Geohistry and Fossils

Yoshio Okamoto

yossi.okamoto@gmail.com

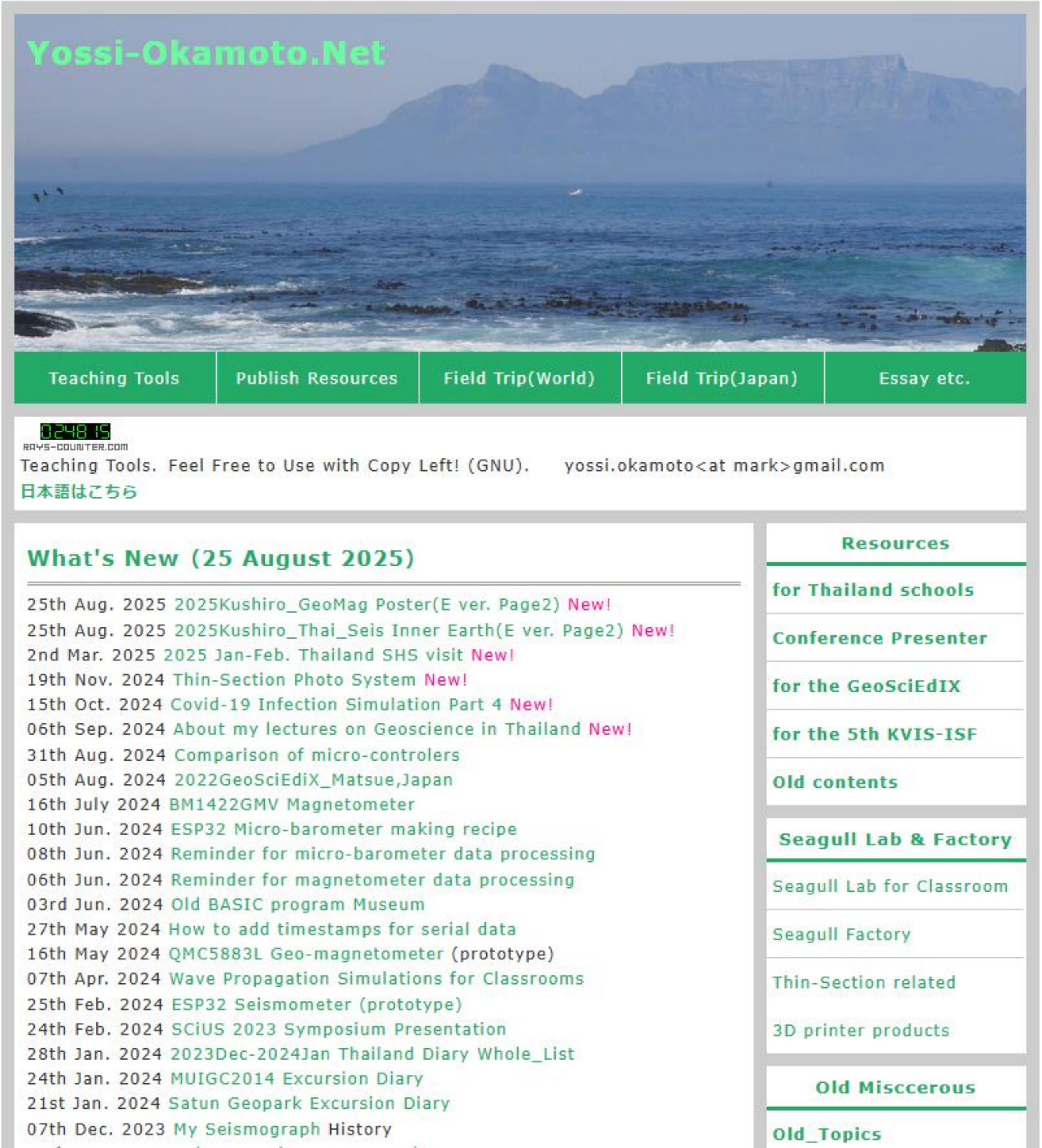
http://yossi-okamoto.net/

Silpakorn University

11th Dec.2025

Who ar

- Earth Science high-school teac
- Associate professor and part-ti
  Osaka-Kyoiku University 20
- Geo Science class at KVIS, PCSI
  Chiang Mai Univ. DS, Phayao U
- School Seismograph System (at
  PCSHS Loei, PCSHS NST, Chiang
  Silpakorn Univ.)
- 3D seismicity maps, tsunami si
- Polarized microscope unit & Th
- 3D printing (2019-)
- Linux Programming (awk, C, Pr
  etc.). Now with the use of Clau



Teaching Tools. Feel Free to Use with Copy Left! (GNU). yossi.okamoto<at mark>gmail.com

日本語はこちら

What's New (25 August 2025)

25th Aug. 2025 2025Kushiro_GeoMag Poster(E ver. Page2) New!
25th Aug. 2025 2025Kushiro_Thai_Seis Inner Earth(E ver. Page2) New!
2nd Mar. 2025 2025 Jan-Feb. Thailand SHS visit New!
19th Nov. 2024 Thin-Section Photo System New!
15th Oct. 2024 Covid-19 Infection Simulation Part 4 New!
06th Sep. 2024 About my lectures on Geoscience in Thailand New!
31th Aug. 2024 Comparison of micro-controlers
05th Aug. 2024 2022GeoSciEdiX_Matsue,Japan
16th July 2024 BM1422GMV Magnetometer
10th Jun. 2024 ESP32 Micro-barometer making recipe
08th Jun. 2024 Reminder for micro-barometer data processing
06th Jun. 2024 Reminder for magnetometer data processing
03rd Jun. 2024 Old BASIC program Museum
27th May 2024 How to add timestamps for serial data
16th May 2024 QMC5883L Geo-magnetometer (prototype)
07th Apr. 2024 Wave Propagation Simulations for Classrooms
25th Feb. 2024 ESP32 Seismometer (prototype)
24th Feb. 2024 SCiUS 2023 Symposium Presentation
28th Jan. 2024 2023Dec-2024Jan Thailand Diary Whole_List
24th Jan. 2024 MUIGC2014 Excursion Diary
21st Jan. 2024 Satun Geopark Excursion Diary
07th Dec. 2023 My Seismograph History

1991 Unzen Pyroclastic Flow

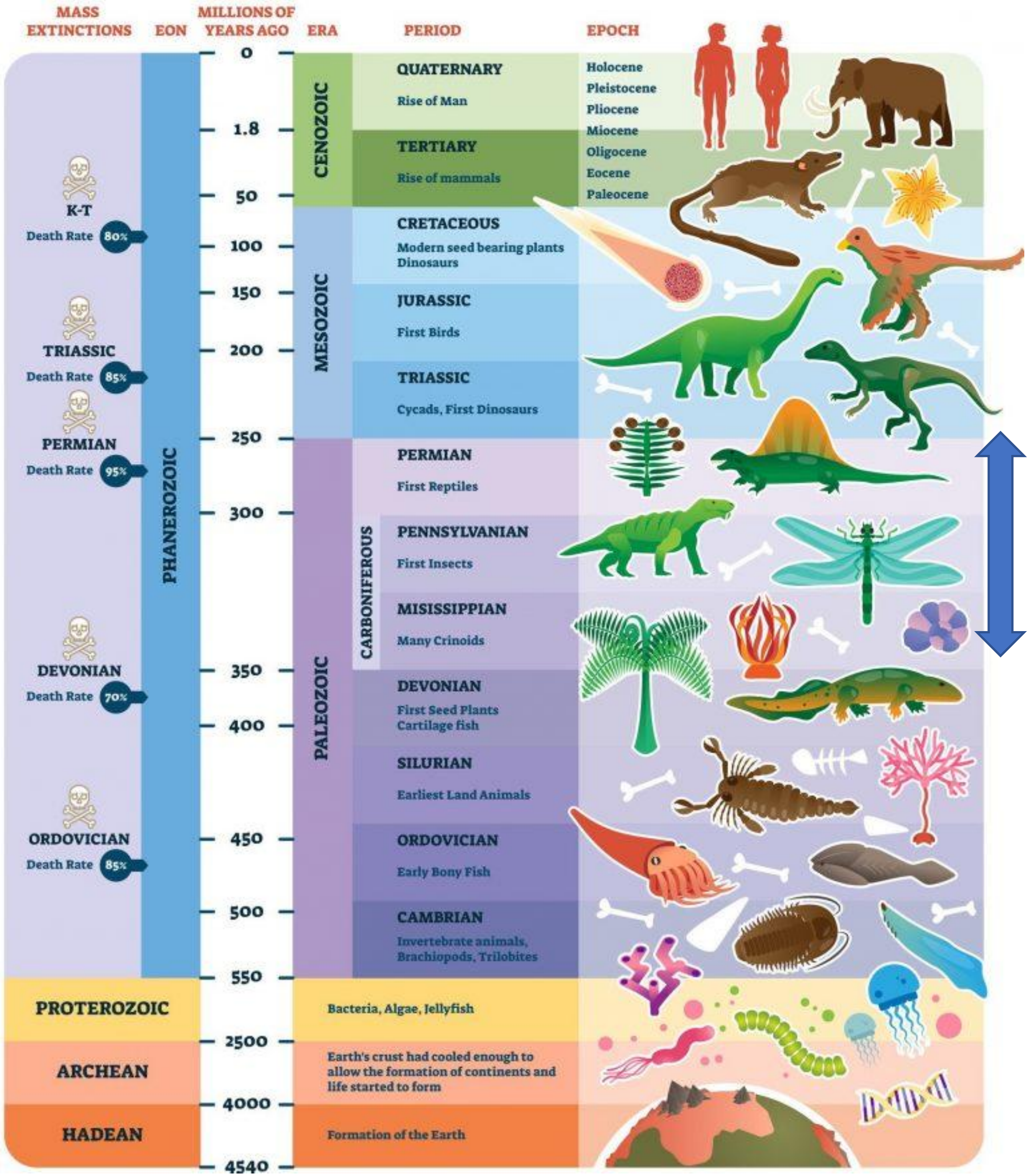
A Day in Pompeii AD79

24 AUGUST 79 AD

Classification of Rocks

- Igneous Rocks
- Sedimentary Rocks
- Metamorphic Rock

->Some figures are not used in my lecture



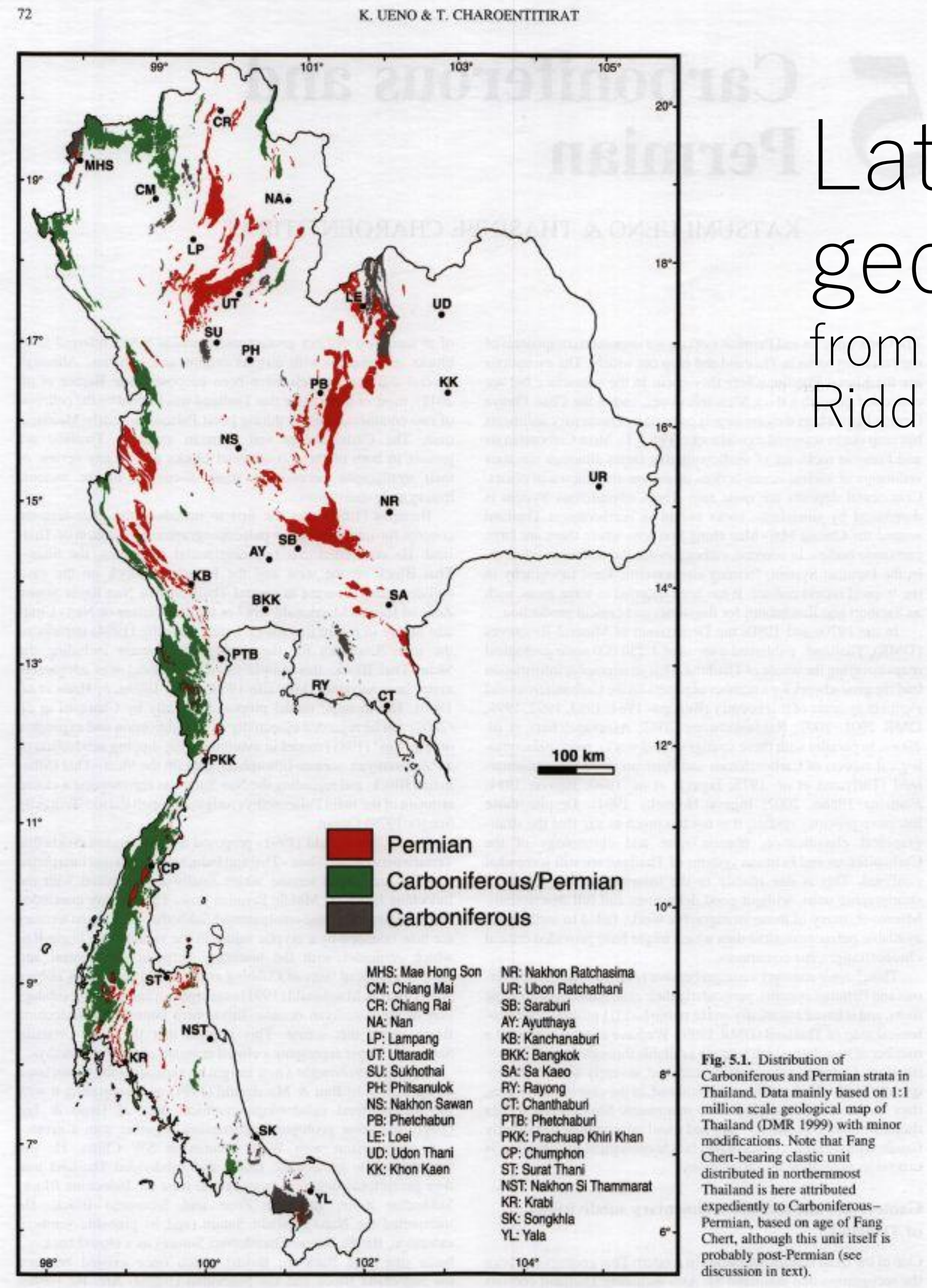
Carboniferous to Permian

Phetchaburi/Ratchaburi Limestone

Phetchaburi and Ratchaburi provinces in Thailand are famous for their extensive Permian limestone formations, rich in diverse marine fossils like **fusulinids, corals** (Sinopora), **brachiopods** (Stereochia, Marginifera), **gastropods, trilobites**, and **nautiloids**, indicating ancient shallow seas. Key fossil sites include Khao I-bit in Phetchaburi (huge fusulinids) and formations around Ratchaburi (Ratburi Limestone), part of the larger Ratburi Group, showcasing a vibrant marine ecosystem from millions of years ago, with some deposits also yielding older Silurian-Devonian fossils and Tertiary mammals in coal mines

Later Paleozoic geological map

from “The Geology of Thailand”
Ridd et. al., 2011



🟥 Permian
🟩 Carboniferous/Permian
⬛ Carboniferous

MHS: Mae Hong Son
CM: Chiang Mai
CR: Chiang Rai
NA: Nan
LP: Lampang
UT: Uttaradit
SU: Sukhothai
PH: Phitsanulok
NS: Nakhon Sawan
PB: Phetchabun
LE: Loei
UD: Udon Thani
KK: Khon Kaen

NR: Nakhon Ratchasima
UR: Ubon Ratchathani
SB: Saraburi
AY: Ayutthaya
KB: Kanchanaburi
BKK: Bangkok
SA: Sa Kaeo
RY: Rayong
CT: Chanthaburi
PTB: Phetchaburi
PKK: Prachuap Khiri Khan
CP: Chumphon
ST: Surat Thani
NST: Nakhon Si Thammarat
KR: Krabi
SK: Songkhla
YL: Yala

Fig. 5.1. Distribution of Carboniferous and Permian strata in Thailand. Data mainly based on 1:1 million scale geological map of Thailand (DMR 1999) with minor modifications. Note that Fang Chert-bearing clastic unit distributed in northernmost Thailand is here attributed expediently to Carboniferous–Permian, based on age of Fang Chert, although this unit itself is probably post-Permian (see discussion in text).

