Late Neogene History of the Bird's Head Area, West Papua, Indonesia: An Insight From Detrital Zircon*

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Abstract

This study presents a review of new results from the Upper Neogene Formation and no research has been carried out concerning its zircon geochronolgy prior to this project. Late Neogene sedimentation in the Bird's Head was characterized by siliciclastic deposition that followed the widespread Early Neogene of the New Guinea Limestone Group. These siliciclastic rocks include the Klasafet, Steenkool, Klasaman Formations, and newly defined Konjah Formation. They are underlain by an extensive carbonate platform, the Kais Formation. In the Bird's Head the important sedimentological change from carbonate to siliciclastic deposition occurred in the Middle to Late Miocene when the Kais Formation was conformably overlain by the Klasafet Formation. For the Phanerozoic zircons, there are three important age group; Pliocene (ca. 3 to 5 Ma), Miocene (ca. 12 to 20 Ma), and Permian–Triassic (ca. 205 to 275 Ma). The most abundant group is Pliocene, found only in the Konjah Formation. In the Precambrian, there are three important group ages. These groups are Neoproterozoic (ca. 0.9 to 1.2 Ga), Mesoproterozoic (ca. 1.4 to 1.6 Ga), and Palaeoproterozoic (ca. 1.8 to 2.0 Ga). There is an increase in the abundance of detrital Precambrian zircons from the Middle Miocene to Lower Pliocene formations. The much larger proportion of Precambrian zircons compared to Phanerozoic zircons in the Klasafet and Steenkool Formations indicates a new older source was available, and the older zircons were not simply derived by reworking of older sedimentary rocks. It is suggested that this increase in abundance of Precambrian zircons marks unroofing of the northeast part of the Bird's Head, the Kemum High, during the deposition of the Upper Neogene siliciclastic rocks. This caused the Silurian–Devonian Kemum Formation and Upper Carboniferous to Triassic

granitic rocks to become available for erosion. There was a second phase of acid igneous activity during the Pliocene in the area which contributed material to the Middle Pliocene Formation. This activity is indicated by Lower to Middle Pliocene zircons found in the Konjah Formation and was never reported previously. All observations support the suggestions there is a Middle Pliocene unconformity in the Bird's Head that continues offshore to the Seram area. This unconformity is probably related to the Sorong Fault movement and predates Seram Trough development. The Konjah Formation was deposited above this unconformity in a fluvial setting.

Selected References

Hall, R., 2012, Late Jurassic–Cenozoic Reconstructions of the Indonesian Region and the Indian Ocean: Tectonophysics, v. 570–571, p. 1–41. doi.org/10.1016/j.tecto.2012.04.021

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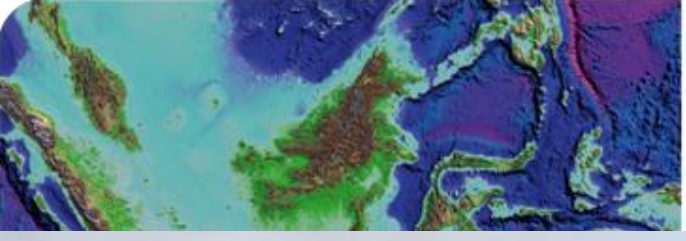

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Late Neogene history of the Bird's Head area, West Papua, Indonesia: an insight from detrital zircon

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AAPG ICE, Melbourne
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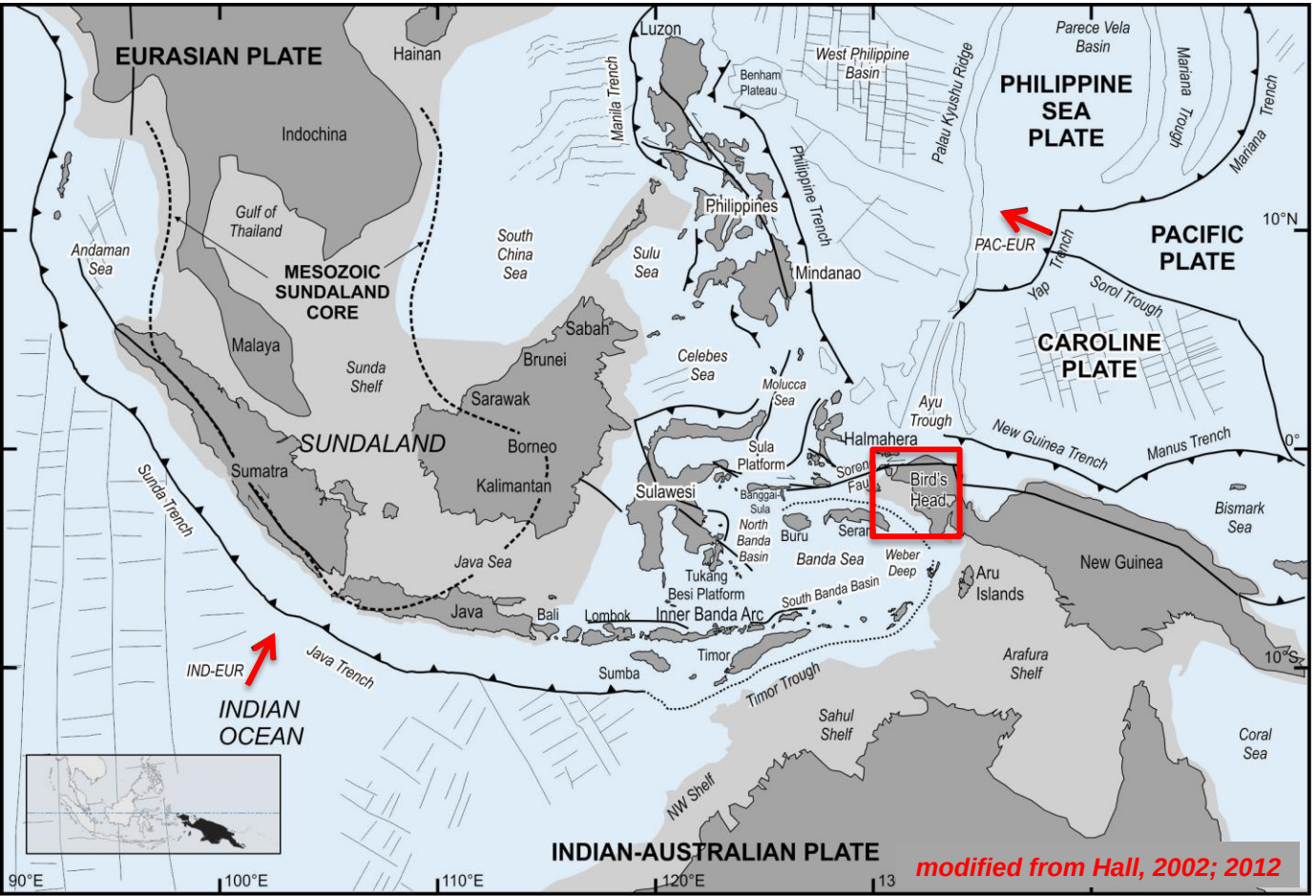
Talk Outline

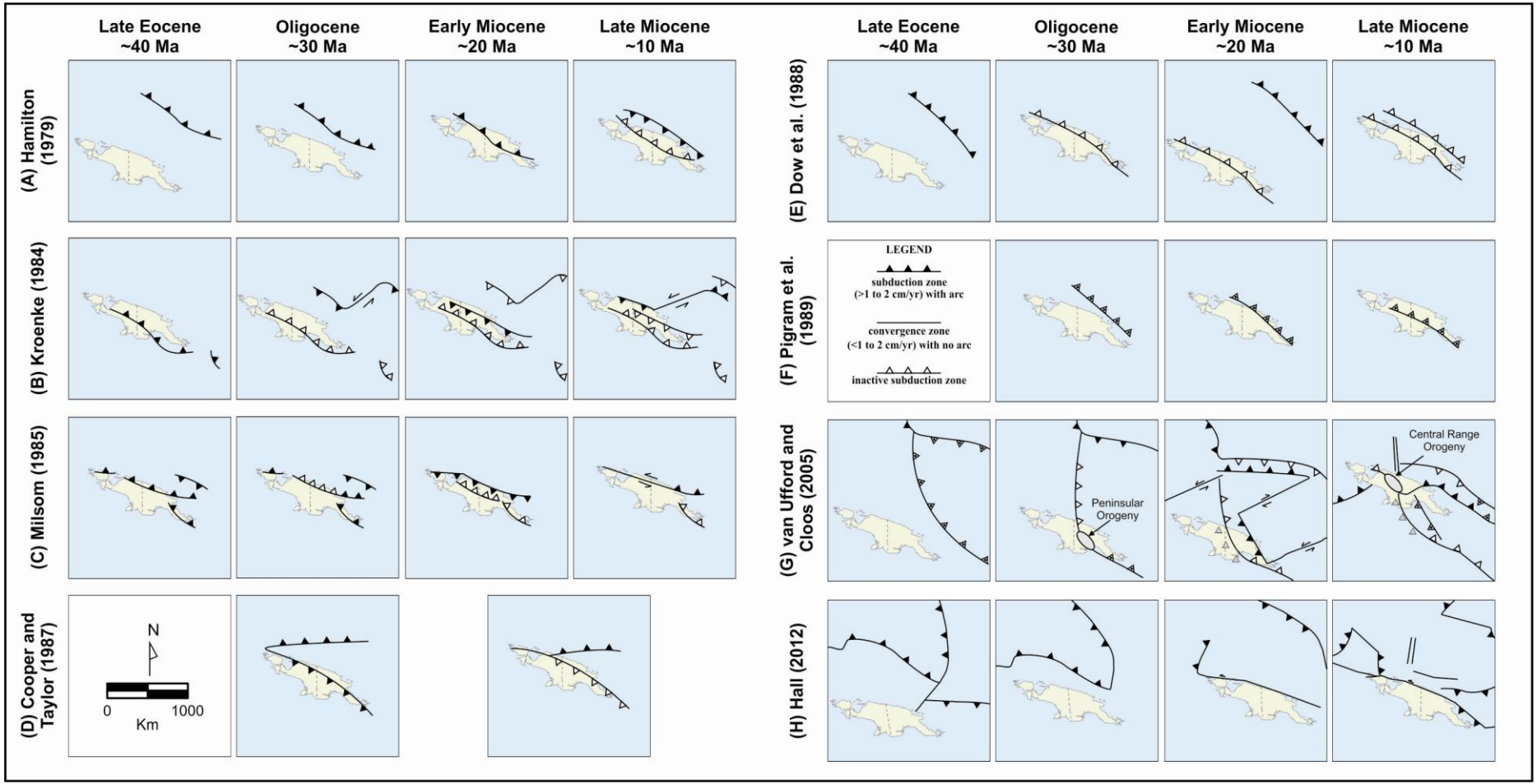
- Introduction
- Upper Cenozoic Stratigraphy
  - Zircon Geochronology
  - Regional Implication

Tectonic setting

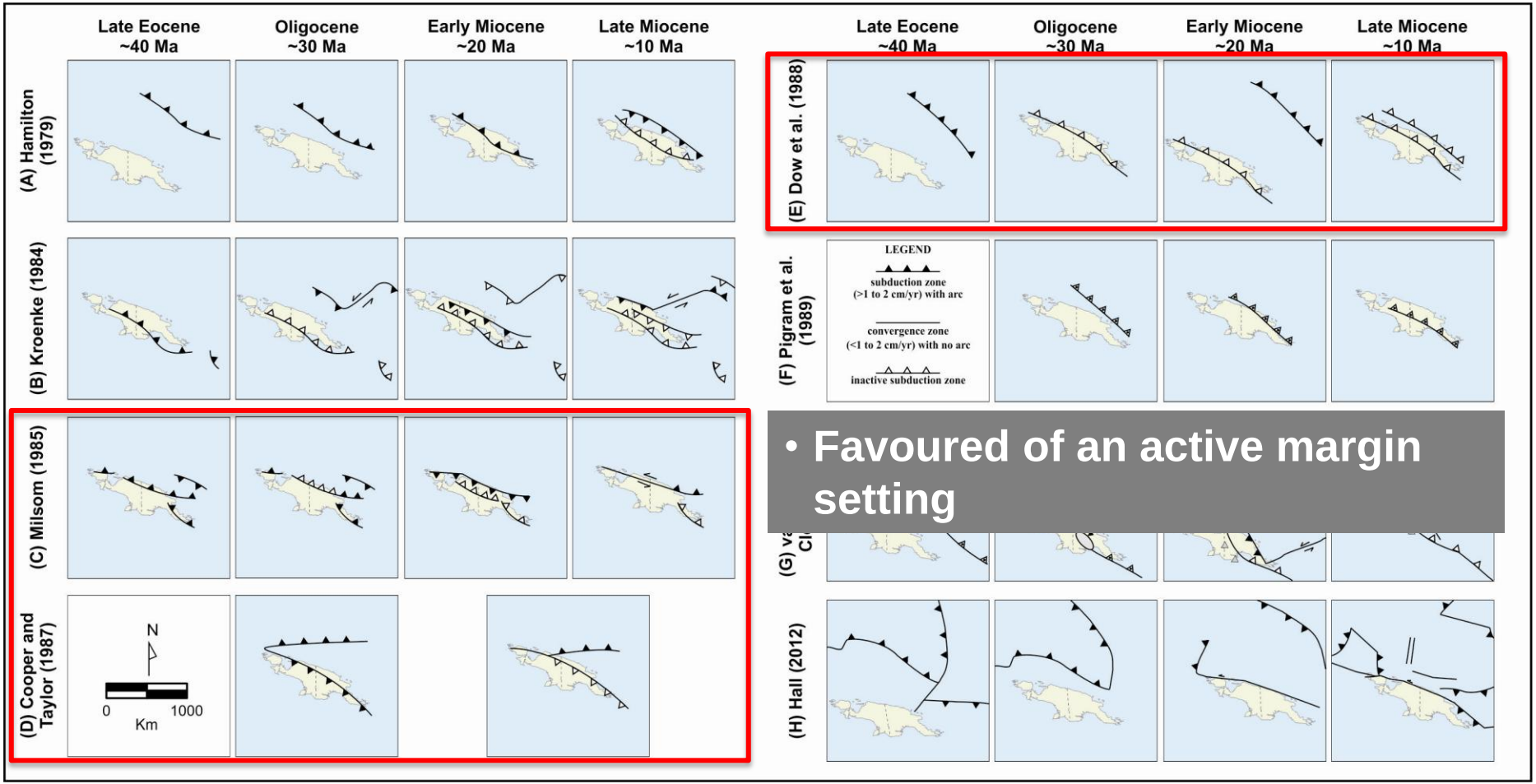


- **Surrounded by active or recently active zones**
- **Indian–Australian plate moving NNE**
- **Pacific Plate moving WNW**
- **Enigmatic Banda arc**
- **Cut by Sorong Fault**

