromatolite 疊層石

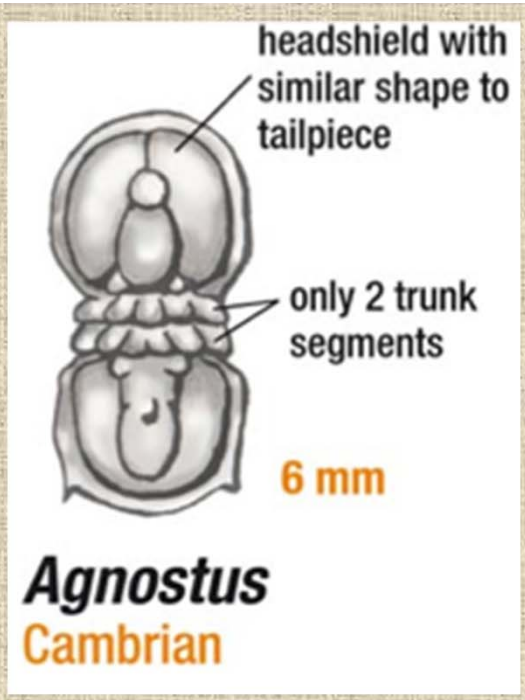

Flat-pebble conglomerate /
Calcirudite


Folding



Ng et al. in press
Lethaia Fig. 3

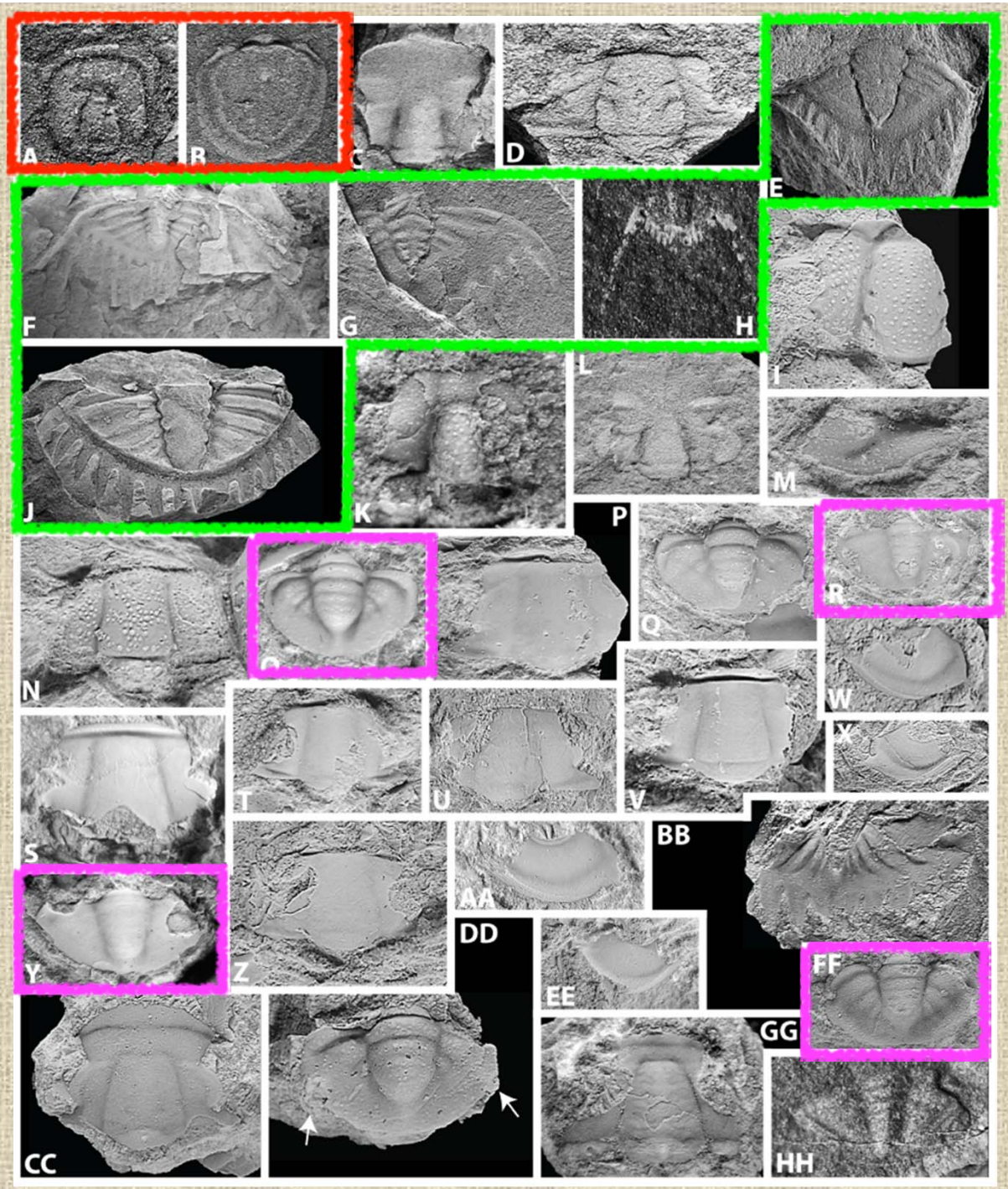




三葉蟲 Trilobite (*Olenoides serratus*)

球接子 Agnostid (trilobite)

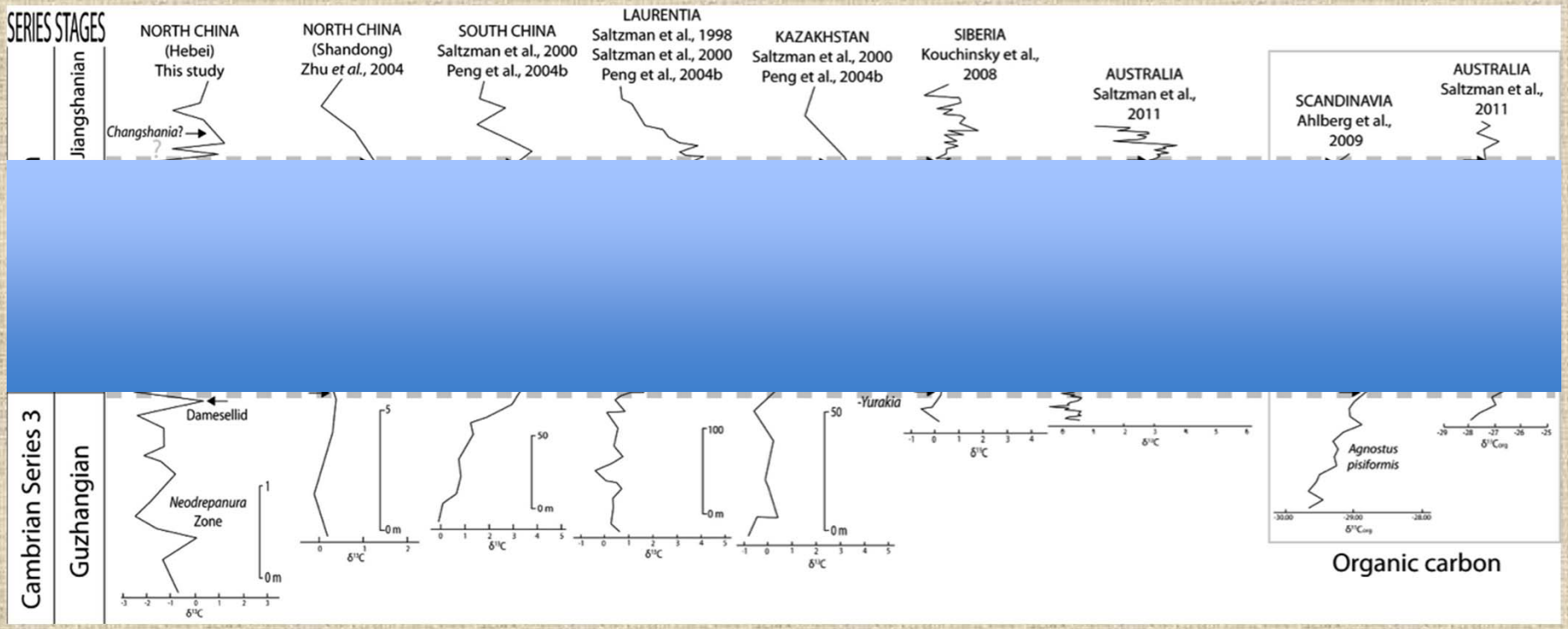
http://burgess-shale.rom.on.ca/en/fossil-gallery/view-species.php?id=11&ref=i&



A. Quadrahomagnostus? sp.
B. Pseudagnostus? sp.
C. Nomadinis? sp.
D. Bergeronites sp.
E. Blackwelderia sp. 1
F. Blackwelderia octaspina
G. Bergeronites sp.
H. Neodrepanura sp.
I. Blackwelderia sp.
J. Blackwederia sinensis
K. Cyclolorenzella? sp.
L. Nomadinis? sp.
M. Blackwelderia sp.
N. Pagodia sp.
O. Pagodia sp.
P. Chuangia cf. *batia*
Q. Pagodia sp.
R. Chuangia cf. *batia*
to
AA. *Chuangia* cf. *batia*
BB. Damesellid
CC. *Pseudoaphelaspis* sp.
DD. *Prochuangia*? sp. 原莊氏蟲
EE. *Chuangia* cf. *batia*
FF. *Pseudoaphelaspis* sp.
GG. *Xiaoshiella* sp.
HH. *Changshania* sp.

Ng et al. in press *Lethaia* Fig. 4

Global SPICE Correlation
全球SPICE事件對比



Ng et al. in press *Lethaia* Fig. 5

Biostratigraphic Correlation
生物地層對比

Ng et al. in press *Lethaia* Fig. 6

The North China Steptoean positive isotope carbon excursion and its global correlation with the base of the Paibian Stage (early Furongian Series), Cambrian

TIN-WAI NG, JIN-LIANG YUAN AND JIH-PAI LIN

LETHAIA

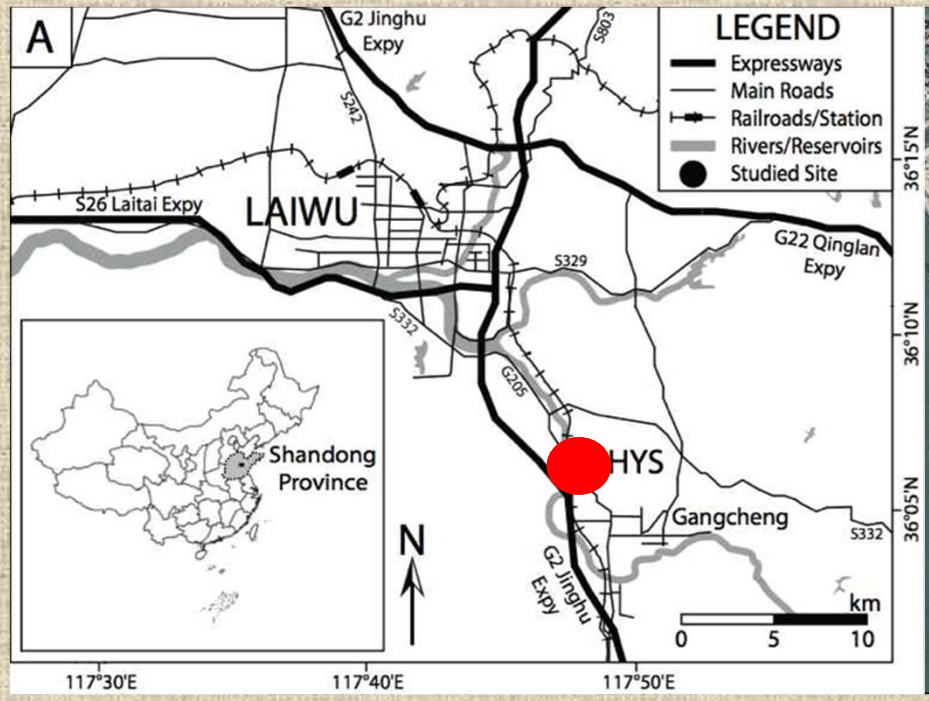
Ng, T.-W., Yuan, J.-L. & Lin, J.-P. 2013: The North China Steptoean positive isotope carbon excursion and its global correlation with the base of the Paibian Stage (early Furongian Series), Cambrian. *Lethaia*, DOI: 10.1111/let.12027.