Weathering

- Physical process: Break
  Thermal expansion
  Frozen expansion

Tropical zone > Polar zone

- Chemical process: change to soil
  Feldspar, Mica -> **clay** minerals
  Quartz -> **sand**

Cf. Limestone

$$CaCO_3 + H_2O + CO_2 \rightarrow Ca^{2+} + 2HCO_3^-$$

Rain water

Water solution

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

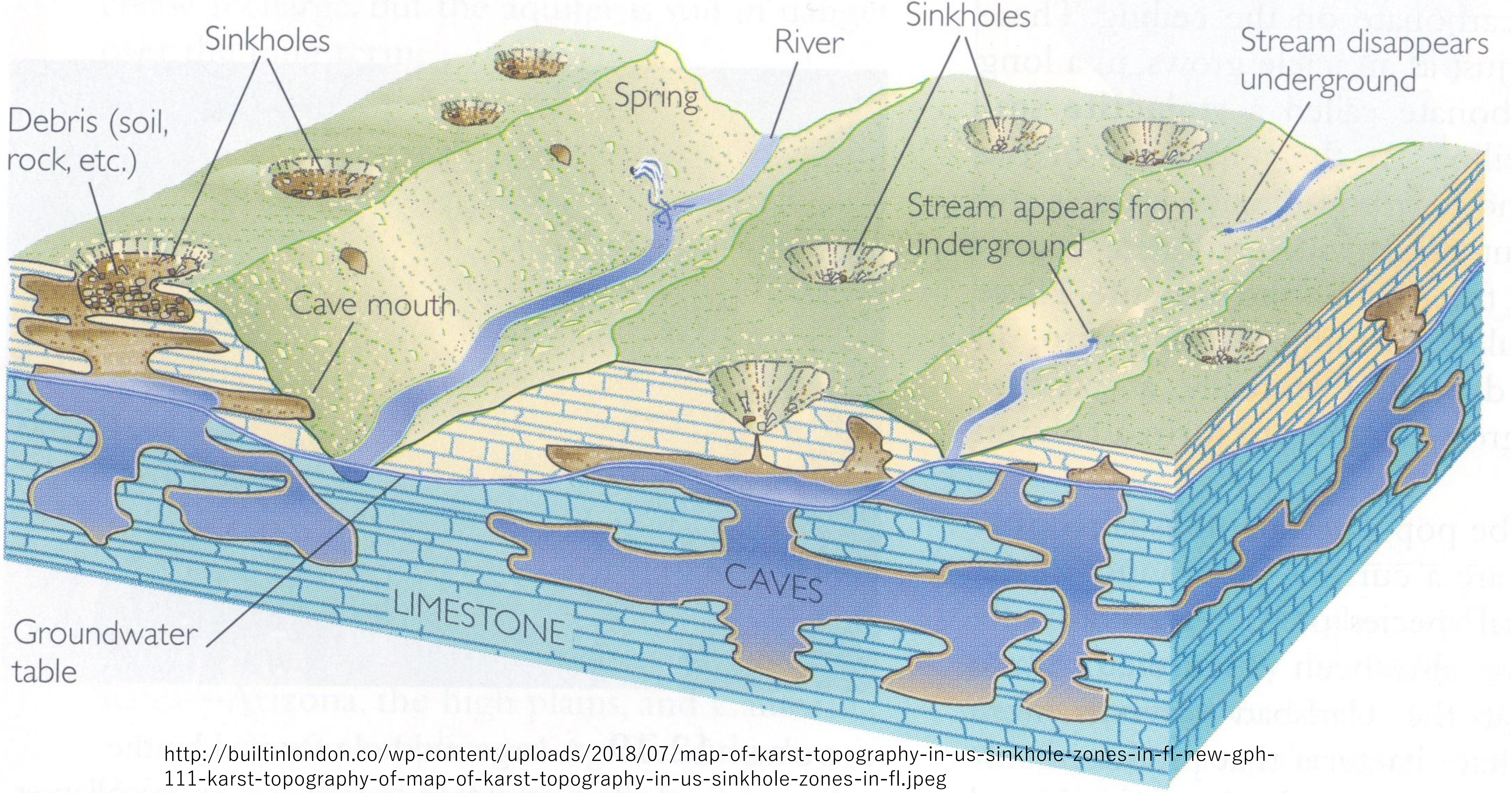
Thailand Karst (lime stone)

Limestones are dissolved by rain

- Ao Phang Nga National Park, Thailand
- Krabi region, Thailand
- Phangnga Bay Area, southern Thailand
- Doi Nang Non, northern Thailand

Limestone weathering

- Karst landforms



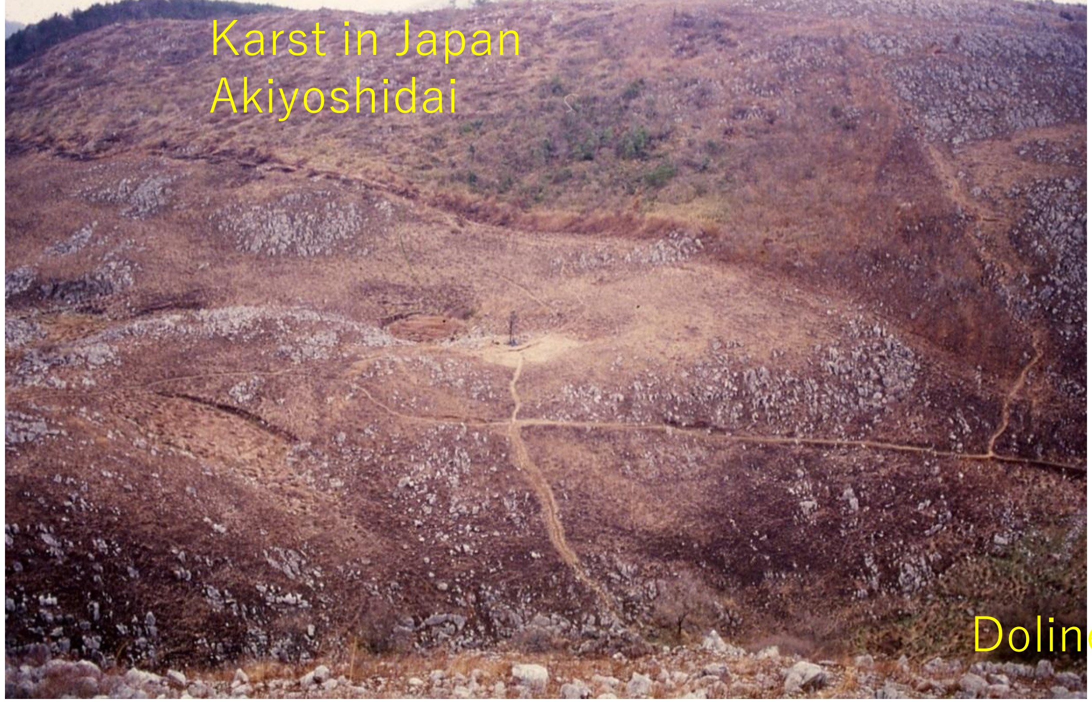
http://builtinlondon.co/wp-content/uploads/2018/07/map-of-karst-topography-in-us-sinkhole-zones-in-fl-new-gph-111-karst-topography-of-map-of-karst-topography-in-us-sinkhole-zones-in-fl.jpeg

Ordovician Lime stone at Chonburi

My visit to Surat Thani in 2017

RAJJAPRABHA DAM,
SURAT THANI

Tower Karst


Karst in Japan
Akiyoshidai
Doline


Karrenfeld


Limestone cave in
Surat Thani
Stalactites


Stalagmites

Thailand Karst

Ao Phang Nga National Park, Thailand

Krabi region, Thailand

Phangnga Bay Area, southern Thailand

Doi Nang Non, northern Thailand!!

Images from Wiki

Phra Nang Beach at Railay

Why the limestone pebbles are sunk in?

Limestone conglomerates dissolved by acid rain!

Limestone(white) and Terra rossa(brown)
Atetsudai Japan 300Ma

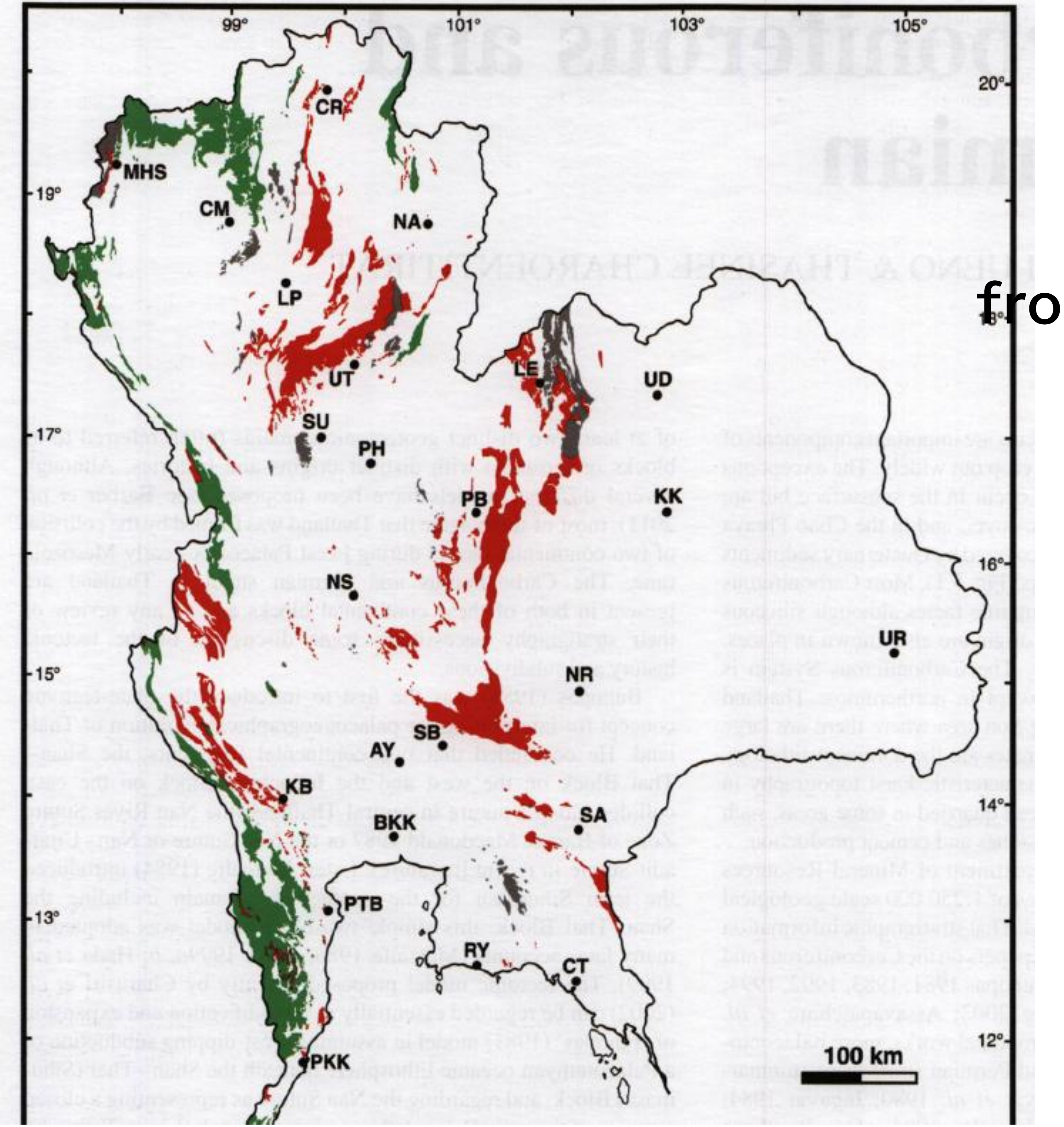
Ancient Human fossils are found in lime stone caves.

Australopithecus africanus
was found in this cave. 2.7 Ma
Sterkfontein cave, SouthAfrica

Terra Rossa soil is a very good environment
For fossil human skull preservation!

Animal bones in the Sterkfontein Cave, SouthAfrica

An animal bone (white color) is buried in the lime stone debris.



K. UENO & T. CHAROENTITIRAT

Later Paleozoic geological map

from “The Geology of Thailand”
Ridd et. al., 2011

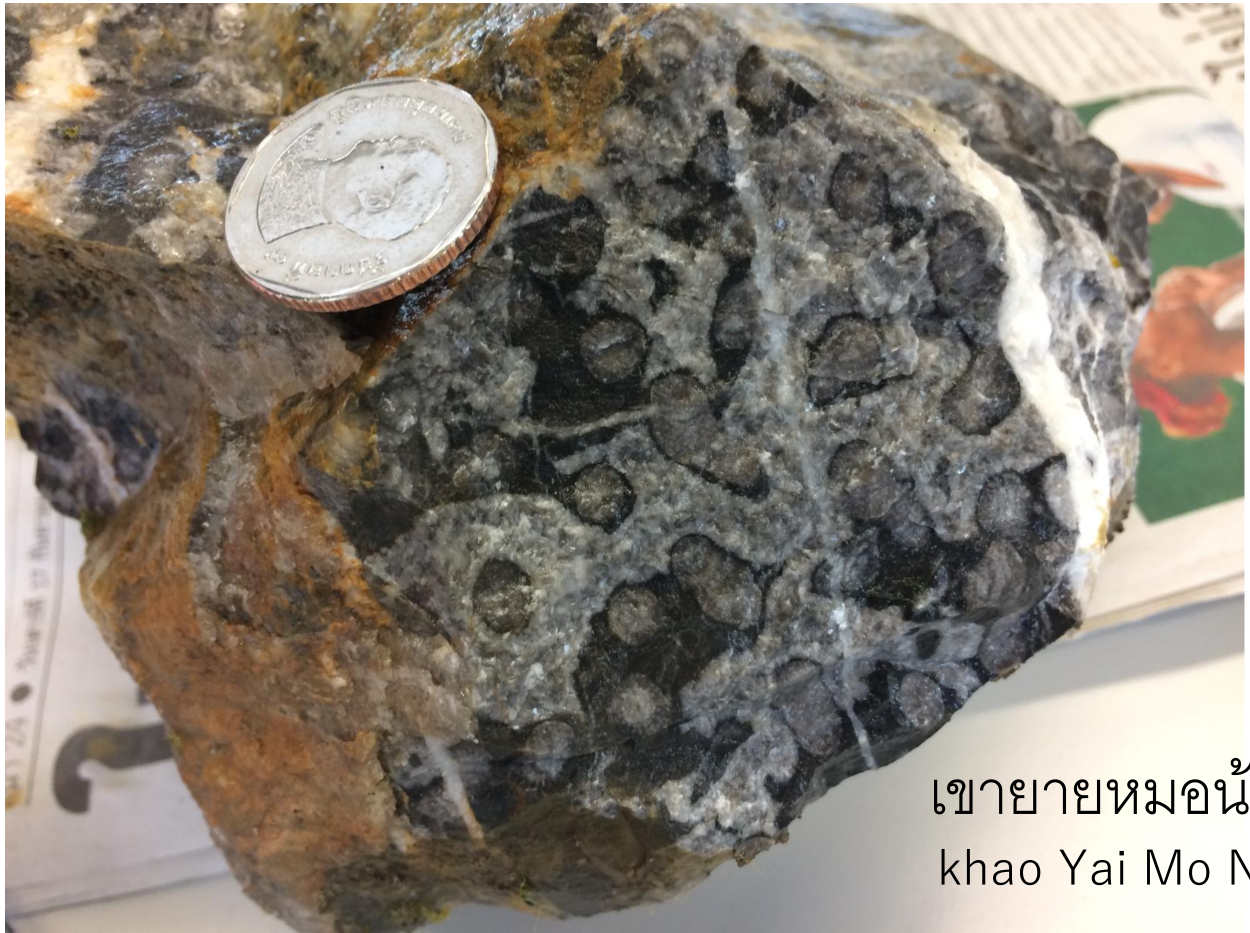
🟥 Permian
🟩 Carboniferous/Permian
⬛ Carboniferous

MHS: Mae Hong Son
CM: Chiang Mai
CR: Chiang Rai
NA: Nan
LP: Lampang
UT: Uttaradit
SU: Sukhothai
PH: Phitsanulok
NS: Nakhon Sawan
PB: Phetchabun
LE: Loei
UD: Udon Thani
KK: Khon Kaen

NR: Nakhon Ratchasima
UR: Ubon Ratchathani
SB: Saraburi
AY: Ayutthaya
KB: Kanchanaburi
BKK: Bangkok
SA: Sa Kaeo
RY: Rayong
CT: Chanthaburi
PTB: Phetchaburi
PKK: Prachuap Khiri Khan
CP: Chumphon
ST: Surat Thani
NST: Nakhon Si Thammarat
KR: Krabi
SK: Songkhla
YL: Yala

Fusulina flourishing (late Paleozoic)

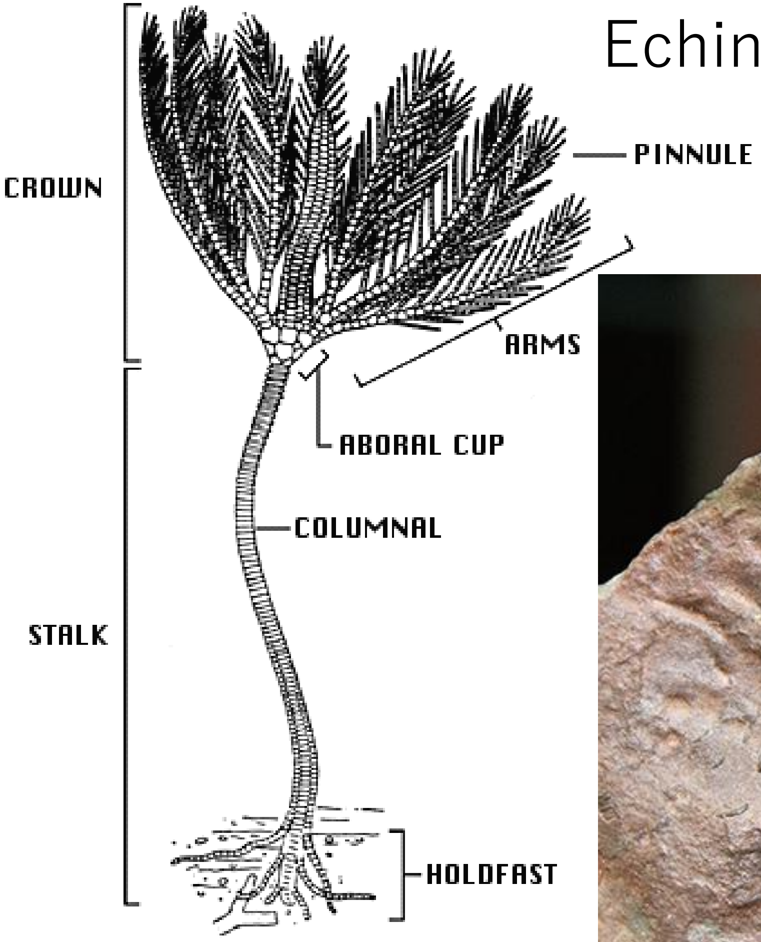
- Carboniferous to Permian
- “Fusulina period”
- Shallow warm ocean: Corals and Fusulinas



