



NORTH-ATLANTIC OPENING AND THE FIRST MIXING OF OCEAN WATERS FROM PACIFIC AND TETHYAN REALMS: A NANNOFOSSIL APPROACH

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SUMMARY

Objective

Boundaries

Database

Results

Conclusions





Immediate Goal

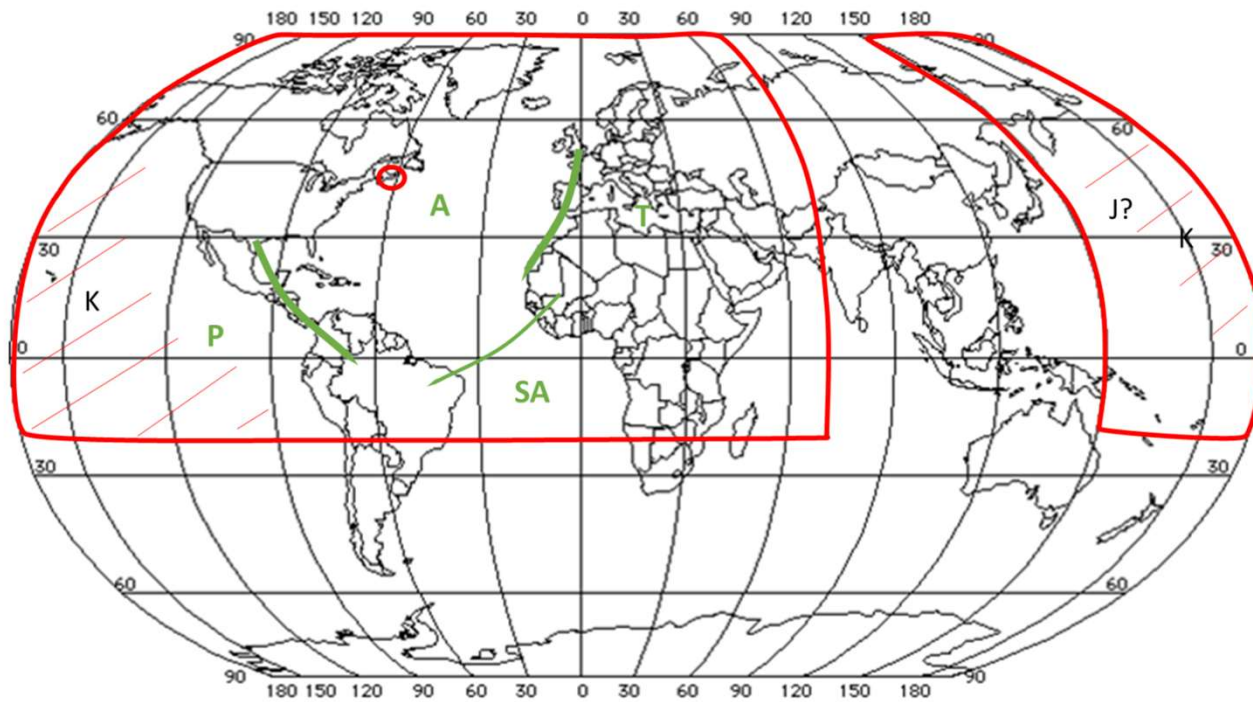
Use **nannofossil data** to find the proxies that better **approximate first water mixing between the Atlantic, Tethyan, and Pacific** geographic domains.

Mediate Goal

Build the most comprehensive database of nannofossil (secondary) data possible, to fulfil the immediate goal but also to reuse in future studies.

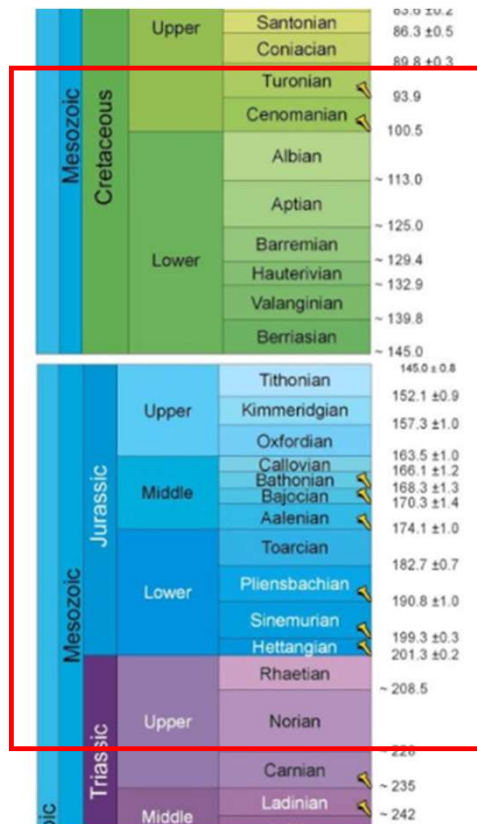






Latitude: 90°N to 20°S
Longitude: All, excluding 80°E to 150°E





Initial influence from **SOUTH** (? relevance)
APTIAN TO ALBIAN (125.0 – 100.5 MA)



Initial **PACIFIC** influence estimation
AALENIAN TO BAJOCIAN (174.1 -168.3 MA)



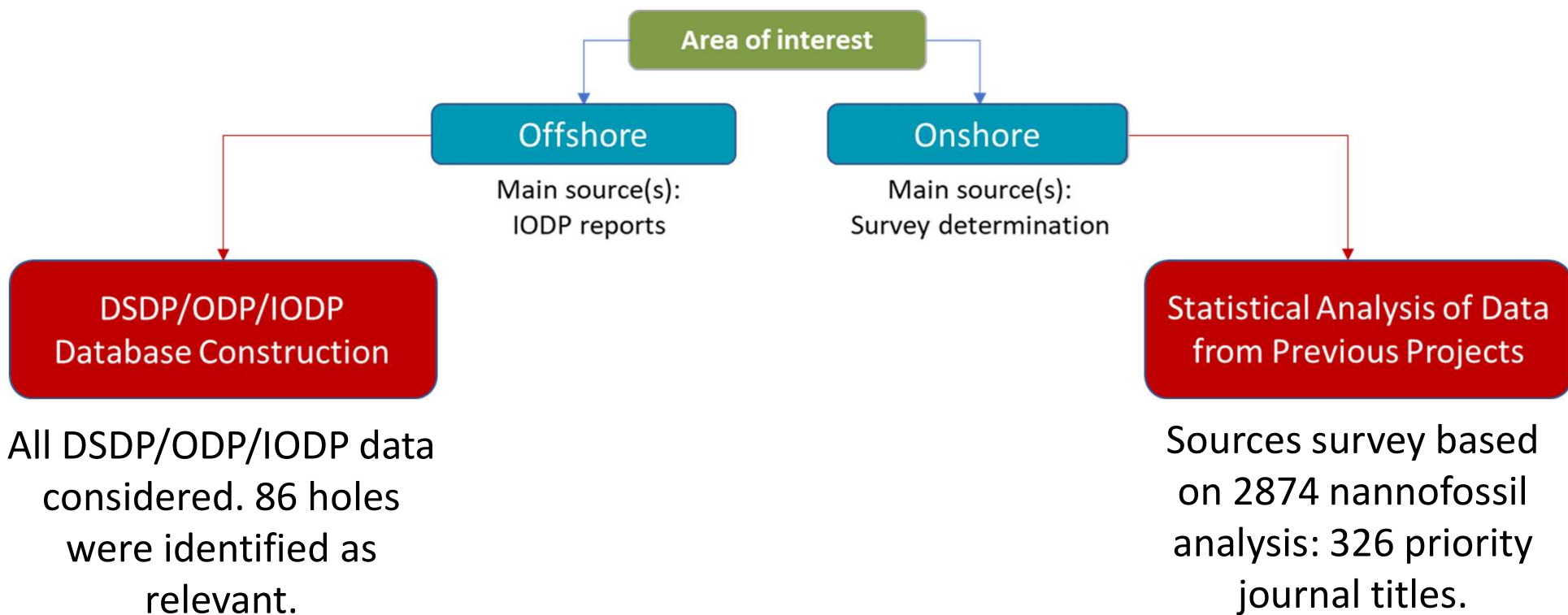
Initial **TETHYS** influence estimation
RHAETIAN TO HETTANGIAN (208.5 – 199.3 MA)

