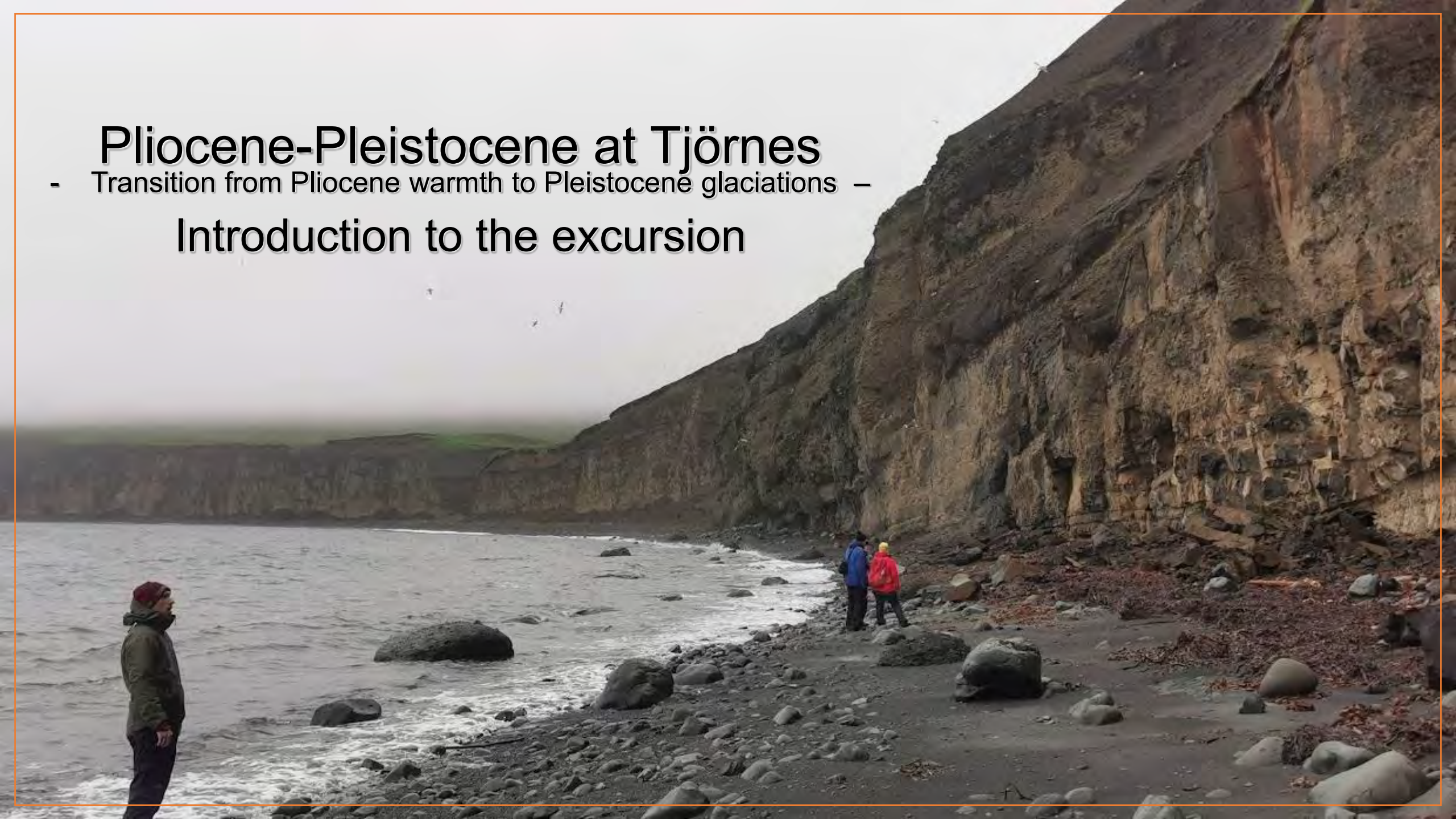
# Pliocene-Pleistocene at Tjörnes

- Transition from Pliocene warmth to Pleistocene glaciations –

## Introduction to the excursion



# Pliocene-Pleistocene at Tjörnes – secrets of the strata revealed by Jón Eiríksson and Leifur A. Símonarson

Reviewed research article

## Tjörnes – Pliocene and Pleistocene sediments and faunas

Leifur A. Símonarson and Jón Eiríksson
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**Abstract** — *On the western side of the Tjörnes Peninsula in North Iceland a long sequence of fossiliferous marine sediments, basalts, and diamictites records the climatic history of the North Atlantic during the Pliocene and Lower Pleistocene. The Pliocene Tjörnes beds are divided in three biozones; the* Tapes *Zone (oldest), the* Mactra *Zone, and the* Serripes *Zone (youngest). The Tjörnes beds consist mainly of marine silt- and sandstones, but there are also several fossiliferous terrestrial beds in the lower part. The marine faunas in the* Tapes *and* Mactra *Zones are mainly boreal, but during the deposition of the* Serripes *Zone the fauna greatly diversified with immigration of Pacific molluscan species with more arctic elements. They reached the North Atlantic at 3.6 Ma after migration through the Bering Strait coeval with closing of the Central American Seaway. Marine molluscs of Pacific ancestry in the* Tapes *and* Mactra *Zones post-date also the first opening of the Bering Strait. In the Breiðavík Group, diamictite beds alternate with volcaniclastic mudrocks and sandstones, and basaltic lava flows. Fourteen lithological cycles are identified in the Breiðavík Group each one starting with a diamictite interpreted as lodgement tillite and ending with terrestrial sediments and lava flows. Interbedded marine fossiliferous mudrocks and sandstones contain arctic to boreal faunal assemblages. The oldest cycle in the Breiðavík group was probably deposited about 2.5 Ma, just after the Gauss/Matuyama polarity reversal.*

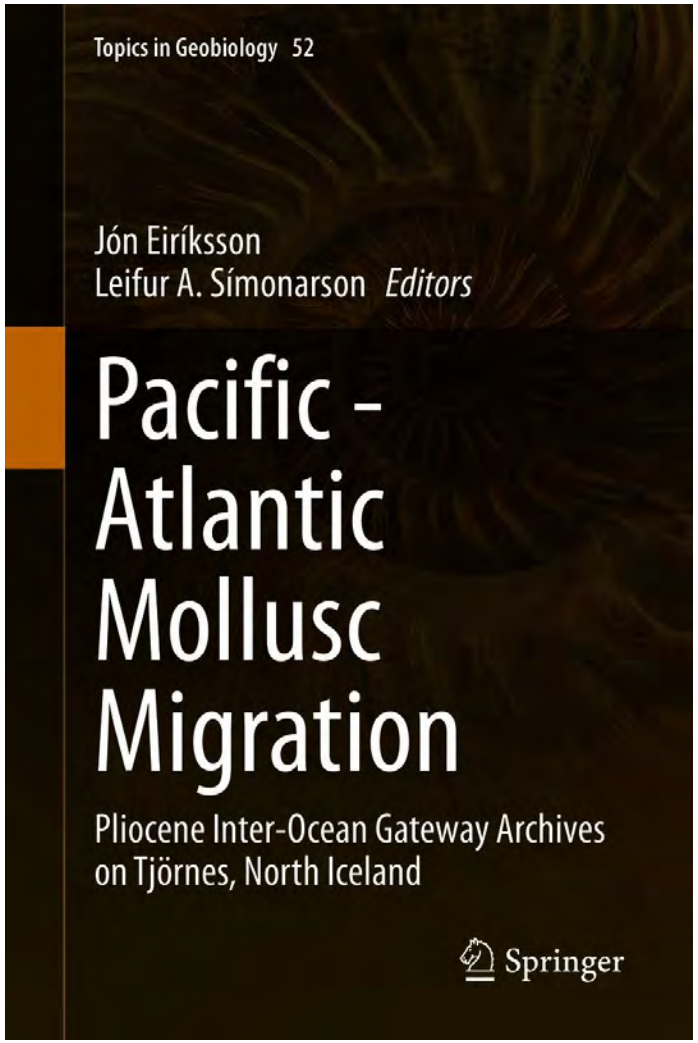
### INTRODUCTION

On the Tjörnes Peninsula in northern Iceland there is a well-exposed sequence of Pliocene and Pleistocene fossiliferous marine and non-marine sedimentary rocks intercalated with basaltic lava flows and, in the higher part, with tillite layers recording at least fourteen glaciations (Eiríksson *et al.*, 1992). The Tjörnes sequence contains a unique record of environmental and faunal changes from the Upper Tertiary to the Quaternary in the shallow-marine and terrestrial North Atlantic region. This is reflected in lithological and faunal variations in the sequence where marine and terrestrial sediments are intercalated between lava flows and pyroclastic rocks. In fact the proximity to the Arctic Polar Front makes North Iceland a key area for understanding climatic variations in the North Atlantic (Eiríksson *et al.*, 1992; Buchardt and Símonarson, 2003).

The abrupt appearance of marine invertebrates of North Pacific origin in the lowermost part of the *Serripes* Zone of the Tjörnes beds at 3.6 Ma is particularly noteworthy. This event has often been interpreted as reflecting the opening of the Bering Strait, but it is probably more related to the closing of the Central American Seaway at this time (Backman, 1979; Marincovich, 2000). New evidence indicates that the Bering Strait first opened at 5.5–4.8 Ma and then the initial phase of faunal interchange took place and some Pacific species reached North Iceland when the lowermost part of the marine sediments of the Tjörnes sequence were deposited (Durham and MacNeil, 1967, Marincovich, 2000, Buchardt and Símonarson, 2003).

The present paper gives an overview of the faunal and sedimentological changes observed on the Tjörnes Peninsula, from relatively stable Pliocene conditions, to the highly variable and periodically harsh climatic conditions of repeated glaciations.





