


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

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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



Cryopterygius kristiansenae

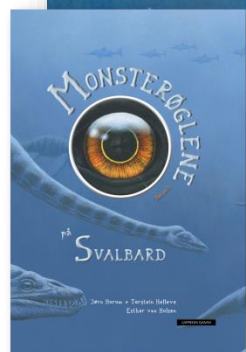


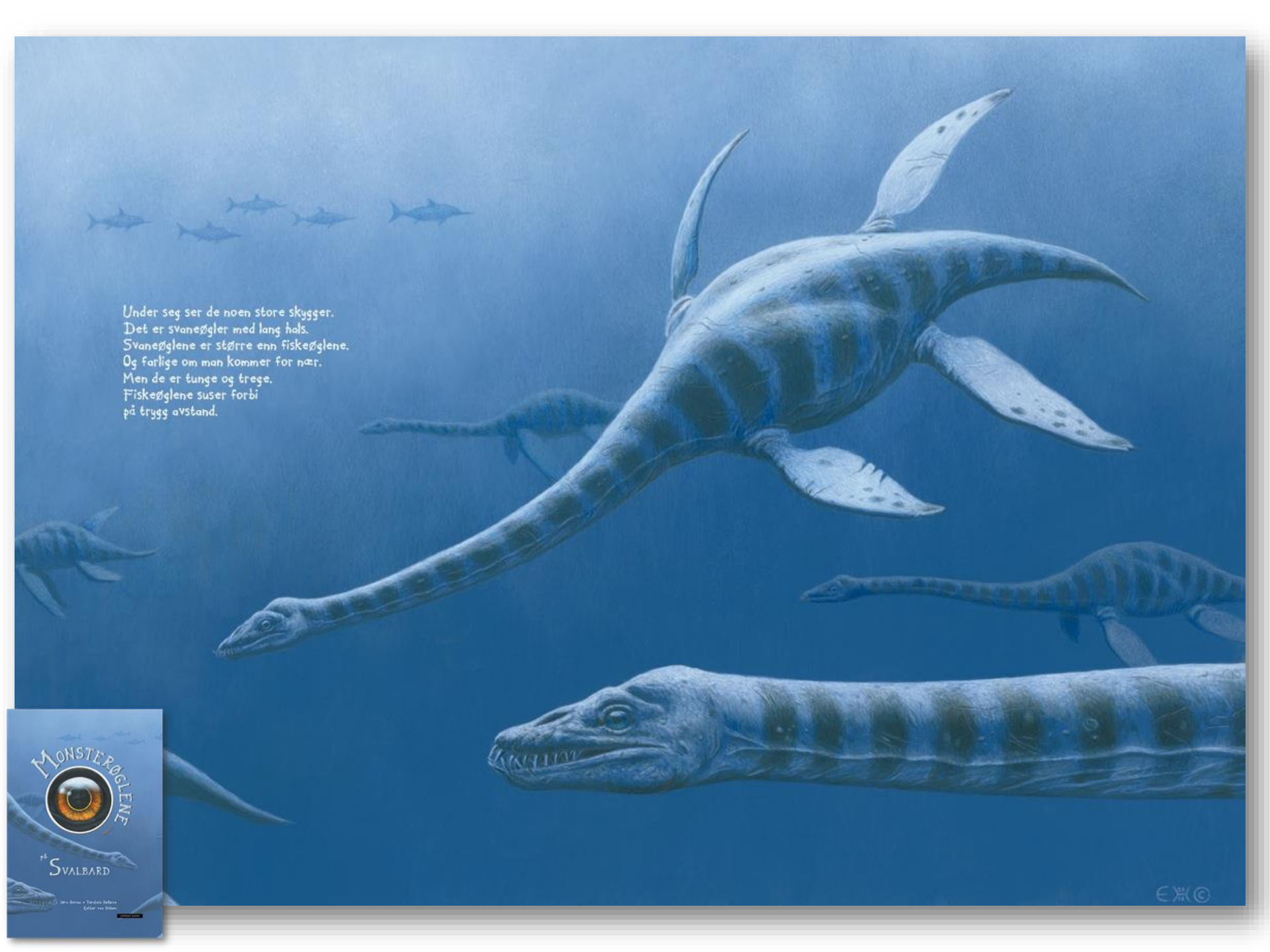


Øglene dykker under vann igjen.
Det er her de lever livet sitt.

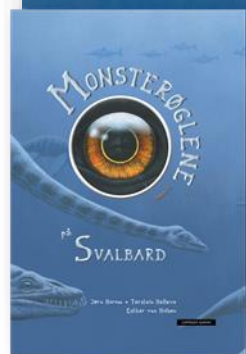
Den største av dem er hannen i flokken.
Kroppen hans er full av arr
etter kamper med andre hanner.
Han har slåss for å være leder for flokken.
De andre dyra er bare hunner.
Hannene har Arrkjempje jagd bort.

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.
Svaneøglerne er større enn fiskeøglerne.
Og farlige om man kommer for nær.
Men de er tunge og trege.
Fiskeøglerne suser forbi
på trygg avstand.

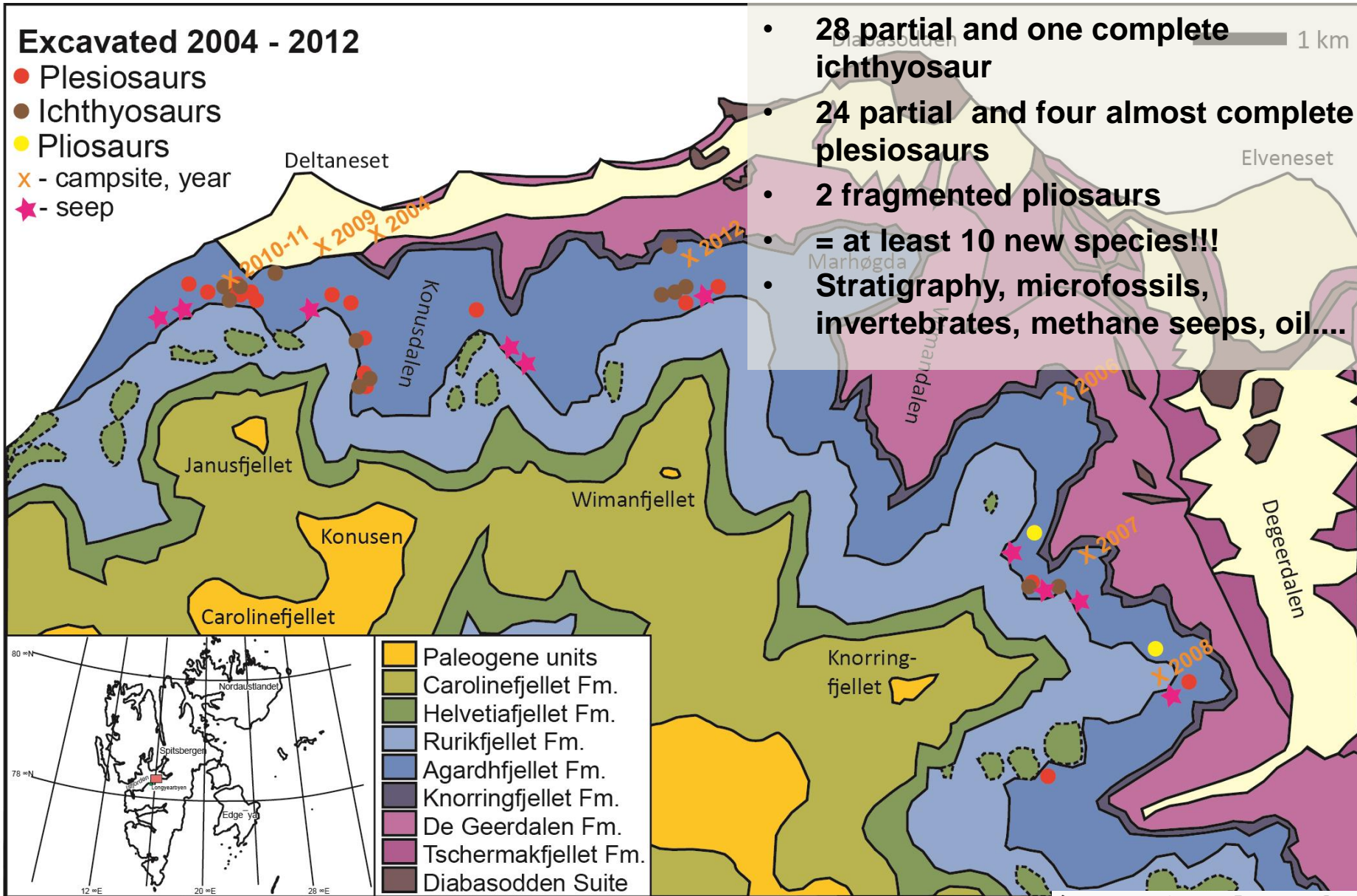


By the end of the 8th field season we have collected...

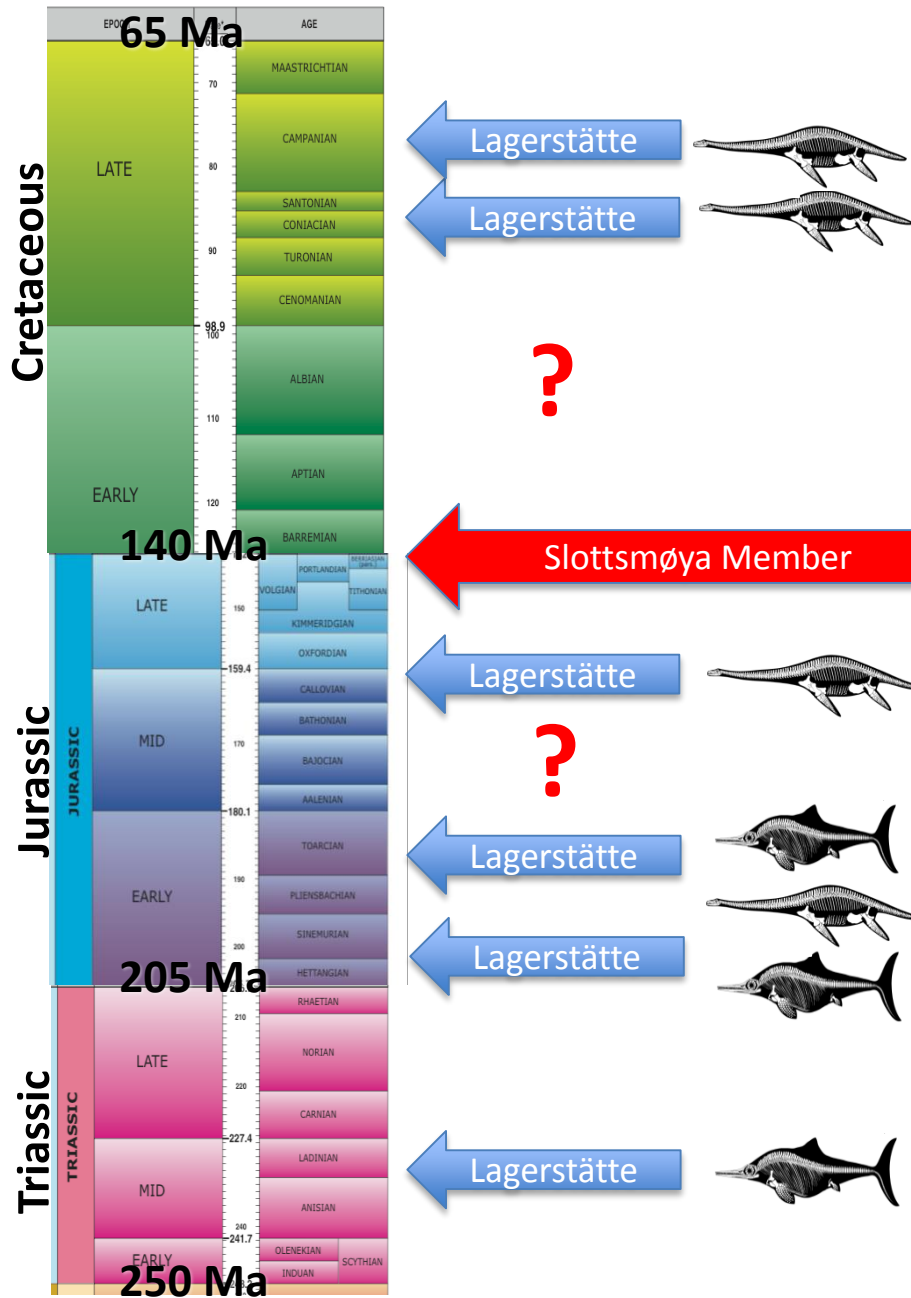
Excavated 2004 - 2012

- Plesiosaurs
- Ichthyosaurs
- Pliosaurus
- × - campsite, year
- ★ - seep

- 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

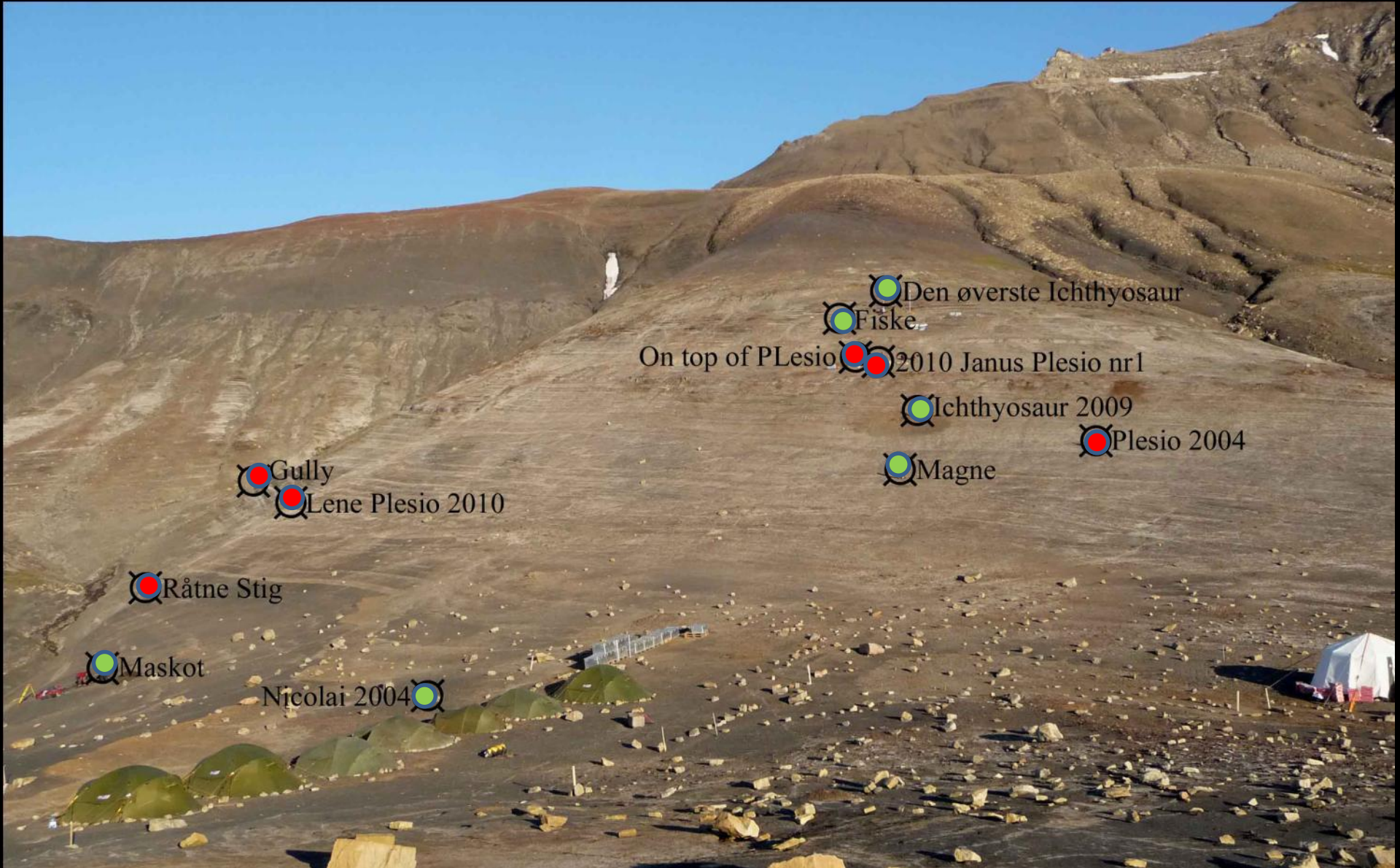


- New plesiosaur taxa:**
- *Djupedalia engeri*
 - *Spitrasaurus wensaasi*
 - *Spitrasaurus larseni*
 - *Pliosaurus funkei*
- New ichthyosaur taxa:**
- *Cryptopterygius kristiansenae*
 - *Palvennia hoybergeti*
 - *Janusaurus lundii*
 - *Keilhauia nui*
- New referral:**
- *Colymbosaurus svalbardensis*

2010-11: the best locality in the World!