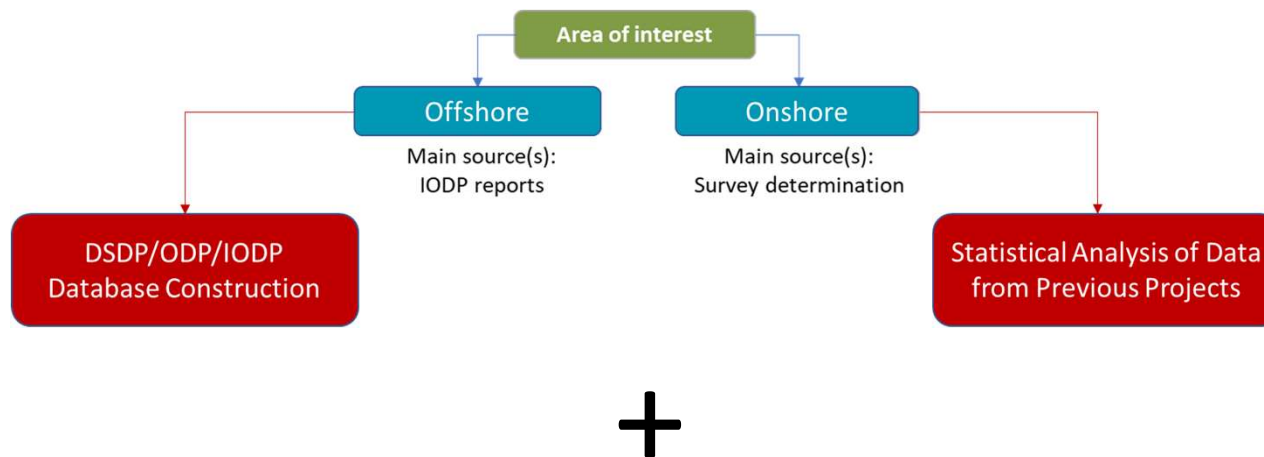


**Norian to Turonian
 (~228 Ma – 89,8 Ma)**







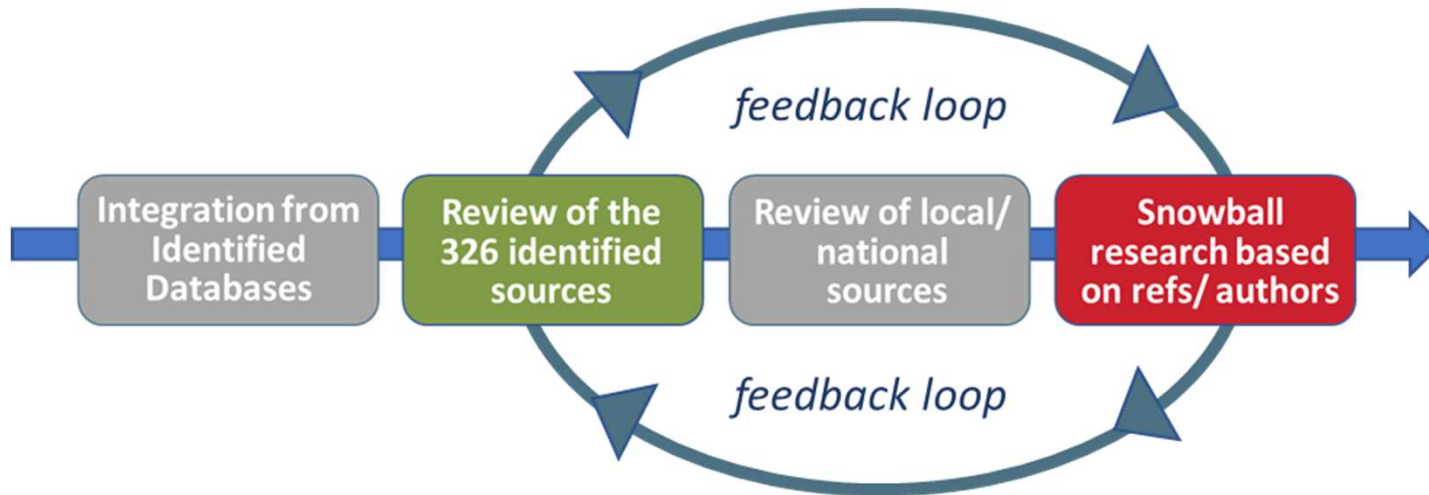


- + Industry data collection: ~550 wells were searched for relevant data
- + Data provided by OERA/ Nova Scotia Government
- + Web scraped data in the public domain (with permission)
- + Review of national/ local sources