Bird's Head Models

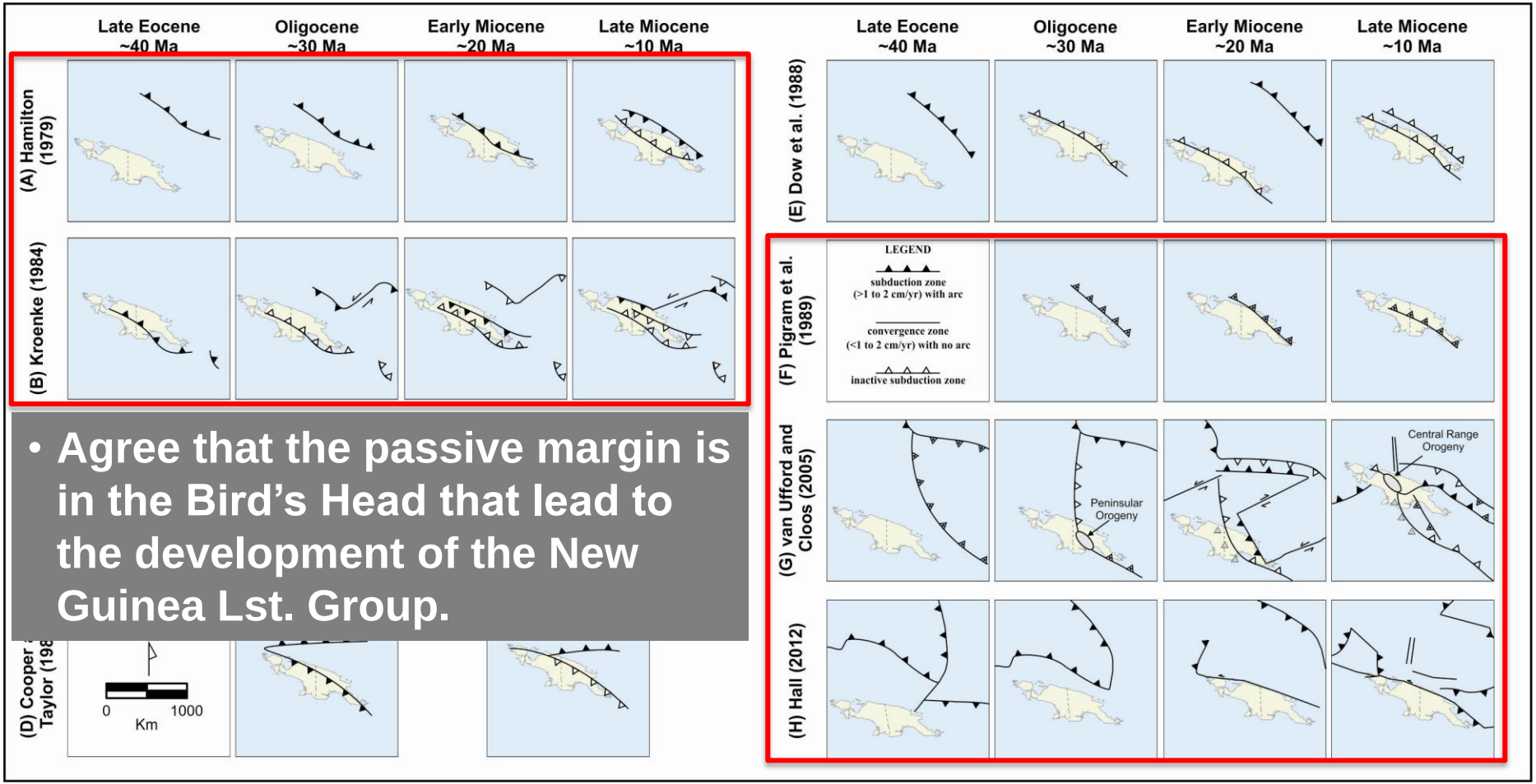


Bird's Head Models



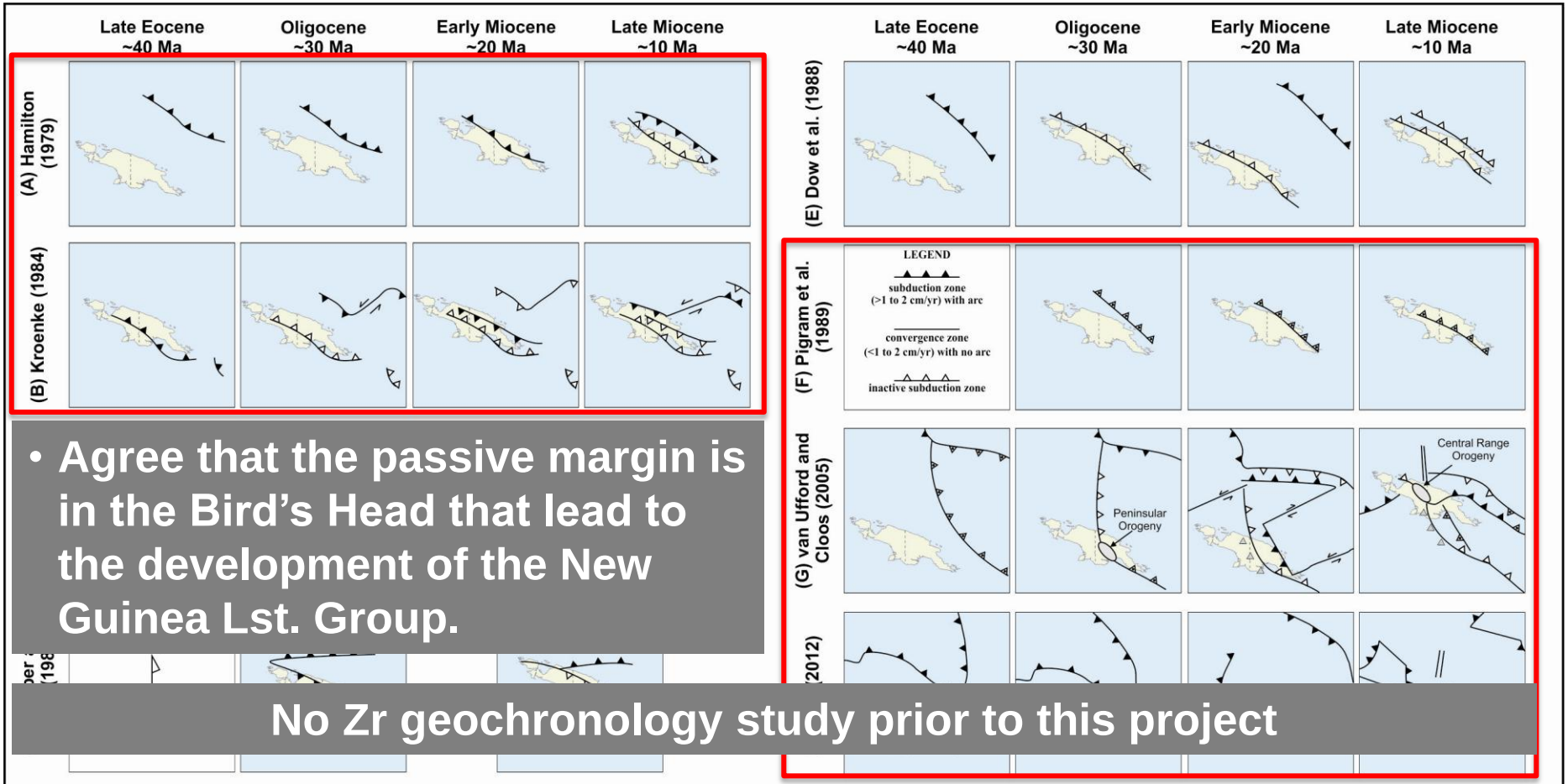
- **Favoured of an active margin setting**

Bird’s Head Models



- **Agree that the passive margin is in the Bird’s Head that lead to the development of the New Guinea Lst. Group.**

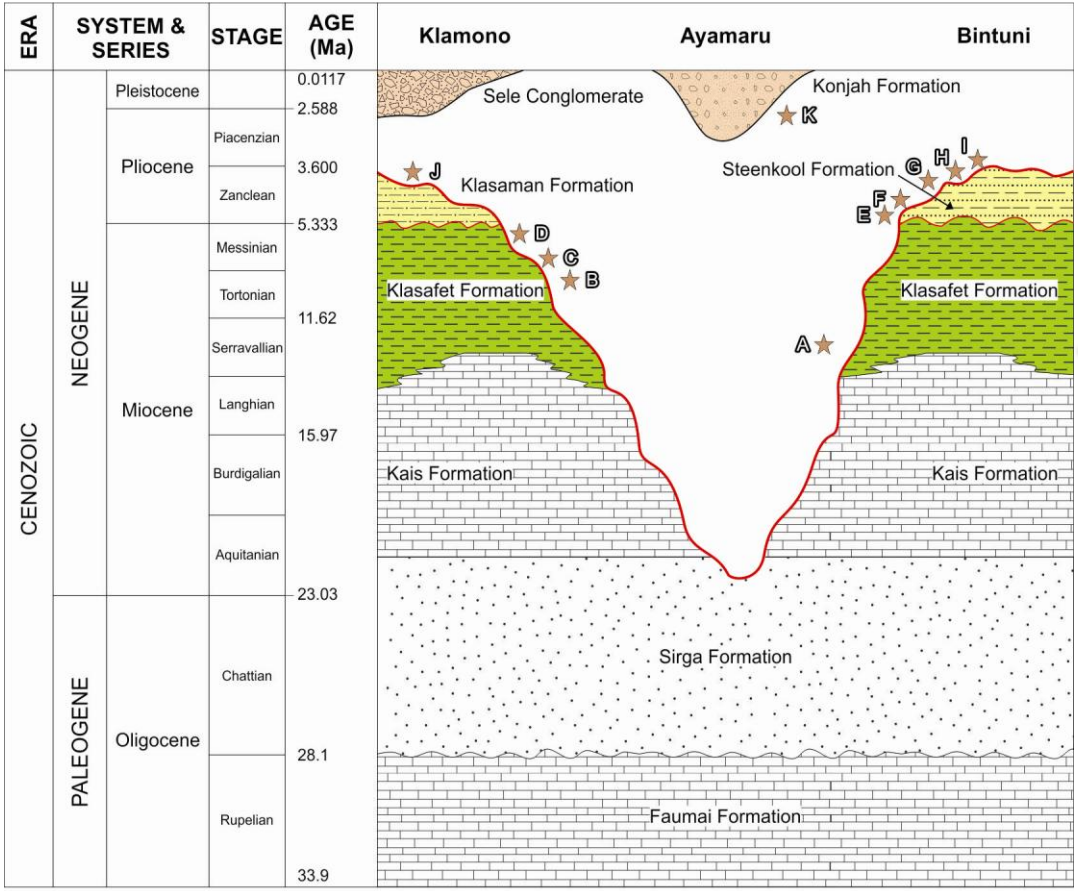
Bird’s Head Models



- **Agree that the passive margin is in the Bird’s Head that lead to the development of the New Guinea Lst. Group.**

No Zr geochronology study prior to this project

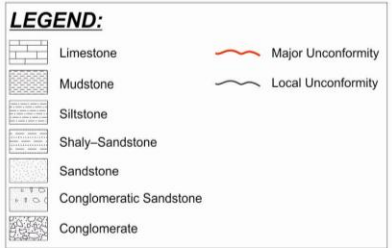
Late Cenozoic Stratigraphy

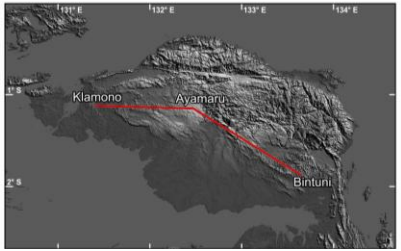


- **Miocene – Pleistocene siliciclastic sequence**

Miocene collision

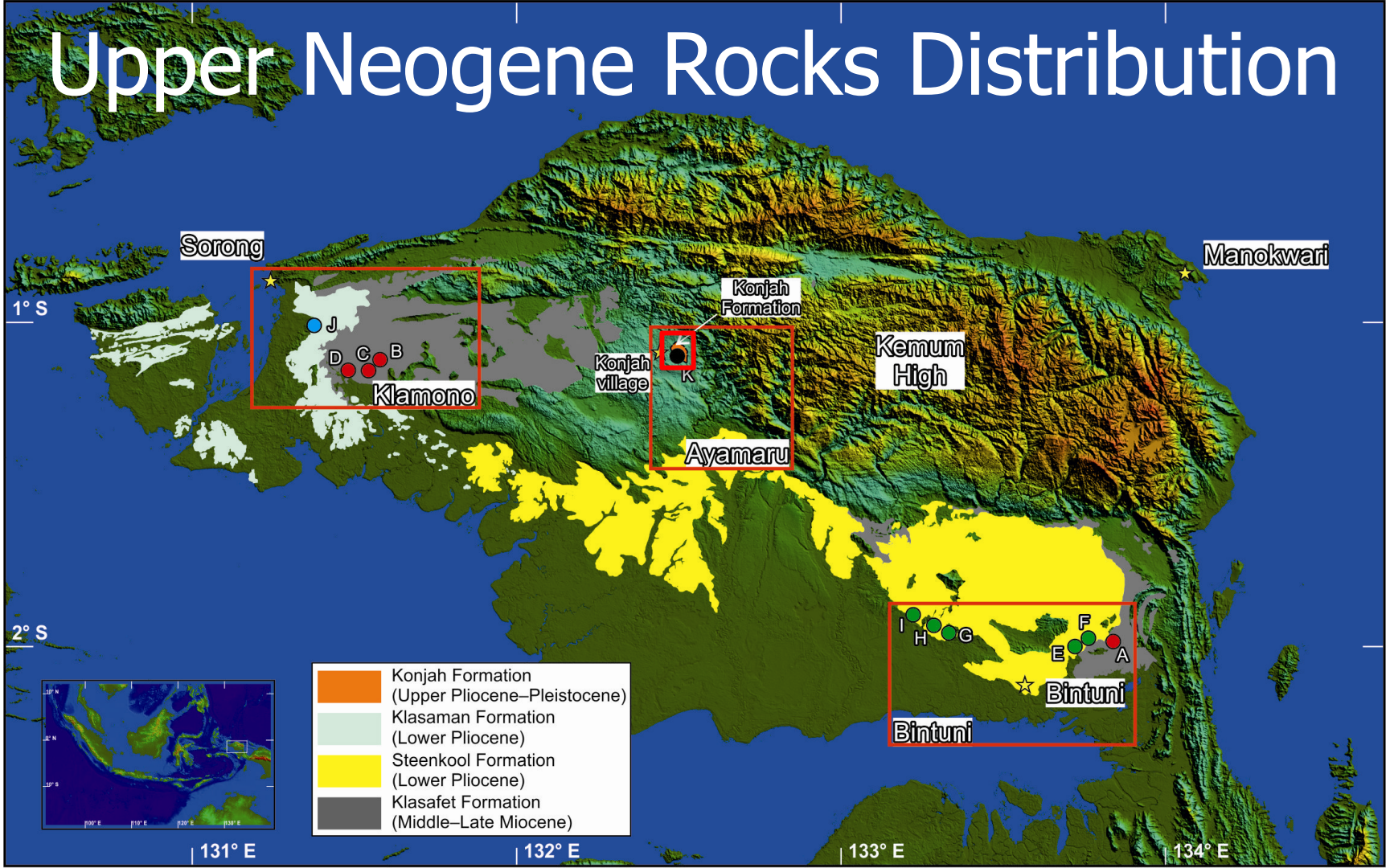
- **Extensive Miocene carbonate platform**



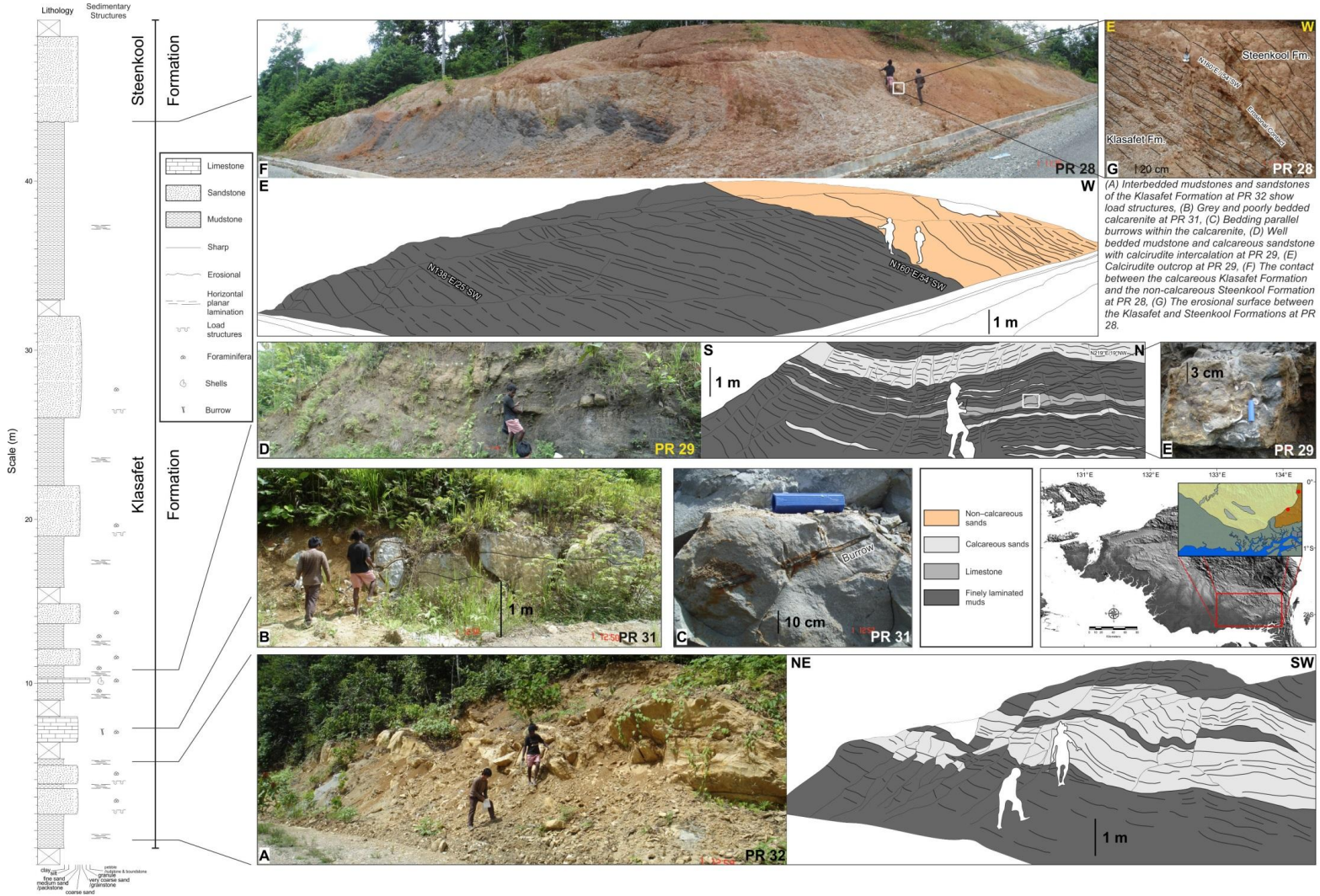


Simplified chronostratigraphic diagram of the Bird's Head area based on field observation

Upper Neogene Rocks Distribution



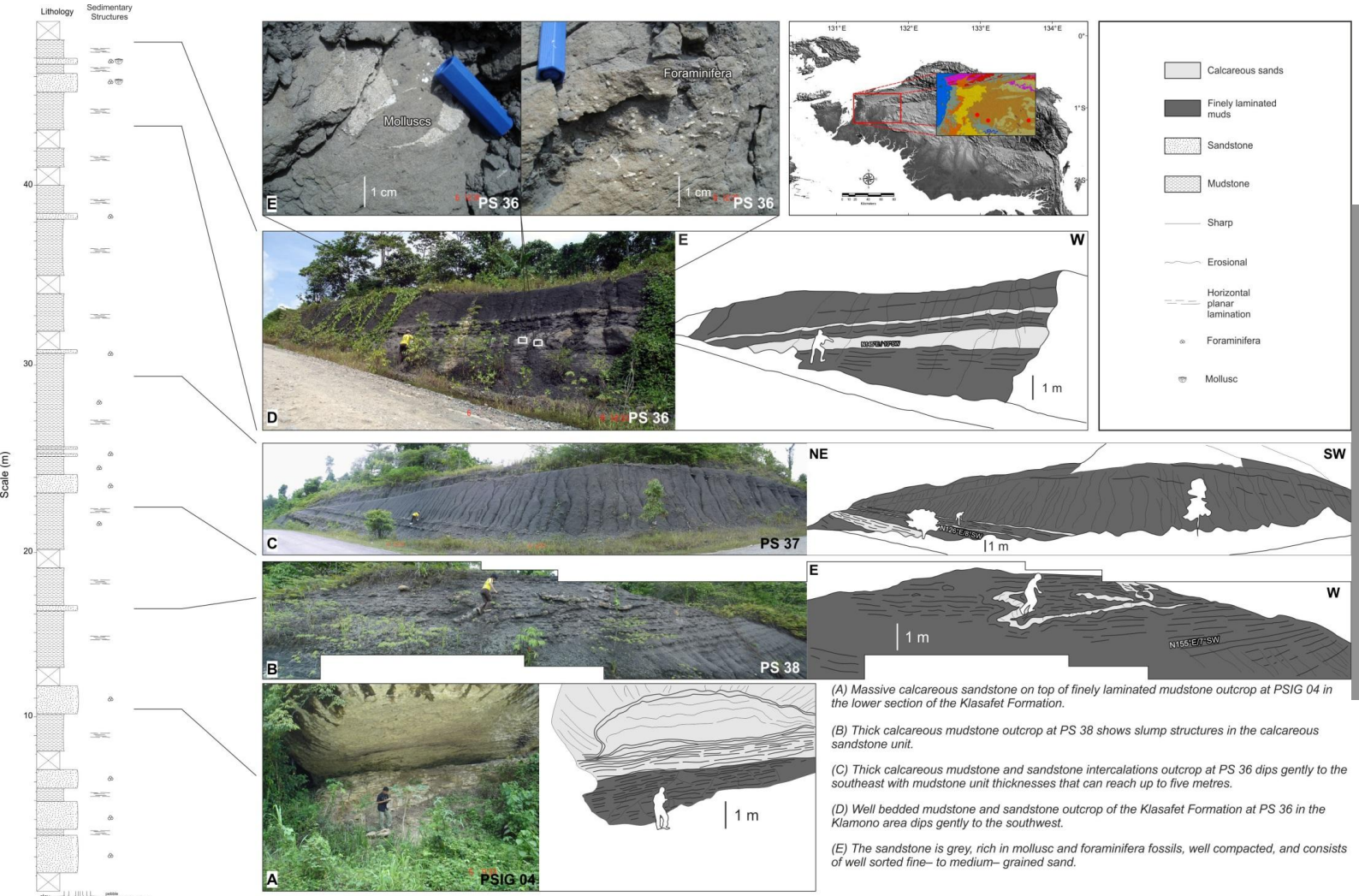
Klasafet Formation (east)



(A) Interbedded mudstones and sandstones of the Klasafet Formation at PR 32 show load structures, (B) Grey and poorly bedded calcarenite at PR 31, (C) Bedding parallel burrows within the calcarenite, (D) Well bedded mudstone and calcareous sandstone with calcirudite intercalation at PR 29, (E) Calcirudite outcrop at PR 29, (F) The contact between the calcareous Klasafet Formation and the non-calcareous Steenkool Formation at PR 28, (G) The erosional surface between the Klasafet and Steenkool Formations at PR 28.

