Basin Development in the arc-collision zones of New Guinea – Examples from Bintuni to the Gulf of Papua

Max Webb and the Southeast Asia Research Group,
Royal Holloway, University of London

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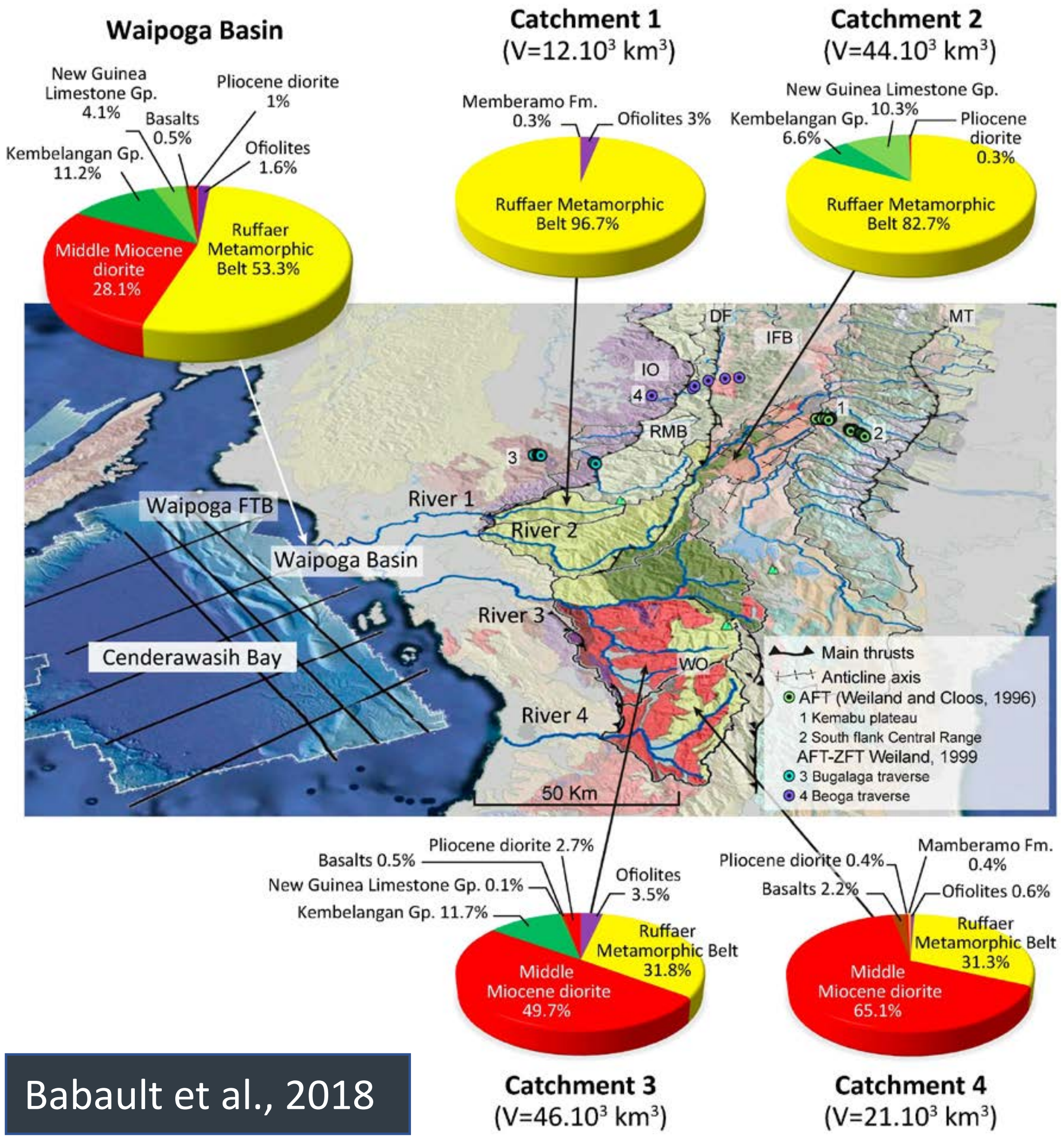
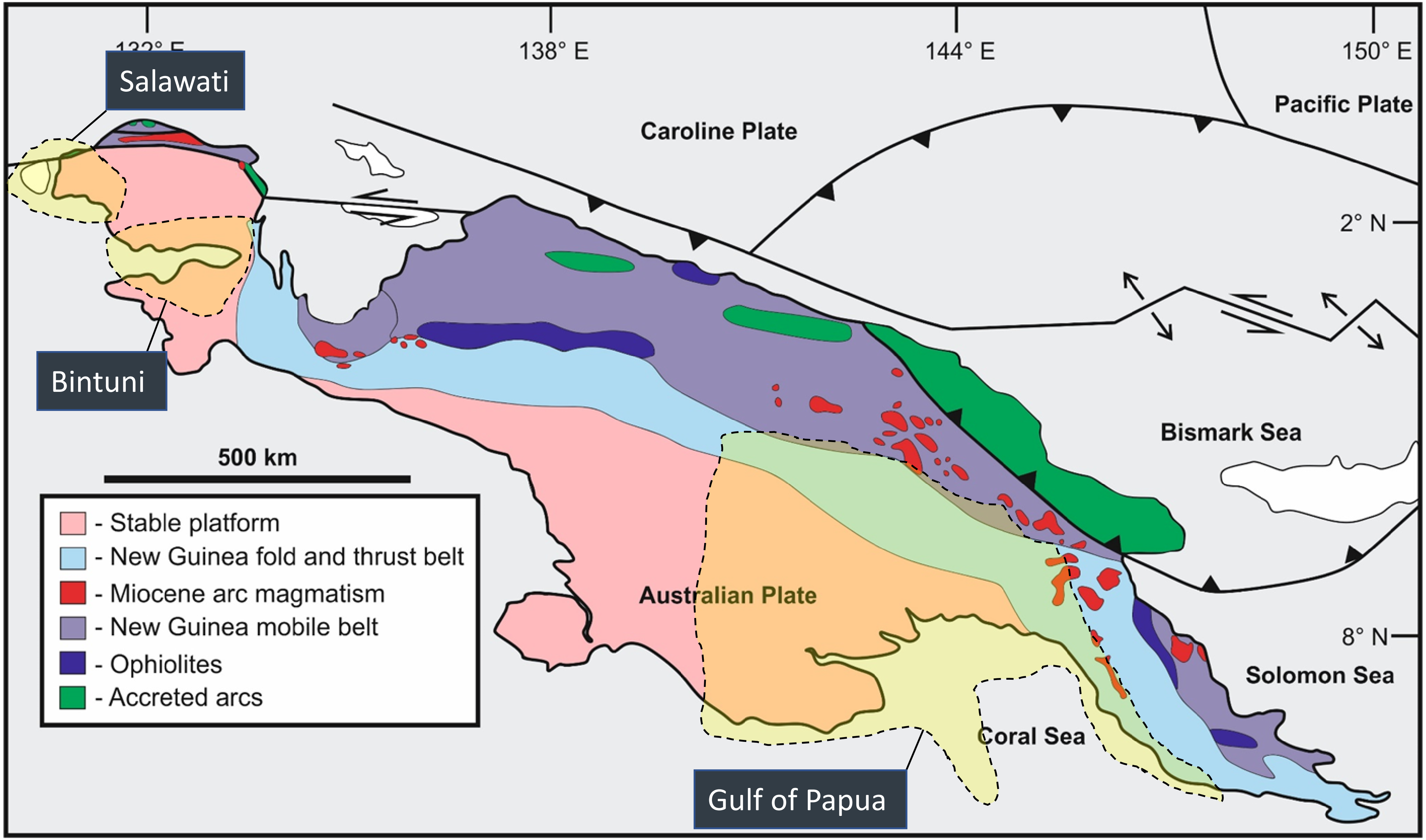
Introduction

- New Guinea is the world’s second largest Island with an average sediment yield of 1756 mt/yr.
- This is equivalent to the whole of North America – despite the island being a fraction of the size.
- Rapid uplift within the last 5 Ma and mountain ranges up to 4,800m make it one of Earth’s youngest major orogens – this has driven high sedimentation.
- Over 100 years of hydrocarbon exploration in New Guinea with still emerging plays – e.g., Pliocene Gulf of Papua.
- How can fieldwork and geochronology help us to understand what drives this sedimentation and basin development?