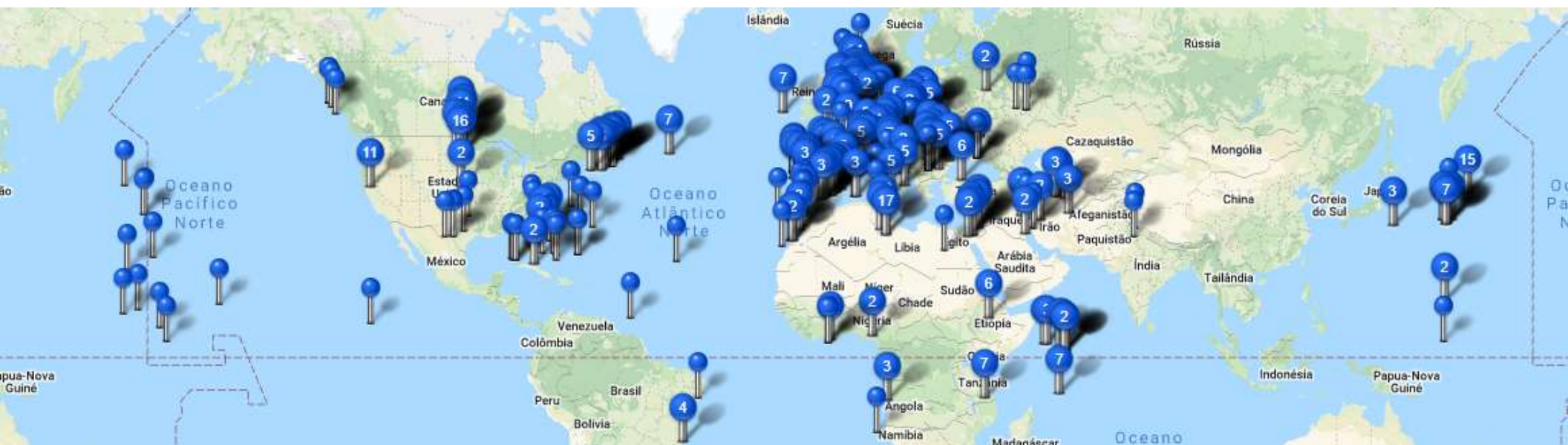


+

+ Snowball research



FINAL DATABASE STATISTICS



1178

Location/ Stage

416

Single Locations

1120

Species/ Variants

207

Genus

21

Ages

86

Zones

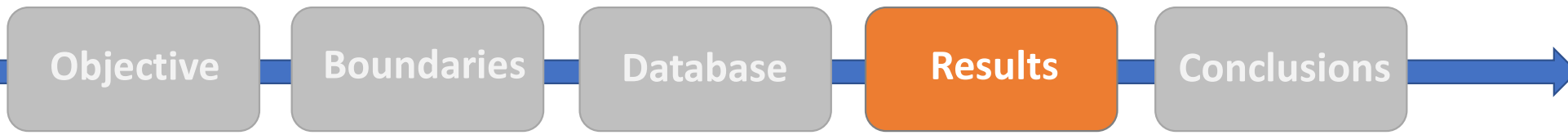
67

Titles

254

Documents

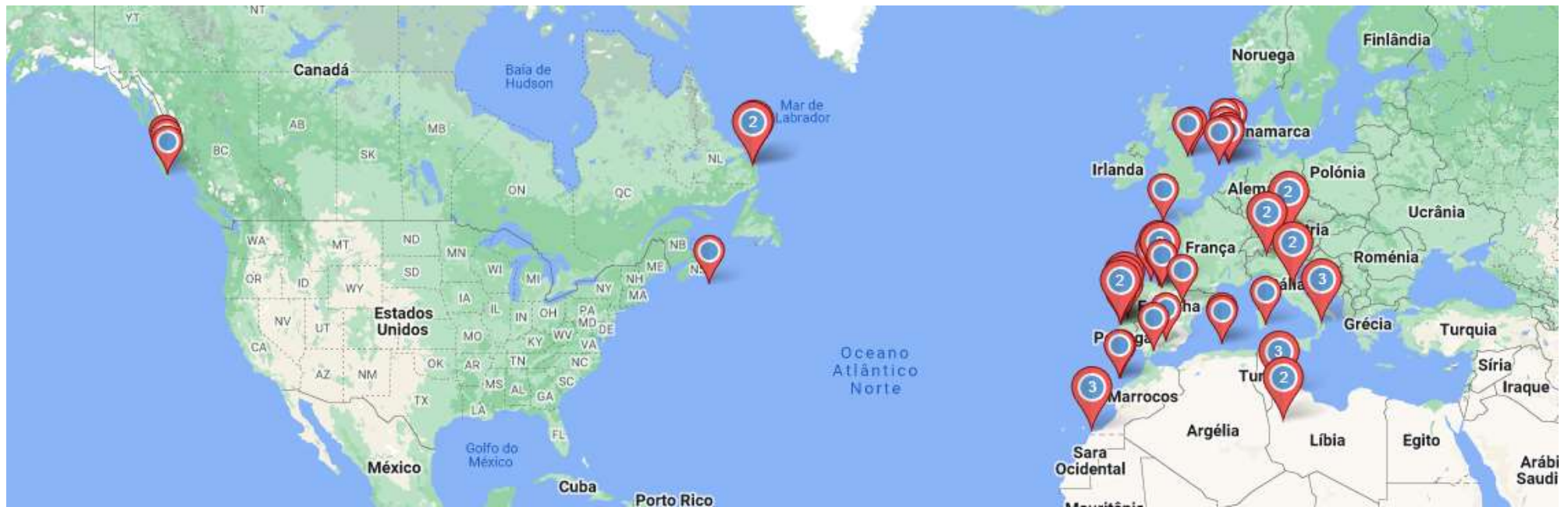


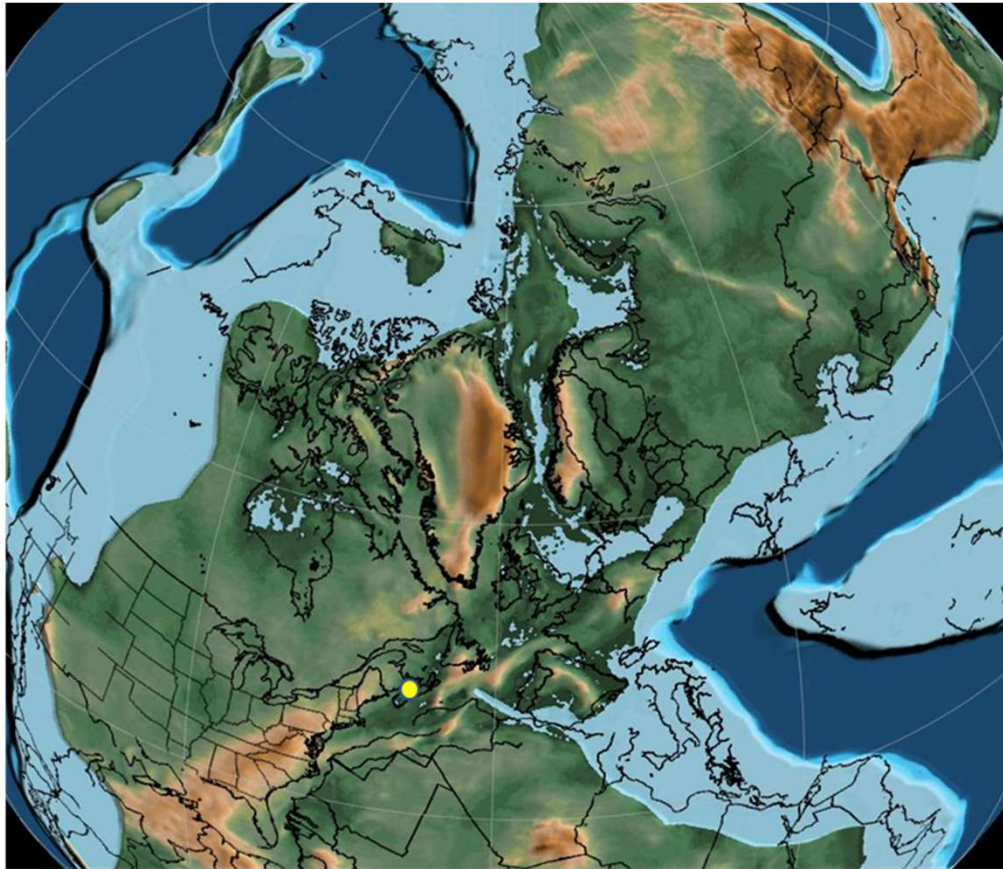


Tethys
Pacific

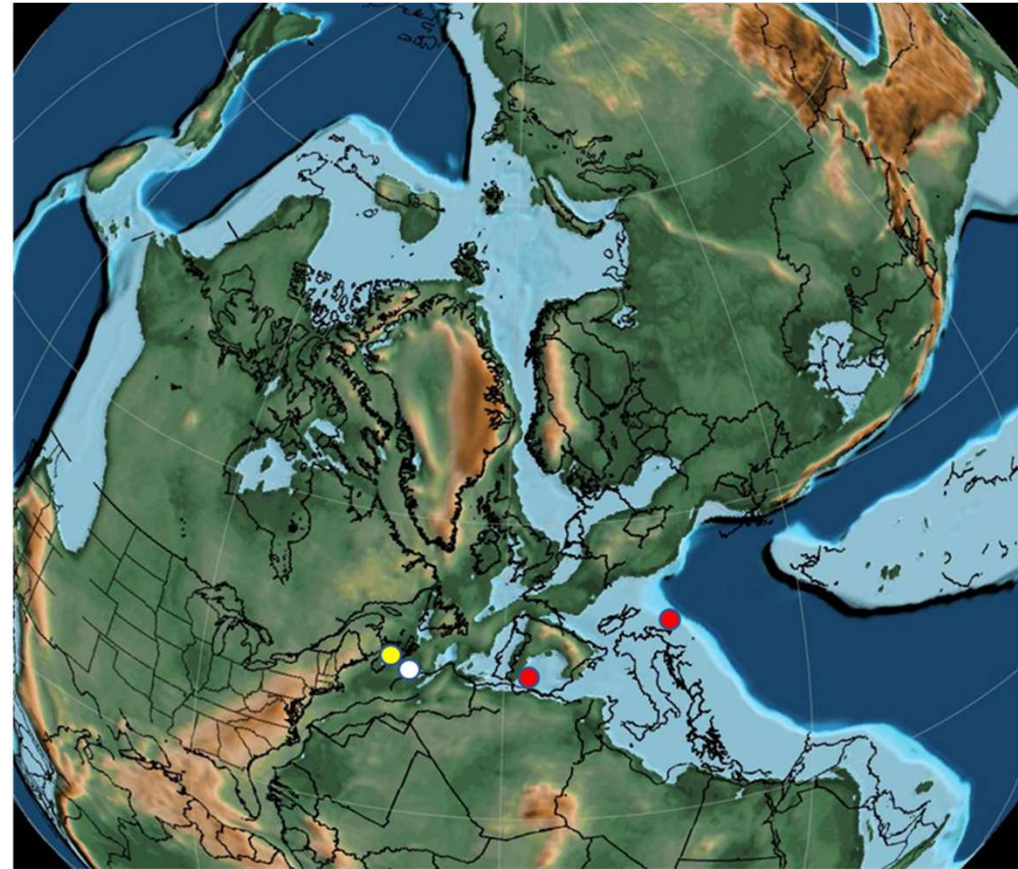


Norian to Pliensbachian (~228.5 to 182.5 Ma)