The use of carbon isotope excursion in Cambrian stratigraphical correlation is a standard practice at both the intercontinental and intracontinental scales. The Steptoean positive isotope carbon excursion (SPICE) is one of the prime examples in this regard in correlating the base of the Paibian Stage and Furongian Series. A lack of definite SPICE evidence in the North China craton has been a challenge in precision correlation between North China and other palaeo-continents. This study provides new carbonates carbon isotope data from the type locality of the Changshan Formation in Hebei Province, North China. Our new $\delta 13C_{carb}$ data provide new objective evidence for the presence of the SPICE in North China. The sampling section is relatively condensed, and the interval of the SPICE curve is less than one and half-metres after analysing 64 samples (the sampling interval within the SPICE is less than 10 cm). The onset of the SPICE curve in Tangshan, Hebei, occurs in the barren interval between the *Neodrepanura* and *Chuangia* trilobite zones. According to (Acta Palaeontologica Sinica, 48, 2009a and 437; Chinese Science Bulletin, 54, 2009b and 4161), this could imply the middle part of the *Prochuangia-Paracoosia* trilobite Zone in North China and can be correlated with the base of the Paibian Stage and Furongian Series. □ *Biostratigraphy, Cambrian, chemostratigraphy, North China, Steptoean positive carbon isotope excursion, trilobites.*

袁金良 J.-L. Yuan NIGPAS

林日白 J.-P. Lin NIGPAS

Huangyangshan, Laiwu, Shandong
山東省萊蕪市黃羊山剖面

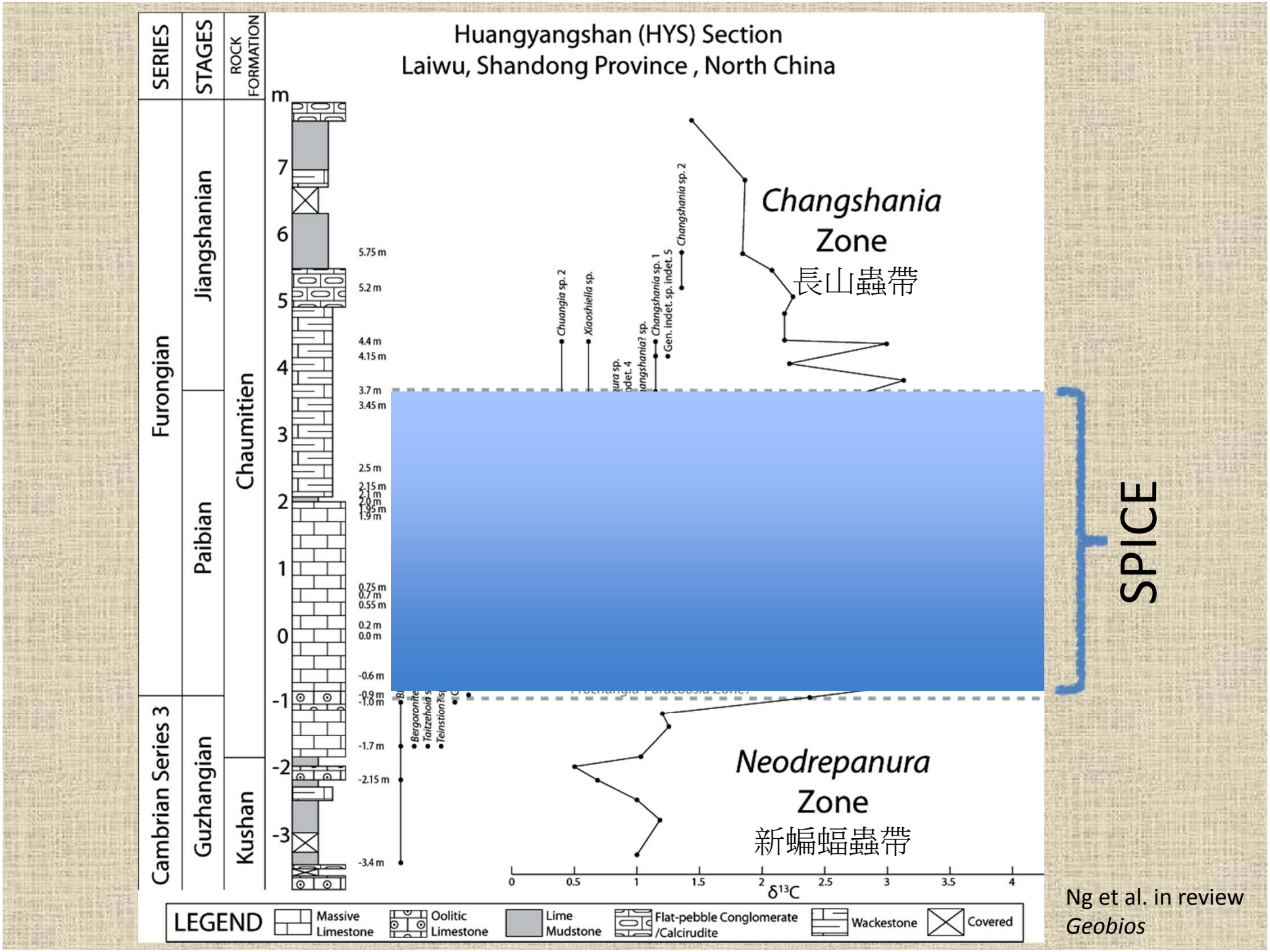


Ng et al. in review *Geobios*

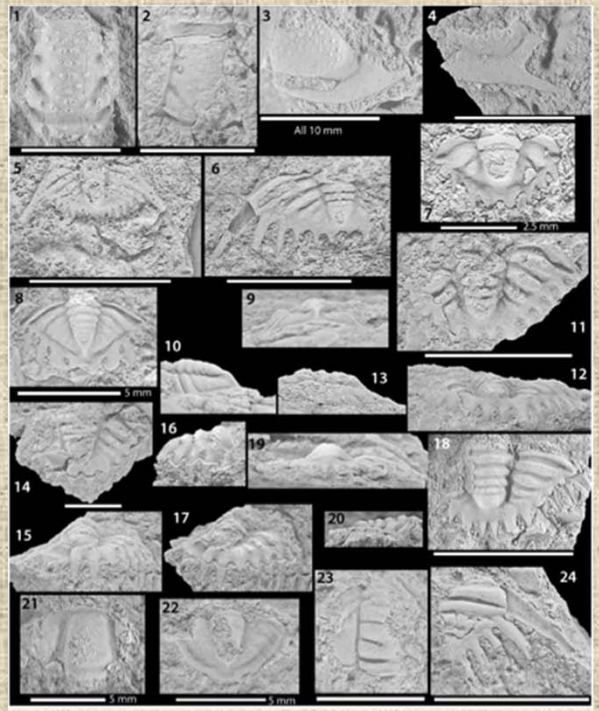
Huangyangshan Section 黃羊山剖面

Flat-pebble conglomerate / Calcirudite

Lime mudstone

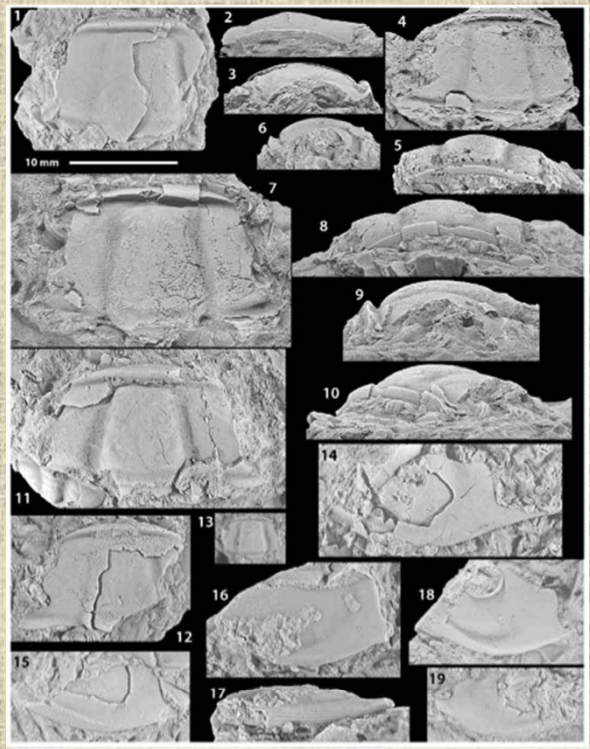


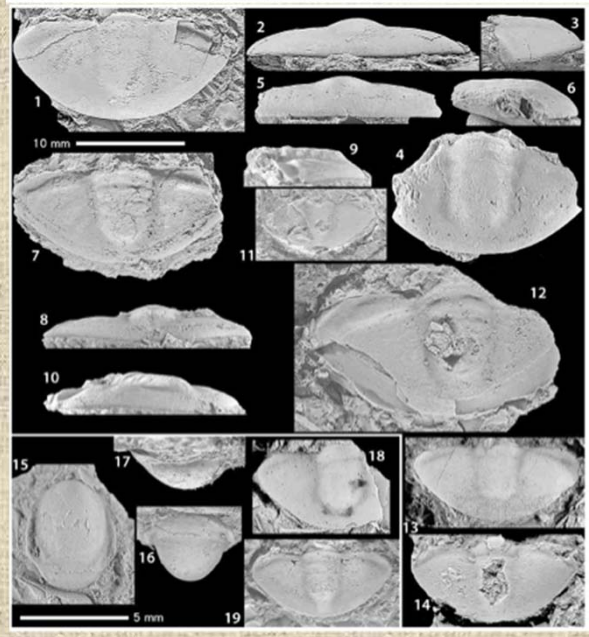
Ng et al. in review
Geobios

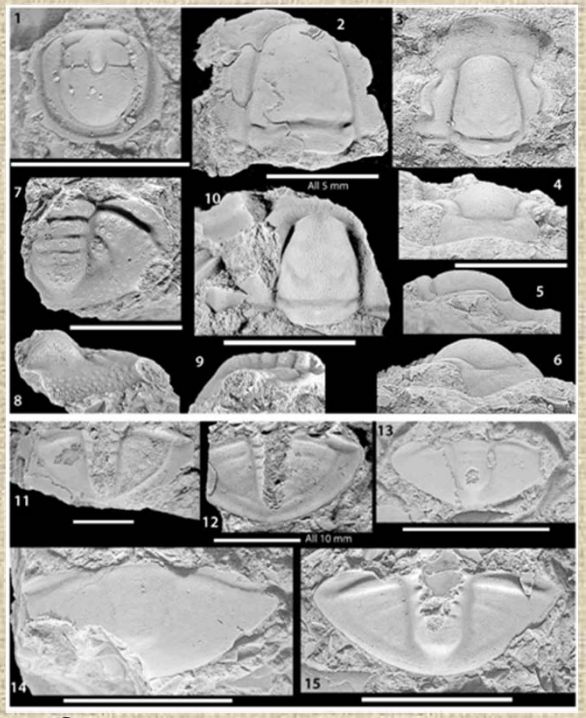


Blackwelderia spp.
Bergeronites sp.
Teinistion sp.
Taitzehoia sp.
Gen. indet. sp. indet. 1
Gen. indet. sp. indet. 2

Guzhangian
古丈階



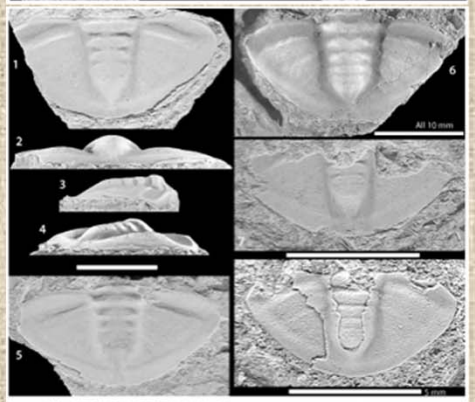


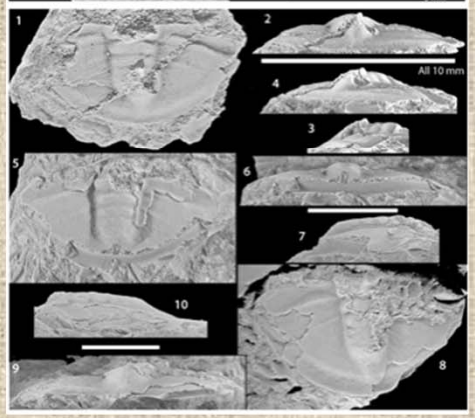


Connagnostus sp.
Yokusenia sp.
Prochuangia sp.
Gen. indet. sp. indet. 3
Chuangia? sp.
Chuangia sp. 1