Babault et al., 2018

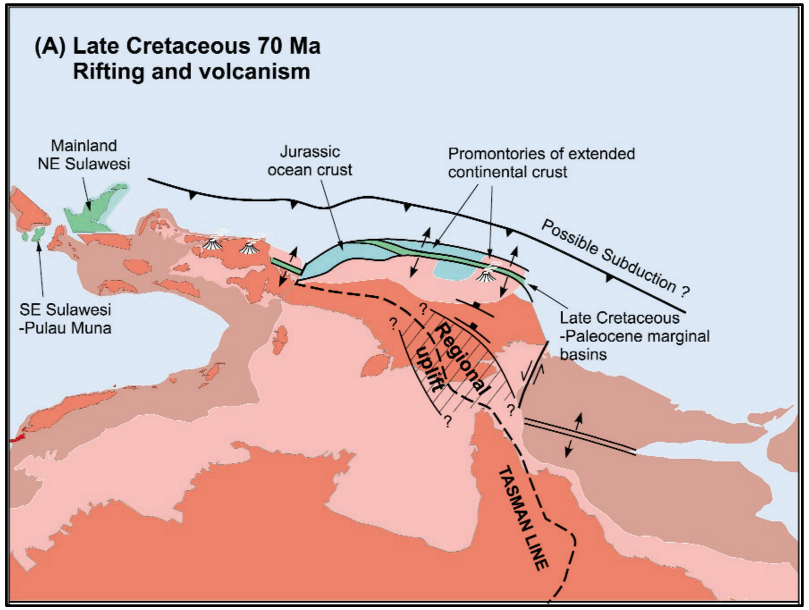
New Guinea tectonics and basins

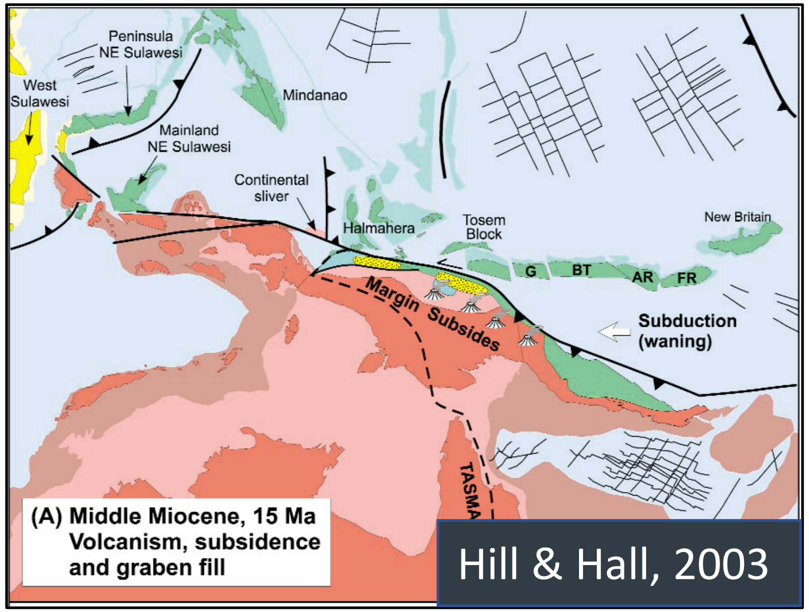


New Guinea tectonics – original models

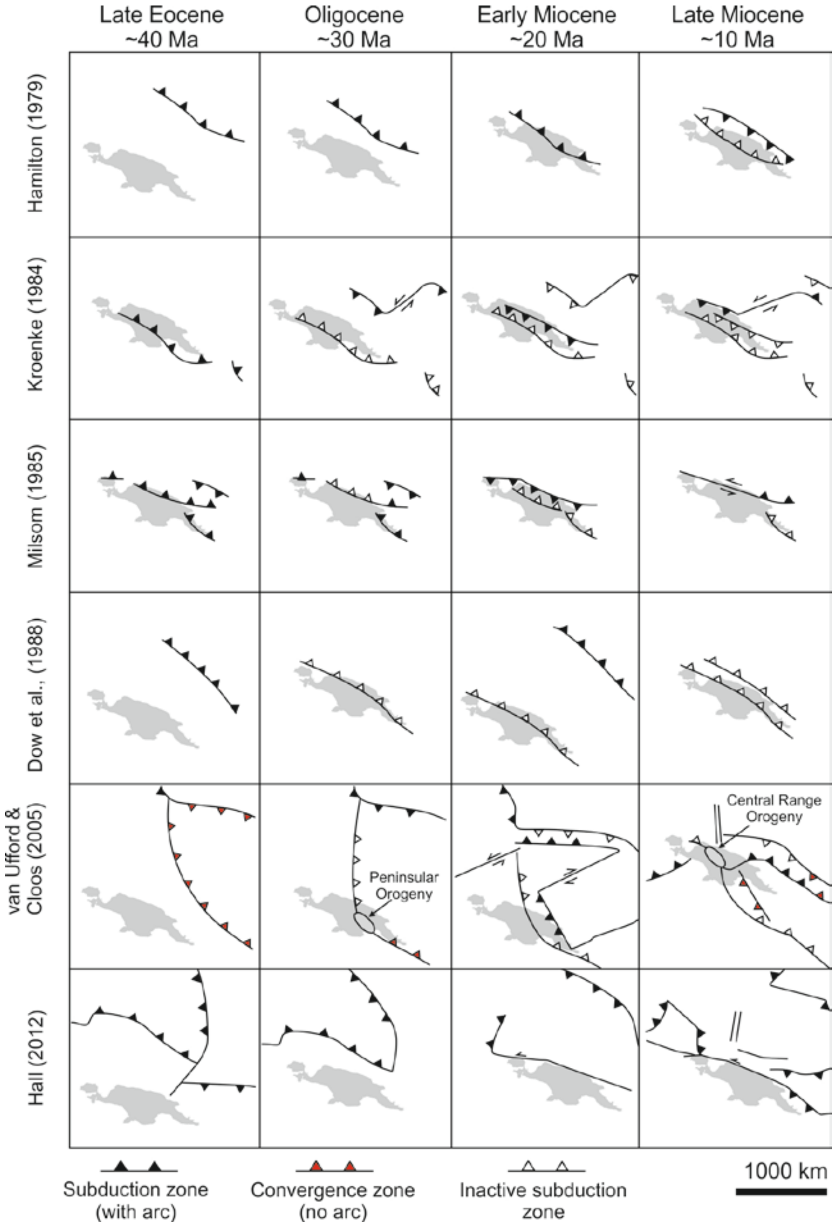
Original models:

- Cretaceous rifting event evident but the extent of this was undetermined.
- Much disagreement on the timing and number of arc-continent collisions.
- Differences in tectonic history between Eastern and Western New Guinea.
- Lack of detailed geochronology.