● -ichthyosaurs

● -plesiosaurs



● Den øverste Ichthyosaur
● Fiske

On top of Plesio ● ● 2010 Janus Plesio nr1

● Ichthyosaur 2009

● Plesio 2004

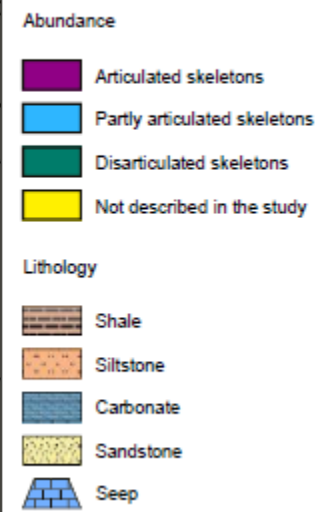
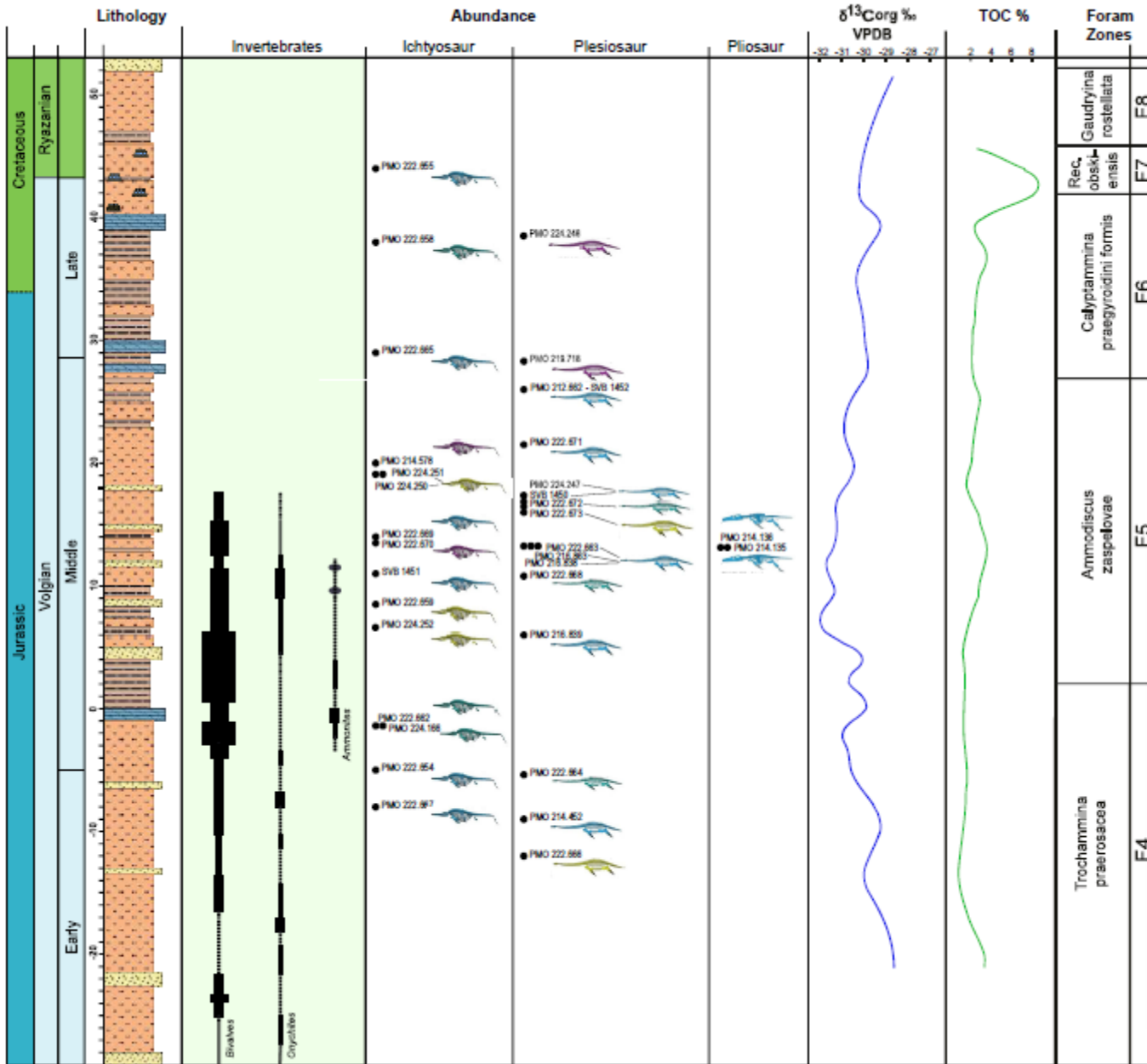
● Magne

● Gully
● Lene Plesio 2010

● Råtne Stig

● Maskot

Nicolai 2004 ●



Downloaded from <http://jhs.sagepub.com> at Universitet i Oslo on December 18, 2015

The Stottosmyva marine reptile Lagerstätte: depositional environments, taphonomy and diagenesis

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Abstract: The Late Jurassic Stottosmyva Member Lagerstätte on Spitzbergen offers a unique opportunity to study the relationships between overwater food preservation, overwater occurrence and depositional environment. In this study, 21 phossosaur and 17 ichtyosaur specimens are described with respect to articulation, taphonomy, preservation, and diagenetic processes. We investigate the taphonomic conditions of marine reptiles in the Stottosmyva Member in detail, and a correlation between high total organic content, low oxygen levels, low biotic overprinting and optimal reptile preservation is observed. A new model for 3D preservation of vertebrates in highly compacted organic sands is explained.

Supplementary material: A typomorphic description of each marine reptile specimen is available at <http://dx.doi.org/10.1080/00253152.2015.1055000>.

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Marine reptiles have been known from the Stottosmyva Lagerstätte for more than 150 years, particularly from Triassic units (Meyer & Koenig 1913; Huxon *et al.* 2014). However, it was not until 1914 that Wiman described the first Jurassic marine reptile, a phossosaur, from the island of Spitzbergen (Wiman 1914; Koenig & Meyer 2013). Beginning in 2004, an extensive new field survey for Jurassic marine reptiles was undertaken by the Spitzbergen Jurassic Research Group (SJRG), an international team of palaeontologists and geologists. During eight field seasons (2004 and 2006–12) on Spitzbergen, SJRG collected more than 40 marine reptile skeletons from the dark matrix shales of the Upper Jurassic, Lower Cretaceous Stottosmyva Member of the Agardhøllen Formation (Fig. 1). Given the sheer abundance of material and quality of preservation, we have characterized this unit as a Lagerstätte (Huxon *et al.* 2013).

In the course of this work, detailed taphonomical data have been collected, permitting a new insight into phossosaur and ichtyosaur taphonomy. Previous studies were limited primarily to two other Jurassic units: the Oxford Clay and the Posidonia shales (Fornaceo 1985; Martin 1985, 1993). However, the material upon which these studies were based was collected decades ago, and the specimens were not adequately stratigraphically contextualized or contextualized geologically. Thus, taphonomical interpretations presented in these studies are somewhat contentious. Elfrim (2001) also analyzed the taphonomy of a large number of Upper Jurassic and Lower Cretaceous ichthyosaurs from two parts of the Chukotka Region in the Vologda Region.

Here, for the first time, we address phossosaur and ichthyosaur taphonomy based on a large sample size ($n = 30$) with many articulated specimens from a site where stratigraphically, sedimentological and palaeontological data were collected simultaneously (Table 1, Fig. 1A, B). In this paper, we describe the preservational modes of the skeletons, and attempt to interpret the major physical and biotic factors affecting skeletal preservation. We incorporate new surface and wall data to document the stratigraphic distribution of skeletons in the site, especially in relation to the total organic

From: Eklöv, P., Eriksson, J., Huxon, J.H., Madsen, J. & Yano, Y. (eds) *Marine Reptiles of the Mesozoic and the Cenozoic*. Geological Society, London, Special Publication, 438, 1–11. <https://doi.org/10.1111/SPLA.12102>
 © 2015 The Authors. Published by The Geological Society of London.
 Publishing disclaimer: www.geobase.org.uk/pubs_etica

● - 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!

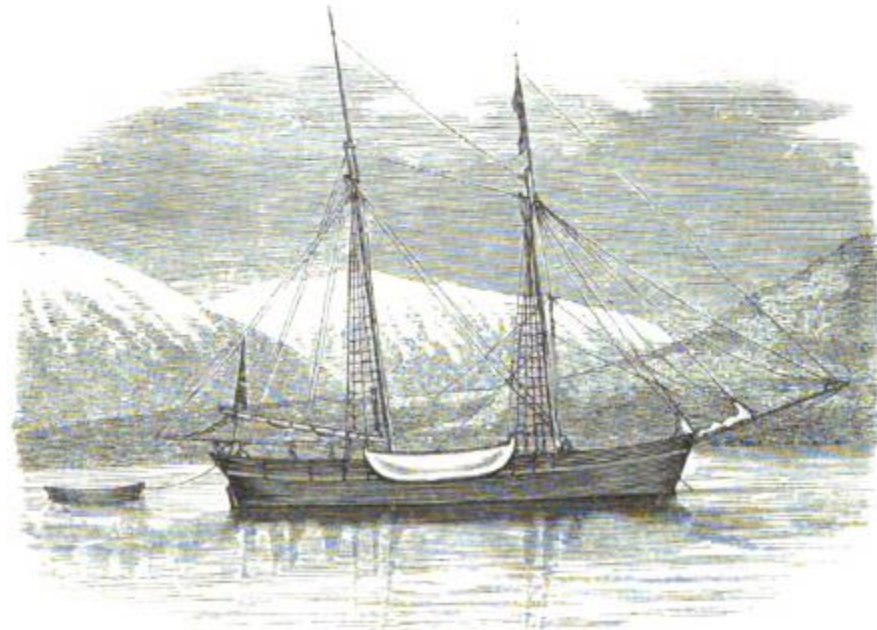
SVENSKA EXPEDITIONEN

TILL

SPETSBERGEN

ÅR 1864

OM BORD PÅ



AXEL THORSEN,

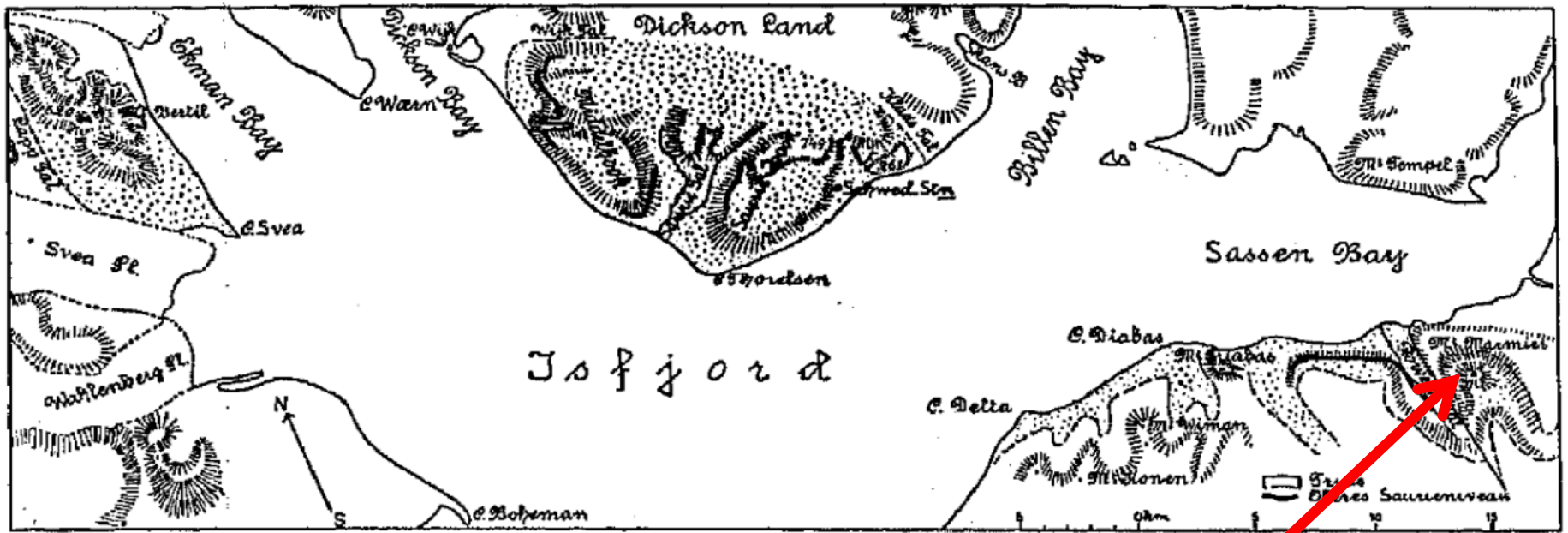


Fig. 1. Trias im Inneren des Isfjord. Skizze von G. De Geer, 1 : 600,000.

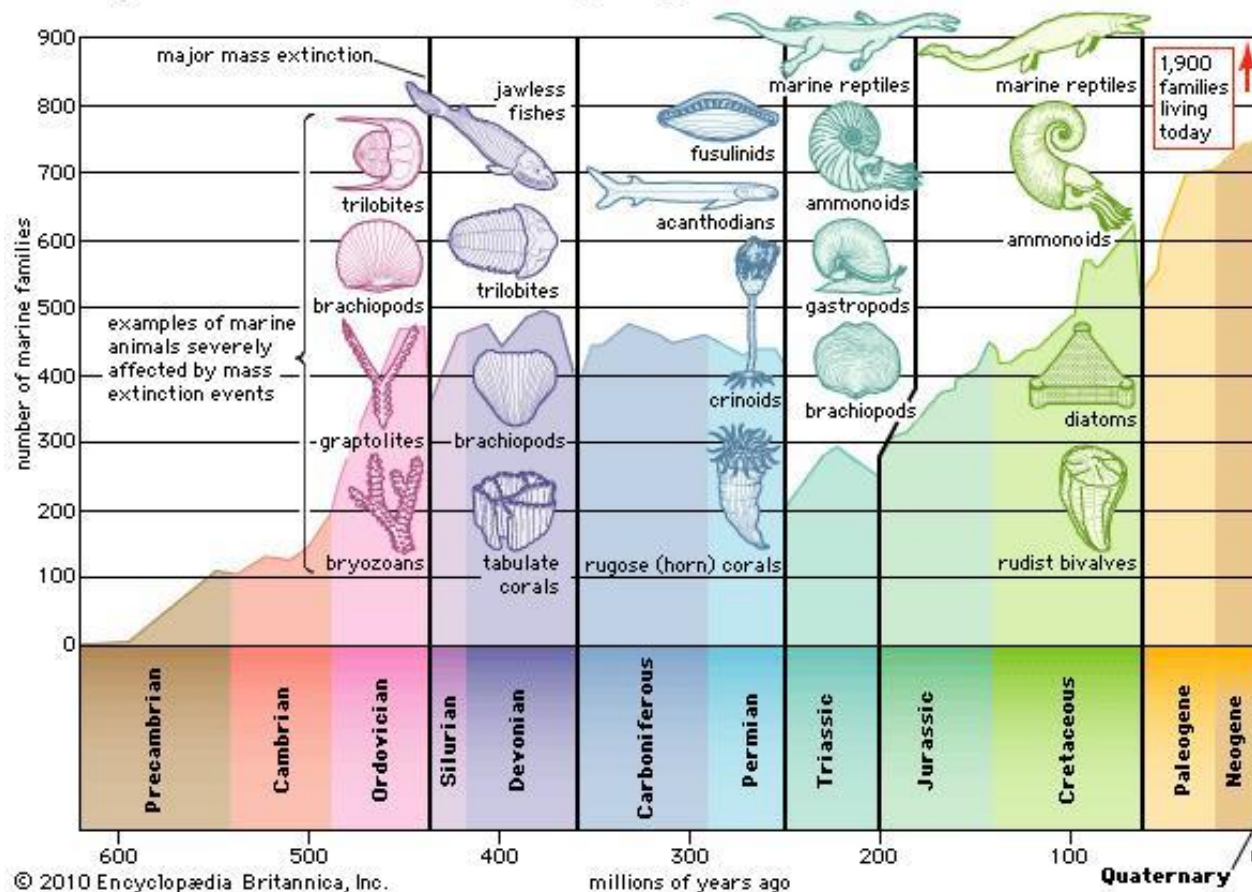
Wiman 1910

96% anyone??