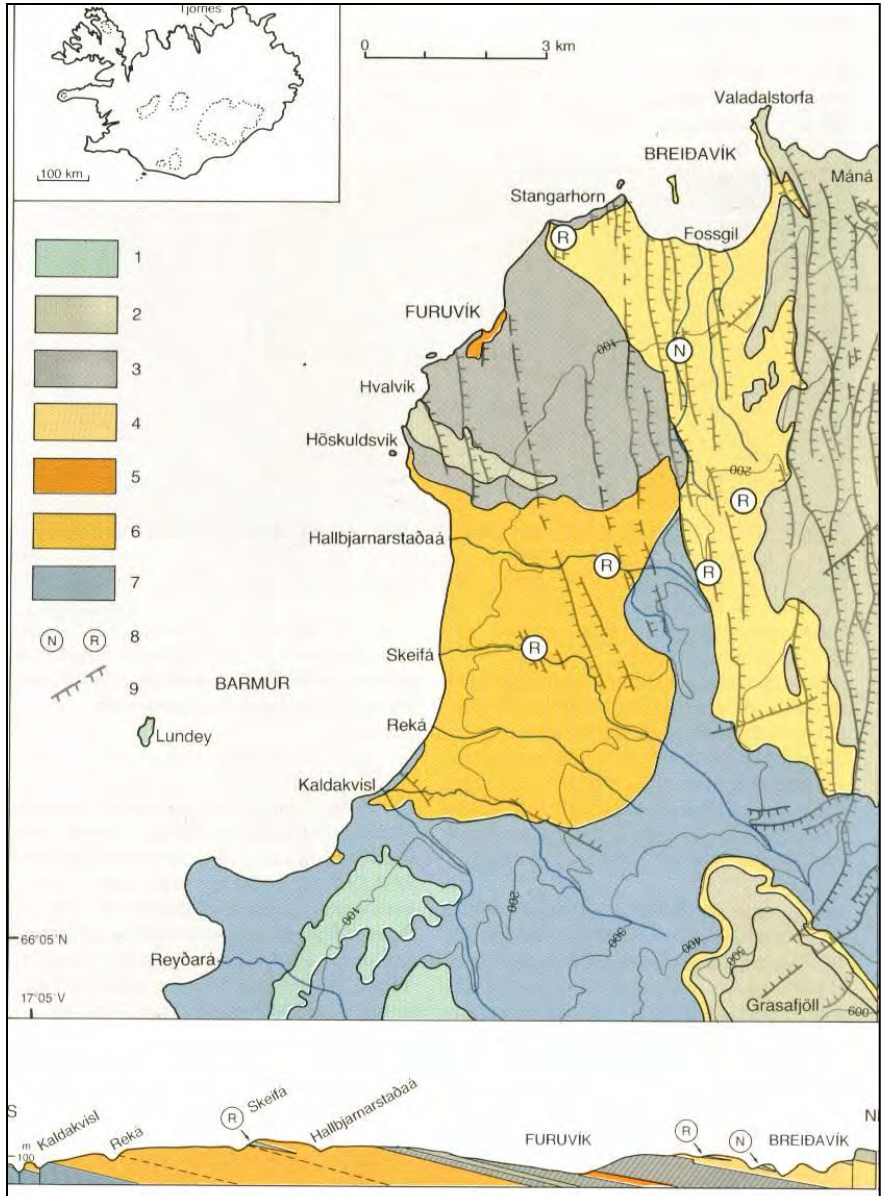
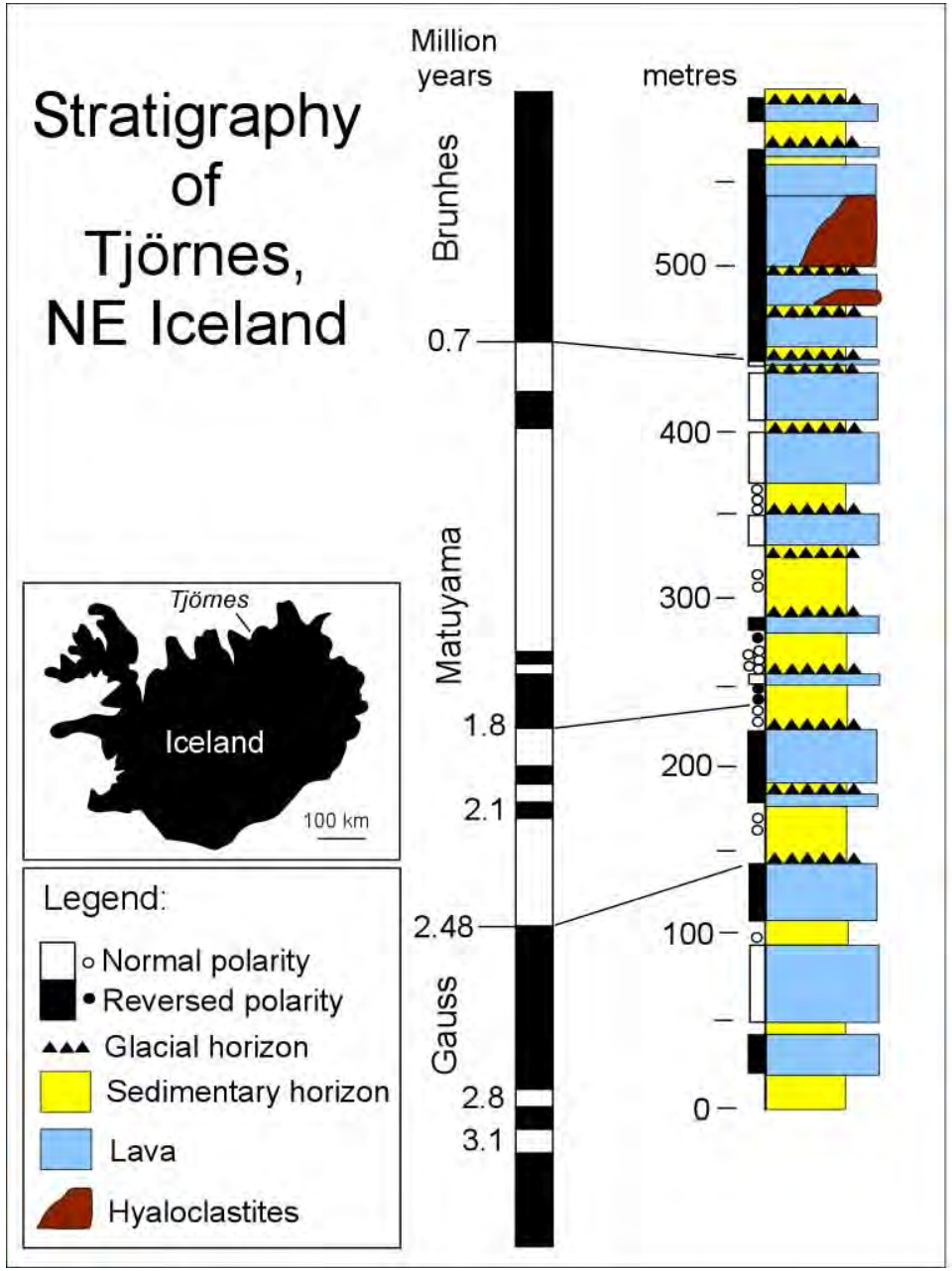




*Figure 24-16. Geological map of the Tjörnes area (above) and geological section from Kaldakvísl to Breiðavík. Symbols: 1) Reyðará grey basalt (late Pleistocene), 2) reverse magnetized lavas, 3) normally magnetized lavas, 4) Breiðavík beds, 5) Furuvík beds, 6) Tjörnes beds, 7) Tertiary basalt, 8) individual lavas in sediments; N normally and R reverse magnetized, 9) faults. The vertical scale is 5X thus greatly exaggerating the dip. (Drawing Þ.E. and G.H.I.)*

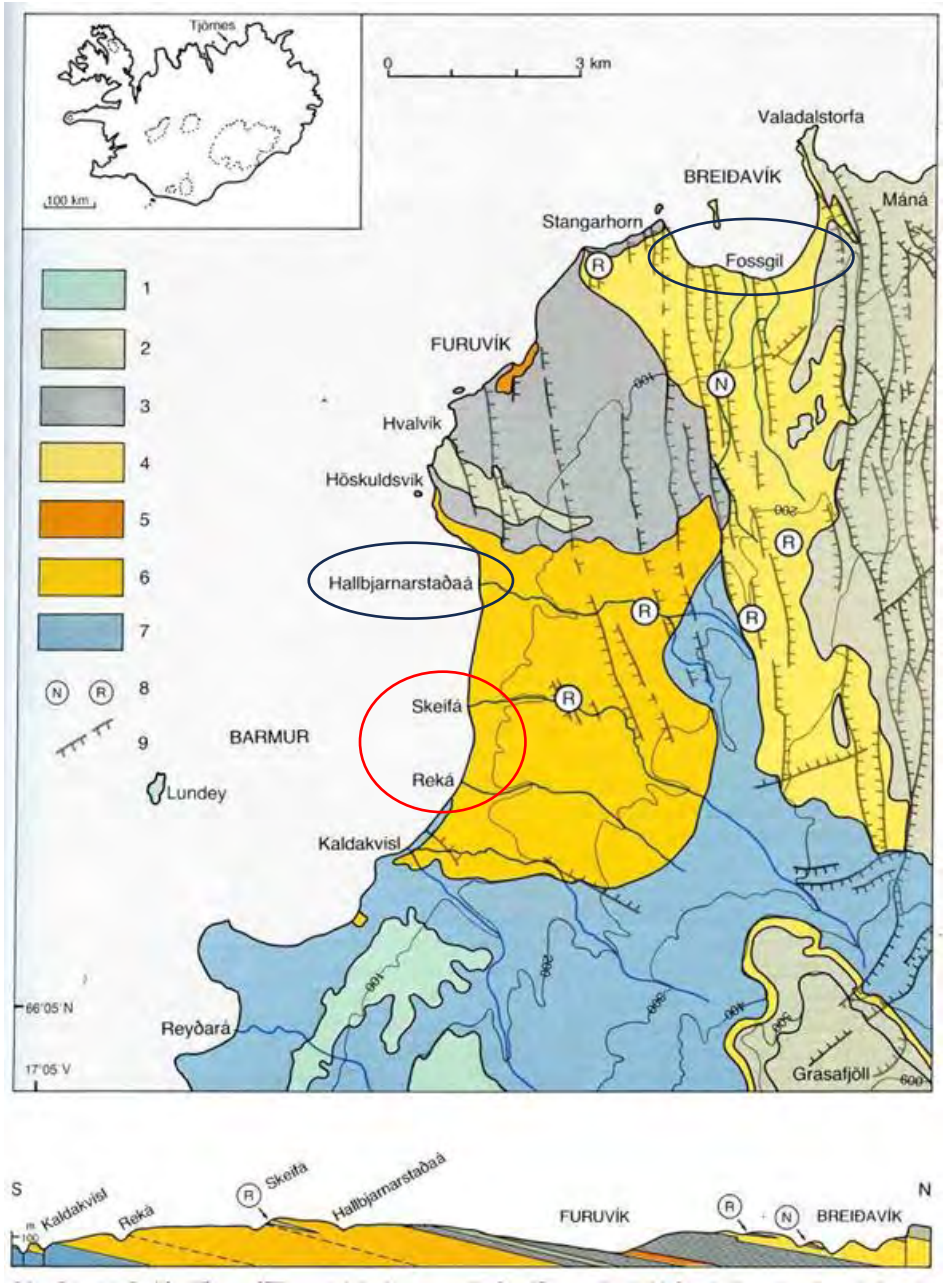
# Pliocene-Pleistocene at Tjörnes

The transition from relatively warm Pliocene climate and the cool/cold Pleistocene climate is recorded at Tjörnes, N Iceland. There, warm fauna is replaced by cold fauna, and tillites enter the strata.




# Tjörnes stratigraphy

- The Tjörnes strata is composed of lava beds, fluvial sediments, lake- and bog sediments, marine and glaciomarine sediments, as well as tills. In time it spans Pliocene-late Pleistocene.




# Tjörnes stratigraphy

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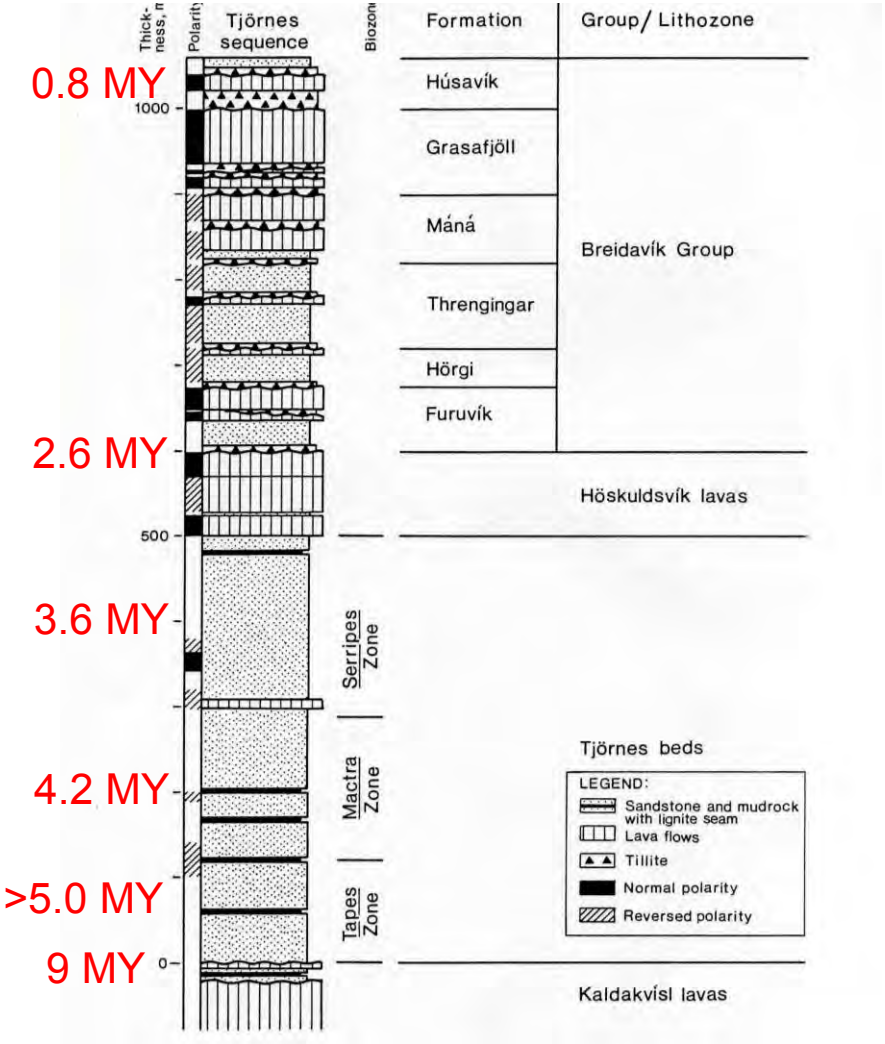
- The total thickness of the Tjörnes strata is >1200 m

# Tjörnes stratigraphy




**Tjörnes beds**: ~500 m thick, marine sediments rich in fossilized shells and snails. Also lignites and lavas in the formation.