Hill & Hall, 2003

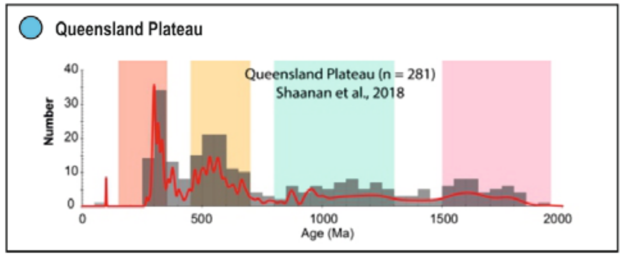


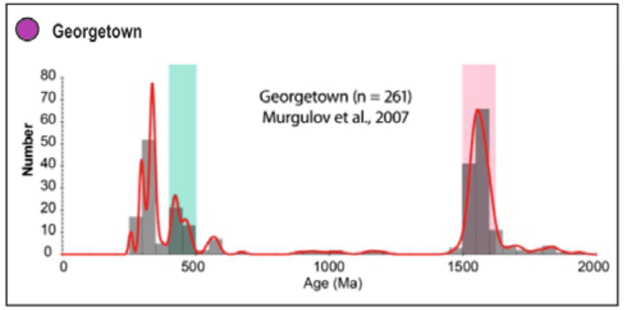
New Guinea tectonics – New Ideas

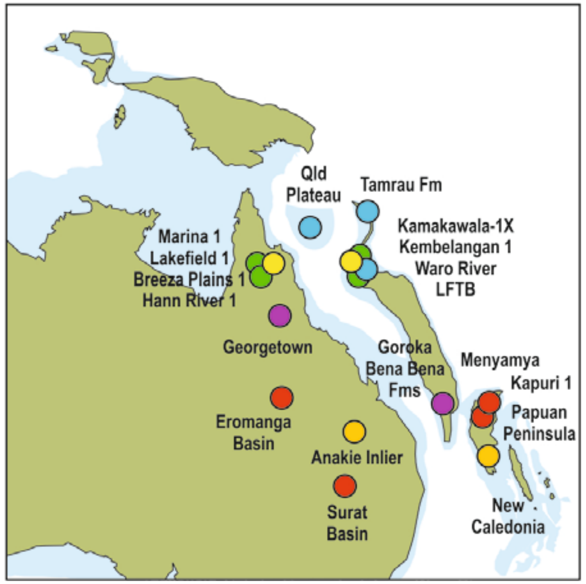
Cretaceous rifting:

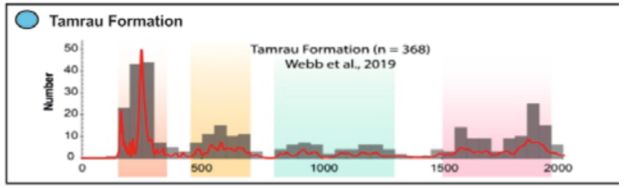
- Tectonic reconstructions show evidence for extensive back-arc spreading in New Guinea.
- Zircon geochronology and biogeography studies support this as an extended continental rifted margin along Eastern Gondwana.
- Collision of continental fragment at ~50-60 Ma.

