The Early Triassic of Svalbard - a new look at old bones

Prof. Jørn H. Hurum

Natural History Museum, University of Oslo, Norway

Spitsbergen Jurassic Research group, first focus on unknown Upper Jurassic faunas

2004-first dig

2006-mapping

2007-first monster dig

2008-second monster (Predator X)

2009- nearly complete plesiosaur and ichthyosaur

2010-two ichthyosaurs one plesiosaur

2011-six skeletons excavated

2012-last excavation in the Jurassic, six skeletons

Background: the Jurassic project, fieldwork 2004-12

Photo: Lene Liebe

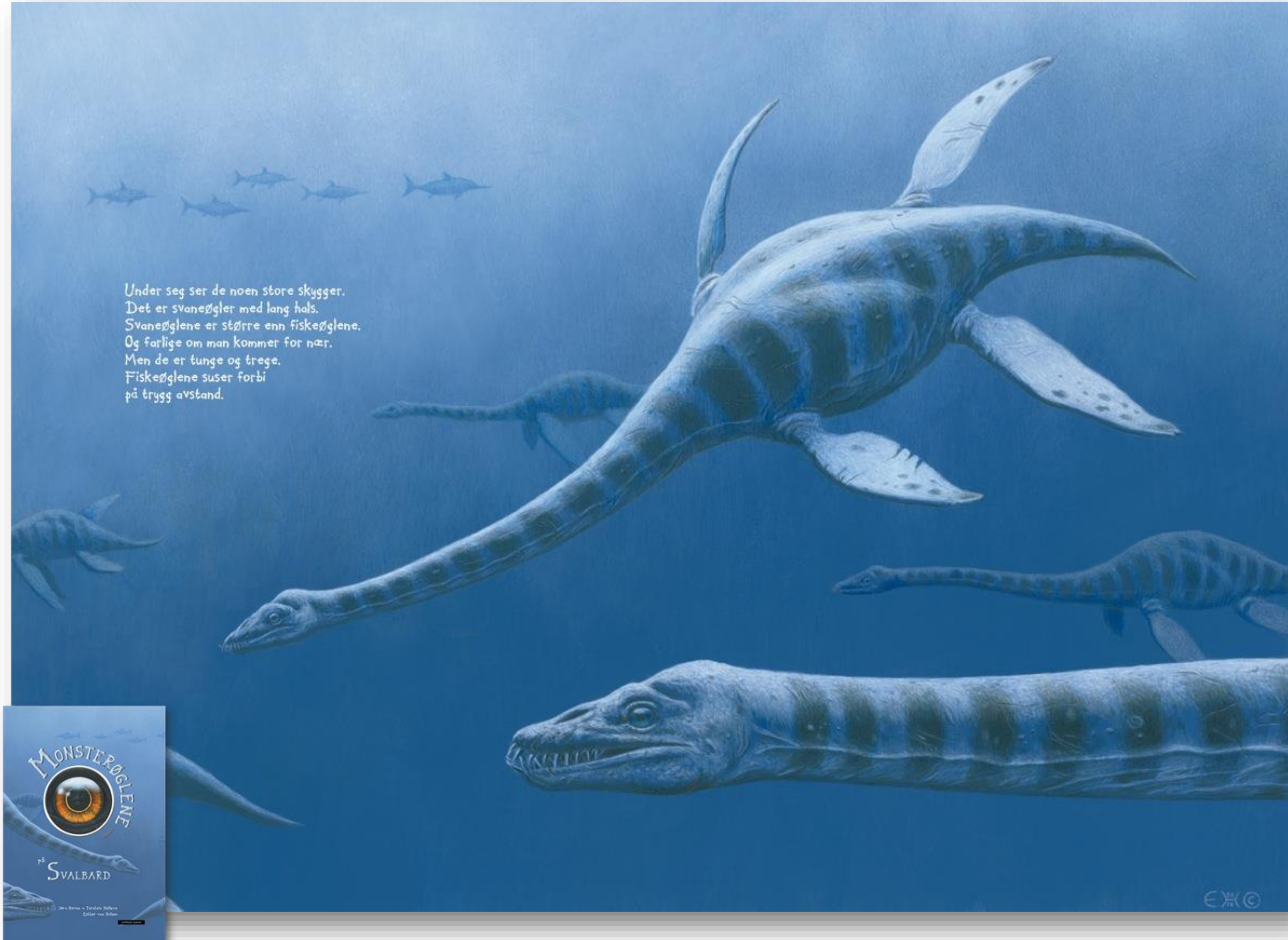
Cryopterygius kristiansenae

Øglene dykker under vann igjen.
Det er her de lever livet sitt.

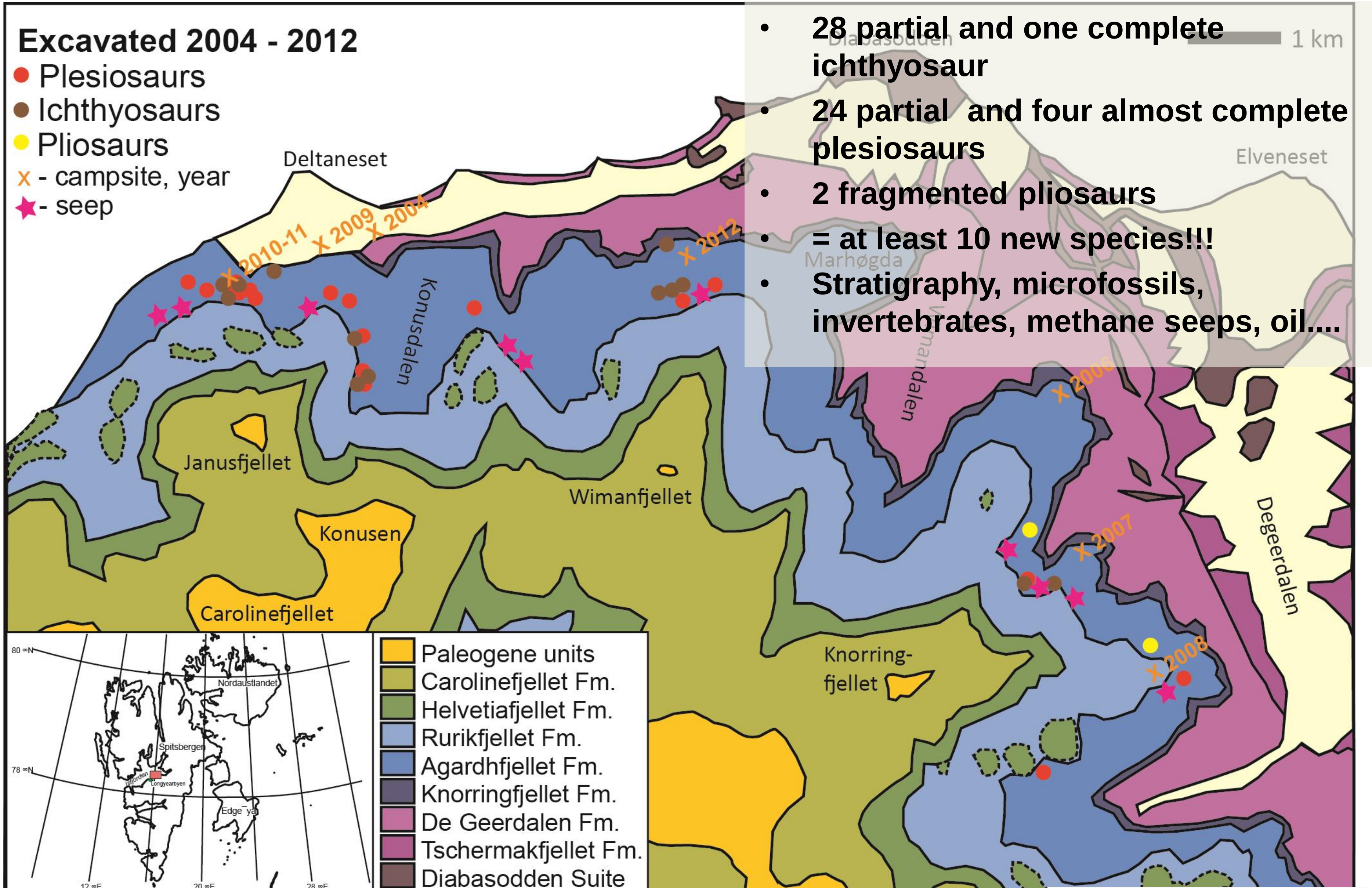
Den største av dem er hannen i flokken.
Kroppen hans er full av arr
etter kamper med andre hanner.
Han har slåss for å være leder for flokken.
De andre dyra er bare hunner.
Hannene har Arrkjempe jagd bort.

En av hunnene er så ung
at hun ikke har fått unger ennå.
Det har de tre andre.
Den eldste hunnen er så gammel
at luffene og halen har begynt
å slå krøll på seg.

Under seg ser de noen store skygger.
Det er svaneøgler med lang hals.
Svaneøglene er større enn fiskeøglene.
Og farlige om man kommer for nær.
Men de er tunge og trege.
Fiskeøglene suser forbi
på trygg avstand.

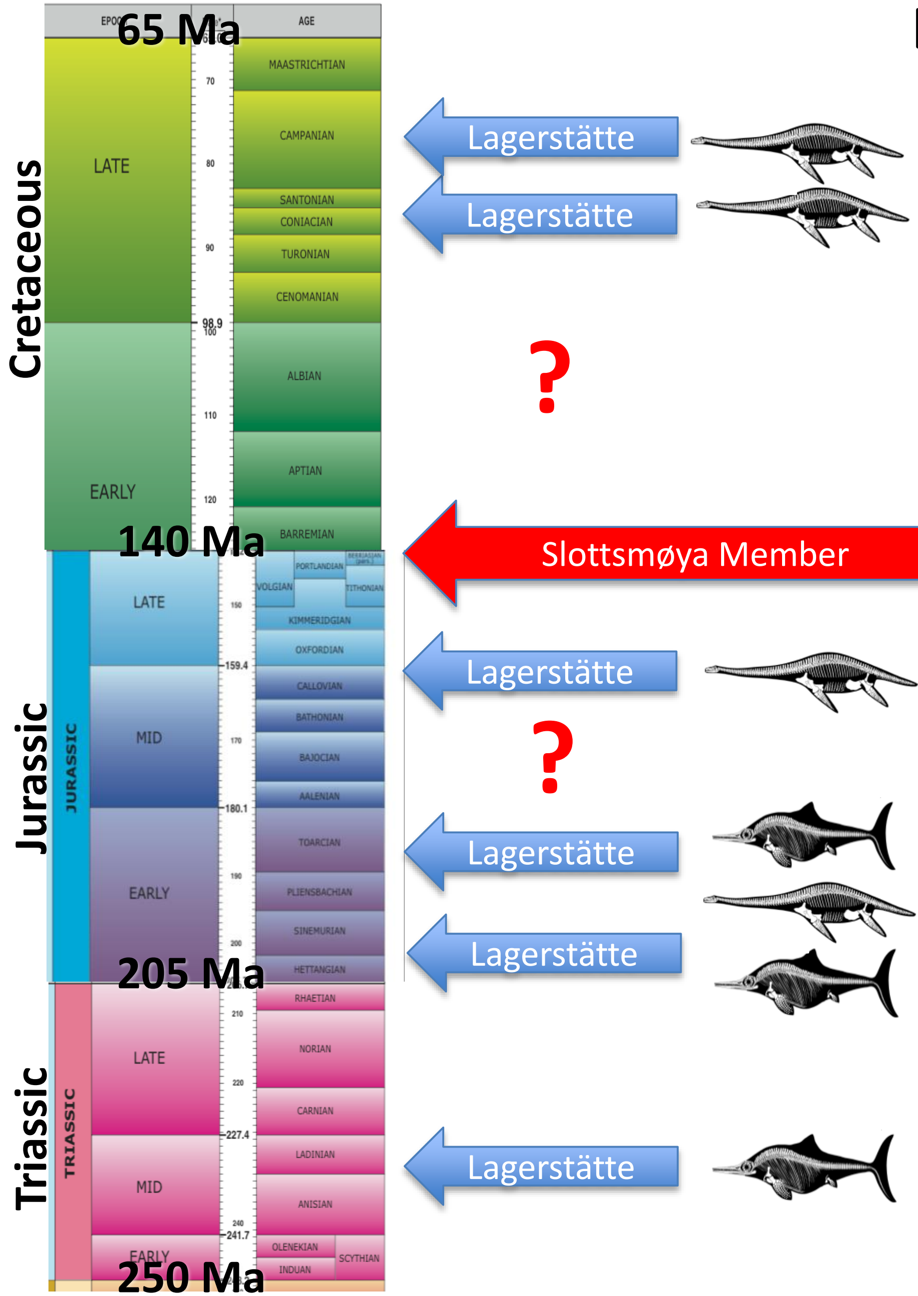


By the end of the 8th field season we have collected...



- **28 partial and one complete ichthyosaur**
- **24 partial and four almost complete plesiosaurs**
- **2 fragmented pliosaurs**
- **= at least 10 new species!!!**
- **Stratigraphy, microfossils, invertebrates, methane seeps, oil....**

Diversity and temporal distribution



New plesiosaur taxa:

- *Djupedalia engeri*
- *Spitrasaurus wensaasi*
- *Spitrasaurus larseni*
- *Pliosaurus funkei*

New ichthyosaur taxa:

- *Cryopterygius kristiansenae*
- *Palvennia hoybergeti*
- *Janusaurus lundi*
- *Keilhauia nui*

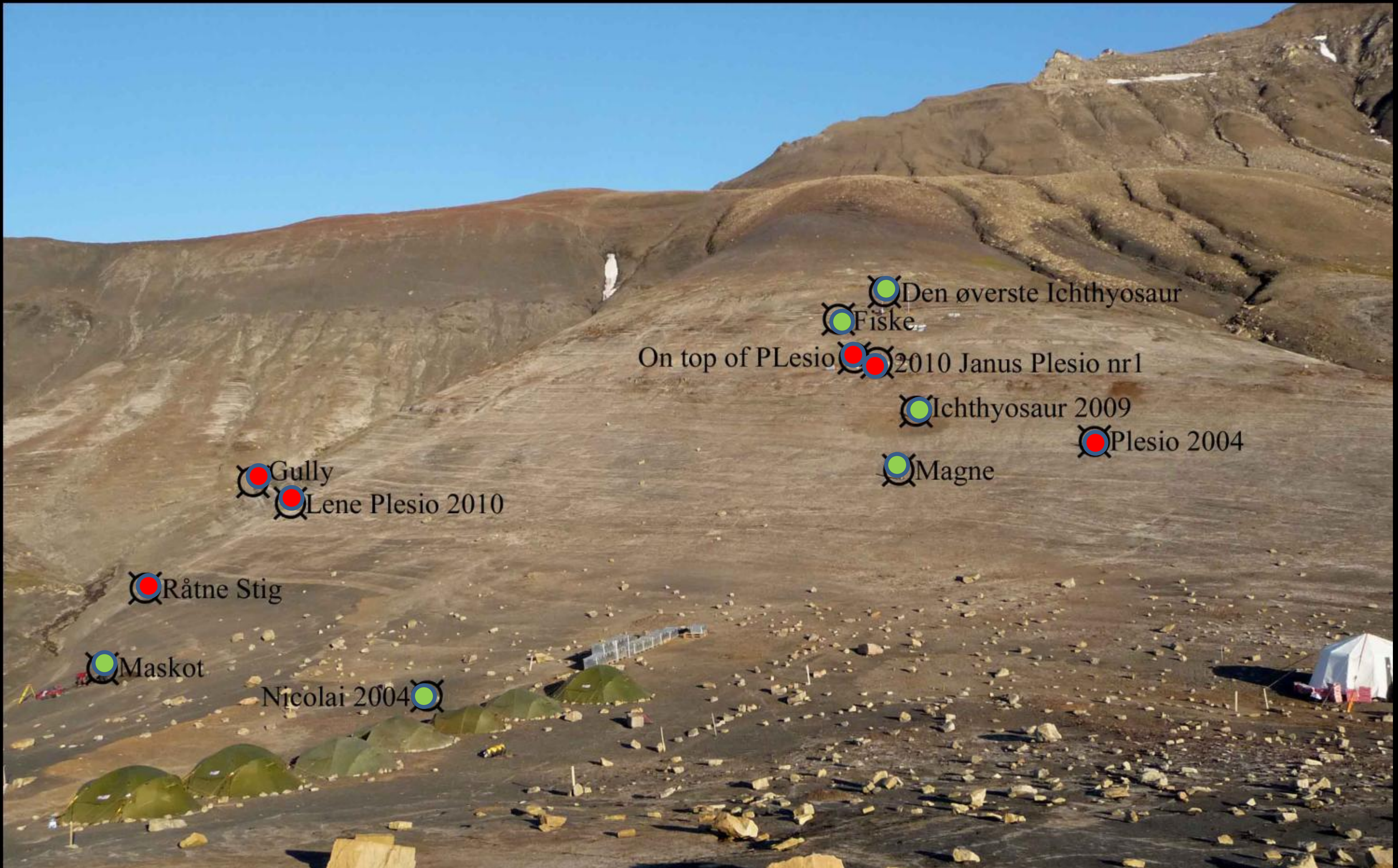
New referral:

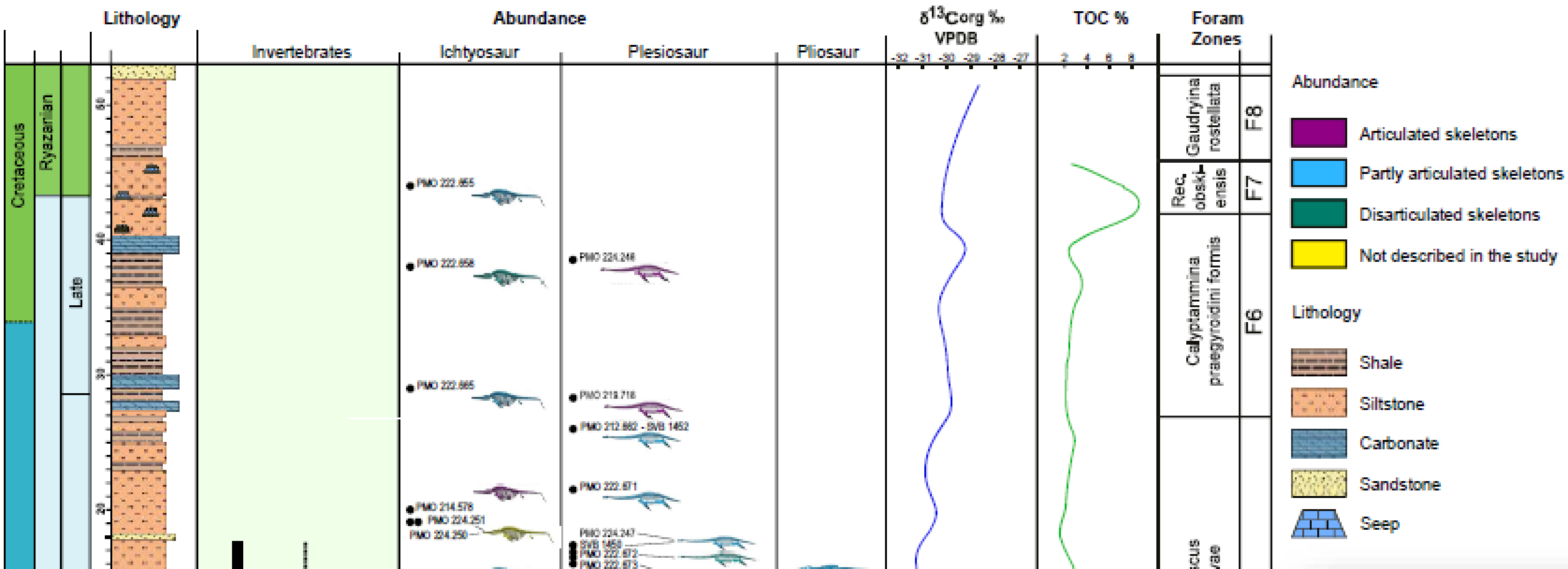
- *Colymbosaurus svalbardensis*

2010-11: the best locality in the World!