- **Uppermost**: The *Serripes layers/zone*. Named after *Serripes groenlandicus*

- **Middle**: The *Mactra layers/zone*. Named after the now extinct *Mactra sp.*

- **Lowest**: The *Tapes beds/zone*. Named after *Tapes sp.*

# Tjörnes stratigraphy

Paleoceanography and Paleoclimatology

RESEARCH ARTICLE
10.1029/2022PA004539

## Timing and Consequences of Bering Strait Opening: New Insights From $^{40}Ar/^{39}Ar$ Dating of the Barmur Group (Tjörnes Beds), Northern Iceland

**Jonathan R. Hall[1], Matthew S. Allison[1], Max T. Papadopoulos[1], Dan N. Barfod[2], and Stephen M. Jones[1]**

[1]School of Geography, Earth and Environmental Sciences, University of Birmingham, Birmingham, UK, [2]NERC Argon Isotope Facility, Scottish Universities Environmental Research Centre, East Kilbride, UK

**Key Points:**

- New Ar-Ar dating shows a late Miocene to early Pliocene (6.0–4.4 Ma) age range for the Barmur Group (Tjörnes beds), northern Iceland
- Arrival of Pacific bivalves in Iceland is dated at 5.2–4.9 Ma (chrons C3n.4n–C3n.3r), soon after first Bering Strait opening at 5.6–5.4 Ma
- Opening of the Bering Strait gateway did not directly cause the development of large northern hemisphere icecaps

**Supporting Information:**

Supporting Information may be found in the online version of this article.

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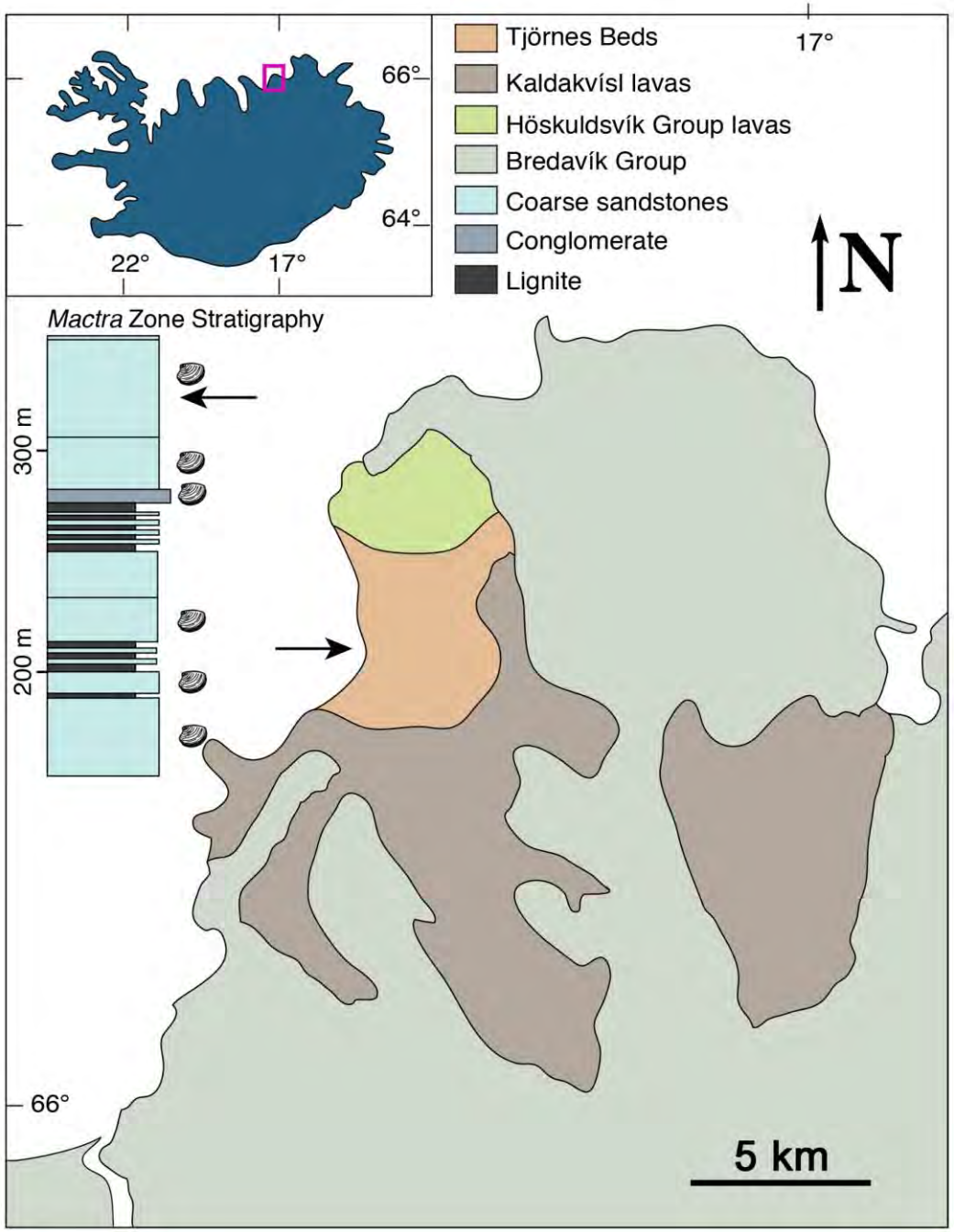
**Citation:**

Hall, J. R., Allison, M. S., Papadopoulos, M. T., Barfod, D. N., & Jones, S. M. (2023). Timing and consequences of Bering Strait opening: New insights

**Abstract** The Barmur Group (informally Tjörnes beds) sedimentary succession of northern Iceland is key to reconstructing the opening of the Bering Strait oceanic gateway because these rocks record migration of bivalve molluscs from the Pacific to the Atlantic via the Arctic. However, the timing of the migration event is poorly constrained owing to a lack of reliable absolute ages. To address this problem, we present the first Ar-Ar radiometric dates from four basaltic lavas that underlie, are intercalated with, and overlie the Barmur Group, and integrate them with existing paleomagnetic records. We show that the Barmur Group has a latest Miocene to early Pliocene age range (c. 6.0–4.4 Ma; C3r–C3n.2n), older than all previous age models. Thus, the Barmur Group does not record the mid-Piacenzian Warm Period, contra some previous suggestions. Abundant Pacific bivalve molluscs appeared in the Barmur Group during subchrons C3n.4n–C3n.3r at 5.235–4.896 Ma, over 1.3 million years earlier than previously suggested. Appearance of Pacific bivalves in the northern Atlantic occurred shortly after the 5.6–5.4 Ma age previously inferred for first appearance of Arctic bivalves in the Pacific. Thus, our data suggest that first opening of the Bering Strait gateway by the latest Miocene (c. 5.5 Ma) was soon followed by bidirectional trans-Arctic faunal exchange, and argue against a hypothesized two-stage faunal exchange process spanning c. 2 million years. Our results also confirm that first opening of the Bering Strait gateway was not directly associated with the growth of large northern hemisphere icesheets, which occurred several million years later.