- **characterised by interbedded sandstone and mudstone with locally intercalations of limestone).**

Klasafet Formation (west)



(A) Massive calcareous sandstone on top of finely laminated mudstone outcrop at PSIG 04 in the lower section of the Klasafet Formation.

(B) Thick calcareous mudstone outcrop at PS 38 shows slump structures in the calcareous sandstone unit.

(C) Thick calcareous mudstone and sandstone intercalations outcrop at PS 36 dips gently to the southeast with mudstone unit thicknesses that can reach up to five metres.

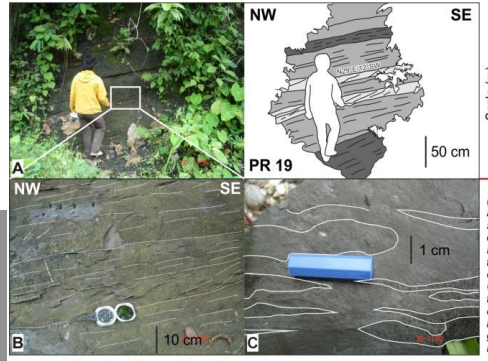
(D) Well bedded mudstone and sandstone outcrop of the Klasafet Formation at PS 36 in the Klamono area dips gently to the southwest.

(E) The sandstone is grey, rich in mollusc and foraminifera fossils, well compacted, and consists of well sorted fine– to medium– grained sand.

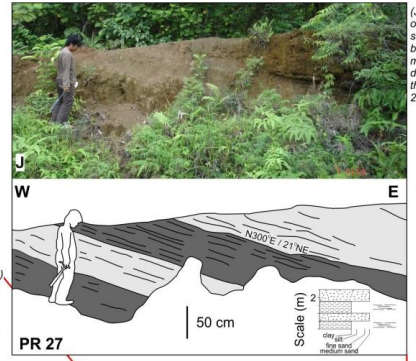
- **characterised by thick calcareous mudstone with locally intercalations of sandstone and limestone).**
- **shallow marine environment**

Steenkool Formation

- **The Steenkool Formation consists of interbedded carbonaceous siltstone and mudstone.**
- **shallow marine to deltaic environment**



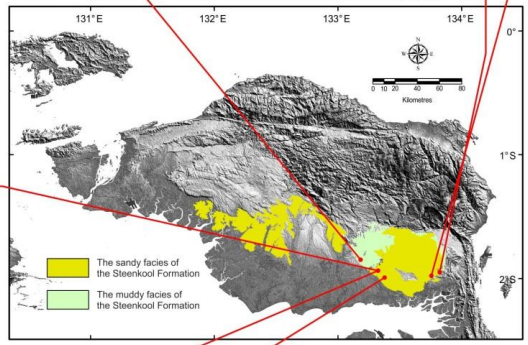
(A) Interbedded siltstone and mudstone with sandstone intercalations outcrop of the Steenkool Formation at PR 19 dips to the southwest and covered by vegetation, (B) Cross–stratification within the sandstone unit is common, (C) Sandstone lenses within the dark grey, carbonaceous, and micaceous siltstone.

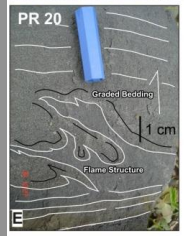


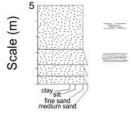
(J) Interbedded orange medium sandstone and brownish grey mudstone outcrop dips moderately to the northeast at PR 27.

(I) Slightly weathered brown to grey interbedded siltstone and mudstone outcrop dips moderately to the northwest at PR 26.

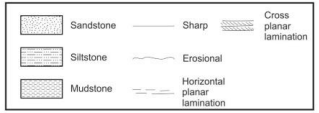
(H) The grey fine- to medium–grained sandstone at PR 23 shows planar horizontal– and cross–lamination.

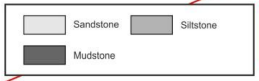


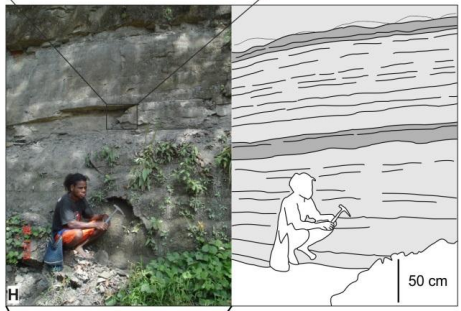


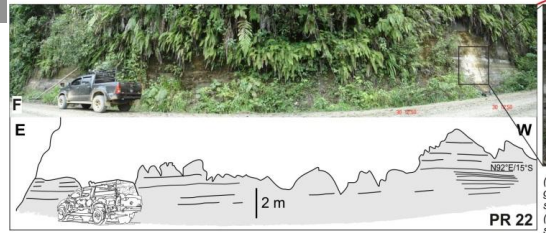


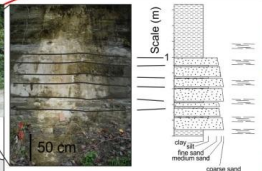
(D) Well laminated bedded sandstone outcrop of the Steenkool Formation sandy facies at PR 20.
(E) Graded bedding and flame structures within the sandstone facies at PR 20.



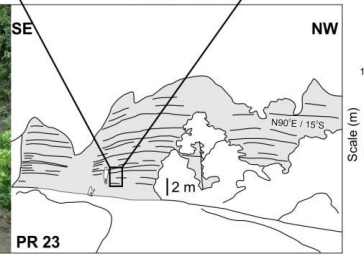


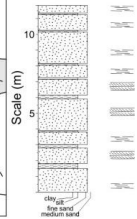




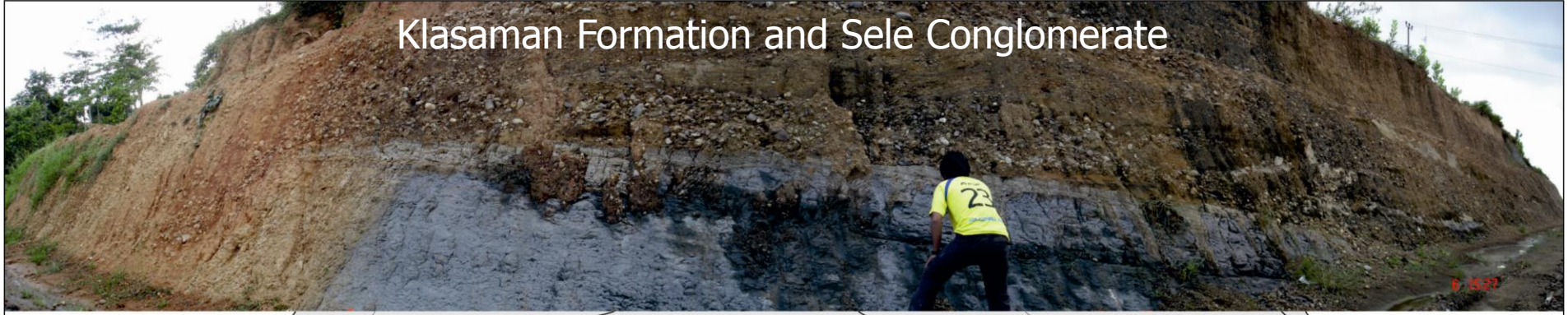


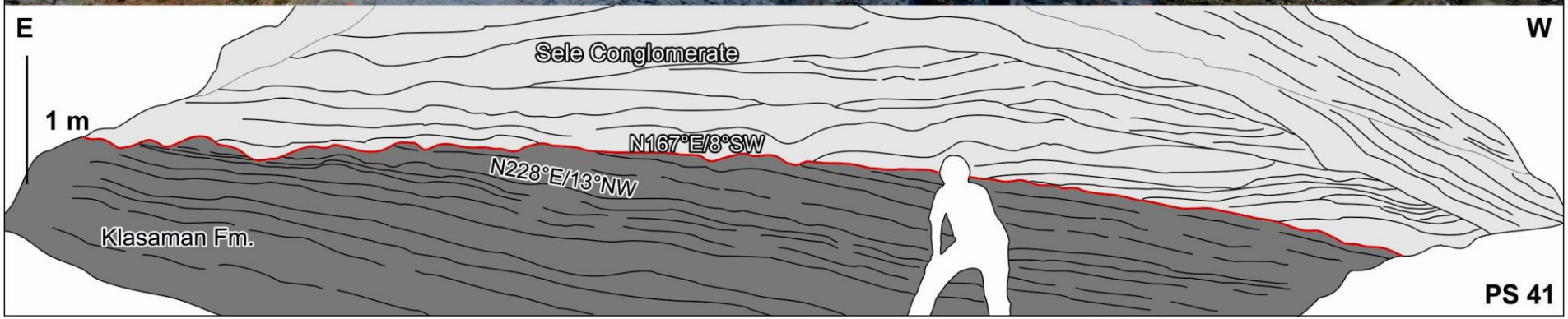
(F) Interbedded siltstone and medium– to coarse–grained sandstone at PR 22 shows a fining upward succession.
(G) Alternating siltstone and fine– to medium–sandstone outcrop at PR 23.

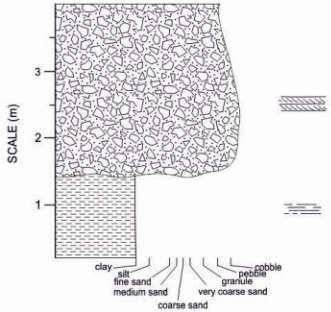


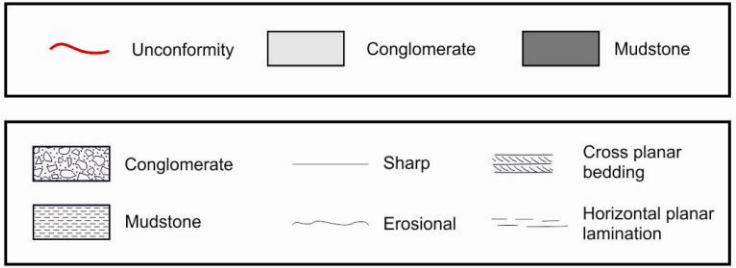


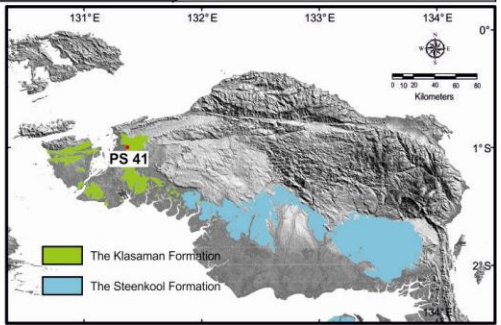
Klasaman Formation and Sele Conglomerate



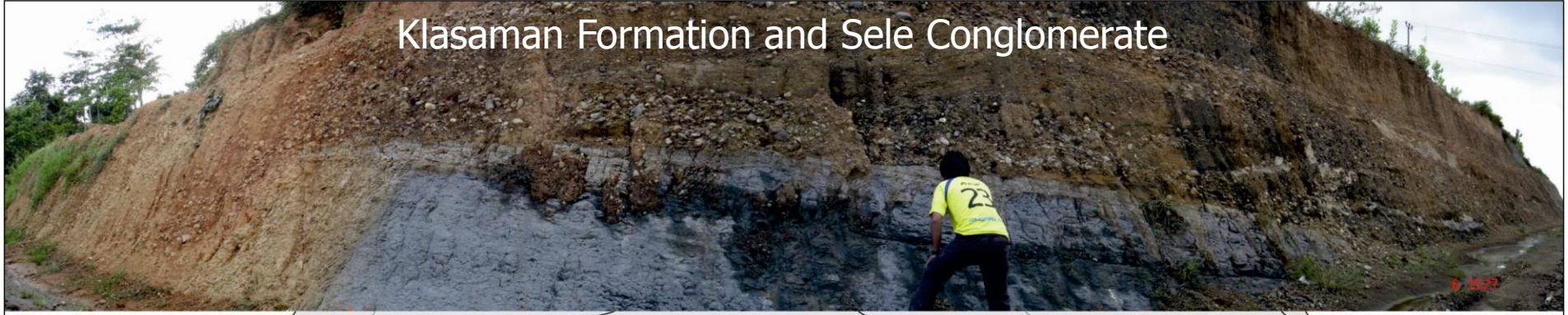


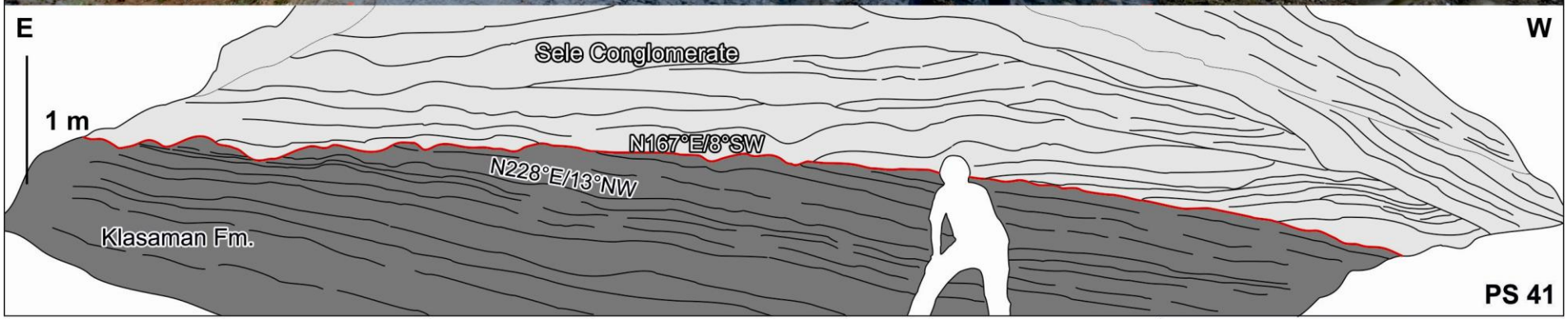


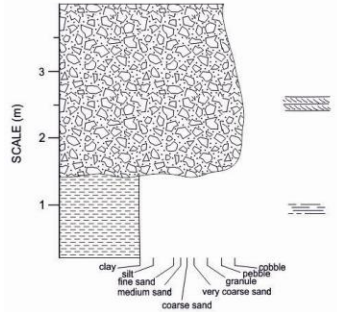


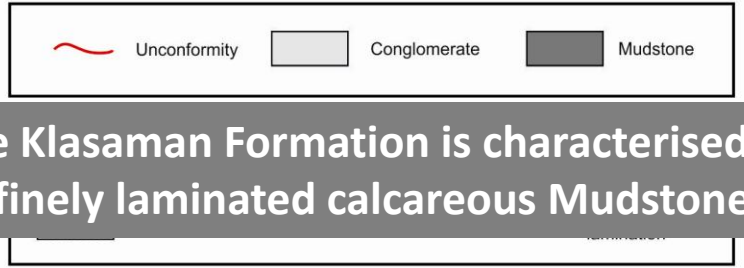


Klasaman Formation and Sele Conglomerate

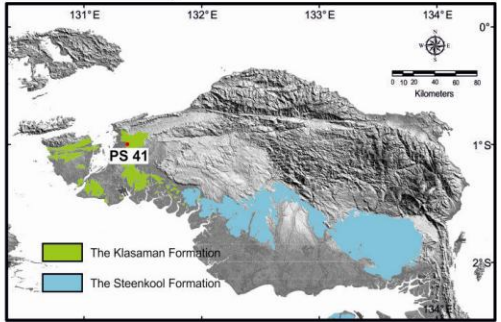




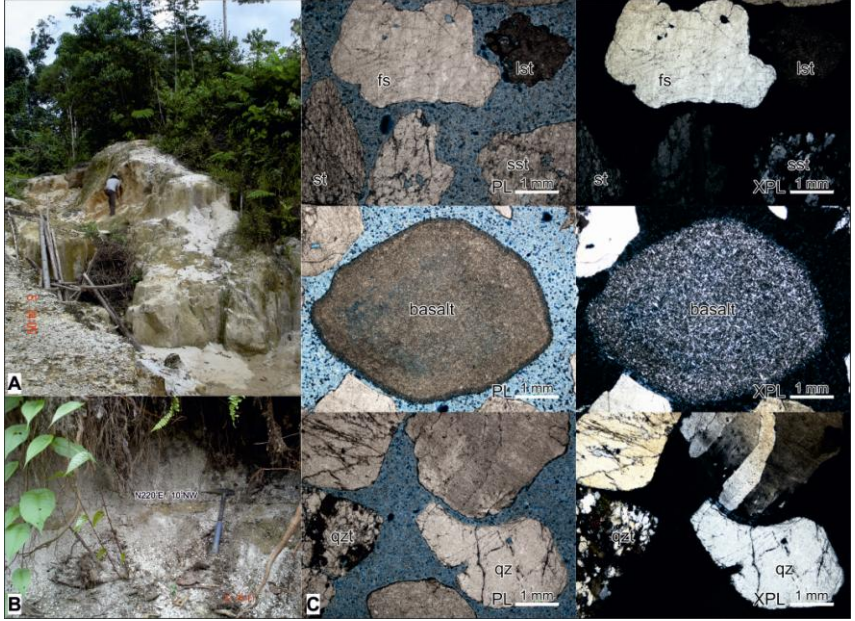




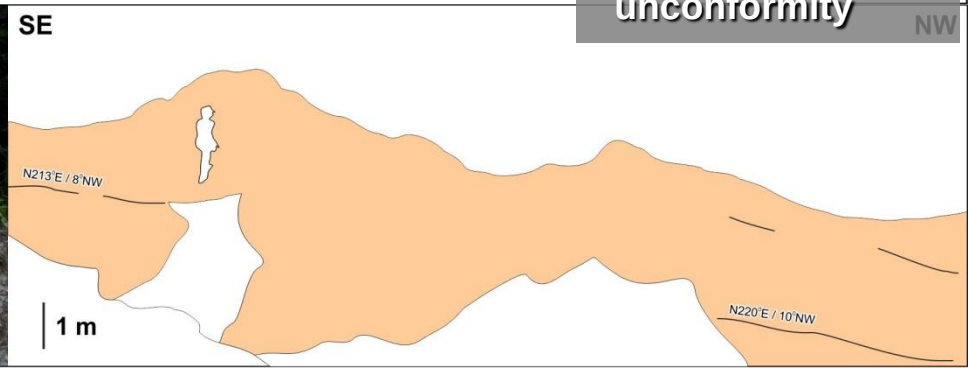
The Klasaman Formation is characterised by finely laminated calcareous Mudstone



Konjah Formation



- The Konjah Formation is newly defined and It was previously mapped as Sirga Formation by previous authors
- characterised by loose quartz rich sandstone
- Middle Pliocene unconformity