-icthyosaurs

-plesiosaurs

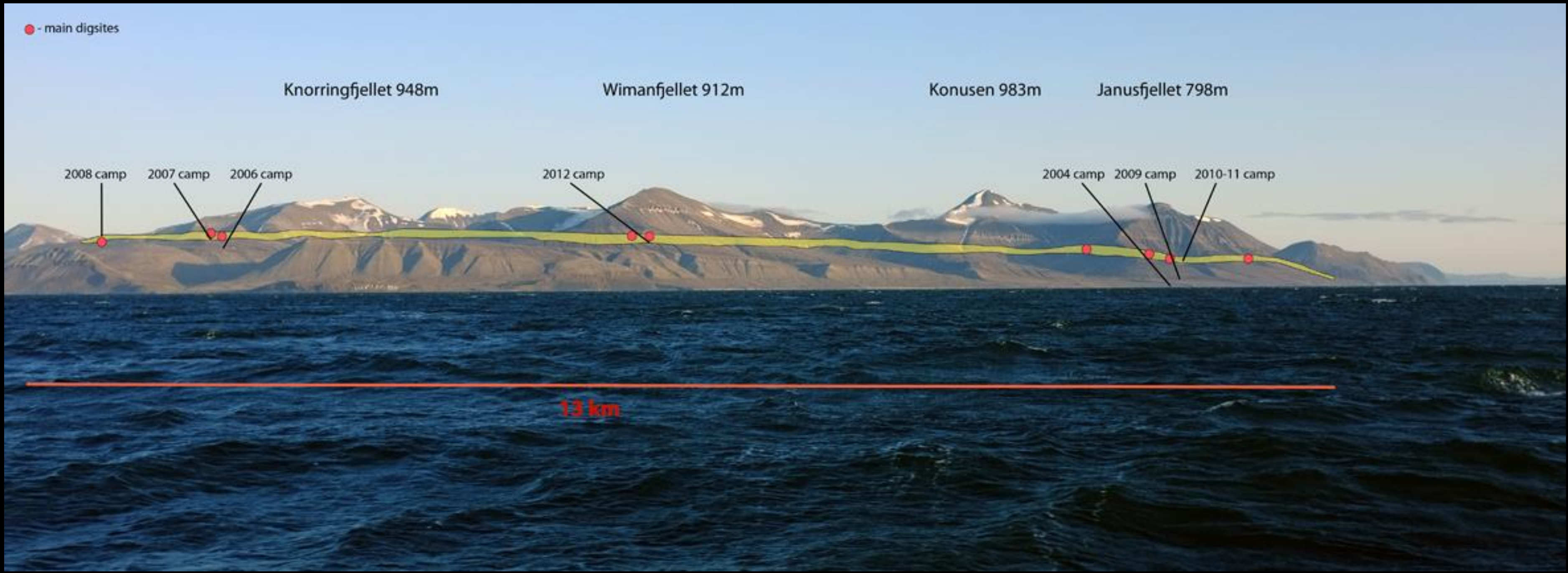


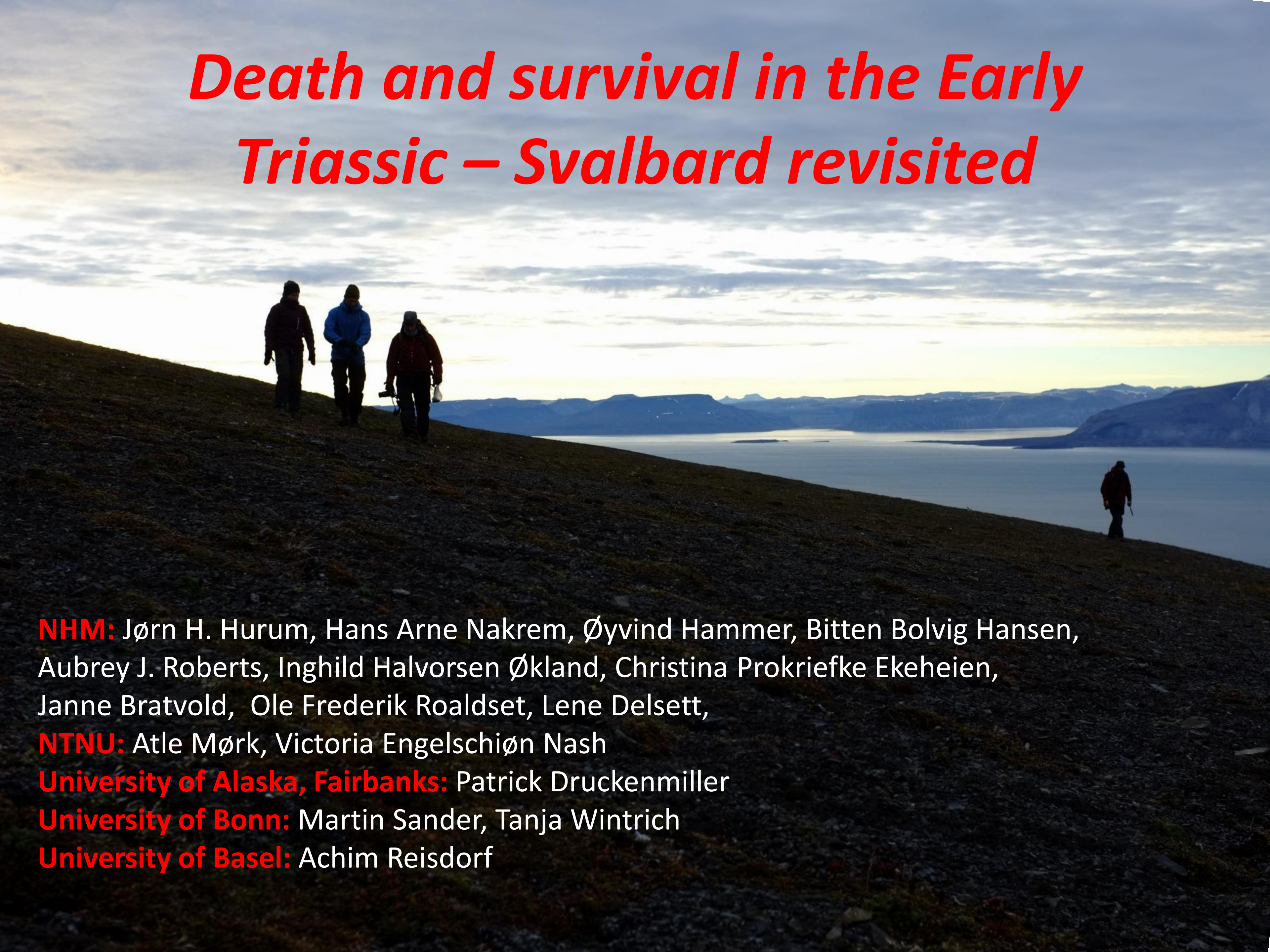



The Slottsmøya marine reptile *Lagerstätte*: depositional environments, taphonomy and diagenesis

LENE L. DELSETT, LINN K. NOVIS, AUBREY J. ROBERTS, MAAYKE J. KOEVOETS, ØYVIND HAMMER, PATRICK S. DRUCKENMILLER & JØRN H. HURUM

Delsett et al. 2016


- main digsites
Knorringfjellet 948m
Wimanfjellet 912m
Konusen 983m
Janusfjellet 798m
2008 camp
2007 camp
2006 camp
2012 camp
2004 camp
2009 camp
2010-11 camp
13 km



Death and survival in the Early Triassic – Svalbard revisited

NHM: Jørn H. Hurum, Hans Arne Nakrem, Øyvind Hammer, Bitten Bolvig Hansen, Aubrey J. Roberts, Inghild Halvorsen Økland, Christina Prokriefke Ekeheien, Janne Bratvold, Ole Frederik Roaldset, Lene Delsett,
NTNU: Atle Mørk, Victoria Engelschiøn Nash
University of Alaska, Fairbanks: Patrick Druckenmiller
University of Bonn: Martin Sander, Tanja Wintrich
University of Basel: Achim Reisdorf

NOW: adding the Triassic to the largest and longest lasting research excavations in the Arctic ever!

2004-first dig

2006-mapping

2007-first monster dig

2008-second monster (Predator X)

2009- nearly complete plesiosaur and ichthyosaur

2010-two ichthyosaurs one plesiosaur

2011-six skeletons excavated

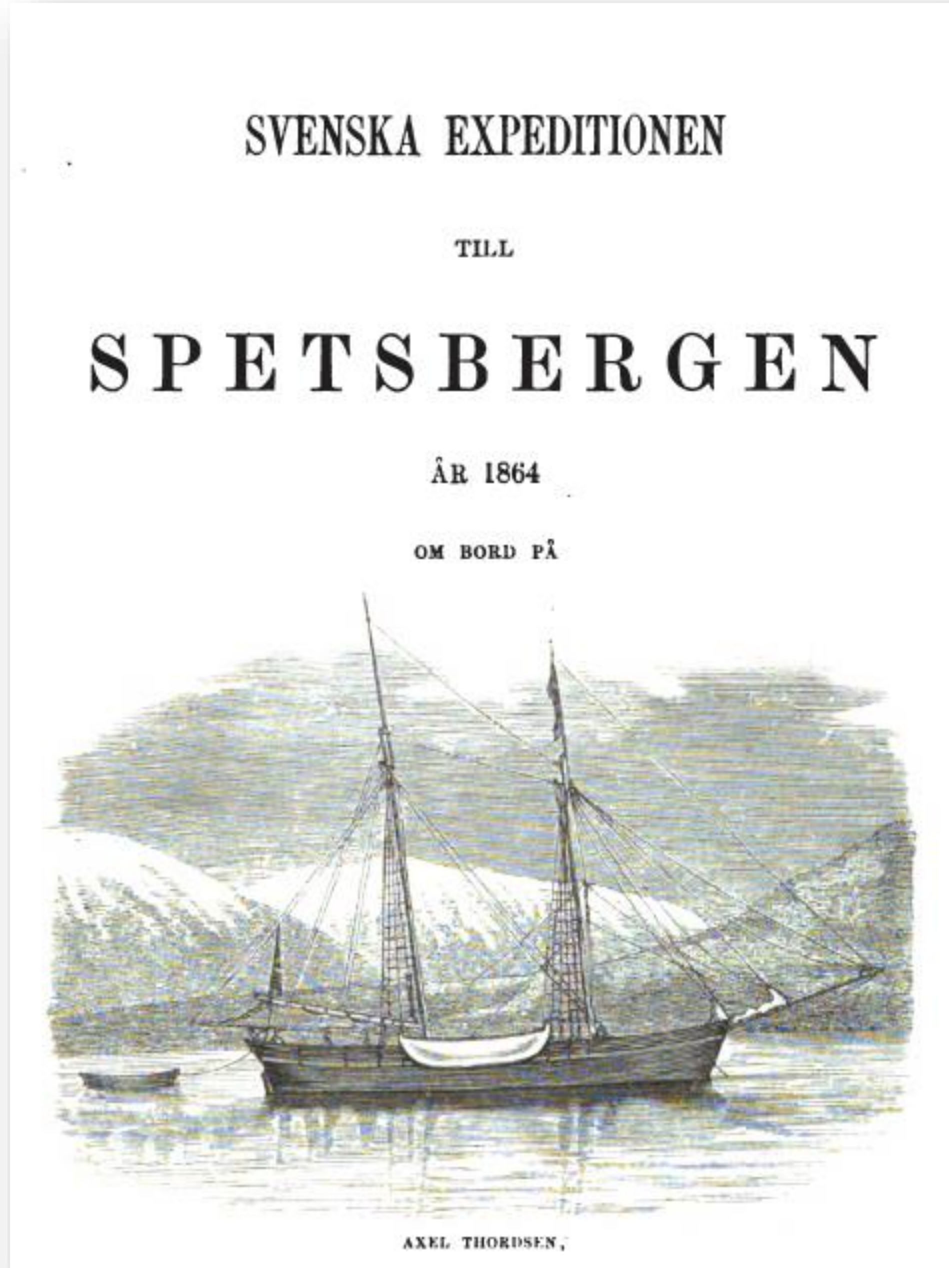
2012-last excavation in the Jurassic, six skeletons

2014- Triassic mapping of marine reptiles

2015- Triassic excavations, large ichthyopterygian, bonebed

2016- Triassic excavations, *Grippia* bonebed

Revisited!



SVENSKA EXPEDITIONEN

TILL

SPETSBERGEN

ÅR 1864

OM BORD PÅ

AXEL THORDSEN,

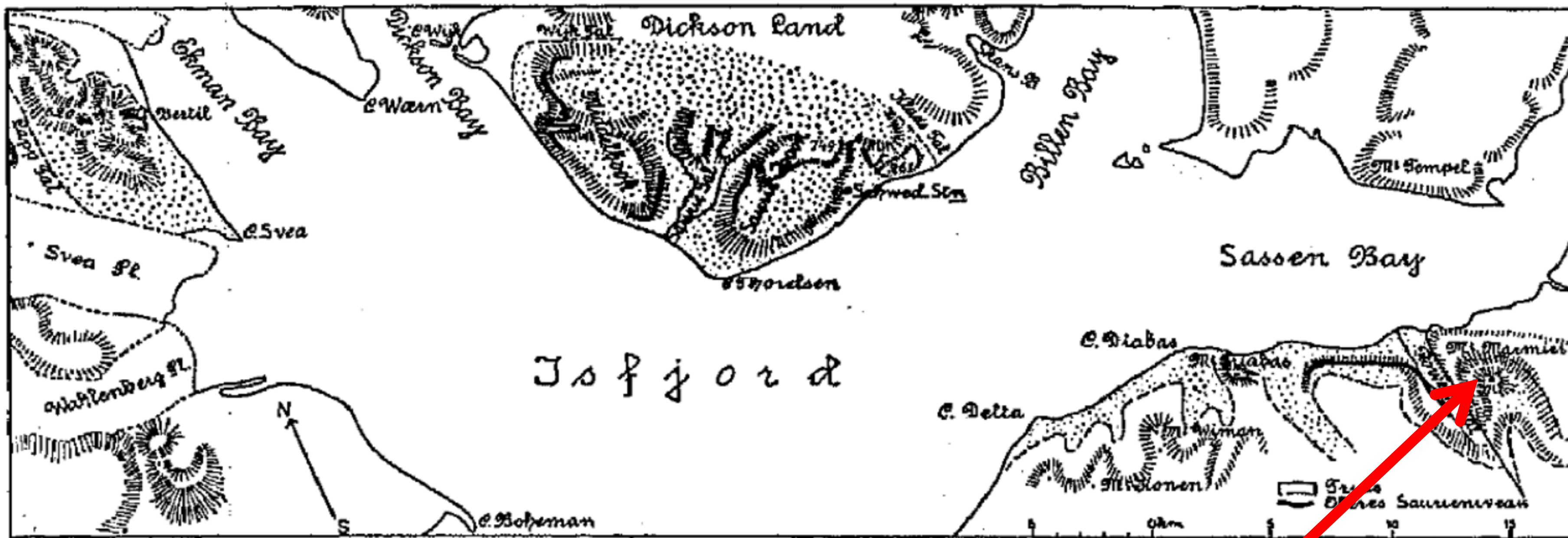


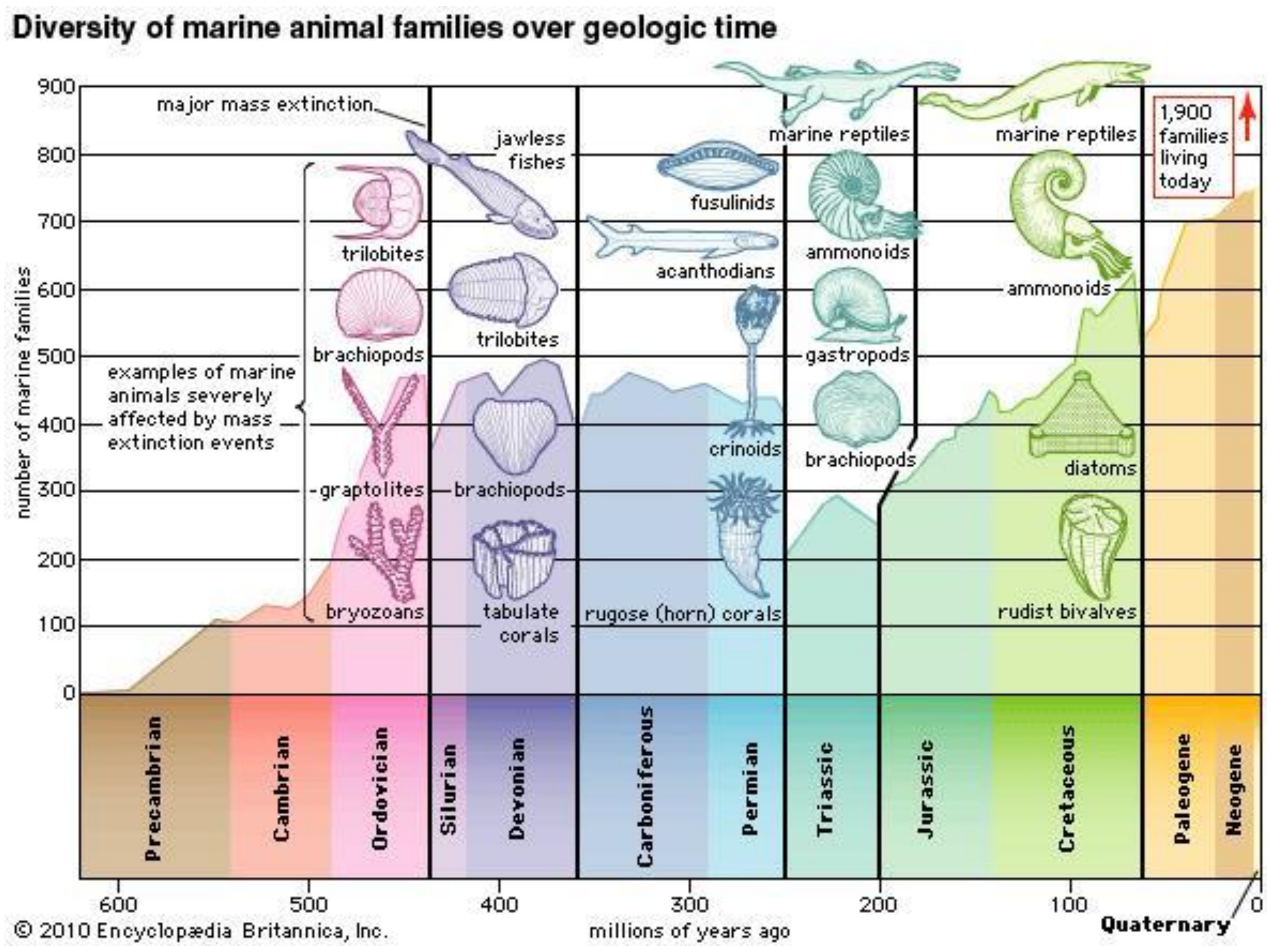
Fig. 1. Trias im Inneren des Isfjord. Skizze von G. De Geer. 1 : 600,000.