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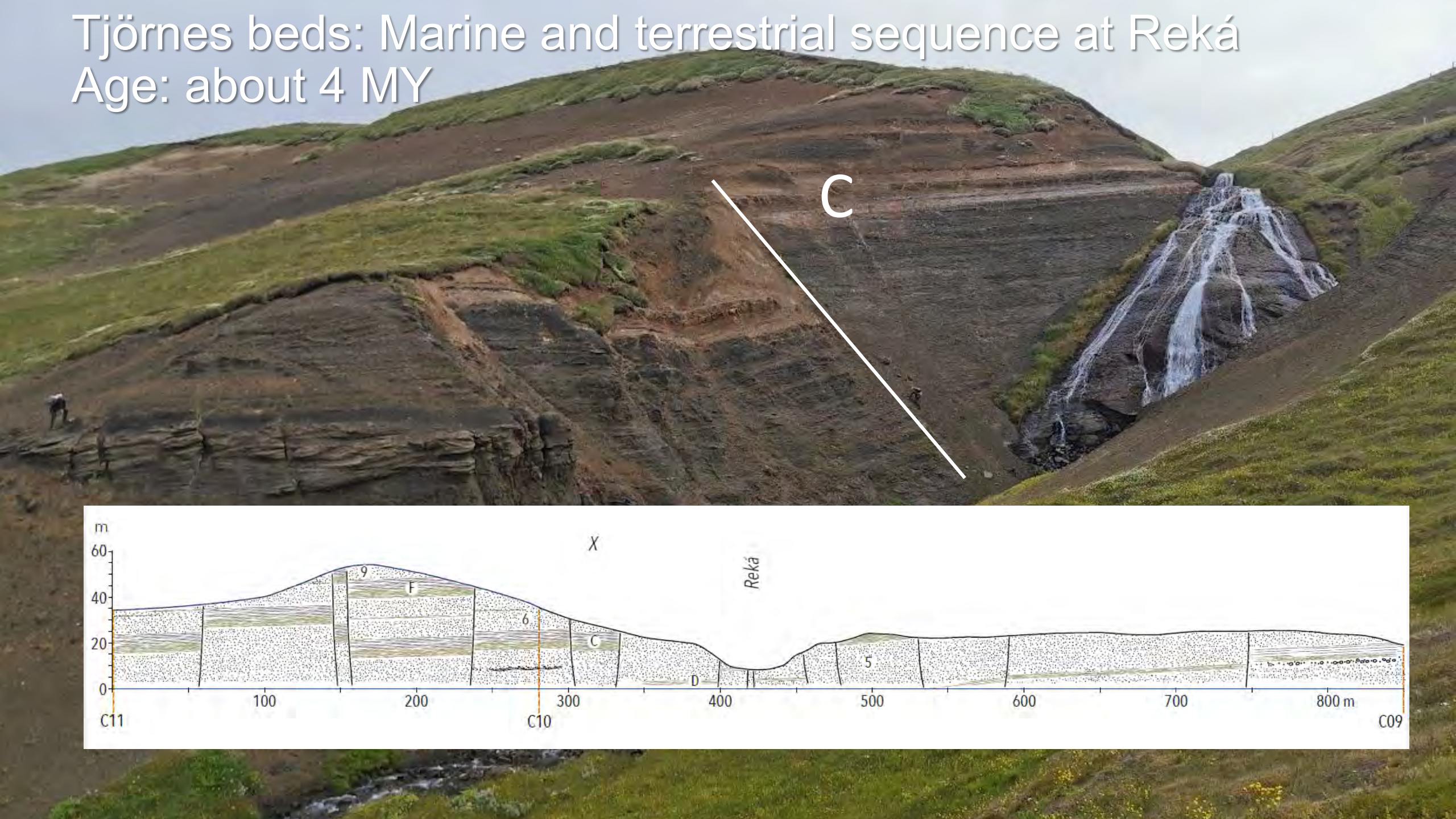
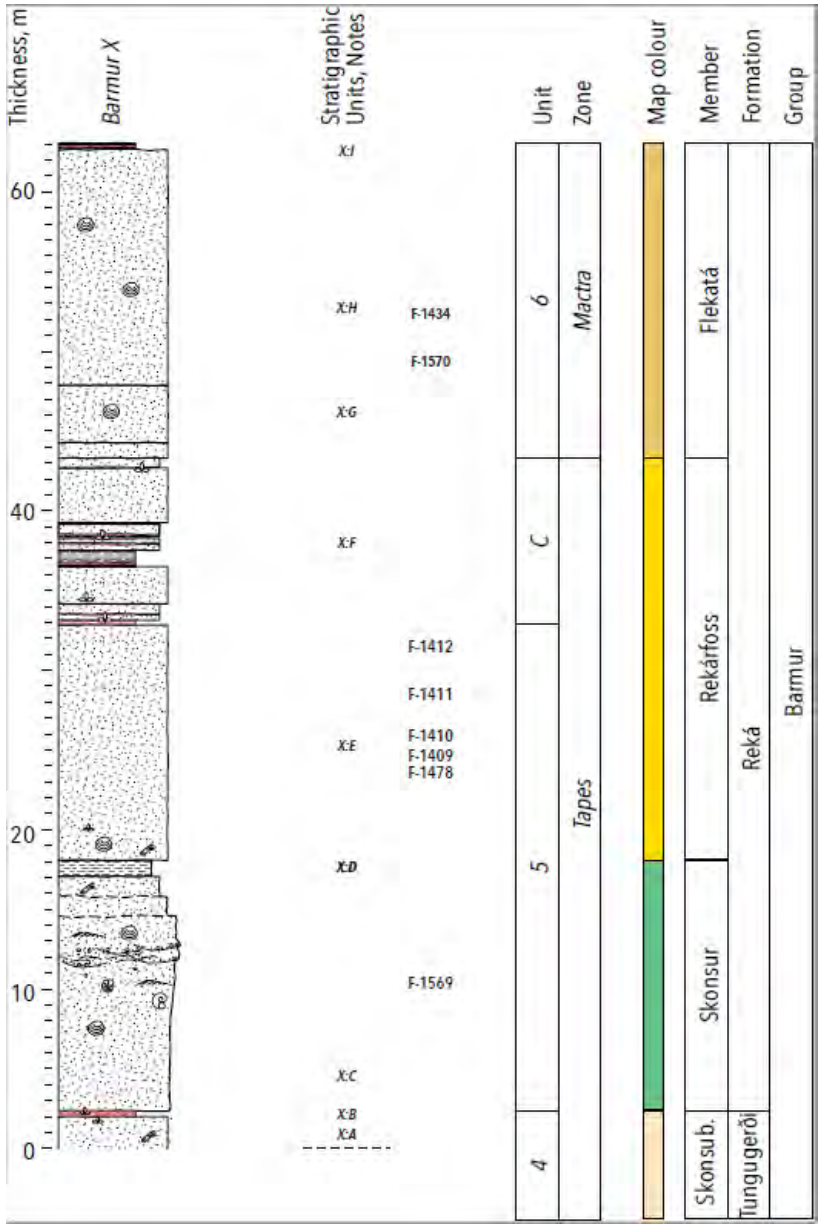
# Tjörnes beds: Marine and terrestrial sequence at Reká
# Age: about 4 MY




Thickness, m
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Stratigraphic Units, Notes
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F-1478
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Reká
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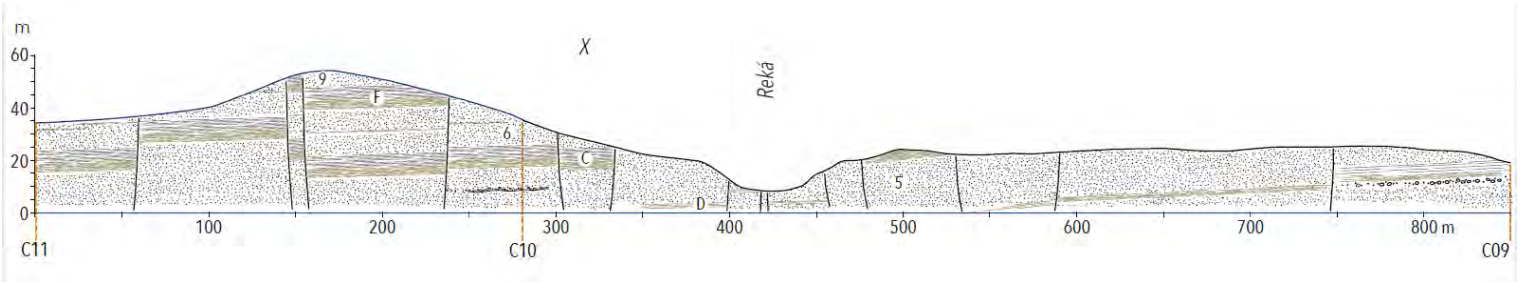
m
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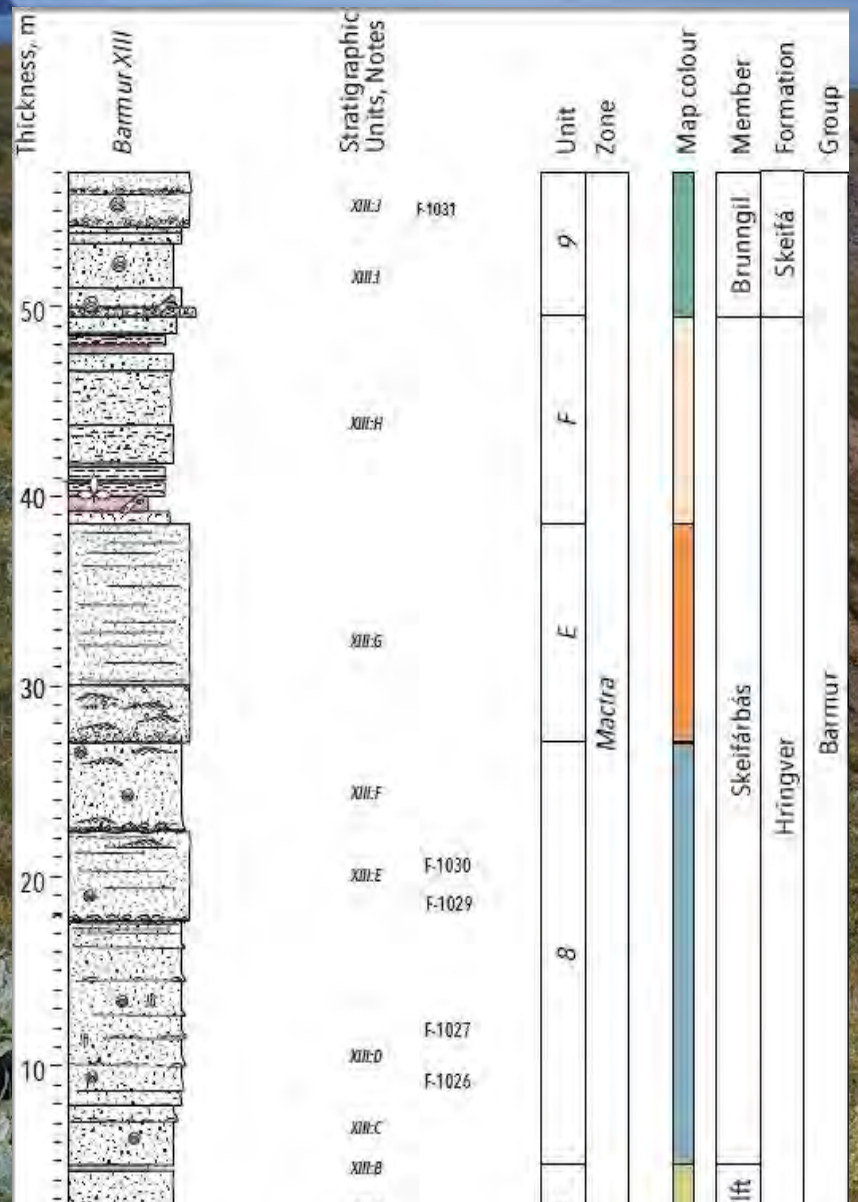
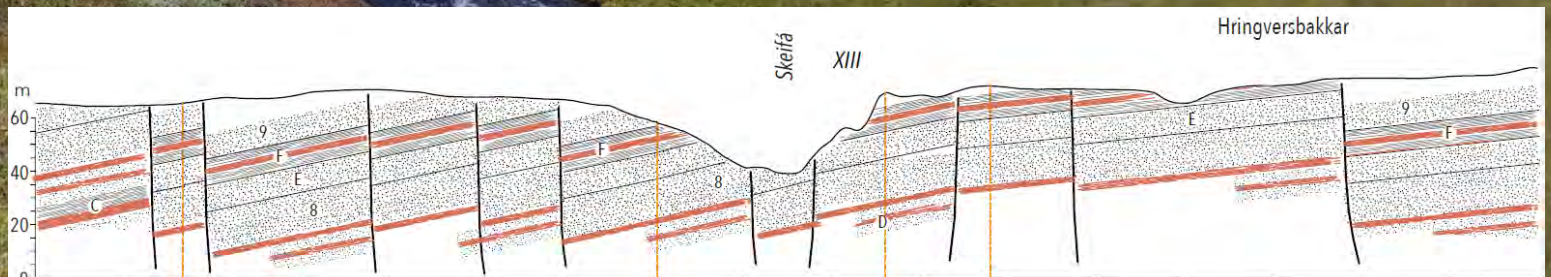
Tjörnes beds: Marine and terrestrial sequence at Reká
Age: about 4 MY