เขายายหมอน้อย, ฉะเชิงเทรา
khao Yai Mo Noi, Chachoengsao

crinoid

Echinoderms: a kind of Starfish and sea urchin



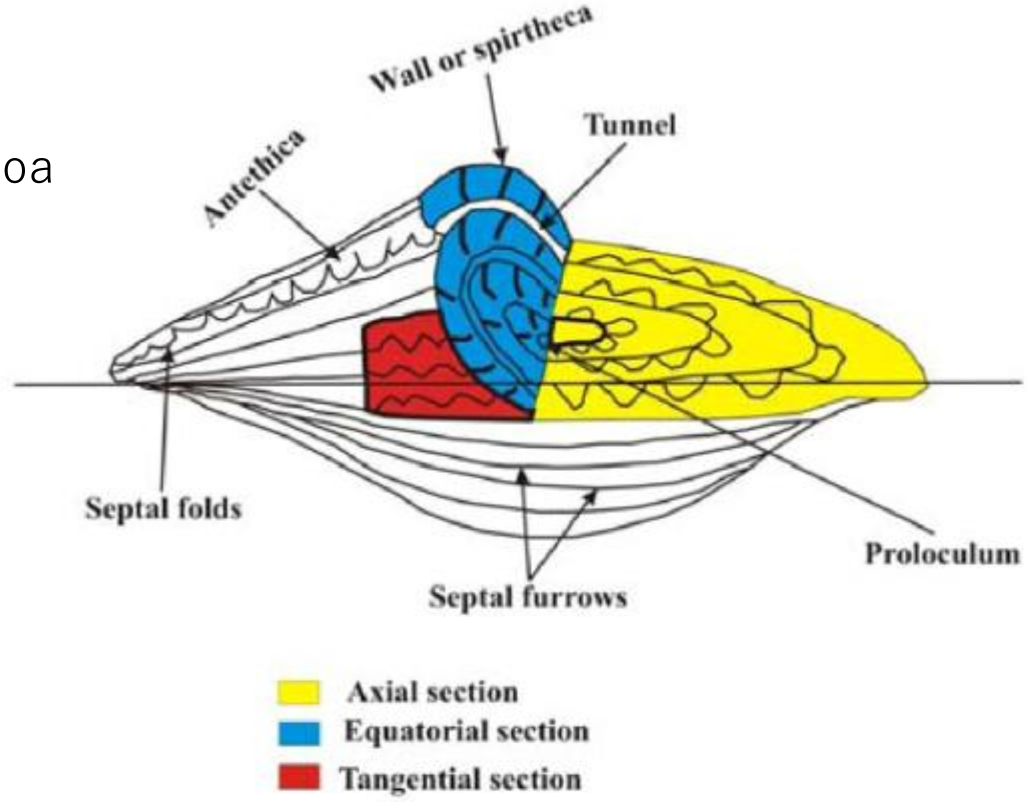
wikipedia

http://www2.padi.com/blog/2017/03/22/curious-facts-crinoids/

Fusulina shell ($CaCO_3$)

- A few mm to 10cm: usually 3mm ~ 2cm
- Protozoa: a kind of ameba

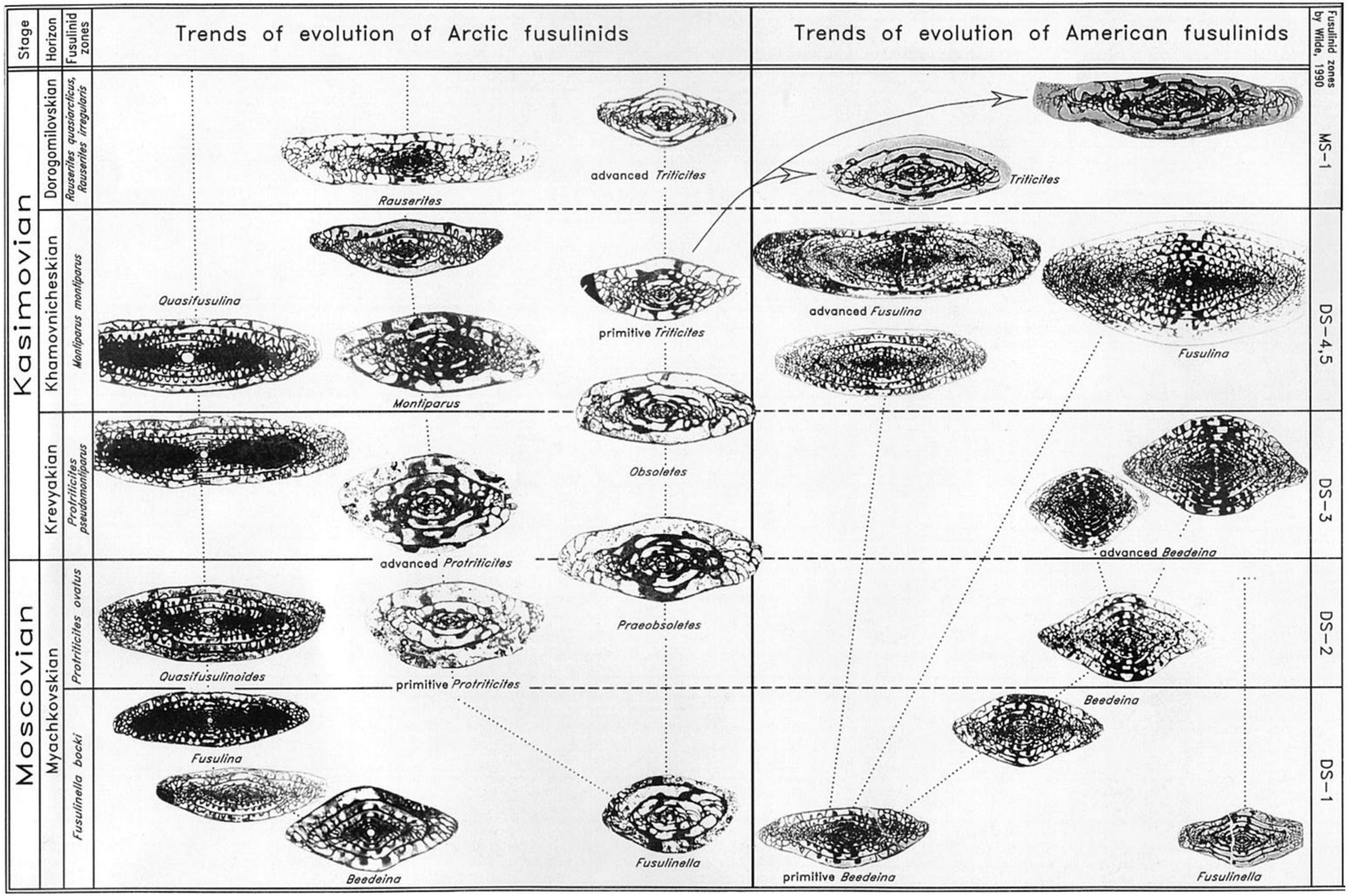
Protozoa



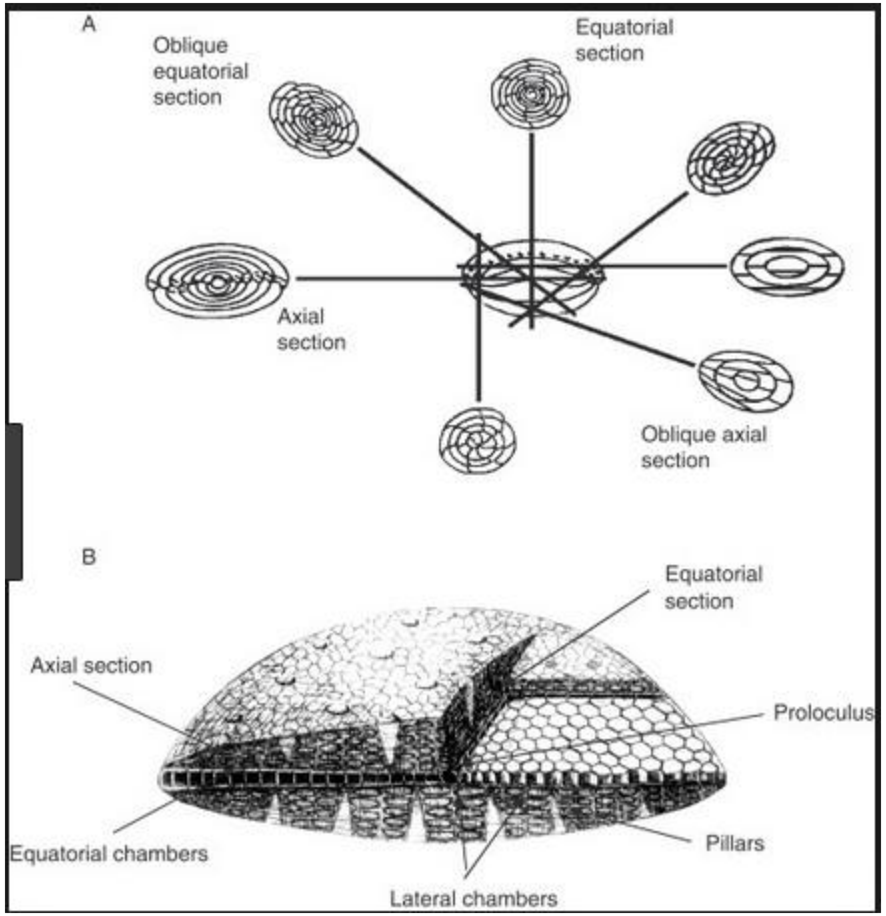
Three types of sections in Fusulina

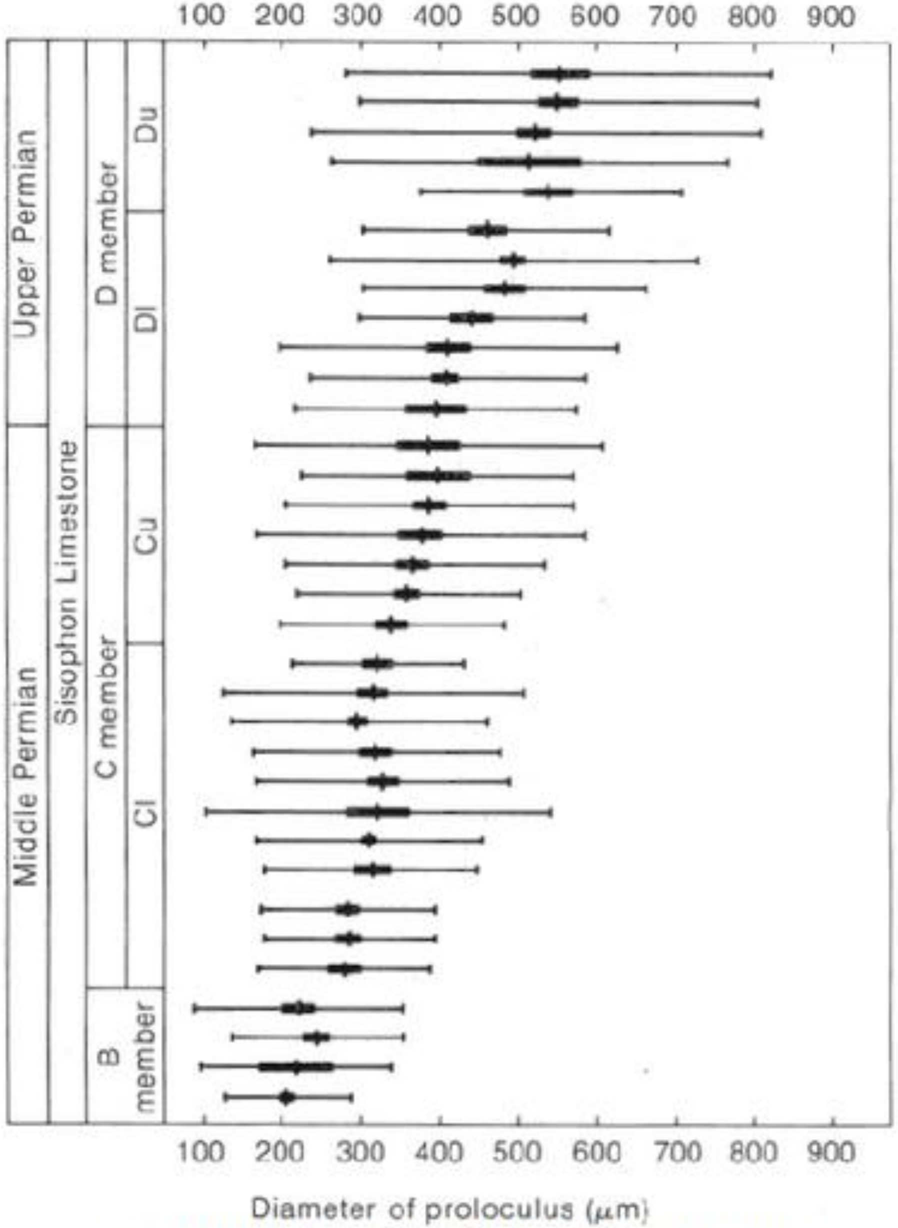
“Micropaleontology”
By Abdelbaset S. El-Sorogy
King Saud University

Fusulina evolution! And Extinction!



"Evolutionary increase in the diameter of the **proloculus** (initial chamber) of the fusulinid foraminiferan *Lepidolina multiseptata*. For each population, the horizontal line represents the range of sizes, and the black rectangle depicts the 95 percent confidence limits for the mean, which is inidcated by the vertical line. The six clusters of populations are in stratigraphic succession, but within each cluster, the vertical ordering of populations is aribtrary (From Ozawa, 1975)" [Stanely 1976]





Evolutionary trends in *Lepidolina*

Marcelle K.Bou
Developments in Palaeontology and Stratigraphy

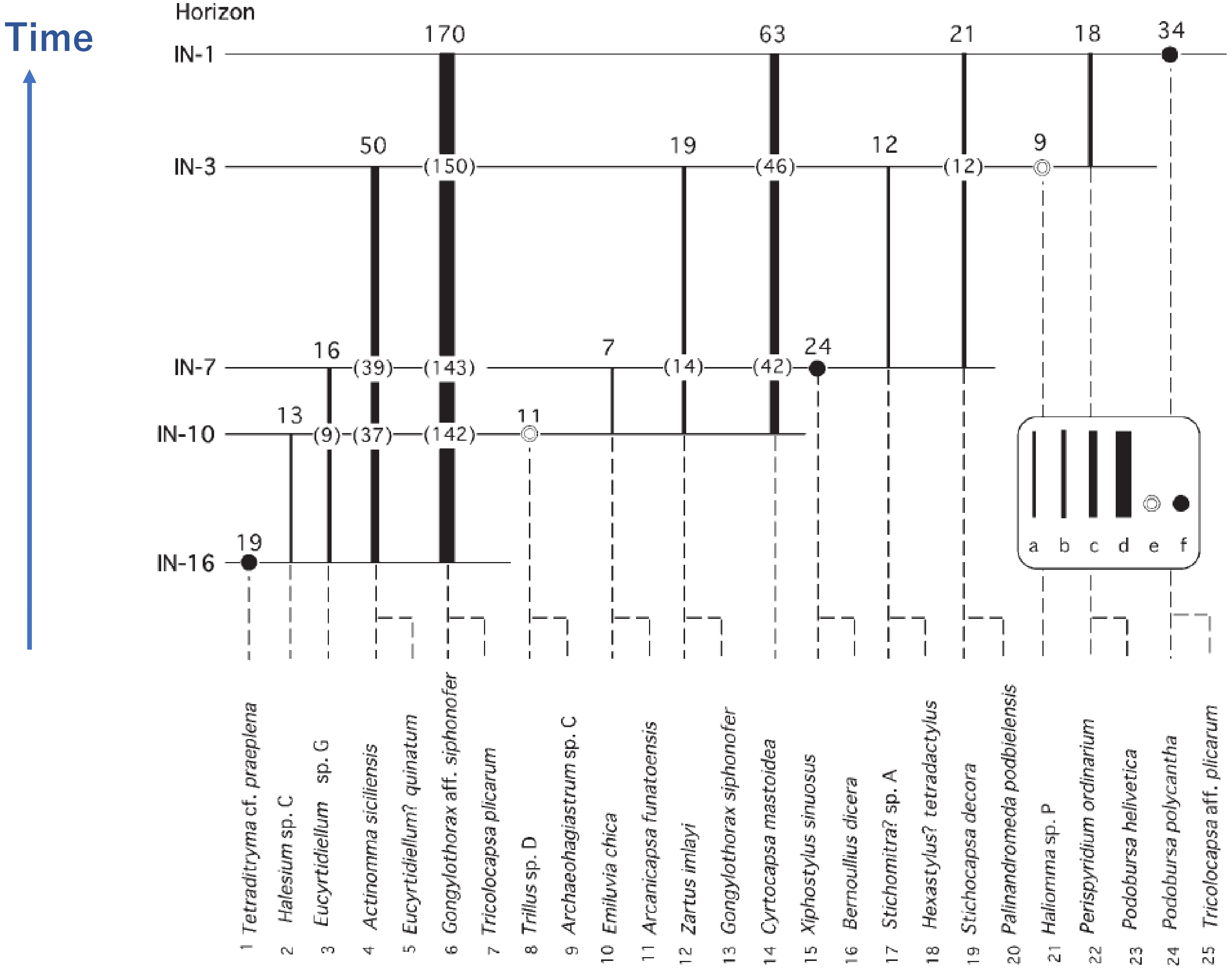
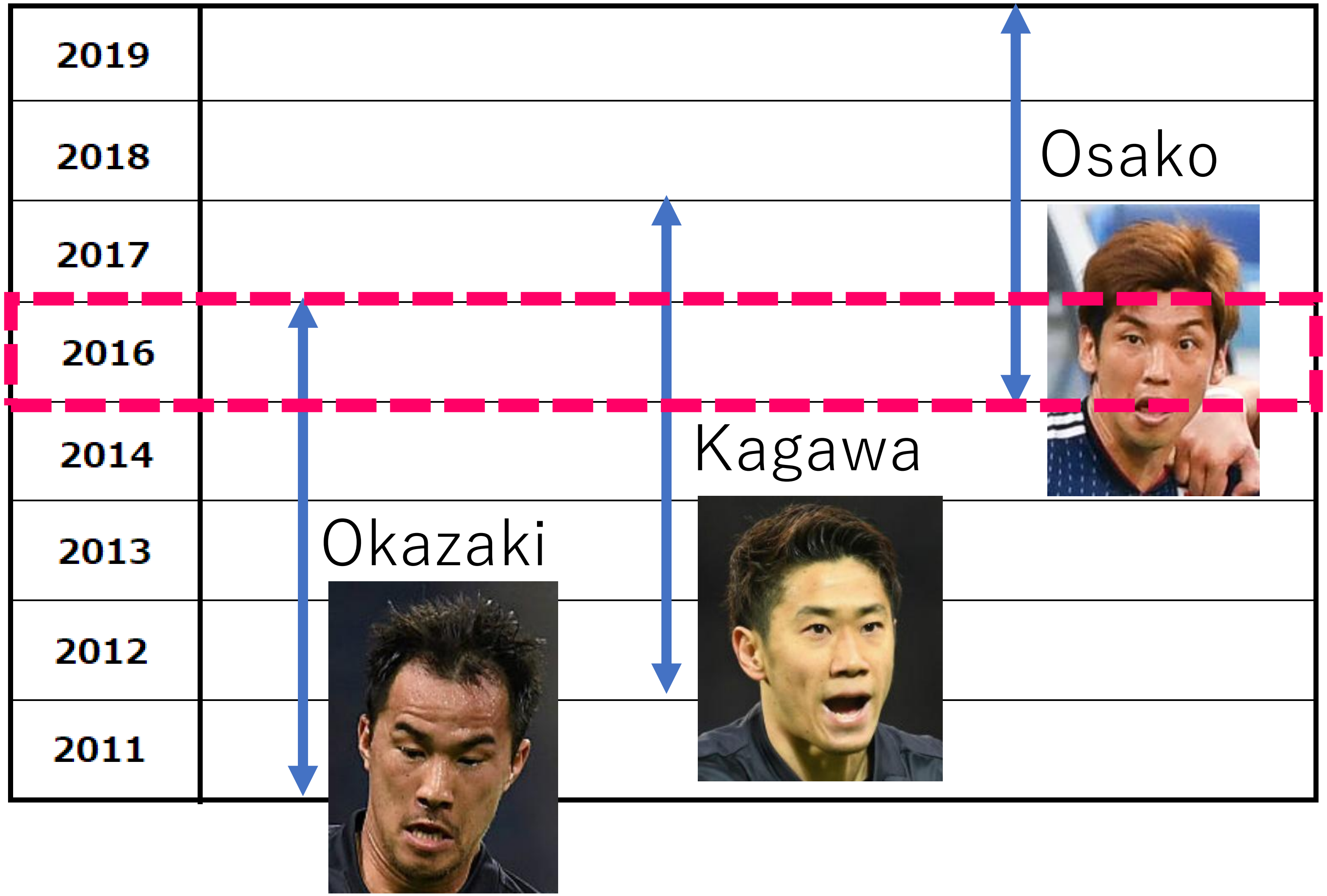