230 Ma – Late Carnian

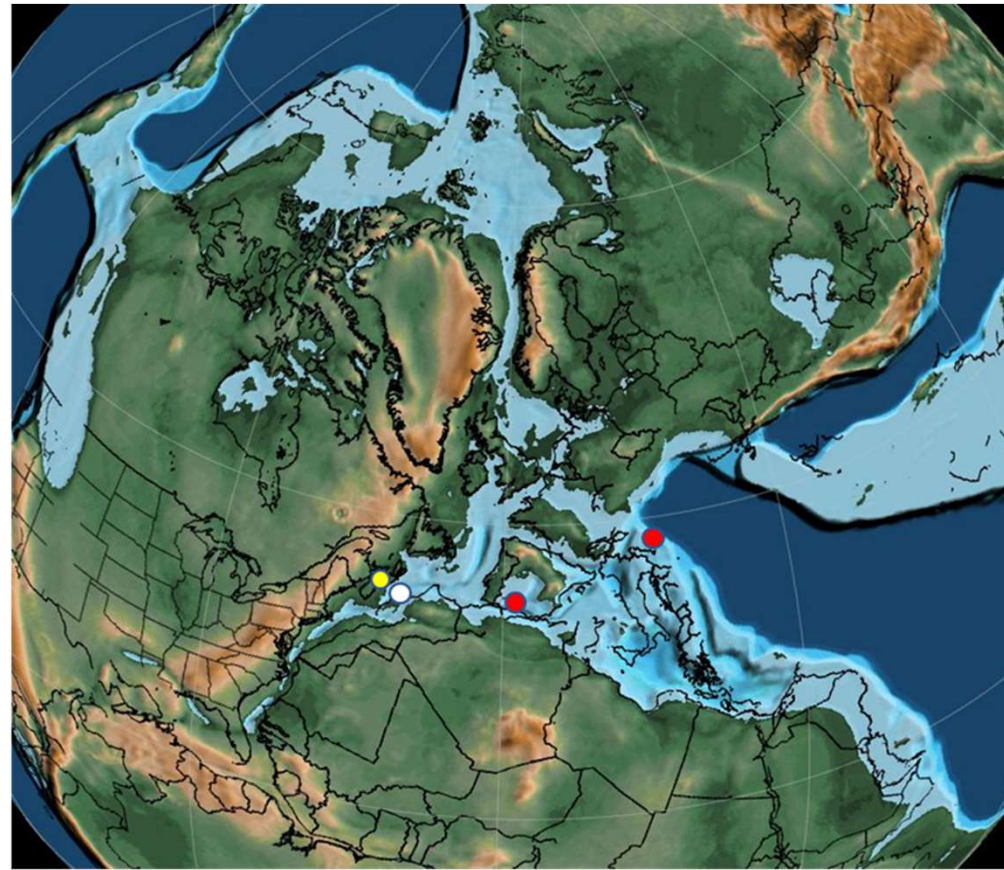


225 Ma – Early Norian



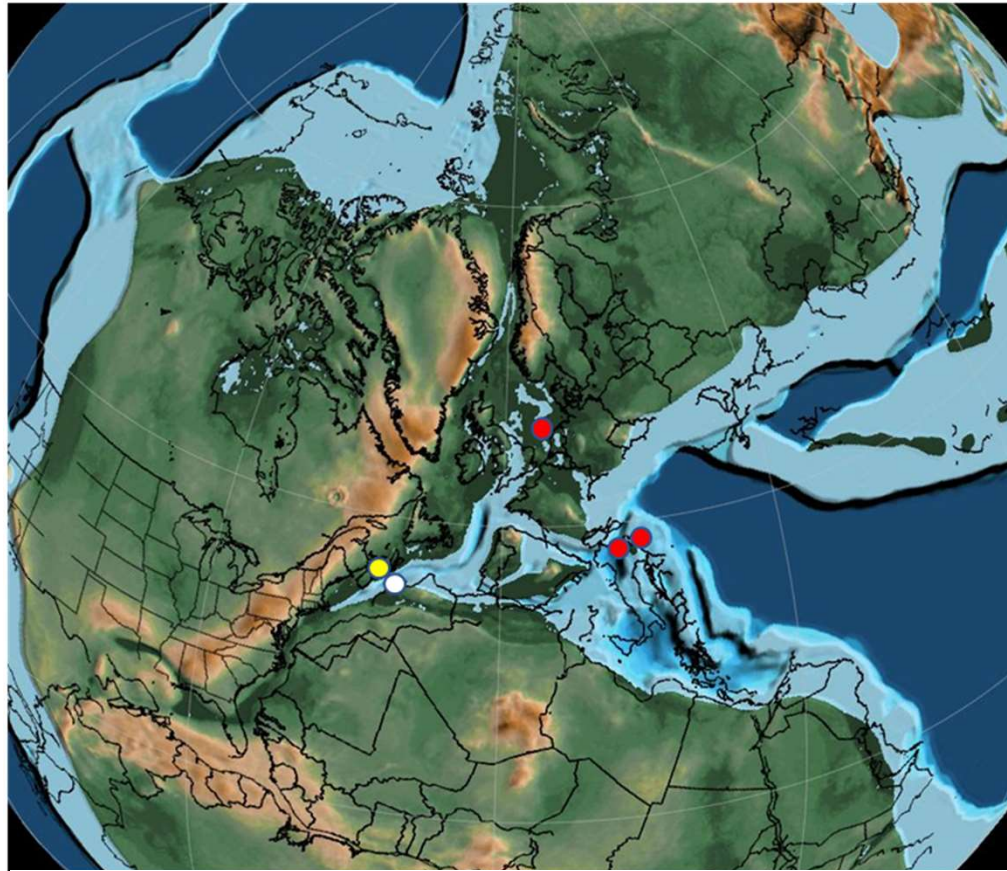


215 Ma – Late Norian

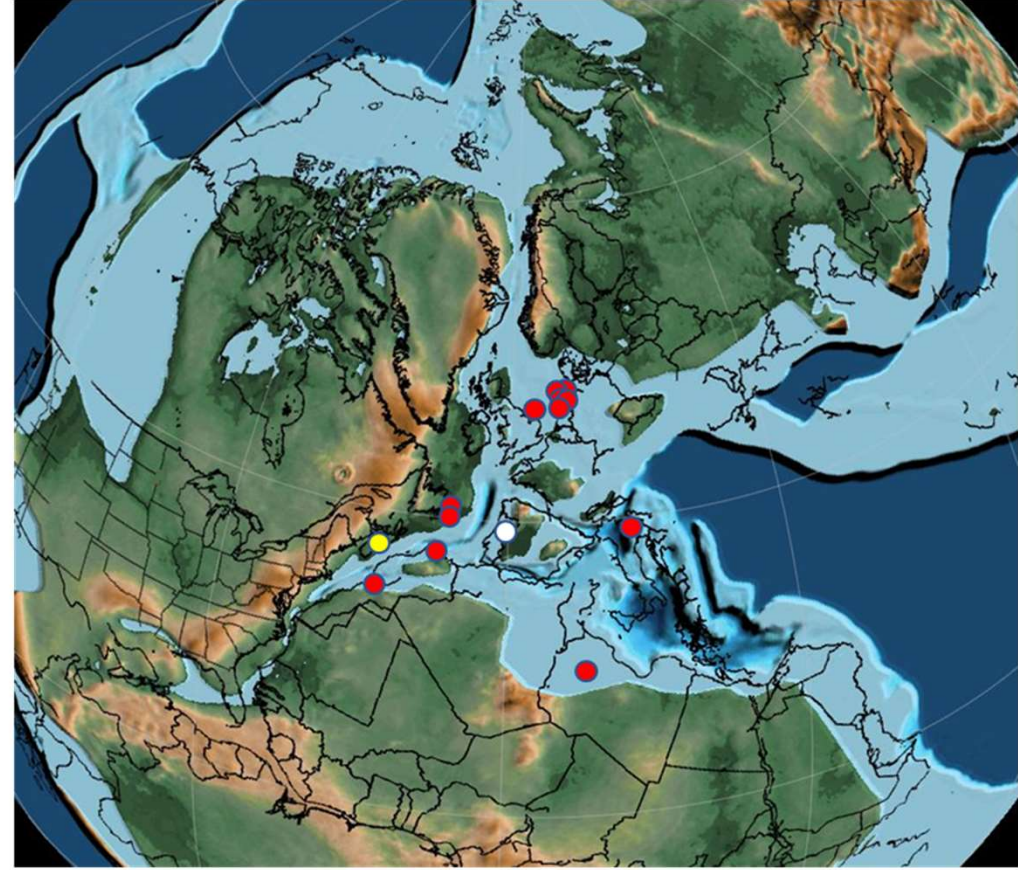


210 Ma – Late Norian



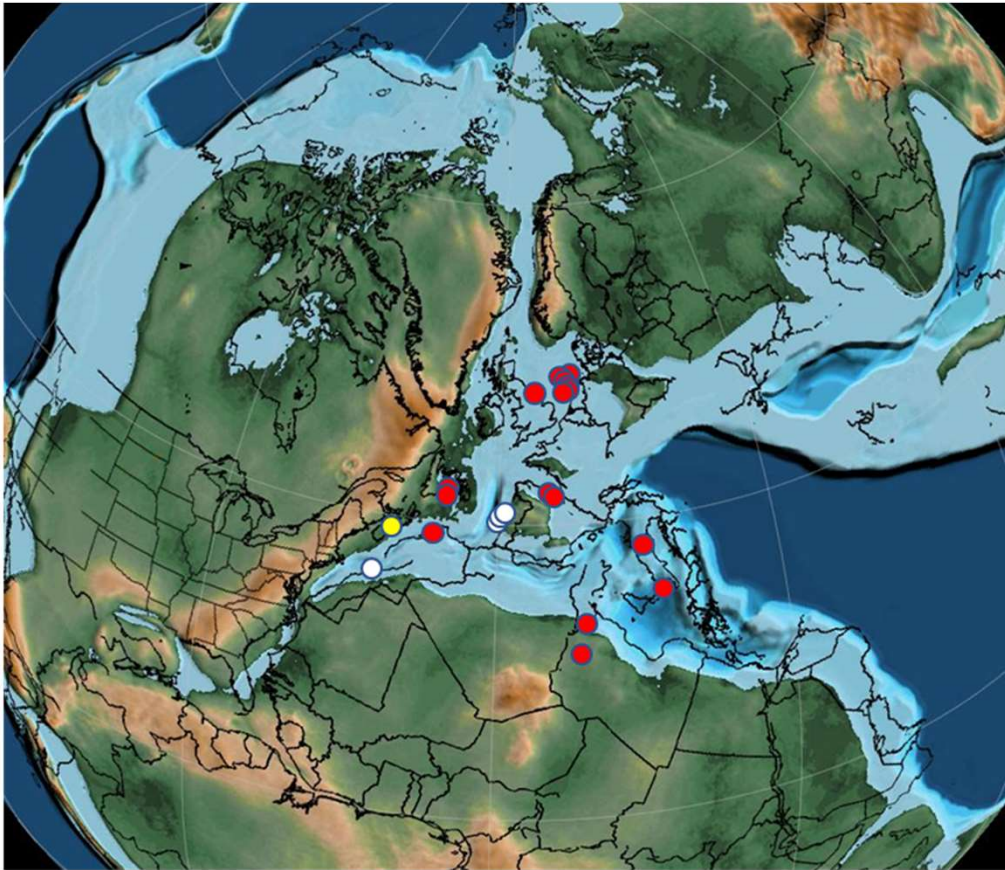


205 Ma – Middle Rhaetian

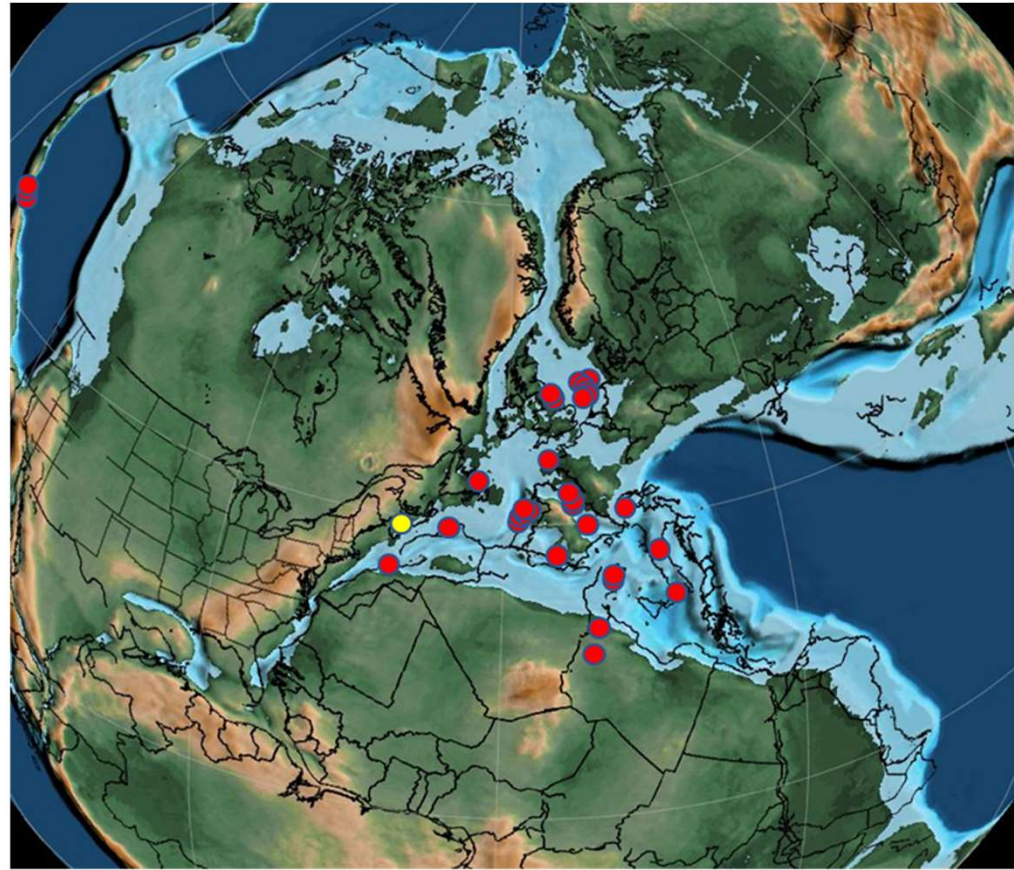


200 Ma – Hettangian





195 Ma – Middle Sinemurian



190 Ma – Early Pliensbachian





Paleo-Atlantic realm

North Paleo-Atlantic

Norian to Pliensbachian
(~228.5 to 182.5 Ma)

- 1** single locations
- 1** locations/ Stages
- 12** species

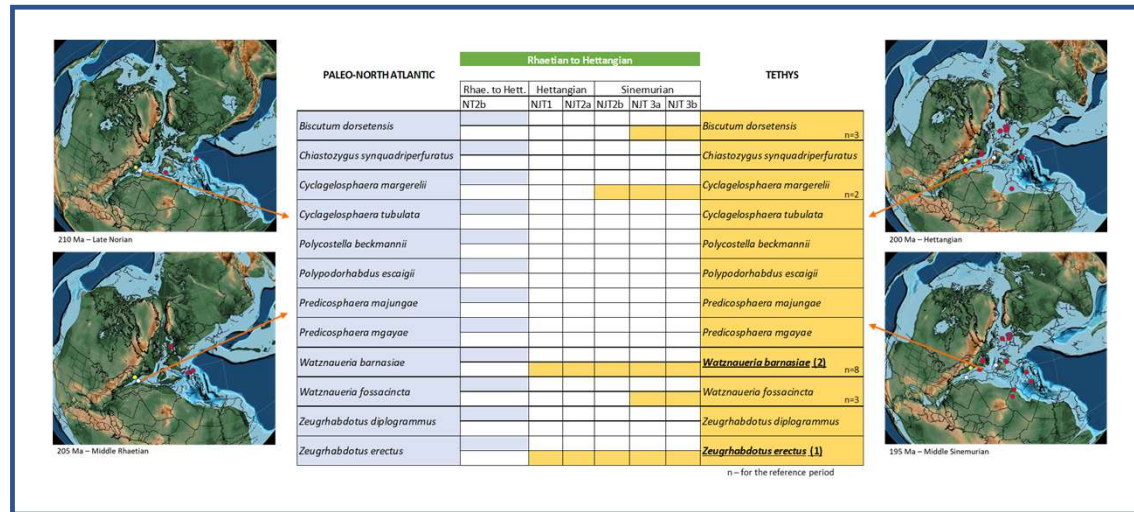
Location: Nova Scotia (Isolated Ecological Association)

Tethyan realm

Norian to Pliensbachian
(~228.5 to 182.5 Ma)

- 43** single locations
- 64** locations/ Stages
- 124** species





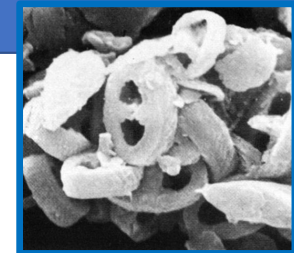
1. Faunas from the most relevant locations were compared.
2. FAD of an isolated species from one realm in the other (across the boundary under study) marks the first evidence of water mixing.
3. The said species is compared to others in similar circumstances to choose best suggested proxies.



1. *Zeugrhabdotus erectus*

- ✓ Common in assemblages
- ✓ Rapid dissemination
- ✓ Easily identifiable

First Tethys appearance is the best proxy for Paleo-North Atlantic and Tethys water mixture since we found no information of wider distribution.



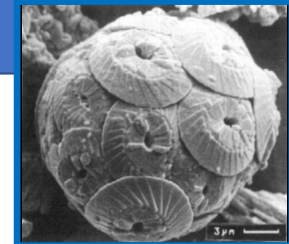
Nannotax: Pliensbachian (base 182.70-190.82 Ma) to Late Maastrichtian (66.04-69.91 Ma)
Our Study: FAD: Norian



2. *Watznaueria barnasiae*

- ✓ Common in assemblages
- ✓ Rapid dissemination
- ✓ Easily identifiable

First Tethys appearance is second best for Paleo-North Atlantic and Tethys water mixture since its restriction to the Nova Scotia basin is doubtful.