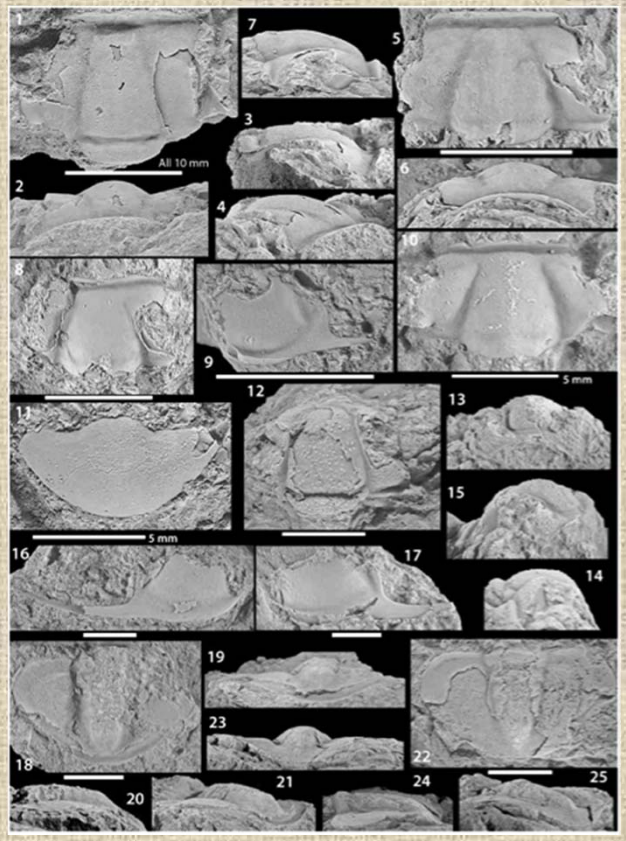
Paibian
排碧階

Chuangia sp. 1 Ng et al. in review *Geobios*





Chuangia sp. 2



Chuangia sp. 2
Chuangia sp. 3
Gen. indet. sp. indet. 4

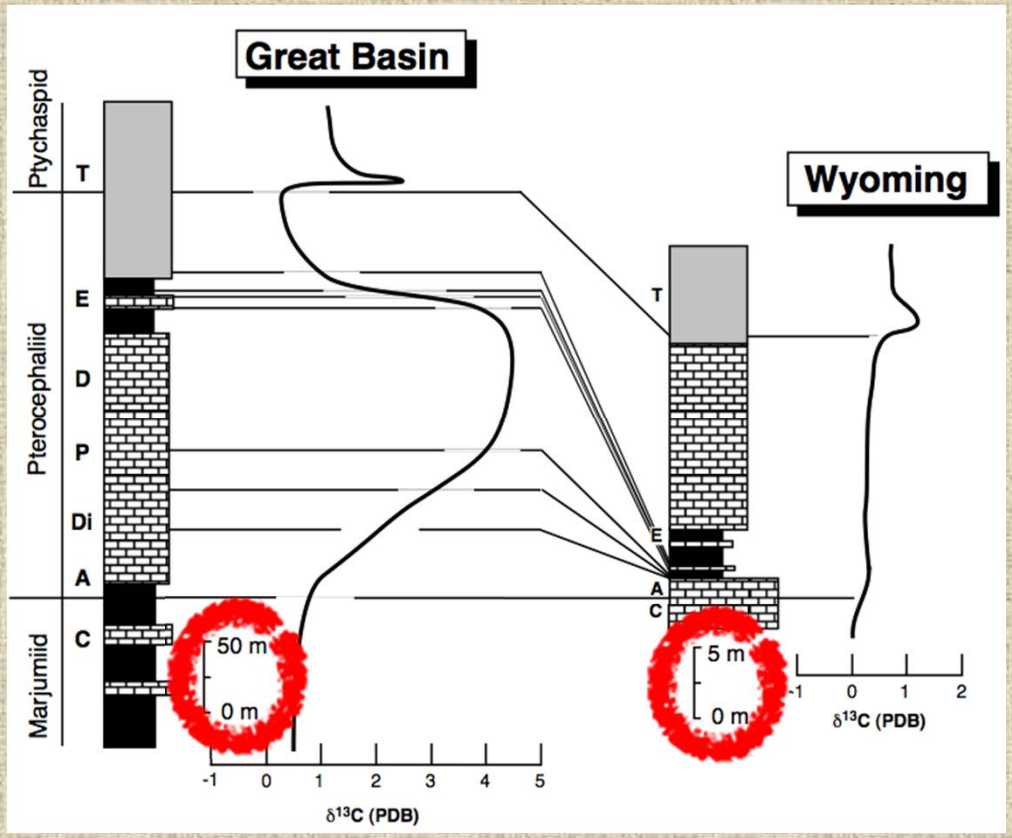
Paibian
排碧階

Xiaoshiella sp.
Maladioides sp.
Chuangia sp. 2
Changshania?
Changshania sp. 1
Changshania sp. 2
Gen. indet. sp. indet. 5

Jiangshanian 江山階

Ng et al. in review *Geobios*

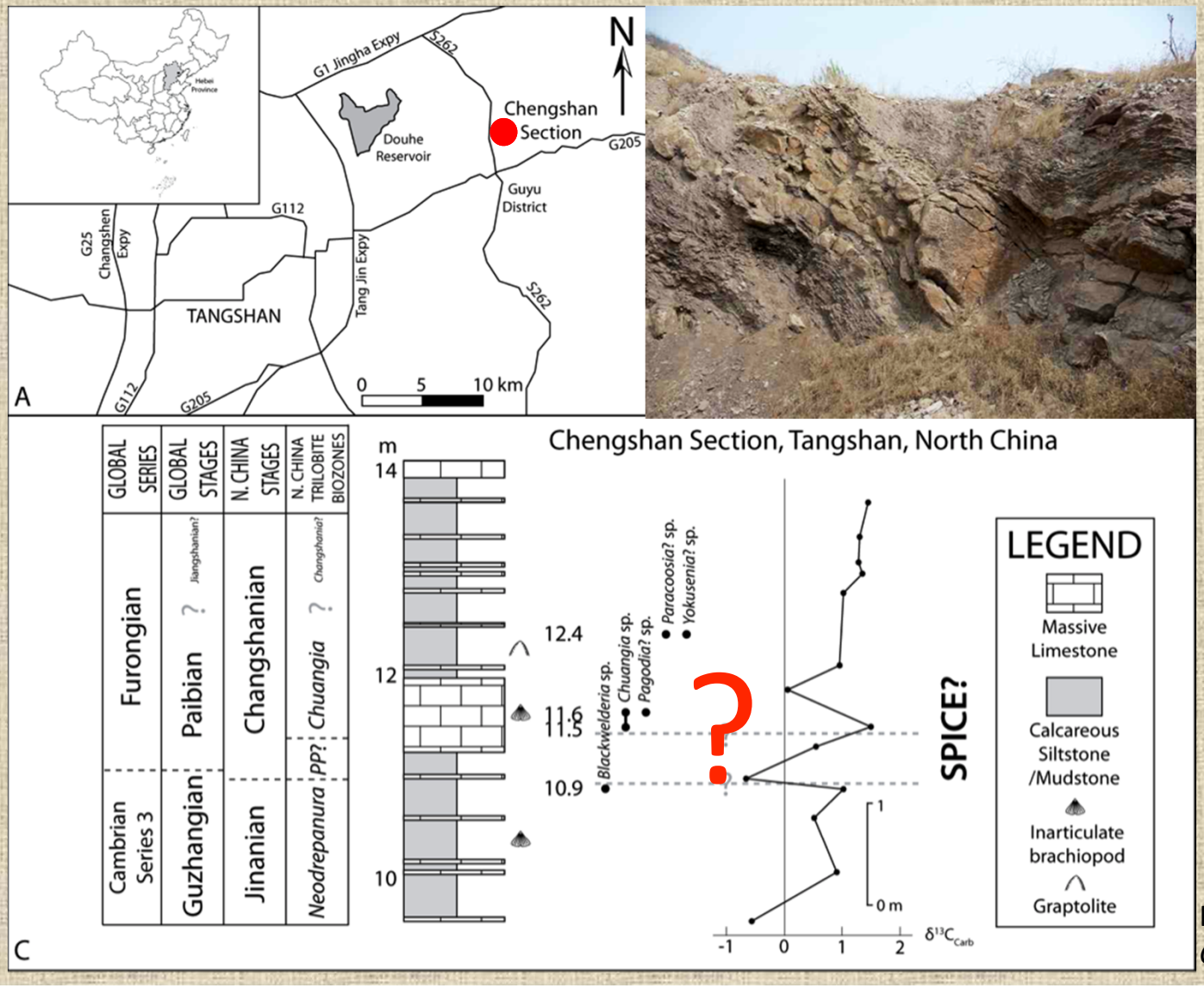
Erosion? Nondeposition?
侵蝕？無沉積？



Saltzman et al., 1998 *GSA Bull.* Fig. 8

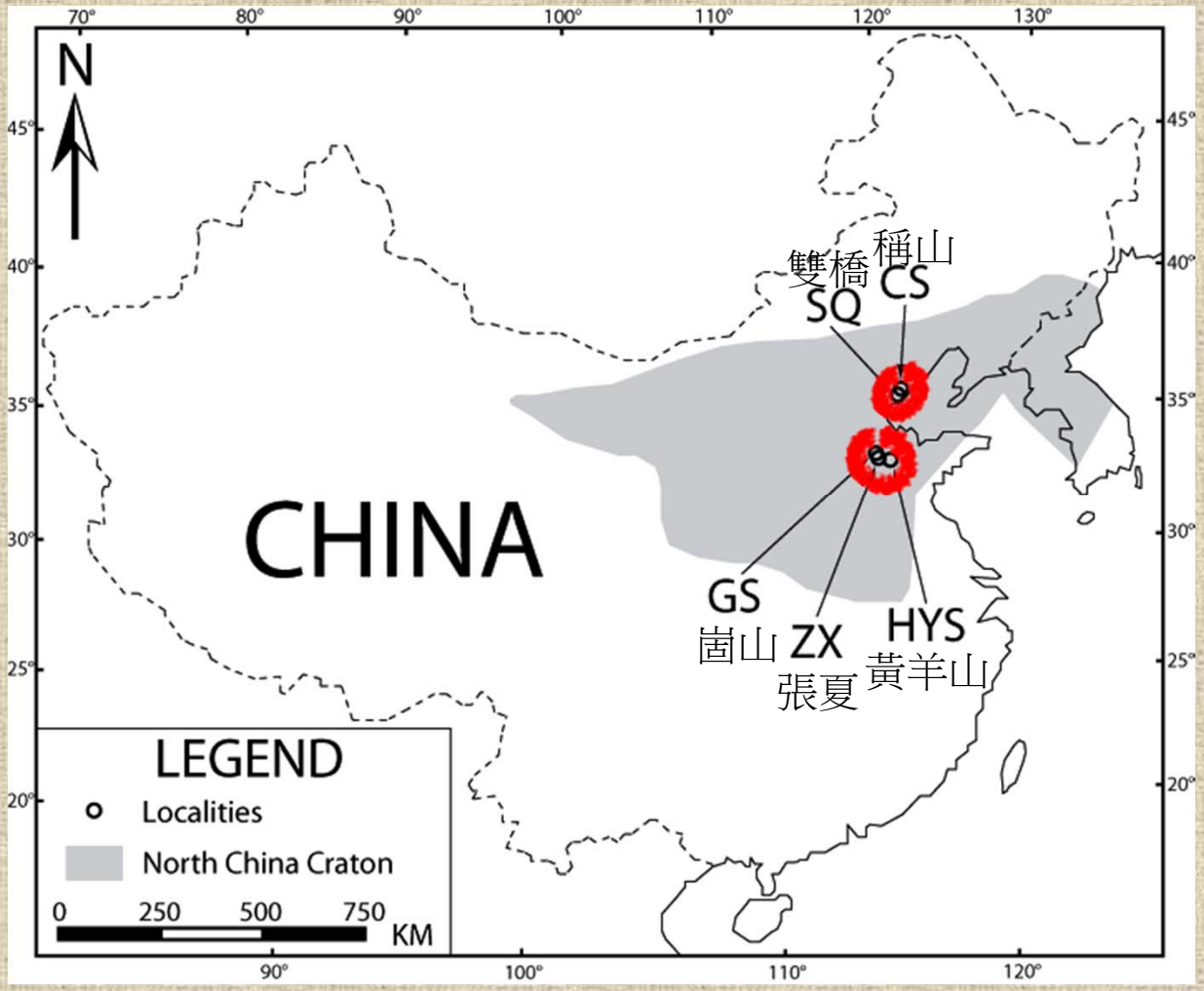
"…Carbon isotope analyses from cratonal sections in Wyoming provide independent evidence that a major sedimentary hiatus took place on the craton during the time of the SPICE excursion."