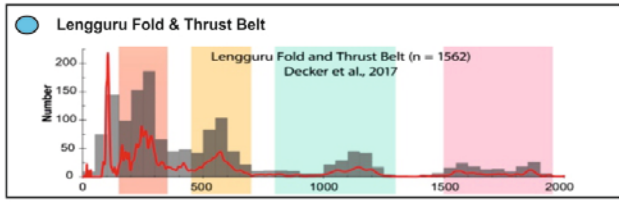
Gold et al., 2020

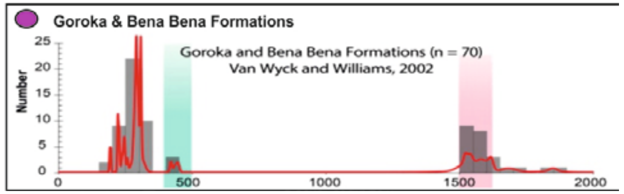






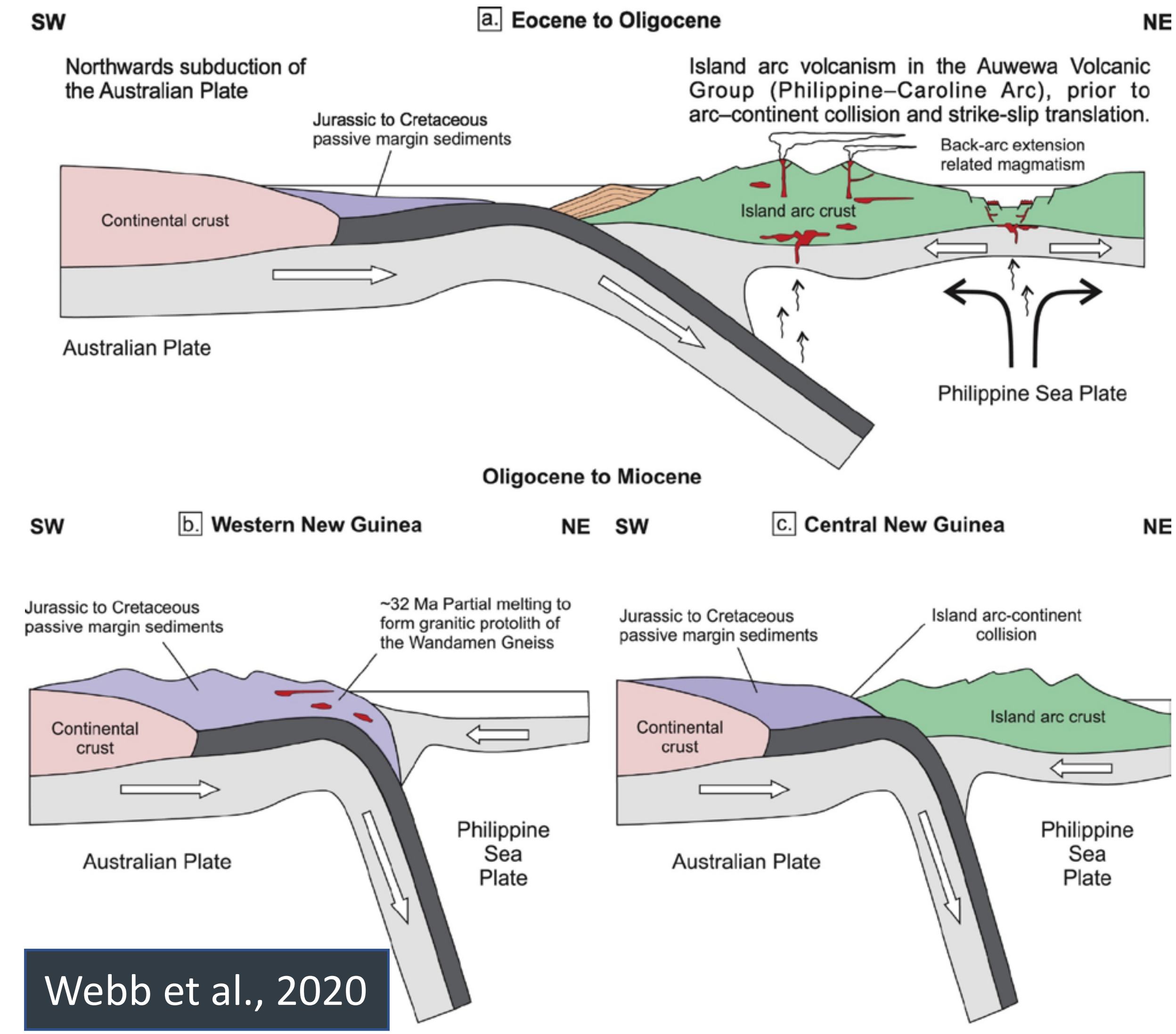




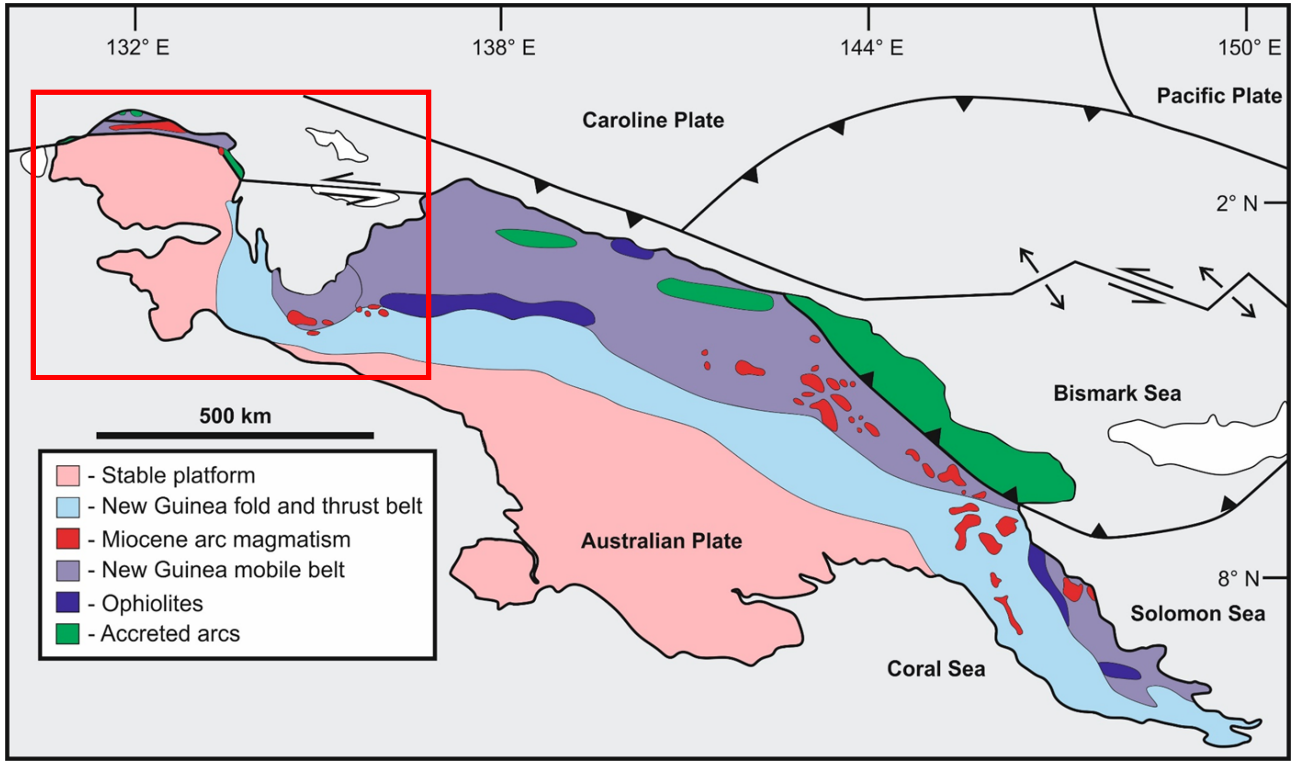


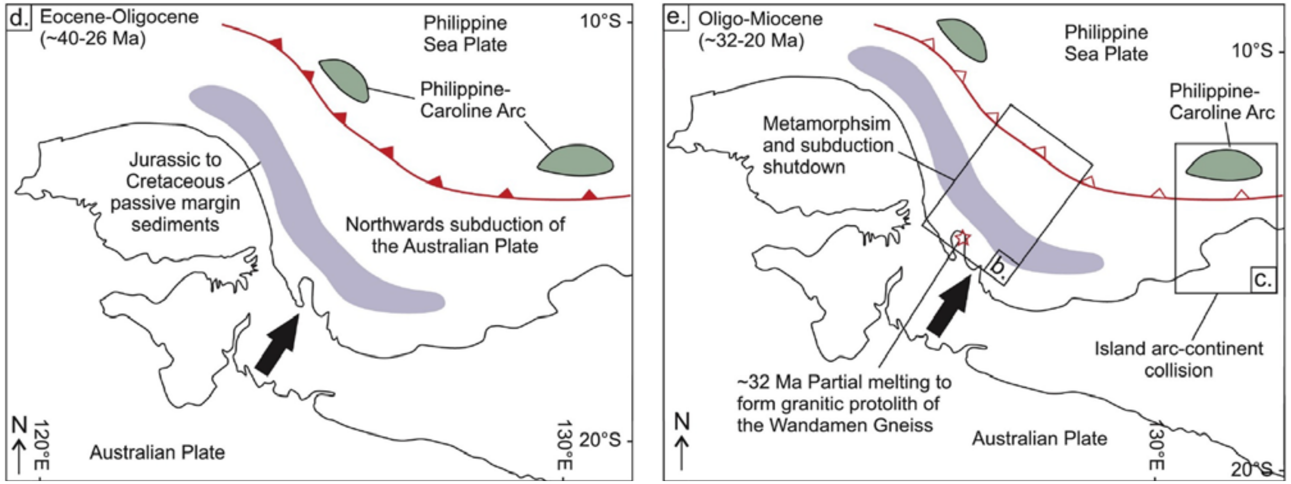
New Guinea tectonics – New ideas

Cenozoic arc magmatism – Western New Guinea



Webb et al., 2020

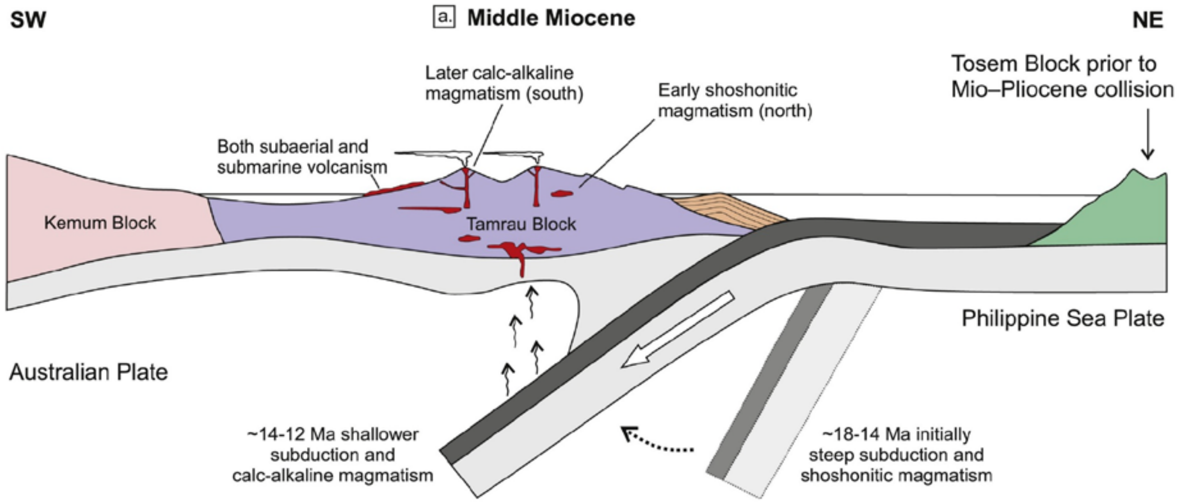




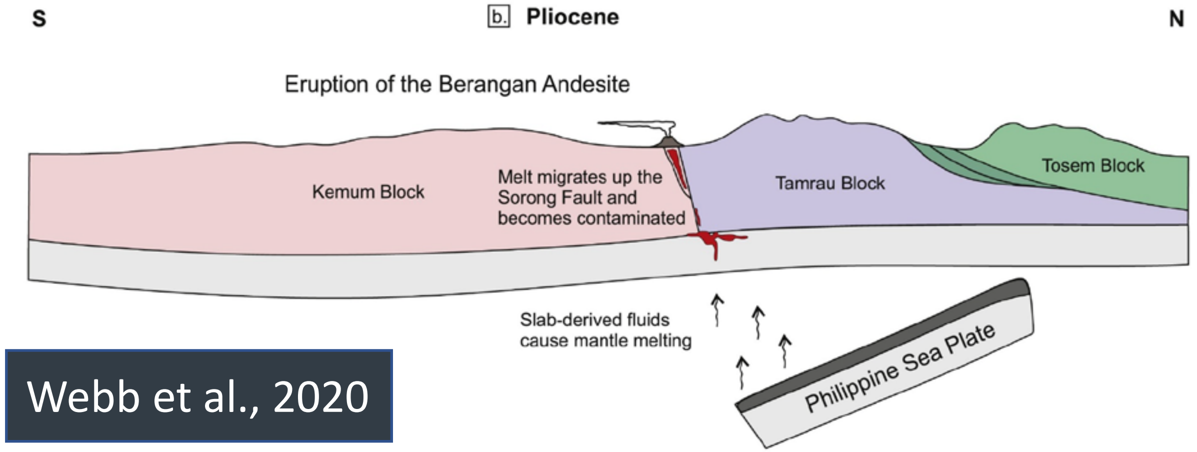
New Guinea tectonics – New ideas