Nannotax: Bathonian (base of NJT11 – 168.2 Ma) to Danian (NP1 - 66.0 Ma)
Our Study: FAD: Norian

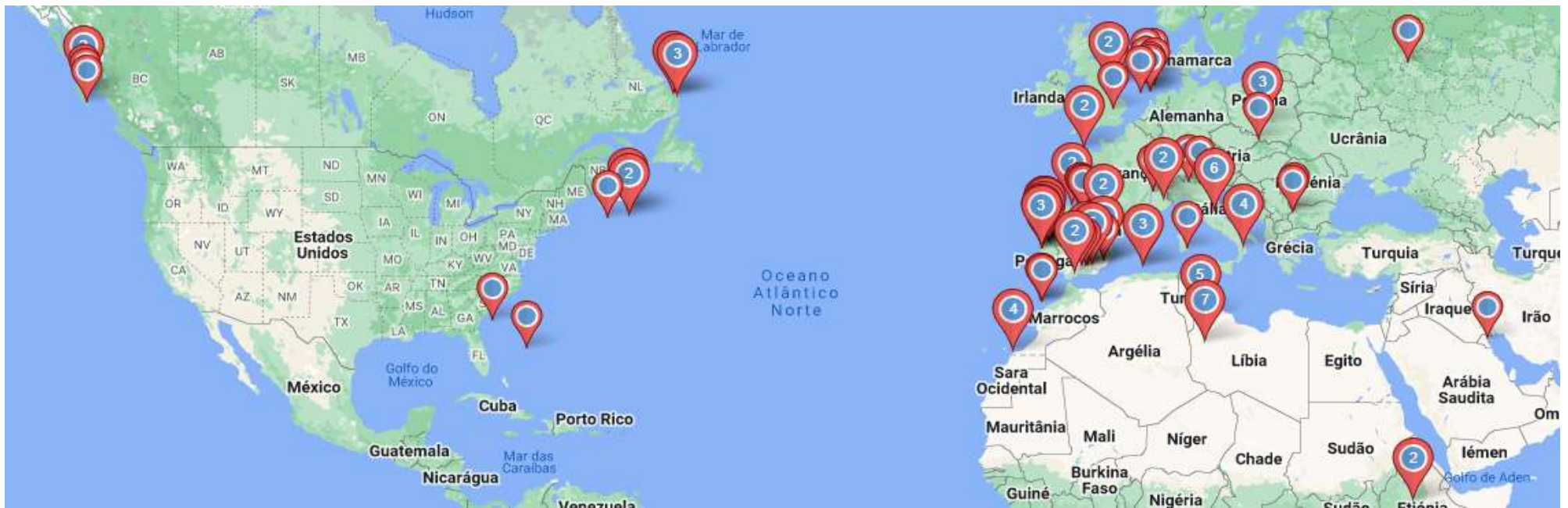


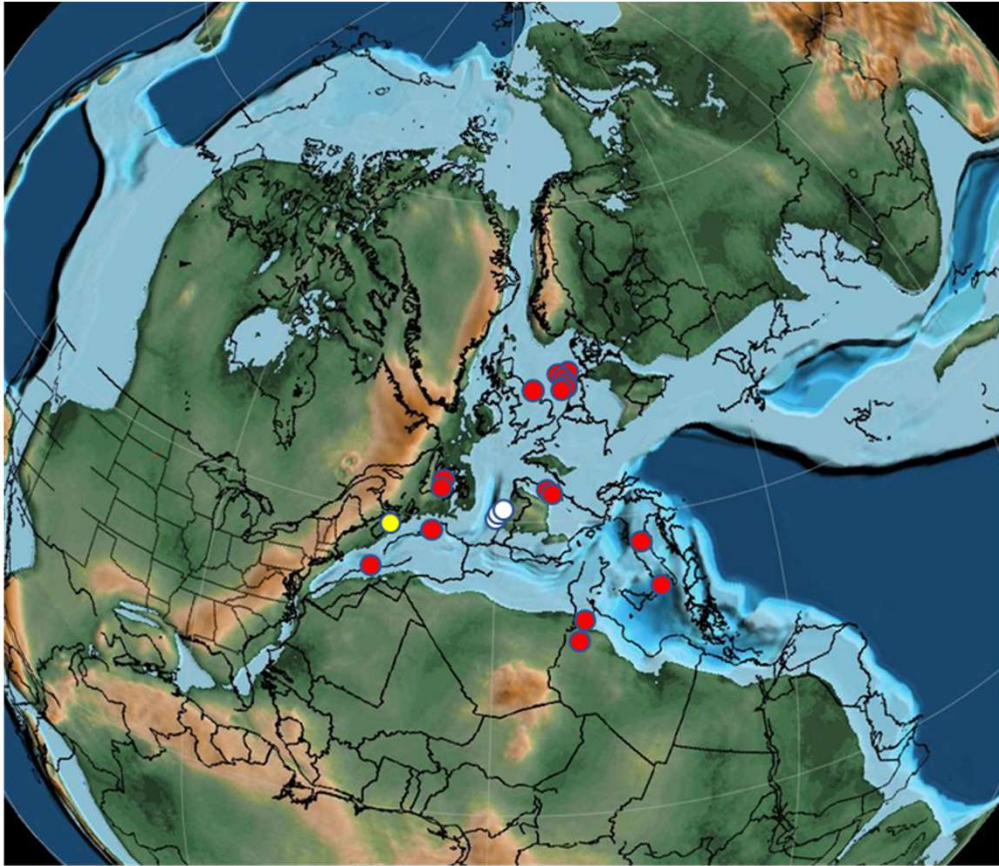


Tethys
Pacific

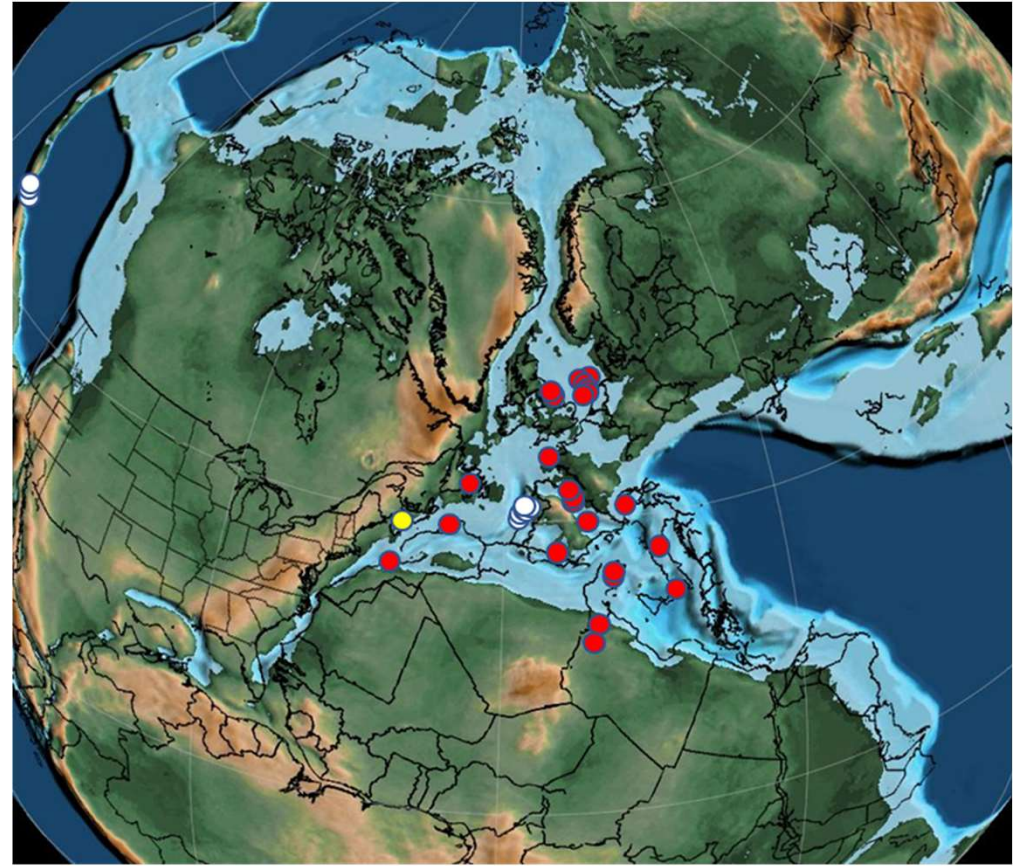


Sinemurian to Toarcian (~199.5 to 174.0 Ma)