Chengshan Section, Tangshan, Hebei
河北省唐山市稱山剖面



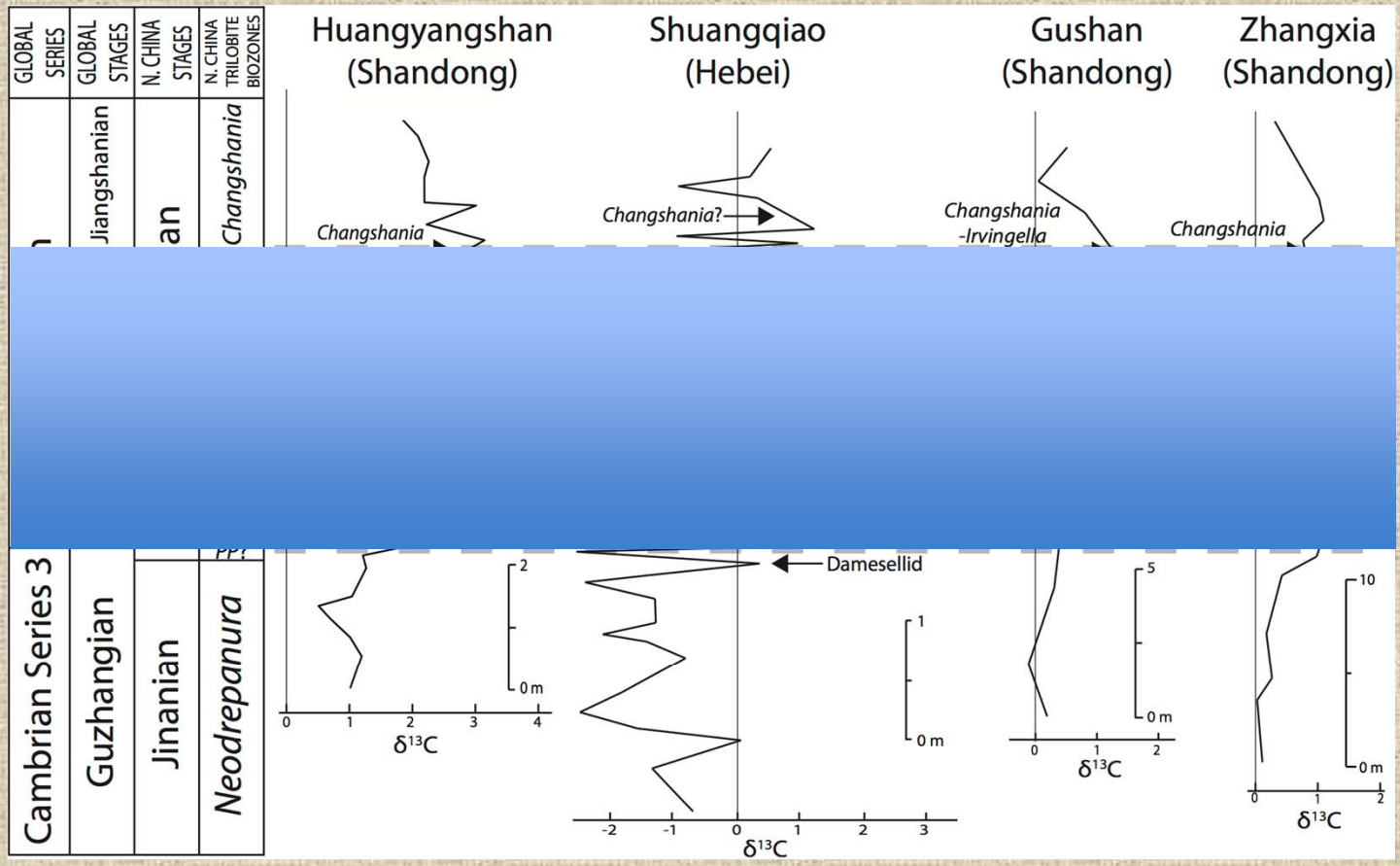
Ng et al. in review
Geobios

North China SPICE Localities
華北SPICE事件研究地點



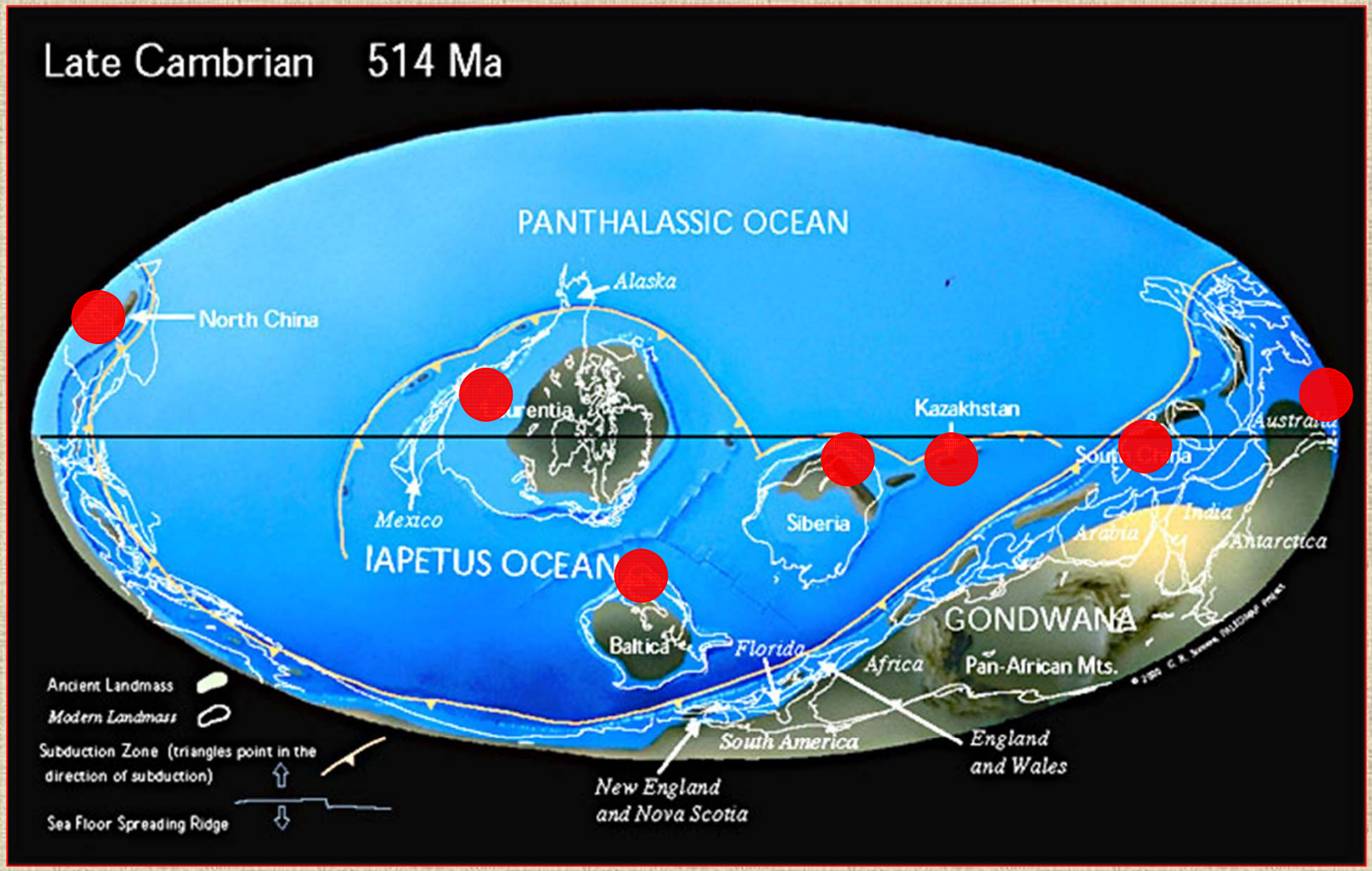
Ng et al. in review *Geobios*

North China SPICE Correlation
華北SPICE事件對比



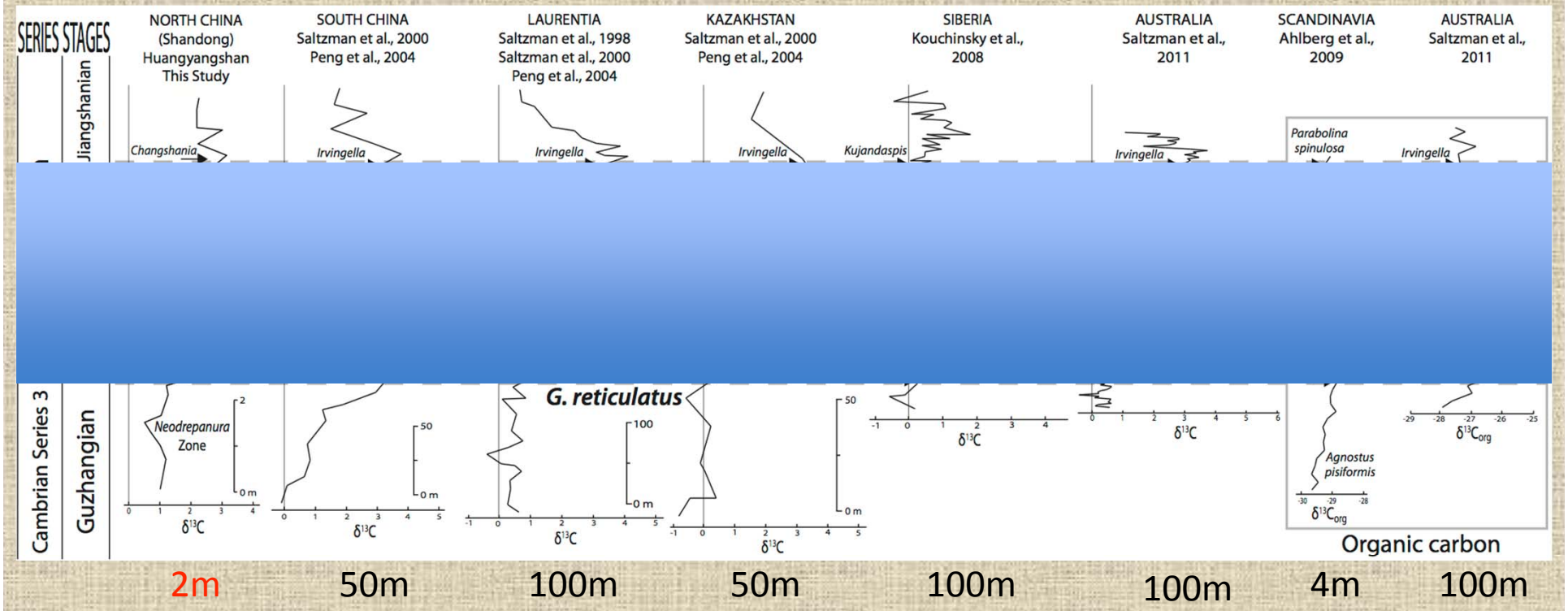
2m 1m 5m 10m

Ng et al. in review *Geobios*



http://www.scotese.com/newpage12.htm

Global SPICE Correlation
全球SPICE事件對比



Ng et al. in review *Geobios*

Peak $\delta^{13}C$ and Difference $\Delta\delta^{13}C$

Normal SPICE:

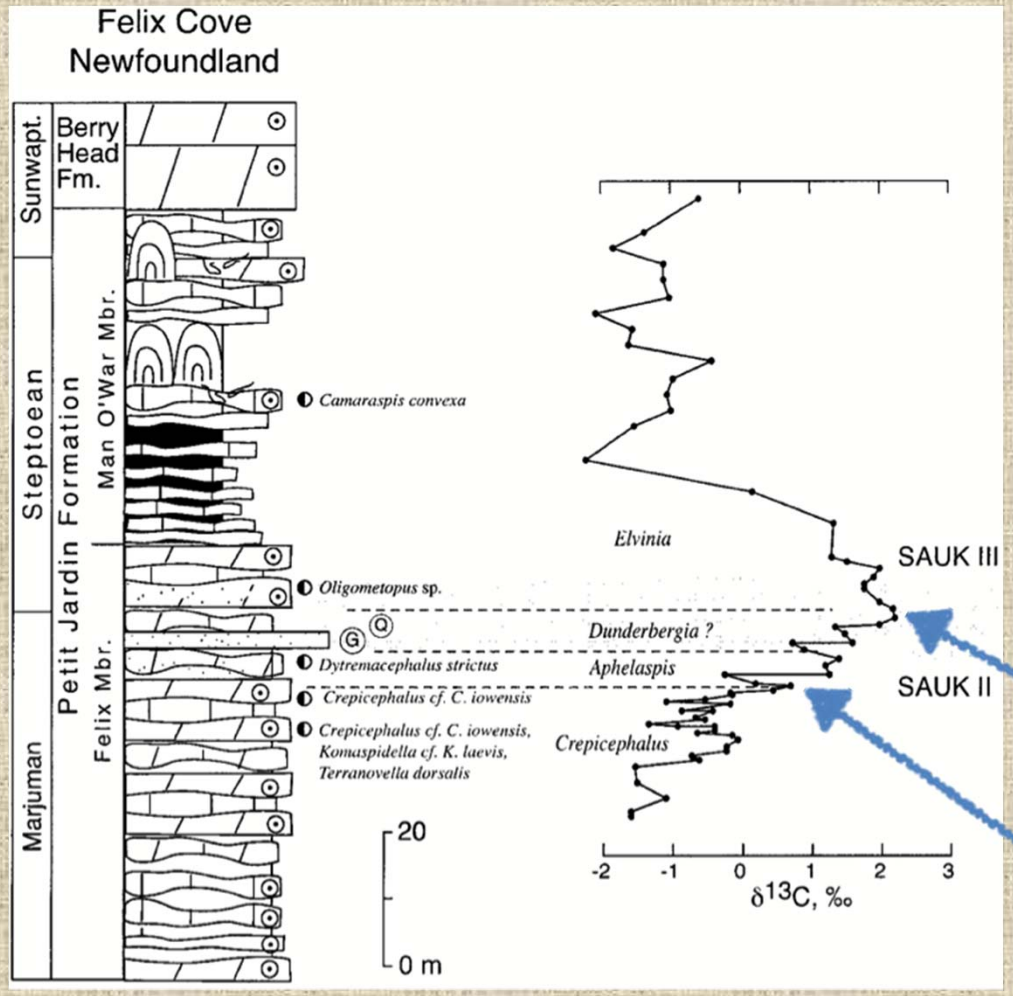
Peak $\delta^{13}C$ ~+4 to +5 ‰

$\Delta\delta^{13}C$ ~4 ‰

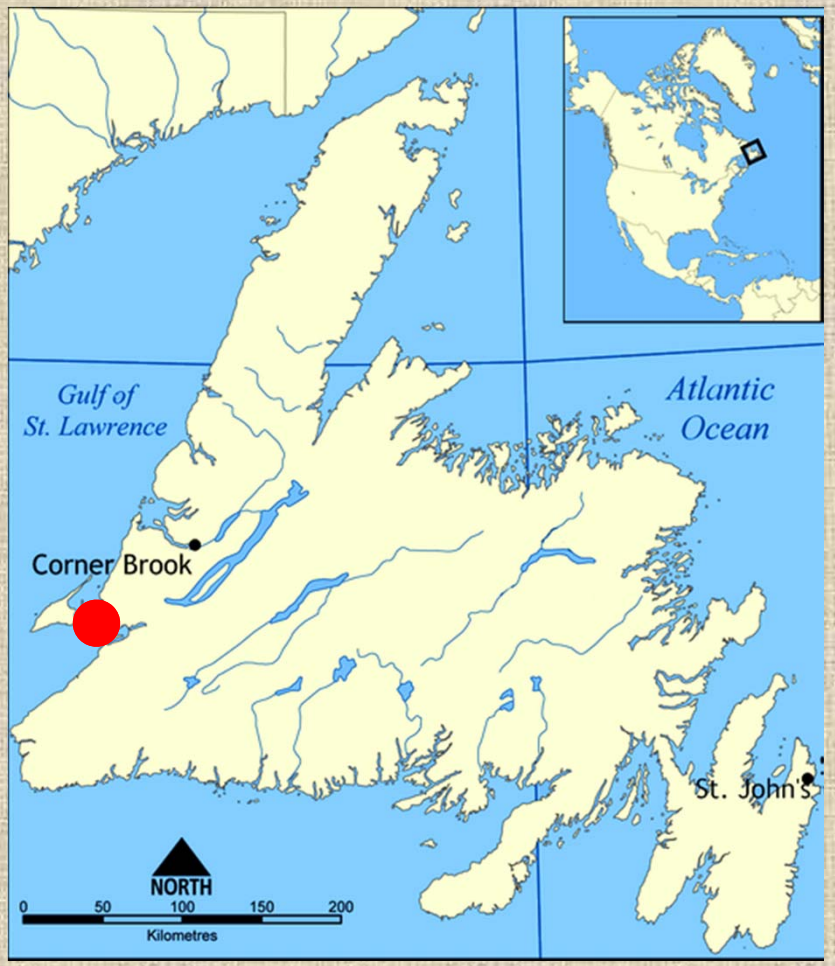
Section	Peak $\delta^{13}C$ value (I)	Initial $\delta^{13}C$ value (II)	Difference $\Delta\delta^{13}C$ (I-II)
Shuangqiao (SQ)	*+3.22 ‰*	*+0.87 ‰*	*2.35 ‰*
Huangyangshan (HYS)	*+4.144 ‰*	*+2.413 ‰*	*1.731 ‰*
Gushan (GS)	*+2.226 ‰*	*+0.416 ‰*	*1.81 ‰*
Zhangxia (ZX)	*+1.58 ‰*	*-0.2 ‰*	*1.78 ‰*
Chengshan (CS)	*+1.448 ‰*	*-0.748 ‰*	*2.196 ‰*

Ng et al. in review *Geobios*

Newfoundland
紐芬蘭



Saltzman et al. 2004



Peak value about +2.2 ‰

Onset values 0 to +1 ‰

Possible Reasons

Regional changes in ocean environment (Holmden et al. 1998; Panchuk et al. 2006; Young et al. 2005)

Aquafacies variations (Holmden et al. 1998; Young et al. 2005; Young et al. 2008)

Oxidation of organic matter (Hayes et al. 1999; Young et al. 2008; Saltzman et al. 2011)

Isolation of water masses (Patterson & Walter, 1994)

More restricted and higher salinity due to sea-level fluctuations (Sial et al., 2013)

Diagenesis (Ralisback et al, 2003)

Volcanic activities (Shen et al. 2012)

Weathering of siliciclastic or carbonitic rocks, change in organic carbon burial rate (Kump and Arthur, 1999)

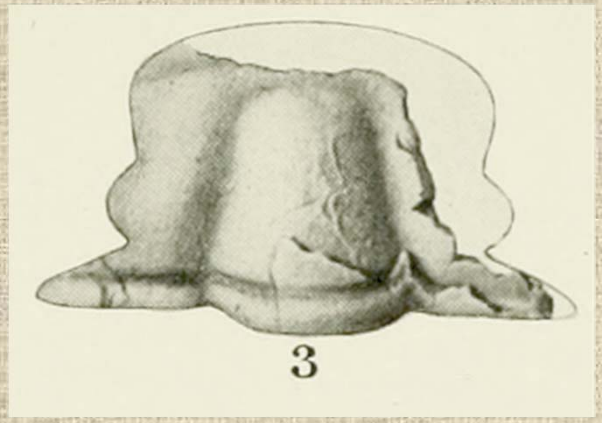
Chuangia batia (Walcott, 1905)

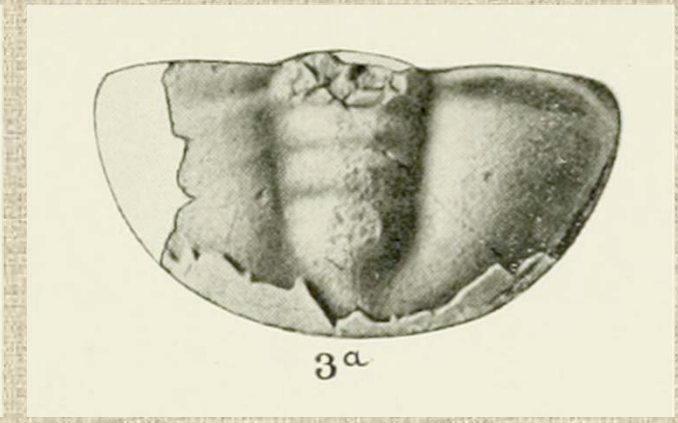
1905 *Ptychoparia*(?) *batia* Walcott, 1905

- Basic description, no illustration

1911 *Chuangia batia* (Walcott, 1905)

- Plate 15, figs. 3, 3a





62 *Bulletin of Zoological Nomenclature*

CHUANGIA WALCOTT, 1911, PROPOSED VALIDATION UNDER THE PLENARY POWERS; *SHANTUNGIA* WALCOTT, 1905, PROPOSED ADDITION TO THE OFFICIAL LIST (TRILOBITA). Z.N.(S.)635

By C. Lochman Balk (*Geology Department, Institute of Mining and Technology, Socorro, Box 1421, New Mexico 87801*), the late J. Marvin Weller (*University of Chicago, U.S.A.*) and C.J. Stubblefield (*35 Kent Avenue, Ealing, London W13 8BE*)

Lochman-Balk et al. 1980, *Bulletin of Zoological Nomenclature*

Christina Lochman
1907-2006

張文堂
Wentang Zhang
1925-2013
NIGPAS

CAMBRIAN TRILOBITES OF NORTH CHINA

CHINESE CAMBRIAN TRILOBITES
HOUSED IN THE
SMITHSONIAN INSTITUTION

by

Zhang Wentang
(Nanjing Institute of Geology and Palaeontology, Academia Sinica)

P. A. Jell
(National Museum of Victoria, Australia)

With 125 Plates

Science Press, Beijing, China
1987

Zhang (張文堂) & Jell, 1987

Summary

SPICE in NC?	Yes!
Where?	Hebei & Shandong Provinces, at least……
Characteristics?	Lower peak & difference values……?
Why?	Not sure……
Correlation?	Yes, the base of the Paibian Stage in North China is somewhere inside the *Prochuangia-Paracoosia* Zone

Implications

More sections from North China in wider geograpahic area

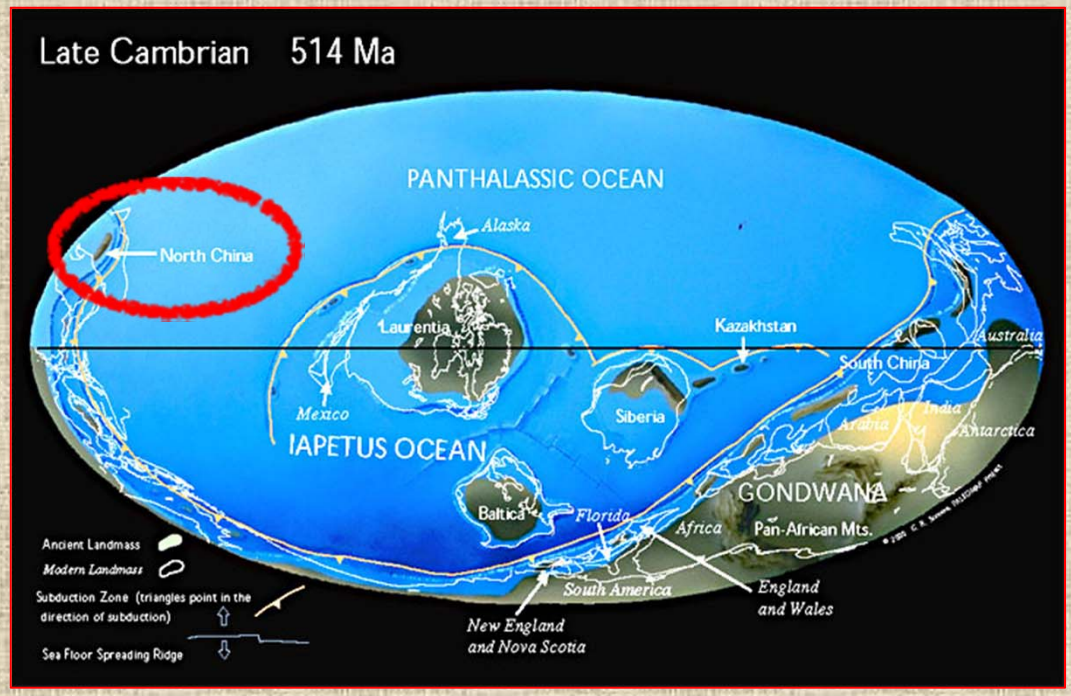
More intensive sampling for both biostratigraphic and chemostratigraphic data

Different types of isotope data

Taxonomic revisions

Ng, T. –W., J. –L. Yuan & J. –P. Lin (in review) The SPICE on the North China craton: new insights towards understanding a global event, *Geobios*.

Location of Cambrian North China craton?



Dong 2001, Fig. 3, ~*Changshanian* Stage

http://www.scotese.com/newpage12.htm

Other Projects

Enrolled Trilobites From Shandong

捲曲三葉蟲

袁金良 J.-L. Yuan
NIGPAS

Jorge Esteve
NIGPAS

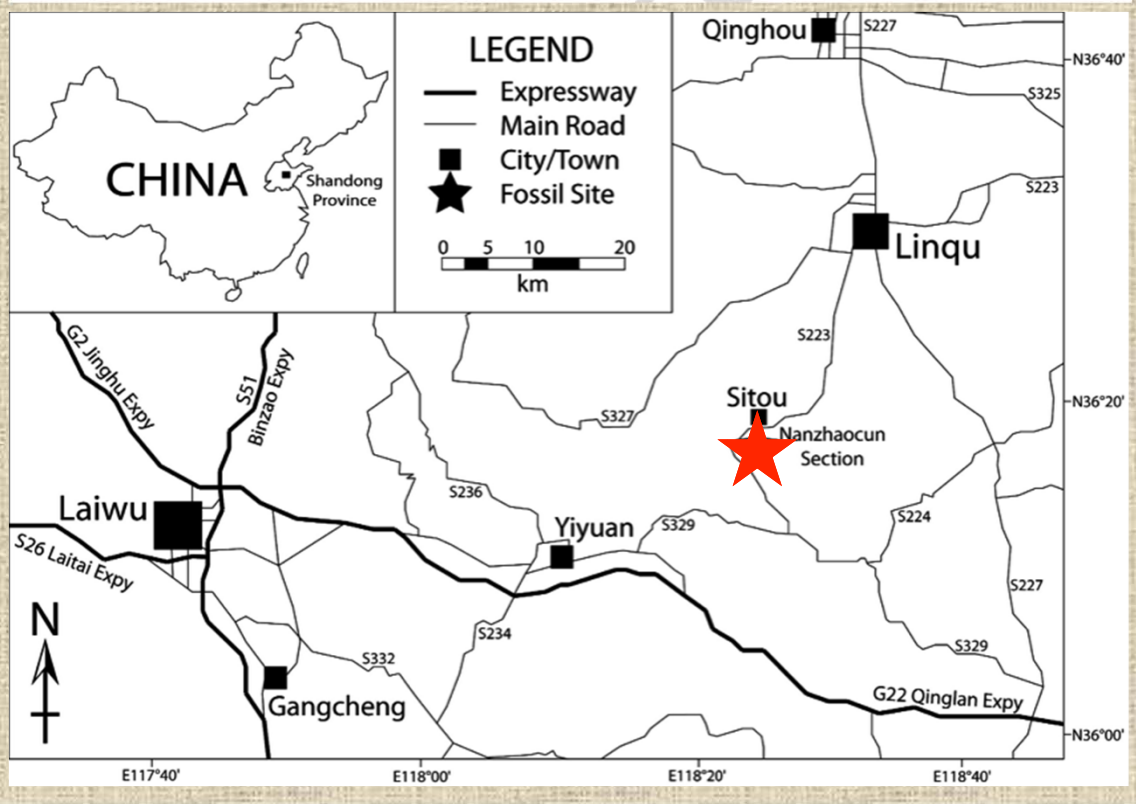
Articulation, interlocking devices and enrolment in *Monkaspis daulis* (Walcott, 1905) from the Guzhangian, middle Cambrian of North China