# Tjörnes beds: Marine and terrestrial sequence at Skeifá
# Age: about 4 MY



Tjörnes beds: Marine and terrestrial sequence at Skeifá
Age: about 4 MY

# The Tjörnes beds: Tapes beds and Mactra layers

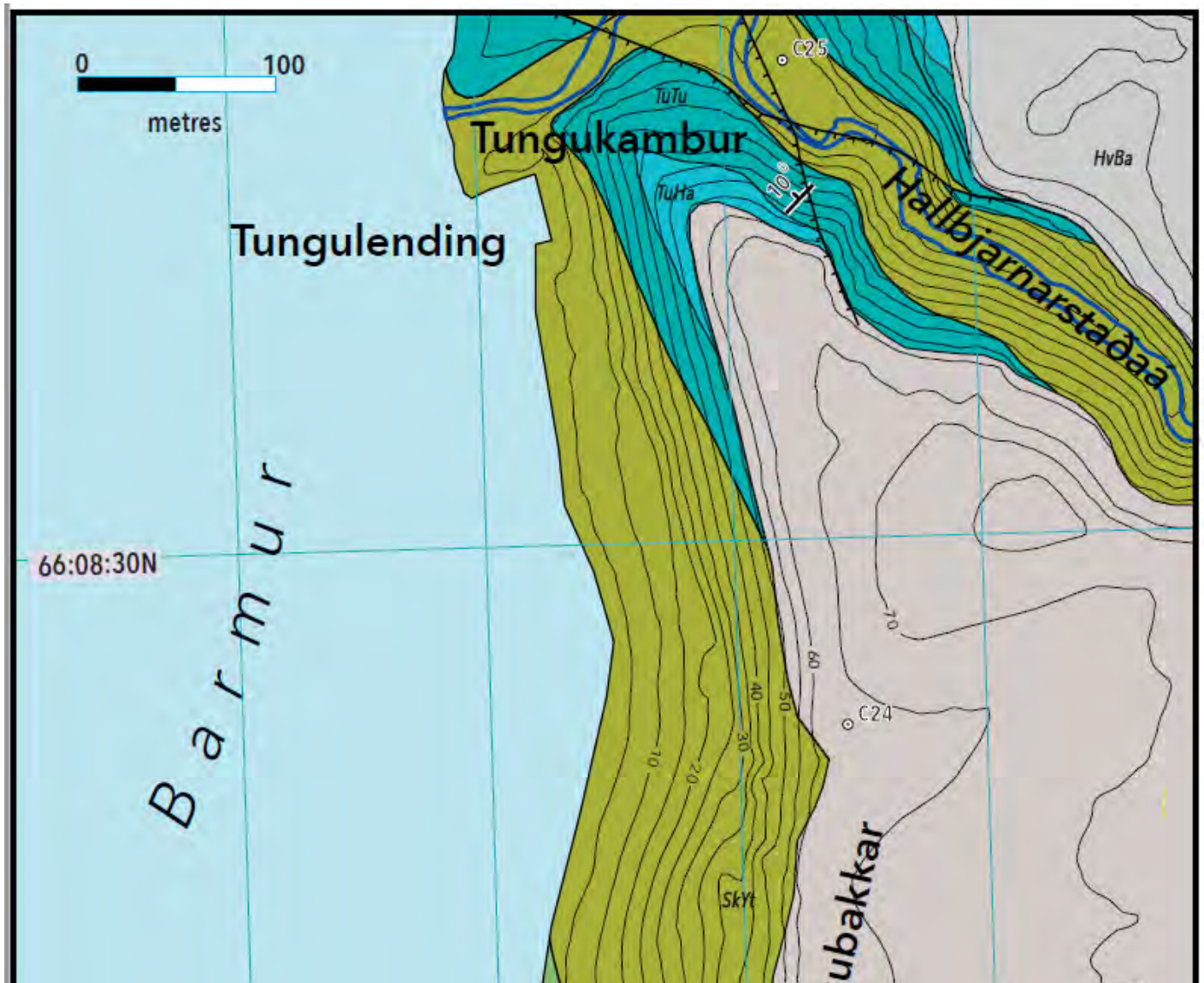
✓ The *Tapes beds* and the *Mactra layers* were deposited in shallow, warm marine environment. *Tapes sp, Cardium sp., Mytilus sp., Glycimeris sp.*

✓ This fauna lives today in waters 5-10$^{o}$C warmer than presently around Iceland.

✓ Pollen analyses from lignite beds show forests close by (spruce, pine, larch, oak, beech, hazel, alder, birch, willow).

✓ Mean temperature of the coldest month rarely below 0$^{o}$C

# Tjörnes beds: Mactra-Serripes transition at Tungukambur. Age: 3.6-4 MY



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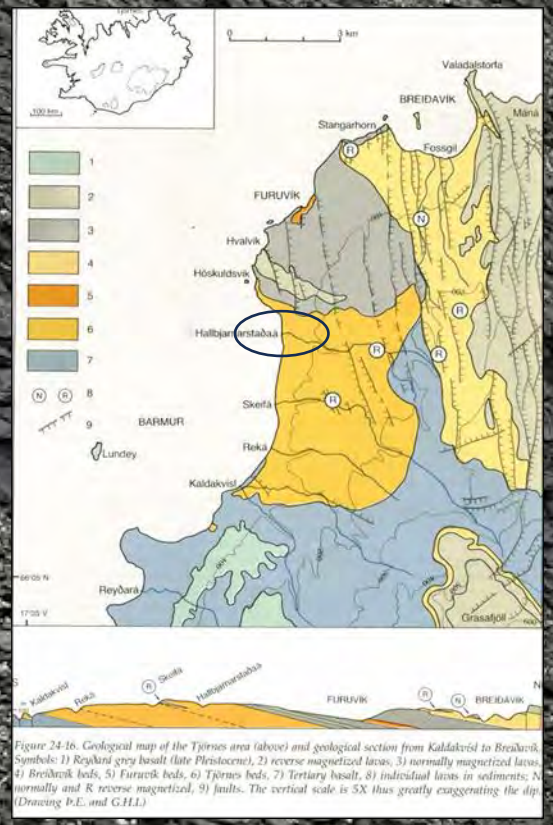


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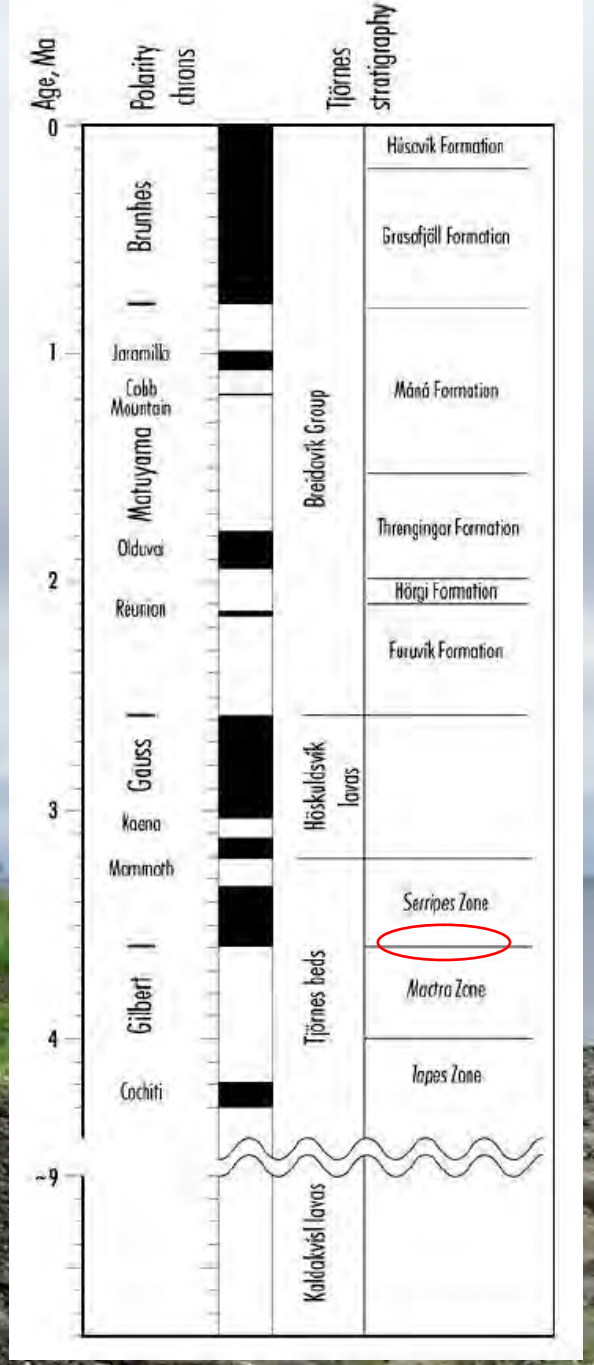
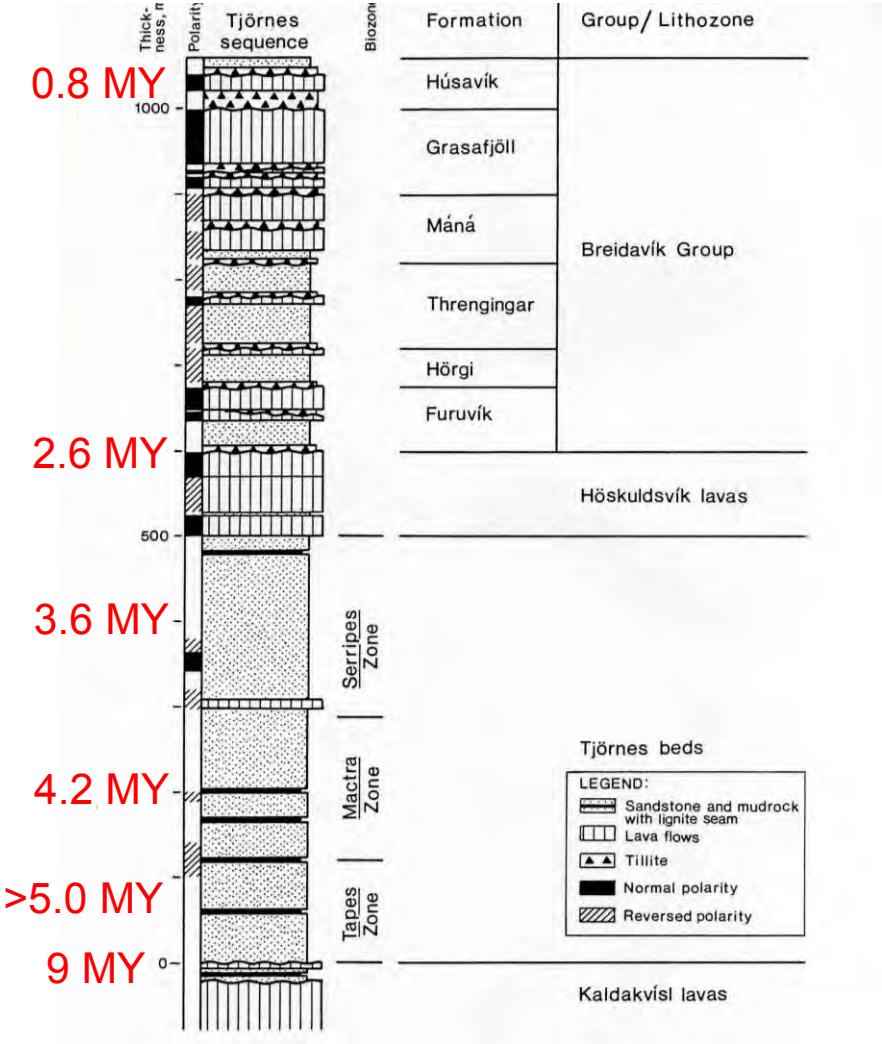