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

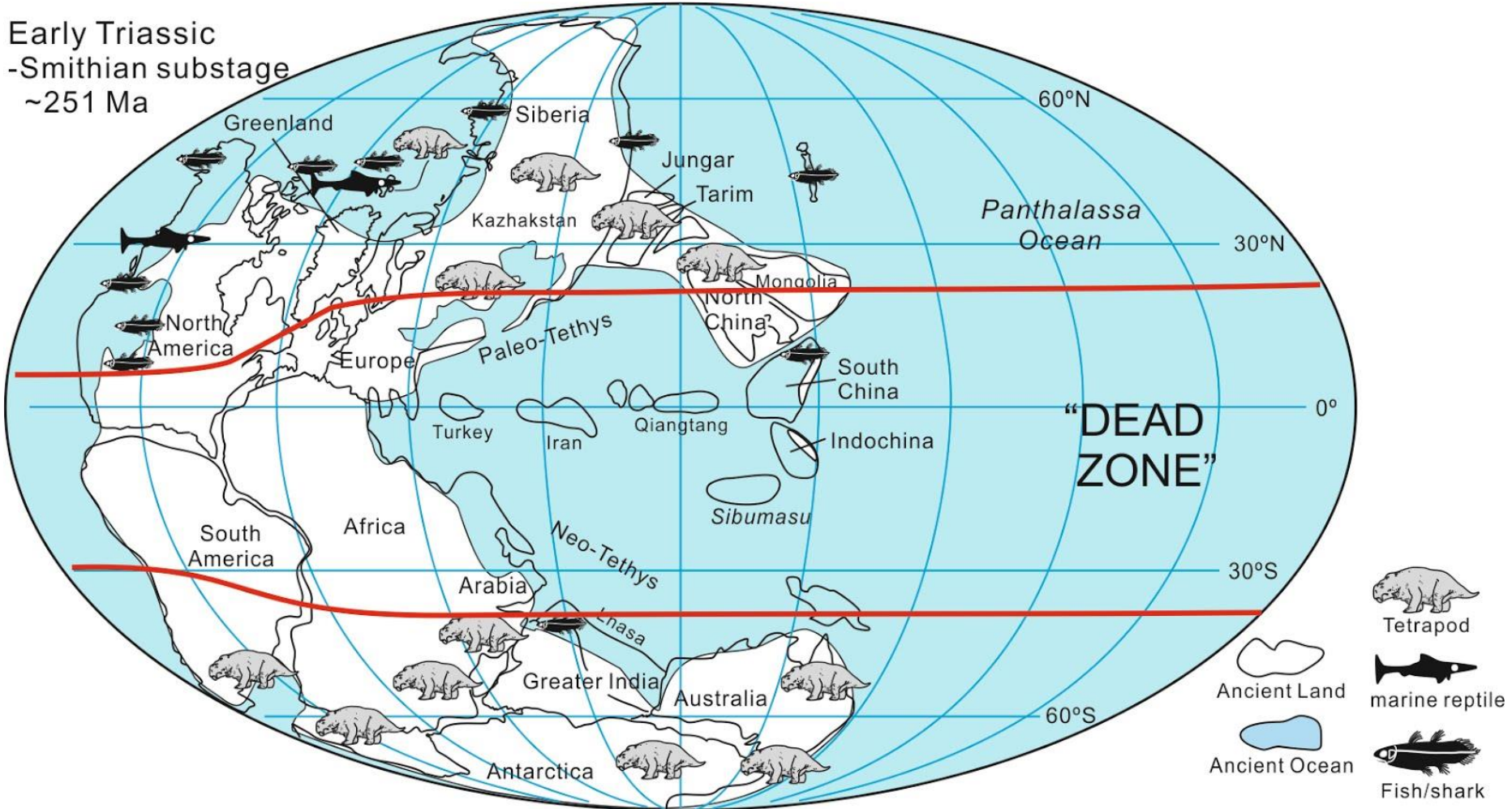
Stanley, S.M. 2016: Estimates of the magnitudes of major marine mass extinctions in earth history. PNAS 2016 113 (42) E6325-E6334;

Diversity of marine animal families over geologic time



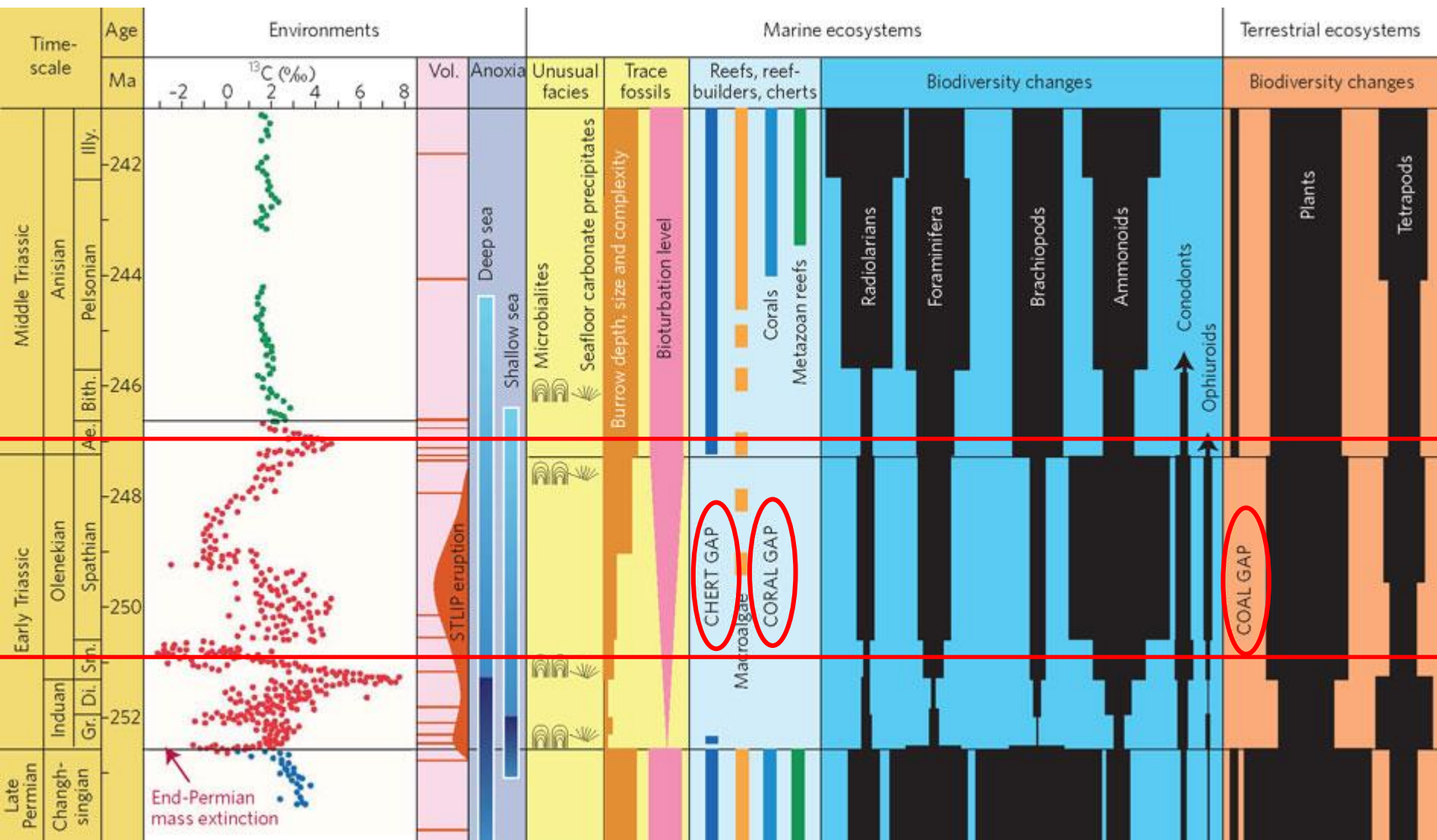
<https://media1.britannica.com/eb-media/42/79542-004-E6AABF42.jpg>

Early Triassic
-Smithian substage
~251 Ma



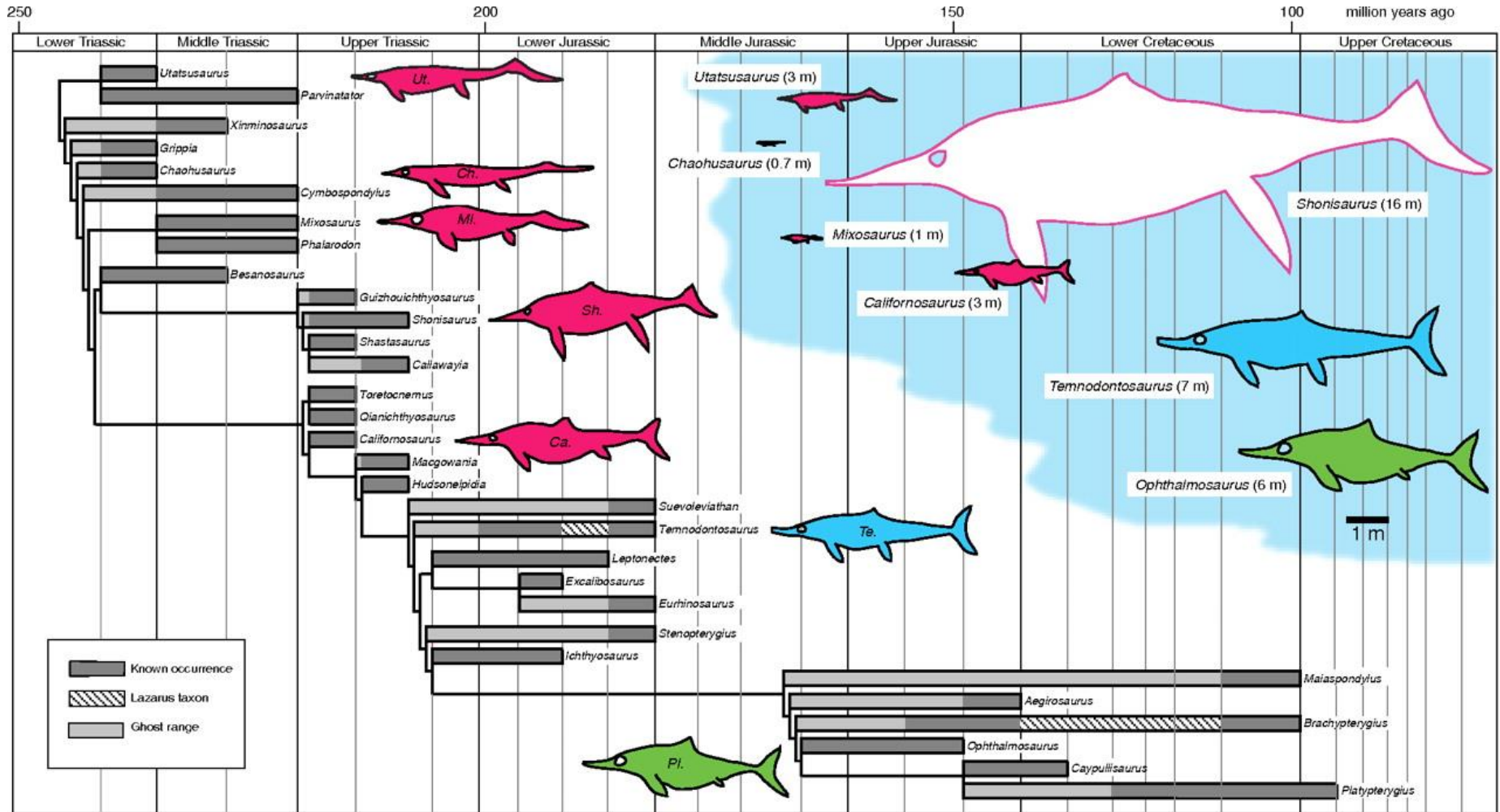
Atmospheric Carbon Injection Linked to End-Triassic Mass Extinction

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.



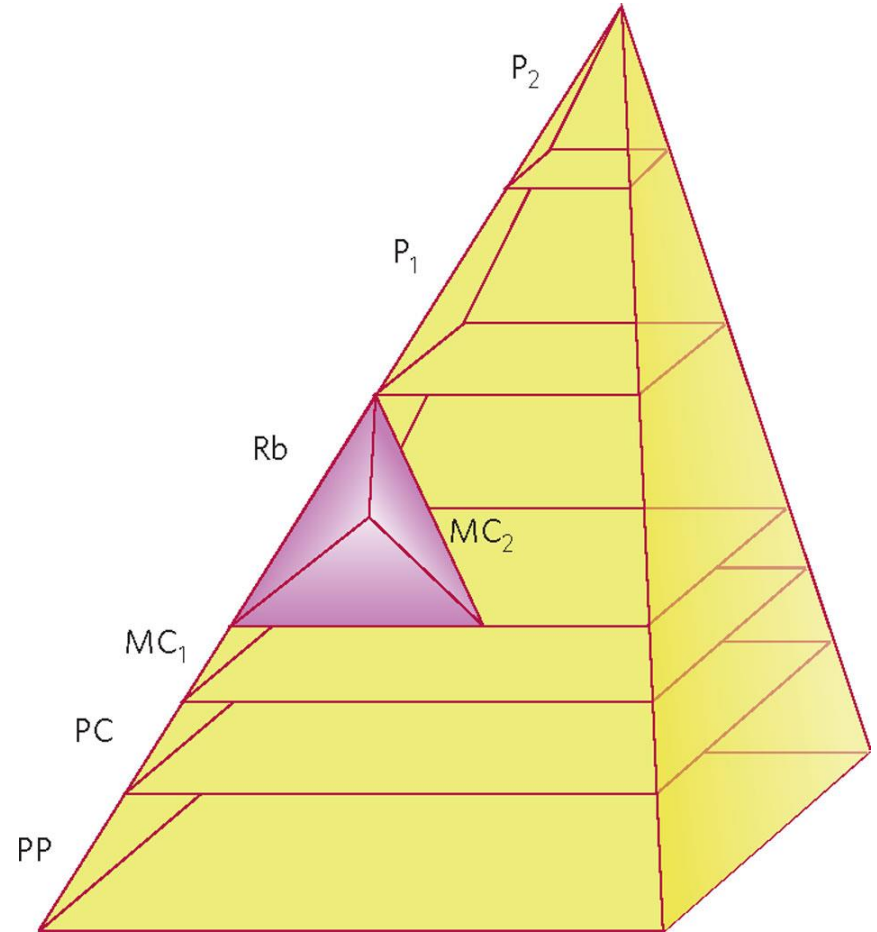
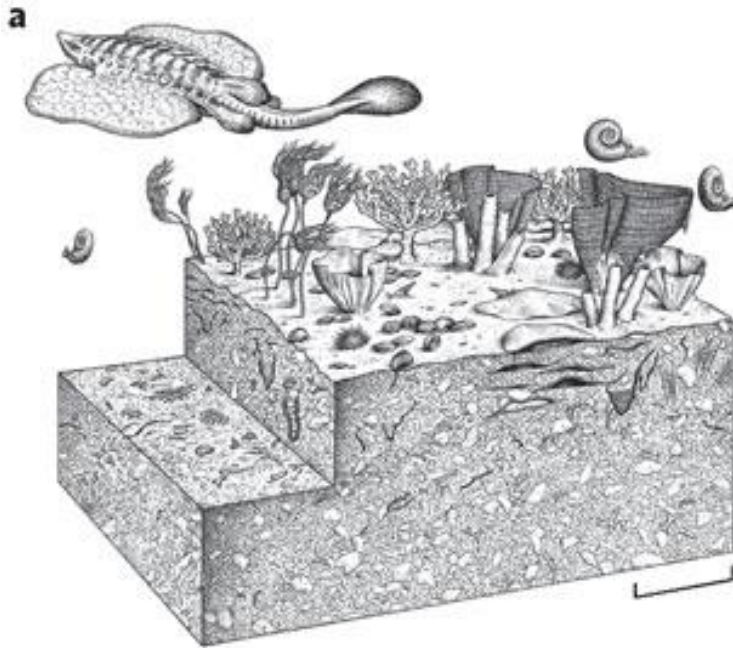
Thorne P M et al. PNAS 2011;108:8339-8344

Spitsbergen Mesozoic Research Group

- multidisciplinary 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

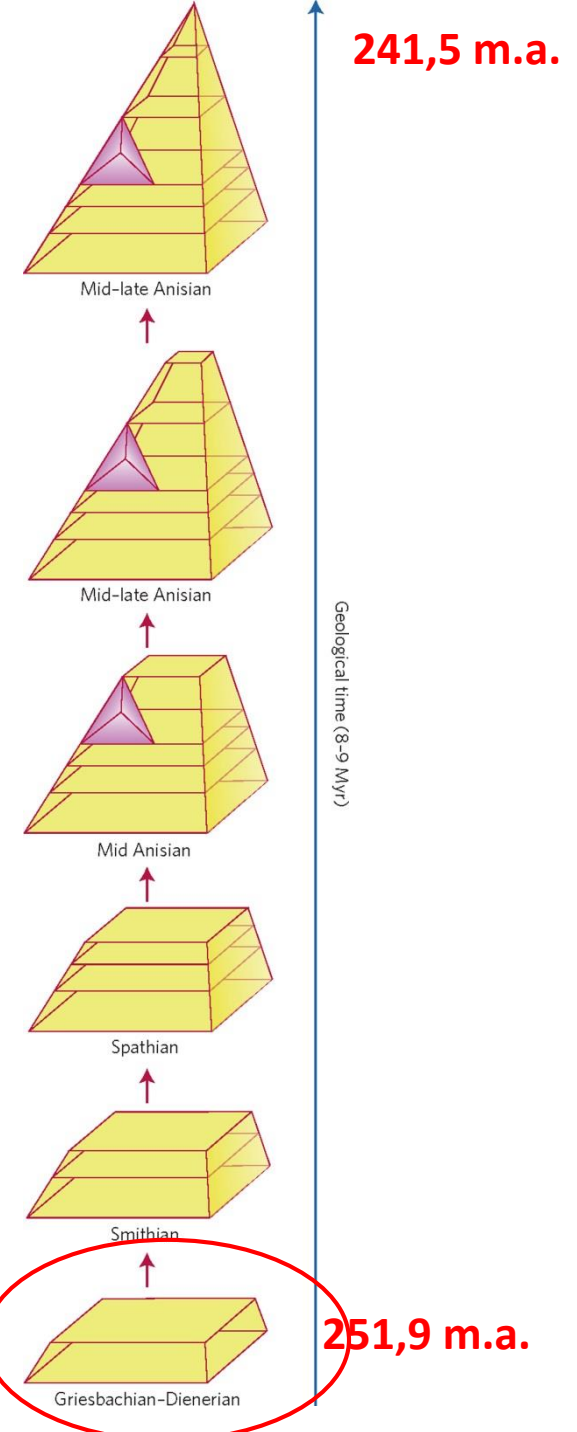
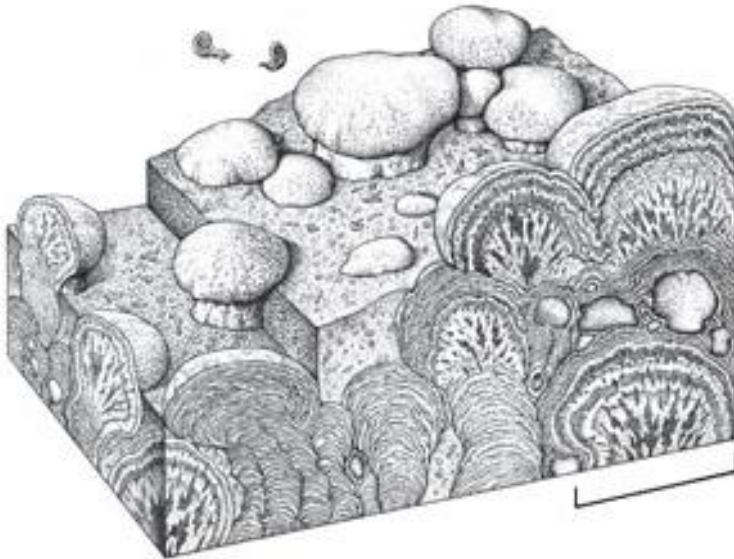
The best studied recovery: China