Wiman 1910

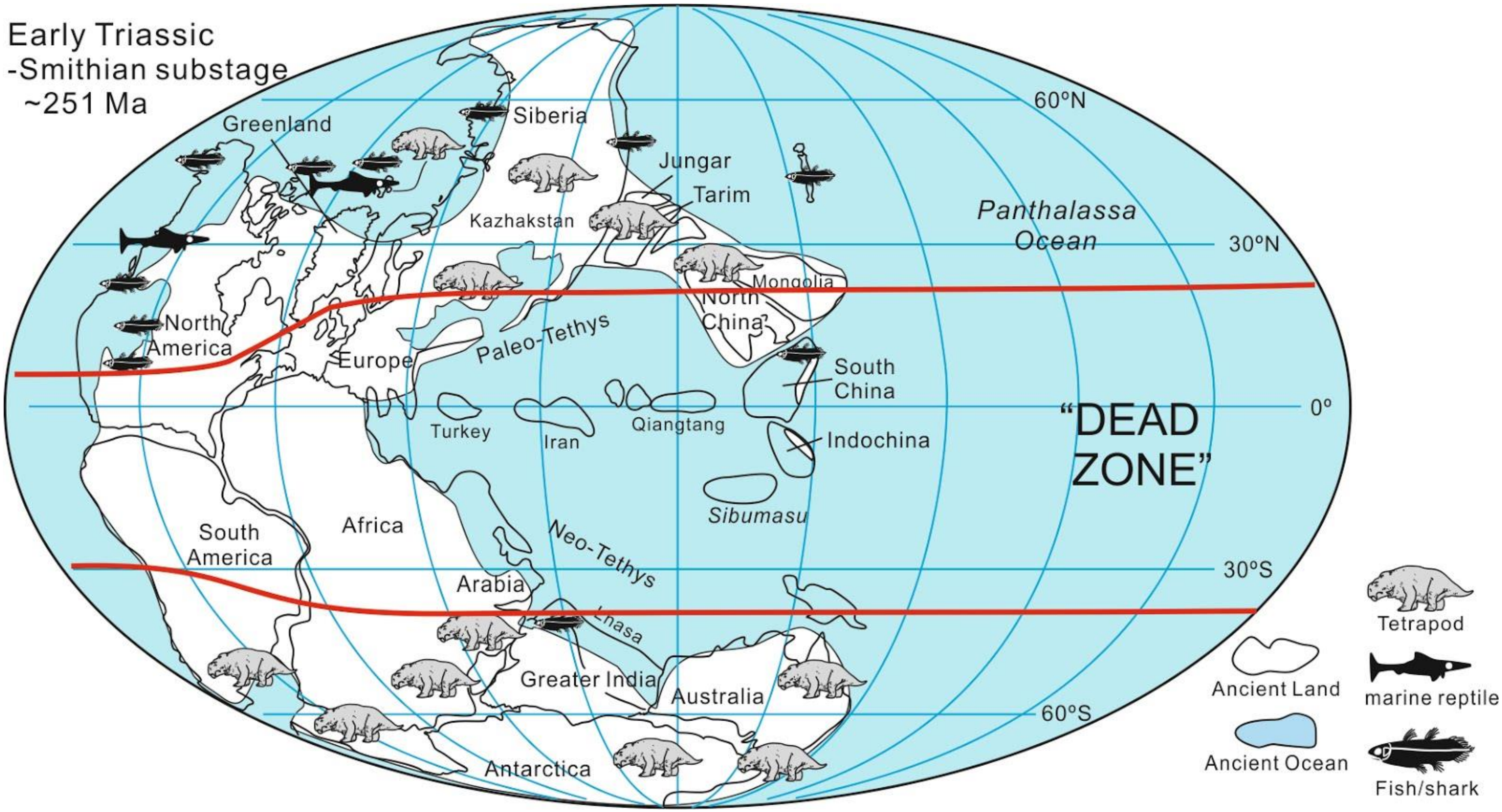
96% anyone??

- **«the great terminal Permian extinction eliminated only about 81% of marine species, not the frequently quoted 90–96%».....**

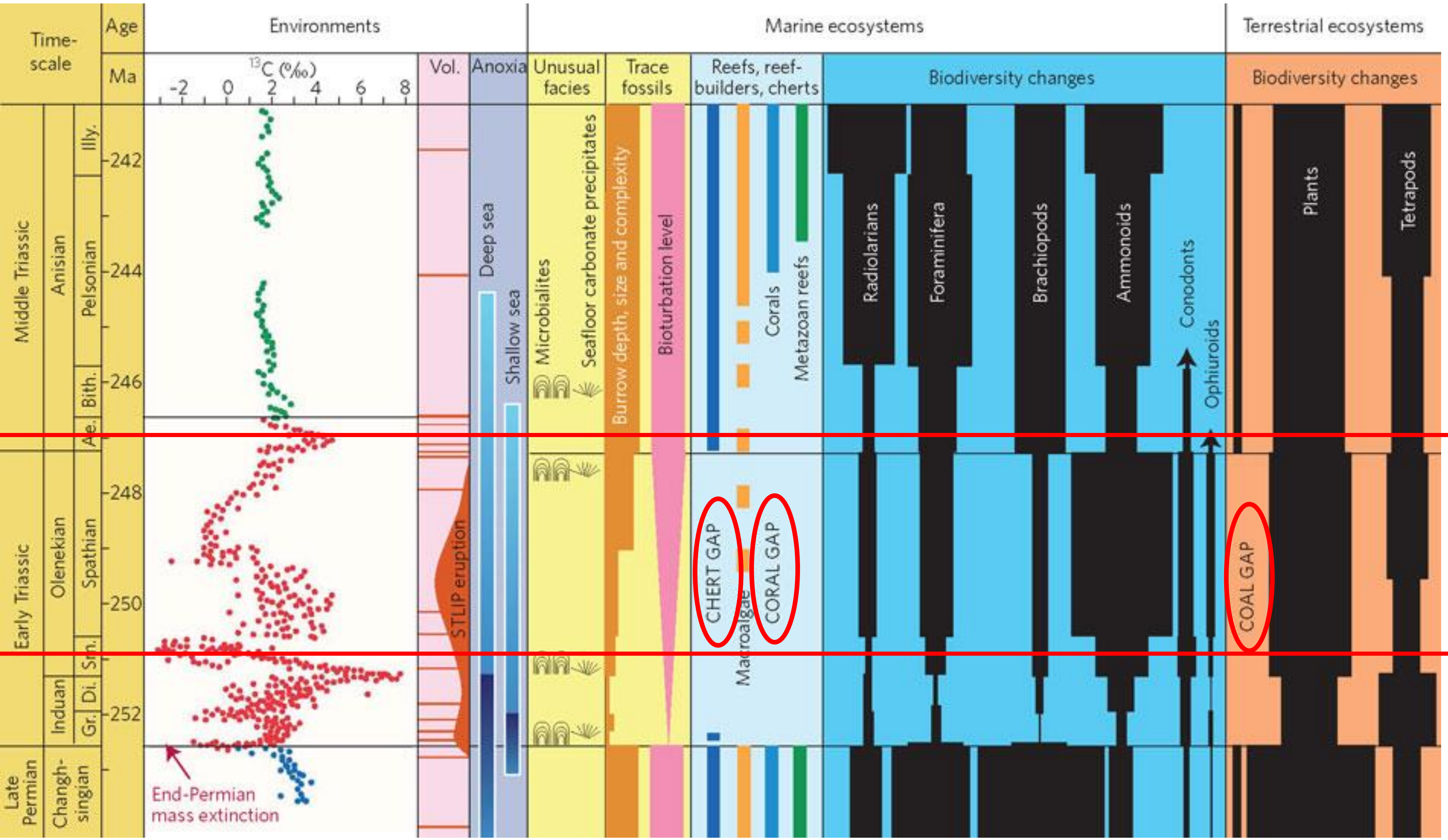
Stanley, S.M. 2016: **Estimates of the magnitudes of major marine mass extinctions in earth history.** PNAS 2016 113 (42) E6325-E6334;



https://media1.britannica.com/eb-media/42/79542-004-E6AABF42.jpg

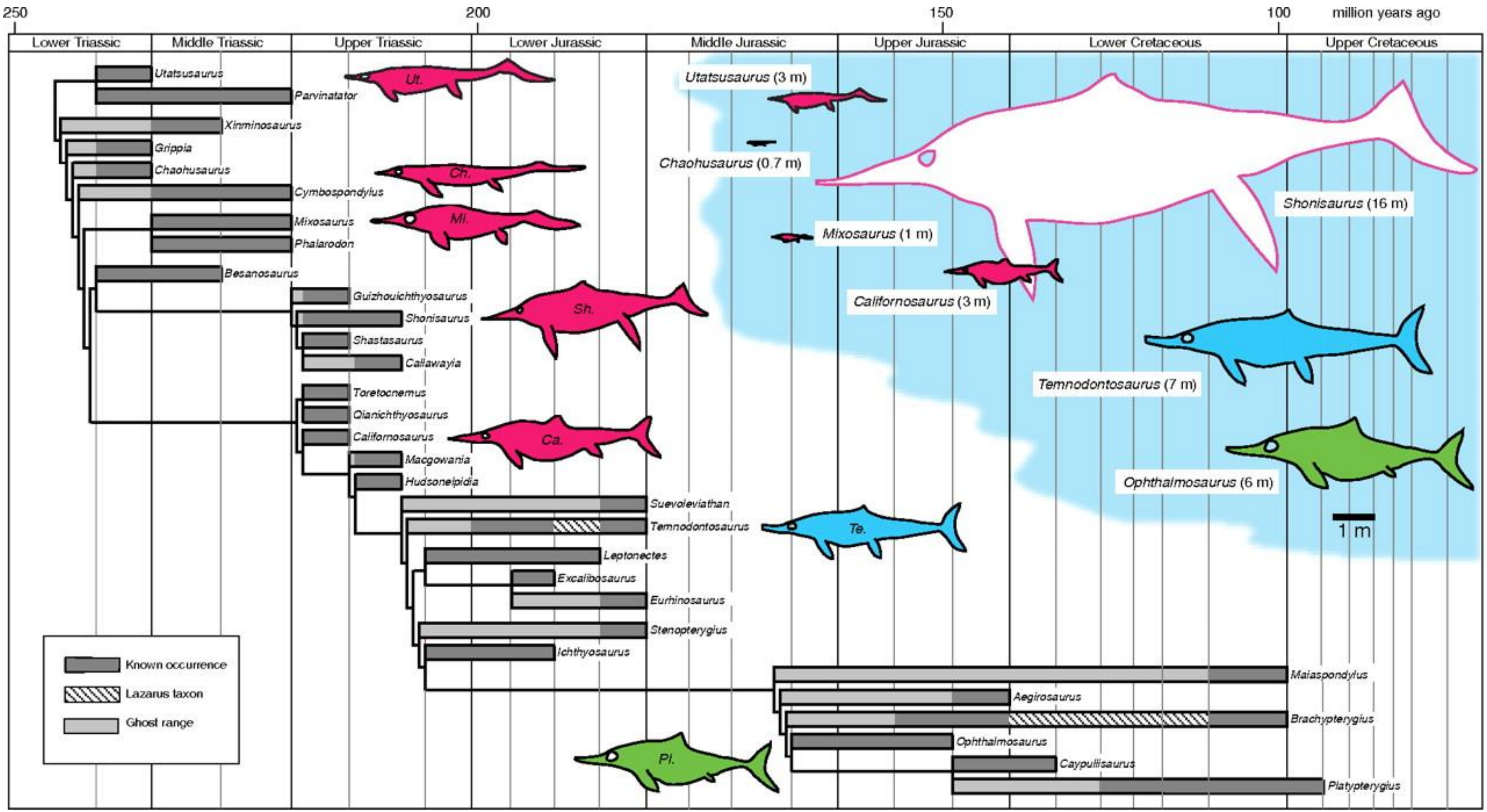


Atmospheric Carbon Injection Linked to End-Triassic Mass Extinction
Micha Ruhl, Nina R. Bonis, Gert-Jan Reichart, Jaap S. Sinninghe Damsté, and Wolfram M. Kürschner
Science 22 July 2011: **333** (6041), 430-434. [DOI:10.1126/science.1204255]



Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

Phylogenetic tree of ichthyosaurs plotted against geological time.



Thorne P M et al. PNAS 2011;108:8339-8344

PNAS

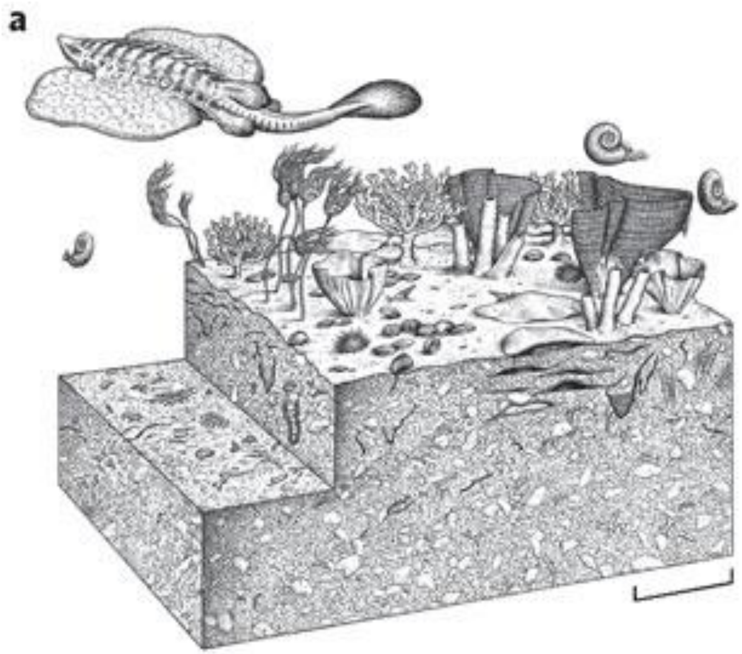
Spitsbergen Mesozoic Research Group

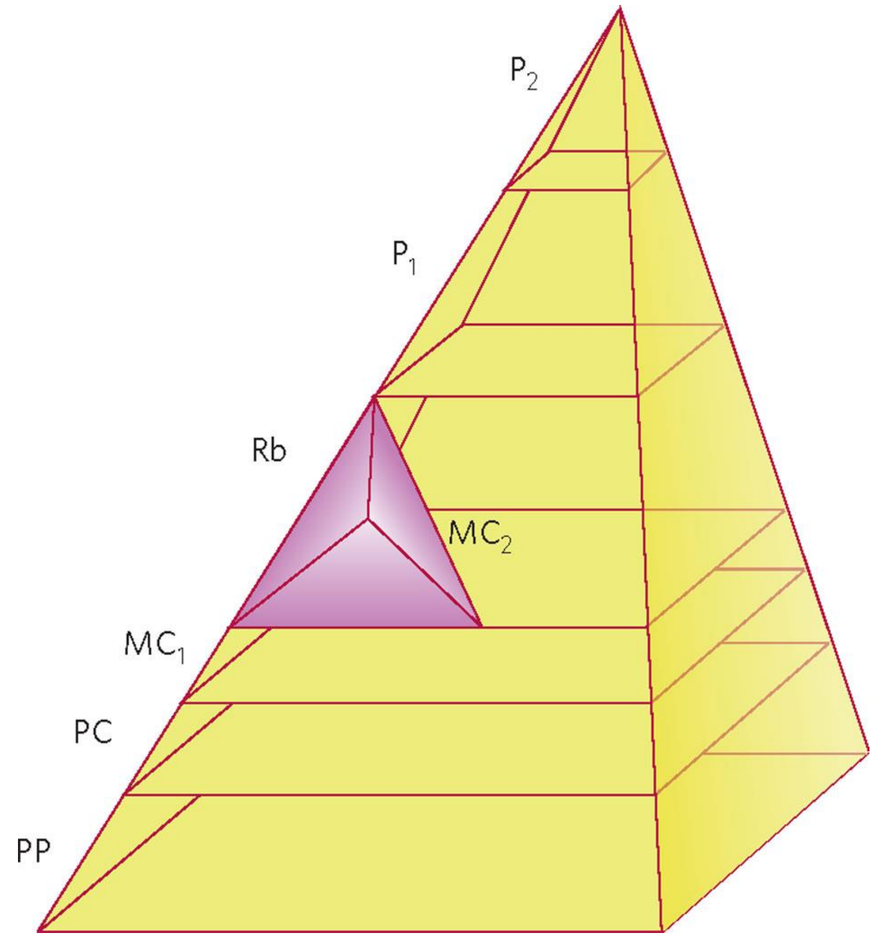
- multidisiplinary studies of the Jurassic and Triassic deposits of Svalbard combining sedimentology, biostratigraphy, isotope-stratigraphy, micropaleontology, invertebrate paleontology, geochemistry and vertebrate paleontology

- 4 main researchers (3 NHM,1 USA)
- 3 PhDs finished, 3 more PhDs under way
- 12 masters finished (all women), first male 2017
- About 12 associated researchers from USA, Germany, Poland, England and Norway
- Svalbard Museum, NTNU and UNiS involved
- about **35** peer-reviewed internationally published scientific papers

The best studied recovery: China

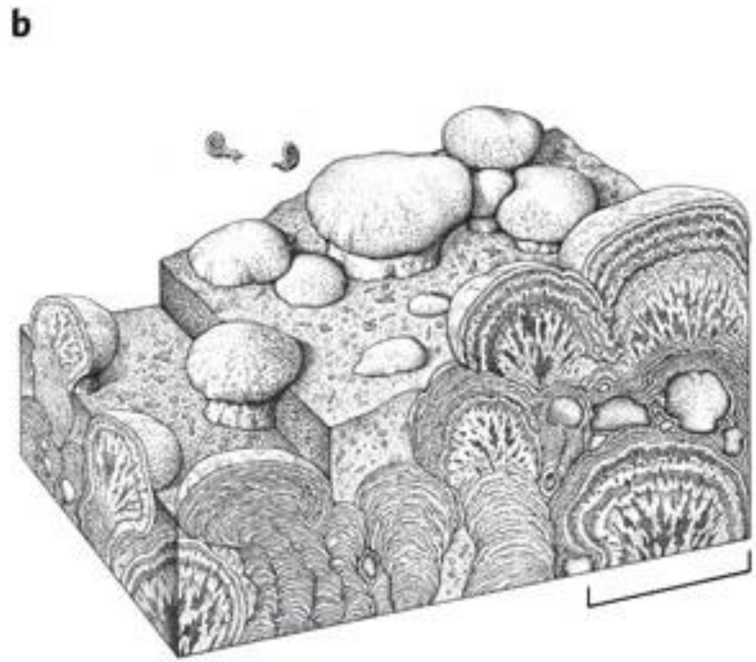
253 ma. Pre-extinction marine benthic ecosystem in the latest Permian; low abundance, high diversity and dominated by brachiopods, corals, crinoids and fusulinid foraminifers.