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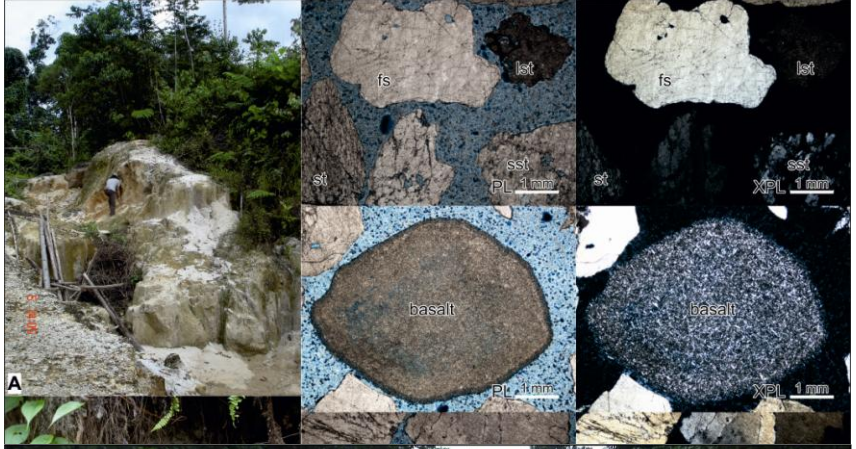

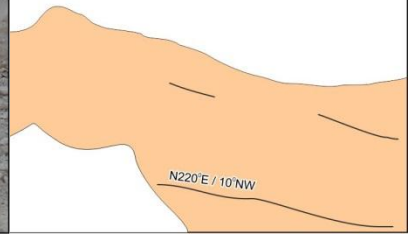

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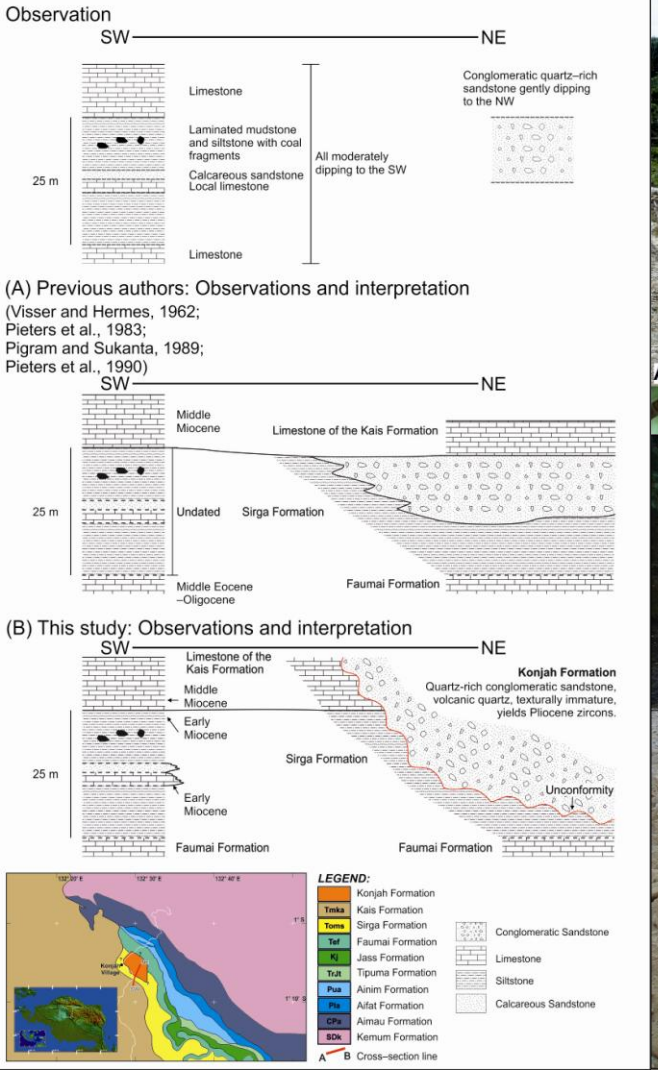

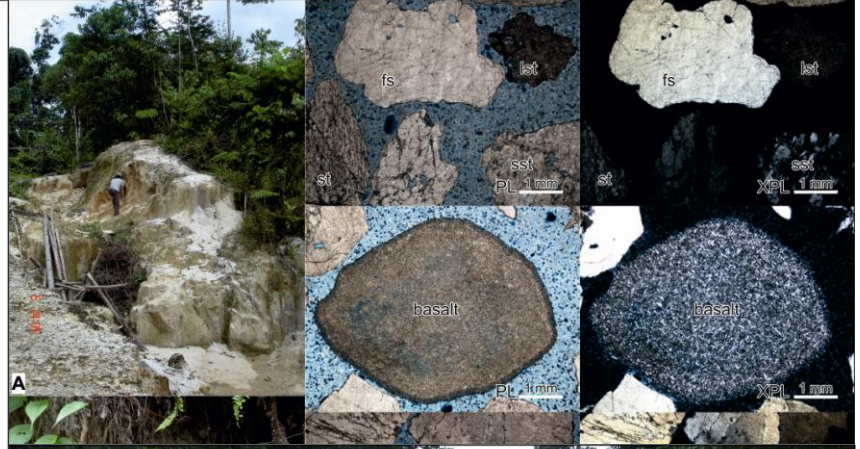

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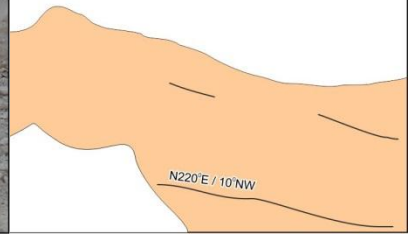
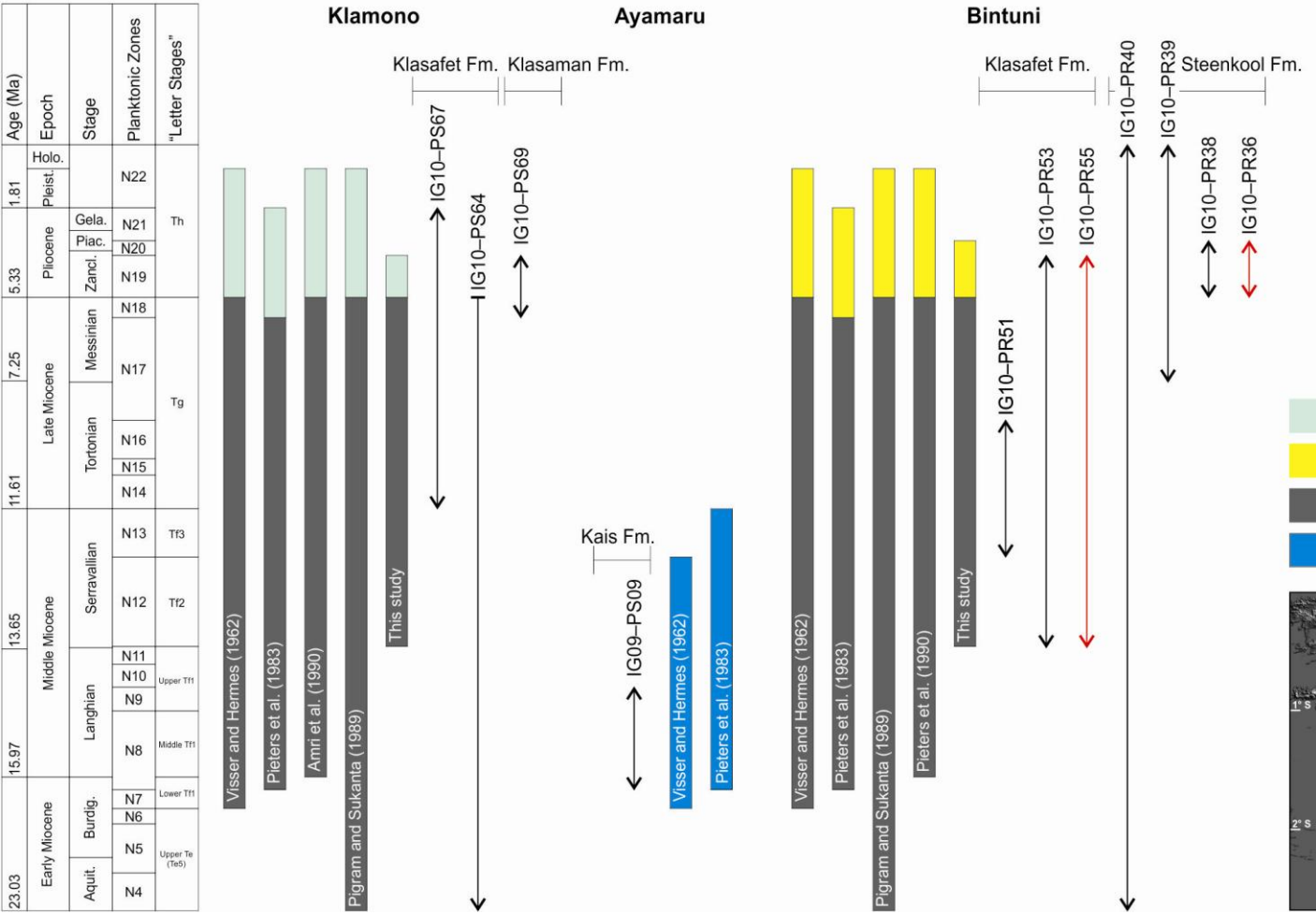
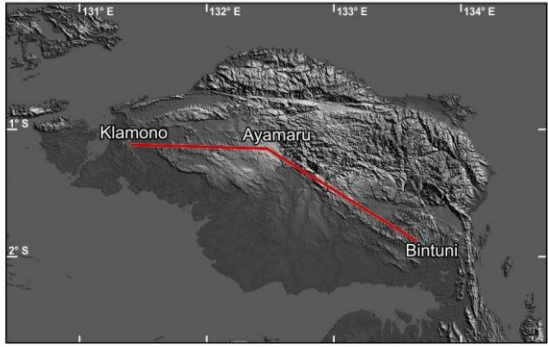


Upper Neogene Biostratigraphy

The depositional age of the Kais, Klasafet, Steenkool, and Klasaman Formations



Klasaman Formation
Steenkool Formation
Klasafet Formation
Kais Formation



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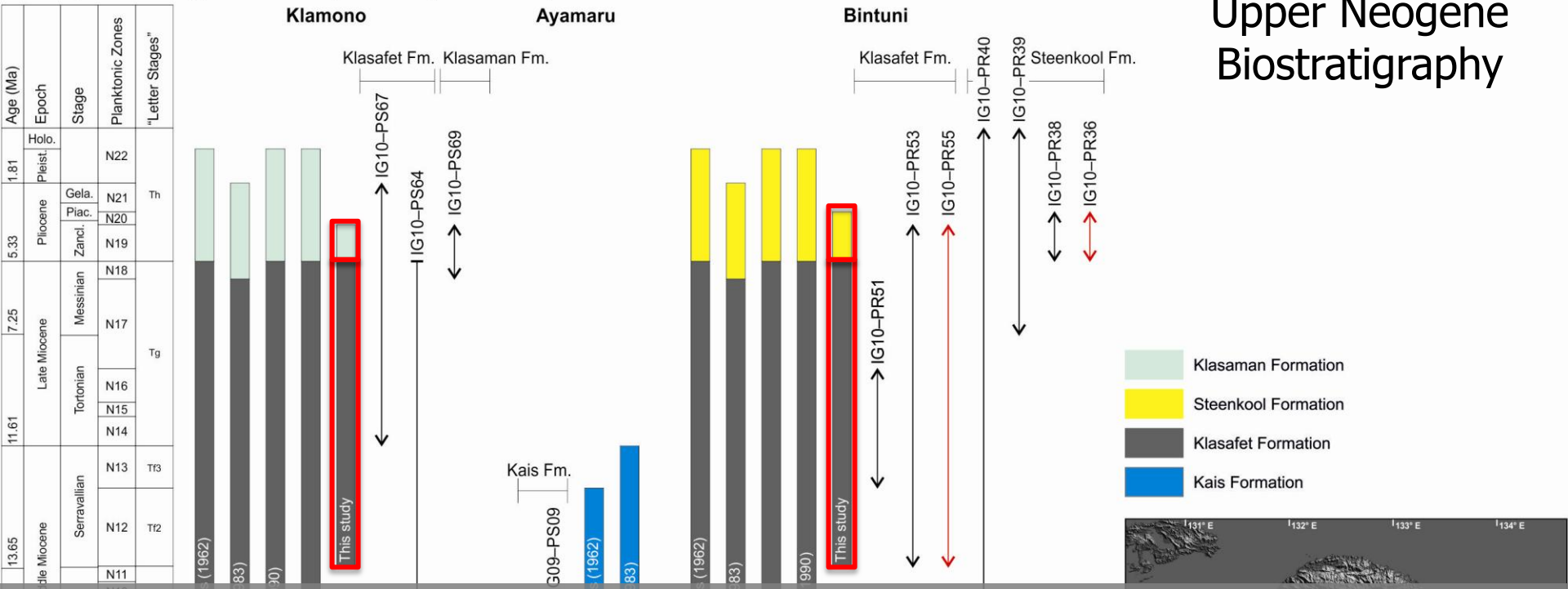
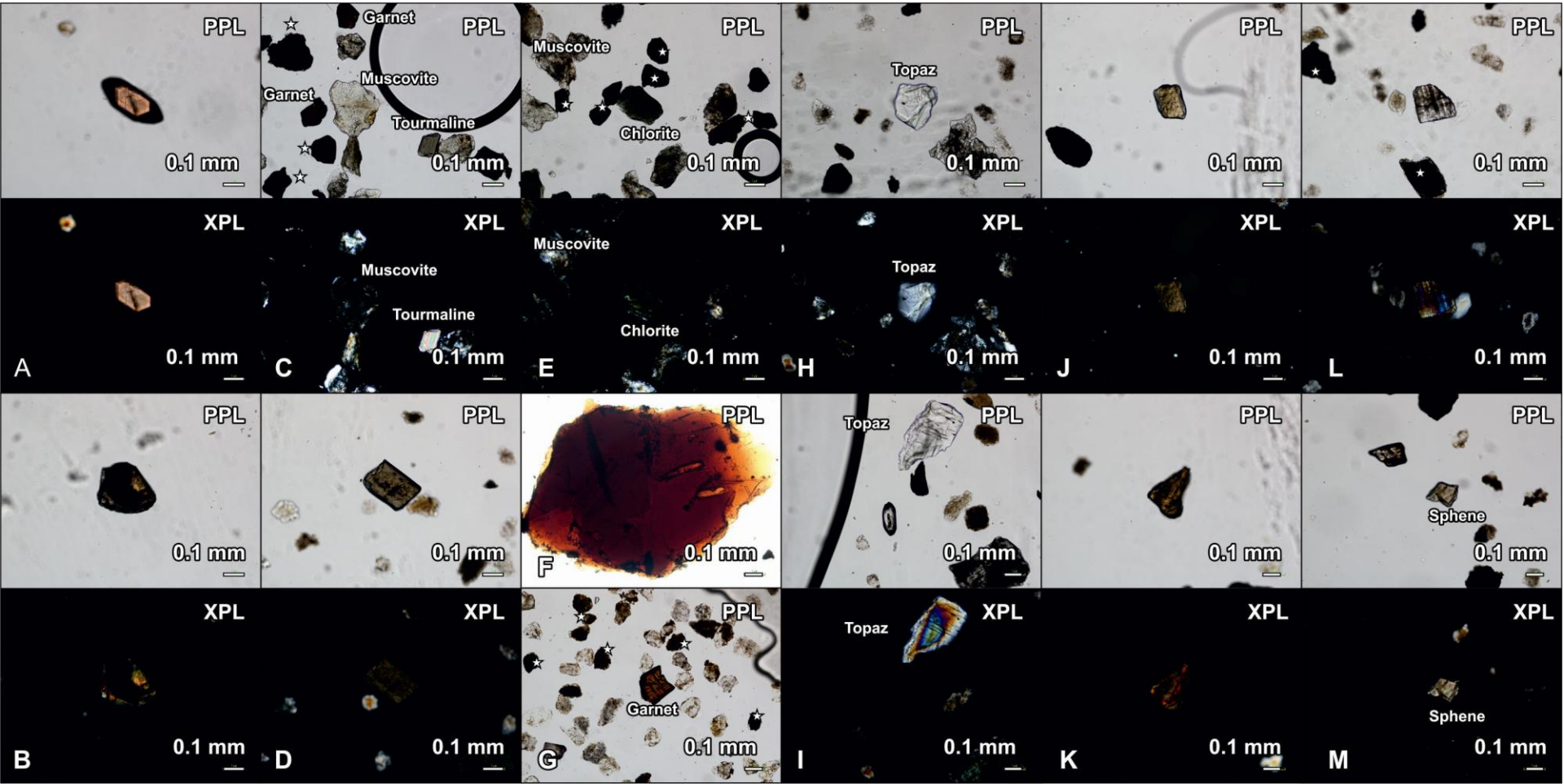


- The Klasafet Fm was deposited in shallow inner neritic environment during the Late Middle Miocene (Serravallian) to Late Miocene (Messinian)
- The lower part of the Klasafet Fm was deposited contemporaneous with the Kais Fm.
- The Steenkool and Klasaman Fms. has a narrow age bracket of Early Pliocene (Zanclean) and were deposited in shallow marine environment