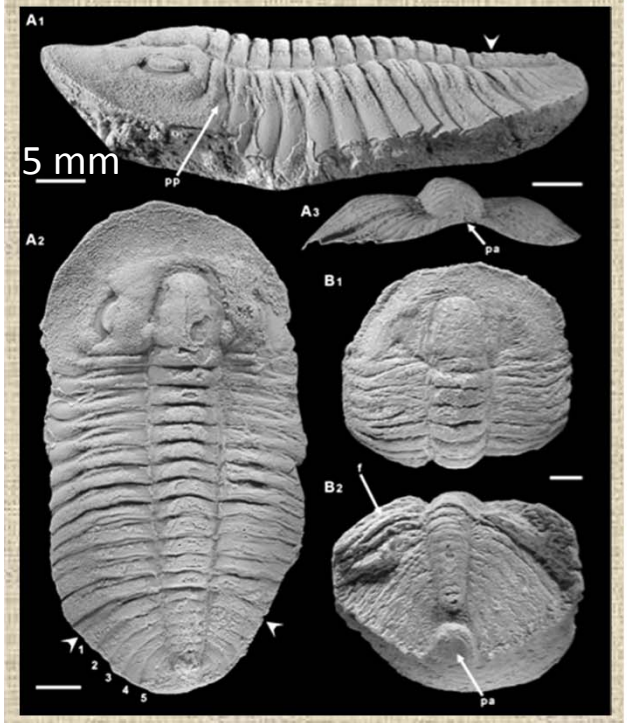
JIN-LIANG YUAN, JORGE ESTEVE AND TIN-WAI NG

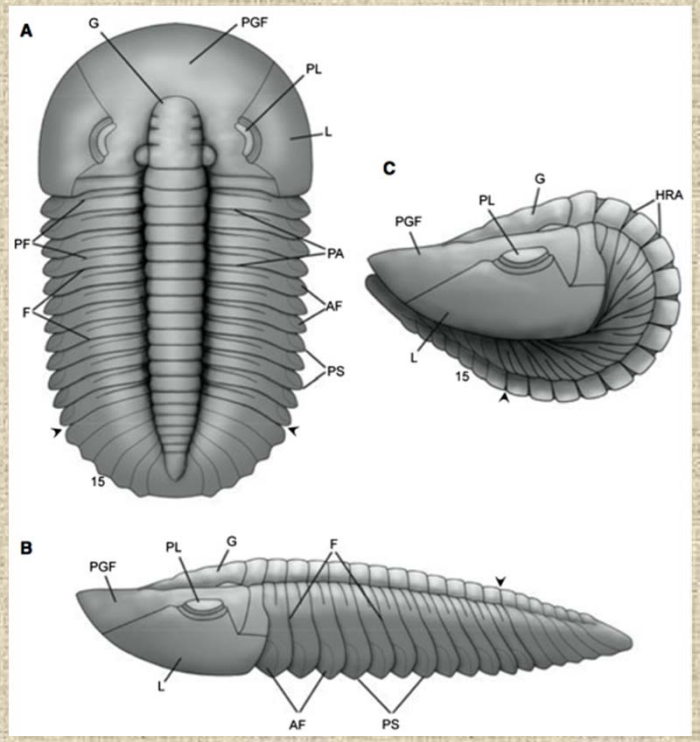
LETHAIA

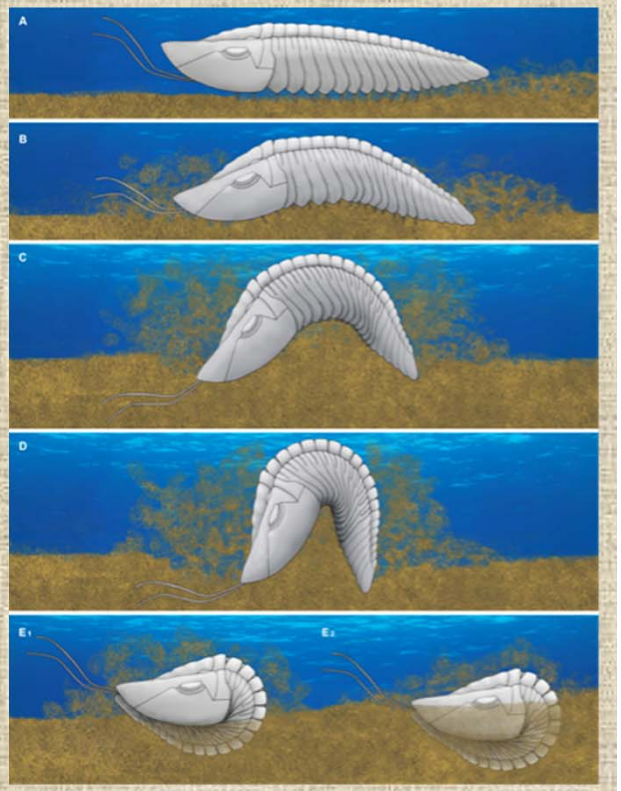
Yuan, J.-L., Esteve, J. & Ng, T.-W. 2013: Articulation, interlocking devices and enrolment in *Monkaspis daulis* (Walcott, 1905) from the Guzhangian, middle Cambrian of North China. *Lethaia*, DOI: 10.1111/let.12059.

Monkaspis daulis (Walcott 1905) is the first enrolled trilobite to be documented from the Kushan Formation (Guzhangian, Cambrian Series 3) of Northern China. It has a wide pygidium that allowed a sphaeroidal enrolment type to be achieved, covering the cephalon and anterior trunk segments. *Monkaspis daulis* is micropygous, but the pygidium is proportionally larger than that of many other Cambrian trilobites, and there is a slightly variable number of segments in the trunk. Articulation structures are very well developed through the trunk, but interlocking or coaptative devices are poorly developed with the exception of the terrace lines and a novel structure, a 'posterior arch', in the pygidium, which would have prevented shear. The absence of genal spines that would otherwise have inhibited sinking into the mud substrate may have enabled *Monkaspis daulis* to use the enrolment procedure to excavate a hole in the sediment for taking shelter. ☐ *Arthropods, asaphids, behaviour, caudalization, evolution.*




A1
5 mm
pp
A3
pa
A2
B1
B2
f
1
2
3
4
5
pa


A
G
PGF
PL
L
PF
PA
AF
F
PS
15
C
PGF
PL
G
HRA
L
15
B
PGF
PL
G
F
L
AF
PS


A
B
C
D
E1
E2

Palaeoscolicids

古蠕蟲

Lucy A. Muir
NIGPAS

張元動 Y.-D. Zhang
NIGPAS

+Model
PALWOR-219; No. of Pages 10

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Palaeoworld

Palaeoworld xxx (2013) xxx–xxx

www.elsevier.com/locate/palwor

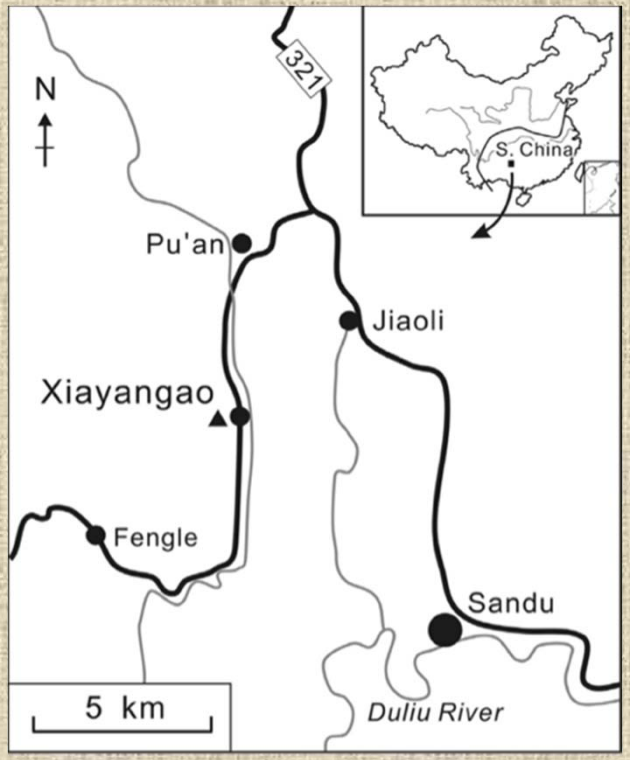
Research paper

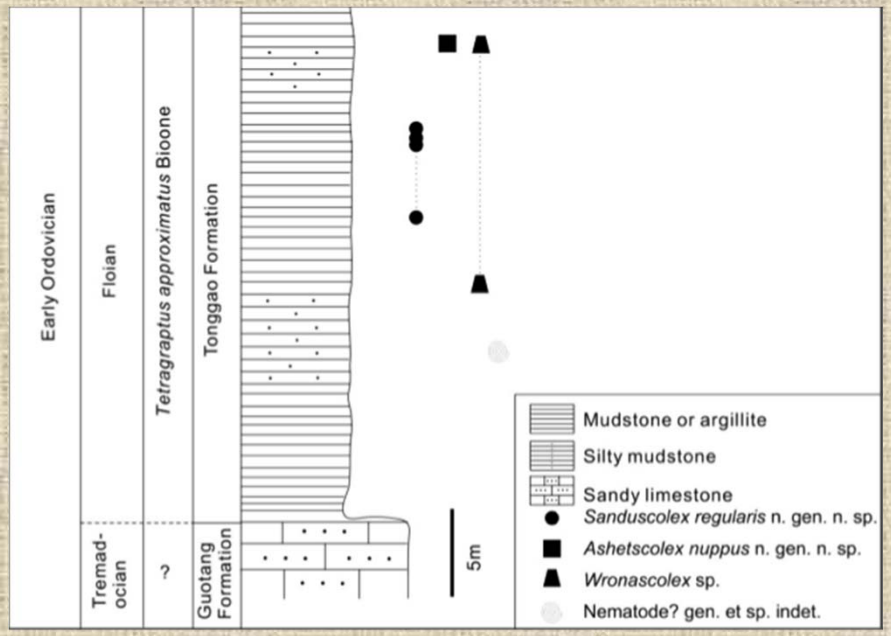
Palaeoscolecidan worms and a possible nematode from the Early Ordovician of South China

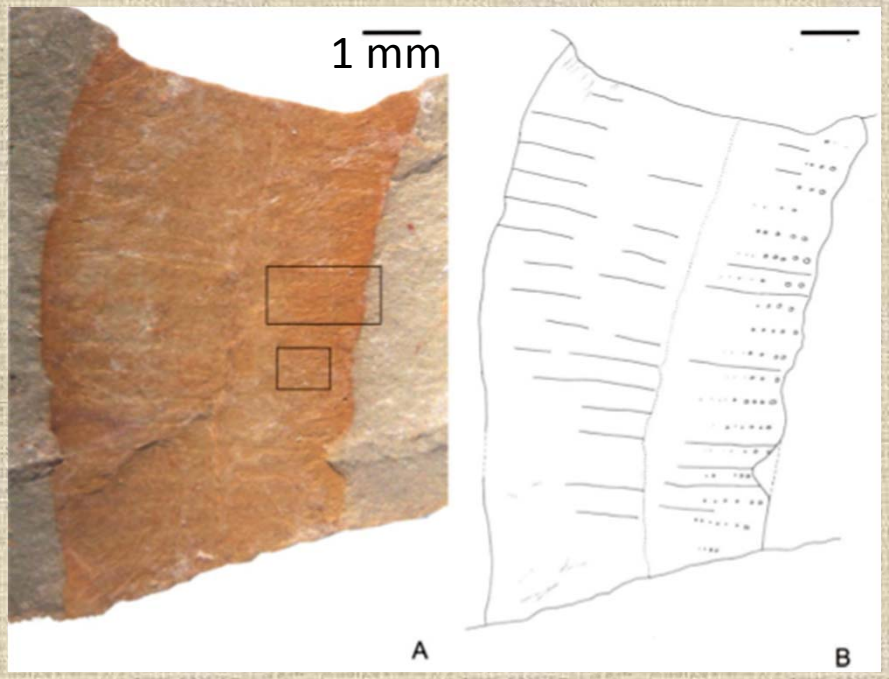
Lucy A. Muir, Tin-Wai Ng, Xiang-Feng Li, Yuan-Dong Zhang, Jih-Pai Lin*