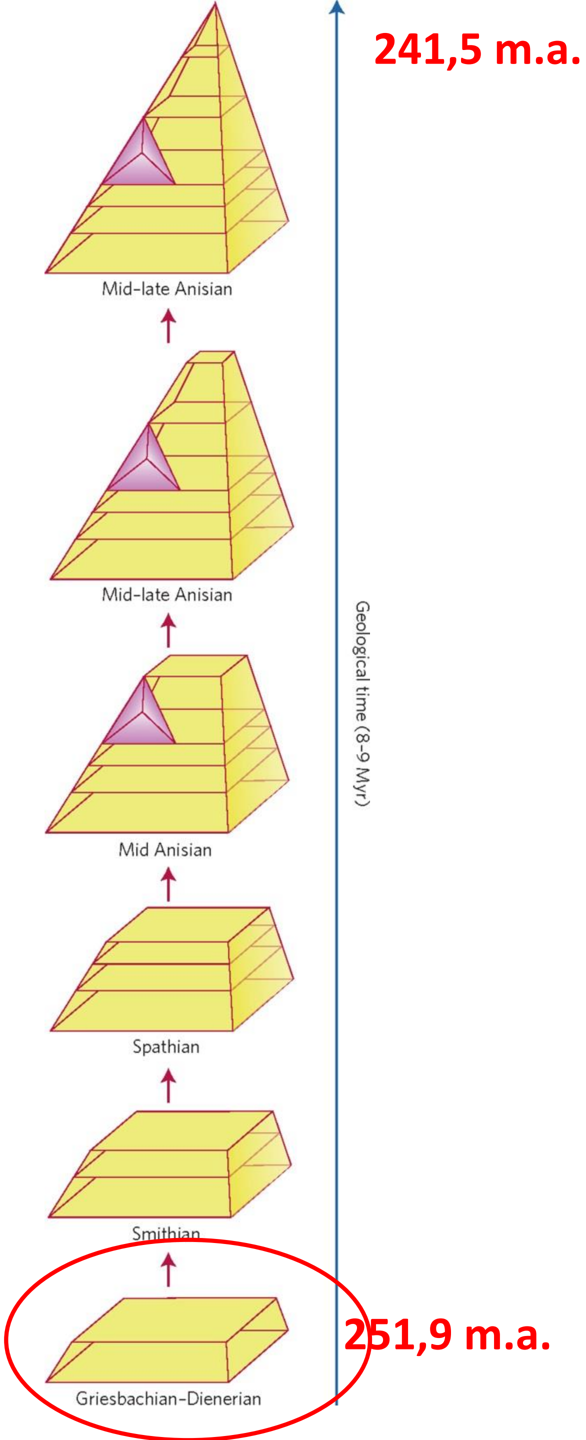




Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

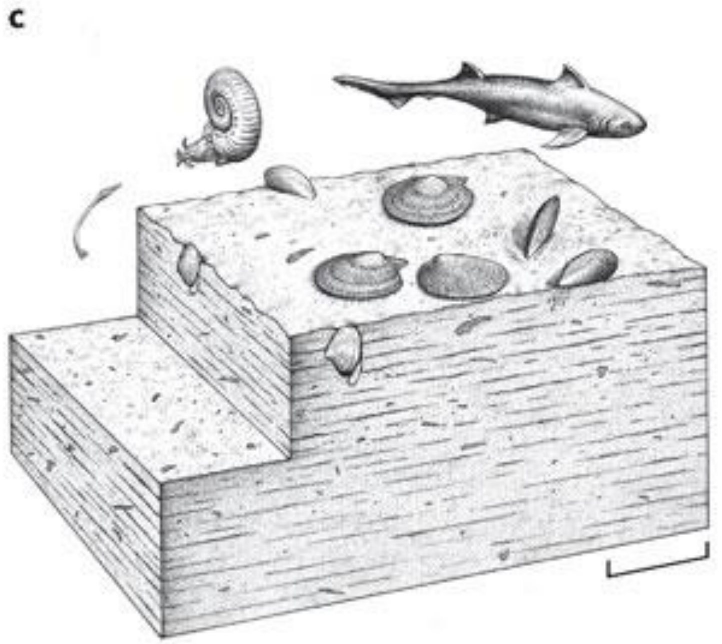
Microbe-dominated ecosystem immediately after the EPME 251,5 ma; primary producers dominate.

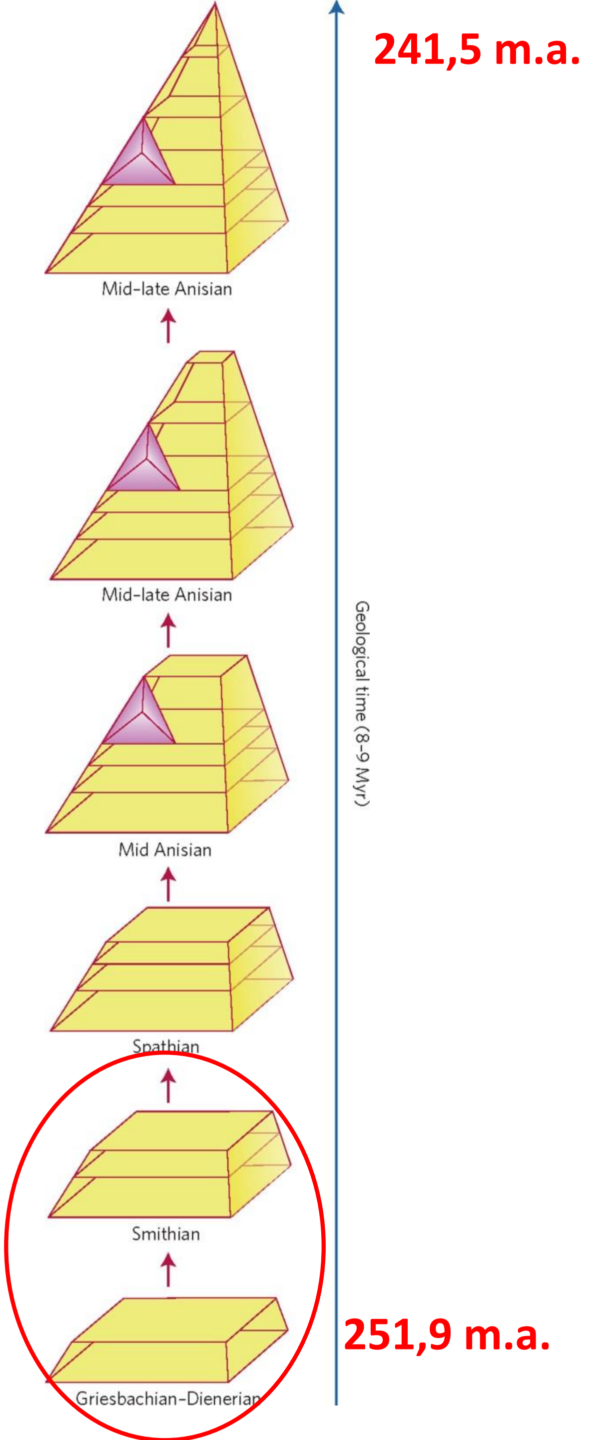




Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

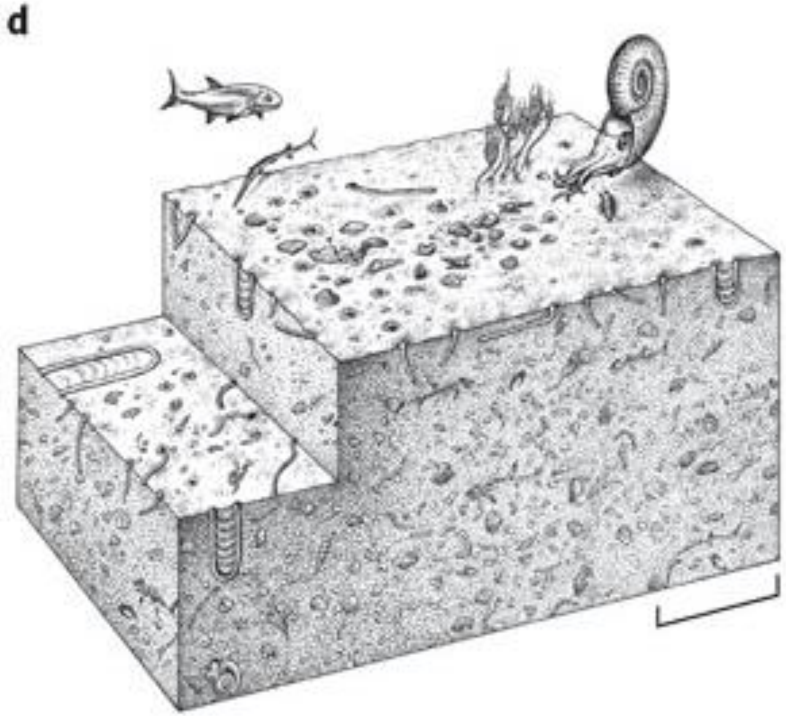
Opportunist-dominated ecosystem 251-250ma (Induan); high abundance, low diversity and dominated by disaster taxa (for example, the bivalve Claraia).

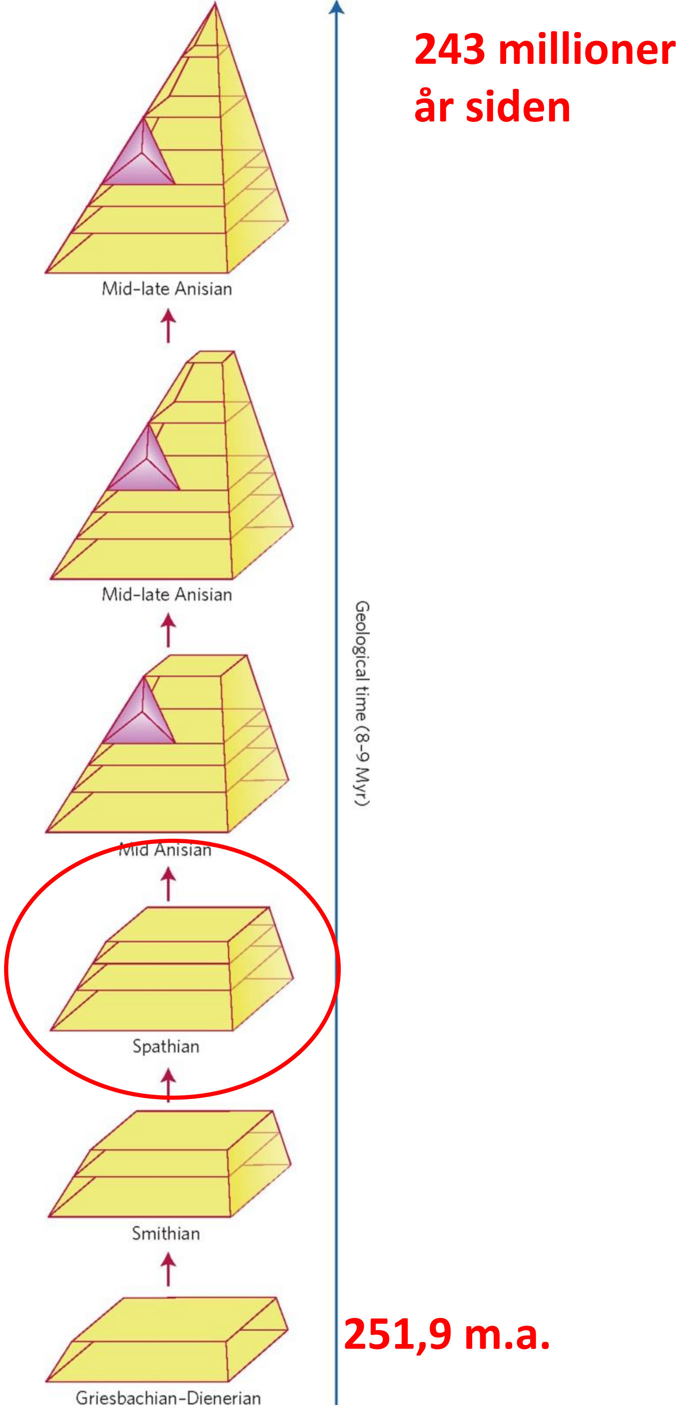




Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

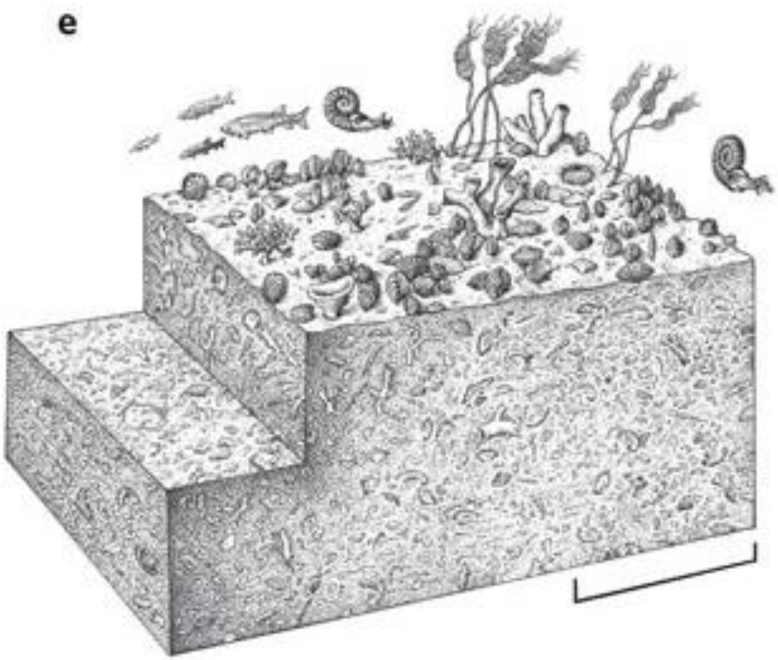
Tracemaker-dominated ecosystem in Spathian (late Olenekian) 248-247ma, indicating recovery of tracemakers.

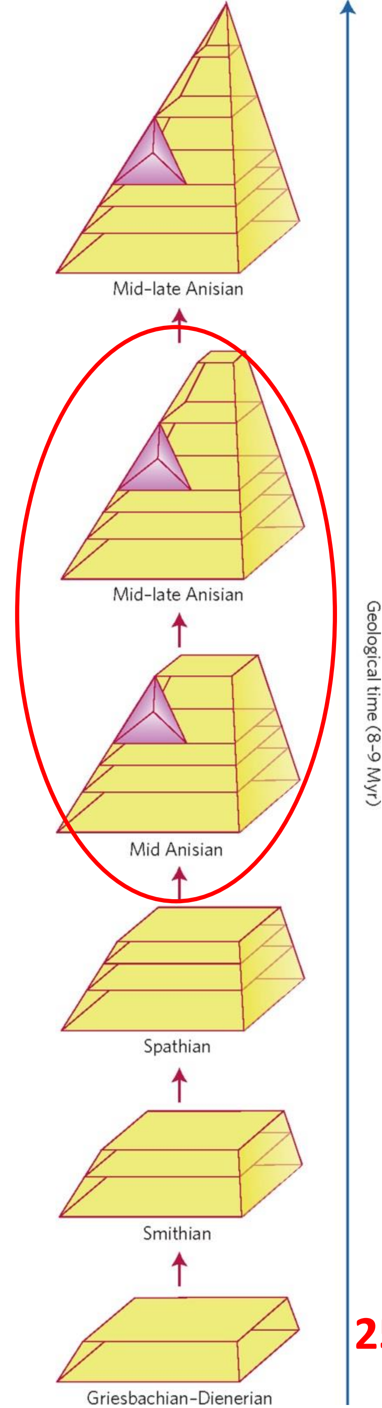




Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

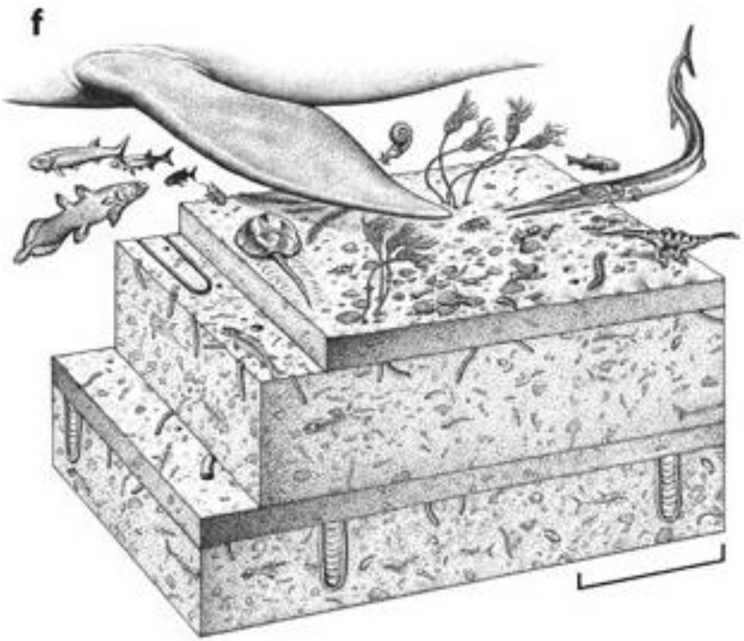
Mid Anisian (Middle Triassic) 243ma, benthic ecosystem; low abundance, high diversity and dominated by brachiopods and crinoids.