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



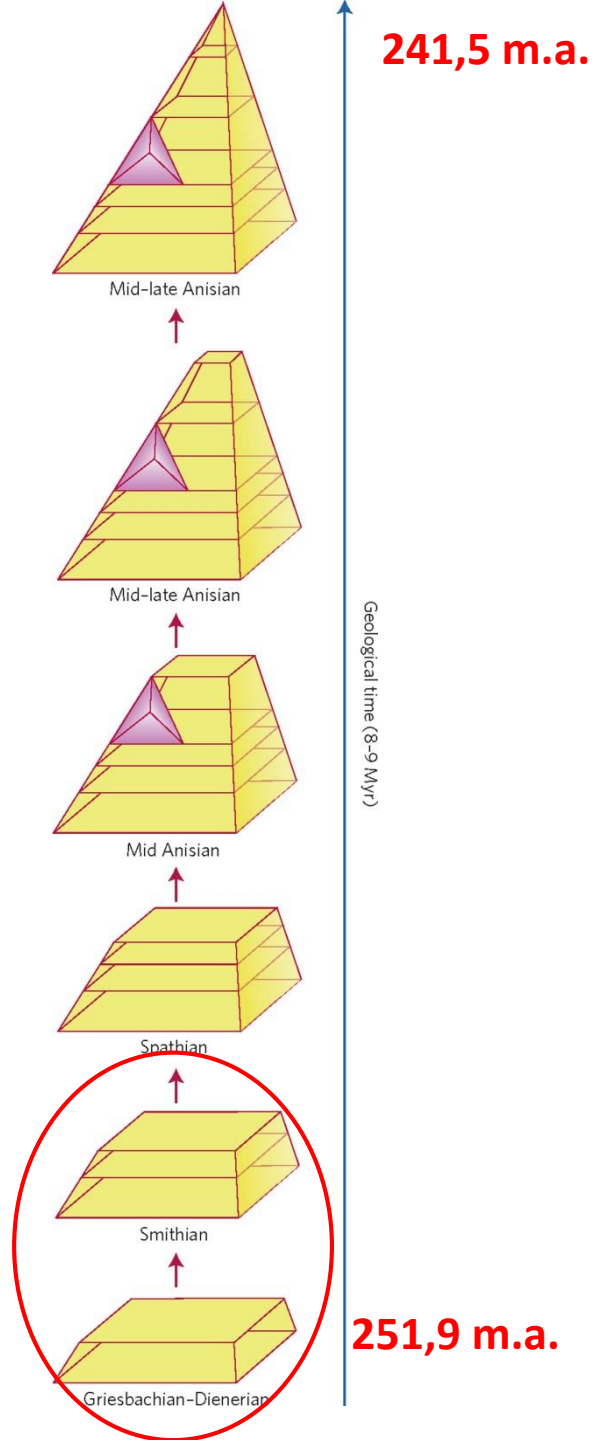
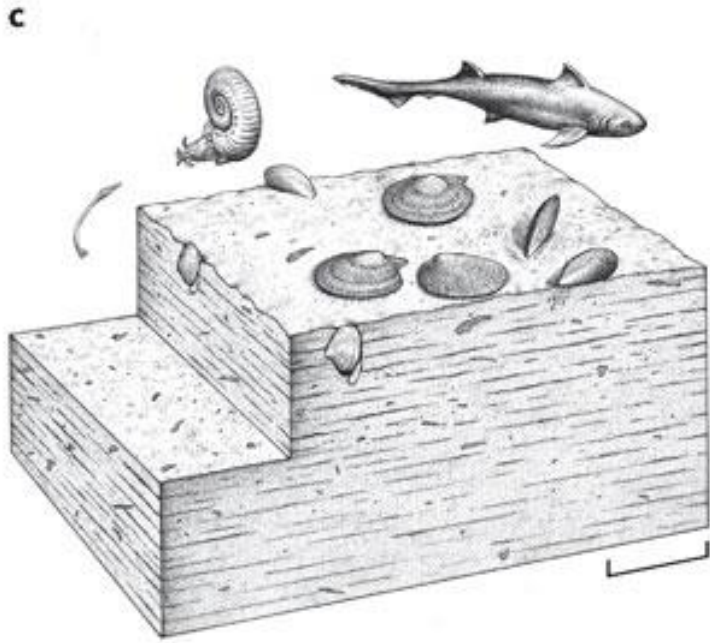
Microbe-dominated ecosystem immediately after the EPME 251,5 ma; primary producers dominate.

b

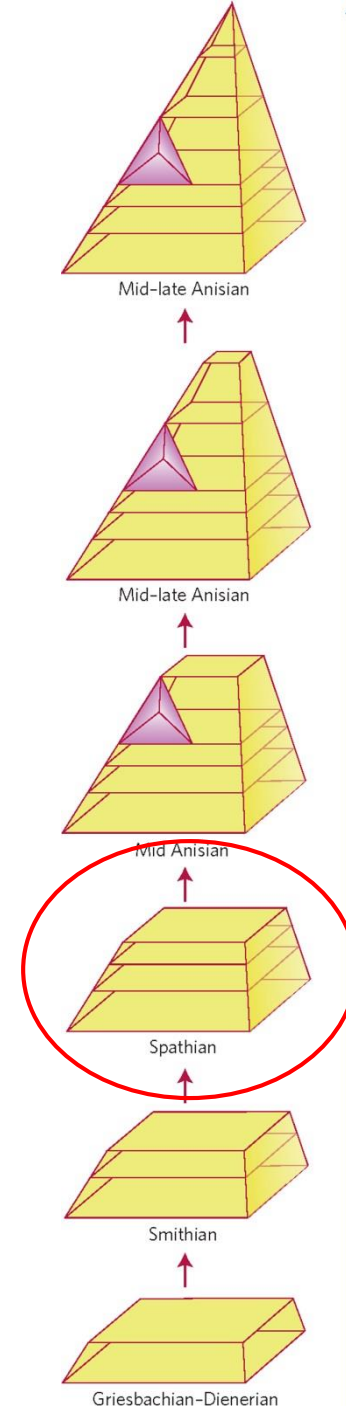
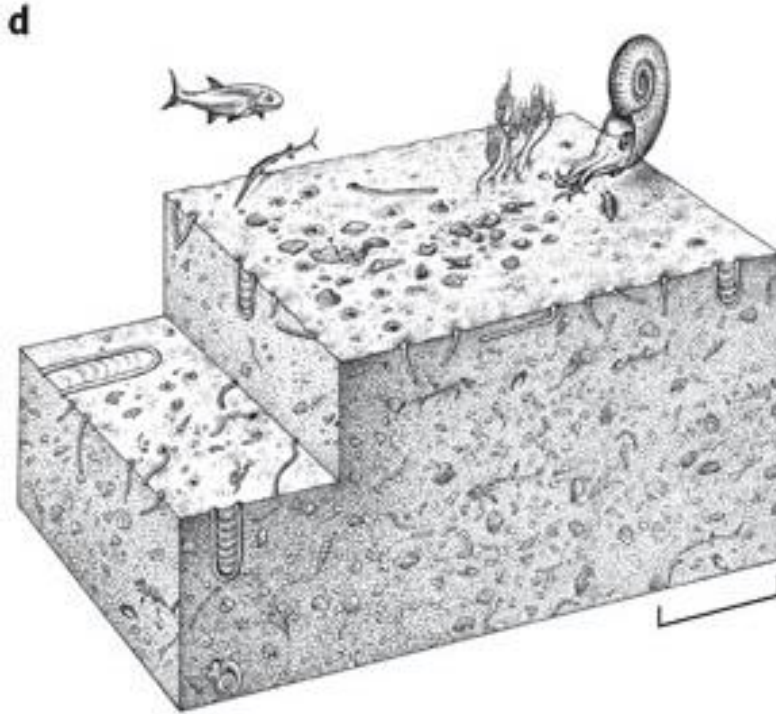


Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. *Nature Geoscience* 5, 375–383 (2012) doi:10.1038/ngeo1475

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



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



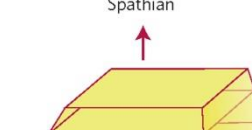
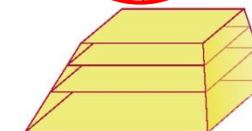
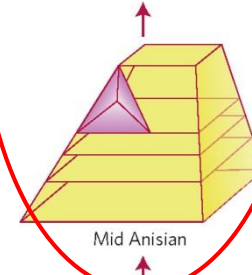
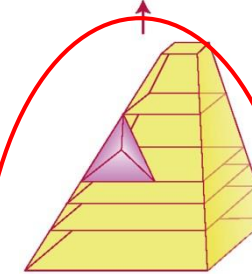
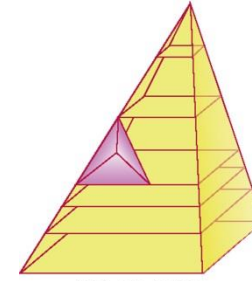
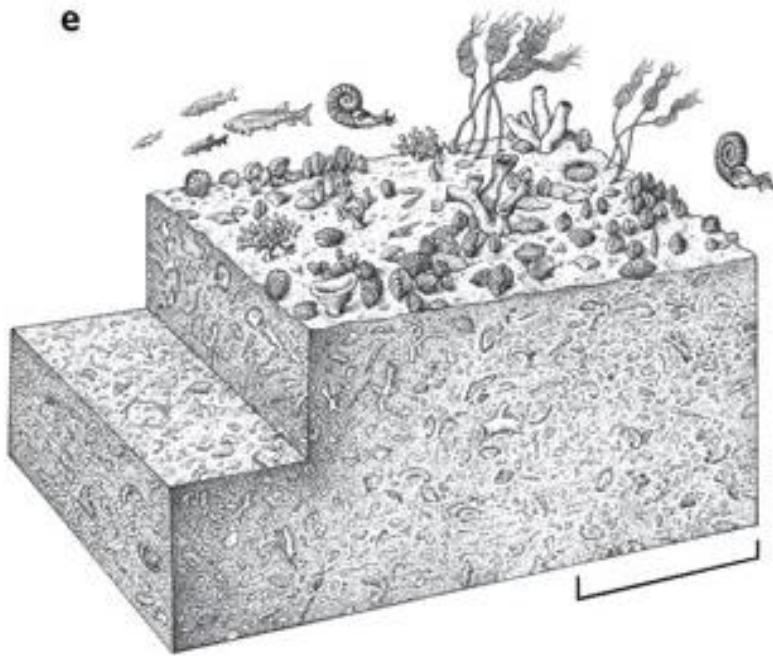
Geological time (8-9 Myr)

243 millioner år siden

251,9 m.a.

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.**

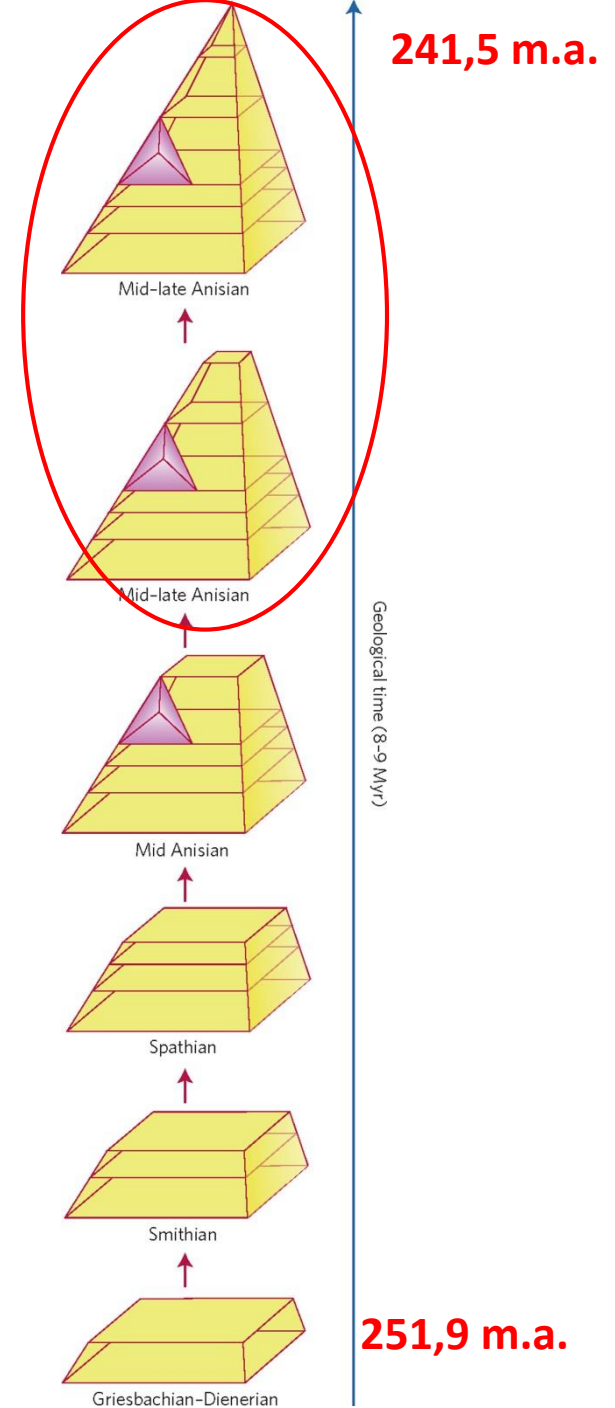
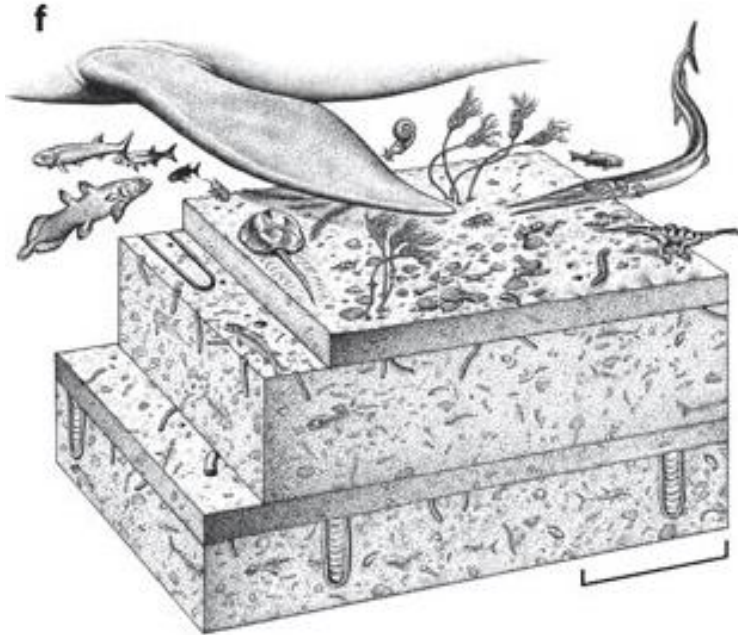


241,5 m.a.

Geological time (8-9 Myr)

251,9 m.a.