State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Nanjing, China

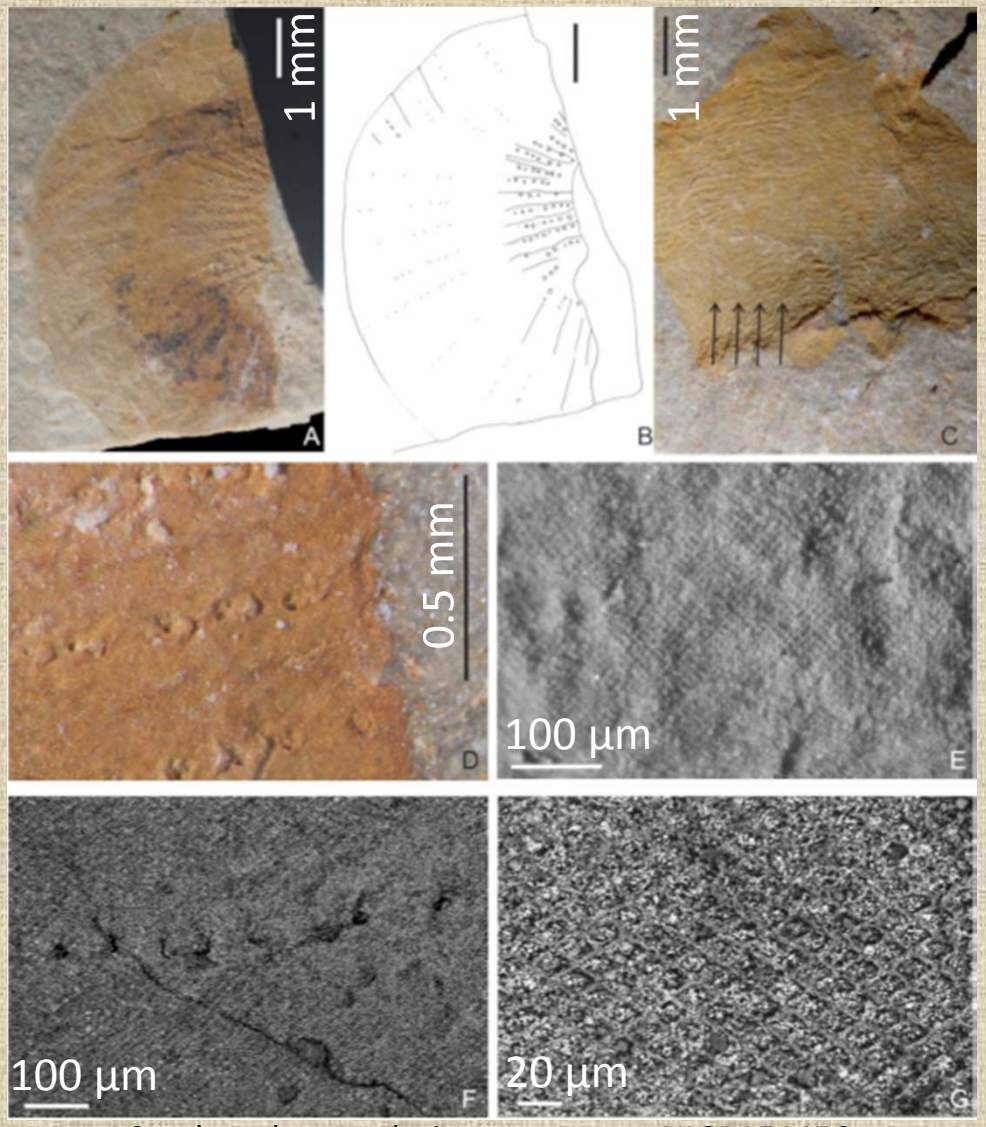
Received 14 December 2012; received in revised form 29 April 2013; accepted 8 June 2013







Sanduscolex regularis n. gen. n. sp. NIGP156068 (holotype)



Sanduscolex regularis n. gen. n. sp. NIGP154456

Paleoecology Of Fossil Assemblages In The Coastal Range, Eastern Taiwan

+Model
PALWOR-231; No. of Pages 21
ARTICLE IN PRESS

Available online at www.sciencedirect.com
ScienceDirect
Palaeoworld
ELSEVIER
Palaeoworld xxx (2013) xxx–xxx
www.elsevier.com/locate/palwor

Quantitative paleoecological analyses and implications of fossil assemblages of the Late Neogene Kangkou Limestone, Coastal Range, eastern Taiwan

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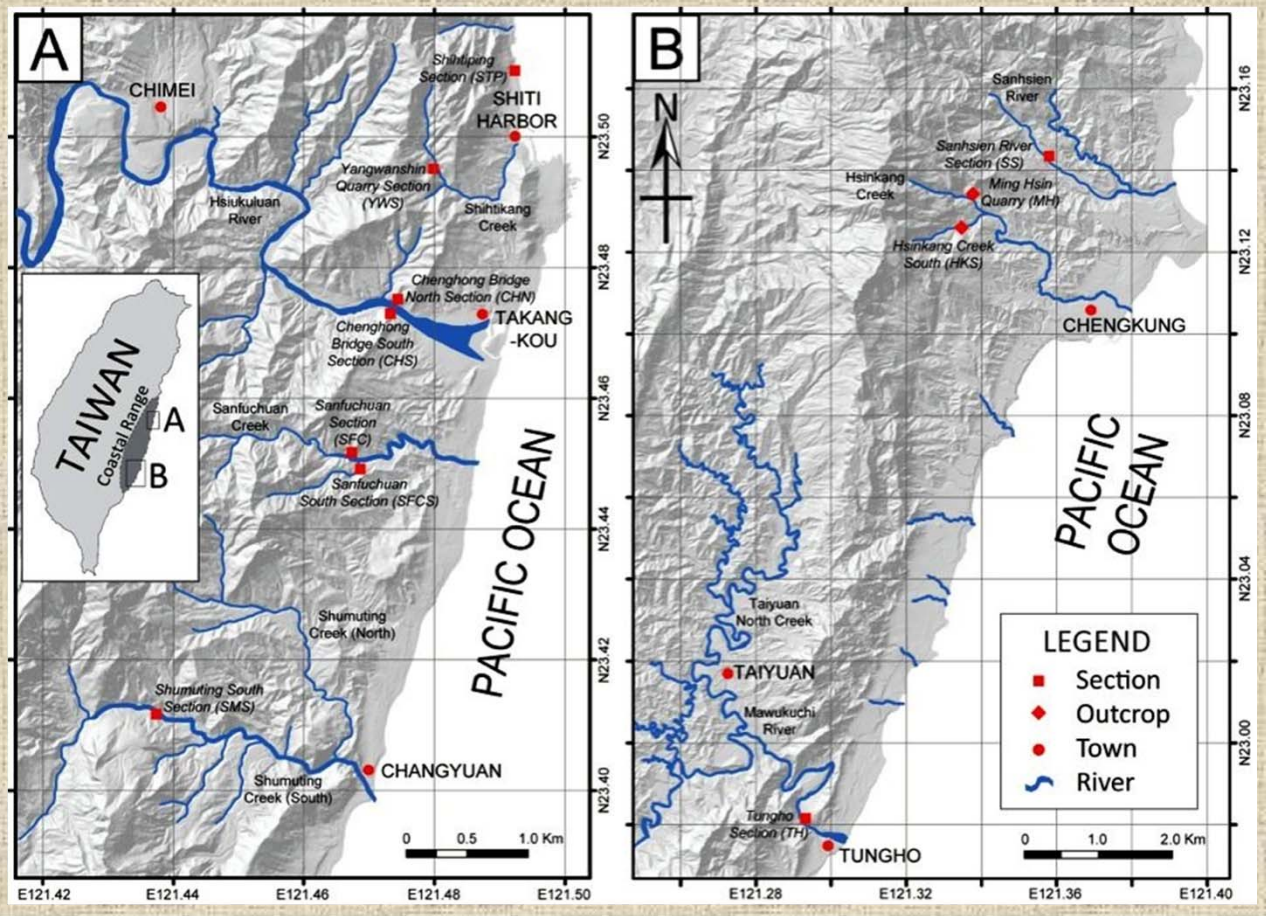
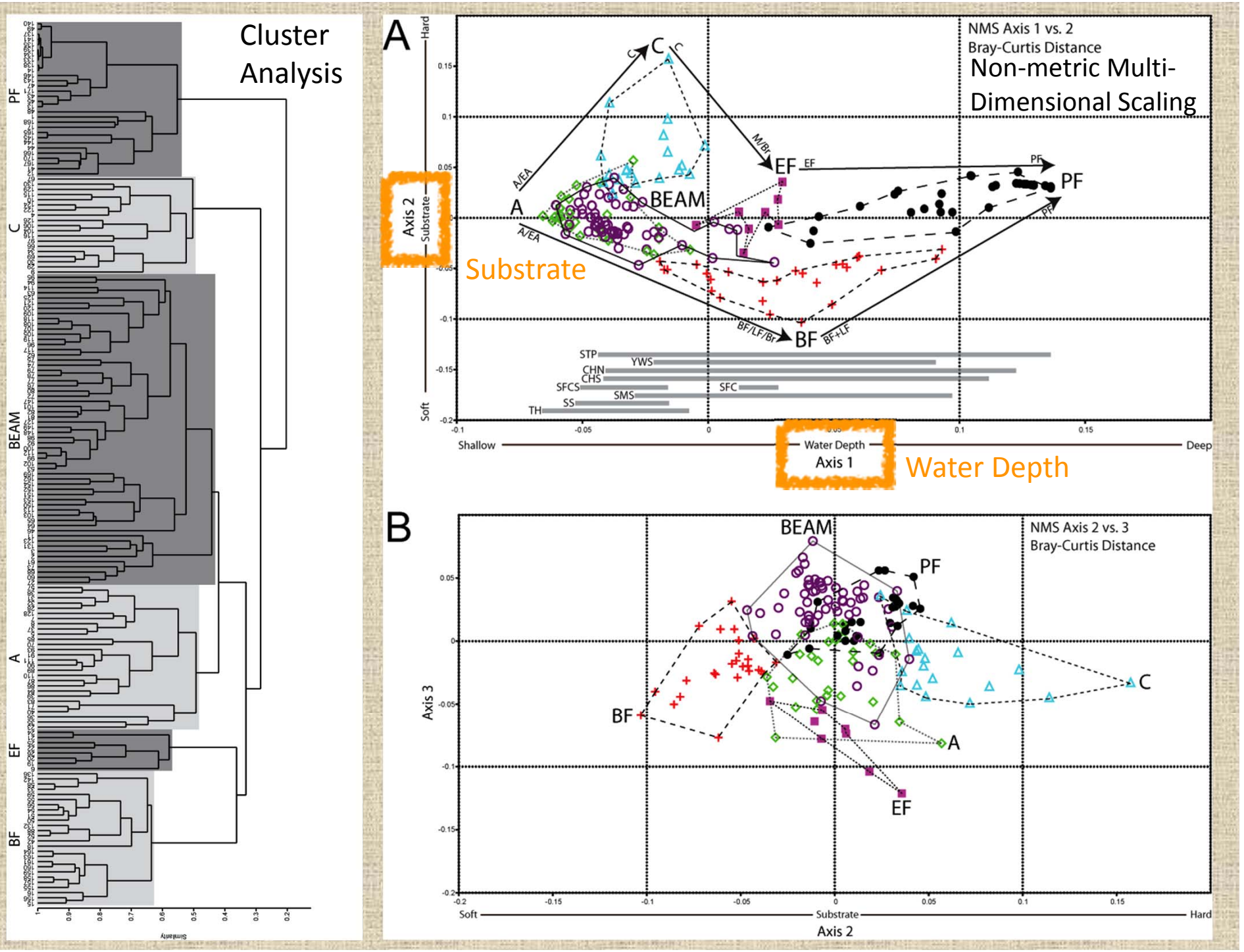
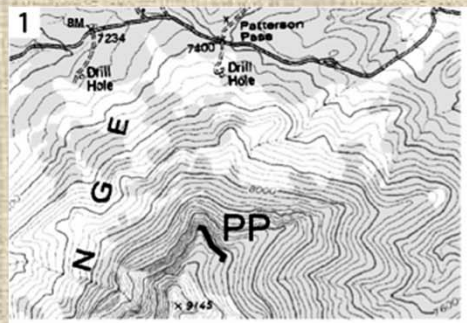
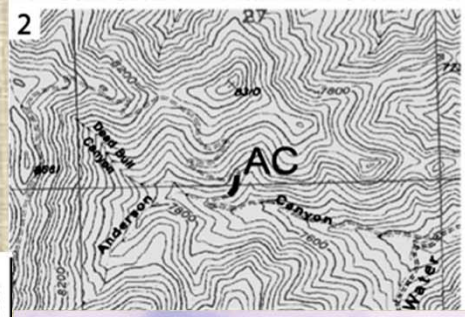