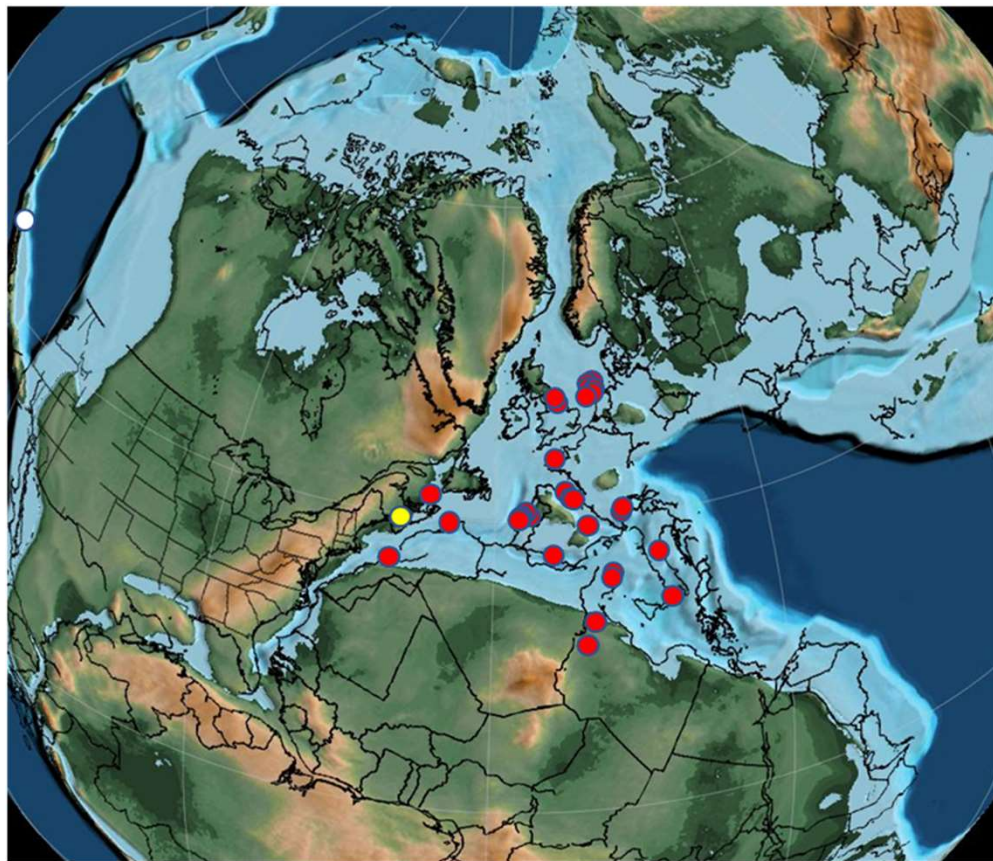


195 Ma – Middle Sinemurian

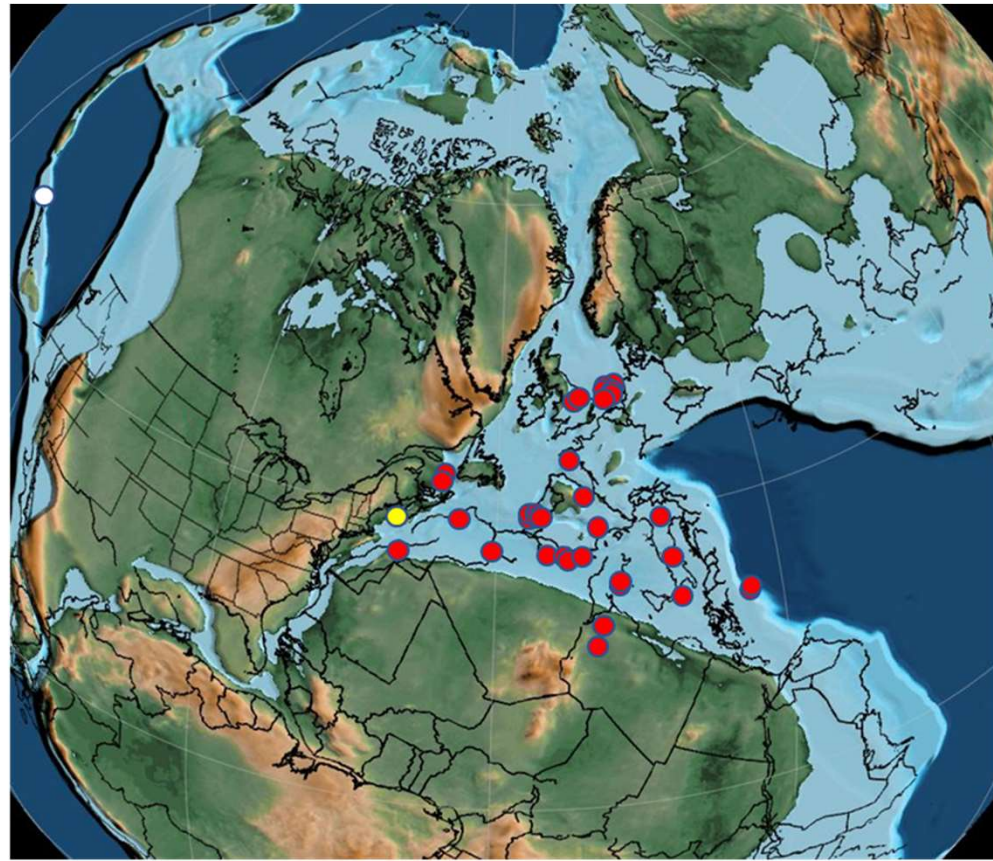


190 Ma – Early Pliensbachian





185 Ma – Late Pliensbachian



180 Ma – Early Toarcian



Pacific realm

Sinemurian to Toarcian
(~199.5 to 174.0 Ma)

4 single locations
5 locations/ Stages
18 species
Location: Queen Charlotte
Islands



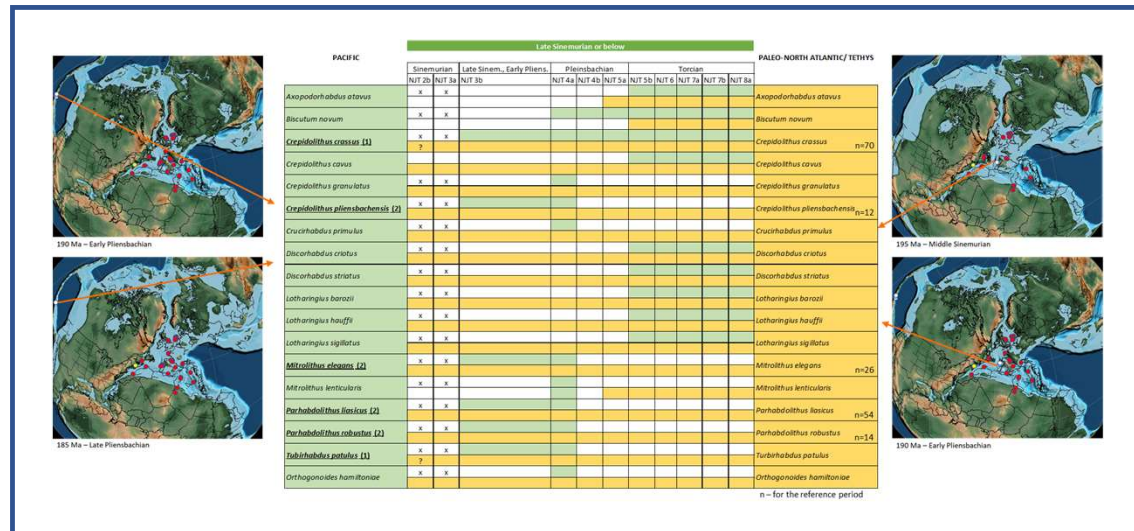
Paleo-Atlantic realm

North Paleo-Atlantic

Sinemurian to Toarcian
(~199.5 to 174.0 Ma)

76 single locations
133 locations/ Stages
289 species



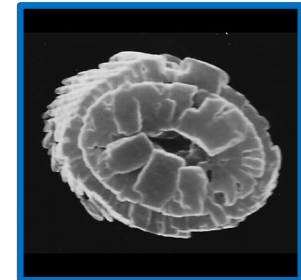
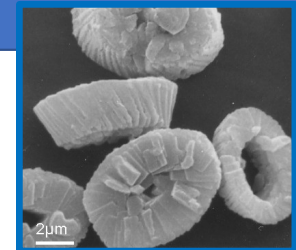


1. Faunas from the most relevant locations were compared.
2. FAD of an isolated species from one realm in the other (across the boundary under study) marks the first evidence of water mixing.
3. The said species is compared to others in similar circumstances to choose best suggested proxies.