# The Tjörnes beds: Mactra-Serripes transition

Photo: Lovísa Ásbjörnsdóttir

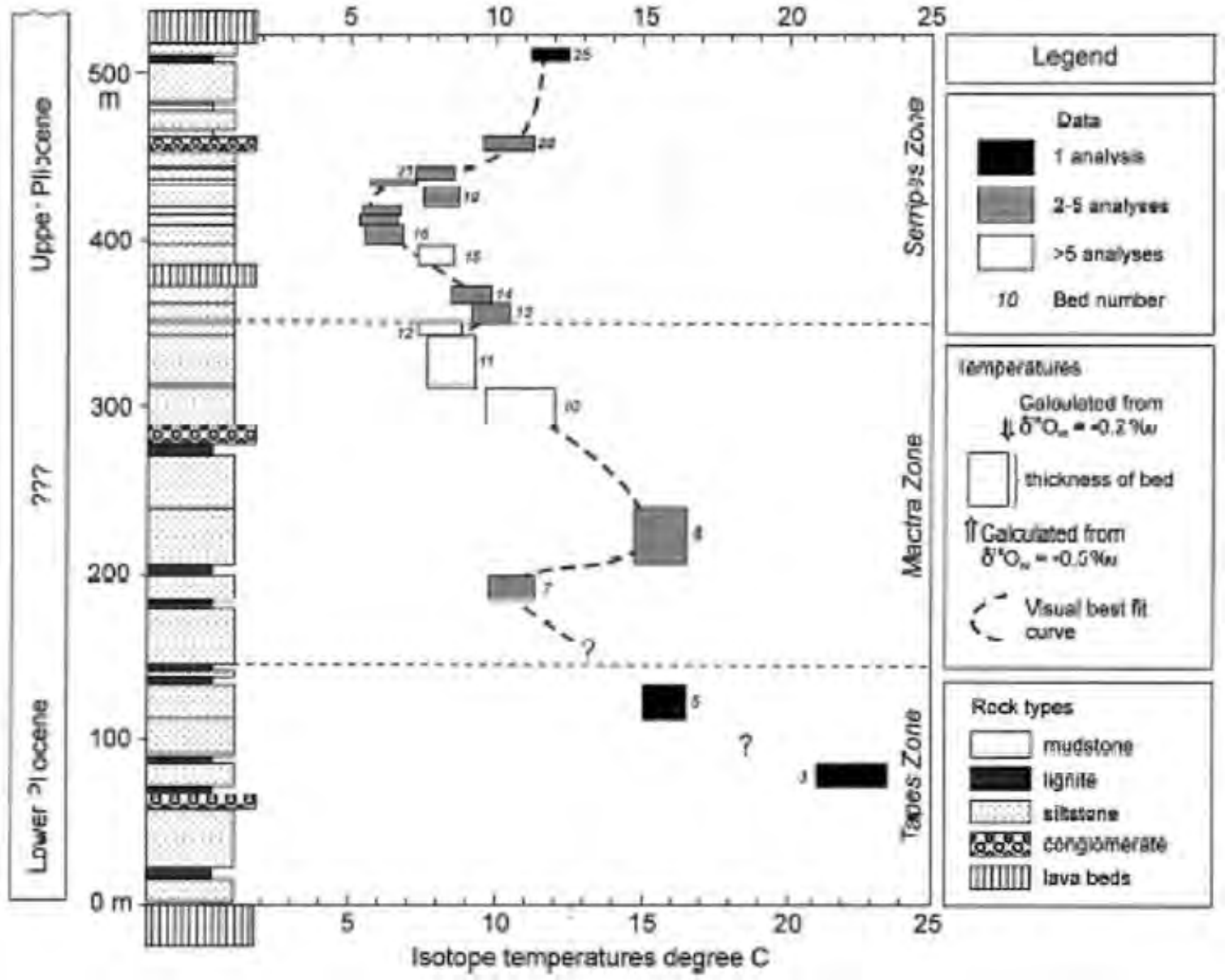

Mactra
Serripes

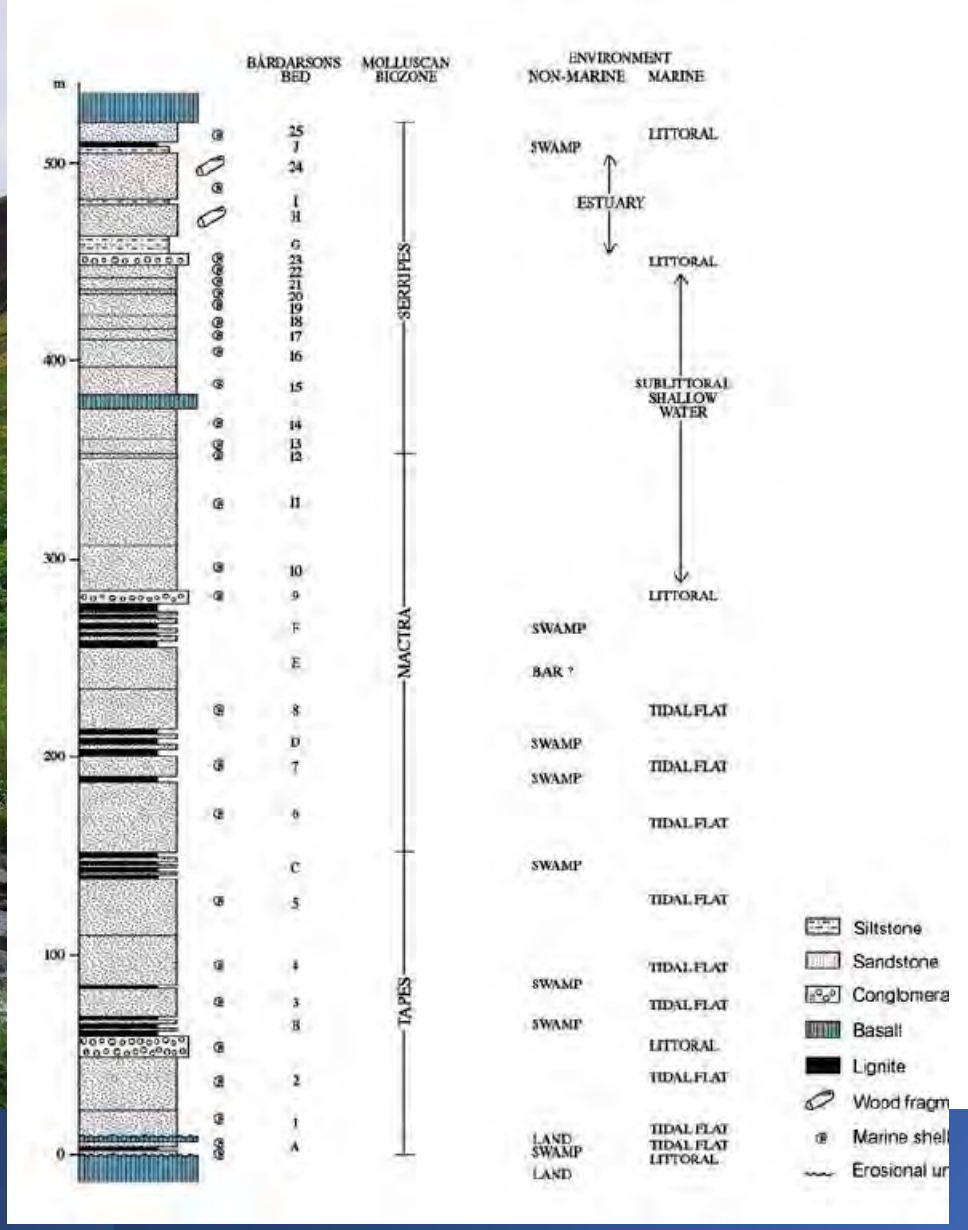
# The *Serripes layers:* Cooling...




- At the base of the Serripes layers most warm-loving molluscs have disappeared. The fauna is similar to present-day fauna.
- Of about 100 different species of molluscs in the Serripes layers, about 25% originate in the Pacific.
- Lava on top of the Serripes layers dates to ~2.6 MY. Their age is 3-4 MY

Study by Buchardt and Simonarson (2003) on isotope paleotemperatures from the Tjörnes beds






Generalised lithostratigraphic section of the Tjörnes beds, with palaeoenvironmental interpretations

# The Furuvík beds

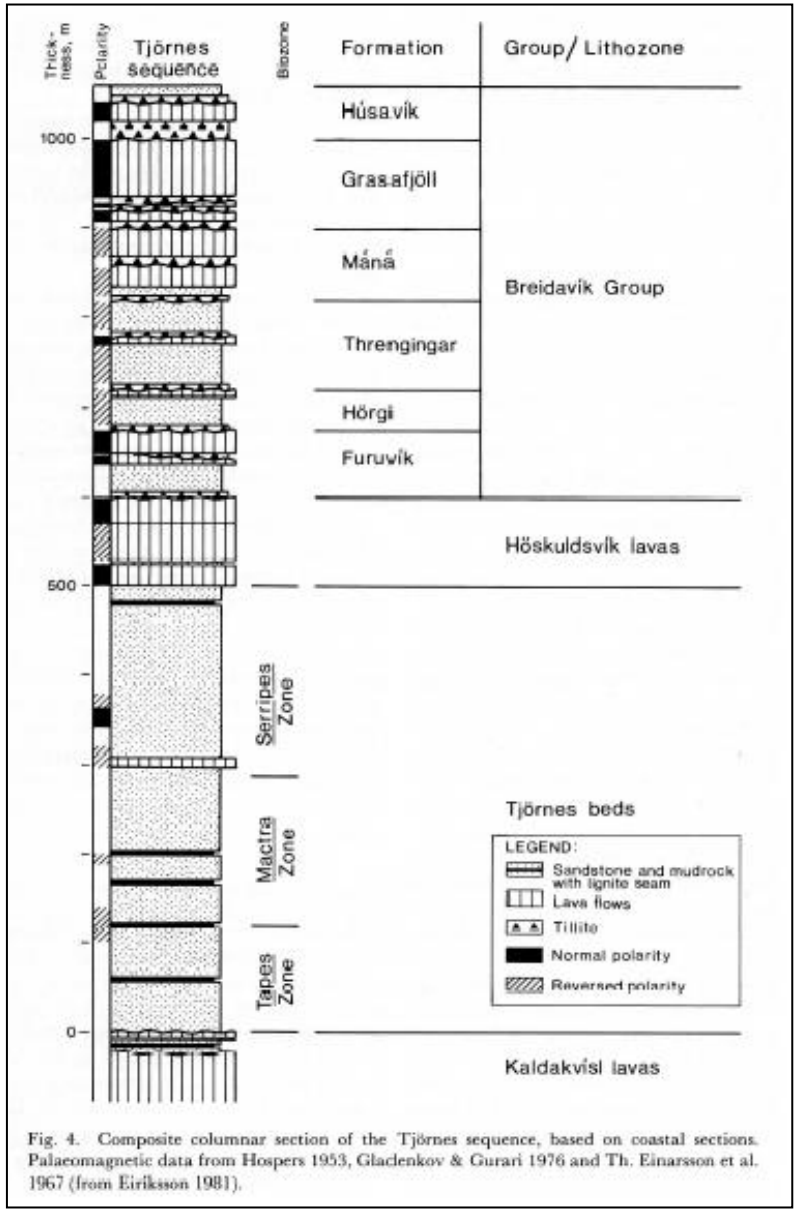
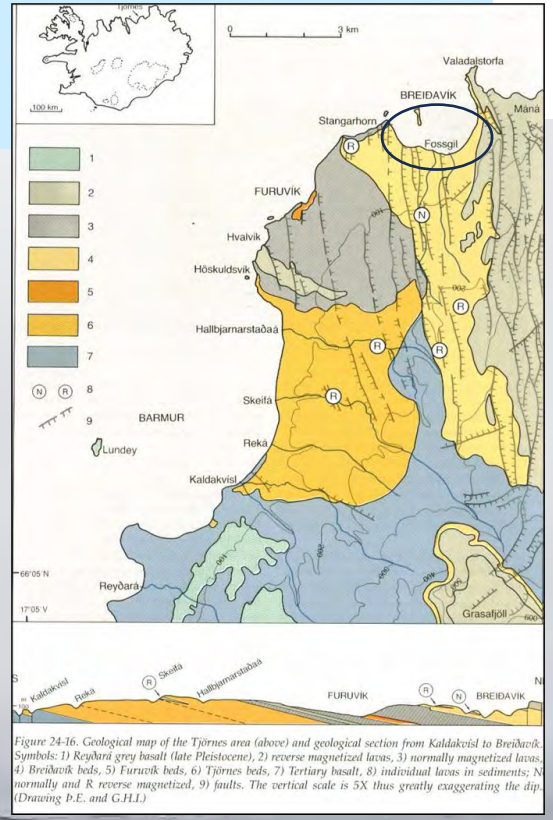



Fig. 4. Composite columnar section of the Tjörnes sequence, based on coastal sections. Palaeomagnetic data from Hospers 1953, Gladenkov & Gurari 1976 and Th. Einarsson et al. 1967 (from Eiríksson 1981).