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



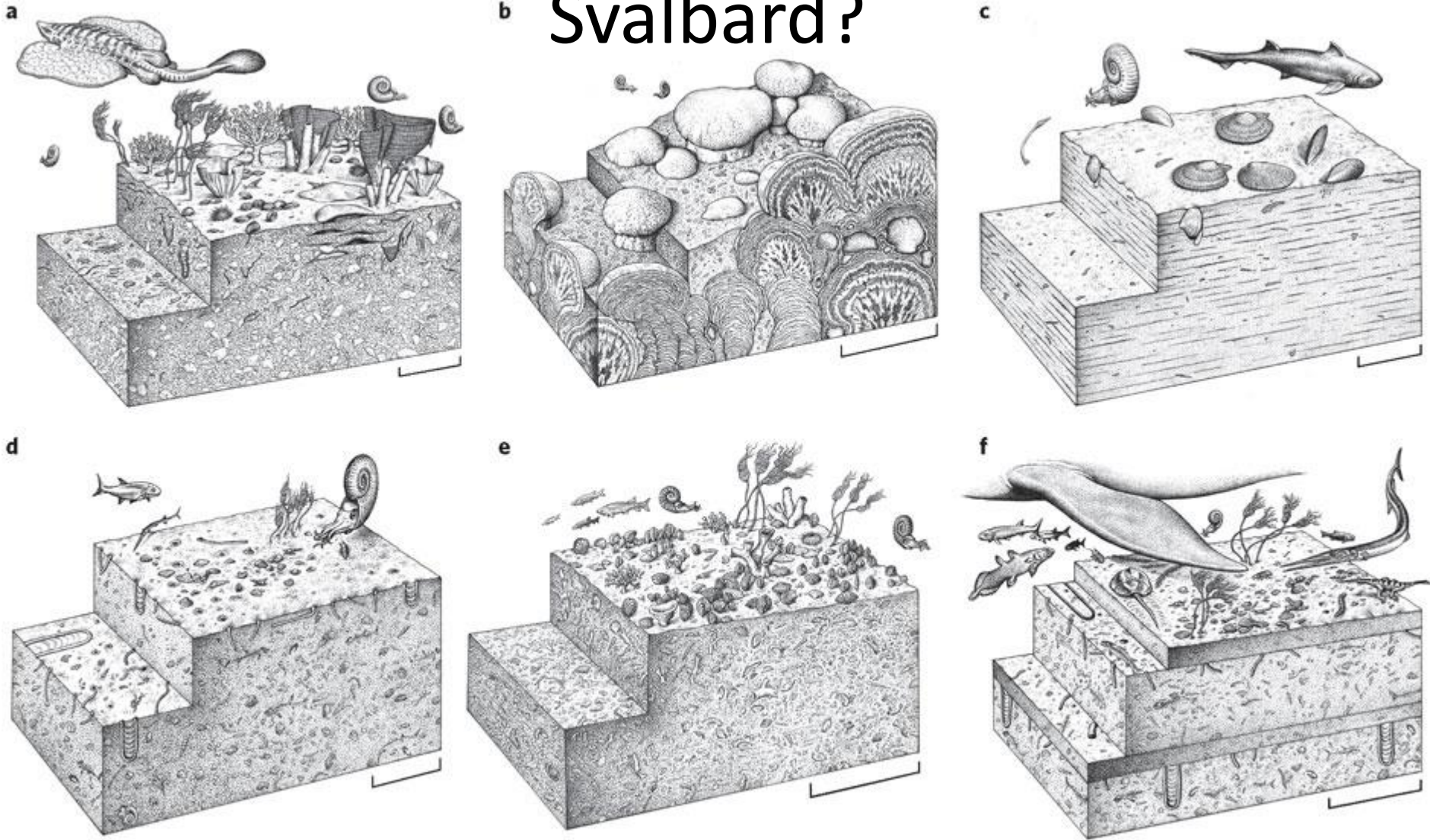
241,5 m.a.


Geological time (8-9 Myr)

251,9 m.a.

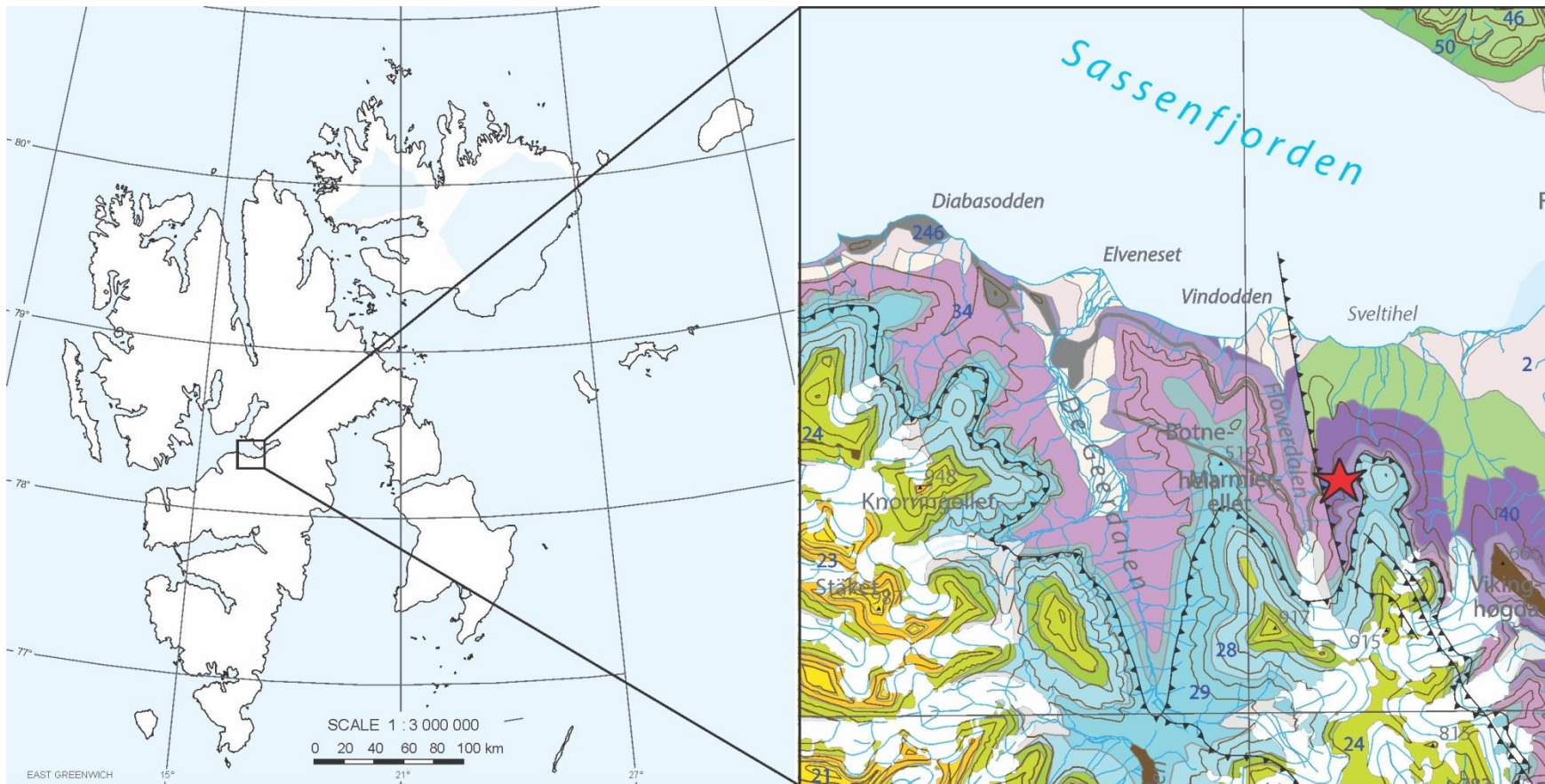
Zhong-Qiang Chen & Michael J. Benton 2012: The timing and pattern of biotic recovery following the end-Permian mass extinction. Nature Geoscience 5, 375–383 (2012) doi:10.1038/ngeo1475

How well does this compare to Svalbard?



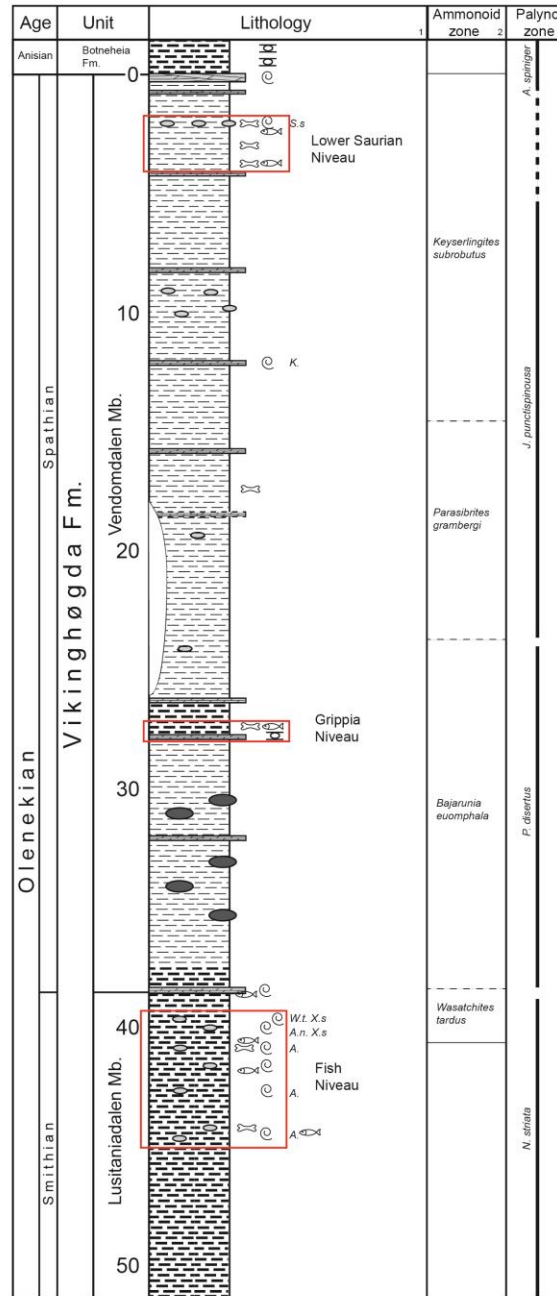


Three summers in Flowerdalen 2014-16



- | | | | |
|----|------------------------|-----|-------------------|
| 2 | Marine deposit | 39 | Botneheia FM |
| 3 | Glaci-fluvial deposits | 40 | Vikingshøgda FM |
| 21 | Grumantbyen FM | 46 | Kapp Starostin FM |
| 23 | Firkanten FM | 50 | Gipshuken FM |
| 24 | Carolinefjellet FM | ▲▲▲ | Reverse fault |
| 28 | Rurikfjellet FM | ★ | Field site |
| 29 | Agardhfjellet FM | | |
| 34 | Storfjorden Subgroup | | |

Stratigraphical log of Marmierfjellet, Spitsbergen



Legend

- Grey shale
- Black shale
- Yellow dolomite
- Yellow dolomitic silt with cross bedding
- Large yellow-brown concretions
- Grey concretions
- Vertebrate bones
- Fish remains
- Phosphatic concretions

Ammonoids

- A. *Arctoceras*
- A.n. *Arctoprioceras nodosus*
- K. *Keyserlingites*
- S.s. *Svalbardiceras spitzbergense*
- W.f. *Wasatchites tardus*
- X.s. *Xenocelites spitzbergensis*

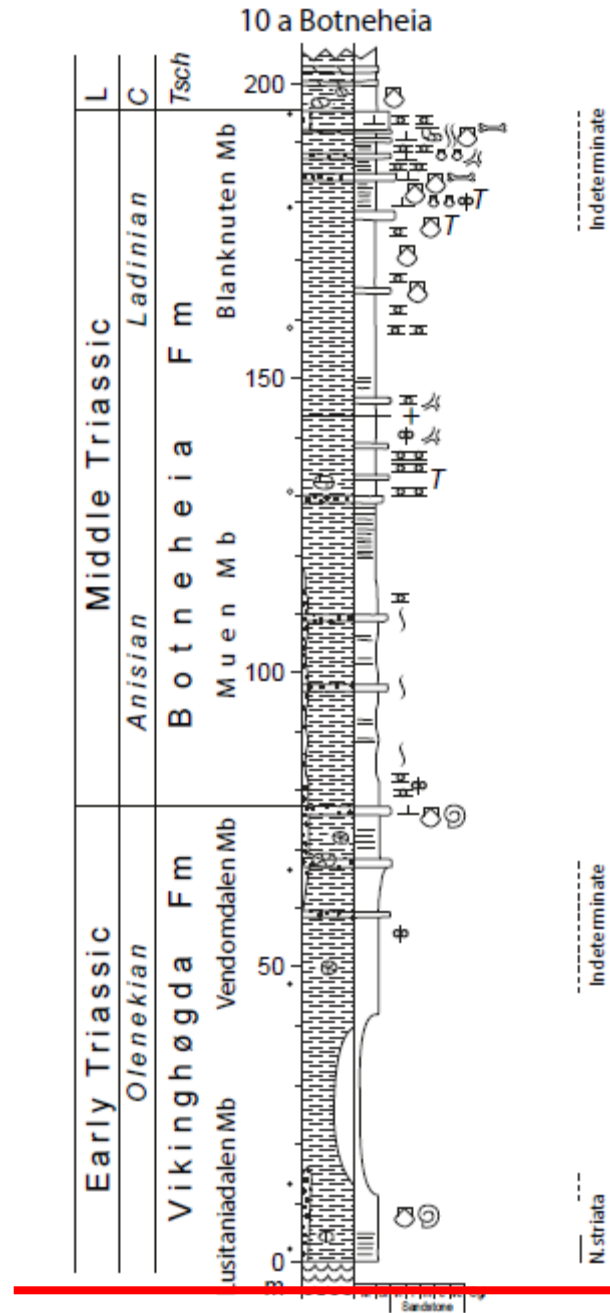
1. Hammer 2014

2. Mark et al. 1999 (fig. 13)

3. Vigran et al. 2014 (fig. 37a)

four layers with bones!

Vigran et al. 2014



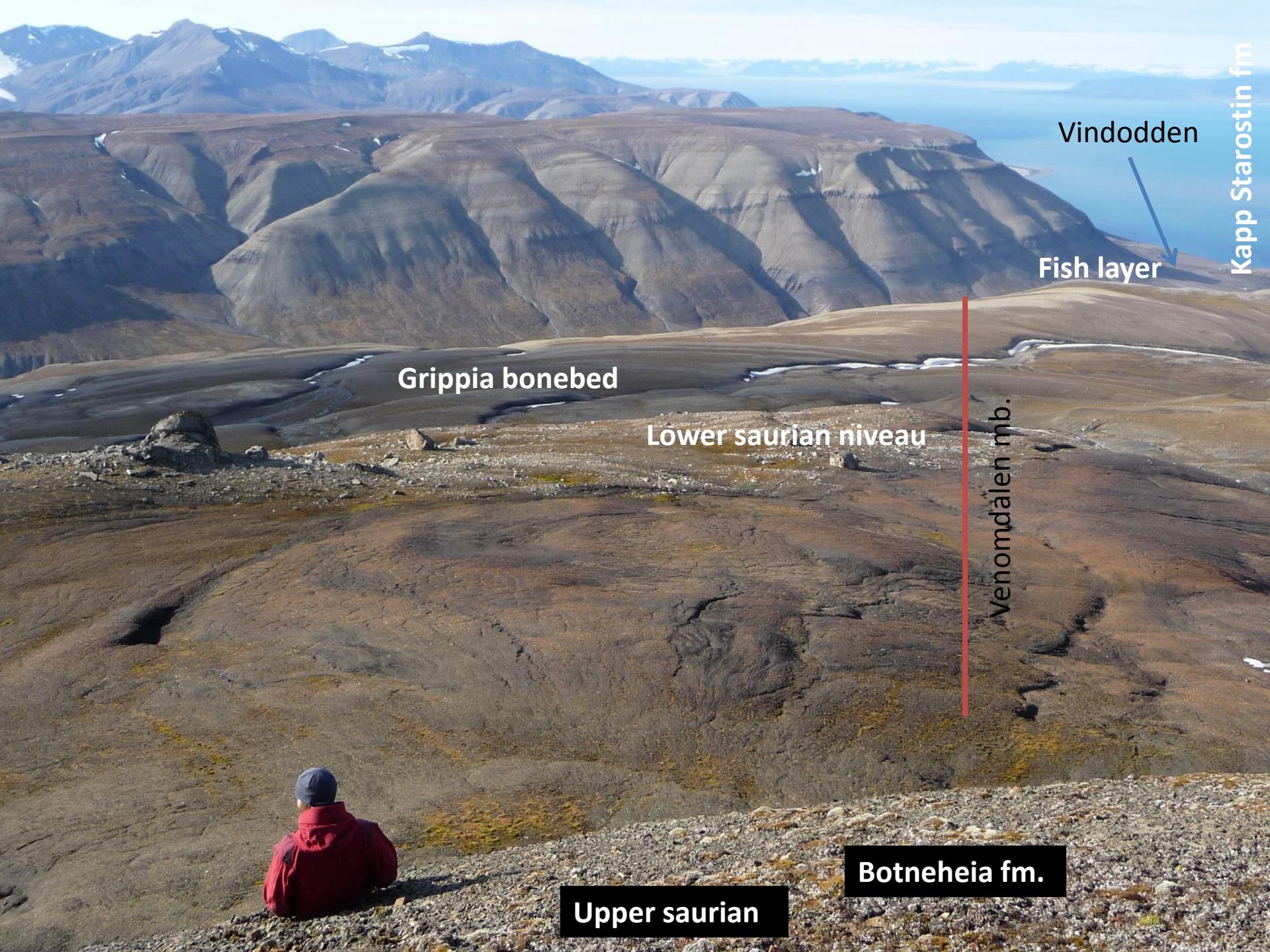
Upper saurian niveau ca 235 m.a.