Upper Neogene Rocks Heavy Mineral Characteristics



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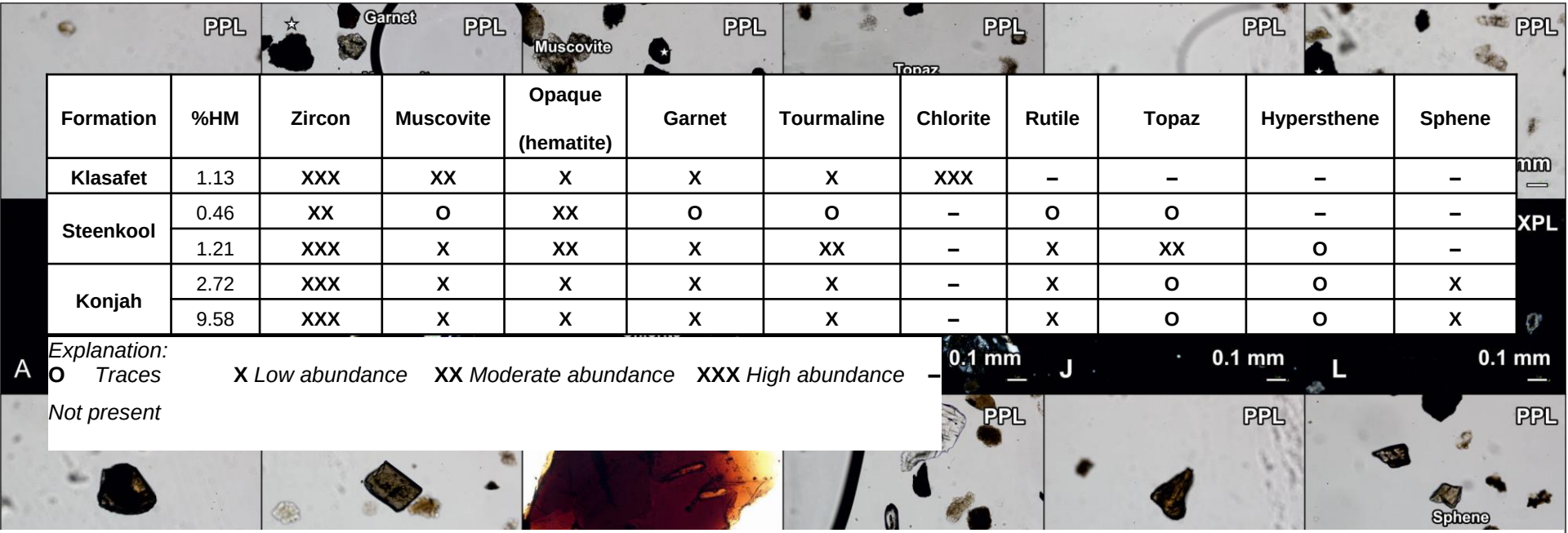
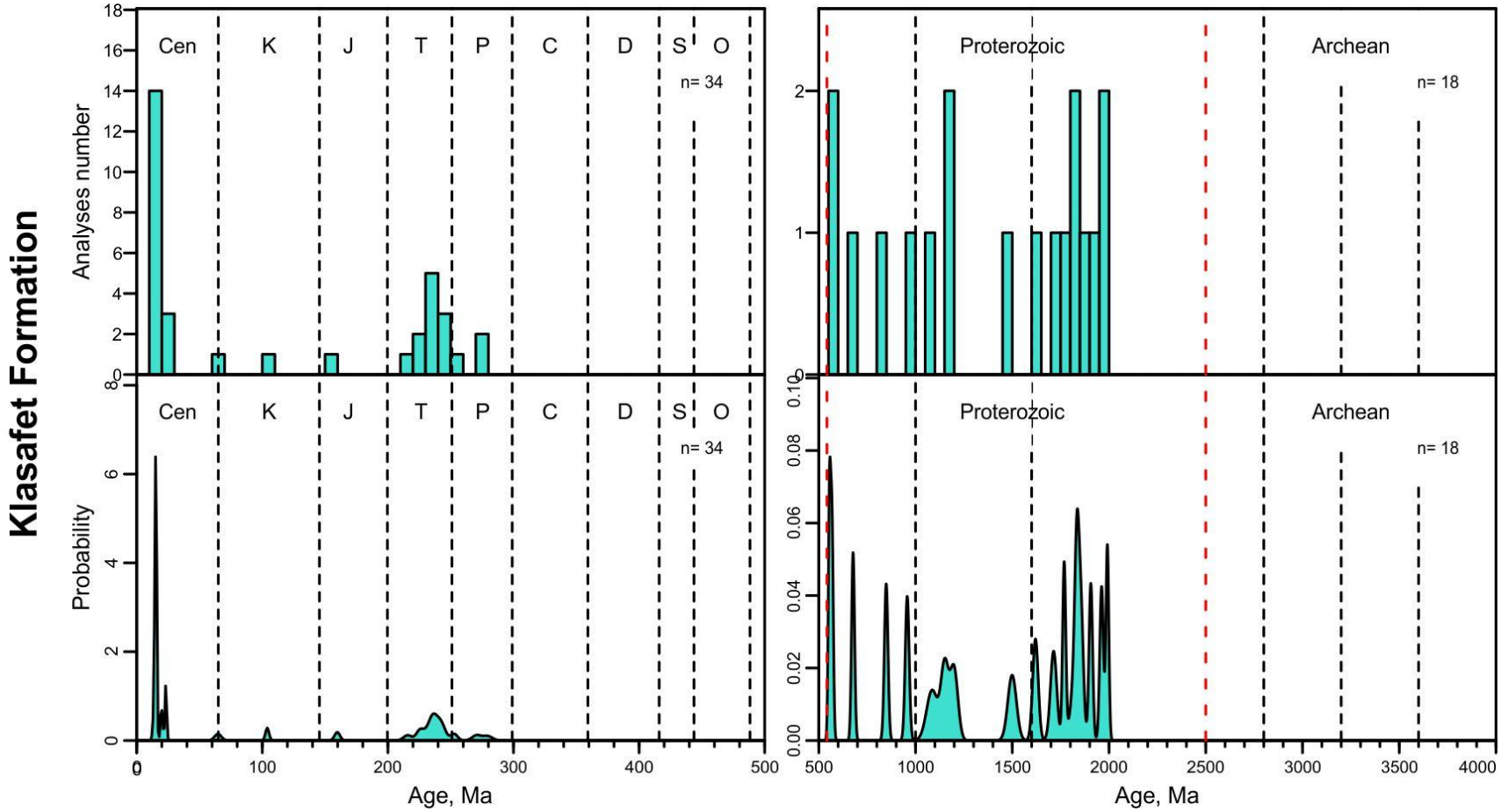


Formation	%HM	Zircon	Muscovite	Opaque (hematite)	Garnet	Tourmaline	Chlorite	Rutile	Topaz	Hypersthene	Sphene
Klasafet	1.13	XXX	XX	X	X	X	XXX	–	–	–	–
Steenkool	0.46	XX	O	XX	O	O	–	O	O	–	–
	1.21	XXX	X	XX	X	XX	–	X	XX	O	–
Konjah	2.72	XXX	X	X	X	X	–	X	O	O	X
	9.58	XXX	X	X	X	X	–	X	O	O	X

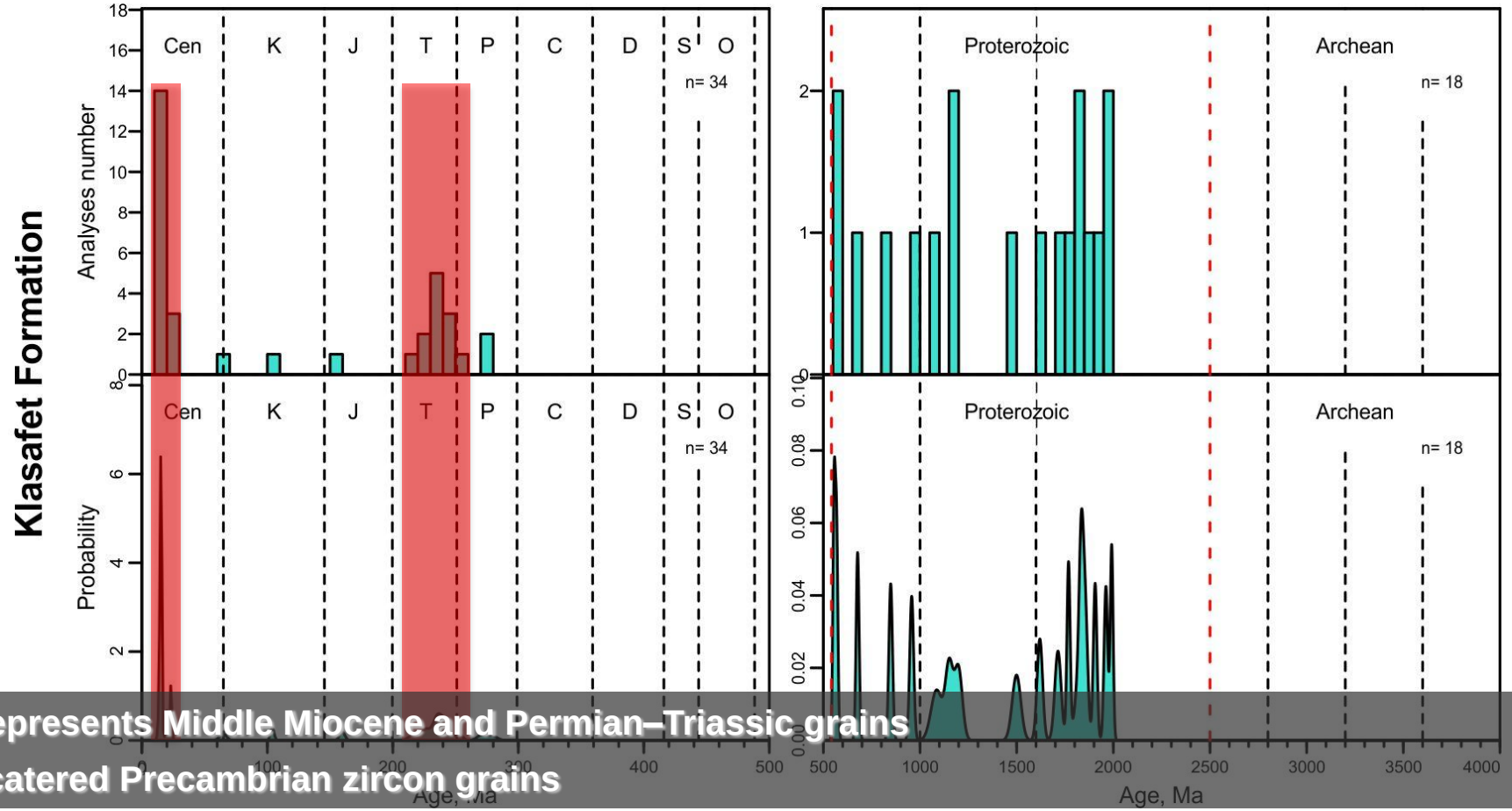
Explanation:
O *Traces* **X** *Low abundance* **XX** *Moderate abundance* **XXX** *High abundance* **–** *Not present*

- **In summary, the heavy minerals of the Late Neogene siliciclastic samples characterised by granitic and older sedimentary source rocks.**
- **The heavy minerals of the Klasafet Fm. were also derived from low-grade metamorphic rocks and Steenkool and Konjah Formations were sourced from, basic to intermediate igneous rocks.**
- **No known arc-continental collision association**

Zircon Geochronology

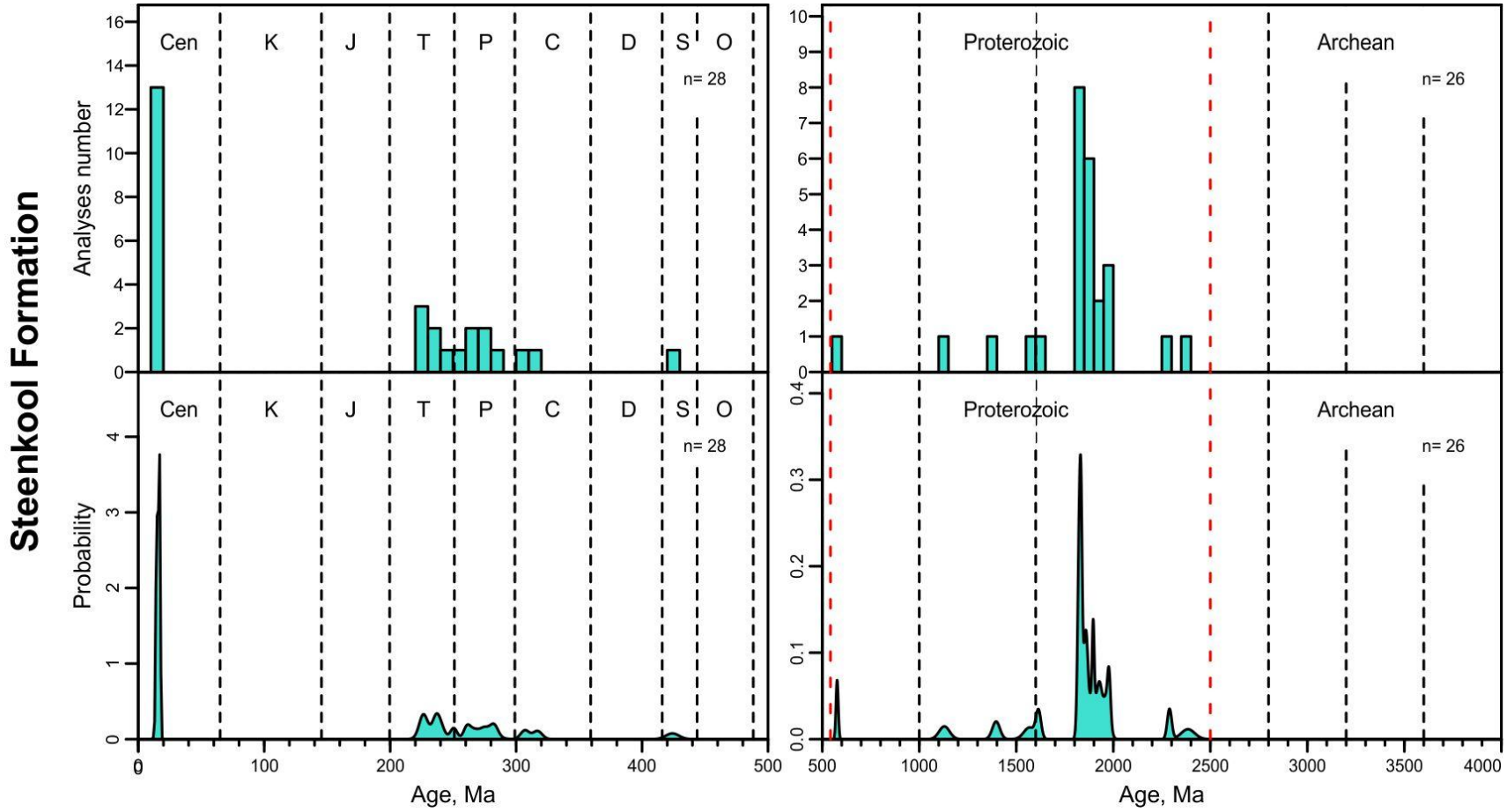


Zircon Geochronology

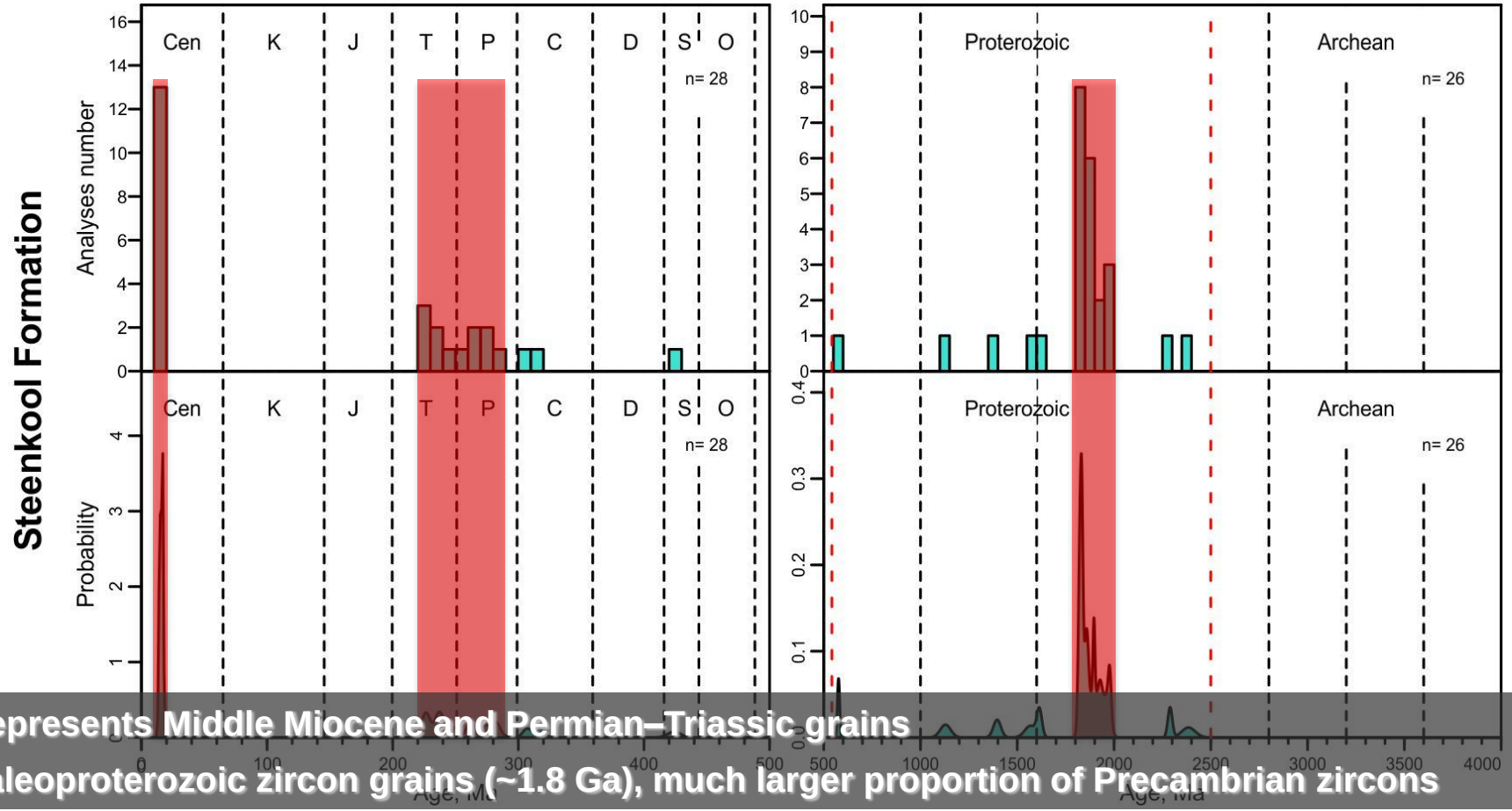


- Represents Middle Miocene and Permian–Triassic grains
- Scatered Precambrian zircon grains

Zircon Geochronology

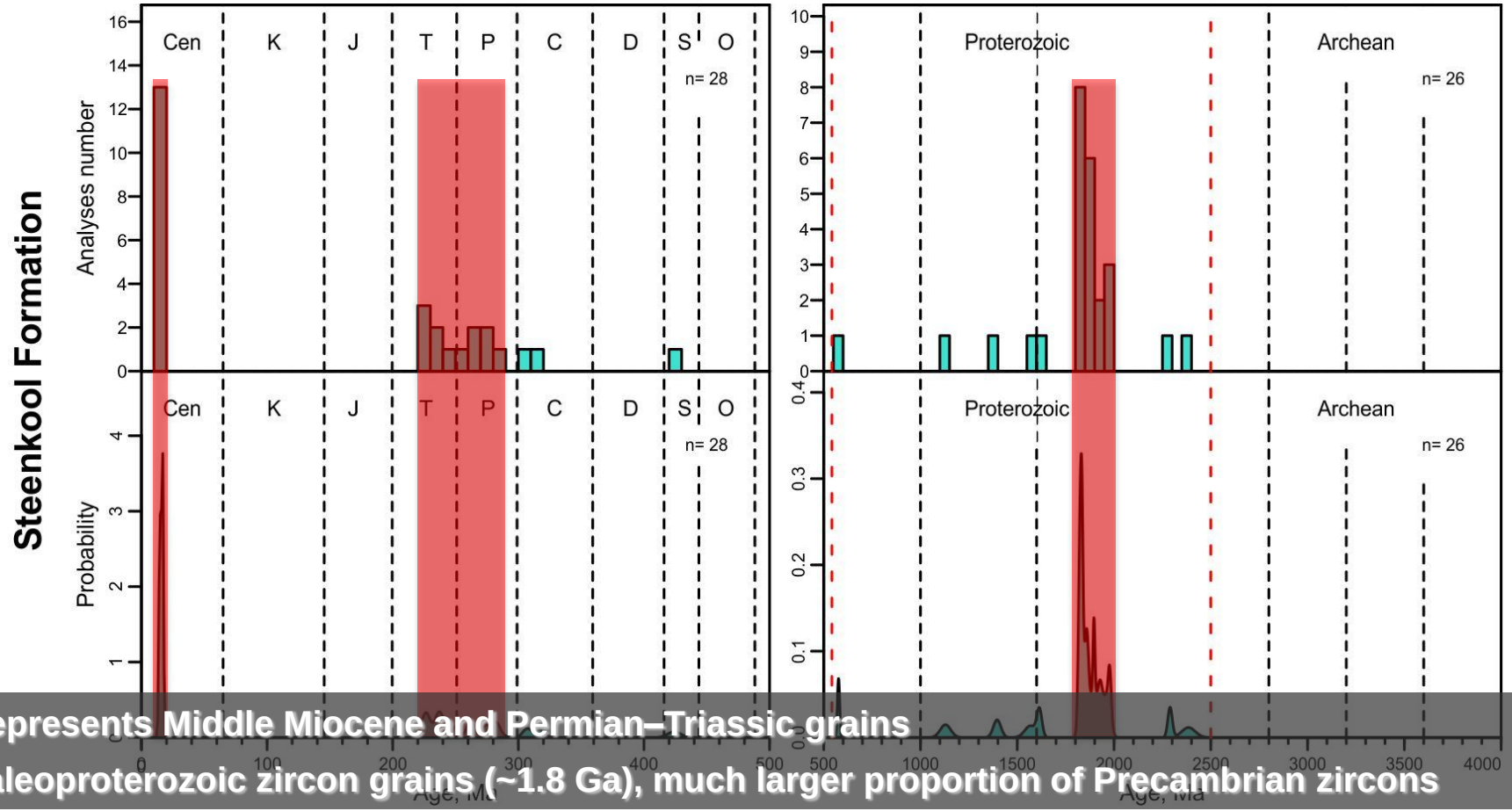


Zircon Geochronology



- Represents Middle Miocene and Permian–Triassic grains
- Paleoproterozoic zircon grains (~1.8 Ga), much larger proportion of Precambrian zircons