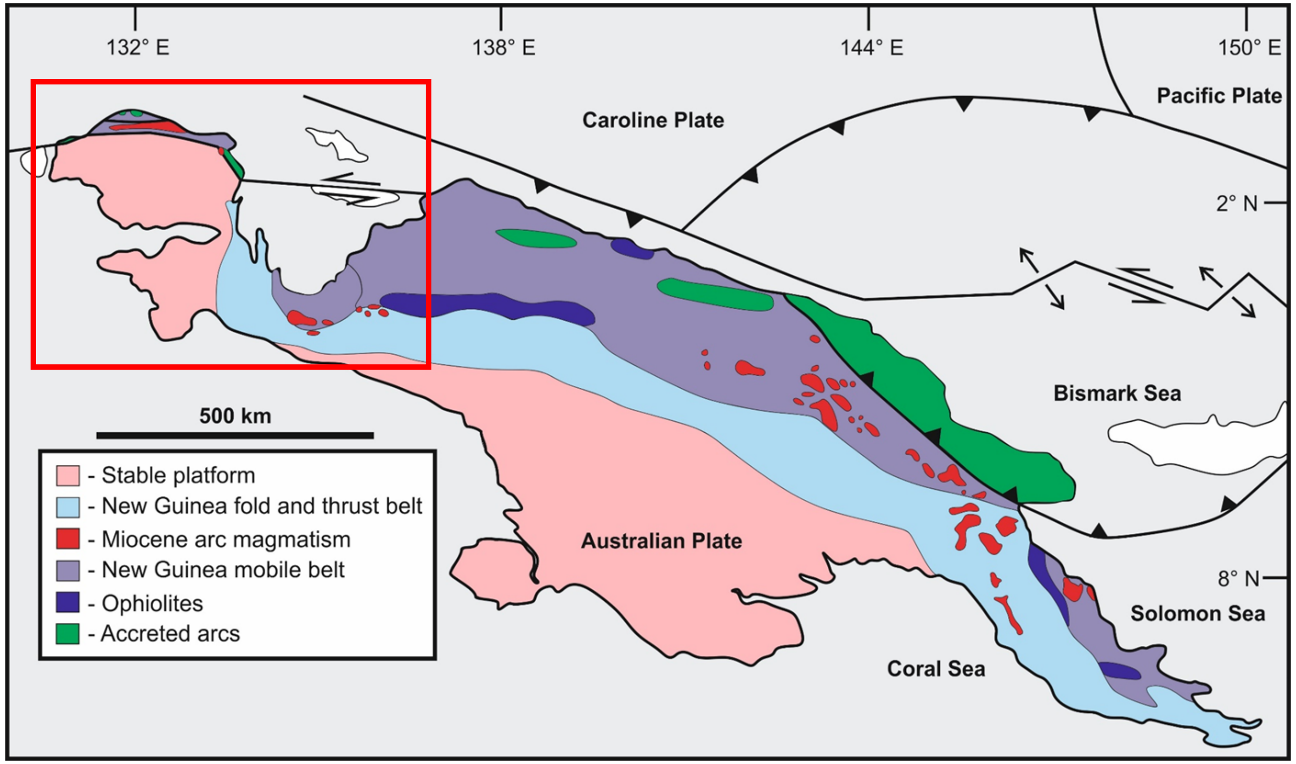
Cenozoic arc magmatism – Western New Guinea

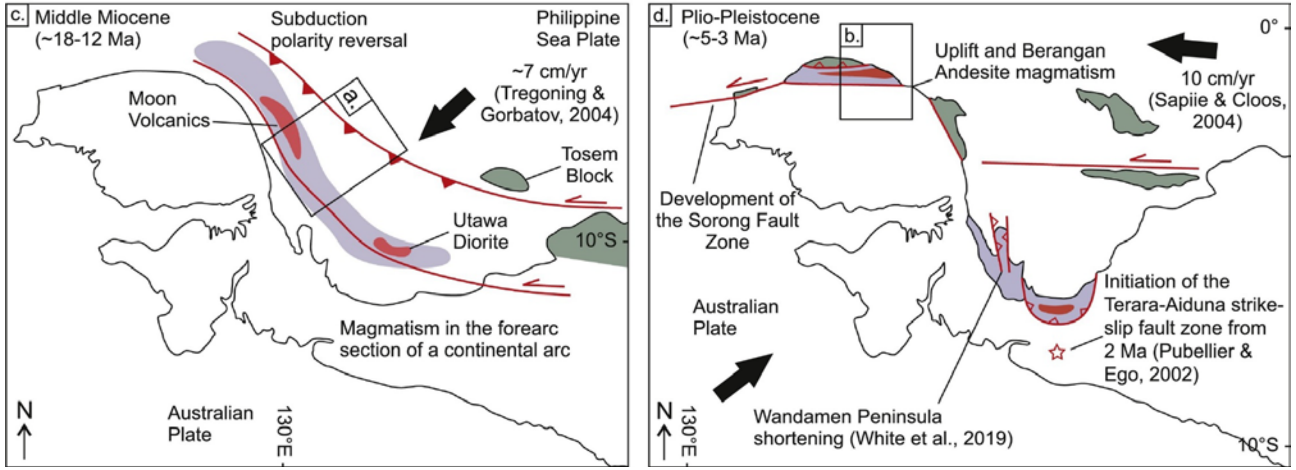
Following collision in the Oligocene to Miocene there is a subduction polarity reversal, resulting in continental arc magmatism in the Moon Volcanics throughout the middle Miocene



Collision of the Tosem and Tamrau blocks occurs in the late Miocene–Pliocene shutting down south-facing subduction