**Furuvík beds:** At the base of the sequence there are two thick tillites, together >40 m thick. Paleomagnetism and potassium-argon dates of Höskuldsvík lavas suggest tillite ages of <2.5 and >2.0 MY

# The Breiðavík deposits

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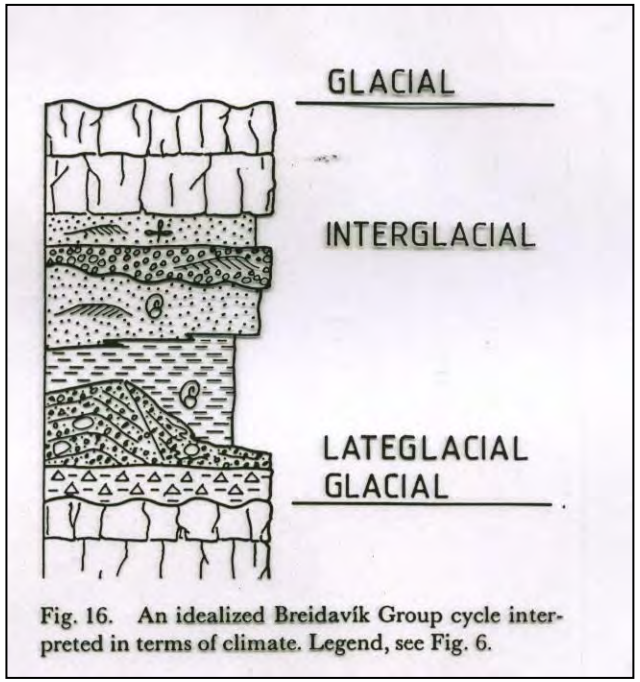
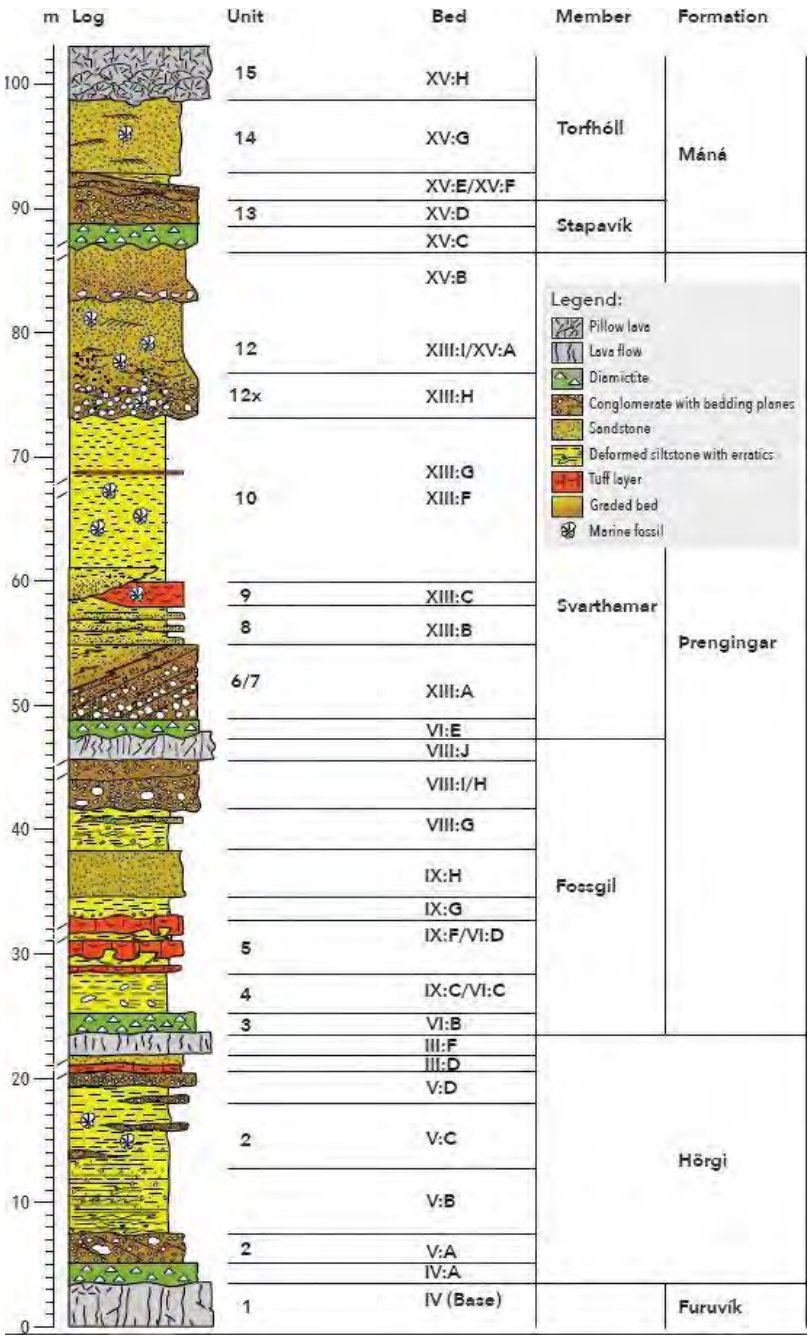


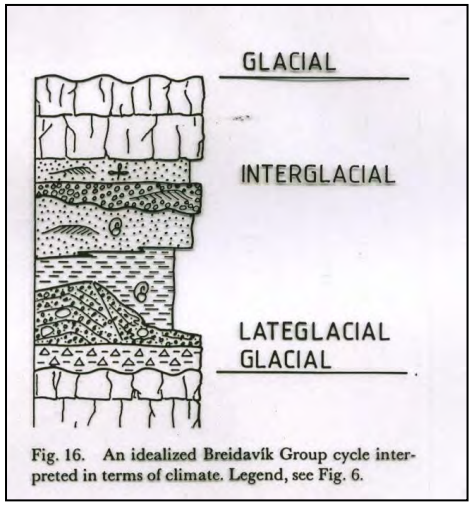
Fig. 16. An idealized Breidavík Group cycle interpreted in terms of climate. Legend, see Fig. 6.

Repeated cycles of glacial and interglacial sediments and lavas

Over 100 m thick sequence of alternating lavas, tillites and marine fossiliferous sediments, with 14 lithological cycles identified where each one starts with a diamictite interpreted as lodgement tillite and ending with terrestrial sediments and lava flows. Plant remains are alder, willow and birch. Breiðavík deposits are 2,5-1.2 MY old.




# Breiðavík deposits

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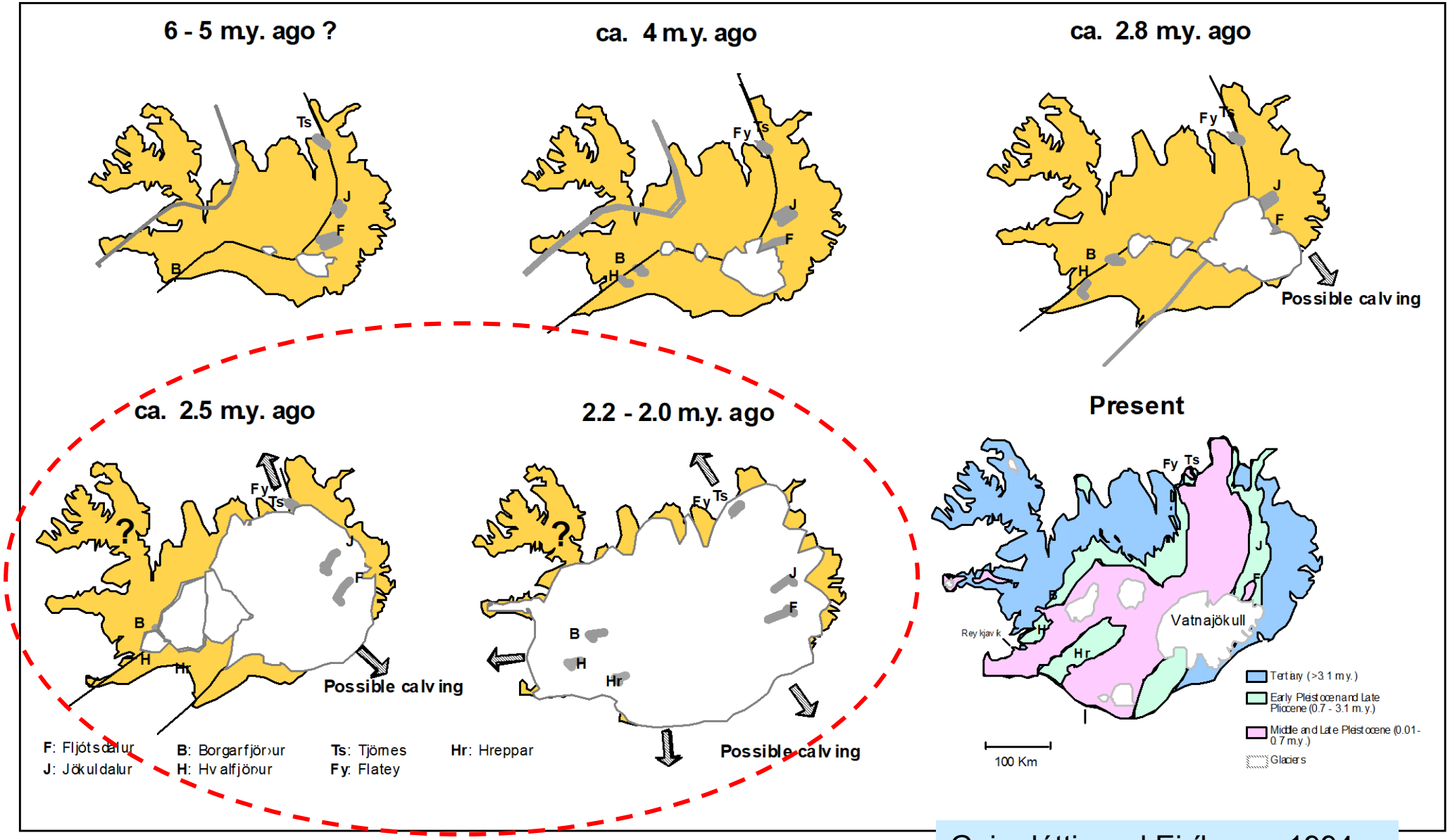
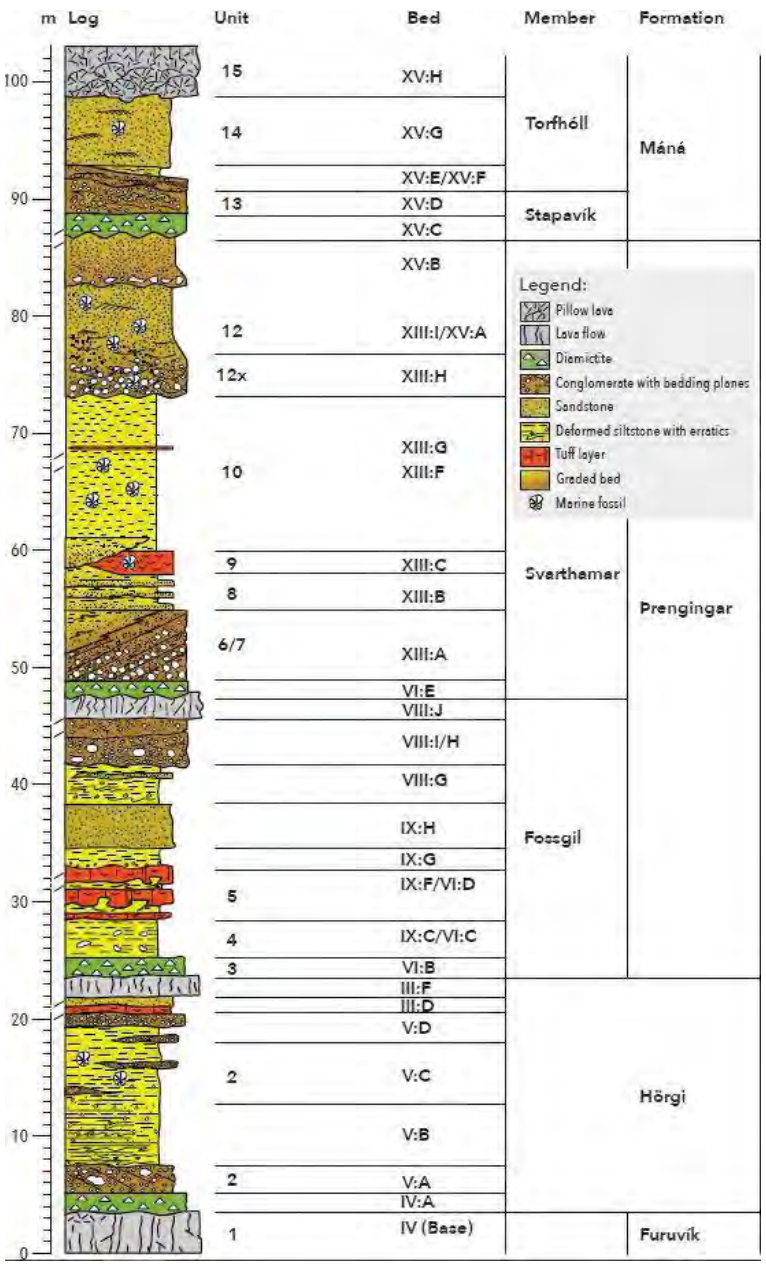
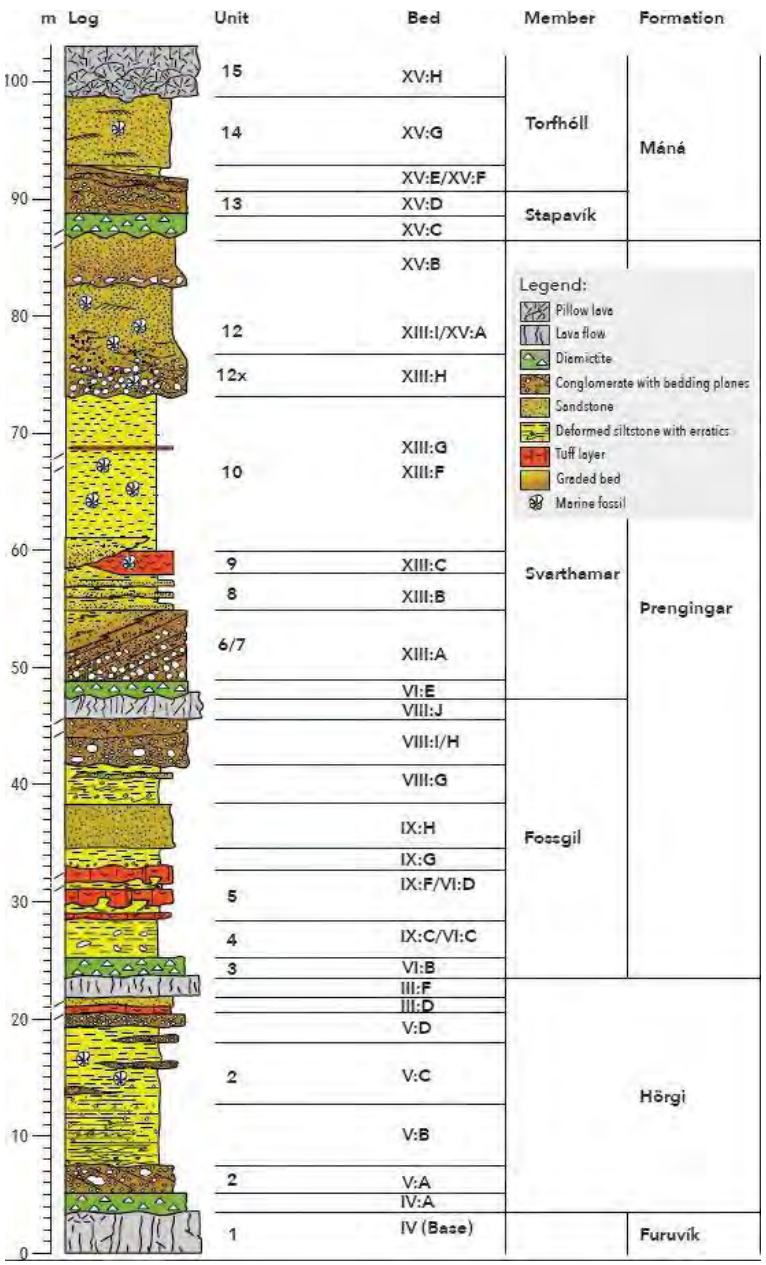
# Glacial extent in Iceland through Pliocene-Pleistocene