Zircon Geochronology



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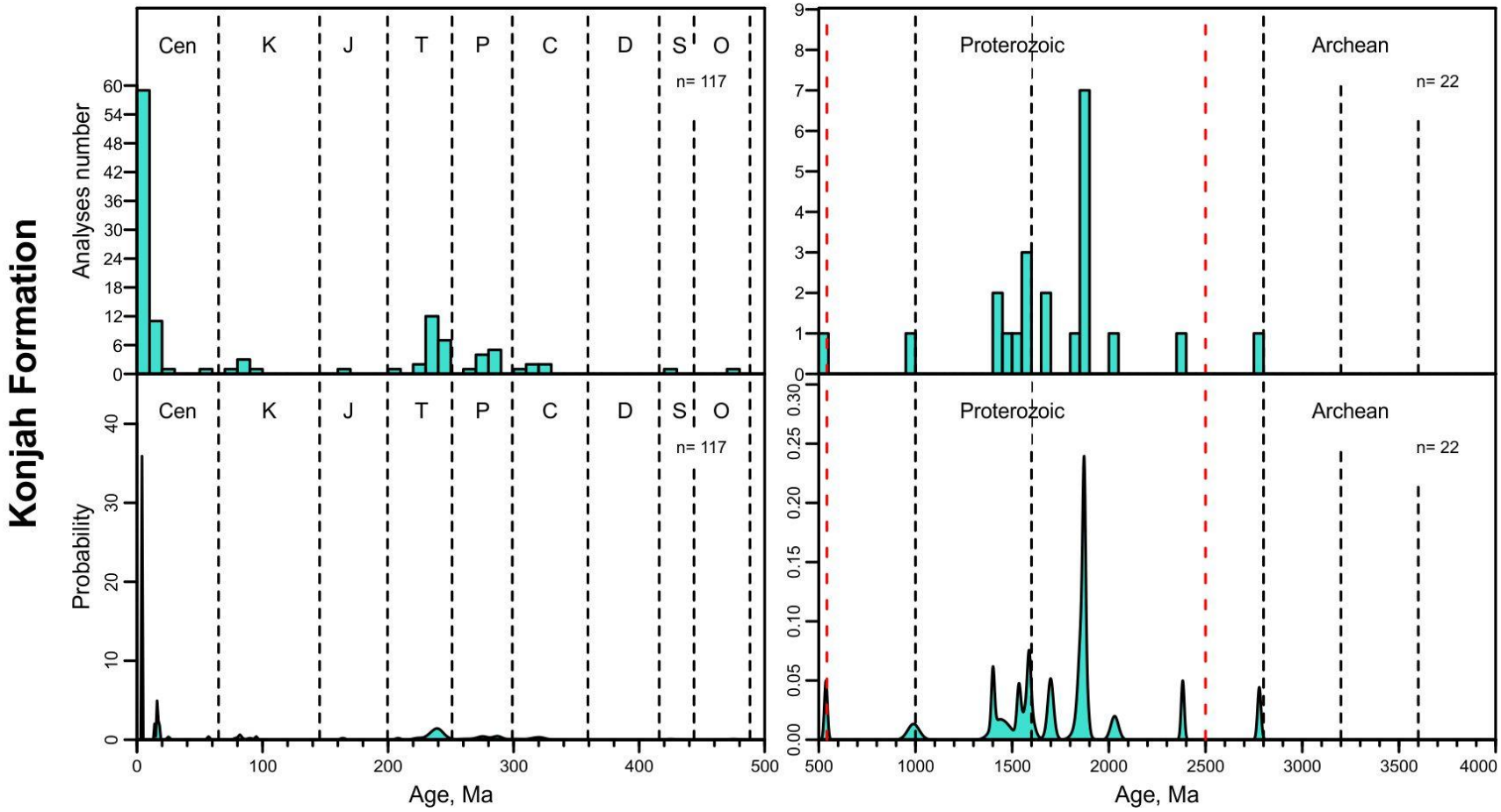
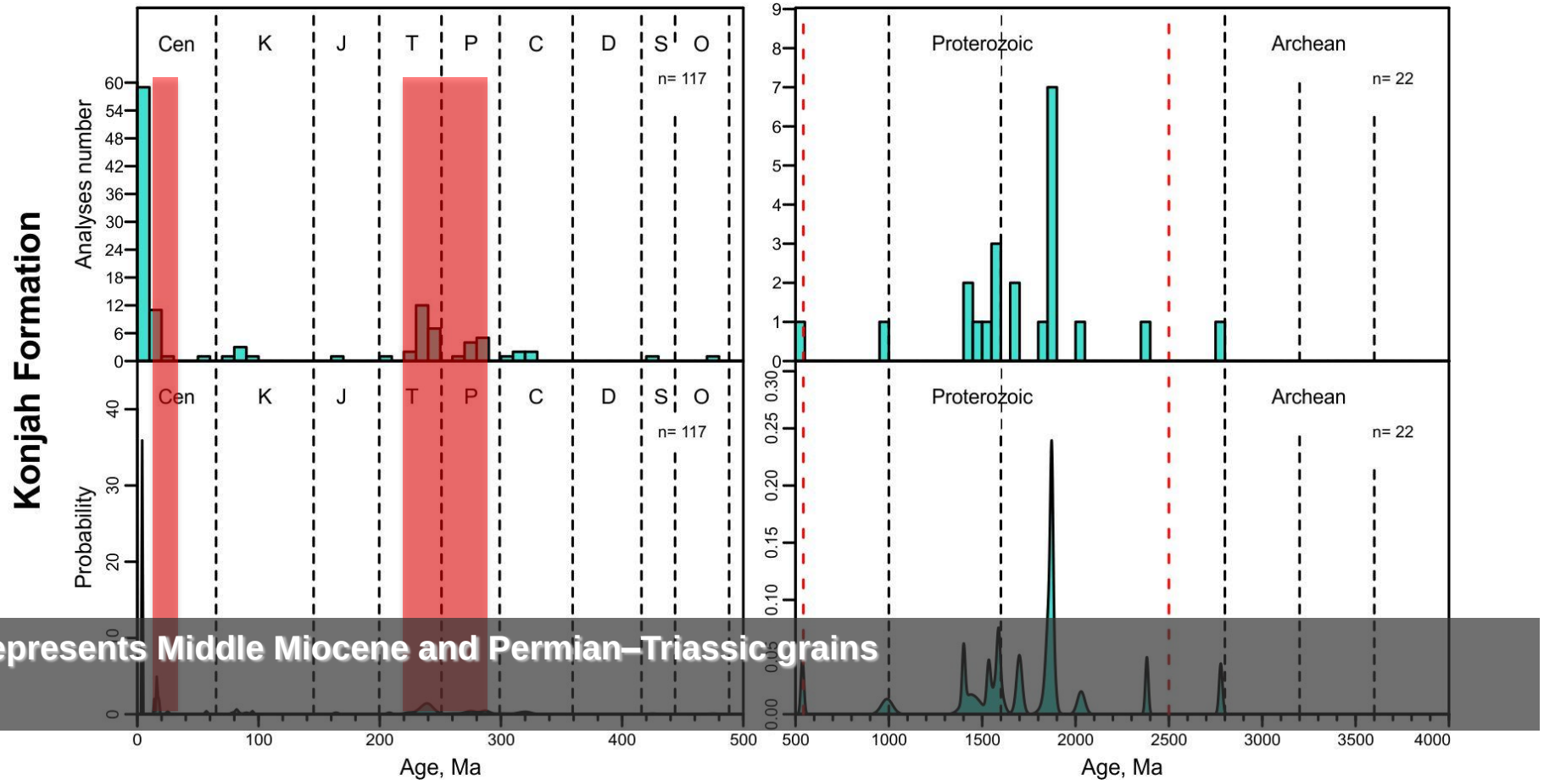
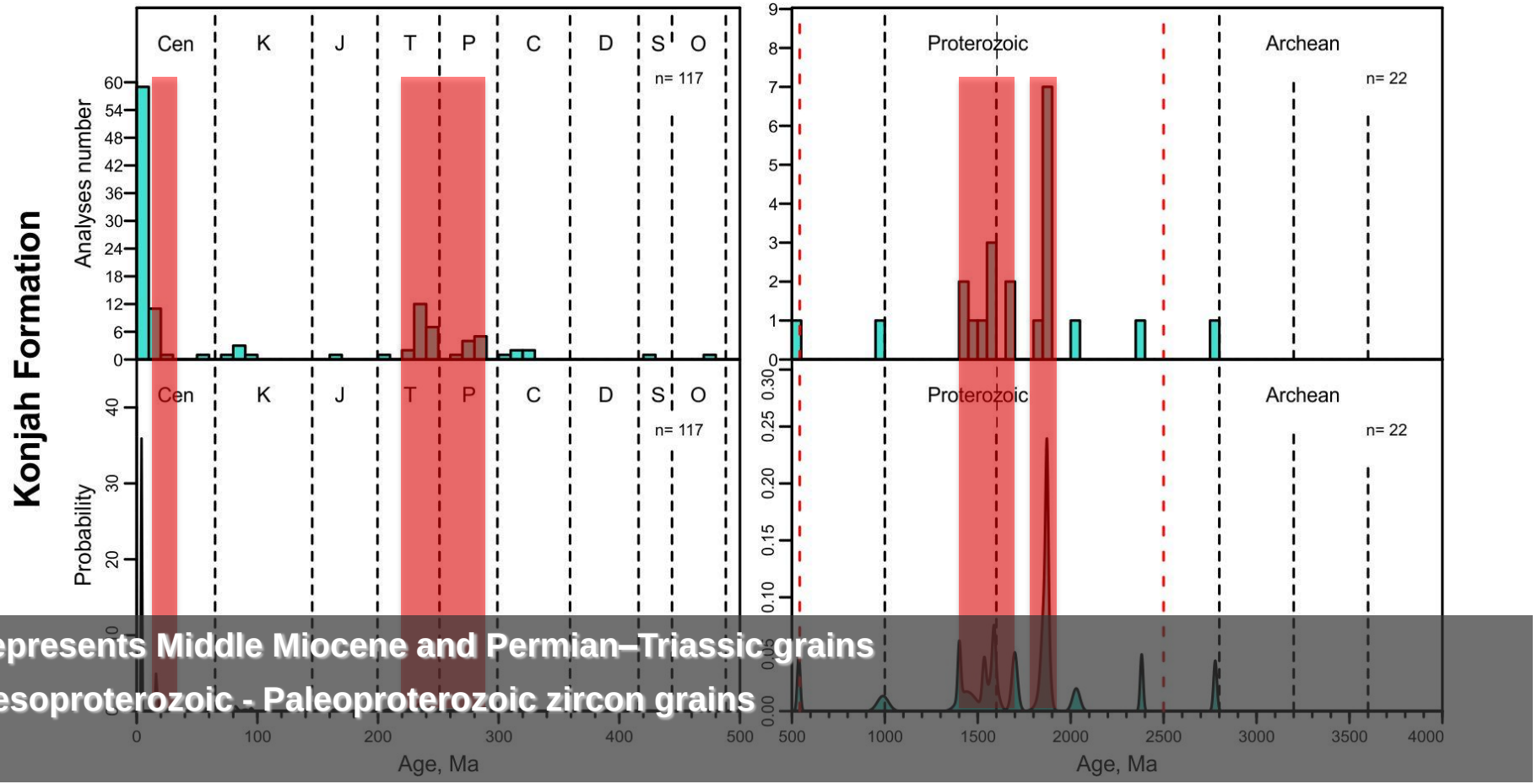


Zircon Geochronology



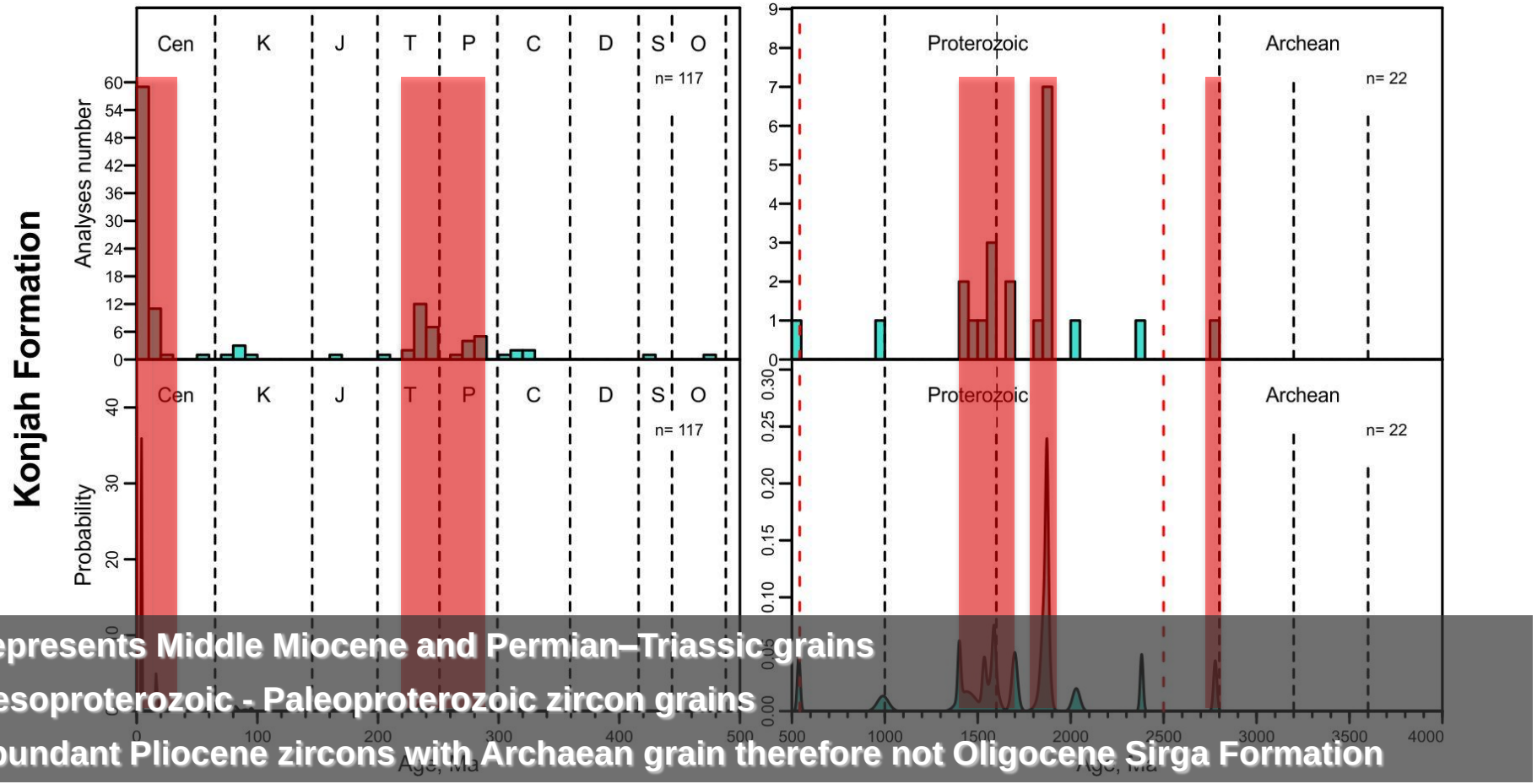
- **Represents Middle Miocene and Permian–Triassic grains**

Zircon Geochronology



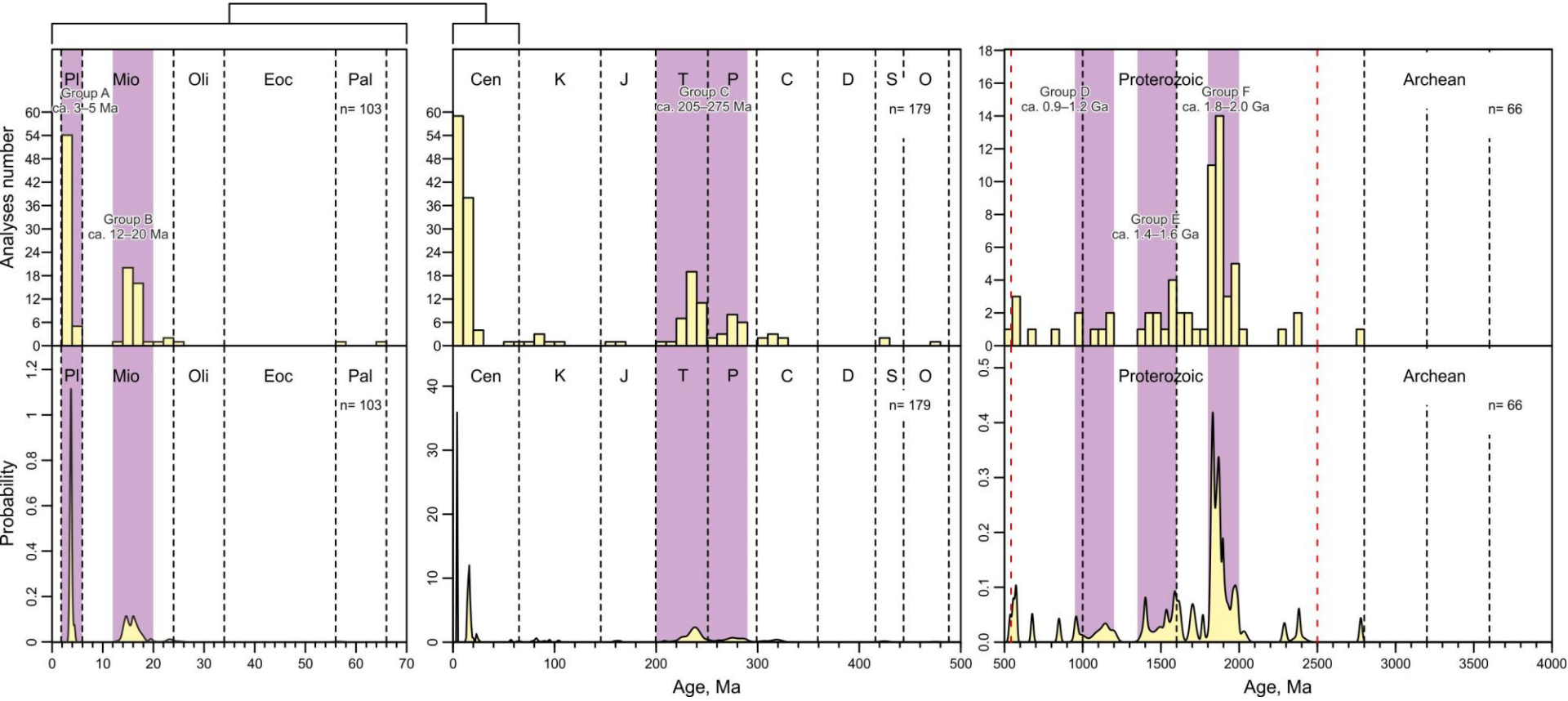
- **Represents Middle Miocene and Permian–Triassic grains**
- **Mesoproterozoic - Paleoproterozoic zircon grains**