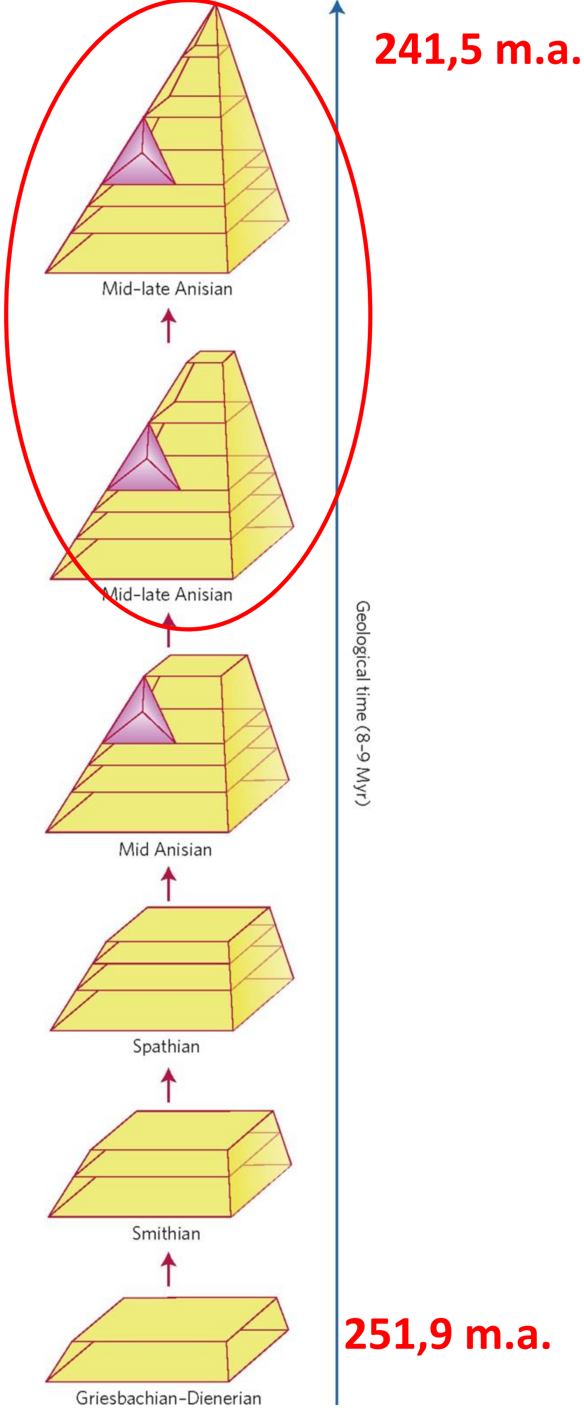




Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

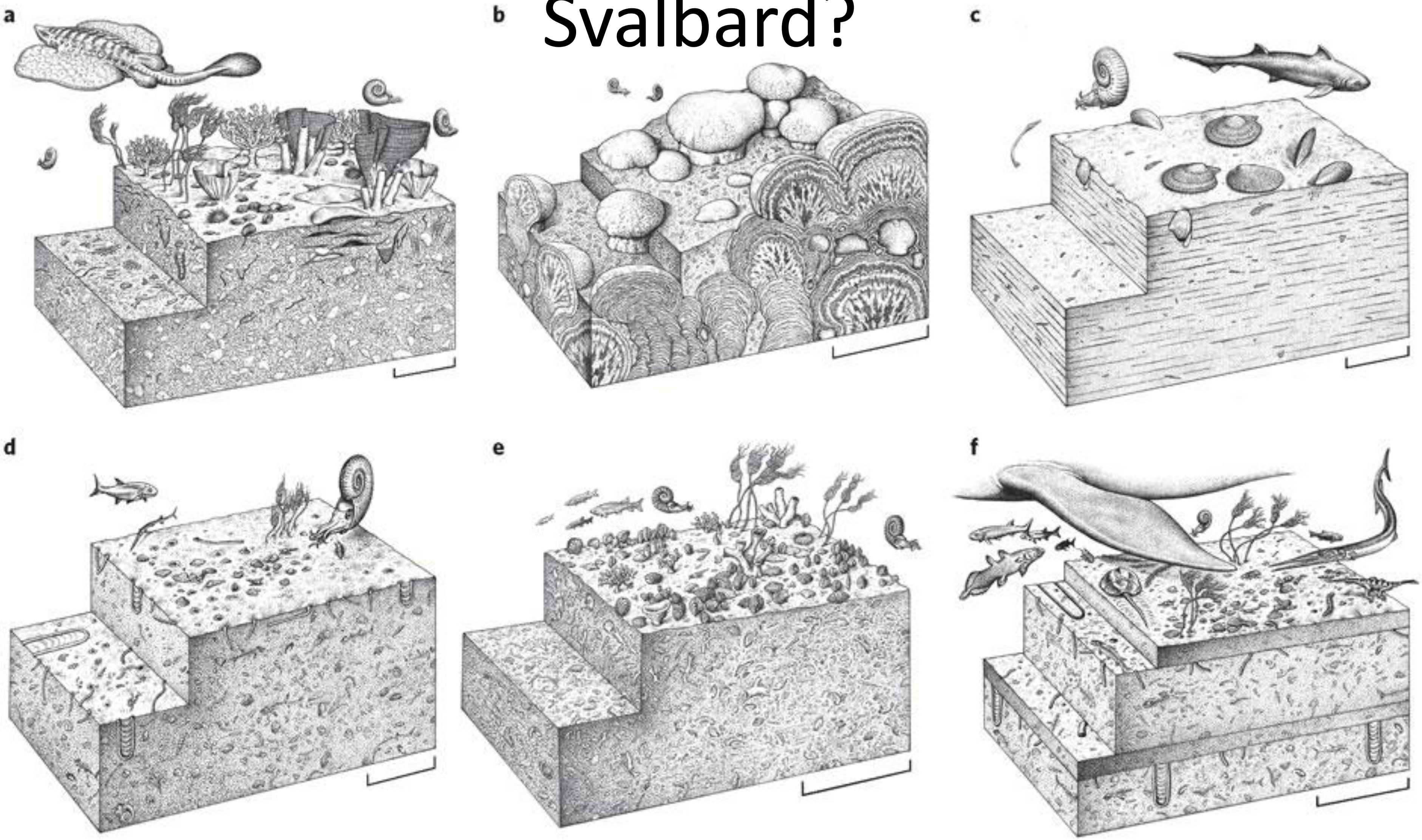
Mid–late Anisian, 242ma, ecosystem; dominated by marine fishes and reptiles, marking the rebuilding of top-predator trophic structure





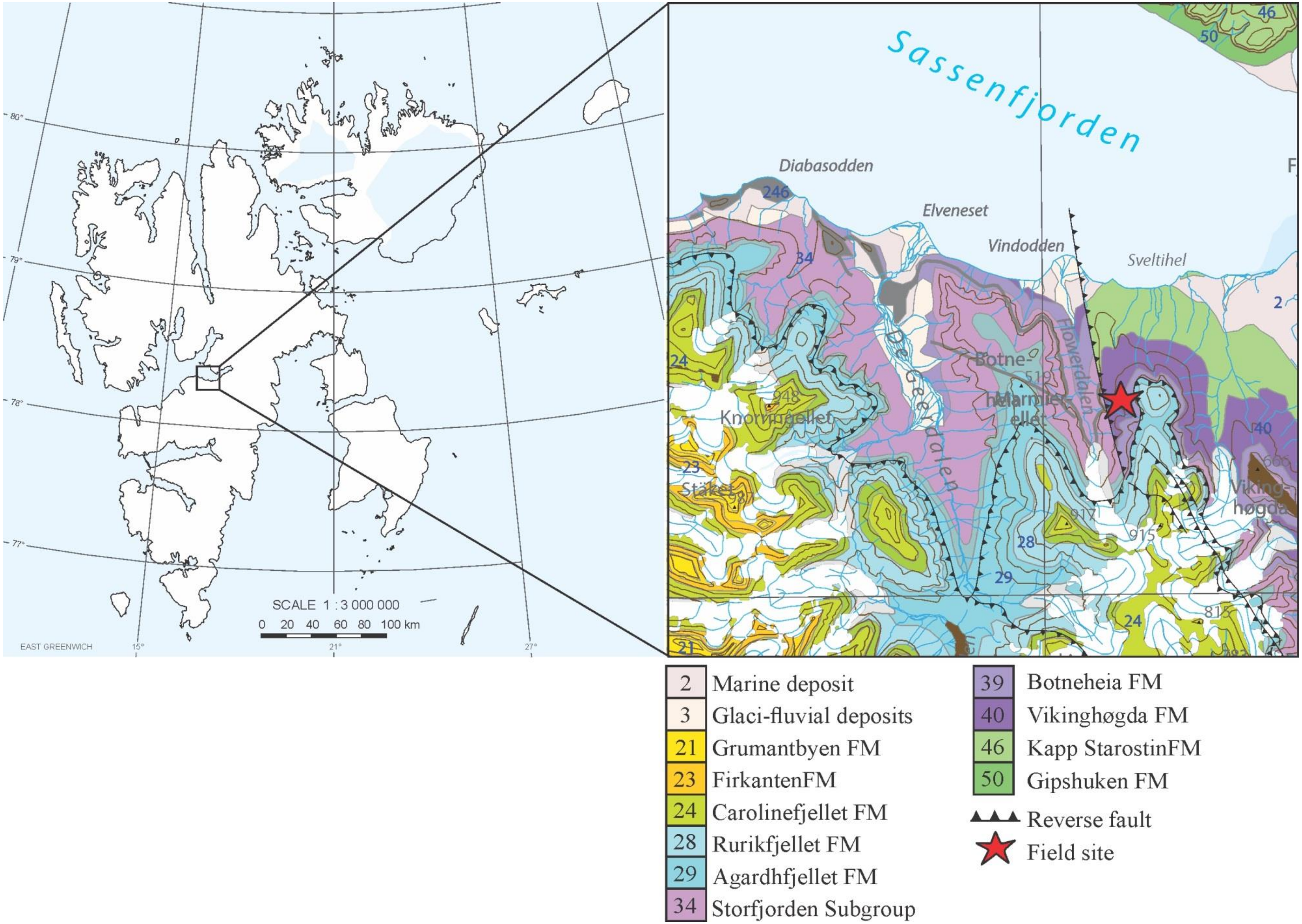
Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

How well does this compare to Svalbard?



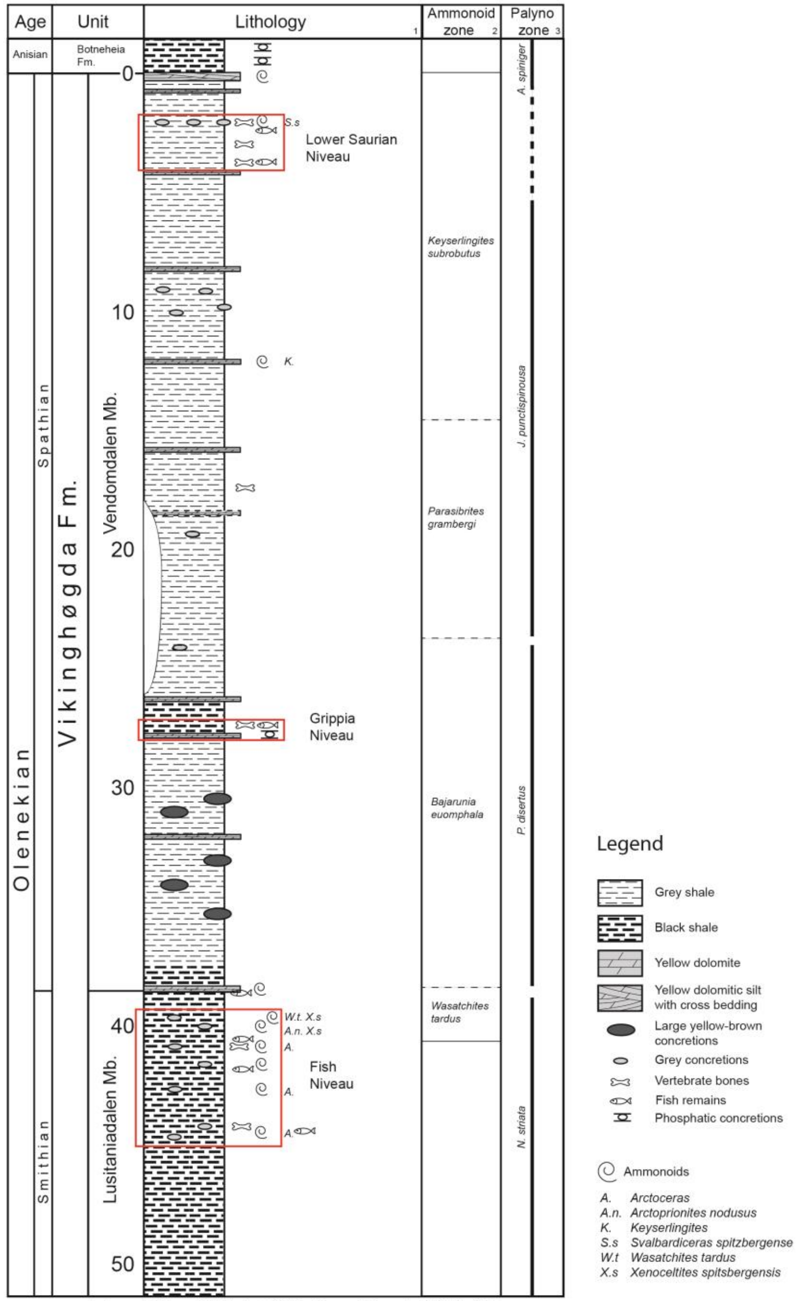
Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475


Three summers in Flowerdalen
2014-16



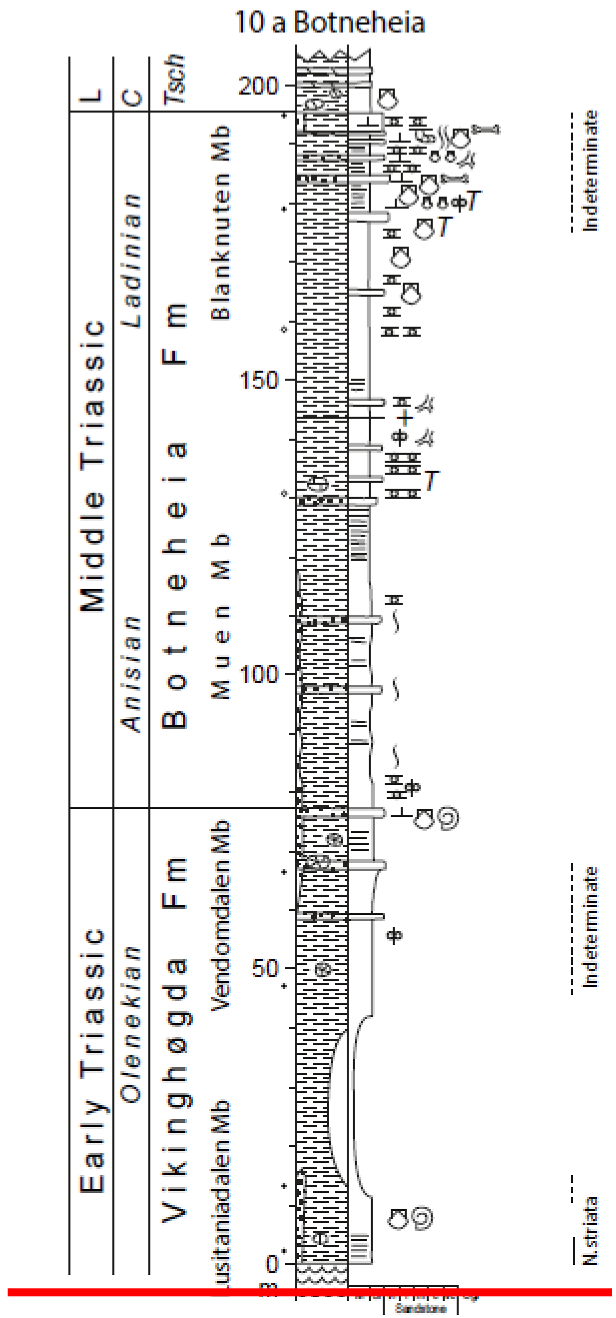
80°
79°
78°
77°
SCALE 1 : 3 000 000
0 20 40 60 80 100 km
EAST GREENWICH
15°
21°
27°
Sassenfjorden
Diabasodden
Elveneset
Vindodden
Sveltihel
De Geerdalen
Flowerdalen
Botne-
Marmier-
ellet
Knorringfjellet
Ståket
Viking-
høgda
246
34
24
23
21
28
29
40
46
50
2
948
519
917
915
666
2 Marine deposit
3 Glaci-fluvial deposits
21 Grumantbyen FM
23 FirkantenFM
24 Carolinefjellet FM
28 Rurikfjellet FM
29 Agardhfjellet FM
34 Storfjorden Subgroup
39 Botneheia FM
40 Vikinghøgda FM
46 Kapp StarostinFM
50 Gipshuken FM
Reverse fault
Field site

Stratigraphical log of Marmierfjellet, Spitsbergen



1. Hammer 2014 2. Mørk et al. 1999 (fig. 13) 3. Vigran et al. 2014 (fig. 37a)

four layers with bones!



Upper saurian niveau ca 235 m.a.

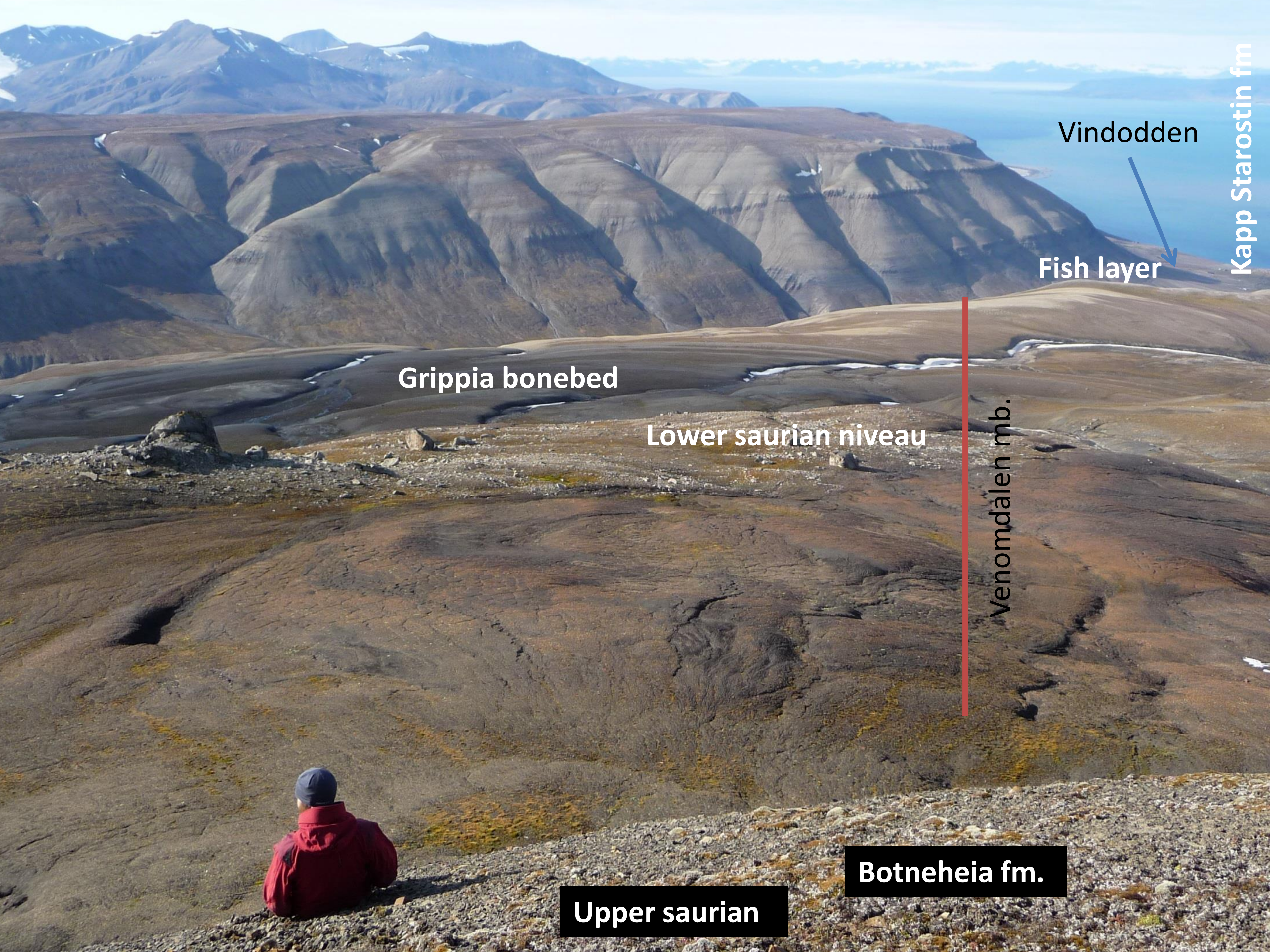
Lower saurian niveau 247 m.a.