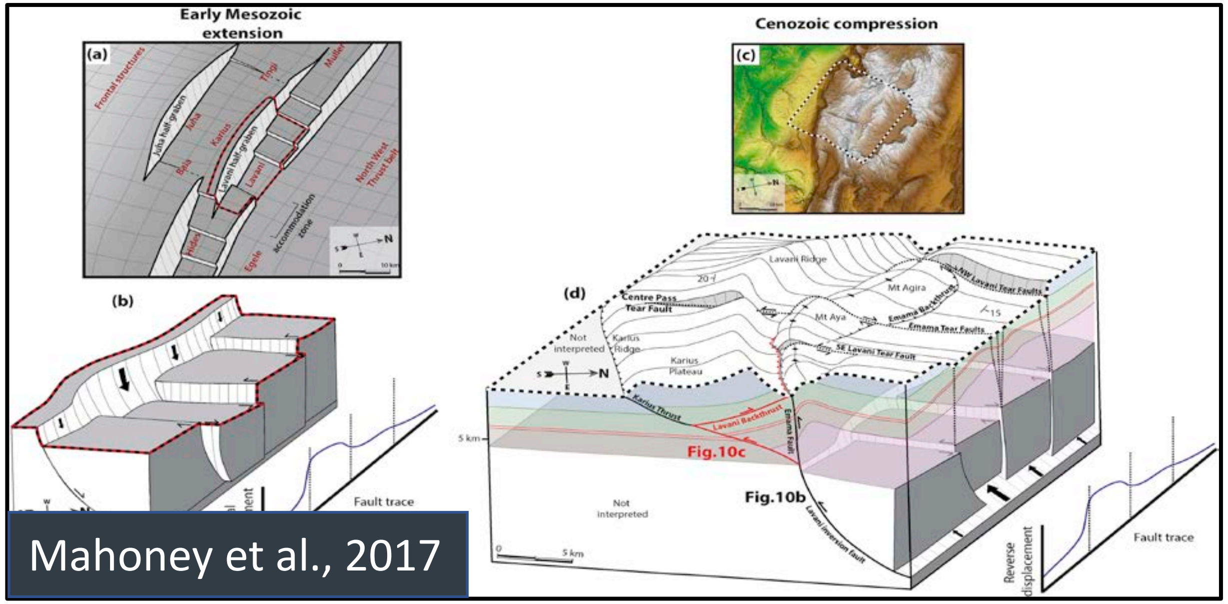




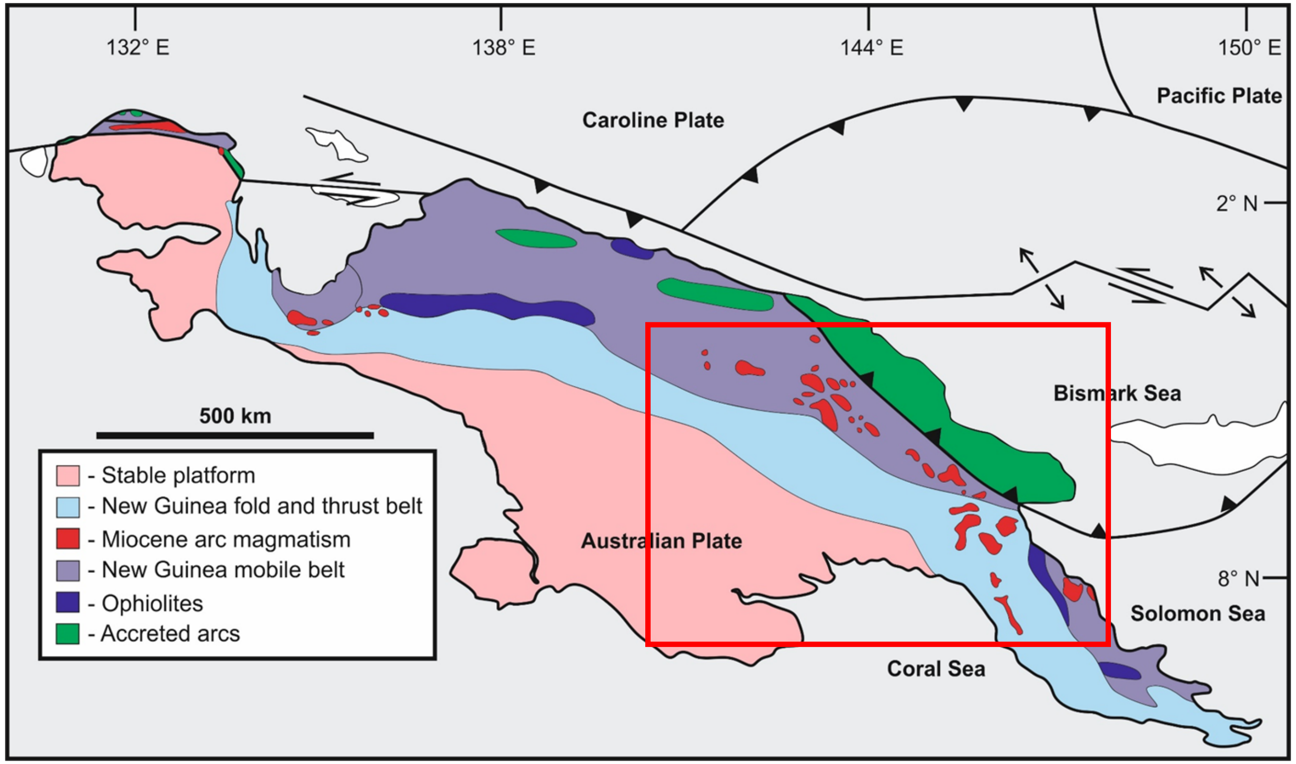
Webb et al., 2020

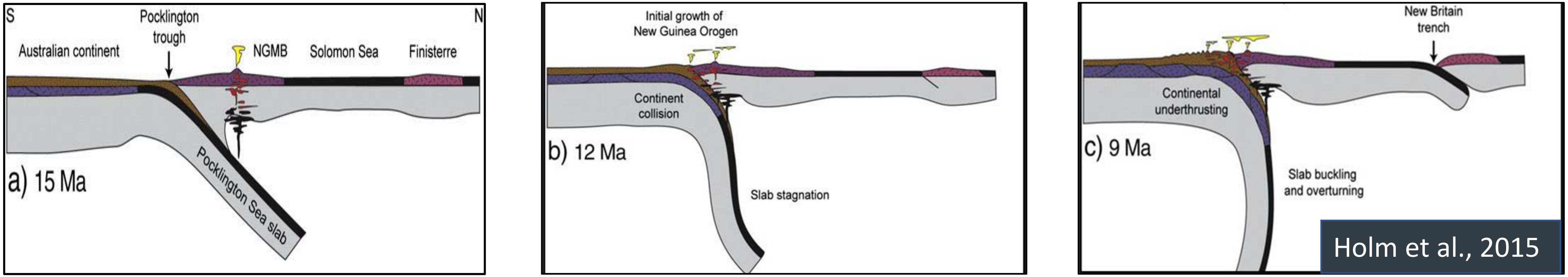
New Guinea tectonics – New ideas

Cenozoic arc magmatism – Eastern New Guinea



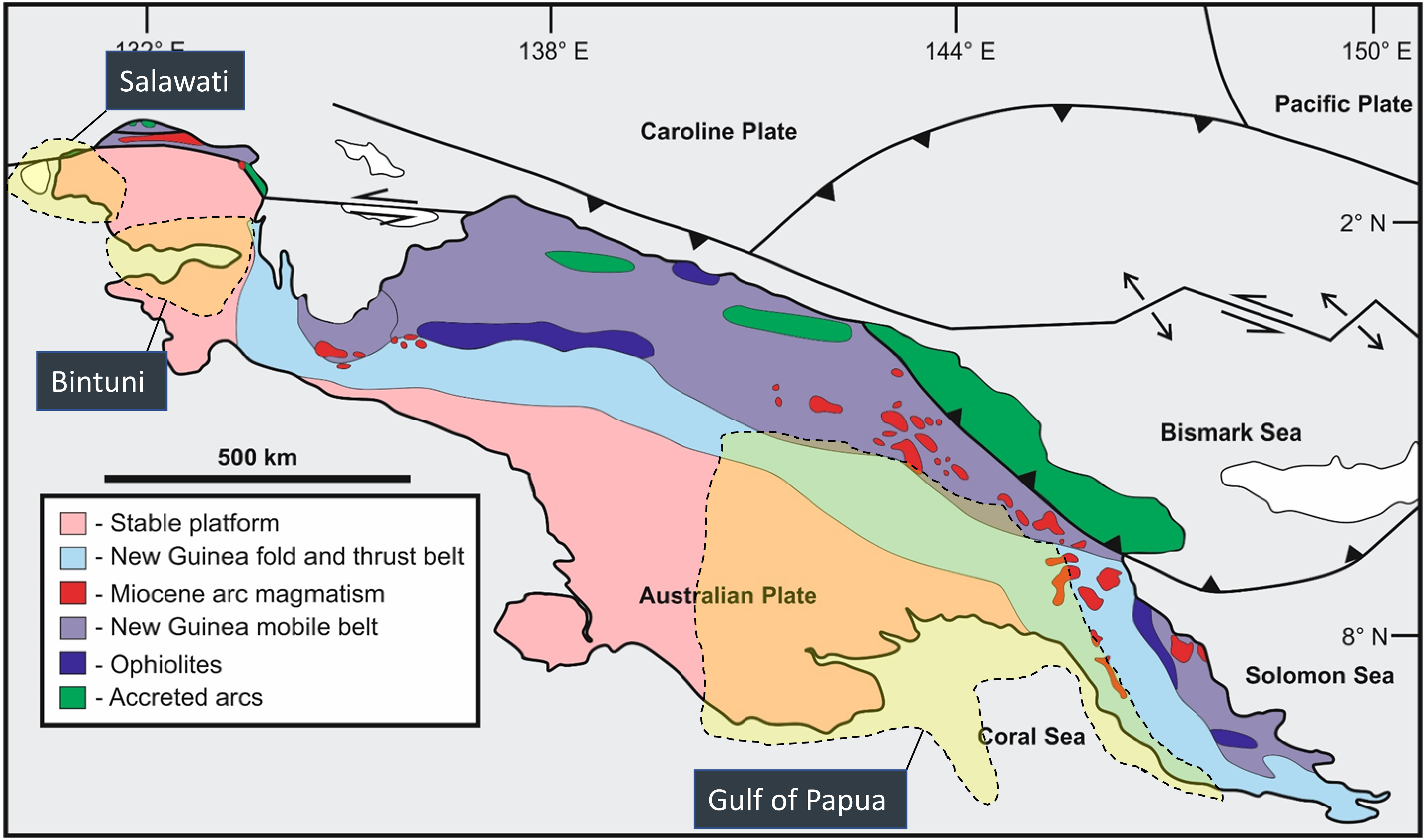
Mahoney et al., 2017





Holm et al., 2015

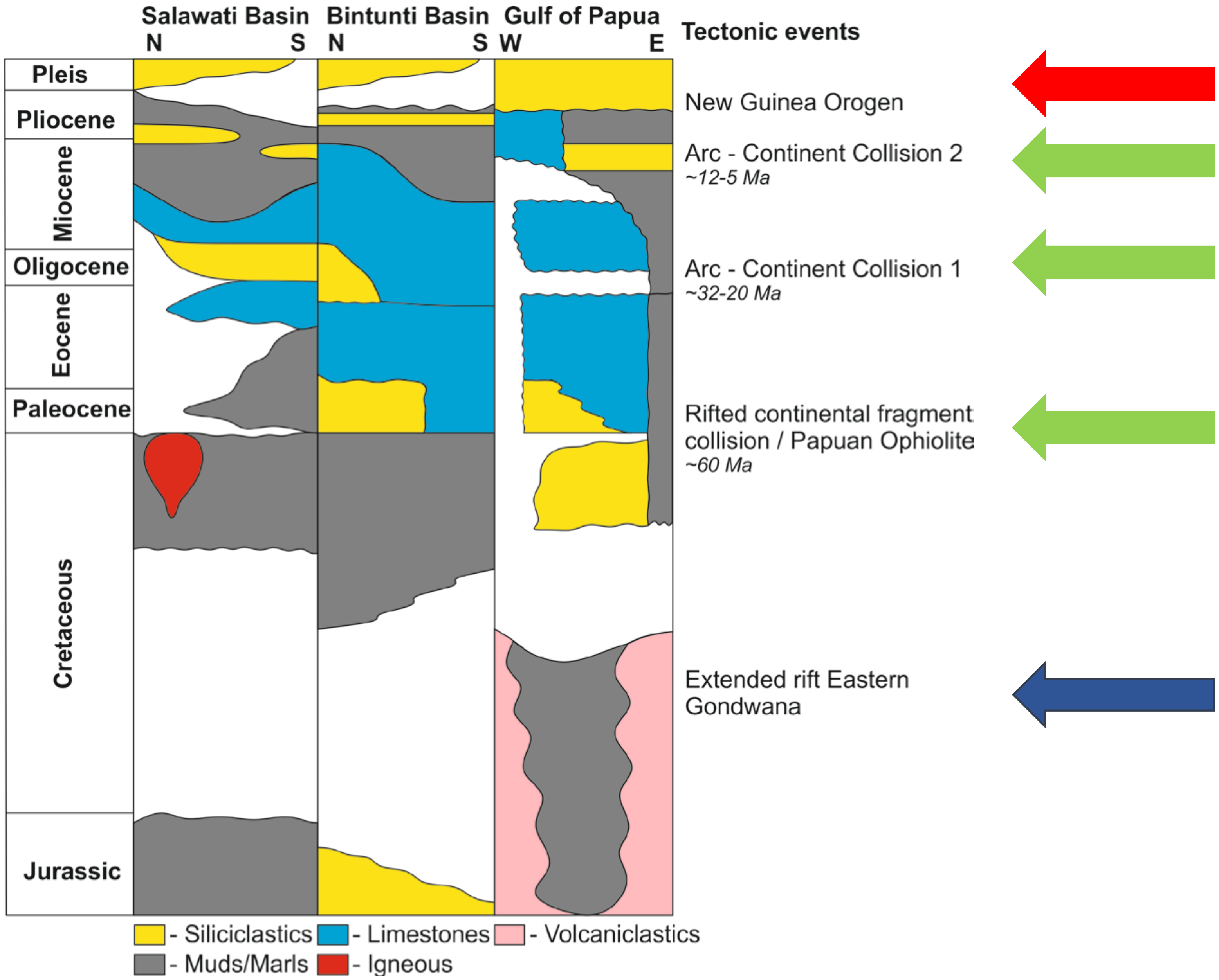
How does this impact the basins?



Basin correlation across New Guinea

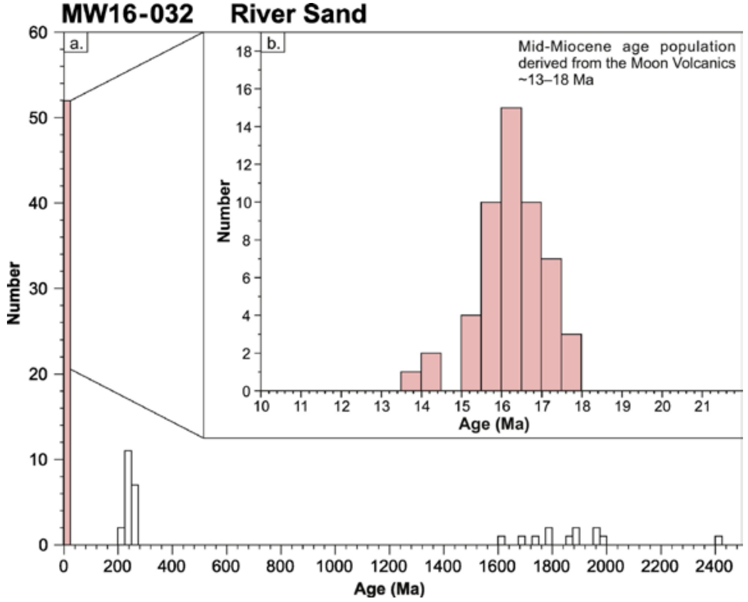