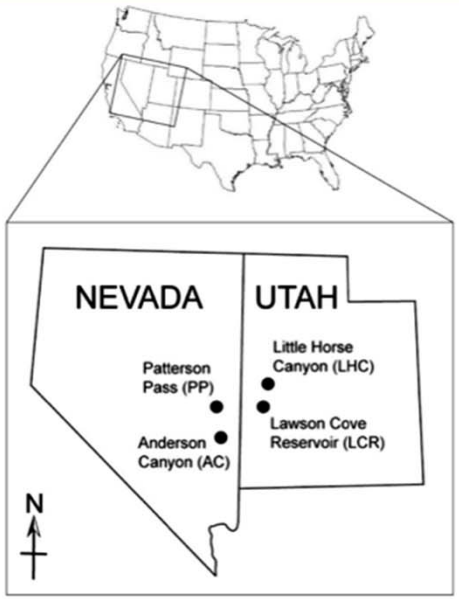
鄧屬予
國立臺灣大學
L. S.-y. Teng
National Taiwan University

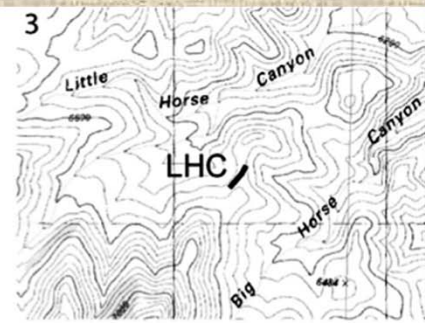

Cluster Analysis
PF
C
BEAM
A
EF
BF
Similarity
A
NMS Axis 1 vs. 2
Bray-Curtis Distance
Non-metric Multi-Dimensional Scaling
Hard
Soft
Axis 2
Substrate
Substrate
C
A
BEAM
EF
PF
A/EA
M/Br
BF/LF/Br
BF+LF
BF
STP
YWS
CHN
CHS
SFCS
SFC
SMS
SS
TH
Shallow
Water Depth
Deep
Axis 1
Water Depth
B
NMS Axis 2 vs. 3
Bray-Curtis Distance
BEAM
PF
C
BF
A
EF
Axis 3
Soft
Substrate
Hard
Axis 2

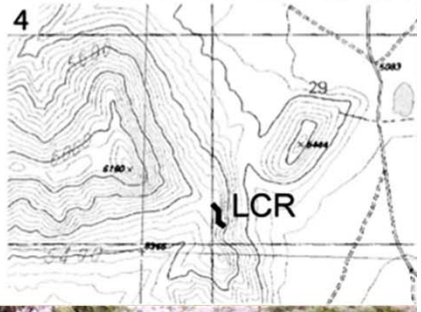
Eastern Great Basin (大盘[盆]地) Utah & Nevada, USA

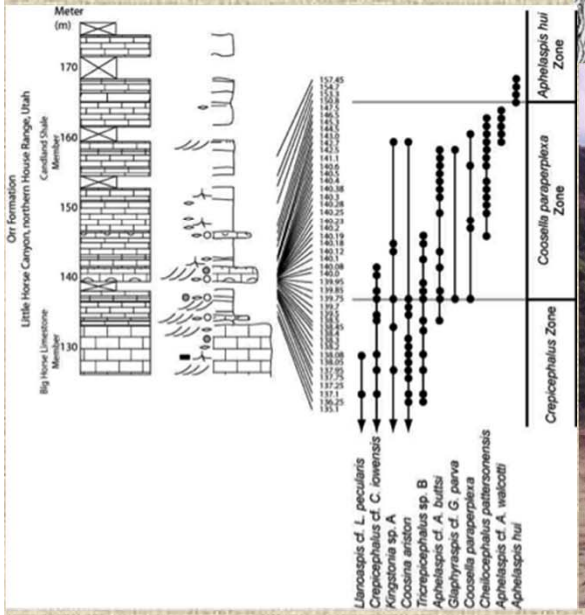


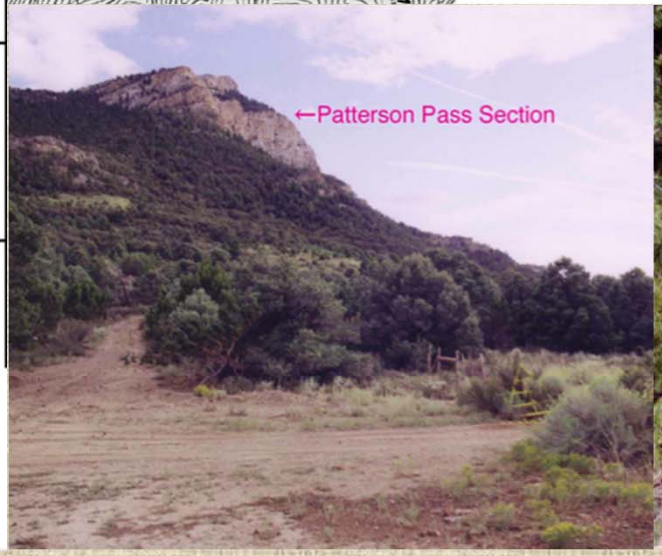












Ng, T. –W., Westrop, S. R., and Adrain, J. M. (in prep) New Trilobite Biozones for the Lowermost Steptoean (Paibian) of eastern Great Basin, Nevada and Utah, Western USA. *Journal of Paleontology*.

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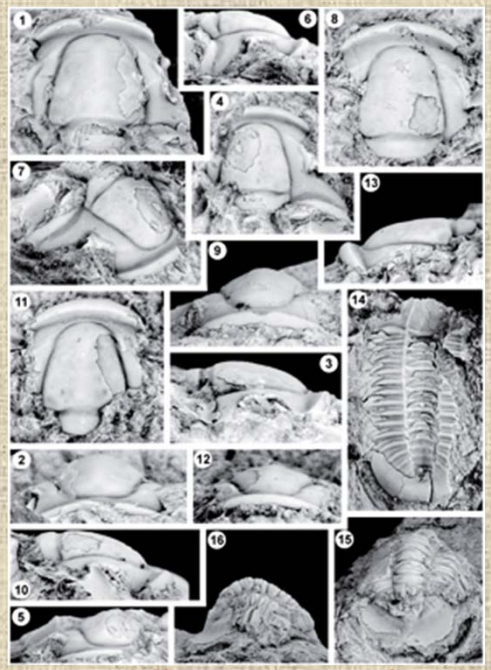
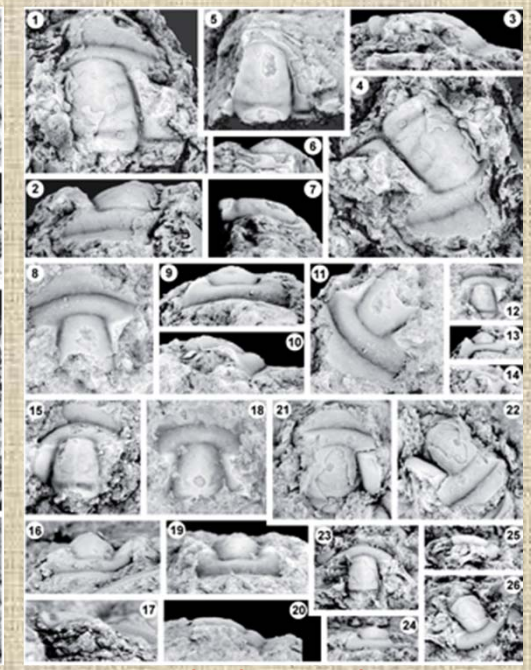
IOWA HAWKEYES

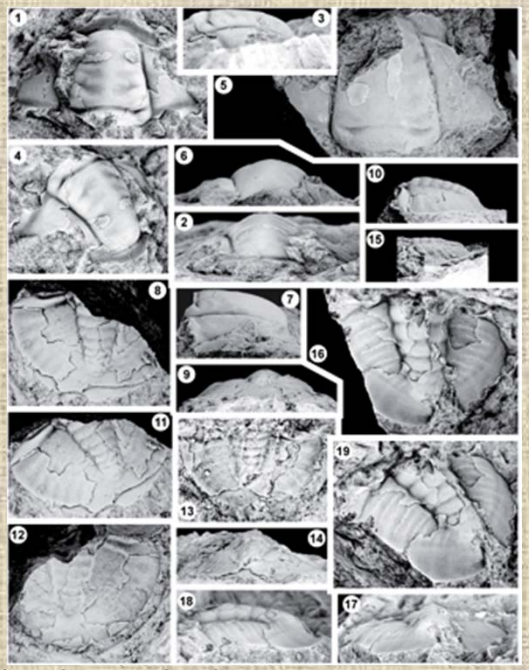


Coosella paraperplexa



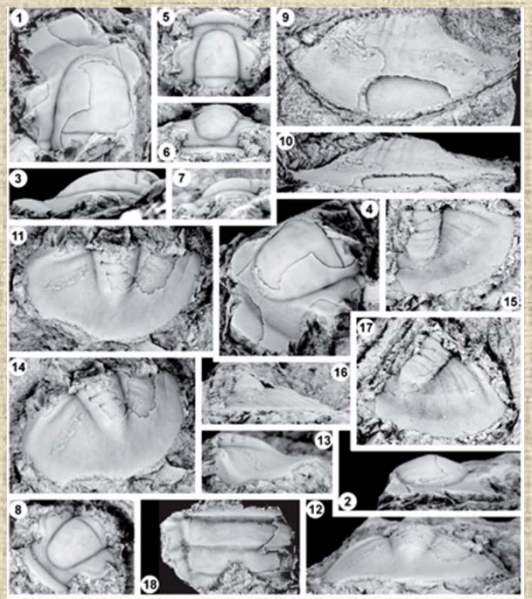
Aphelaspis hui

胡忠恒
C. H. Hu
1924-2010

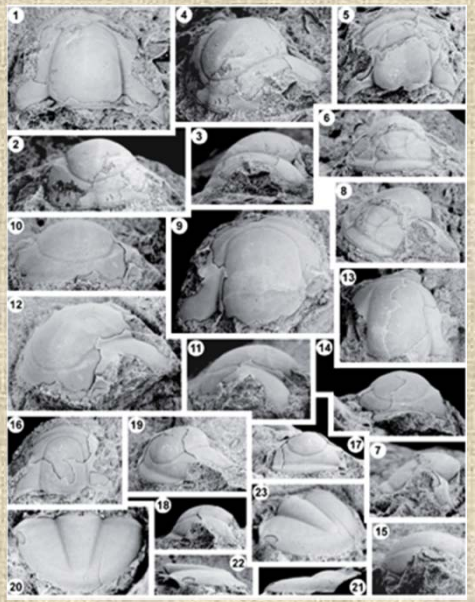


Cheilocephalus pattersonensis

New Trilobites Species



Coosia macro



Blountia lincolnensis

Global Correlation

SERIES	STAGES	LAURENTIA (Great Basin This Study)	LAURENTIA (MacKenzie Mts) Pratt, 1992	SOUTH CHINA Peng, 2009a; 2009b	NORTH CHINA Peng, 2009a; 2009b	AUSTRALIA Peng et al., 2012	KAZAKHSTAN Ergaliev, 1980	SIBERIA Peng et al., 2012	SCANDINAVIA Ahlberg et al. 2008; Terfelt et al. 2010
Furongian	Paibian	Steptoean: *Dunderbergia*	Steptoean: *Parabolinoides calvilimbata*	Paibian: *Tomagnostella orientalis - Corynexochua plumula*	Changshanian: *Chuangia*	Idamean: *Stigmatoa diloma*	Sakian: *Pseudagnostus curtare*	Gorbiyachinian: *Erixanium sentum*	Paibian: *Glyptagnostus reticulatus*: *Olenus scanicus*, *Olenus dentatus*, *Olenus attenuatus*, *Olenus wahlenbergi*, *Olenus truncatus*, *Olenus gibbosus*
		Prehousia	*Olenaspella evansi*	*Agnostus inexpextans - Proceratopyge protrata*		*Erixanium sentum*	*Homagnostus longiformis*	*Stigmatoa destruncta*	
		Dicanthopyge	*Olenaspella regularis*			*Proceratopyge cryptica*			
		Aphelaspis							
		Aphelaspis hui / *Coosella*	*Glyptagnostus reticulatus*	*Glyptagnostus reticulatus*	*Prochuangia - Paracoosia*	*Glyptagnostus reticulatus*	*Glyptagnostus reticulatus*	*Glyptagnostus reticulatus*	
Cambrian Series 3	Guzhangian	Marjuman: *Crepicephalus*	Marjuman: *Cedaria brevifrons*	Guzhangian: *Glyptagnostus stolidotus*	Kushanian: *Neodrepanura [=Drepanura]*	Mindyallan: *Glyptagnostus stolidotus*	Ayusokkanian: *Glyptagnostus stolidotus*	Kulyumbian: *Glyptagnostus stolidotus*	Guzhangian: *Agnostus pisiformis*
			Cedaria prolifica	*Linguagnostus reconditus*		*Acmarhachis quasivespa*	*Kormagnostus simplex*	*Clavagnostus spinosus*	
		Cedaria	*Cedaria selwyni*						
			Cedaria minor	*Proagnostus bulbus*	*Blackwelderia*	*Erediaspis eretes*		*Proagnostus bulbus*	

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M. R. Saltzman, J. Esteve

J. Gao, Y.-G. Tang, Y. Liu, and X.-F. Liu