Zircon Geochronology



- Represents Middle Miocene and Permian–Triassic grains
- Mesoproterozoic - Paleoproterozoic zircon grains
- Abundant Pliocene zircons with Archaean grain therefore not Oligocene Sirga Formation

Possible Sources Area



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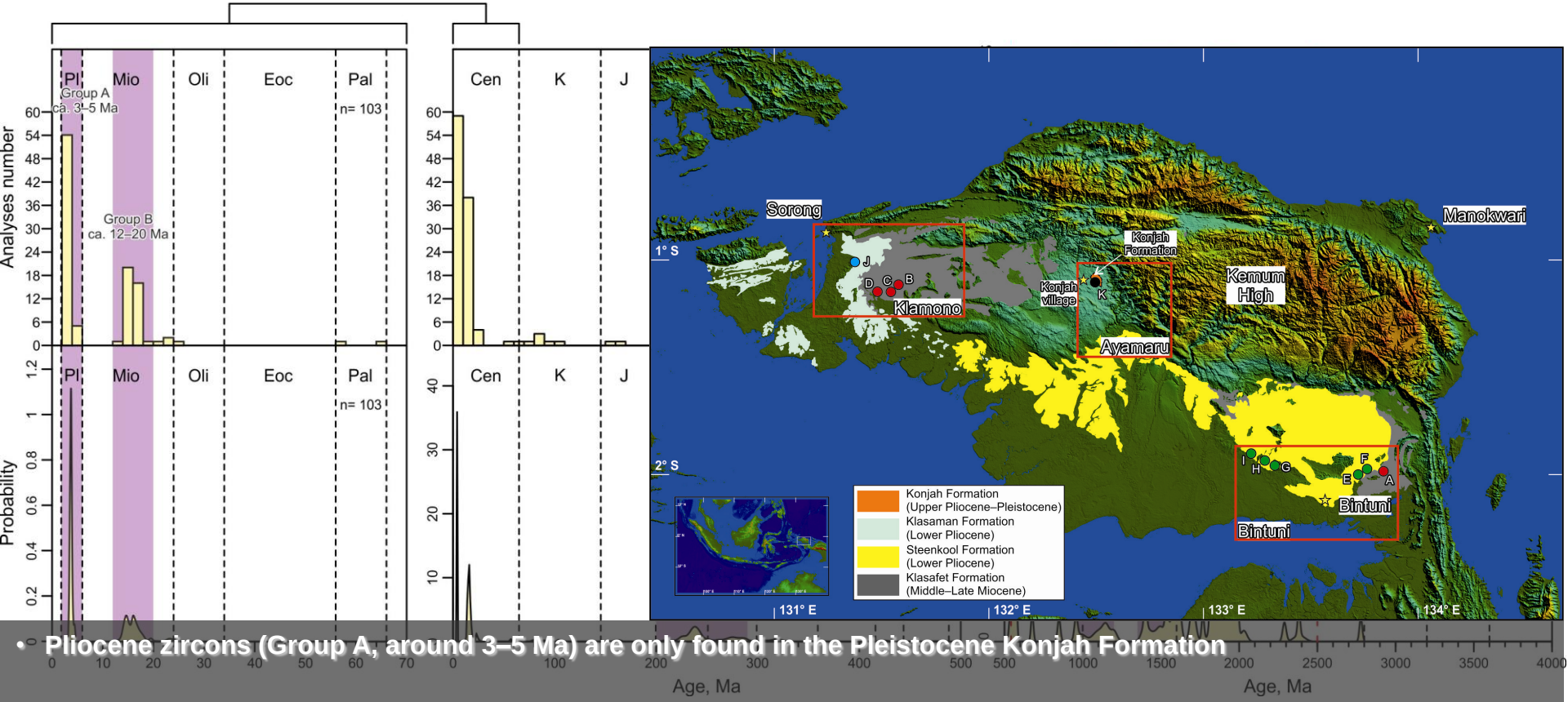

- Pliocene zircons (Group A, around 3–5 Ma) are only found in the Pleistocene Konjah Formation

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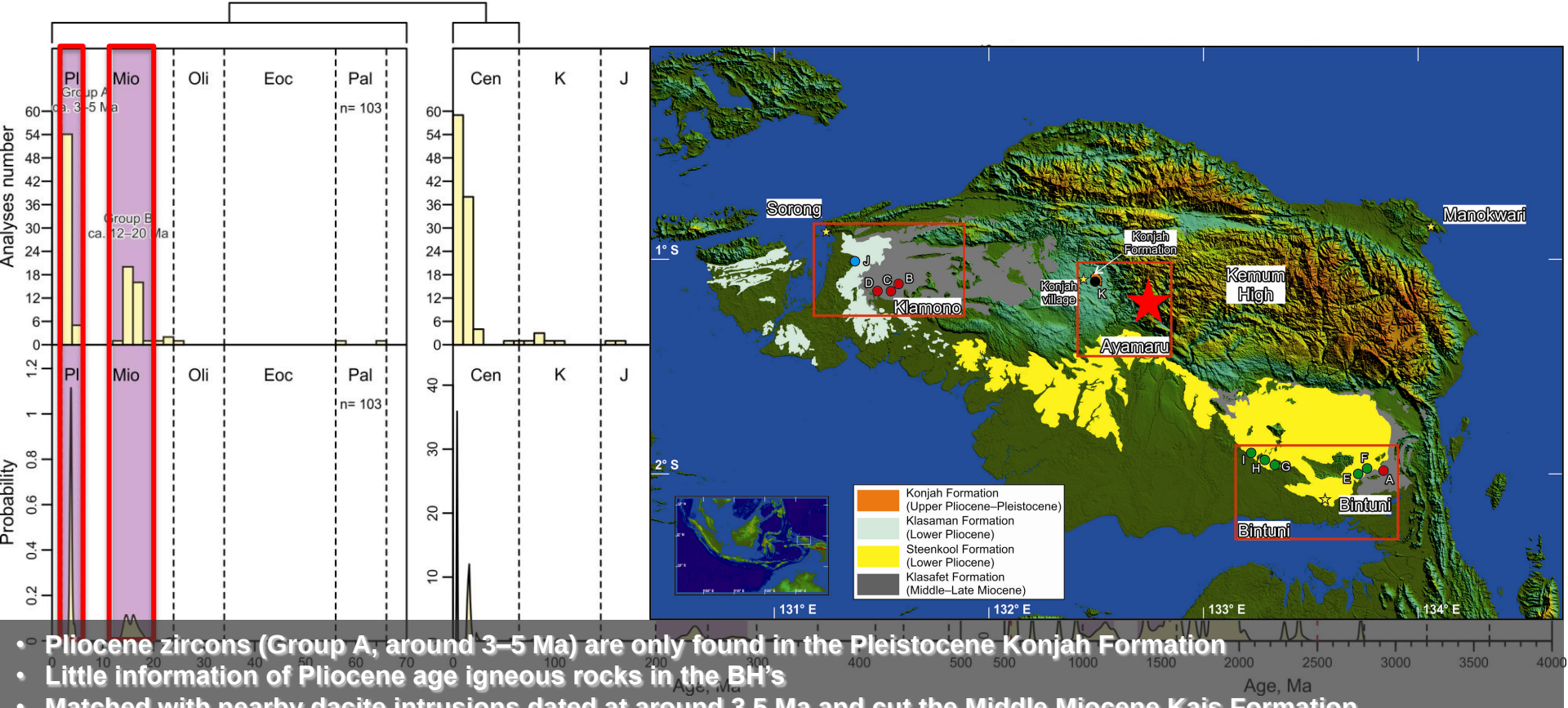
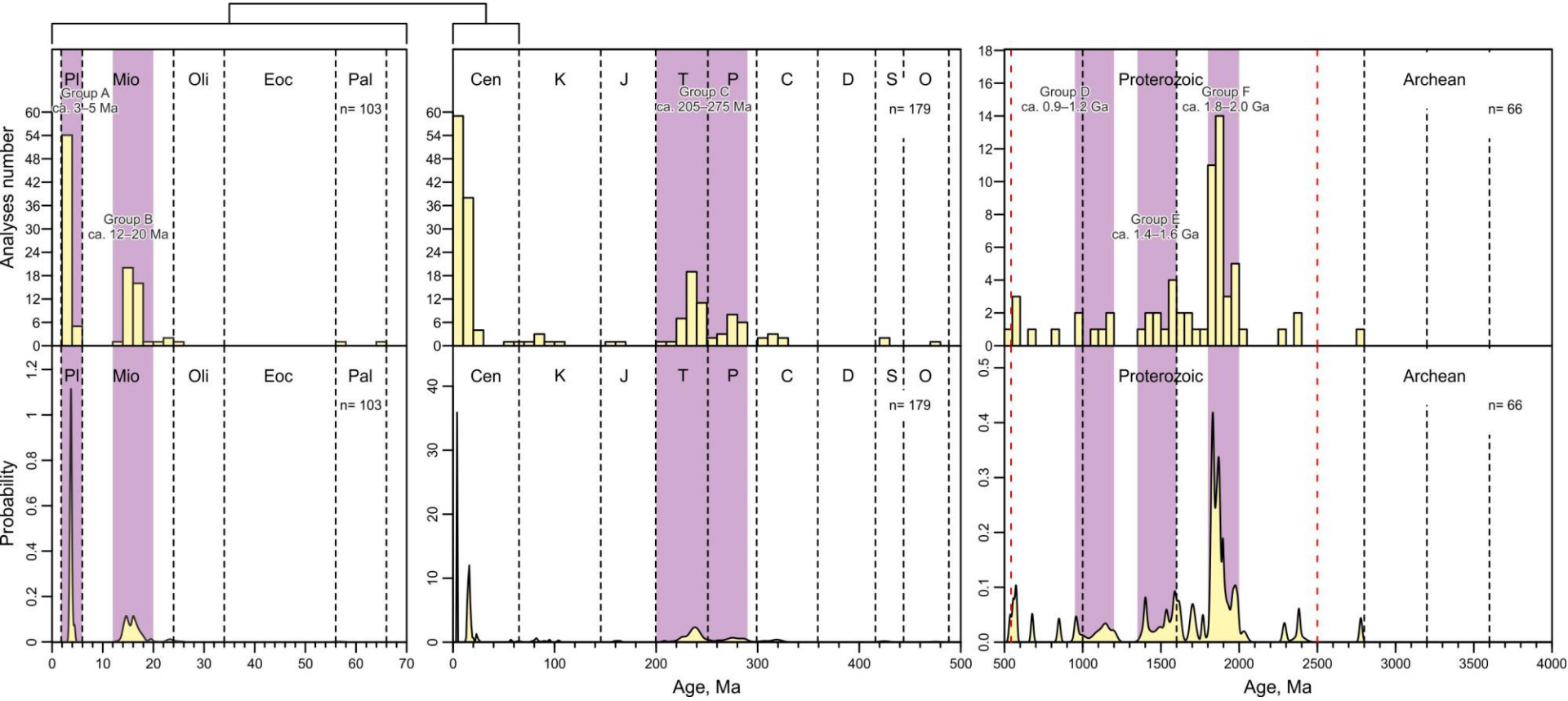


- Pliocene zircons (Group A, around 3–5 Ma) are only found in the Pleistocene Konjah Formation
- Little information of Pliocene age igneous rocks in the BH's
- Matched with nearby dacite intrusions dated at around 3.5 Ma and cut the Middle Miocene Kais Formation
- Another possibility were related to the Sorong Fault movement that was initiated in the Early Miocene and last until the Pliocene (Hall, 2002; Hall, 2011, 2012)

Possible Sources Area



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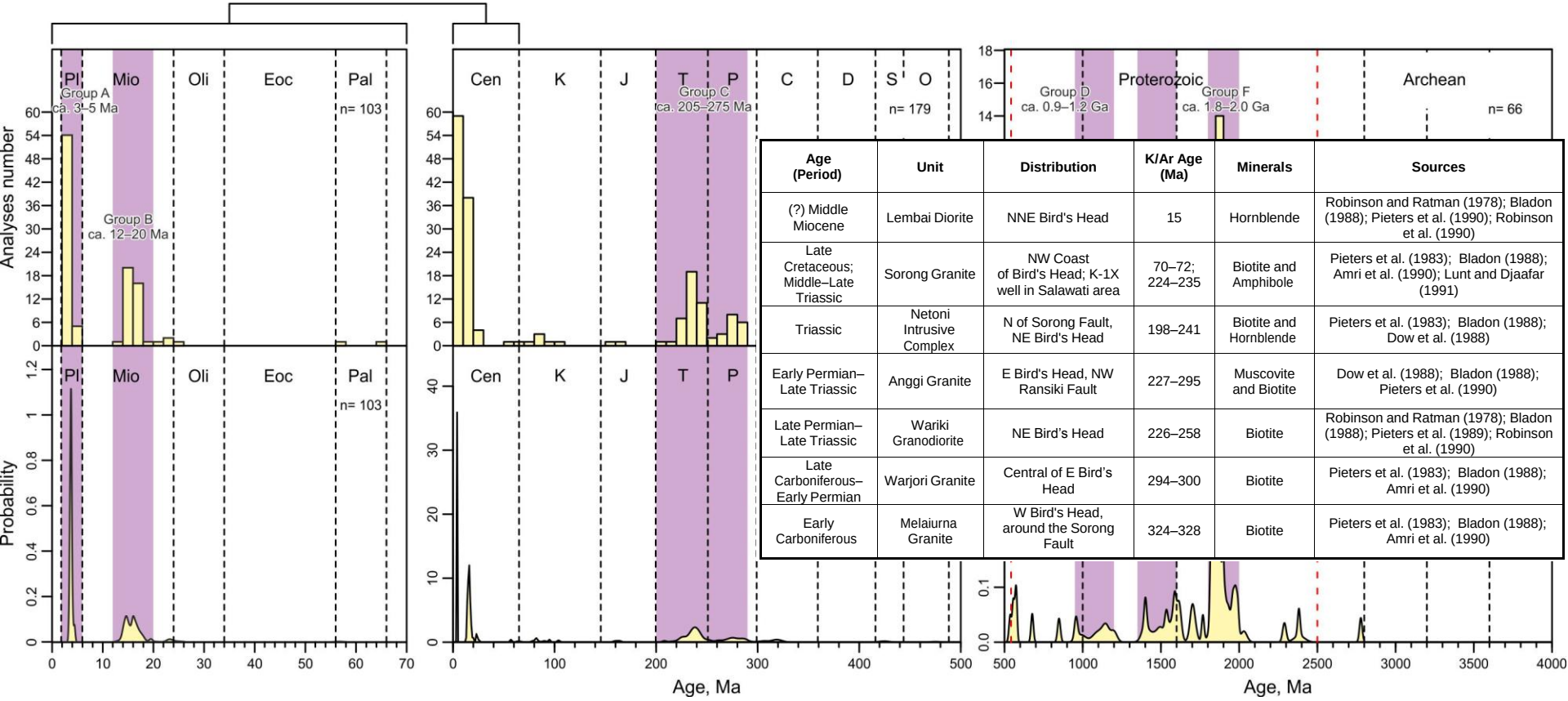

Age (Period)	Unit	Distribution	K/Ar Age (Ma)	Minerals	Sources
(?) Middle Miocene	Lembai Diorite	NNE Bird's Head	15	Hornblende	Robinson and Ratman (1978); Bladon (1988); Pieters et al. (1990); Robinson et al. (1990)
Late Cretaceous; Middle–Late Triassic	Sorong Granite	NW Coast of Bird's Head; K-1X well in Salawati area	70–72; 224–235	Biotite and Amphibole	Pieters et al. (1983); Bladon (1988); Amri et al. (1990); Lunt and Djaafar (1991)
Triassic	Netoni Intrusive Complex	N of Sorong Fault, NE Bird's Head	198–241	Biotite and Hornblende	Pieters et al. (1983); Bladon (1988); Dow et al. (1988)
Early Permian–Late Triassic	Anggi Granite	E Bird's Head, NW Ransiki Fault	227–295	Muscovite and Biotite	Dow et al. (1988); Bladon (1988); Pieters et al. (1990)
Late Permian–Late Triassic	Wariki Granodiorite	NE Bird's Head	226–258	Biotite	Robinson and Ratman (1978); Bladon (1988); Pieters et al. (1989); Robinson et al. (1990)
Late Carboniferous–Early Permian	Warjori Granite	Central of E Bird's Head	294–300	Biotite	Pieters et al. (1983); Bladon (1988); Amri et al. (1990)
Early Carboniferous	Melaiurna Granite	W Bird's Head, around the Sorong Fault	324–328	Biotite	Pieters et al. (1983); Bladon (1988); Amri et al. (1990)