図４．鵜沼セクション５層準の放散虫化石群集の種構成と産出放散虫化石種の例（25種）．図中の数字は各層準において産出した種数であり，()内の数字は中位層準における産出種数を示す．縦の実線は2層準以上の産出種 でa: 1-15種, b: 16-45種, c: 46-90種, d: 90種以上を，丸印は１層準のみの産出種でe: 1-15種, f: 16種以上を表わす．

http://www.palaeo-soc-japan.jp/publications/78_Nishihara_and_Yao.pdf

Index fossils as a combination use

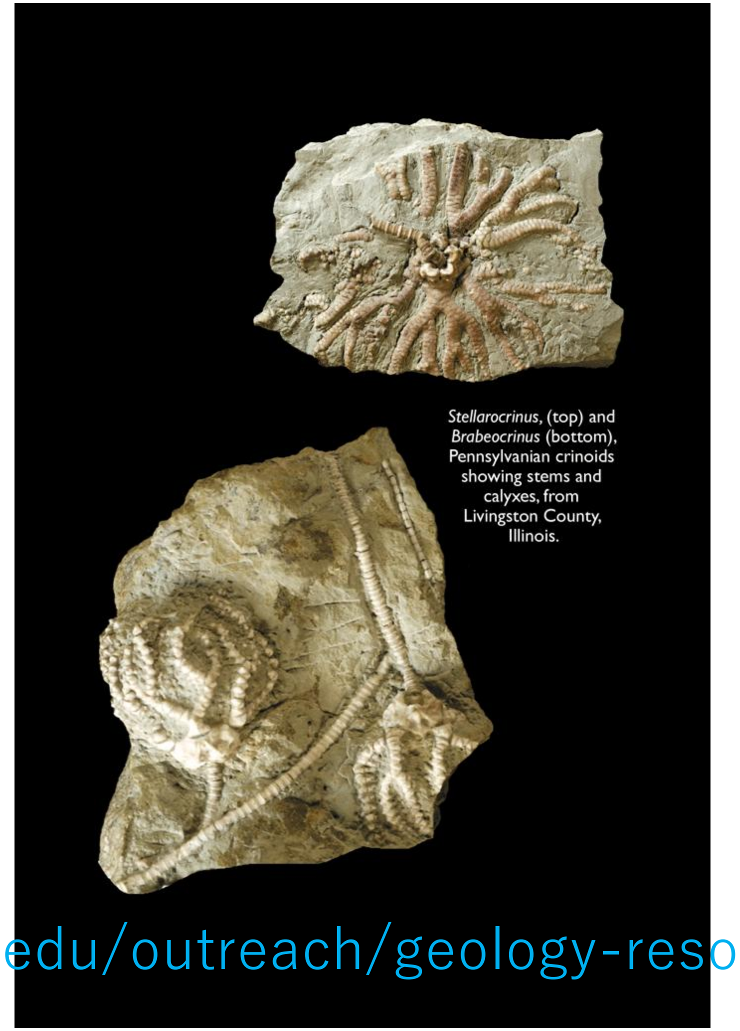
Example: Soccer Japan national team FW



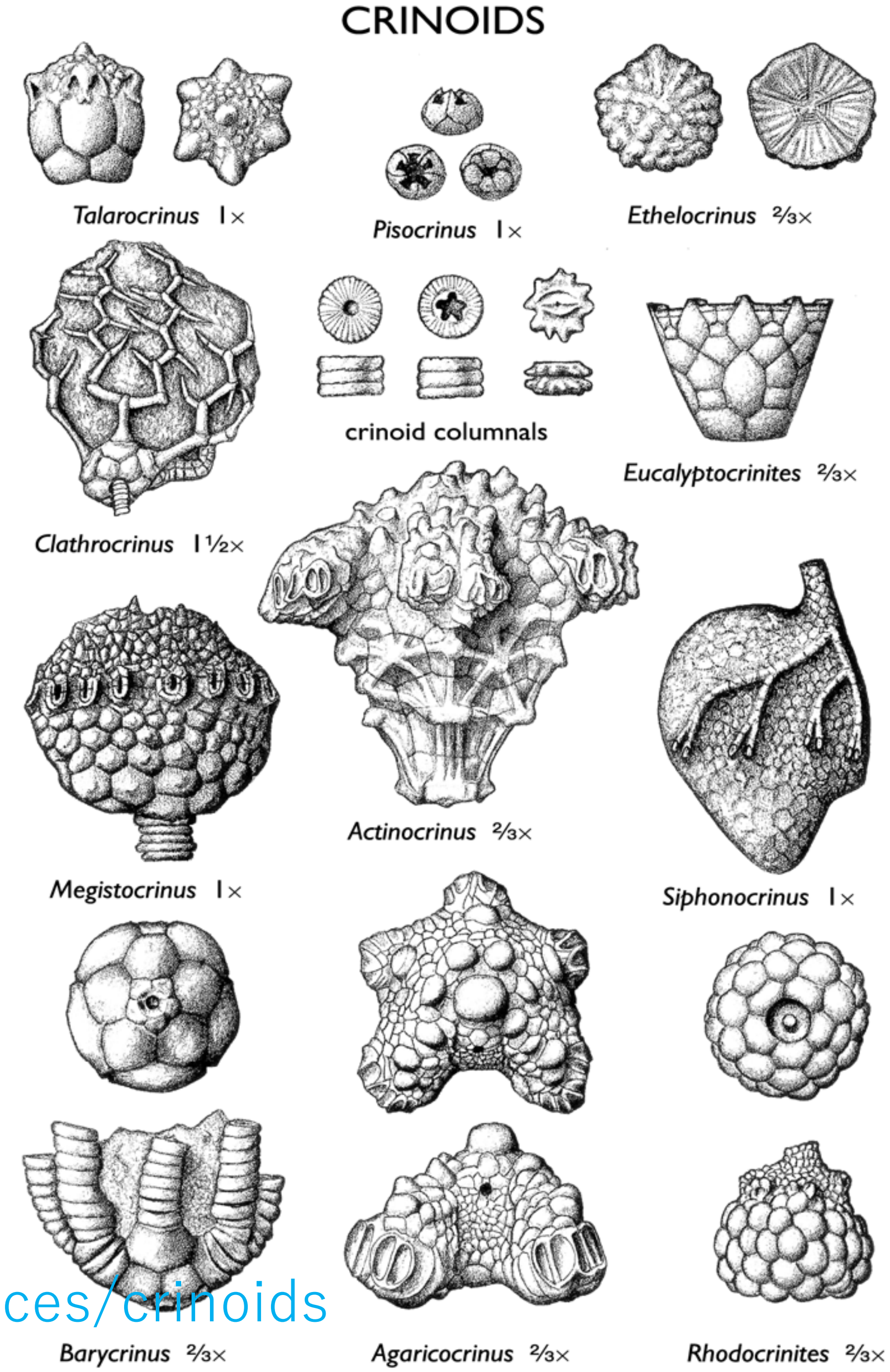
Lets check the fusulina samples!

Crinoid

Fusulina

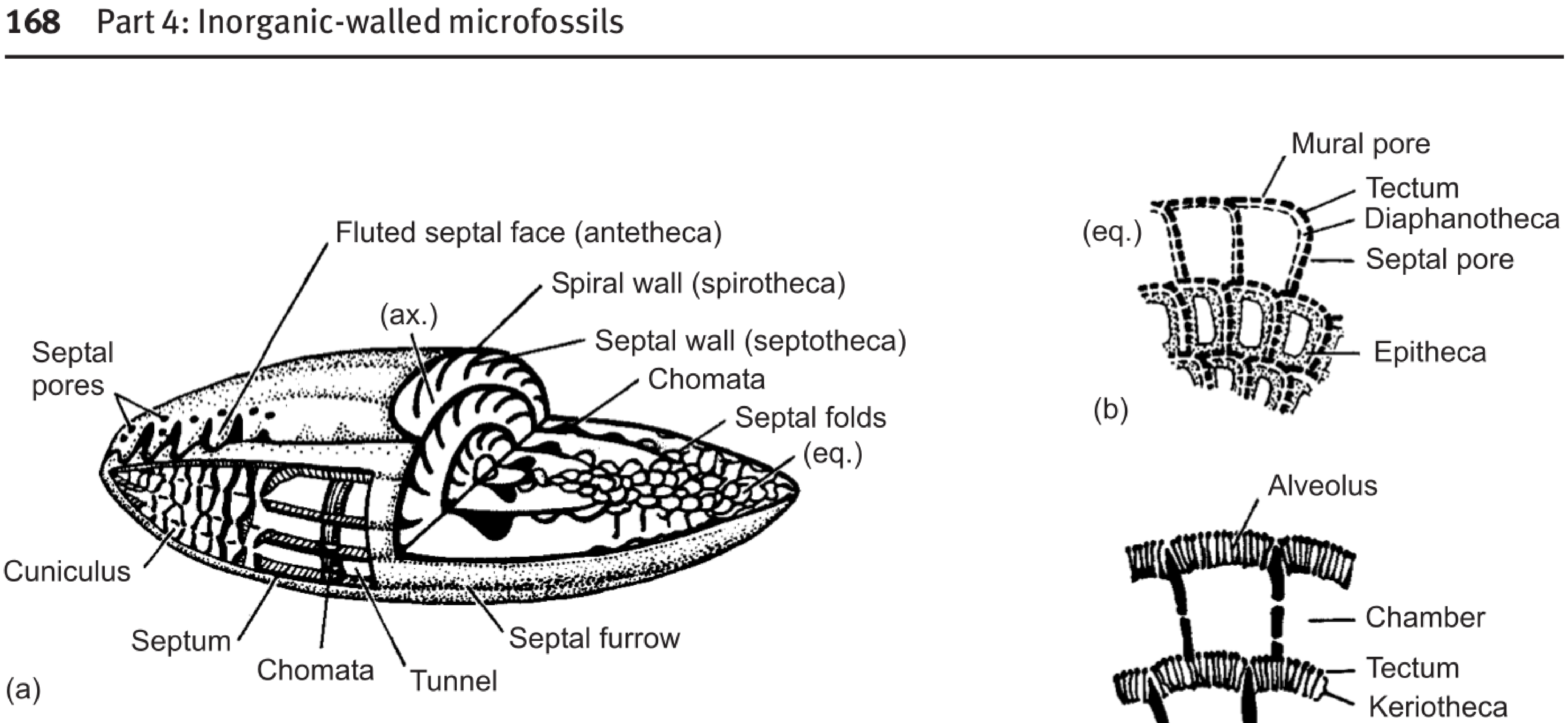


Stellarocrinus, (top) and *Brabeocrinus* (bottom), Pennsylvanian crinoids showing stems and calyxes, from Livingston County, Illinois.

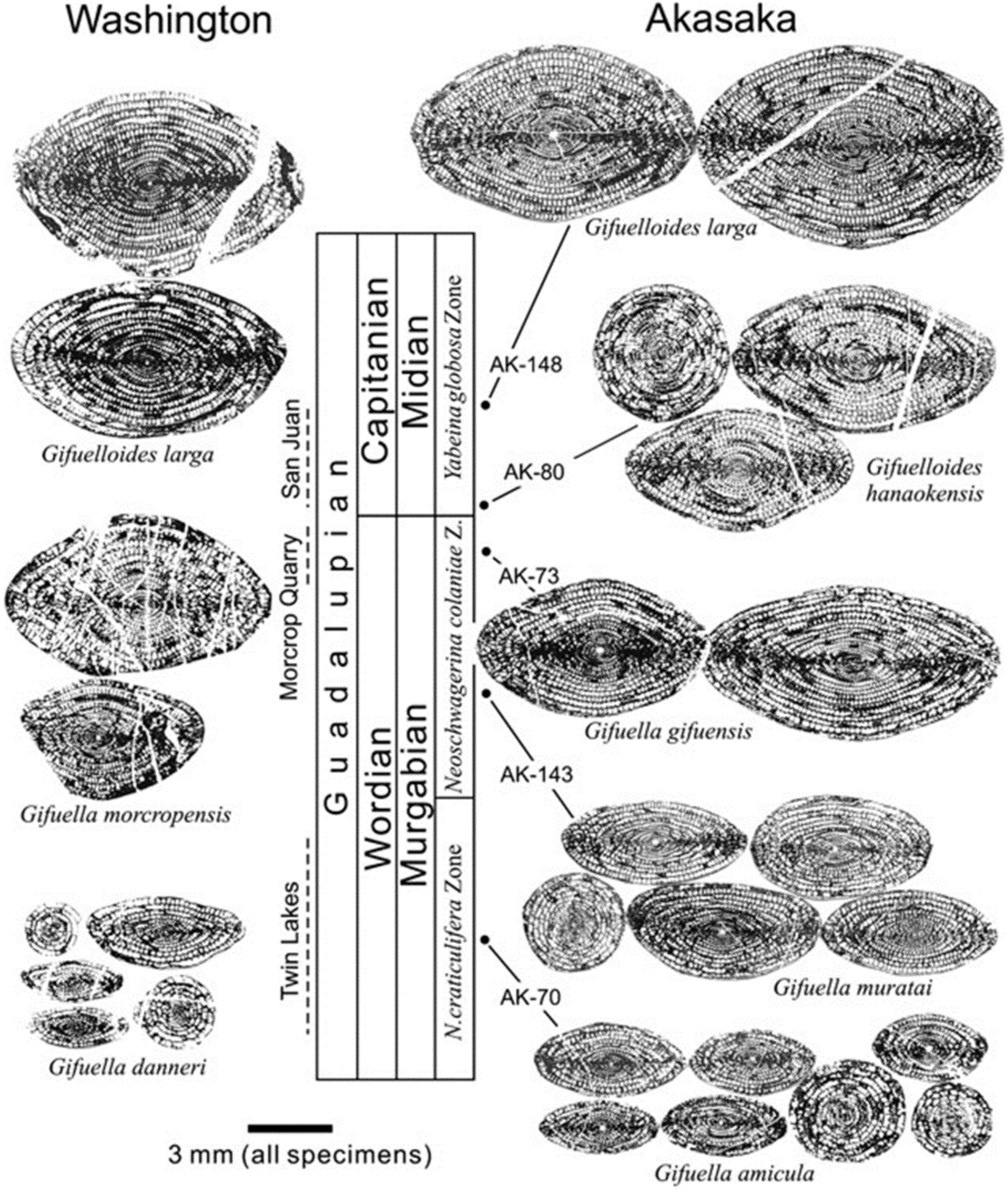


https://isgs.illinois.edu/outreach/geology-resources/crinoids

Fusulina inner structure
A kind of plankton



168 Part 4: Inorganic-walled microfossils

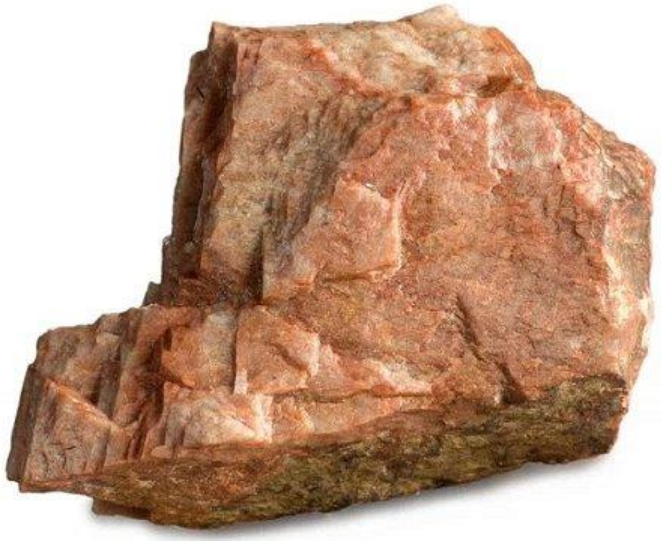

Washington
Akasaka
Gifuelloides larga
Gifuelloides larga
AK-148
Gifuelloides hanaokensis
AK-80
AK-73
Gifuella gifuensis
AK-143
Gifuella muratai
AK-70
Gifuella amicula
Gifuella morcropensis
Gifuella danneri
San Juan
Morcrop Quarry
Twin Lakes
Guadalupian
Capitanian
Wordian
Midian
Murgabian
Yabeina globosa Zone
Neoschwagerina colaniae Z.
N.craticulifera Zone
3 mm (all specimens)


Volcanic Rocks
Basalt
Andesite
Rhyolite
31. Mar
2012
浄土ケ浜流紋岩
Jodogahama Rhyolite
地学 4
Plutonic Rock
Gabbro
Diorite
Granite

Rock-Forming Minerals: Seven Sisters!!