Grippia niveau?248 m.a.

Fish niveau ?249 m.a.

Extinction 251,9 m.a.

Vigran et al. 2014

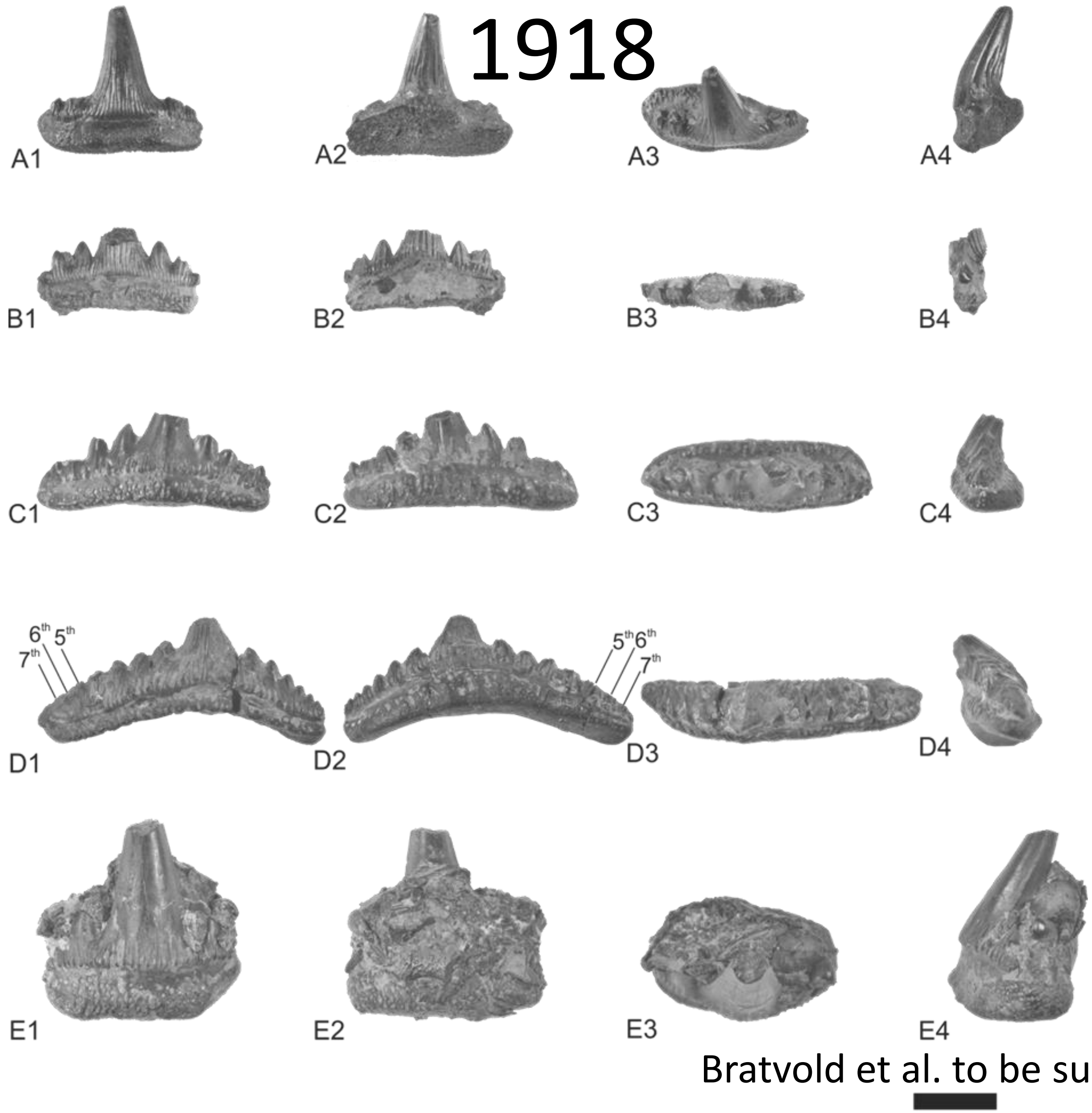


Kapp Starostin fm
Vindodden
Fish layer
Grippia bonebed
Lower saurian niveau
Venomdalen mb.
Botneheia fm.
Upper saurian

Grippia bonebed

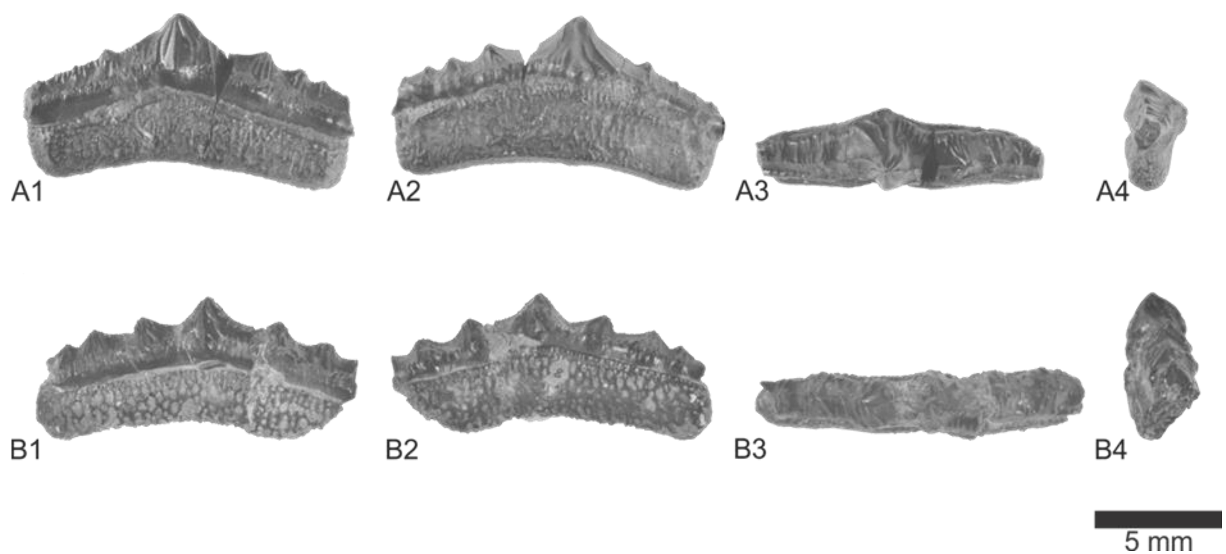

Large *Hybodus* compared with a 1.8 meter tall person.
1
0

Teeth of *Hybodus sasseniensis* Stensiö, 1918



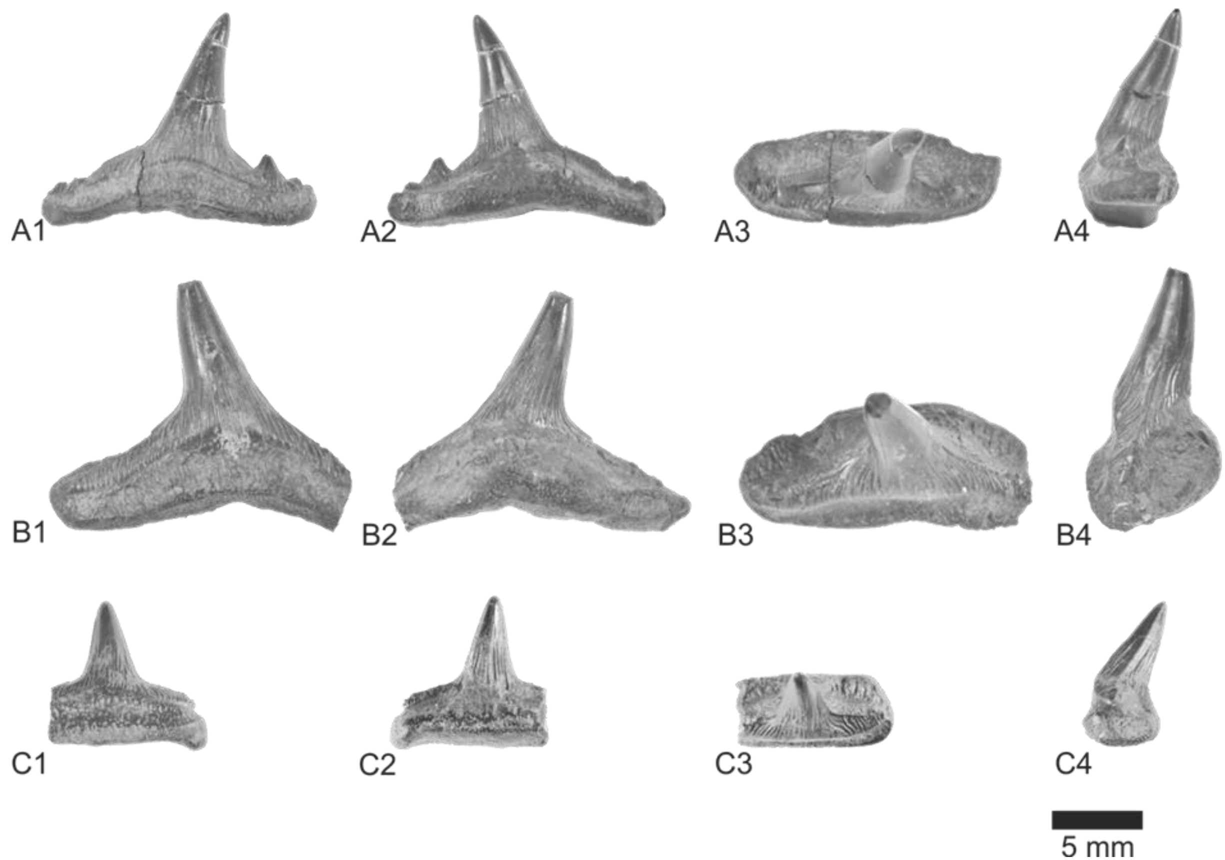
Bratvold et al. to be submitted soon...

Teeth of *Polyacrodus* sp. Jaekel, 1889

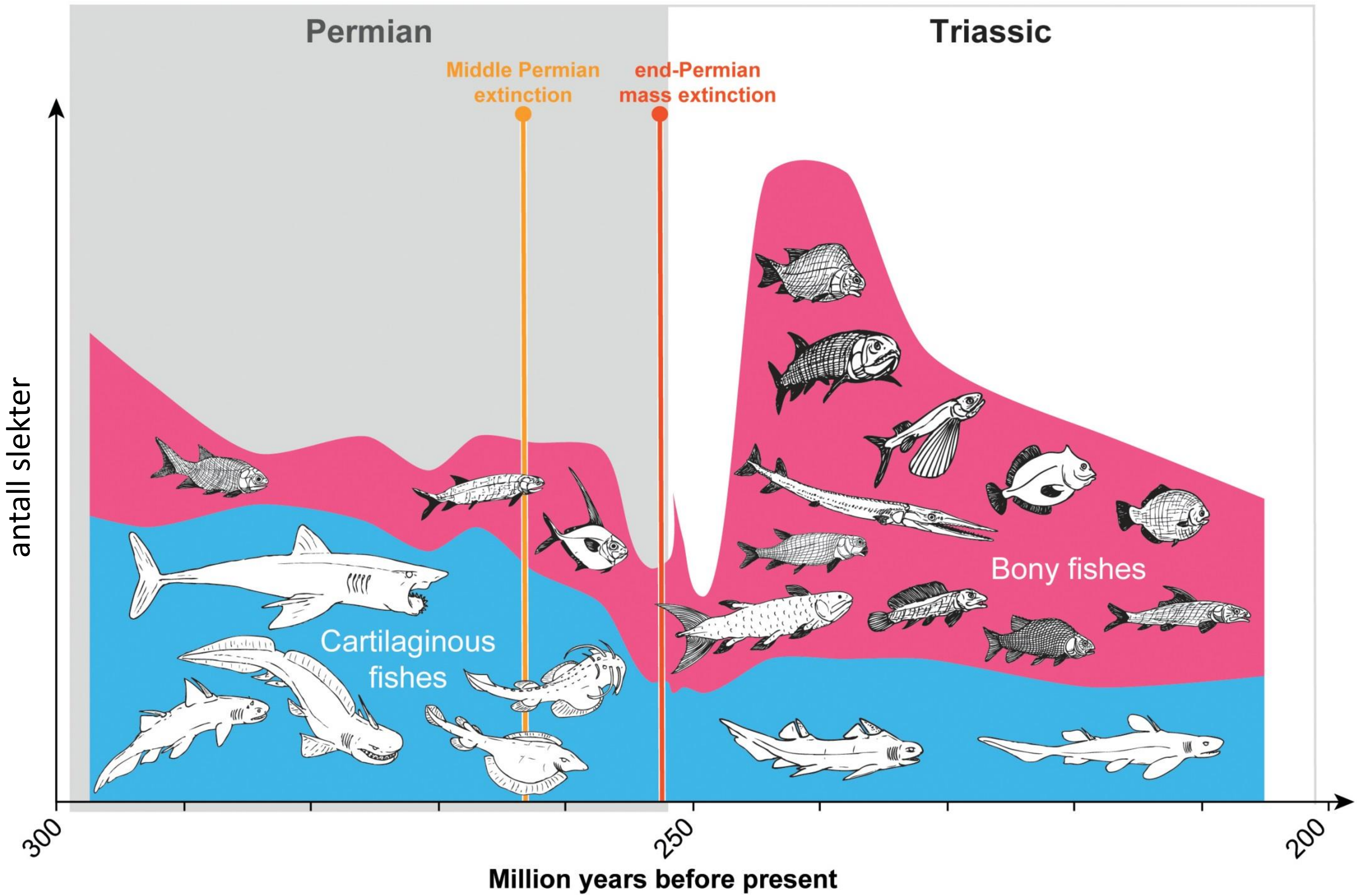


Bratvold et al. to be submitted soon...

Teeth of *Hybodus rapax* Stensiö, 1921

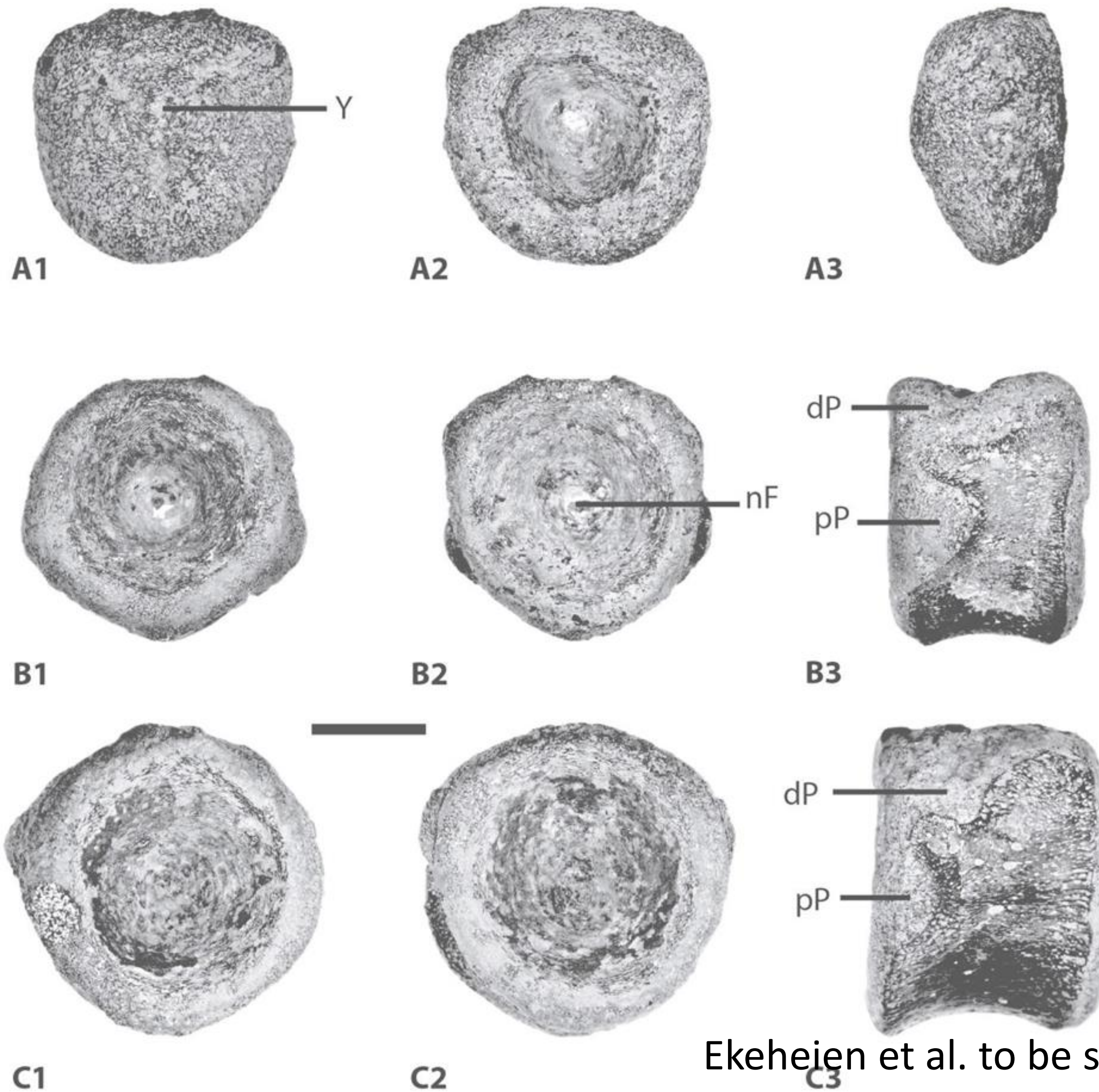


Bratvold et al. to be submitted soon...