Geirsdóttir and Eiríksson 1994




Top of Svarthamar Member, with tephra/tuff horizons. Pro-delta deposit – rapid deposition during deglaciation, trans-gression. *Portlandia arctica* indicates cold marine climate. Fauna of top layers similar to todays (interglacial) marine fauna.




Units 6/7 –Dead ice deposits and contorted/deformed glaciofluvial deposits.

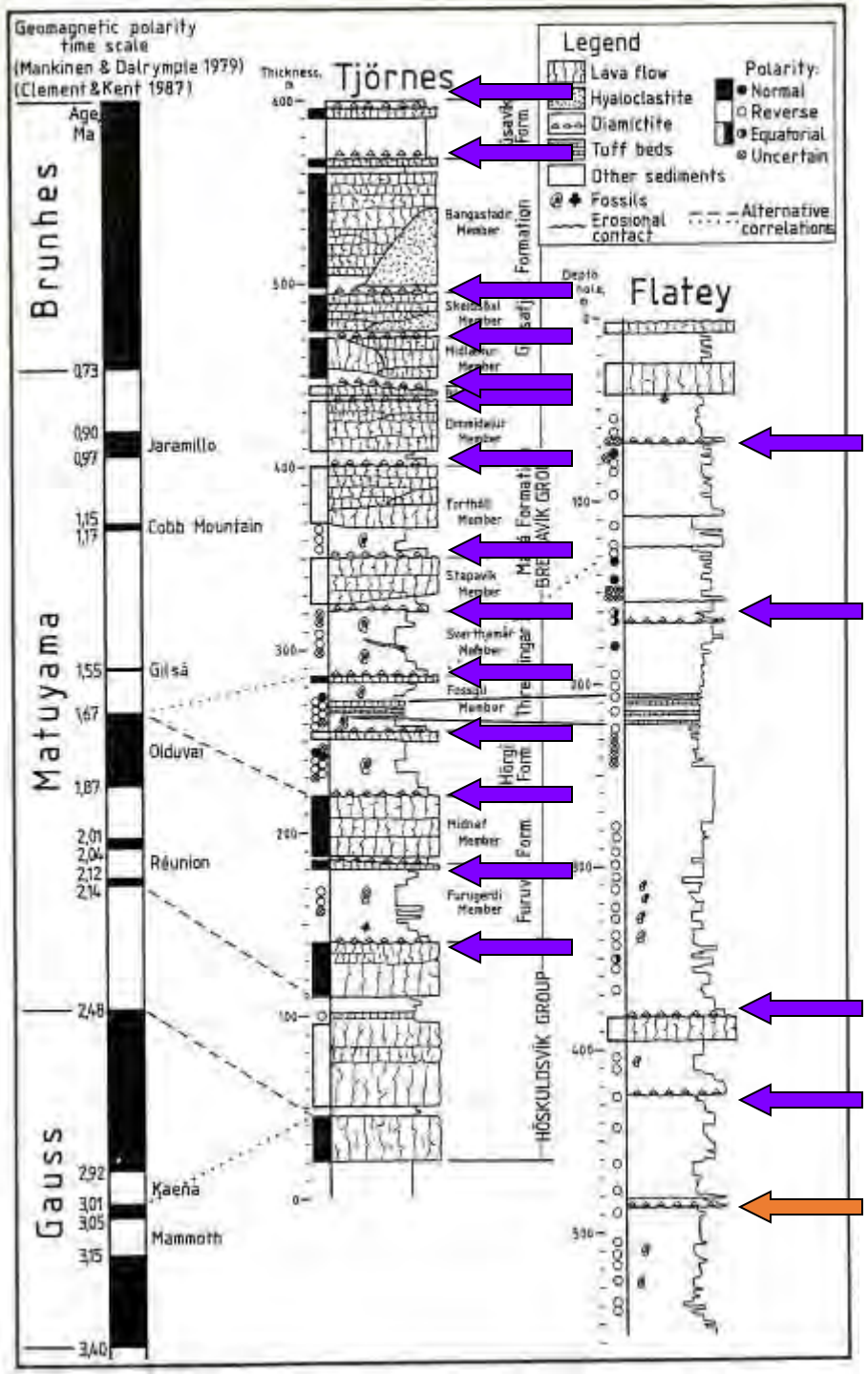
# Breiðavík deposits

# Breiðavík deposits

# Breiðavík deposits

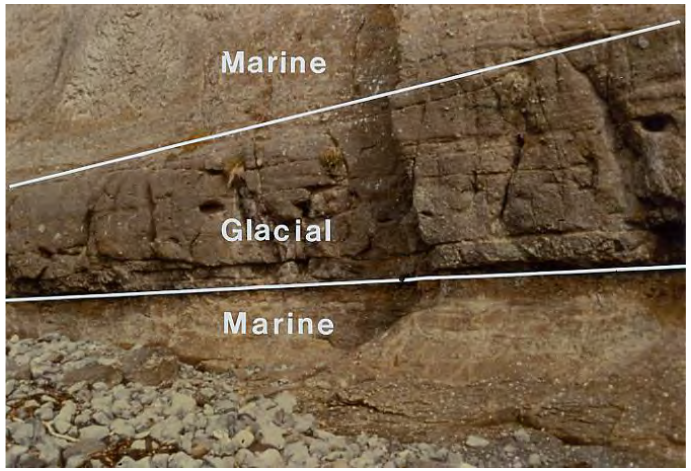
# Breiðavík deposits

# Tjörnes — Flatey




In all, 14 tillites have been recognized in the Tjörnes strata. The oldest tillite is ca. 2,5 MY.

A core record from Flatey island, containing 5 tillites, can be correlated to the Tjörnes sequence



## Summary

(1) The Pliocene Tjörnes beds are divided in three biozones; the *Tapes* Zone (oldest), the *Mactra* Zone, and the *Serripes* Zone (youngest). The Tjörnes beds consist mainly of fossiliferous marine silt- and sandstones, but also contain several fossiliferous terrestrial beds. The marine faunas in the *Tapes* and *Mactra* Zones are mainly boreal, but during deposition of the *Serripes* Zone the fauna greatly diversified with an abrupt immigration of Pacific molluscan species with more arctic elements.

# Summary

(2) The appearance of marine molluscs of Pacific ancestry in the North Atlantic took place at 3.6-4 Ma after migration through the Bering Strait coeval with closing of the Central American Seaway. North Pacific molluscs in the *Tapes* and *Mactra* Zones also post-date the first opening of the Bering Strait at 5.5–4.8 Ma and reached northern Iceland during the initial phases of the interchange.



Fig. 16. An idealized Breidavík Group cycle interpreted in terms of climate. Legend, see Fig. 6.

# Summary

(3) In Breiðavík, diamictite beds alternate with volcaniclastic mudrocks and sandstones, and basaltic lava flows. Fourteen lithological cycles are identified, each one starting with a diamictite interpreted as lodgement tillite and ending with terrestrial sediments and lava flows. Interbedded marine fossiliferous mudrocks and sandstones contain arctic to boreal faunal assemblages. The oldest cycle in the Breiðavík Group was probably deposited about 2.5 Ma, just after the Gauss/Matuyama polarity reversal.