Quartz

SiO_2



Potassium Feldspar

$KAlSi_3O_8$

Plagioclase Feldspar

$NaAlSi_3O_8$ - $CaAl_2Si_2O_8$

https://tesep.org.au/student-online-resources/rock-forming-minerals.html

Biotite

$(Mg,Fe,K,Al)Si_3O_{10}\ (OH)_2$

Amphibole

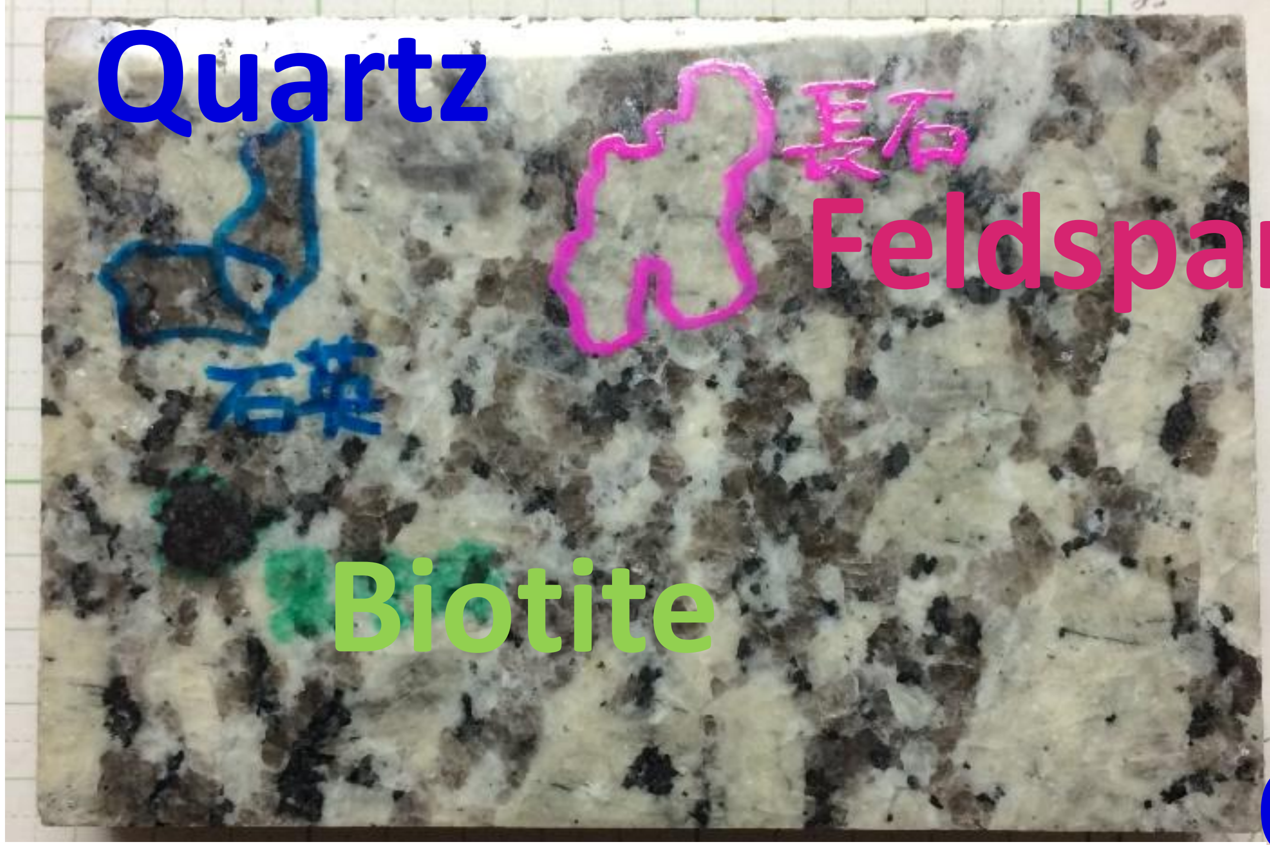
$(Mg,Fe,Ca,Na)Si_8O_{22}\ (OH)_2$

Pyroxene

$(Mg,Fe,Ca,Al)SiO_3$

Olivine

$(Mg,Fe)_2SiO_4$

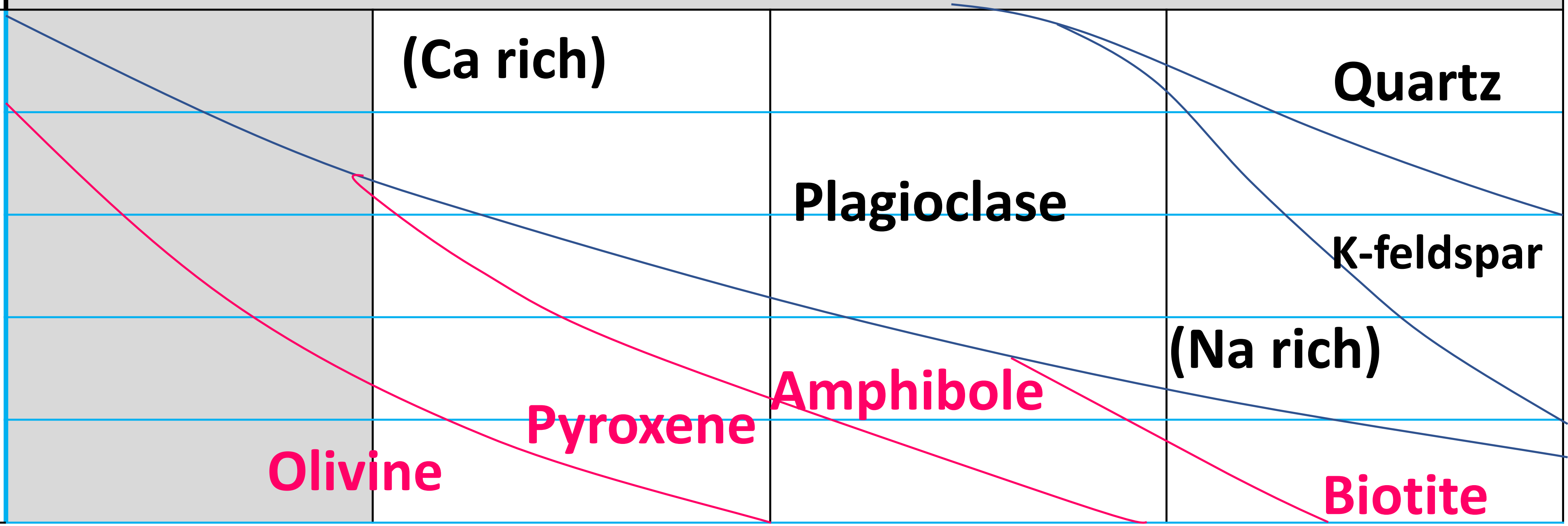

Quartz
石英
長石
Feldspar
Biotite


K-Feldspar
Quartz
Biotite
カリ長石
石英
(SiO_2)
カリ長石
$(KAlSi_3O_8)$
$(K(Mg,Fe)_3AlSi_3O_{10})$

Igneous Rock table (Y.Okamoto2018)

Volcanic Rock (Aphanitic Tex.)	Komatiite	**Basalt**	**Andesite**	**Rhyolite**
Plutonic Rock (Phaneritic Tex.)	Peridotite	**Gabbro**	**Diorite**	**Granite**
SiO_2(wt%)	Ultra Basic	Basic	Mid	Acid
		45	52	66

Major Rock forming minerals (Vol%)



FOSSILS IN THE LIMESTONE

$$CaCO_3(s) + CO_2(g) + H_2O(l) \rightarrow Ca(HCO_3)_2(aq)$$

The most common fossils in the limestone are corals (Fig. 1A), brachiopods (a type of shellfish) (Fig. 1B), snails (Fig. 1C) and crinoids (a relative of starfish) (Fig. 1D).

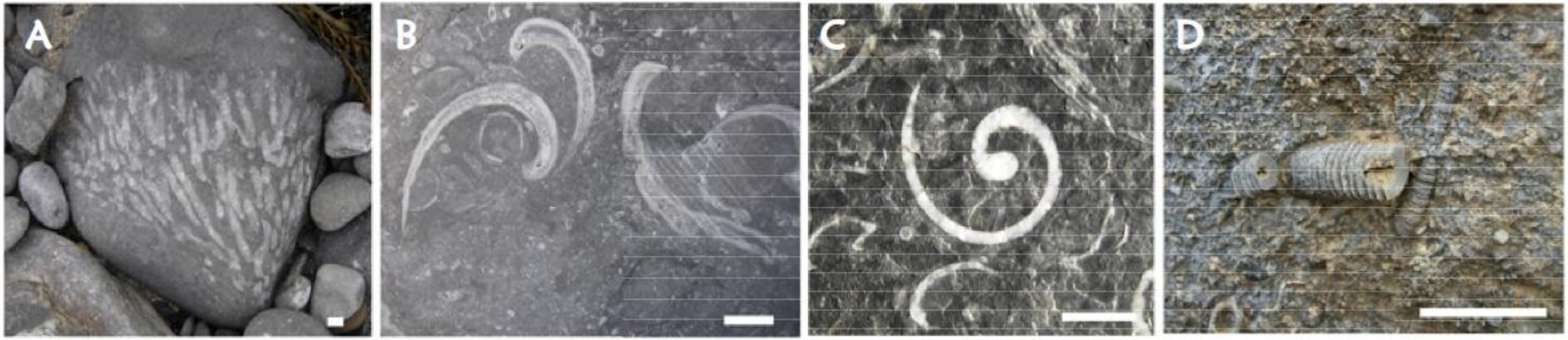
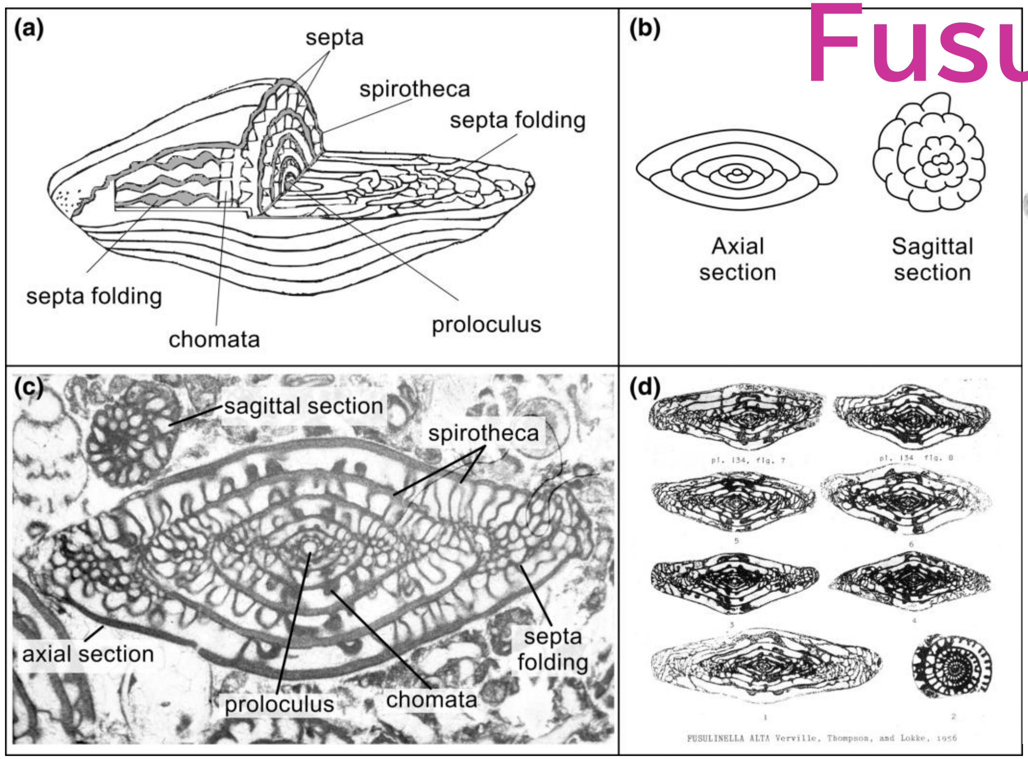


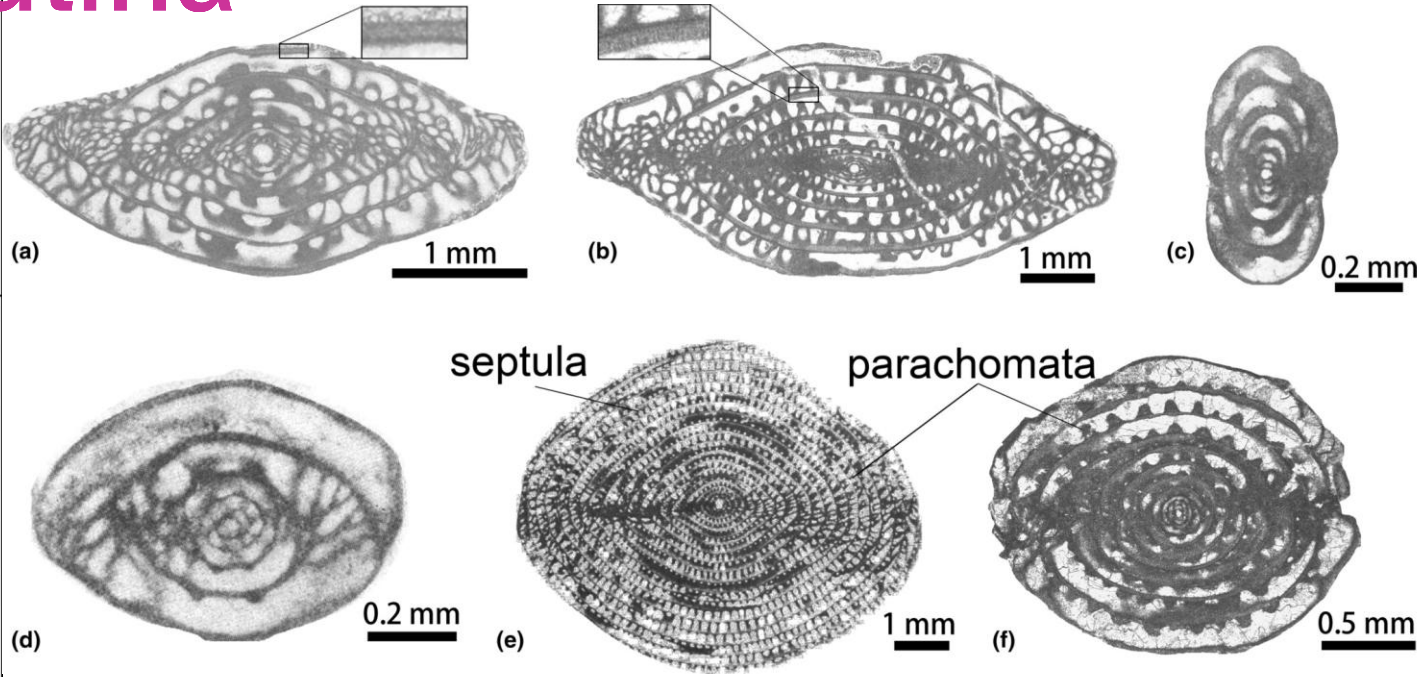
Fig. 1. Common fossils in the limestone, from left to right: corals, brachiopods, snails, and crinoids.

https://www.burrengeopark.ie/wp-content/uploads/2013/04/fossils_in_the_limestone1.pd

Fusulina



Fusulinid sketch and two image data sources. (a) Cutaway view of a schwagerinid fusulinid and its typical features of septation and endoskeleton, after Dunbar and Condra (1927). (b) Schematic diagram of the axial and sagittal section of a fusulinid fossil, after (Sheng et al., 1988). (c) A thin-slice photo of limestone-preserved fusulinids, with main characters illustrated. (d) Scanned image example of a piece of literature on fusulinids.