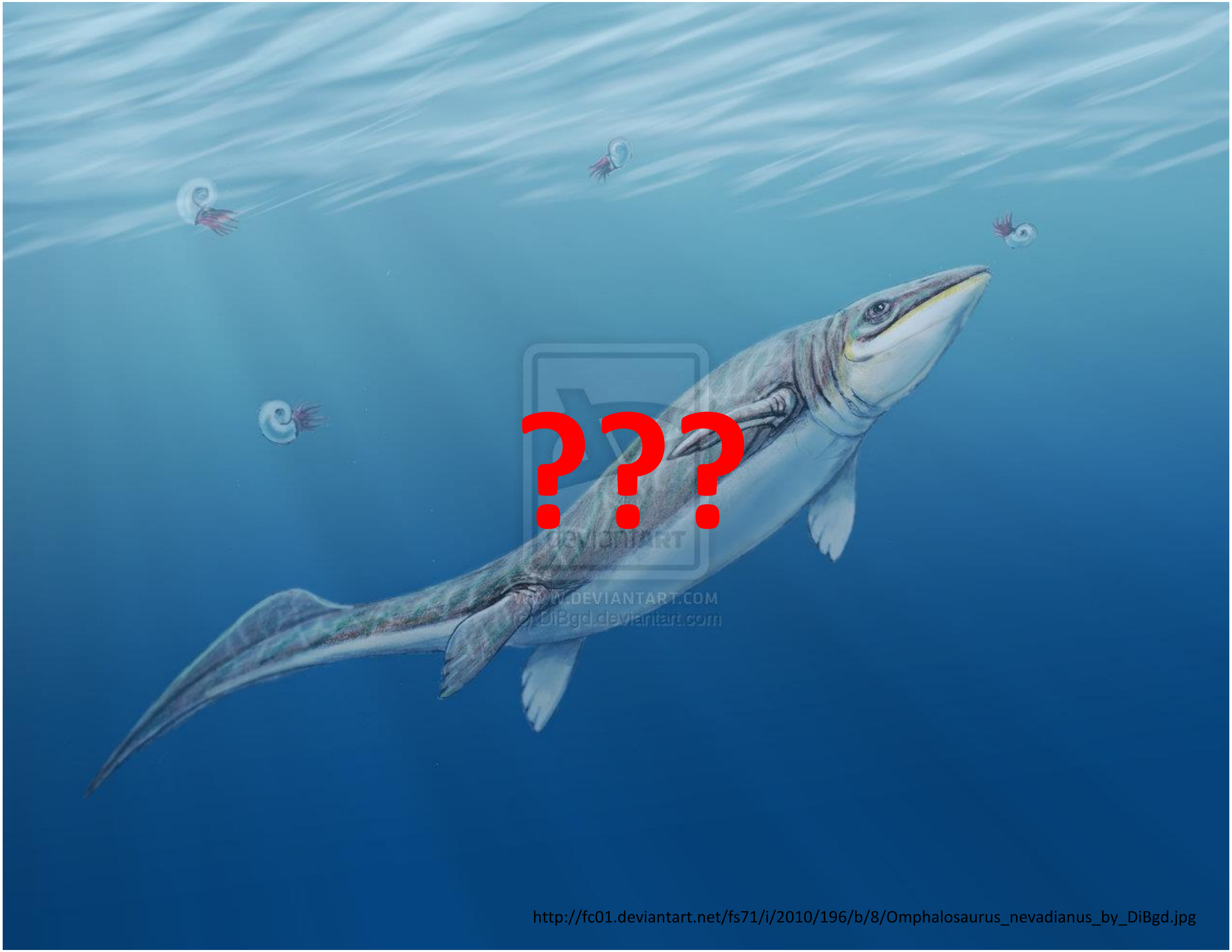
C. Romano, M. B. Koot, I. Kogan, A. Brayard, A. V. Minikh, W. Brinkmann, H. Bucher, J. Kriwet, Permian-Triassic Osteichthyes (bony fishes). Diversity dynamics and body size evolution. Biological Reviews, November xx, 2014. S. 1-44. doi: 10.1111/brv.12161.

Omphalosaurus

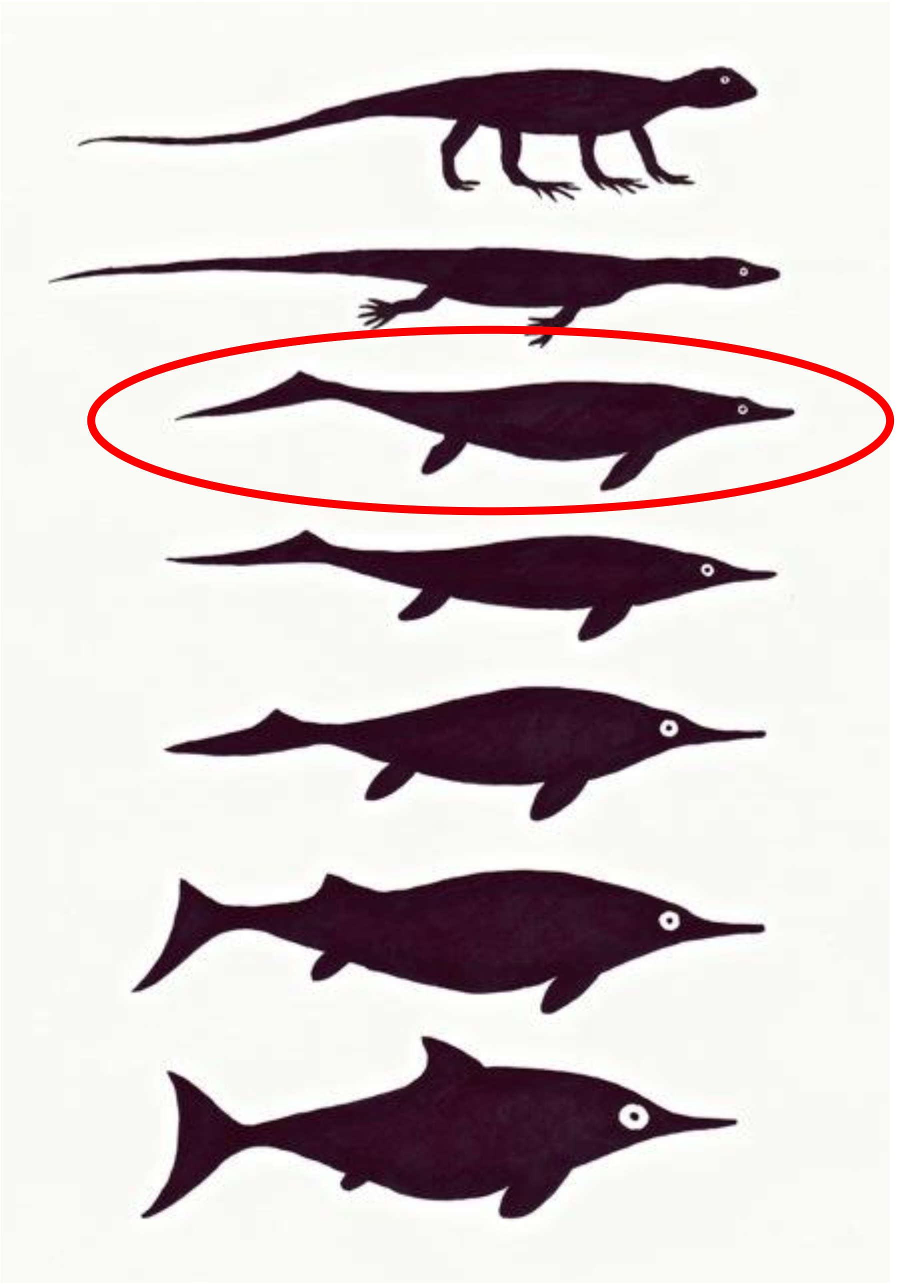


Ekeheien et al. to be submitted soon...


ALASKA DIVISION OF
GEOLOGICAL &
GEOPHYSICAL SURVEYS
cm
mm
in


???
http://fc01.deviantart.net/fs71/i/2010/196/b/8/Omphalosaurus_nevadianus_by_DiBgd.jpg

Lower saurian niveau -oldest large ichthyosaurs in the World



Upper saurian: *Phalarodon* + *Mixosaurus*

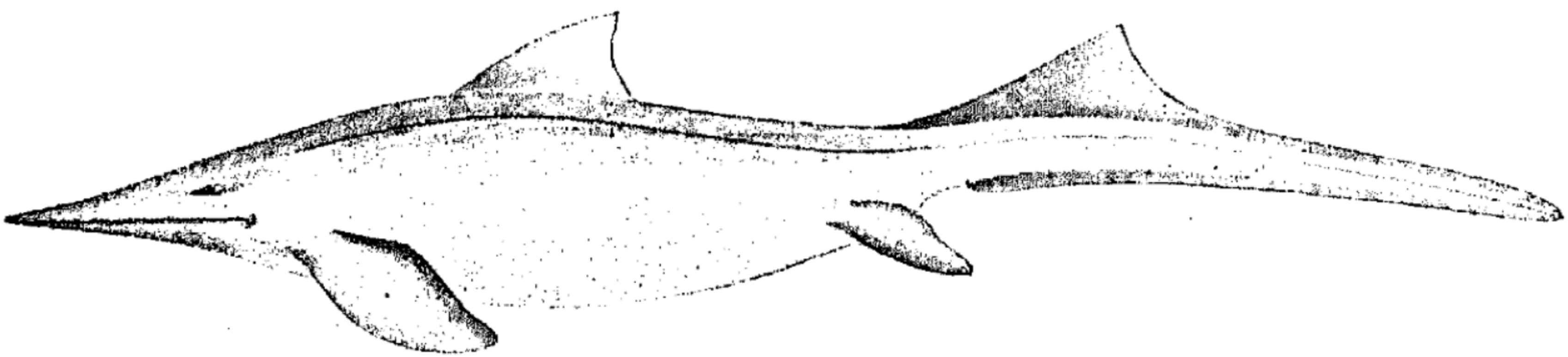
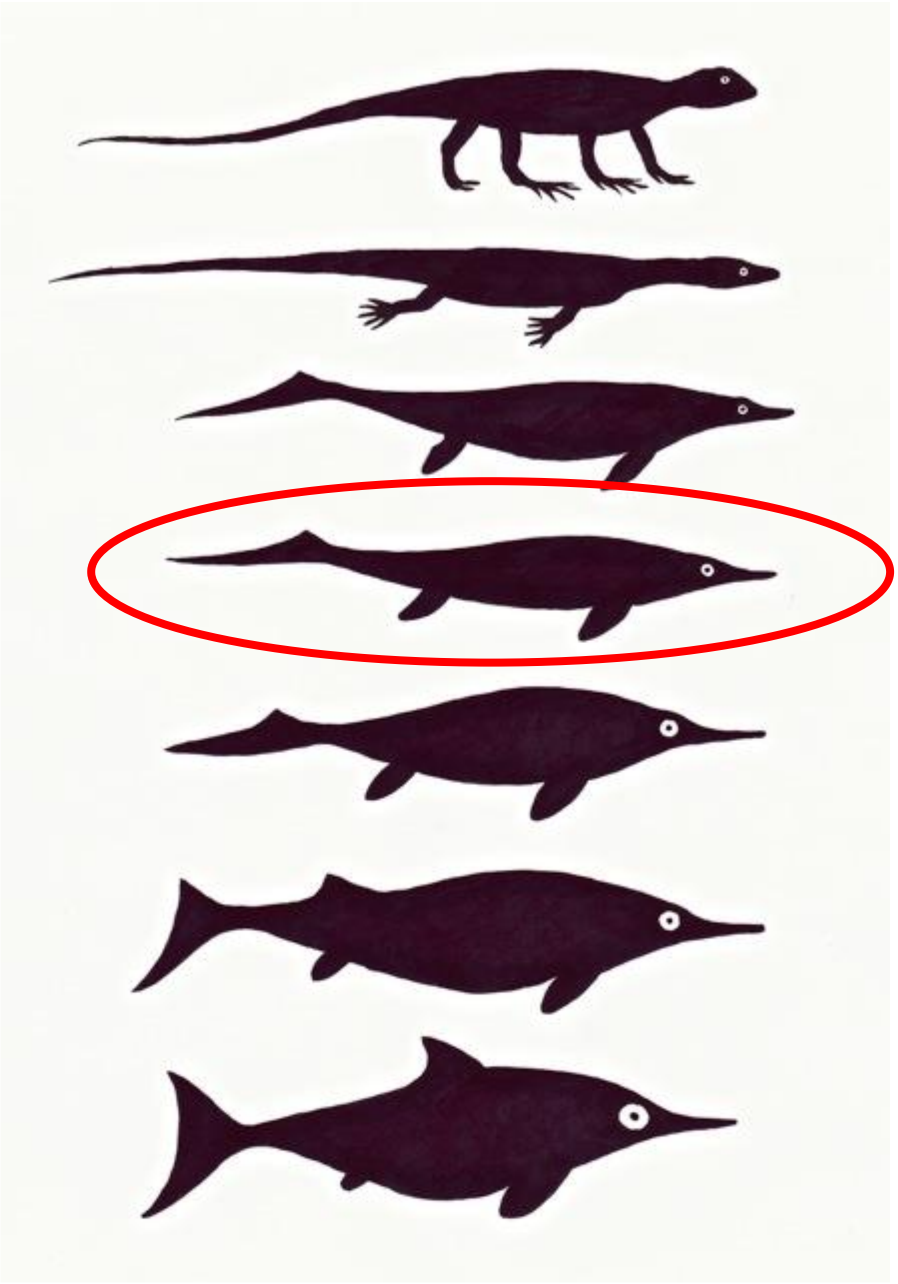
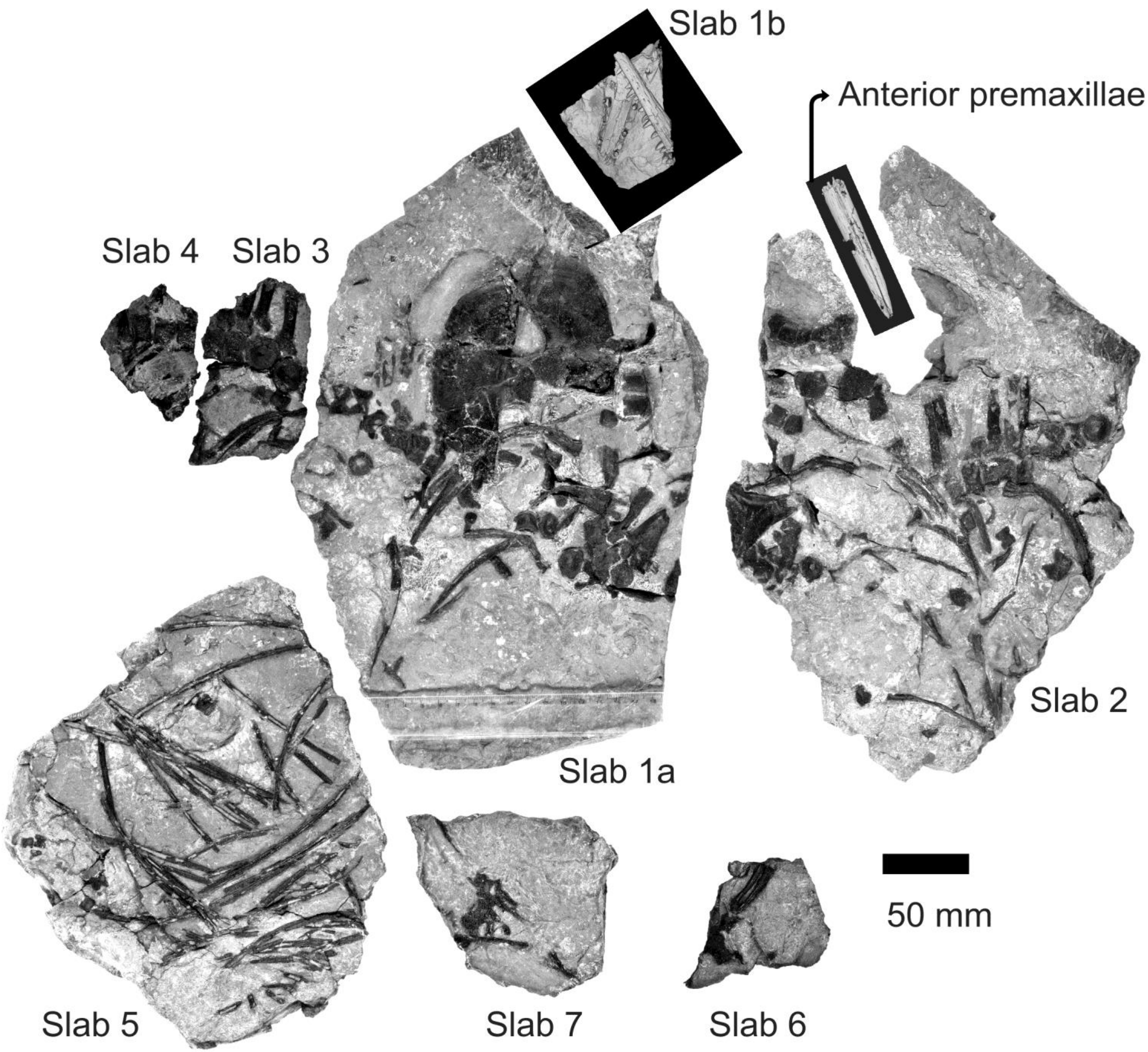


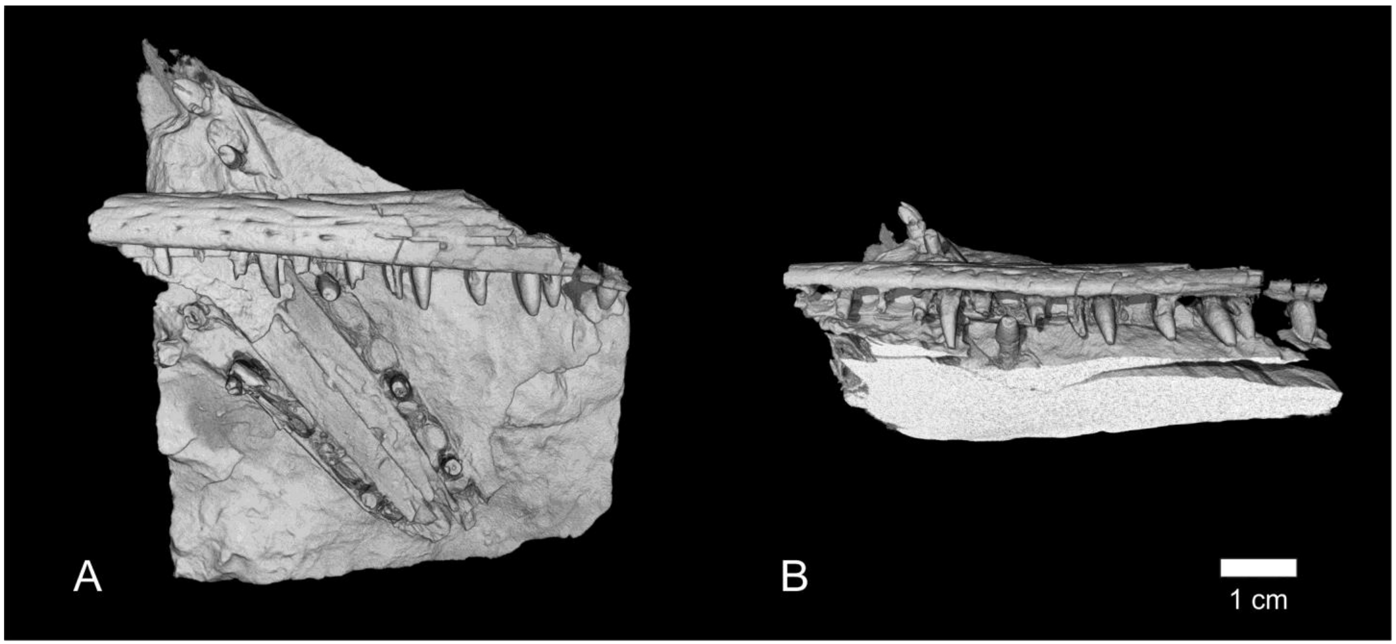
Fig. 3. Rekonstruktion von *Mixosaurus Nordenskiöldii,* um die Form der Schwanzflosse zu zeigen.