- Clear correlation in the timing of carbonate, sandstone, and mudstone deposition throughout the Salawati Basin, Bintuni Basin, and Gulf of Papua.

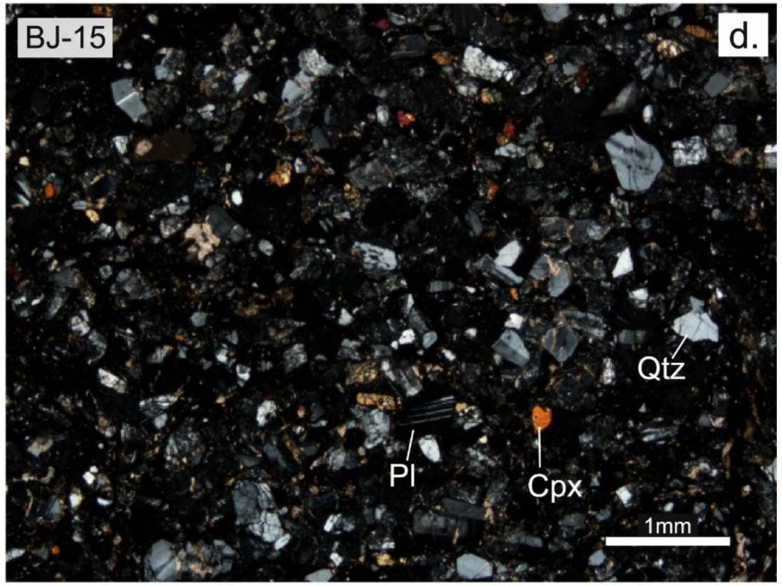
- Five key tectonic events have driven sedimentation and basin formation:
  - Extended rift system along Eastern Gondwana.
  - Collision of the rifted continental fragment.
  - Arc-continent collision 1.
  - Arc-continent collision 2.
  - Final uplift of the New Guinea Orogen.