Lower saurian niveau 247 m.a.

Grippia niveau?248 m.a.

Fish niveau ?249 m.a.

Extinction 251,9 m.a.



Vindodden

Fish layer

Kapp Starostin fm

Grippia bonebed

Lower saurian niveau

Venomdalen mb.

Botneheia fm.

Upper saurian

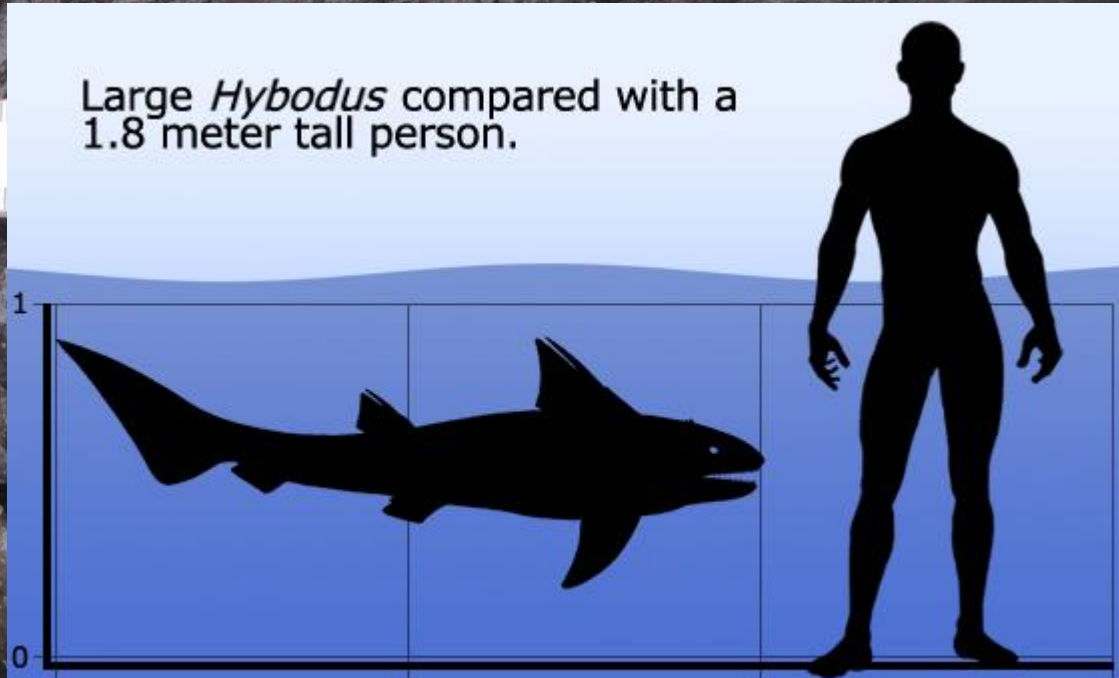


Grippia bonebed





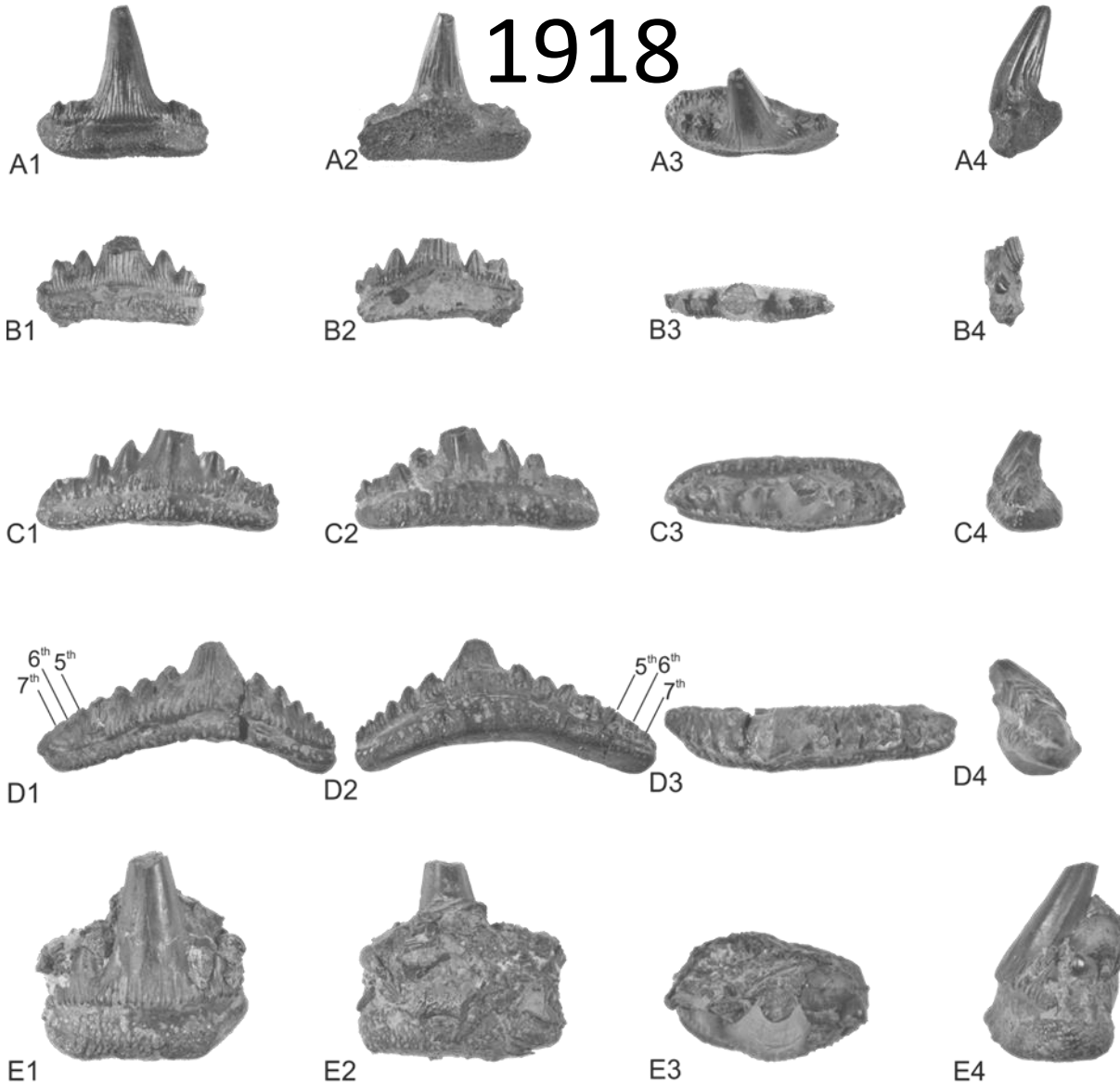
Large *Hybodus* compared with a 1.8 meter tall person.





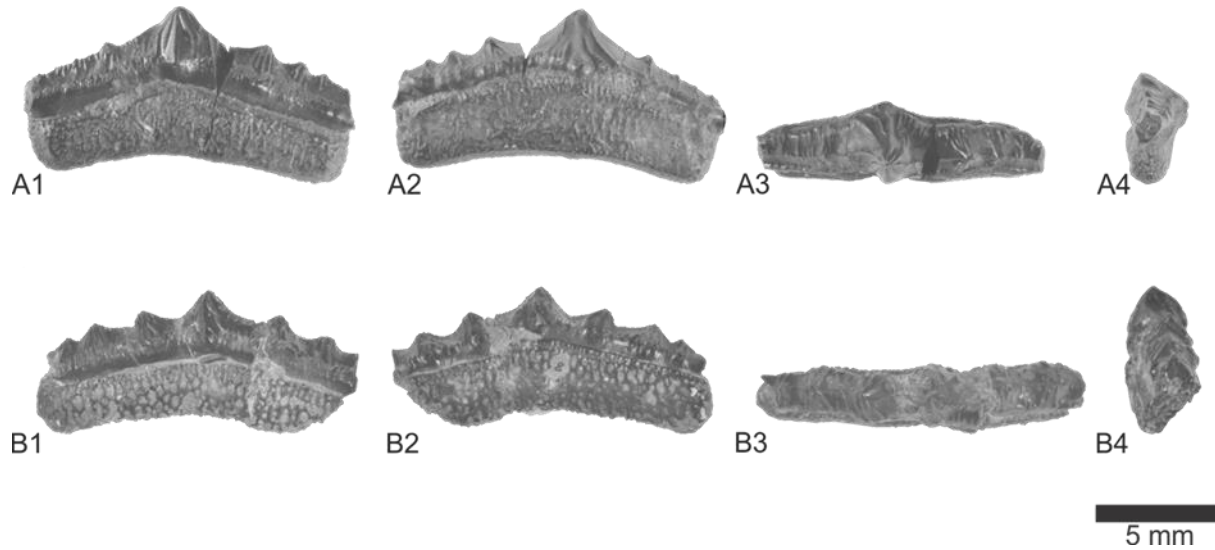
Teeth of *Hybodus sasseni* Stensiö,

1918

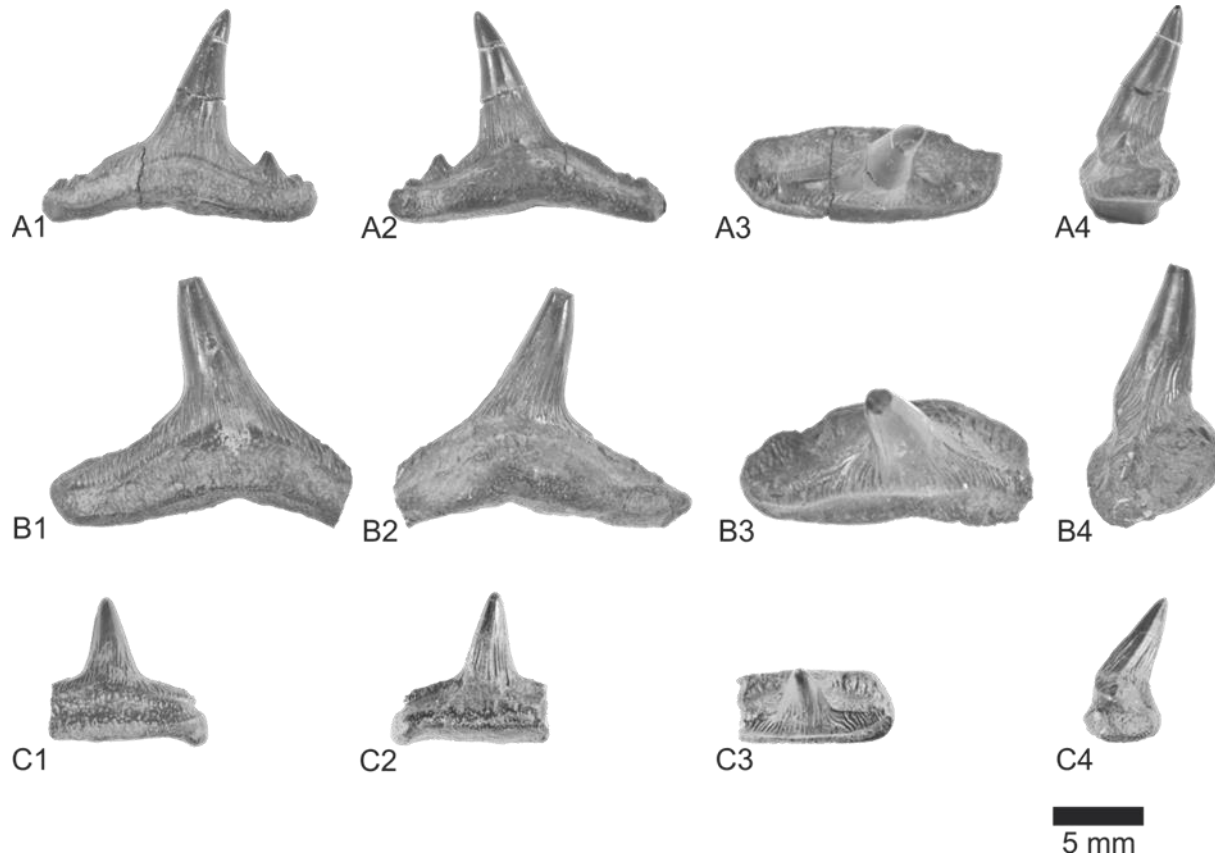


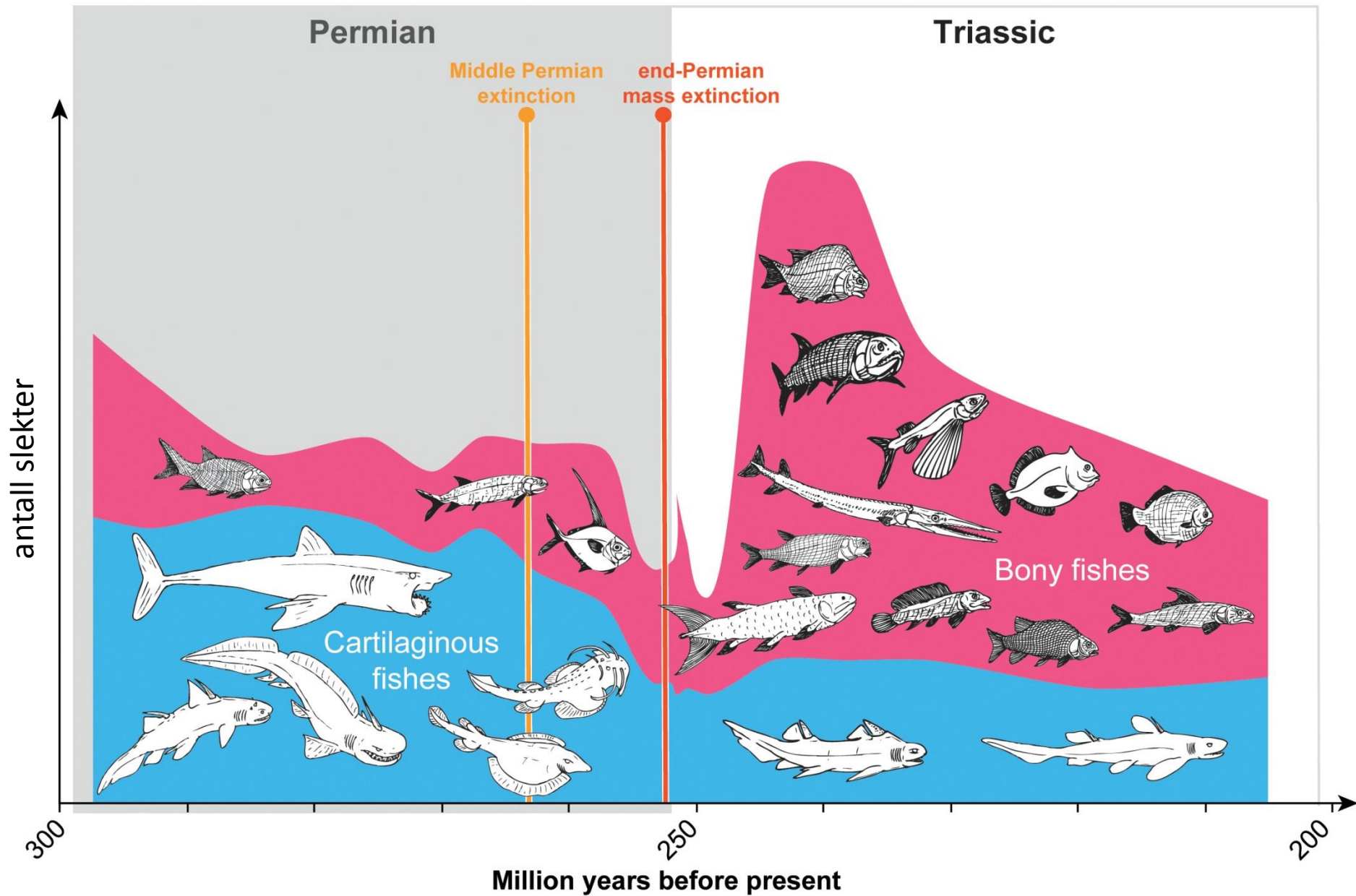
Bratvold et al. to be submitted soon...