Typical images of each fusulinid family in the dataset. (a) Fusulina teilhardi, of Family Fusulinidae, showing spirotheca of three layers (tectum, transparent diaphanotheca and lower tectoria). (b) Schwagerina knightiformis, of Family Schwagerinidae, showing spirotheca of two layers (tectum and alveolar keriotheca). (c) Eostaffella hohsienica, of Family Ozawainellidae, showing small, umbilicate test. (d) Schubertella paramelonica, of Family Schubertellidae. (e) Neoschwagerina glintzboeckeli, of Family Neoschwagerinidae, with inflated fusiform test and distinct parachomata and septula. (f) Misellina megalocula, of Family Verbeekinidae, showing subspherical test and distinct parachomata.

https://rmets.onlinelibrary.wiley.com/doi/10.1002/gdj3.215

History of earth part I
Fossils and Paleozoic era

Yoshio Okamoto

SU Lecture

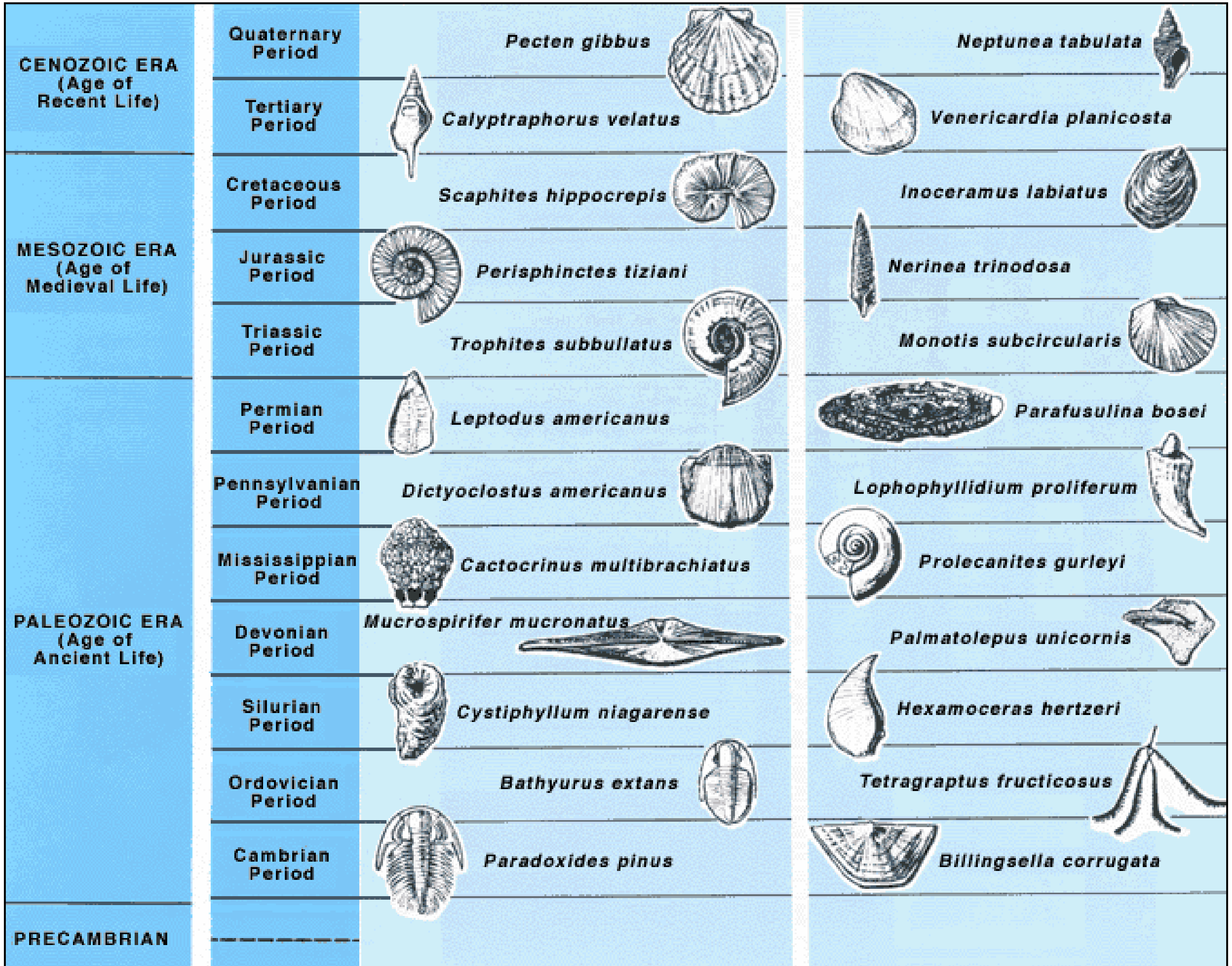
Fossils

- **Body fossils: shell, born, tissue**
- **Trace fossils: cast, foot print, trace etc.**
- **Hard part (shell or born): easy to remain**
- **Soft part (tissue): difficult to remain**

  → a few exception: ex. “Burgess shale”
- **Classification: biological feature (species change)**

  → now using molecular clocks etc.
- **Index fossils: to use confirming period**
- **facies-fossil: to use estimating environment**

Index Fossils (from wiki)



CENOZOIC ERA (Age of Recent Life)	Quaternary Period	*Pecten gibbus*	*Neptunea tabulata*
	Tertiary Period	*Calyptraphorus velatus*	*Venericardia planicosta*
MESOZOIC ERA (Age of Medieval Life)	Cretaceous Period	*Scaphites hippocrepis*	*Inoceramus labiatus*
	Jurassic Period	*Perisphinctes tiziani*	*Nerinea trinodosa*
	Triassic Period	*Trophites subbullatus*	*Monotis subcircularis*
PALEOZOIC ERA (Age of Ancient Life)	Permian Period	*Leptodus americanus*	*Parafusulina bosei*
	Pennsylvanian Period	*Dictyoclostus americanus*	*Lophophyllidium proliferum*
	Mississippian Period	*Cactocrinus multibrachiatus*	*Prolecanites gurleyi*
	Devonian Period	*Mucrospirifer mucronatus*	*Palmatolepus unicornis*
	Silurian Period	*Cystiphyllum niagarense*	*Hexamoceras hertzeri*
	Ordovician Period	*Bathyurus extans*	*Tetragraptus fructicosus*
	Cambrian Period	*Paradoxides pinus*	*Billingsella corrugata*
PRECAMBRIAN			

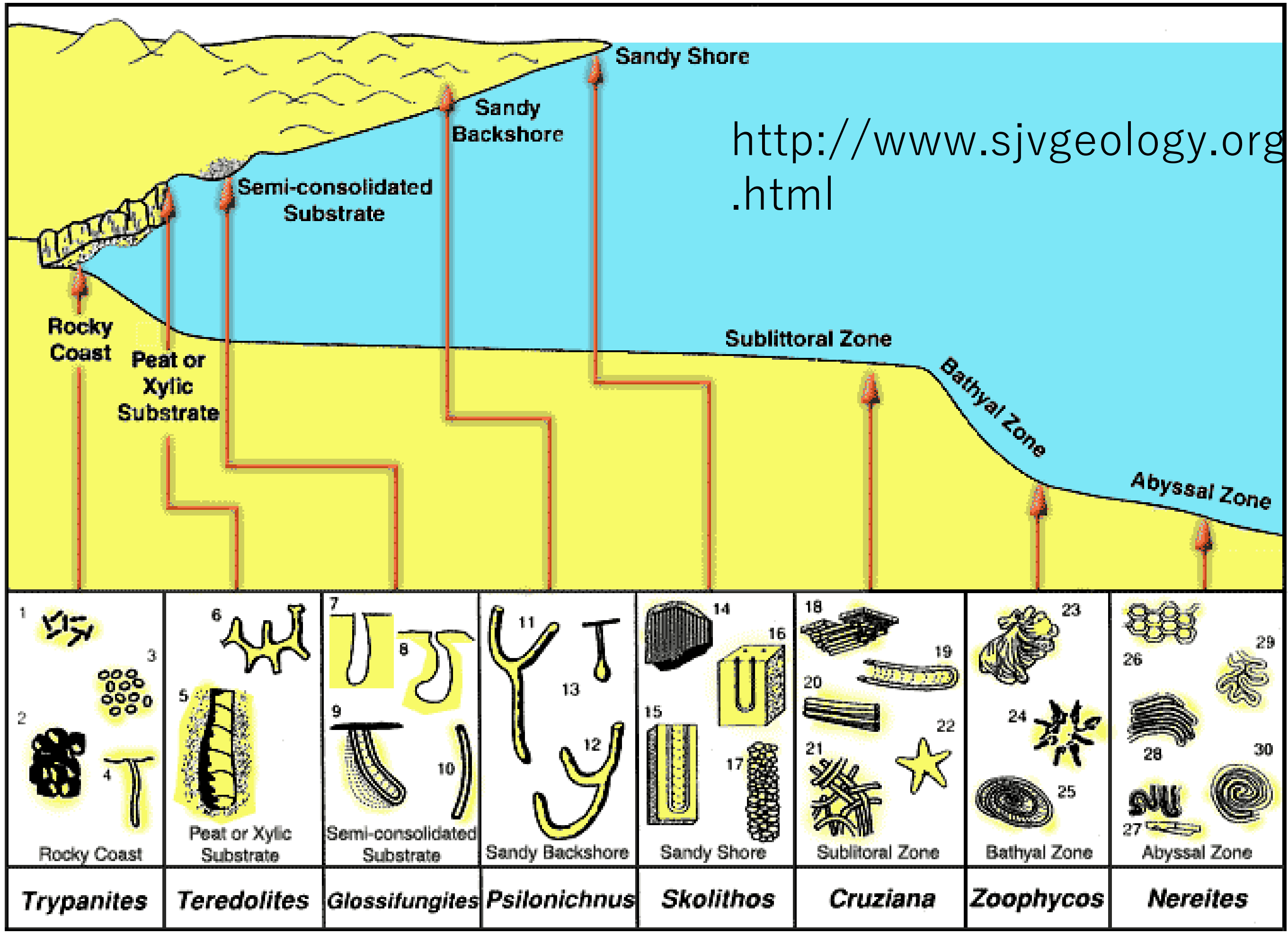
Facies Fossils

- **Coral**: warm sea, shallow, transparent (sun light) etc.
- **Dinosaurs**: warm land, rich plants and animals etc.
- **Peat**: cool swamp, fresh water
- **Coal**: tropical forest, fresh water
- **Bivalves**: sea / fresh water, depth of water etc.
- **Pollen**: climate(warm / cold), land area etc.

Cambrian trace fossils including Rusophycus, made by a trilobite

Trace fossils as facies fossils

http://www.sjvgeology.org/geology/glossary.html



after Seilacher image from http://research.eas.ualberta.ca/ichnology/

Distribution of Common Marine Ichnofacies

Typical trace fossils include: *1) Caulostrepsis; 2) Entobia; 3) echinoid borings; 4) Trypanites; 5) Teredolites; 6) Thalassinoides; 7, 8) Gastrochaenolites or related genera; 9) Diplocraterion (Glossifungites); 10) Skolithos; 11,12) Psilonichnus; 13) Macanopsis; 14) Skolithos; 15) Diplocraterion; 16) Arenicolites; 17) Ophiomorpha; 18) Phycodes; 19) Rhizocorallium; 20) Teichichnus; 21) Planolites; 22) Asteriacites; 23) Zoophycos; 24) Lorenzinia; 25) Zoophycos; 26) Paleodictyon; 27) Taphrhelminthopsis; 28) Helminthoida; 29) Cosmorhaphe; 30) Spirorhaphe.*

Mineralized fossils

An ammonite replaced with opal and pyrite

https://s-media-cache-ak0.pinimg.com/originals/84/52/49/84524997e1ceace0ada41df5651a0427.jpg

Petrified wood

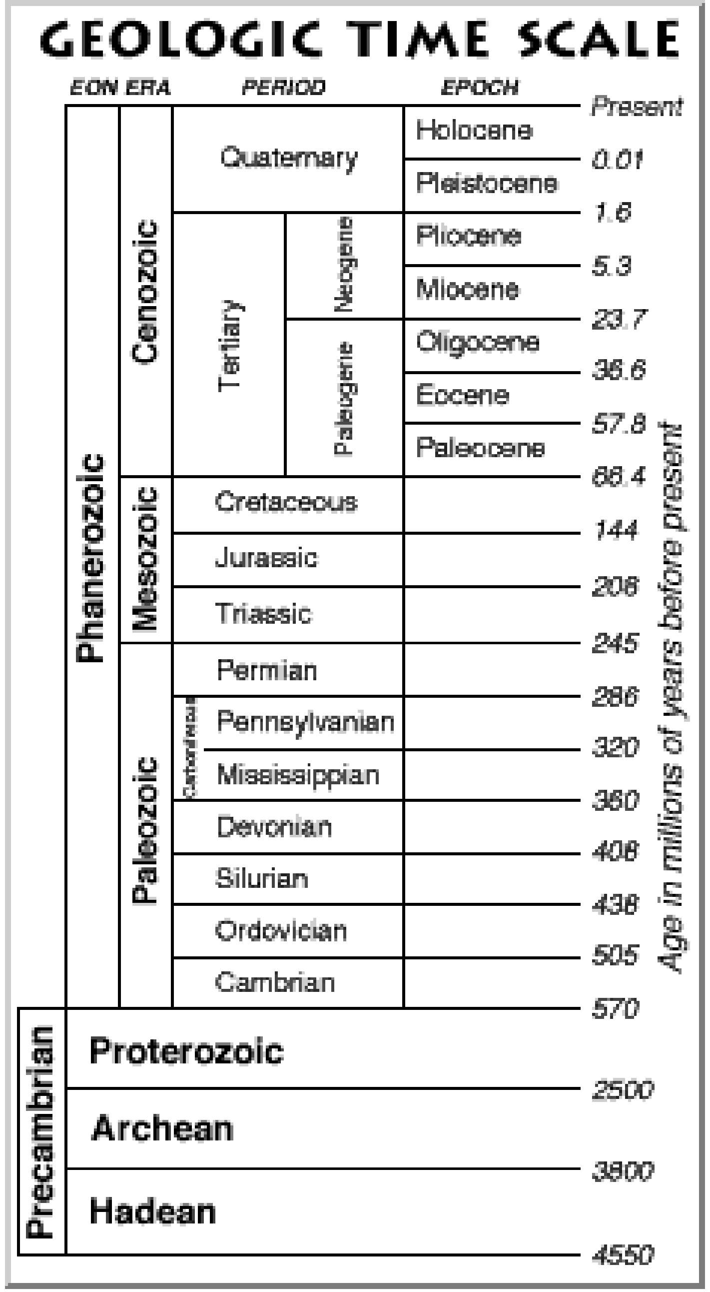
http://petrifiedwoodmuseum.org/Images/Permineralization560.jpeg

http://www.kiseki-jp.com/photo-

Silica-filled Vicarya

http://www.chiba-muse.or.jp/
NATURAL/ex_old/special_ex/2007kaseki/imagekaseki/vicarya01.jpg

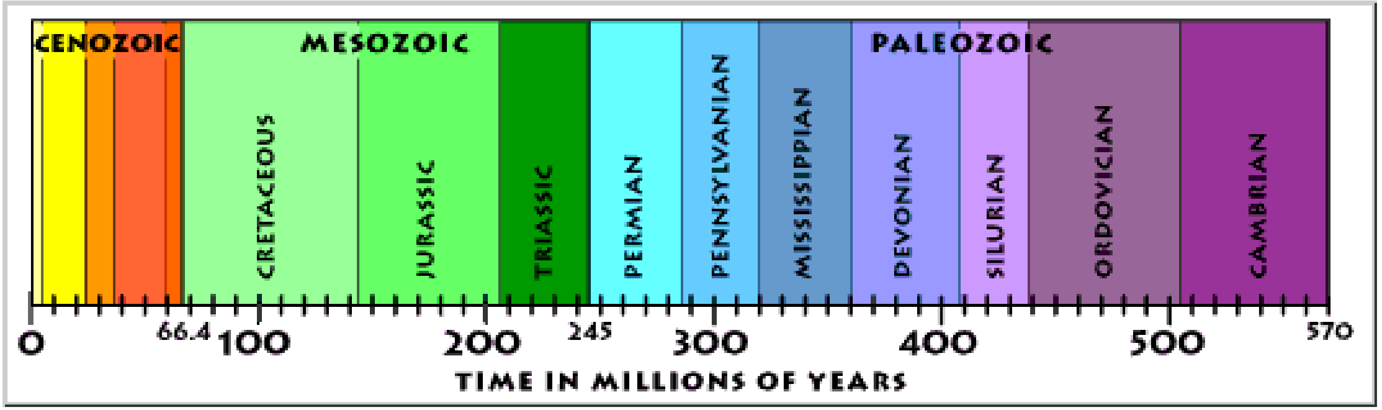
Geologic Time Scale

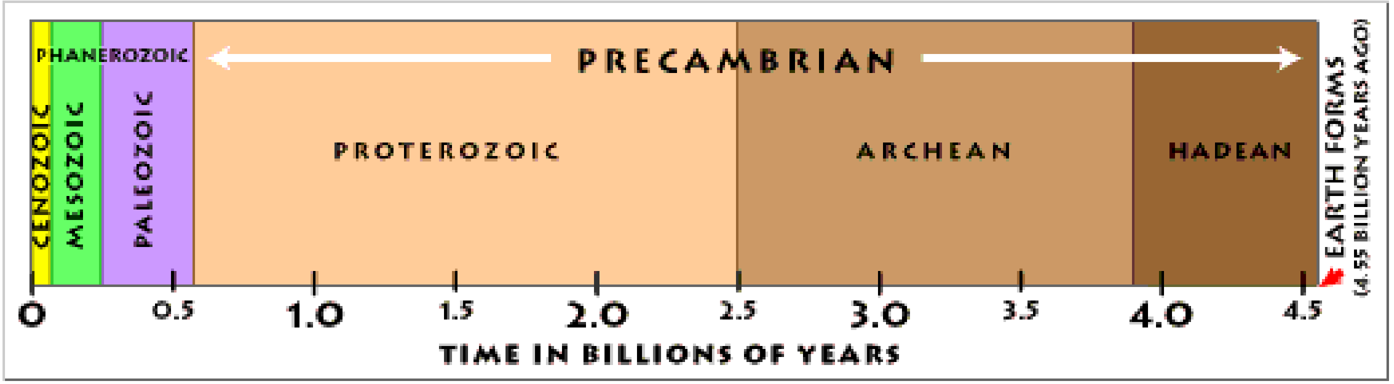


GEOLOGIC TIME SCALE

EON	ERA	PERIOD		EPOCH	Age in millions of years before present
					Present
Phanerozoic	Cenozoic	Quaternary		Holocene	0.01
				Pleistocene	1.6
		Tertiary	Neogene	Pliocene	5.3
				Miocene	23.7
			Paleogene	Oligocene	36.6
				Eocene	57.8
				Paleocene	66.4
	Mesozoic	Cretaceous			144
		Jurassic			208
		Triassic			245
	Paleozoic	Permian			286
		Carboniferous	Pennsylvanian		320
			Mississippian		360
		Devonian			408
		Silurian			438
		Ordovician			505
		Cambrian			570
Precambrian	Proterozoic				2500
	Archean				3800
	Hadean				4550

Major biological changes
Eon → era → period → epoch





Paleozoic era (543Ma to 225Ma)

- Invertebrates

- Trilobite (early stage)
- Fusulina (late stage)

- vertebrate
- armored fish

Cambrian

- Cambrian explosion!