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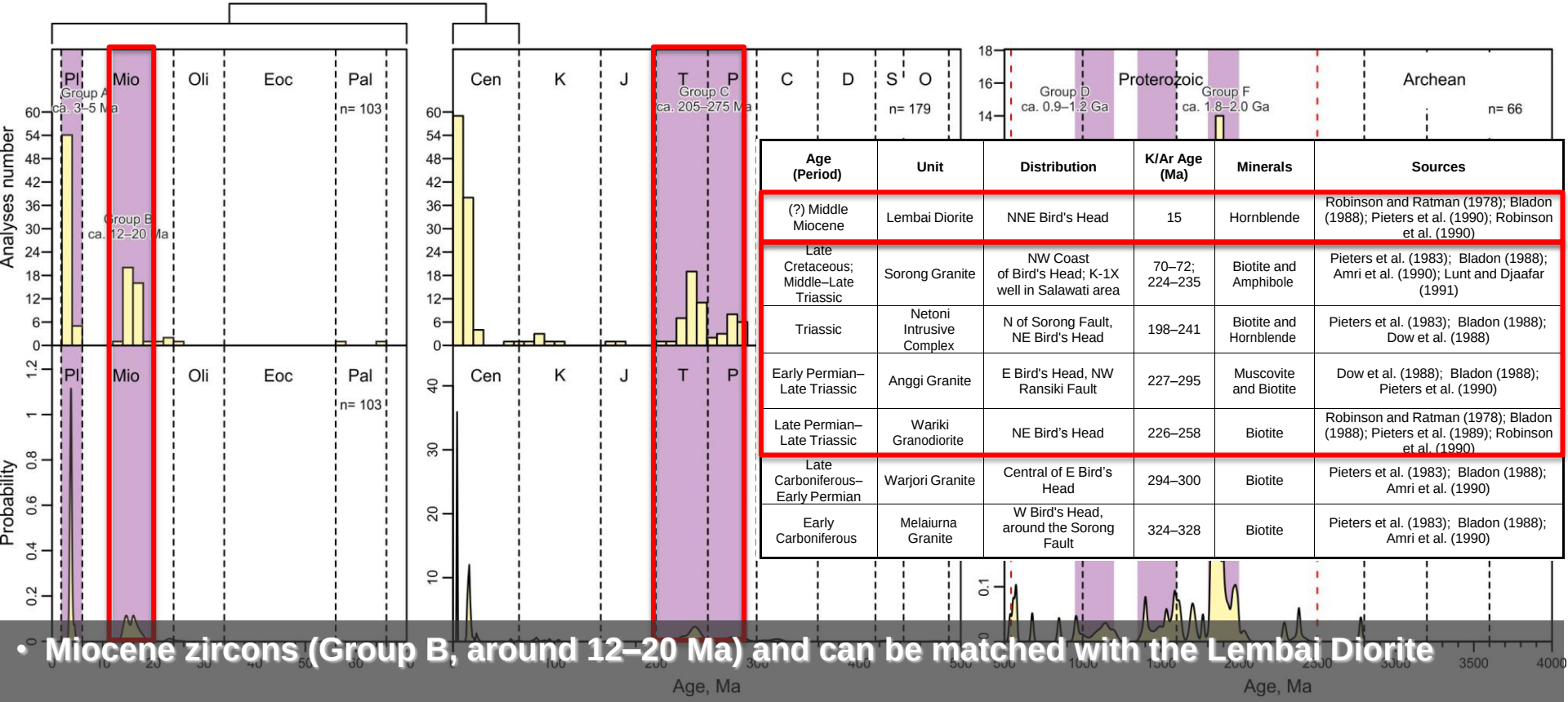

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- **Miocene zircons (Group B, around 12–20 Ma) and can be matched with the Lembai Diorite**

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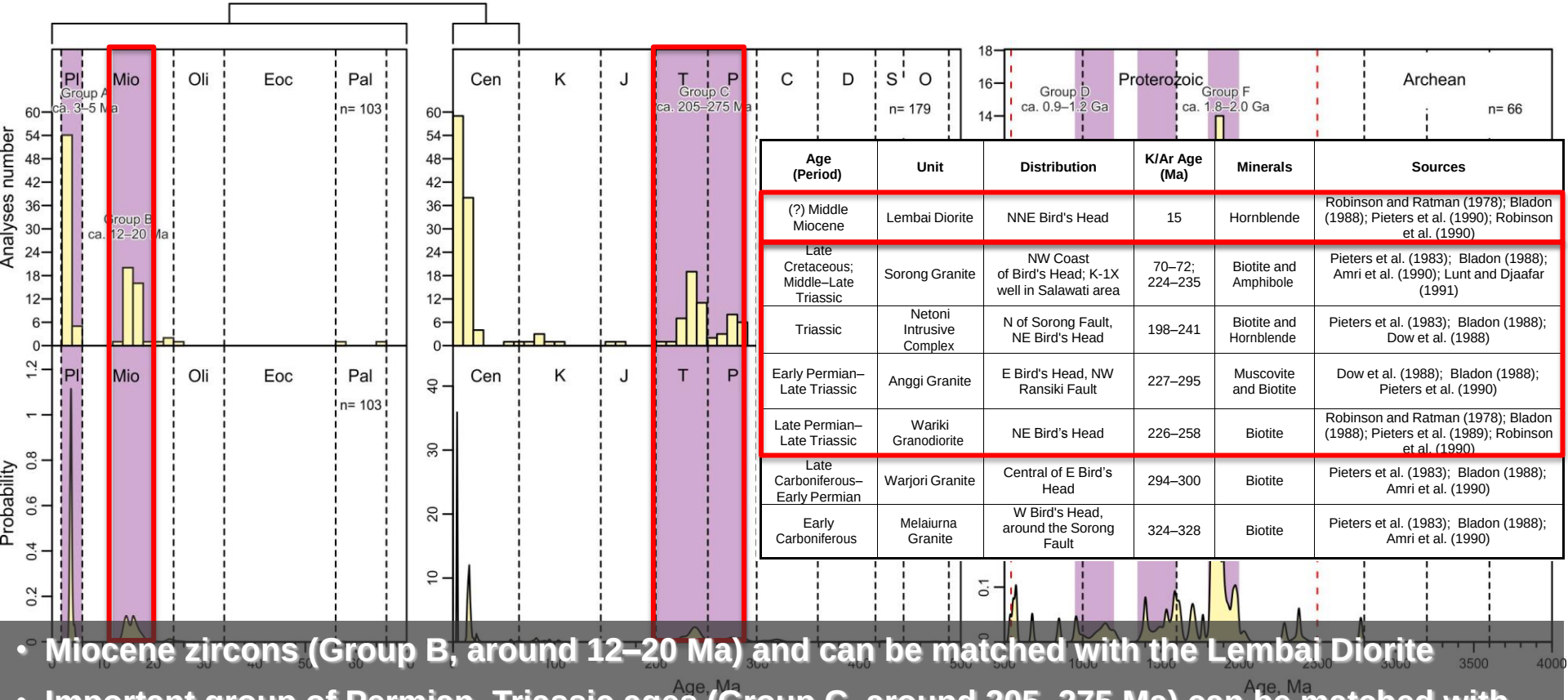

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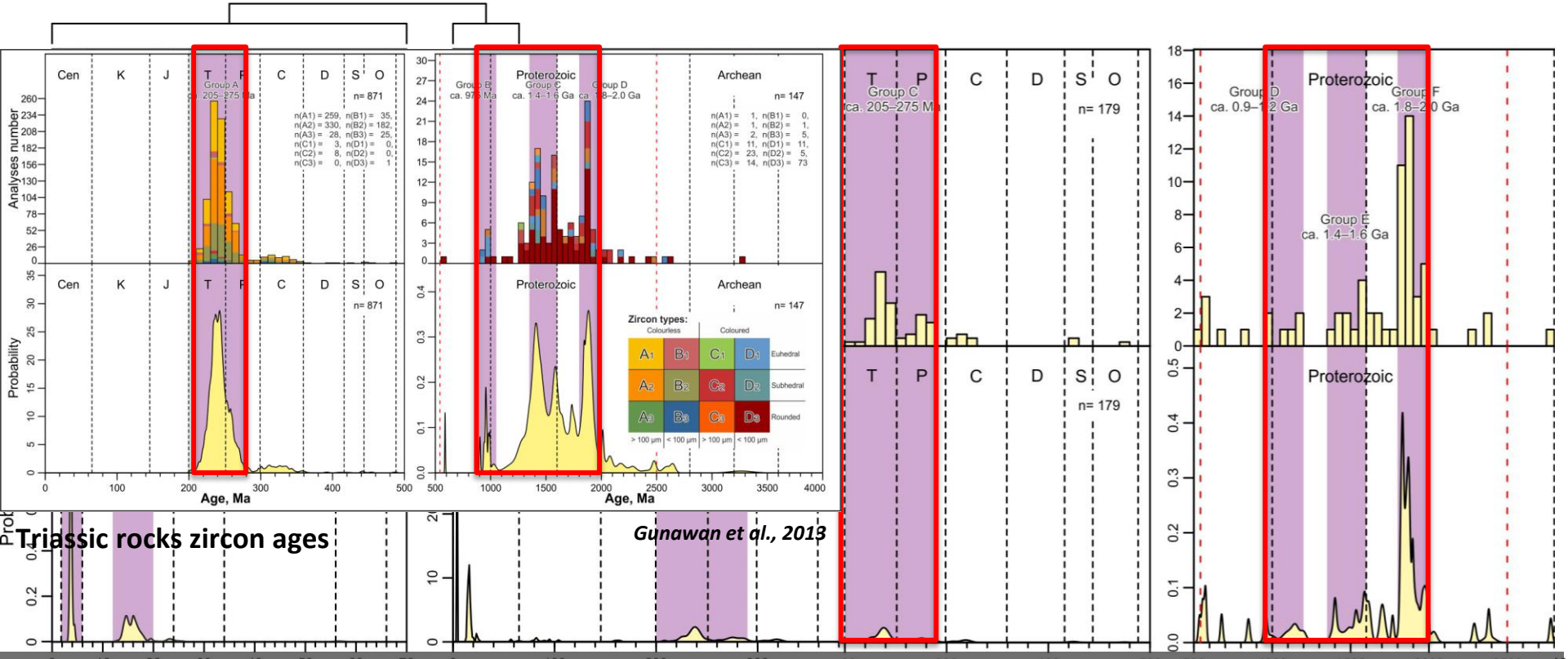
- **Miocene zircons (Group B, around 12–20 Ma) and can be matched with the Lembai Diorite**
- **Important group of Permian–Triassic ages (Group C, around 205–275 Ma) can be matched with those of nearby intrusive bodies outcropping to the northeast of the Ayamaru area.**

Possible Sources Area



Triassic rocks zircon ages

Gunawan et al., 2013

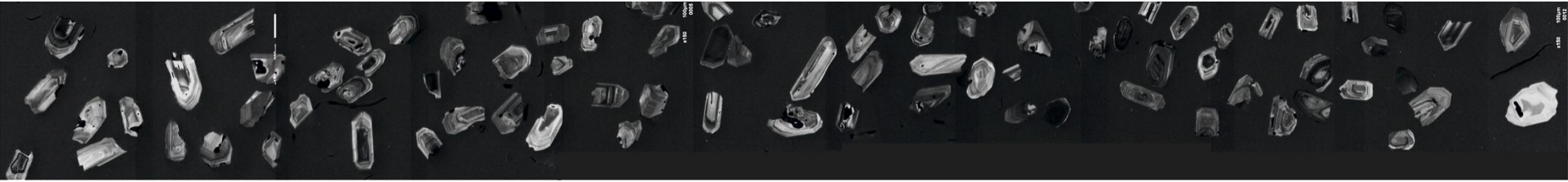
- **The Permian–Triassic and Proterozoic (Group D (around 0.9–1.2 Ga), Group E (around 1.4–1.6 Ga), and Group F (around 1.8–2.0Ga)) zircons from the Late Neogene sequence could be reworked from older sedimentary rocks**

So Far…..

- **Prior to Middle Miocene the BH's was on Passive Margin**
- **Important sedimentological changes occurred in the Bird's Head in the Middle-Late Miocene**
- **Then the transform margin developed to the north of BH's area**

With a little bit ingredient of Zircon

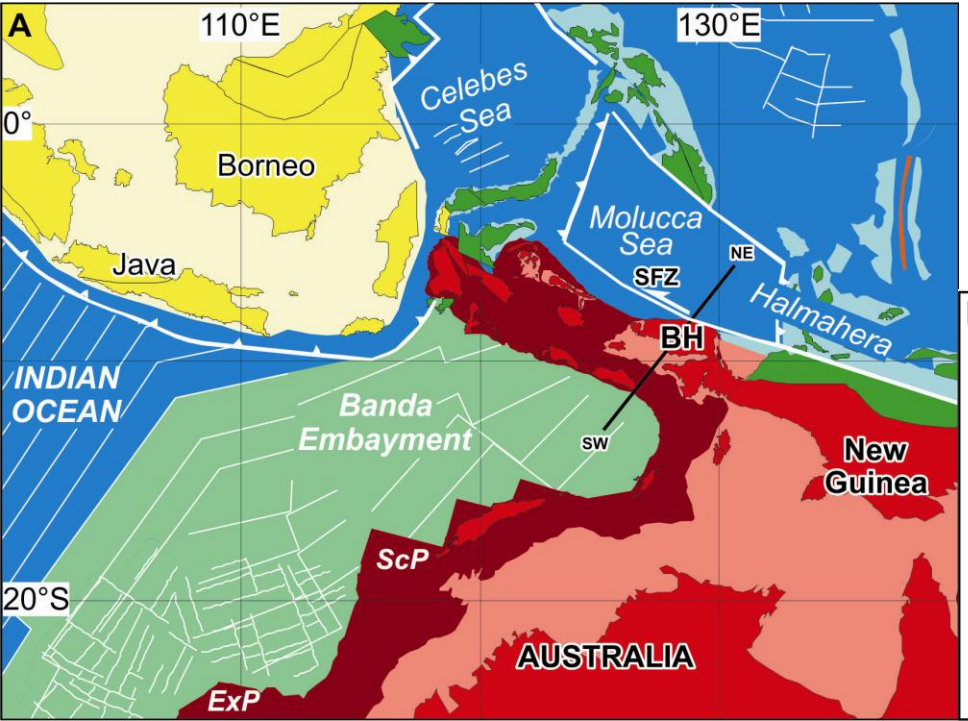
- **Middle Miocene and Pliocene acid igneous activity**
- **Much larger proportion of Precambrian zircons indicates a new older source was available**
- **The Middle Pliocene unconformity in the Bird's Head**

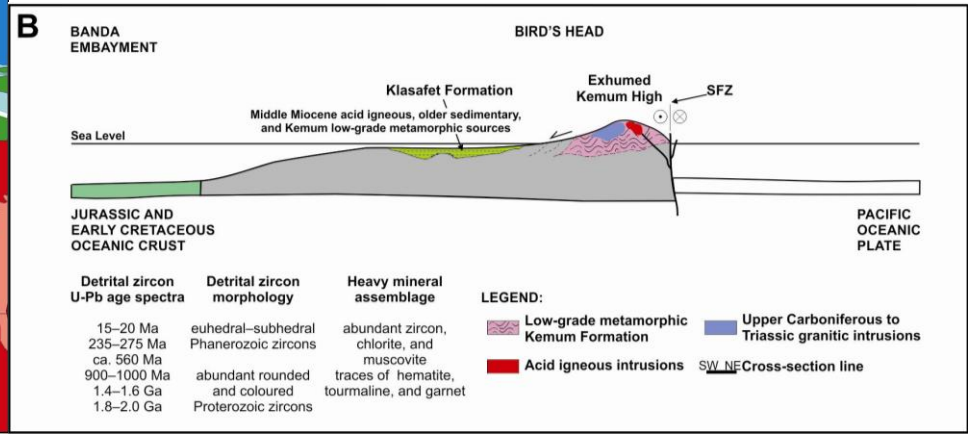


Regional Implication

Middle Miocene

- **There was acid igneous activity during the Middle Miocene**
- **A new older source was available, and the older zircons were not simply derived by reworking of older sedimentary rocks.**
- **Unroofing of the northeast part of the Bird's Head, the Kemum High**

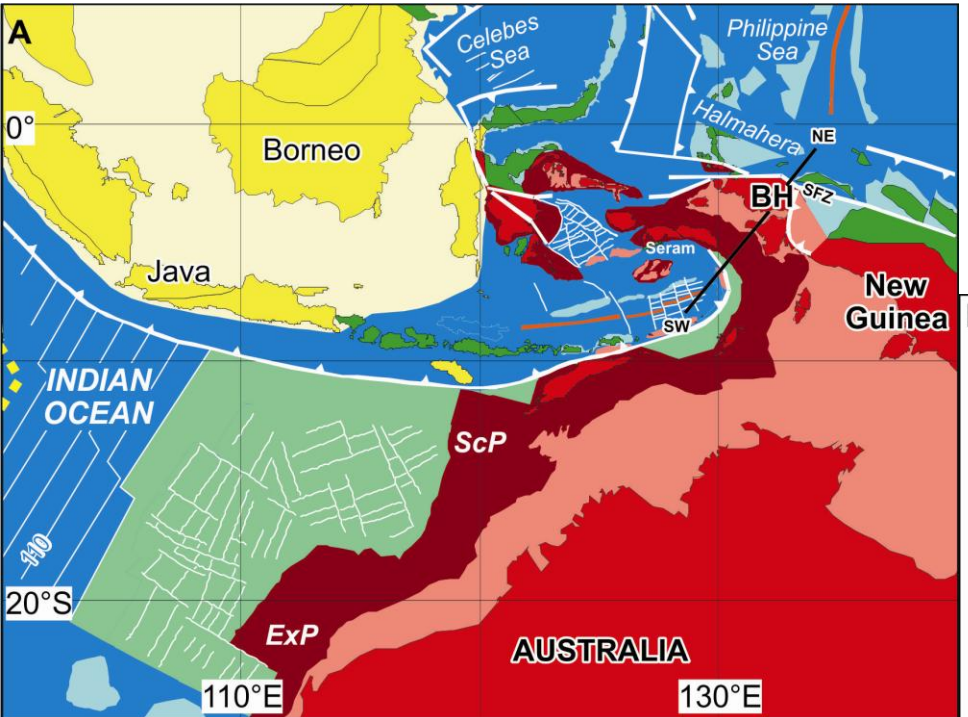


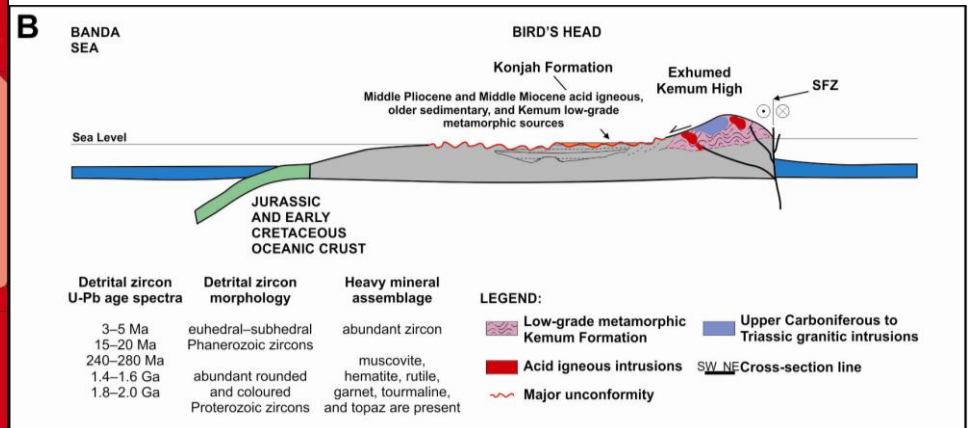


Regional Implication

Pliocene

- **Siliciclastic deposition continued**
- **Second phase of acid igneous activity during the Pliocene in the Bird's Head**
- **The Middle Pliocene unconformity and supports the seismic interpretation of a Pliocene unconformity in the Seram area that was suggested by Pairault et al. (2003)**
- **This major unconformity is probably related to the Sorong Fault movement**





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UPP–Chevron