Teeth of *Polyacrodus* sp. Jaekel, 1889



Teeth of *Hybodus rapax* Stensiö, 1921





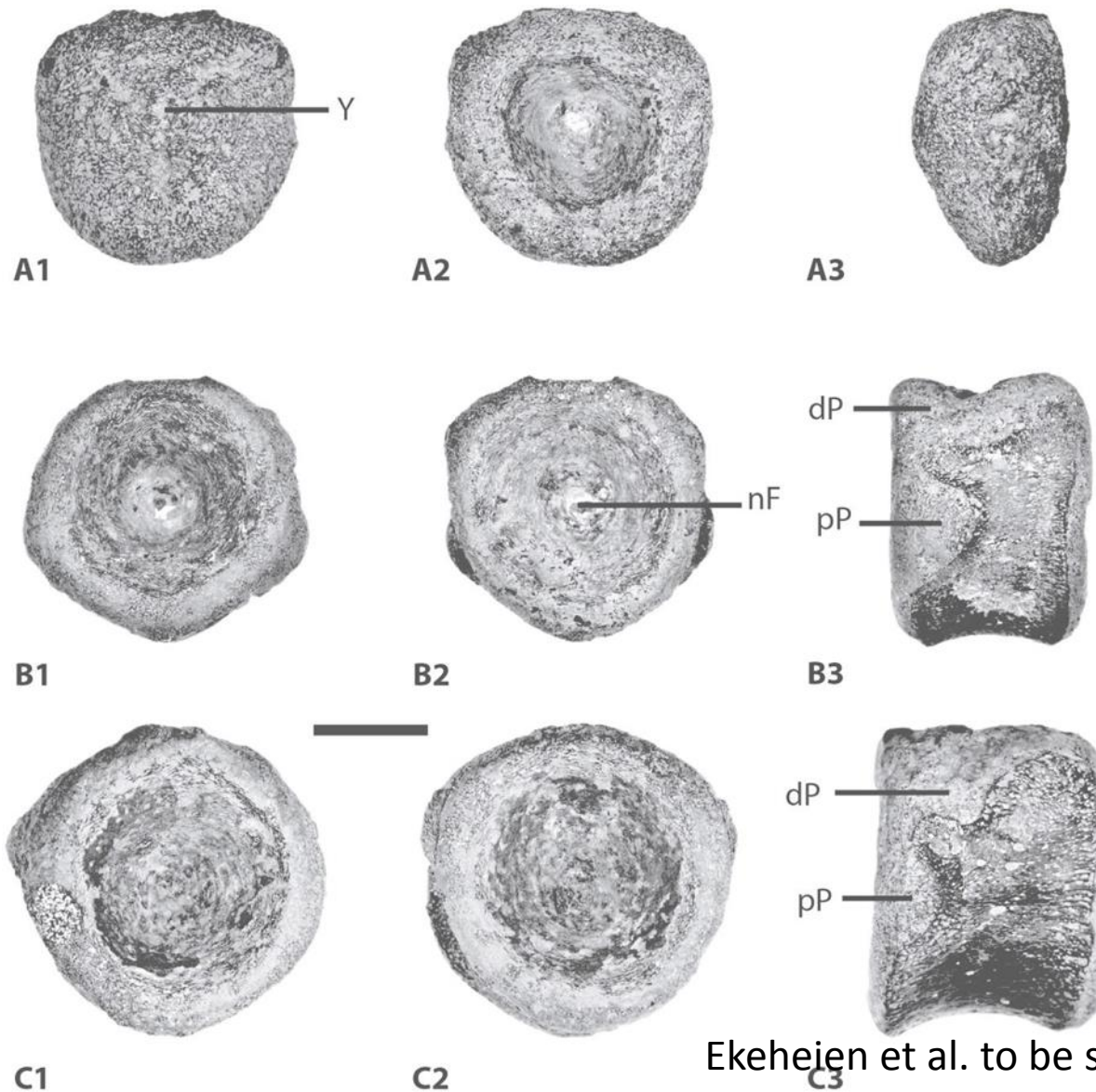
C. Romano, M. B. Koot, I. Kogan, A. Brayard, A. V. Minikh, W. Brinkmann, H. Bucher, J. Kriwet, Permian-Triassic Osteichthyes (bony fishes). Diversity dynamics and body size evolution. *Biological Reviews*, November xx, 2014. S. 1-44. doi: 10.1111/brv.12161.



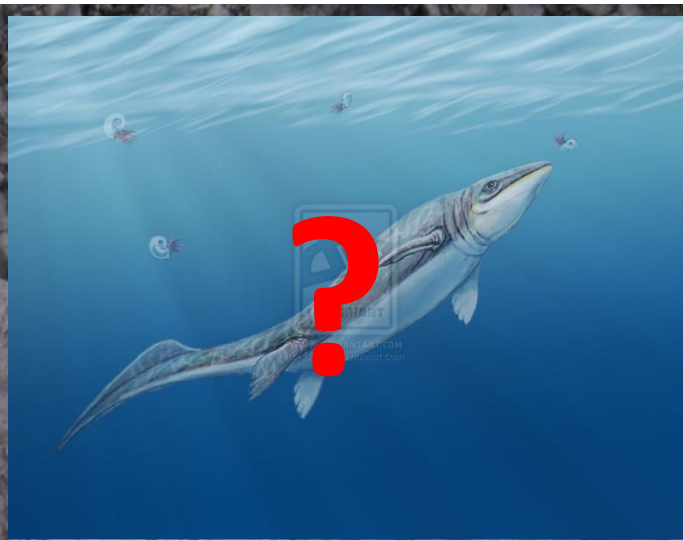


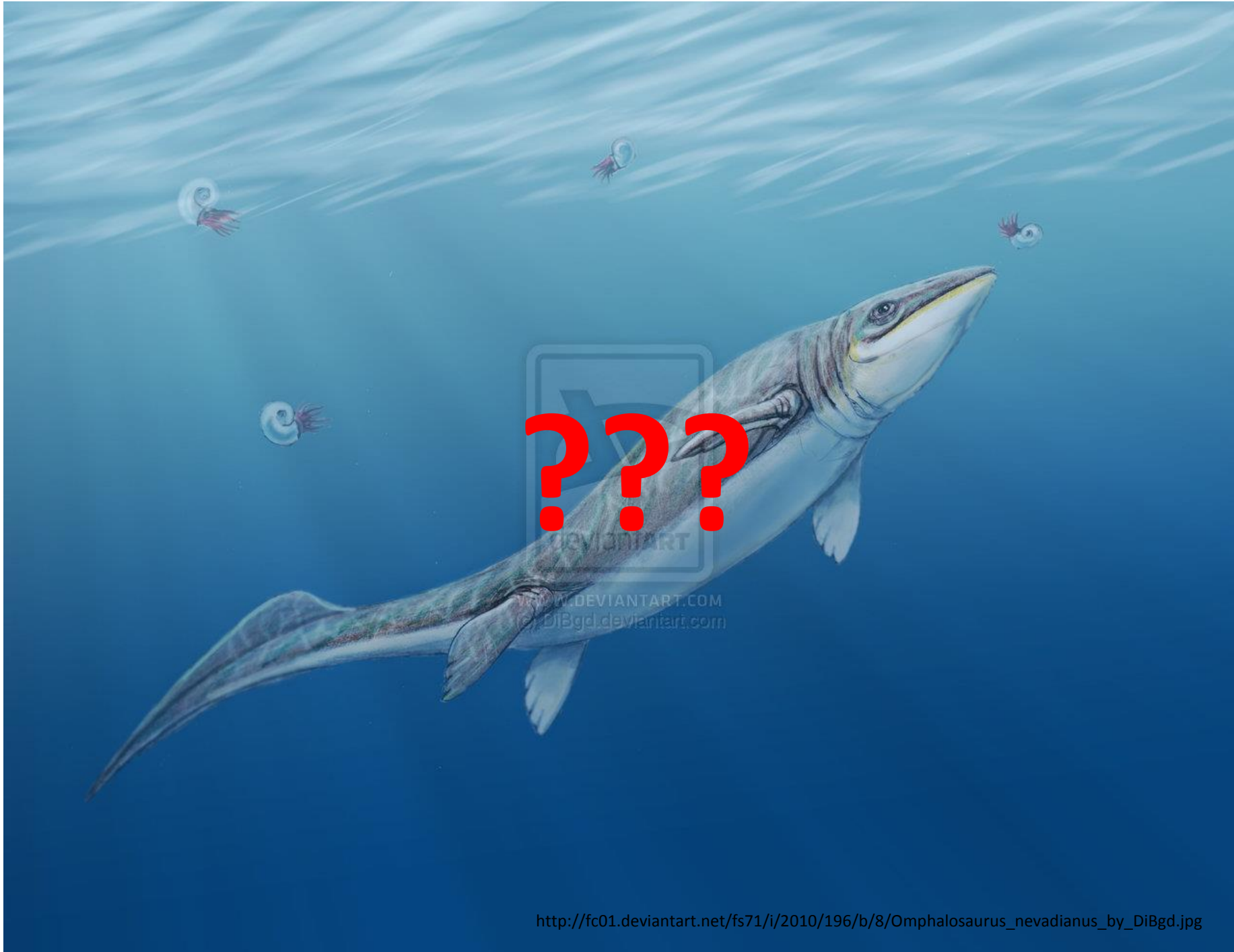


Omphalosaurus



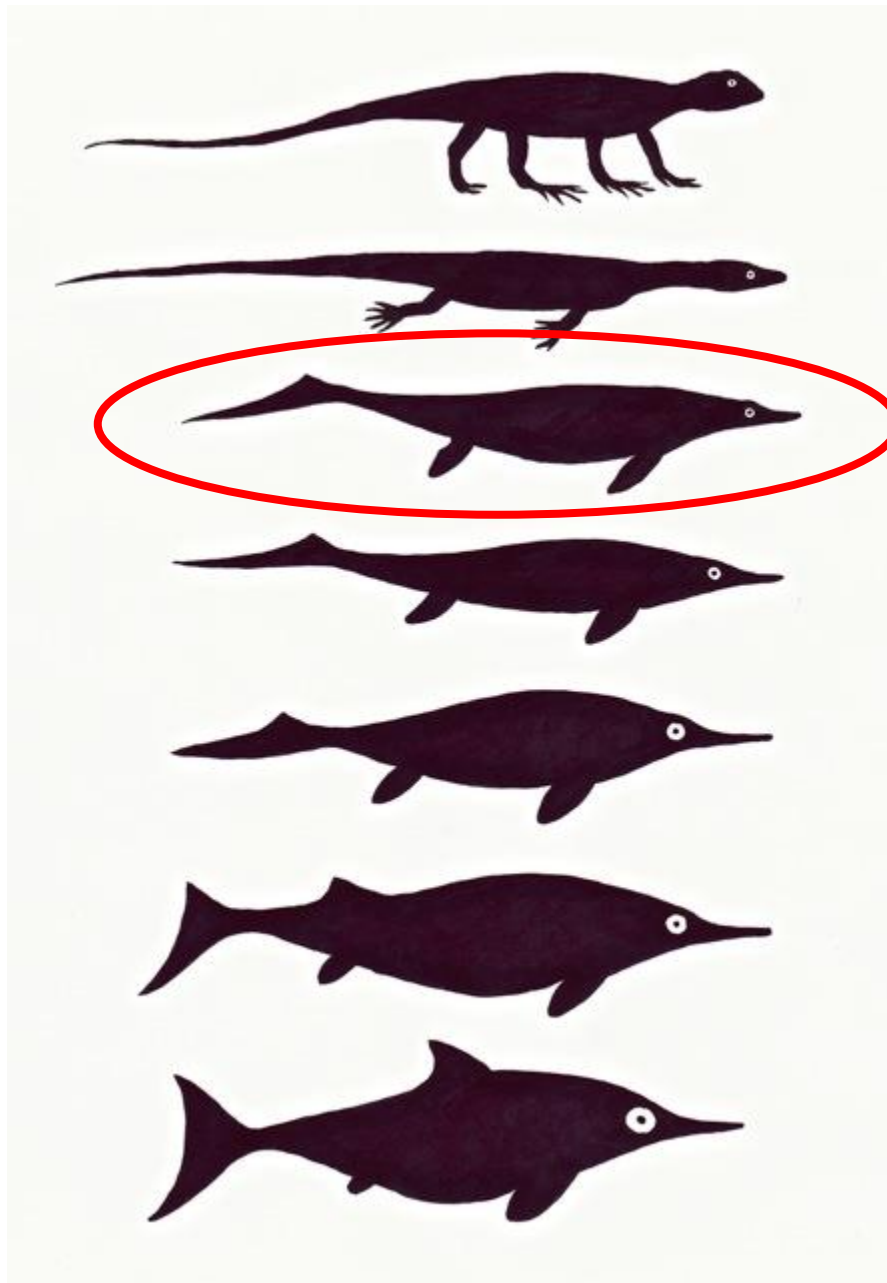
Ekeheijen et al. to be submitted soon...





Lower saurian niveau -oldest large ichthyosaurs in the World





Upper saurian: *Phalarodon* +
Mixosaurus

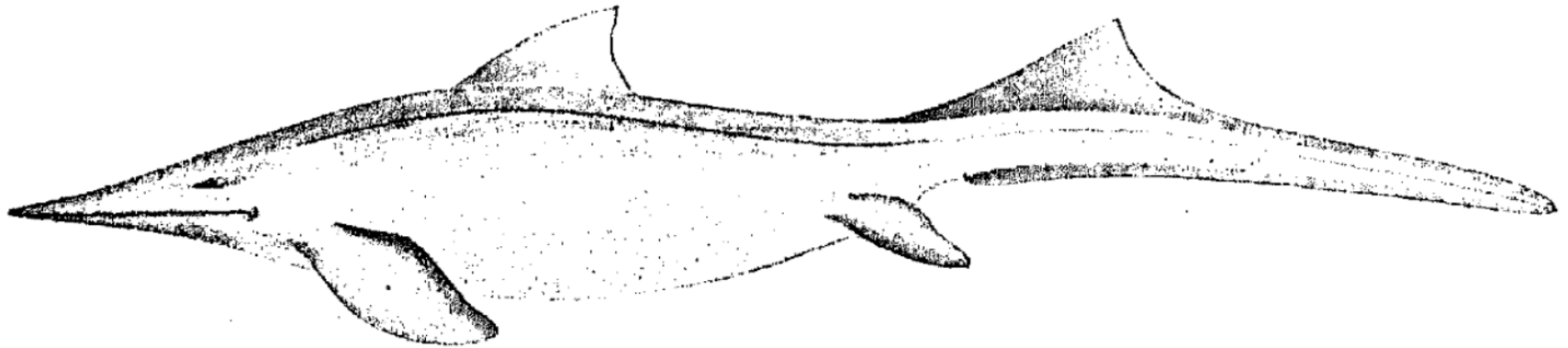
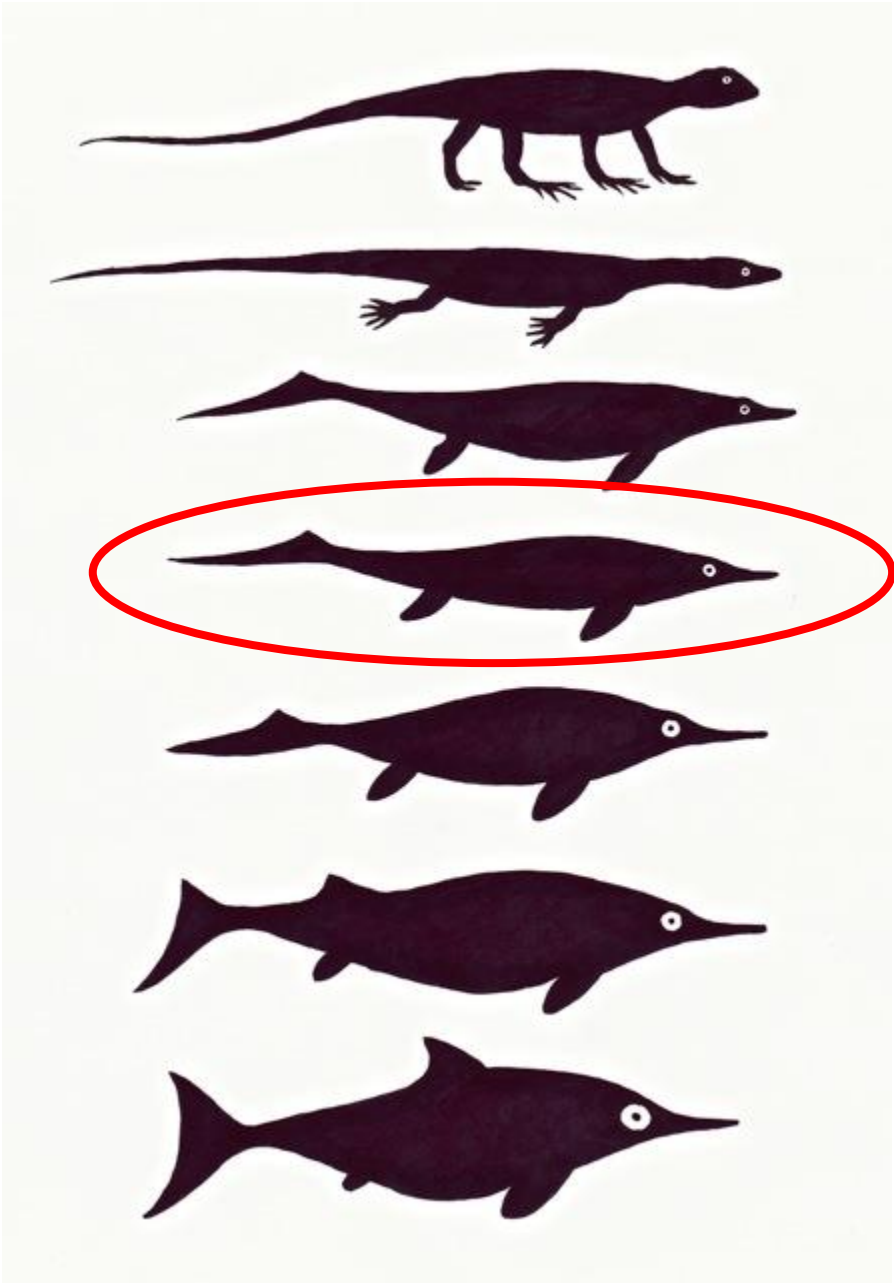


Fig. 3. Rekonstruktion von *Mixosaurus Nordenskiöldii*, um die Form der Schwanzflosse zu zeigen.