1. *Crepidolithus crassus*

- ✓ Common in assemblages
- ✓ Rapid dissemination
- ✓ Easily identifiable

First Pacific appearance is one of the two best proxies for Paleo-North Atlantic/Tethys and Pacific water mixture.



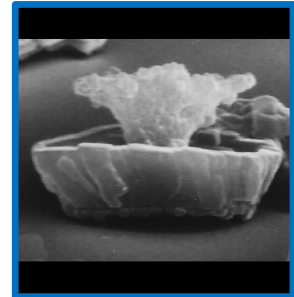
Nannotax: Sinemurian (base of NJ3 – 193,6 Ma) to Tithonian (NJ17b - 148.35-149.09Ma)
Our Study: FAD: Hettangian



1. *Tubirhabdus patulus*

- ✓ Common in assemblages
- ✓ Rapid dissemination
- ✓ Easily identifiable

First Pacific appearance is one of the two best proxies for Paleo-North Atlantic/Tethys and Pacific water mixture.



Nannotax: Sinemurian (base of NJ3 – 193,6 Ma) to Tithonian (NJ17a - 149.09-151.50Ma)
Our Study: FAD: Hettangian



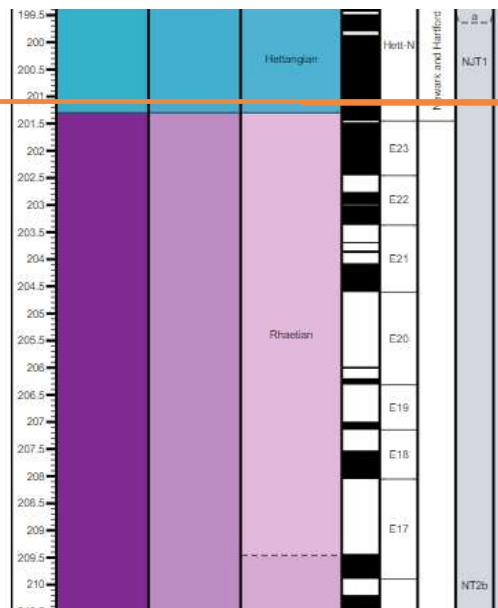
Because of the lack of Pacific data:

- 1 It is not clear whether floras mostly expanded eastwards or westwards.
- 2 It is not clear if the first mixing occurred before Late Sinemurian/ Early Pliensbachian.
- 3 The reference association cannot be evaluated in terms of representativeness or degree of isolation.
- 4 Candidate species to a proxy cannot be chronologically compared.





Tethys



~201 Ma

1

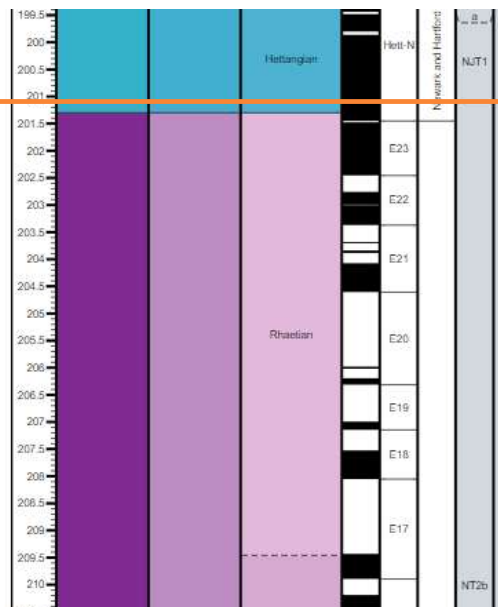
FAD of *Zeugrhabdotus erectus* in the Tethyan realm marks first mixing of Paleozoic North Atlantic and Tethyan waters.

Best approximation of first mixing of Paleozoic North Atlantic and Tethyan waters.

In line with expected.



Tethys



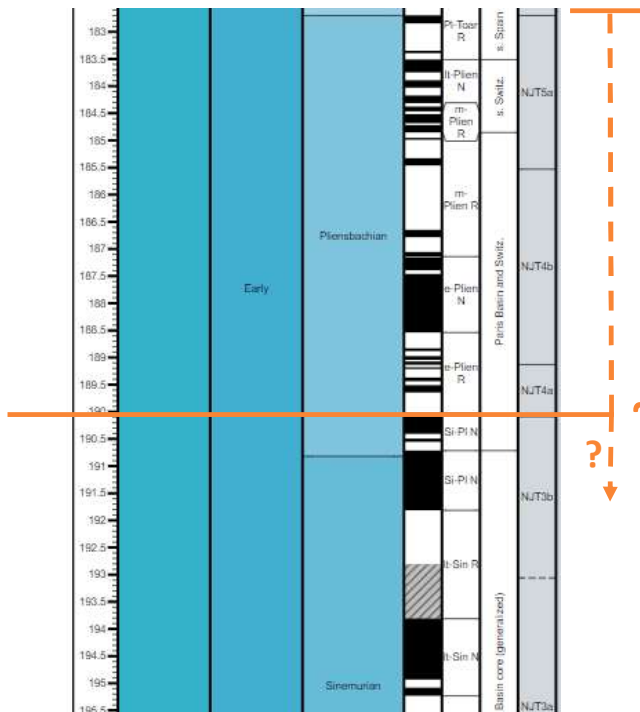
~201 Ma

Overall Quality of Conclusions (+)

- 1 The Tethyan realm is well-documented and is referenced against a clearly isolated nannoflora.
- 2 The species ranges are not in line with consensus (Nannotax). This might be explained by the use of private, non-published data.



Pacific



2 FAD of the *Crepidolithus crassus* association in the Pacific realm marks first mixing of Paleo-North Atlantic and Pacific waters.

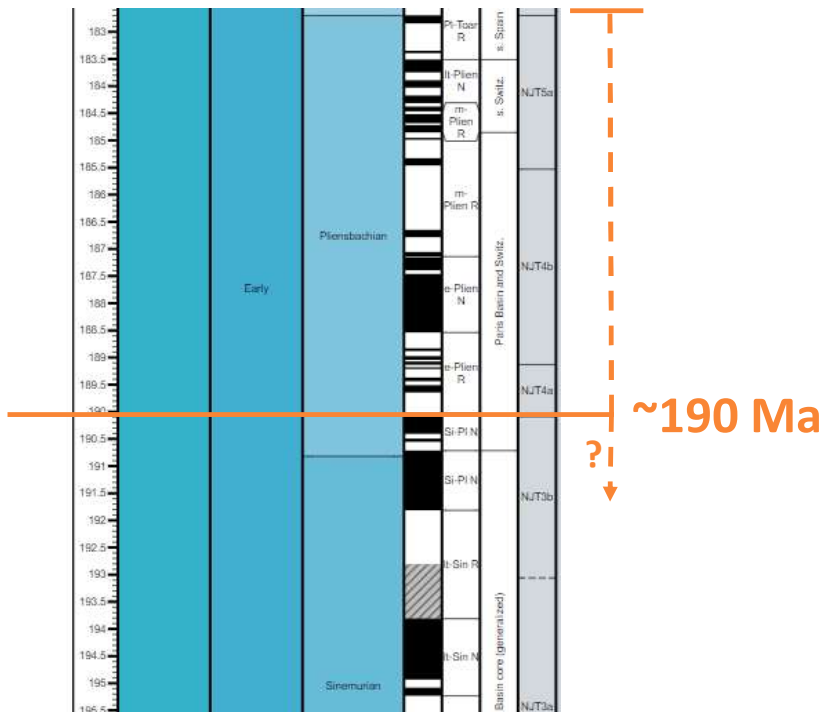
Best approximation of first mixing of Paleo-North Atlantic and Pacific waters.

~190 Ma

Much sooner than expected (~12-20 Ma sooner).



Pacific



Overall Quality of Conclusions (-)

- 1 Surrounding associations are missing, so the reference association is lacking context. Also, it can't be precisely circumscribed in time.
- 2 The species ranges are not in line with consensus (Nannotax). But the difference is minimal.



Data Quality and Validation Procedures

- 1 Data was overall consistent and easily validated through cross-checks, photographic plate analysis and local comparisons. 96% of collected data needed no correction or exclusion.

Pacific Data

- 2 First water mixing in each interface proved too early to be compatible with the oldest oceanic crust. So, the Pacific interface is difficult to interpret.

Calcareous Nannofossils Use

- 3 Very limited data in the Triassic and limited in the Early Jurassic. Recent group with scarce distribution, diversity and quantity. The analysis is only tentative.