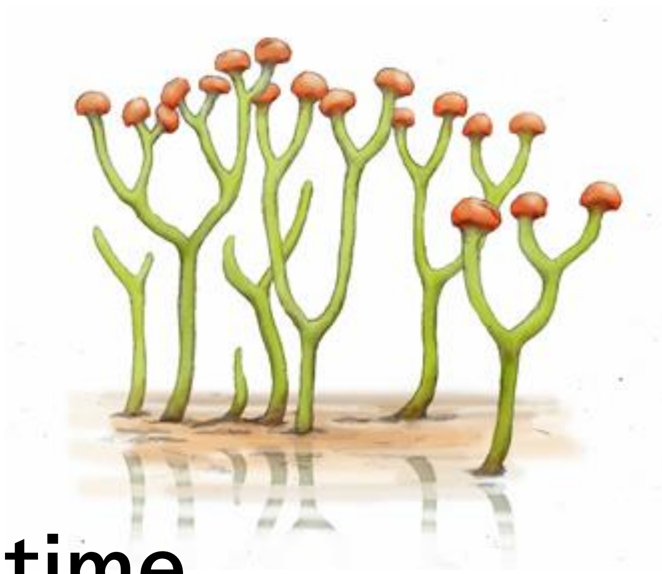
- Many Invertebrates suddenly appeared on this planet
- Some have eyes!

- Trilobite kingdom: an armored arthropod

- But, “Burgess shale” is rediscovered in 1980’s
- “Wonderful life” revolution kicked off!

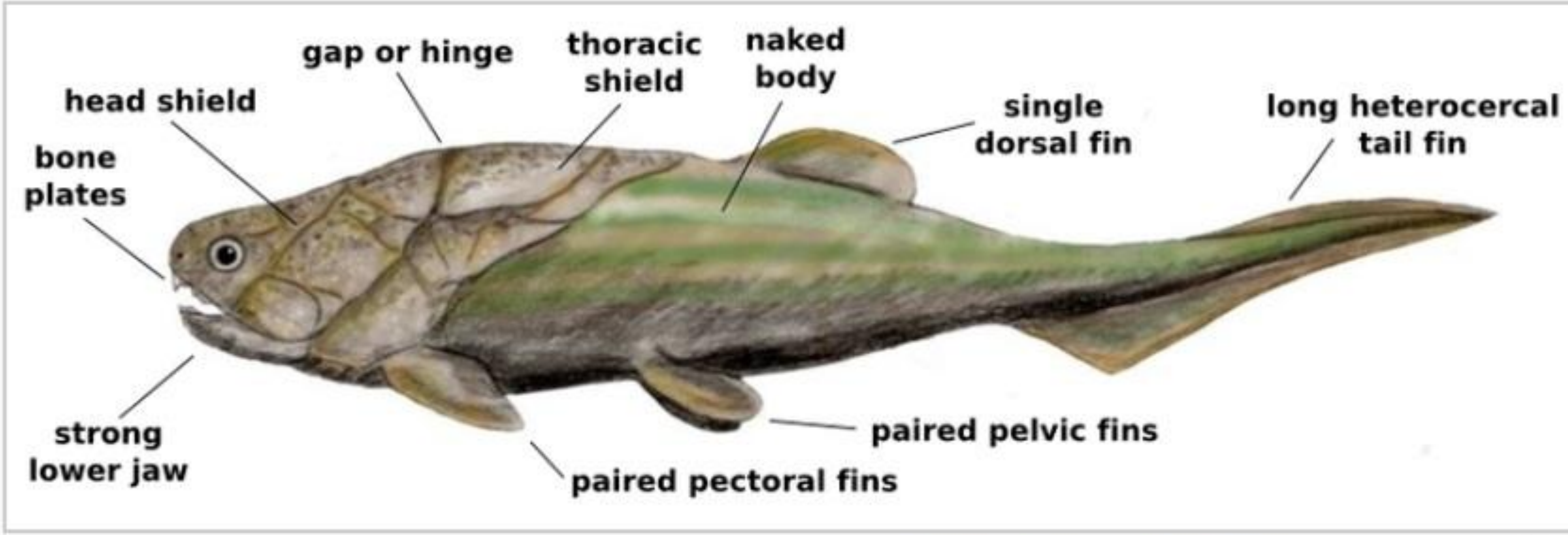
Ordovician to Silurian

- Graptolites are appeared.
- Very strange animal?
- Brachiopod
- Plants landed at the first time (Cooksonia)



Devonian

- Fish kingdom “Armored fish”
- The first land-living arthropods(spider?)



External anatomy of the placoderm *Coccosteus decipiens*

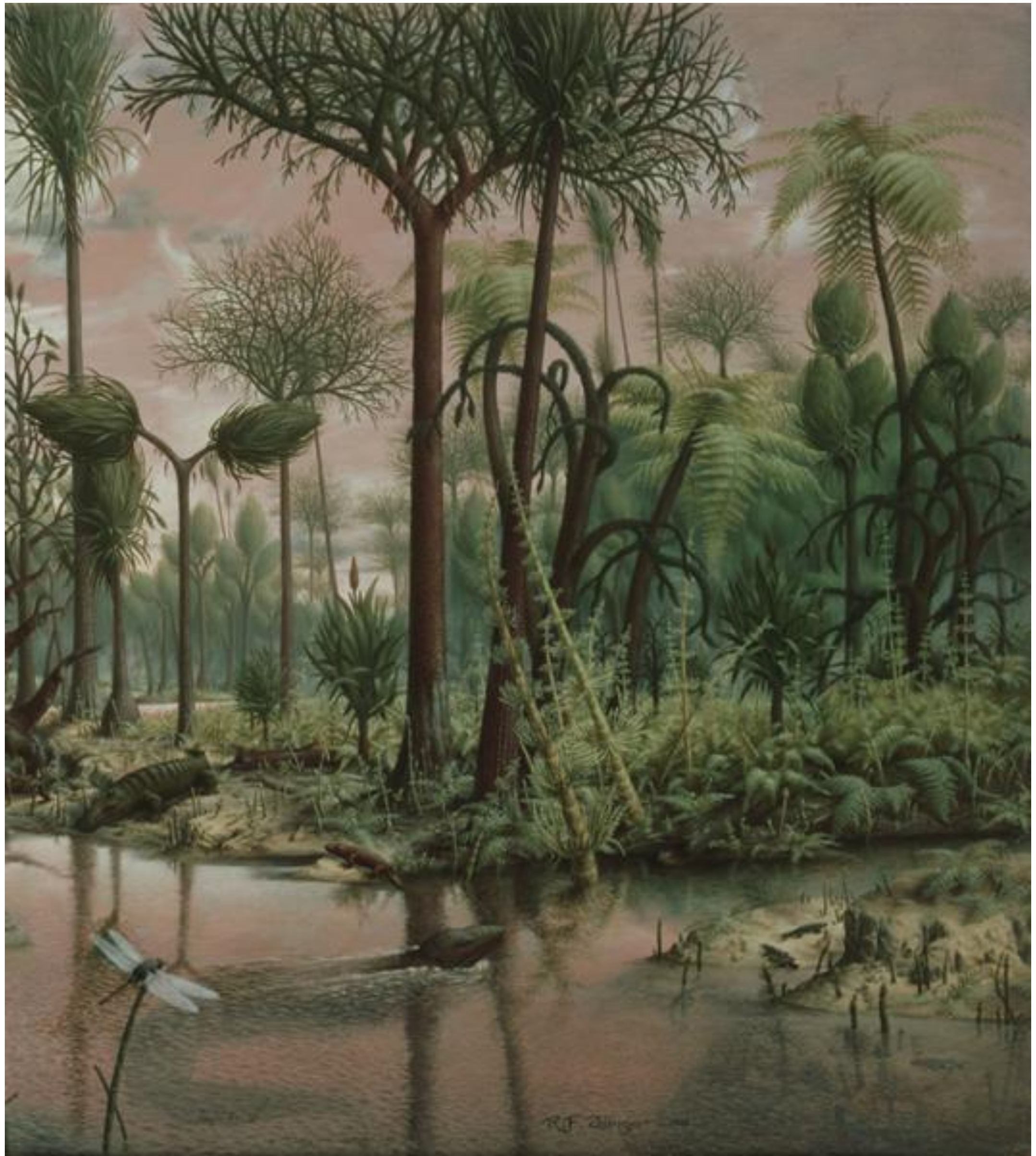
http://blogs.nobl.k12.in.us/hurstes/files/2014/02/image-281b4na.jpg https://s-media-cache-ak0.pinimg.com/originals/95/2c/47/952c47cd521ab0463c99ddd555d92a9d.jpg

Carboniferous

- Big insects and thick forest

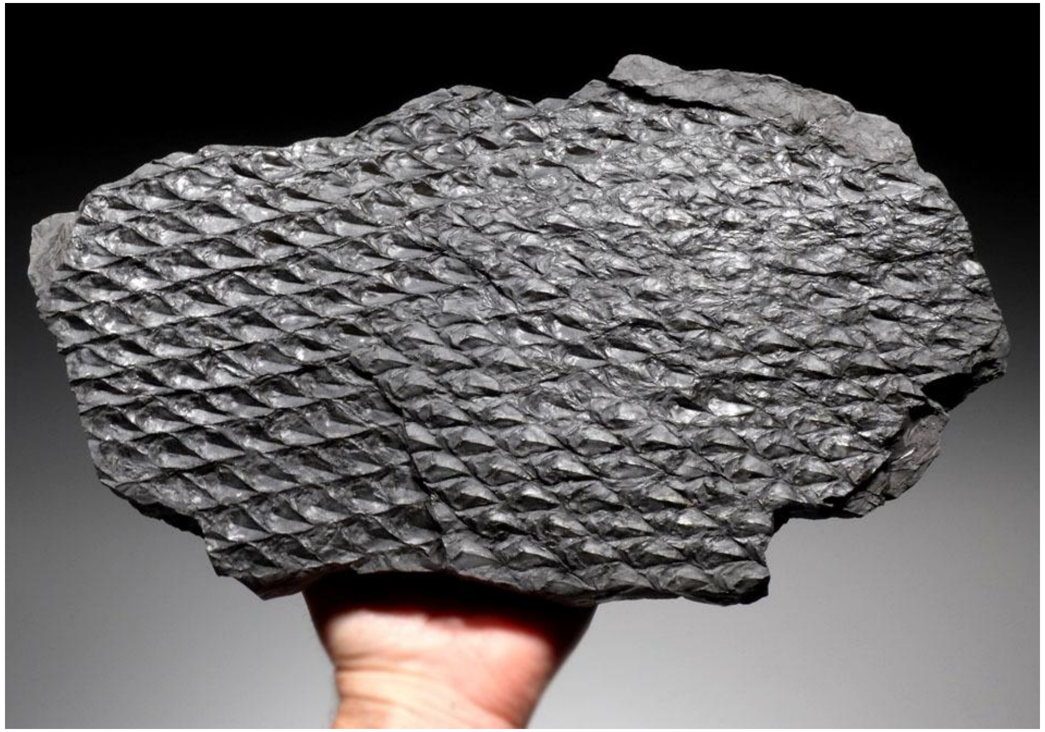
- Fern plants forest
- Later, turn to coal.

- Fusulina appeared and evolved



https://s-media-cache-ak0.pinimg.com/originals/04/22/08/042208100c561c688536a8e08aae0650.jpg

https://cdn6.bigcommerce.com/s-fme25/products/578/images/8546/pl072b__53754.1433981988.1280.1280.jpg?c=2



http://www.fossilguy.com/sites/ambridge/ambridge-fossil-

http://animalia-life.club/openphoto.php?img=http://i.imgur.com/MjEI5hk.jpg

http://greaterancestors.com/wp-content/uploads/2013/06/cucaracha_fosil.jpg

http://2.bp.blogspot.com/_rNMOlewSvvM/TOPQ_oOu0zI/AAAAAAAAAGCM/PG35Qn0o9MQ/s400/bug1.JPG

Giant centipede

Giant Cockroach

Giant Dragonfly

Why this period insects so big?

- Rich O_2
- No natural enemy
- What is the natural enemy for insects?

Permian

- Fusulina kingdom

- Ice age was coming

- The continents began to moving!
(Pangea began to breaking)

P/T boundary

- **Most powerful extinction**

- **Over 93% sea creatures are disappeared.**

P-T boudary

Permian
-Triassic

Most powerfull Extinction

Trilobite

Fusulina

sea organic

93%＜？

Marine extinctions	Genera extinct	Notes
Marine invertebrates		
Foraminifera	97%	Fusulinids died out, but were almost extinct before the catastrophe
Radiolaria (plankton)	99%[43]	
Anthozoa (sea anemones, corals, etc.)	96%	Tabulate and rugose corals died out
Bryozoans	79%	Fenestrates, trepostomes, and cryptostomes died out
Brachiopods	96%	Orthids and productids died out
Bivalves	59%	
Gastropods (snails)	98%	
Ammonites (cephalopods)	97%	
Crinoids (echinoderms)	98%	Inadunates and camerates died out
Blastoids (echinoderms)	**100%**	May have become extinct shortly before the P–Tr boundary
Trilobites	**100%**	In decline since the Devonian; only 2 genera living before the extinction
Eurypterids ("sea scorpions")	**100%**	May have become extinct shortly before the P–Tr boundary
Ostracods (small crustaceans)	59%	
Fish		
Acanthodians	**100%**	In decline since the Devonian, with only one living family