Wiman 1910

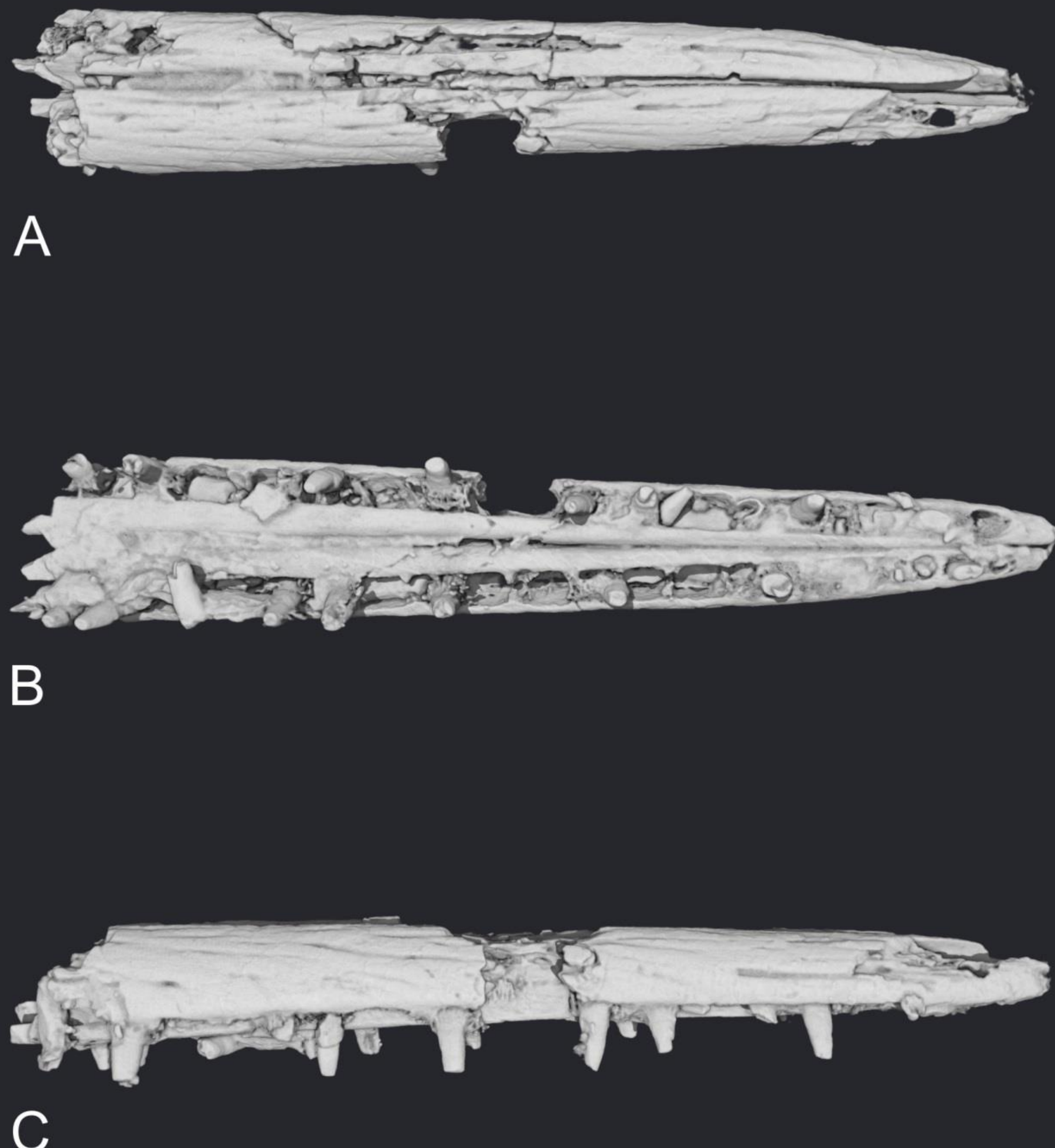




Økland et al. to be submitted soon...



Økland et al. to be submitted soon...

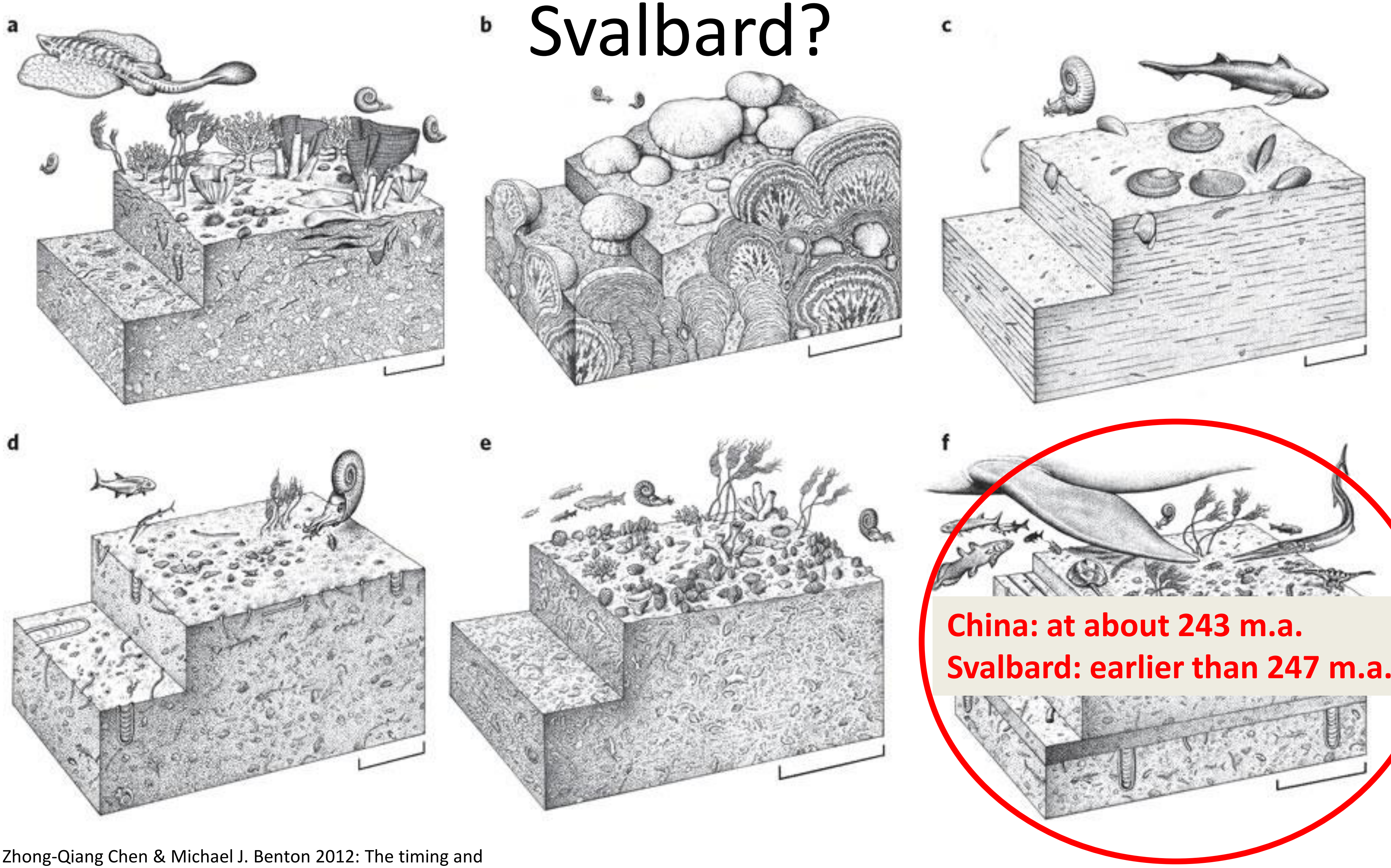


Økland et al. to be submitted soon...

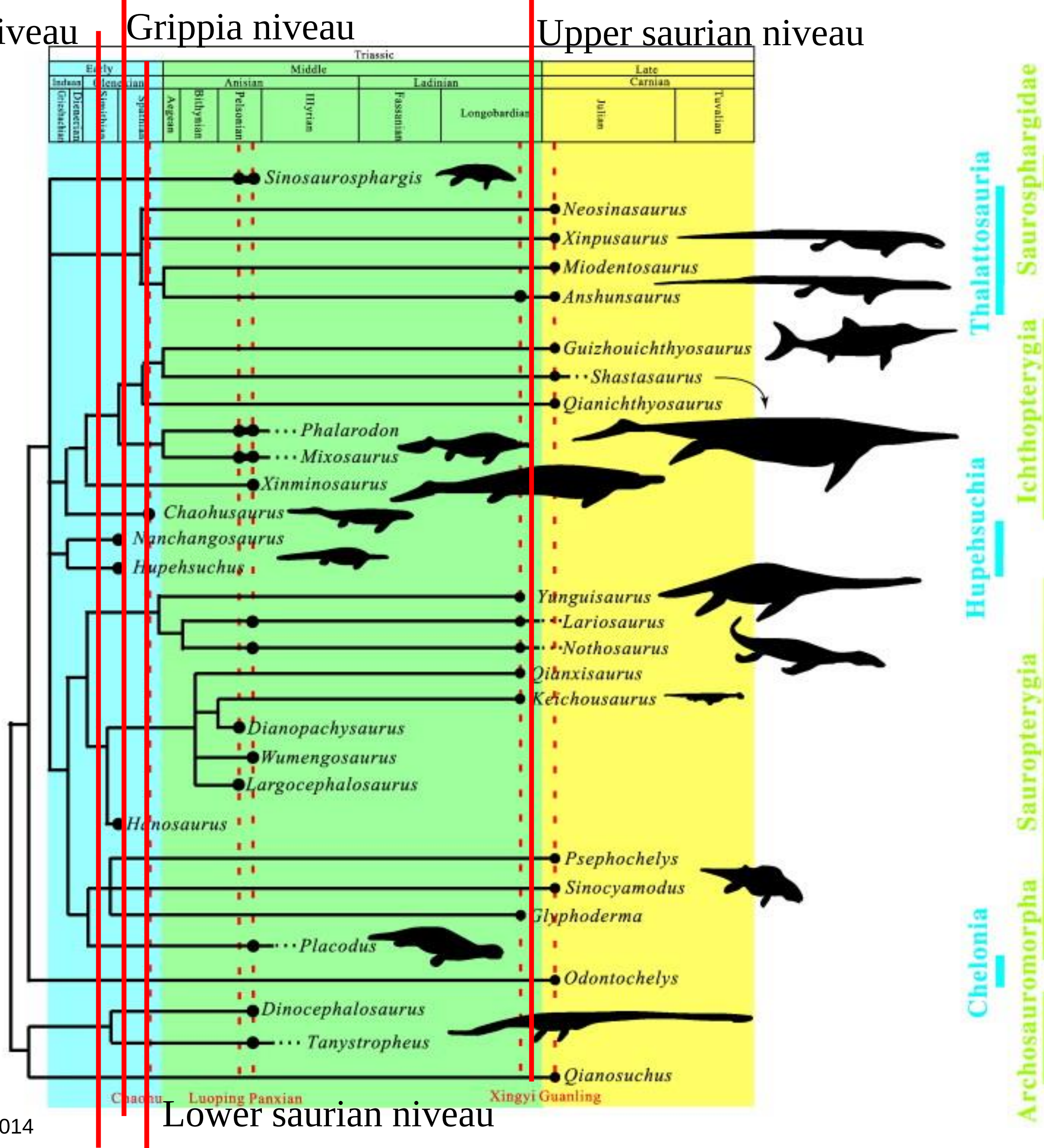

Oil in Botneheia fm.

Preliminary results

How well does China compare to Svalbard?



Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475



Michael J. Benton , Qiyue Zhang , Shixue Hu , Zhong-Qiang Chen , Wen Wen , Jun Liu , Jinyuan Huang , Changyong Z...

Exceptional vertebrate biotas from the Triassic of China, and the expansion of marine ecosystems after the Permo-Triassic mass extinction

Earth-Science Reviews, Volume 125, 2013, 199 - 243

http://dx.doi.org/10.1016/j.earscirev.2013.05.014

Research

- multidisiplinary studies of the Jurassic and Triassic deposits of Svalbard combining sedimentology, biostratigraphy, isotope-stratigraphy, micropaleontology, invertebrate paleontology, geochemistry and vertebrate paleontology

- 4 main researchers (3 NHM,1 USA)
- 3 PhDs, 2 more PhDs under way
- 13 masters finished (12 women, one male)
- About 12 associated researchers from USA, Germany, Poland, England and Norway
- Svalbard Museum, NTNU and UNiS involved
- more than **35** peer-reviewed internationally published scientific papers

Collections of fossils 2004-2016

The largest Mesozoic fossil collection from Svalbard in the World:

- 60 skeletons of marine reptiles from the Late Jurassic
- about 20 skeletons of marine reptiles from the Middle Triassic
- approx. ten thousand disarticulated bones and teeth from bonebeds in the Early Triassic
- thousands of invertebrate fossils, microfossils and rock samples
- a unique research collection for the future
- a revitalization for old polar fossil collections at the Natural History museum in Oslo

Take home messages - Triassic

- Previous work on Triassic marine reptiles from Svalbard demonstrates that they are crucial in understanding the evolution of the marine reptiles globally.
- no major field-based research program has been conducted on Triassic marine reptiles in Svalbard for a century.
- we will within a few years contribute largely to the understanding of the recovery of the marine biota after the (still) biggest extinction of them all – the Permian-Triassic extinction.
- the evolution of large marine reptiles were much earlier north of Pangea compared to equatorial areas (China)

Spitsbergen Mesozoic Research Group thank our sponsors and supporters 2004-2016!

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UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

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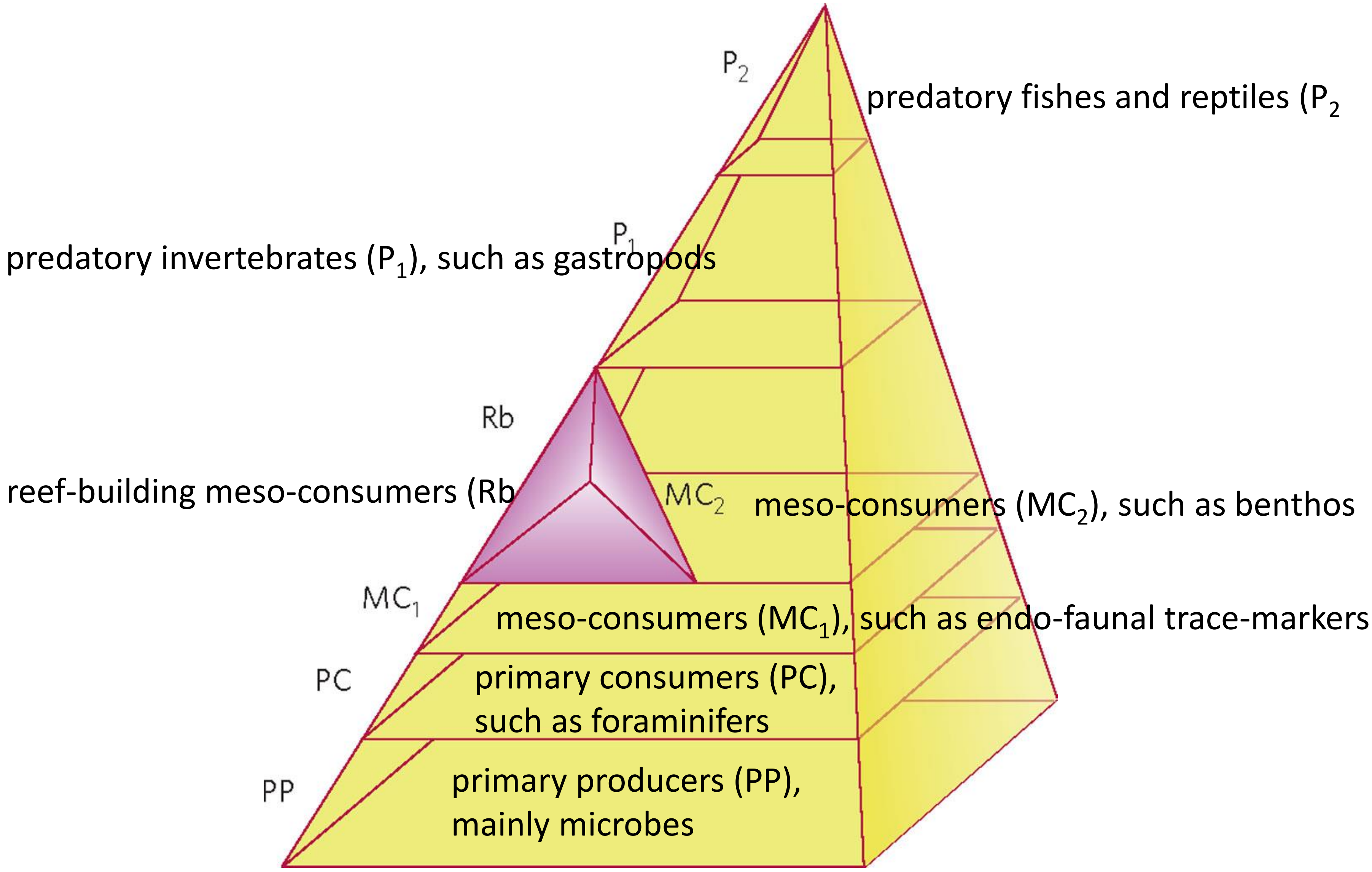
Thank you for li



Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475