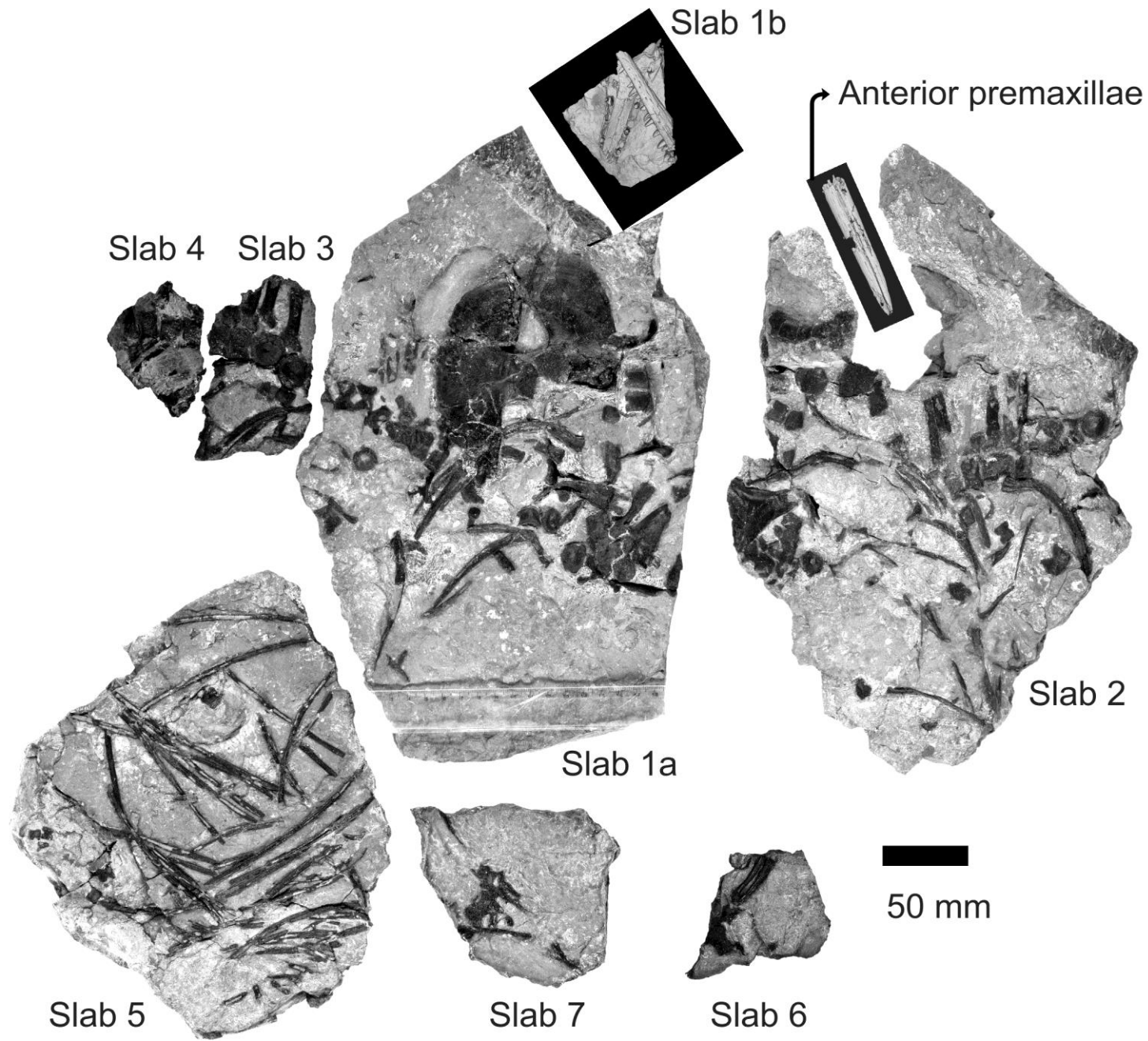
Wiman 1910

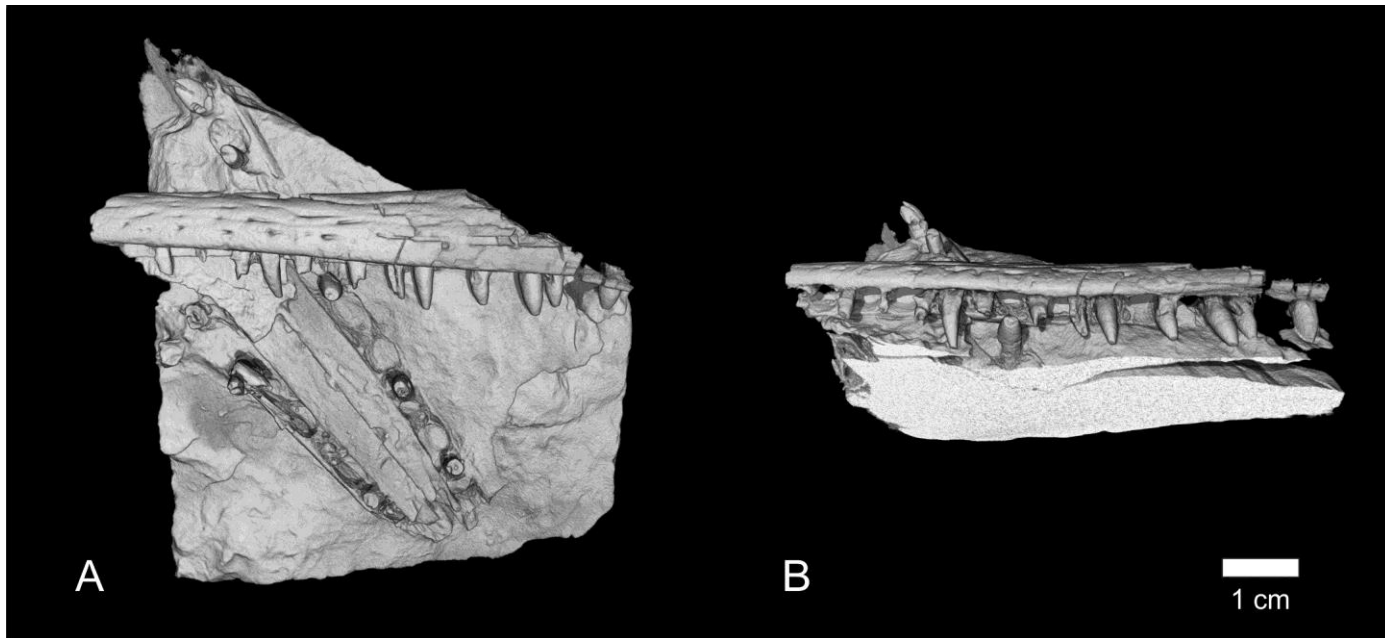




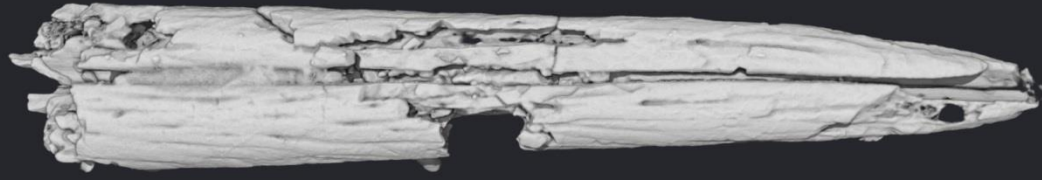




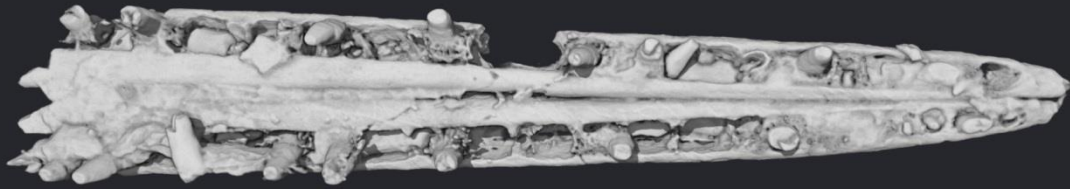




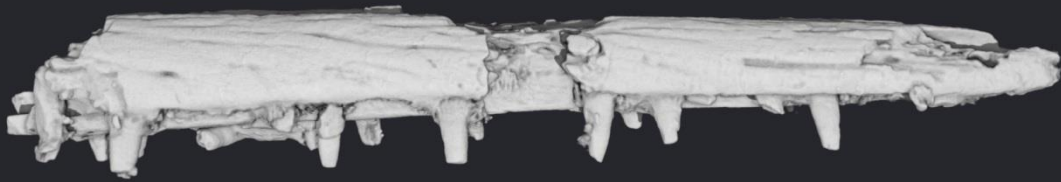
Økland et al. to be submitted soon...



A



B



C

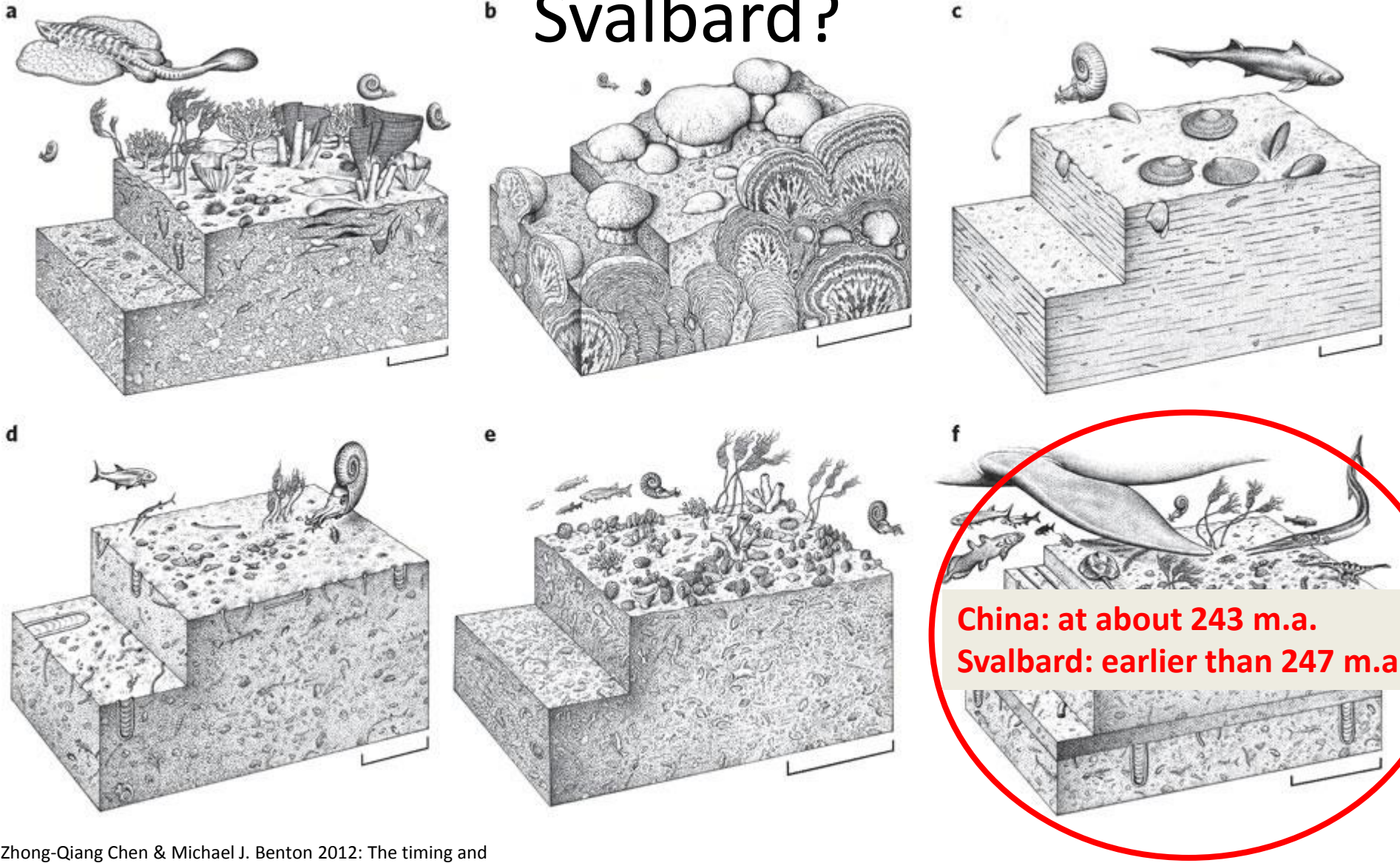
Økland et al. to be submitted soon...

Oil in Botneheia fm.



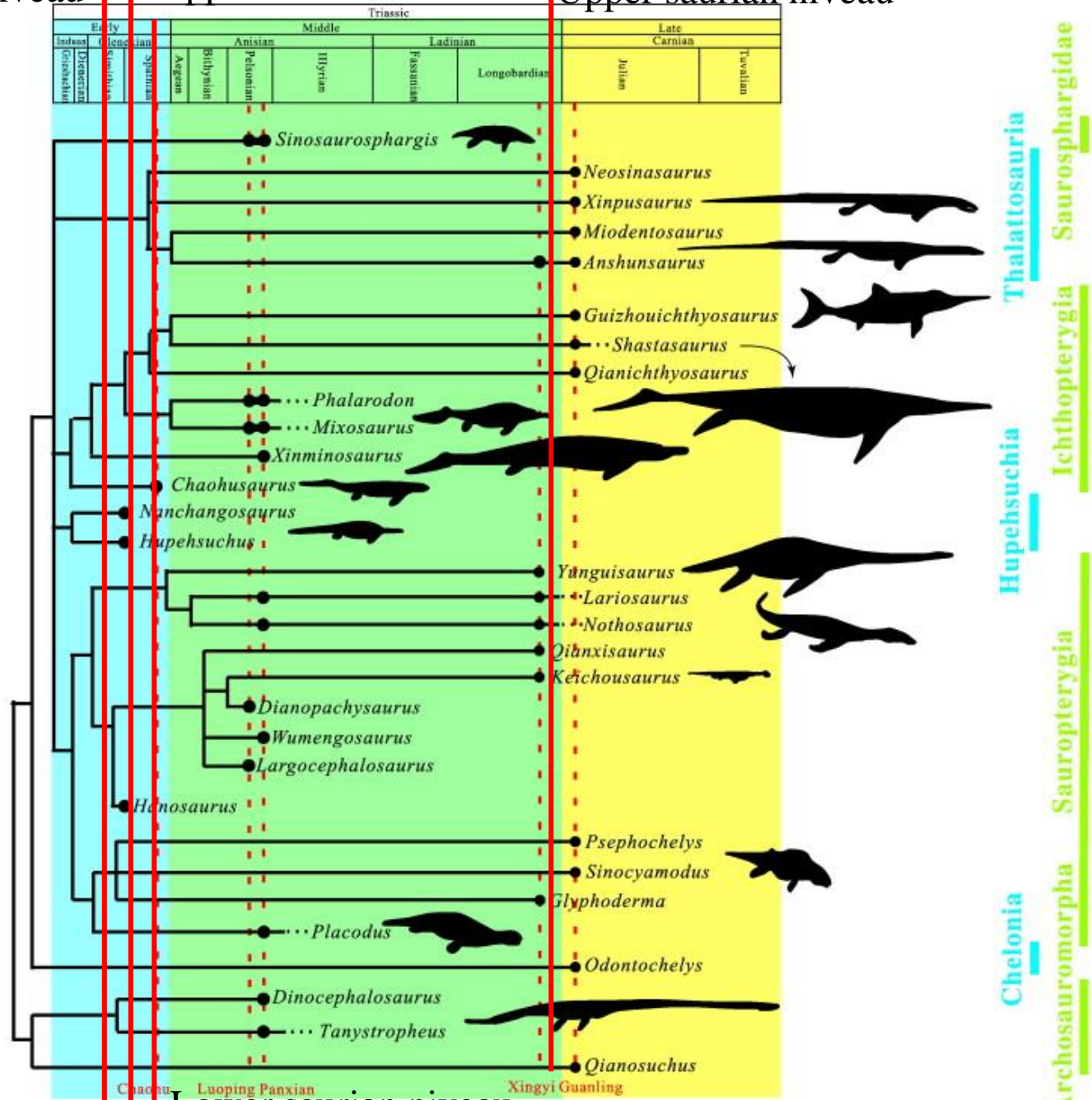
Preliminary results

How well does China compare to Svalbard?



China: at about 243 m.a.
Svalbard: earlier than 247 m.a.

Fish niveau Grippia niveau Upper saurian niveau



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

Lower saurian niveau

Research

- multidisciplinary 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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Volunteers : T. Wensaas, Ø. Enger, S. Larsen, L. Kristiansen, M. Høyberget, B. Funke and M-L.Funke



Thank you for li