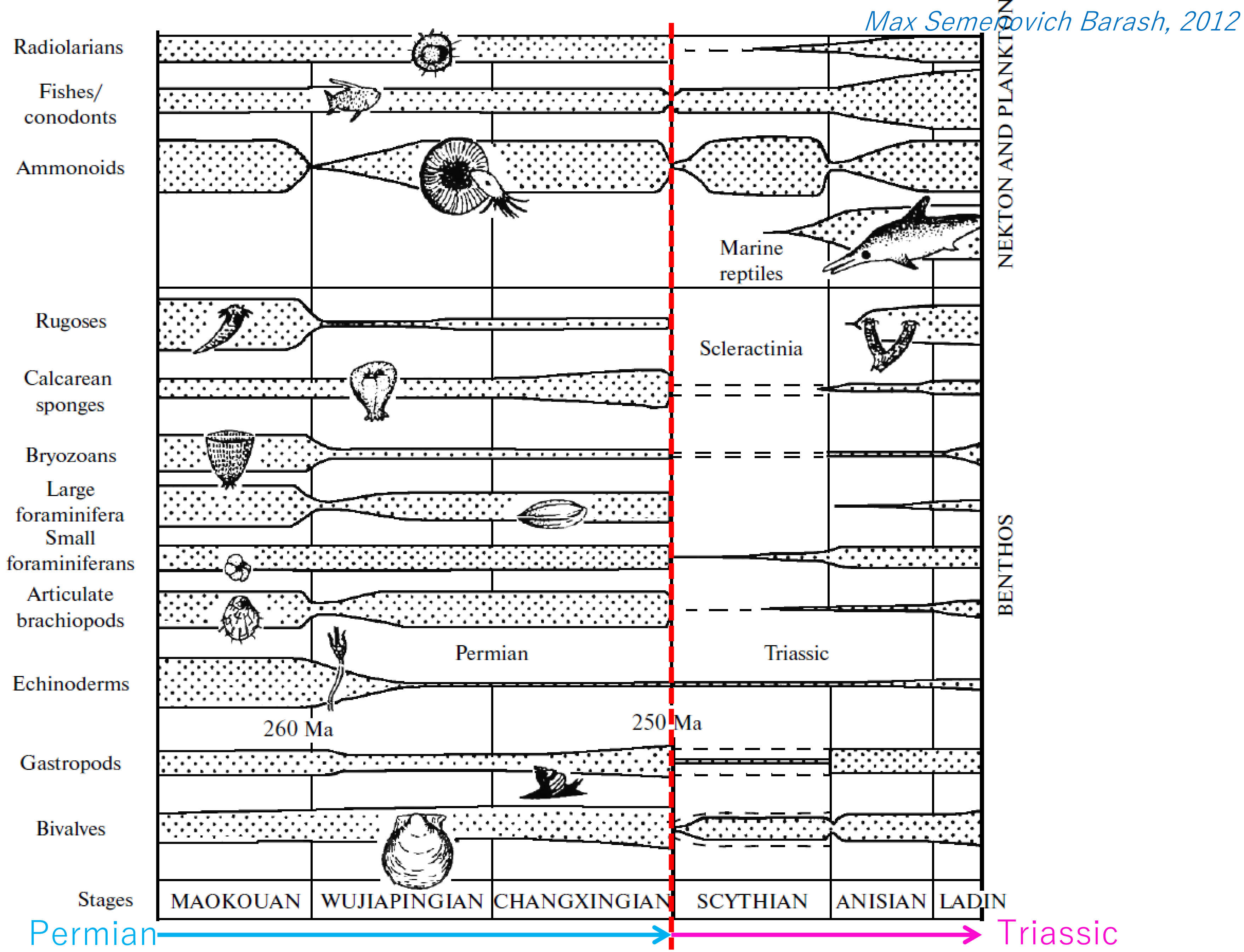
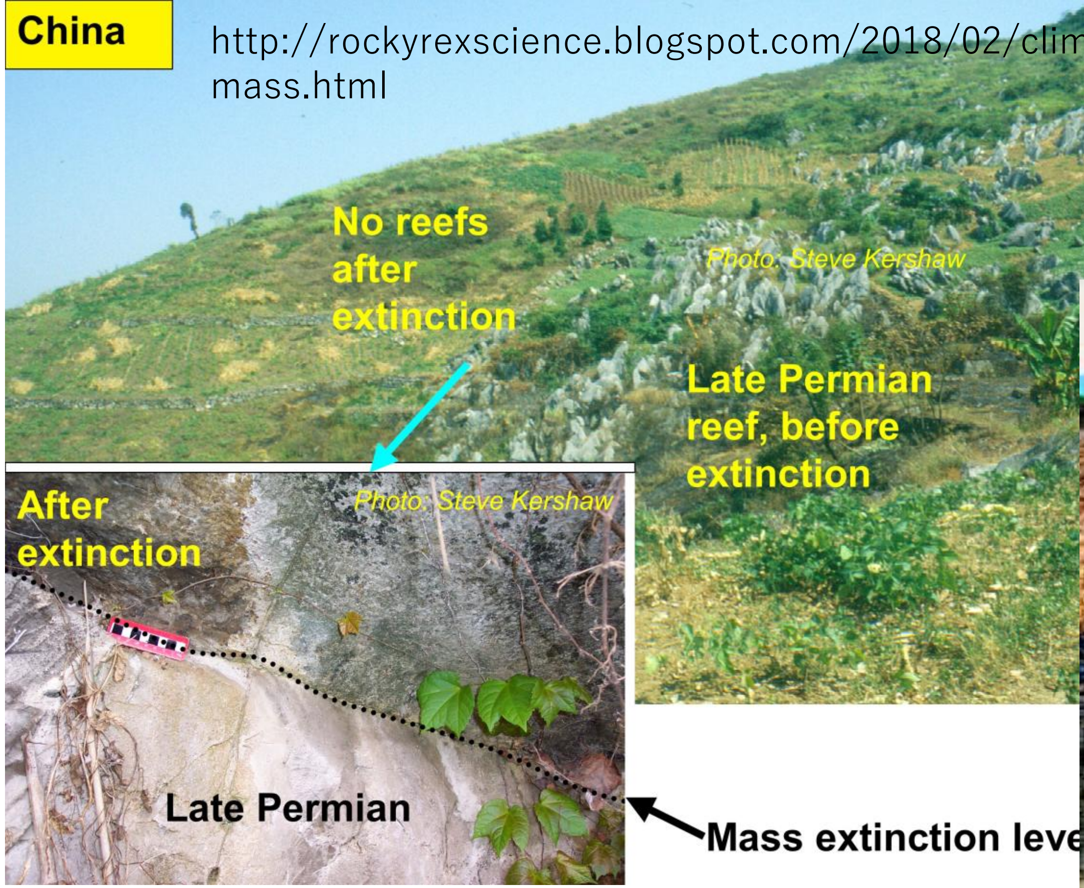
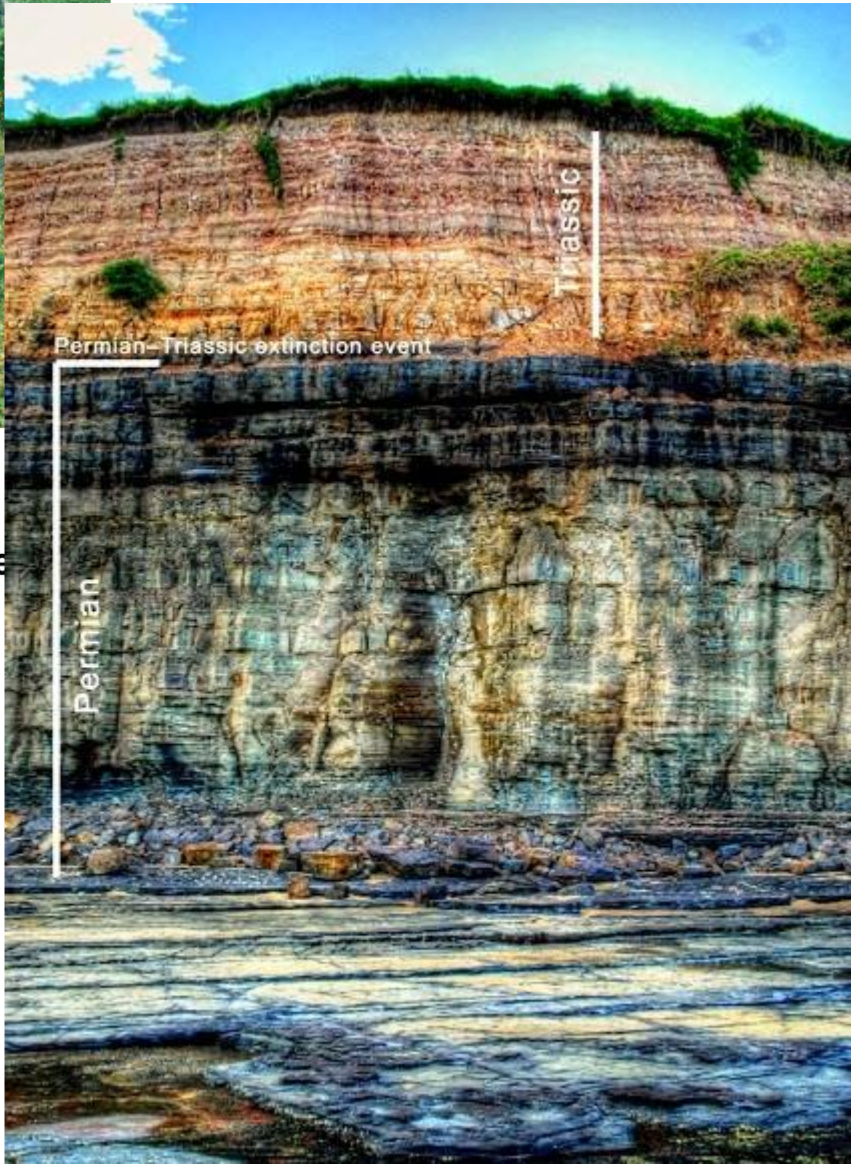


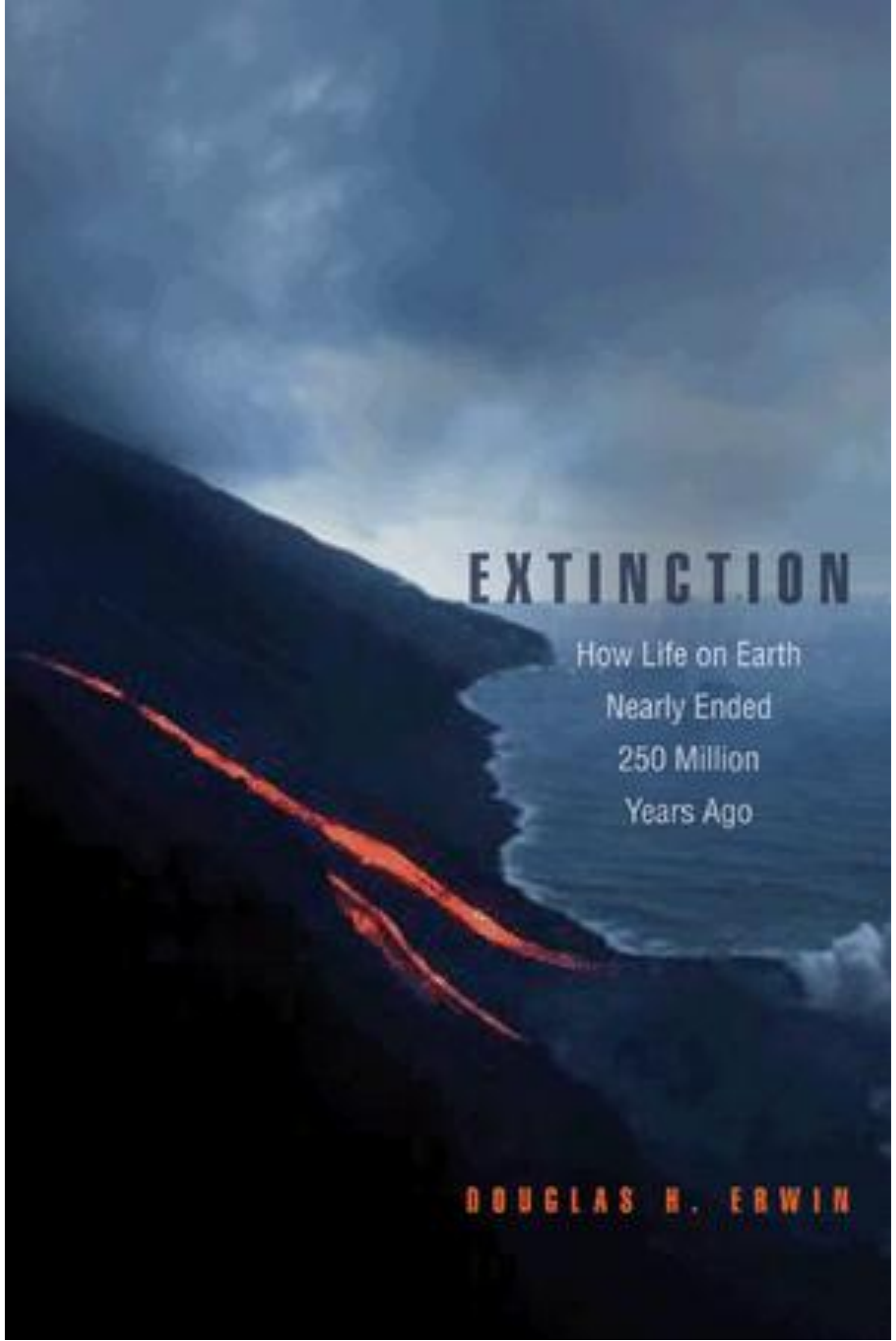
Fig. 1. Development of some plankton, nekton, and benthos representatives during the Late Permian to Early Triassic (after [16], with modifications). The dashed lines denote the "temporarily disappeared" taxa.

http://rockyrexscience.blogspot.com/2018/02/climate-change-link-with-mass.html





This place is located at Austinmer, a coastal suburb between Sydney and Wollongong.
Photo Credit: Allosauroid Enthusiast
http://www.geologyin.com/2015/12/permian-triassic-boundary.html#zDRId3Ri0OktGyPU.99 Follow us: @GeologyTime on Twitter


EXTINCTION

How Life on Earth Nearly Ended 250 Million Years Ago

DOUGLAS H. ERWIN

Causes:

1) Impact event (external)

2)Volcanism

3)Methane hydrate gasification

4)Anoxia

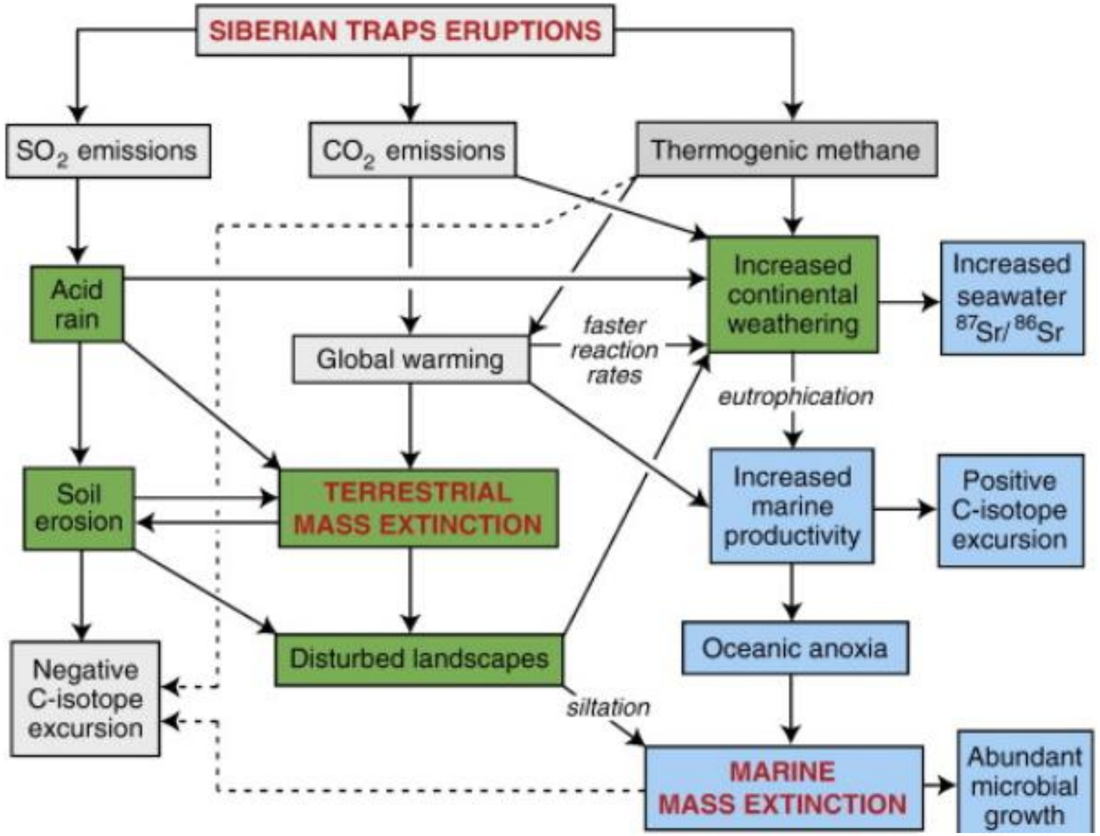
5)Hydrogen sulfide emissions

6)The supercontinent Pangaea

7)Microbes

Etc. (by Wikipedia)

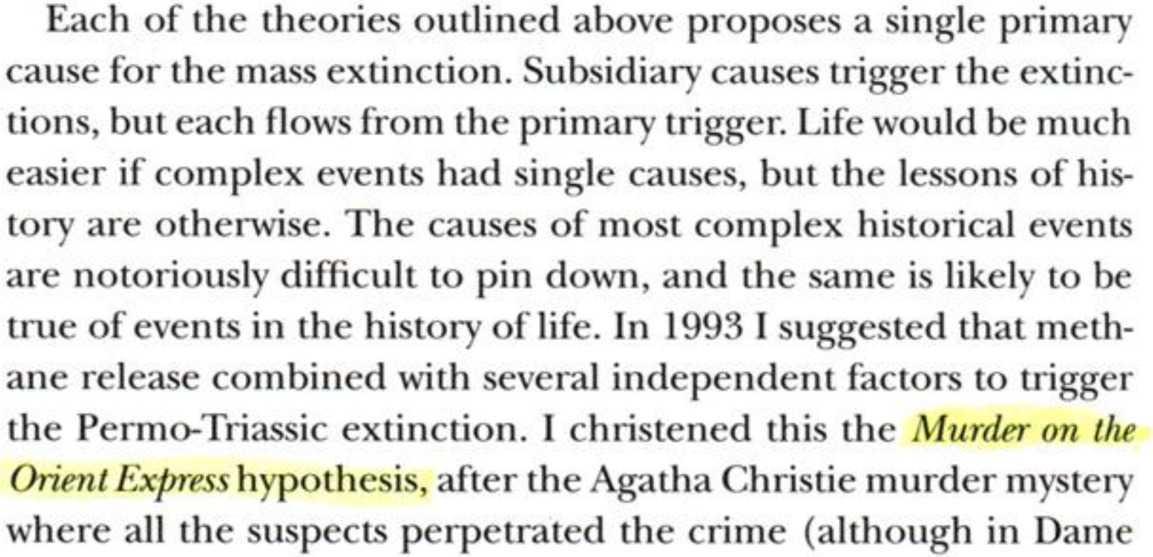
Combination of all causes?
“?????” hypothesis



http://palaeo.gly.bris.ac.uk/PTB/causes.html
One of most recent hypothesis of a super volcanic eruption in Siberia

Other, older, explanations for the PTME, are sur

1. Impact: Evidence for impact at the Permo-Tri
presented by Becker et al. (2004) - a possible c
indicators, but these have been disputed.
2. Climate change was also noted in earlier yea
and glaciation sometimes mentioned, and more c
made that climates became steadily warmer. The
Permian is widely accepted (Joachimski et al. 20
this on its own could have caused the profound
3. Supercontinent fusion was one of the first su
and Laurasia moved closer and drove together in
supercontinent Pangea was formed. This had ma
the loss of inland seas, increase of the inland, c
and associated reduction in endemicity, as regio
land and in shallow seas mixed together.
4. Glaciation had been suggested, perhaps caus
northern and southern portions of Pangaea over
build-up of ice sheets. This idea is though much
limited.



Each of the theories outlined above proposes a single primary cause for the mass extinction. Subsidiary causes trigger the extinctions, but each flows from the primary trigger. Life would be much easier if complex events had single causes, but the lessons of history are otherwise. The causes of most complex historical events are notoriously difficult to pin down, and the same is likely to be true of events in the history of life. In 1993 I suggested that methane release combined with several independent factors to trigger the Permo-Triassic extinction. I christened this the *Murder on the Orient Express* hypothesis, after the Agatha Christie murder mystery where all the suspects perpetrated the crime (although in Dame