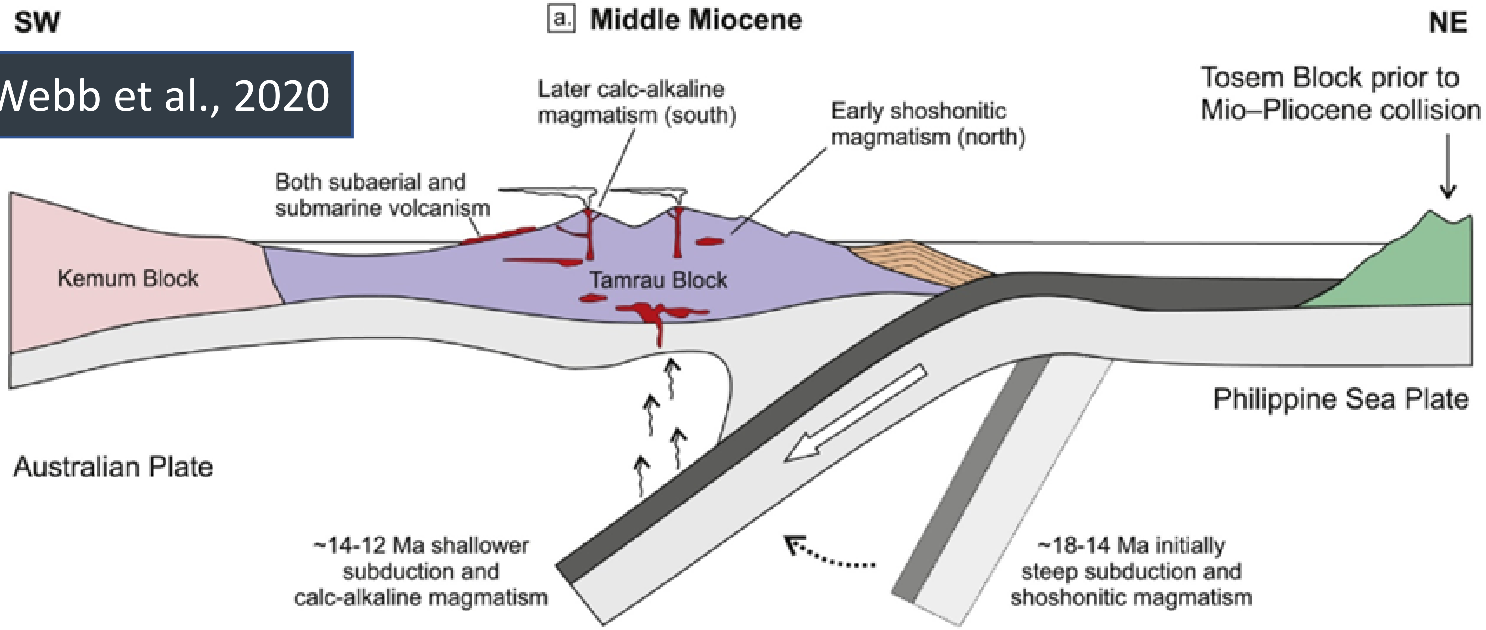
New Guinea tectonics – Importance of arc volcanism

- Collision of the volcanic arcs directly drives deformation and sedimentation into the basins.
- Direct studies of these arcs and their collision history improves chronology of basin evolution.
- Clear age signatures recorded in the detrital record of the sediment.
- Volcaniclastic input important for understanding potential reservoir quality.



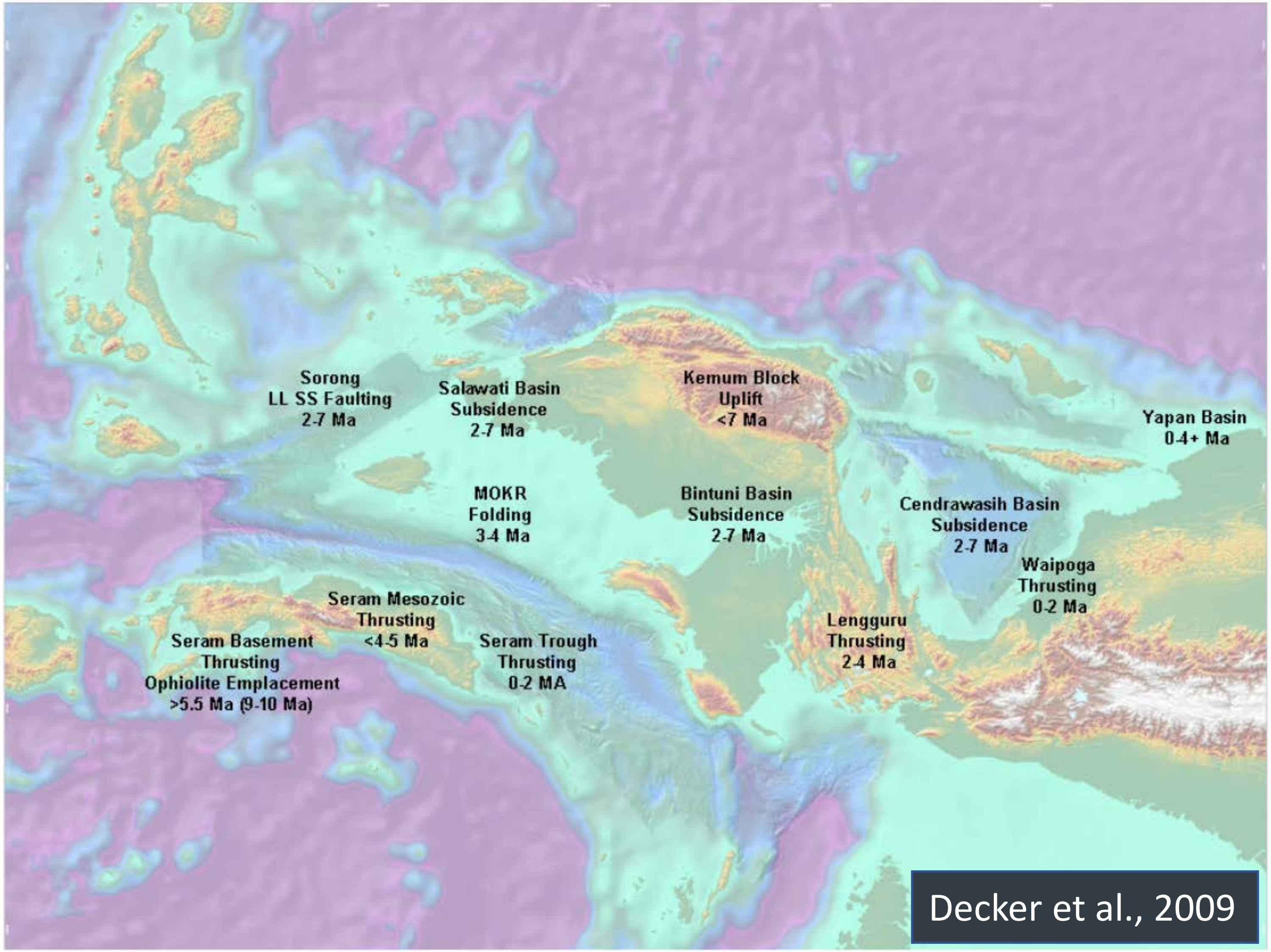


Webb et al., 2020



Bintuni Basin - Overview

- Main hydrocarbon system in Jurassic to Cretaceous quartz-rich clastic sequences.
- Basin impacted by Miocene to Pliocene arc-continent collision.
- Major uplift of the basin bounding highs (Kemum Basement High, Lengguru Fold and Thrust Belt, Misool-Onin-Kumawa Ridge).
- Alternating carbonate and siliciclastic deposition throughout the Cenozoic.

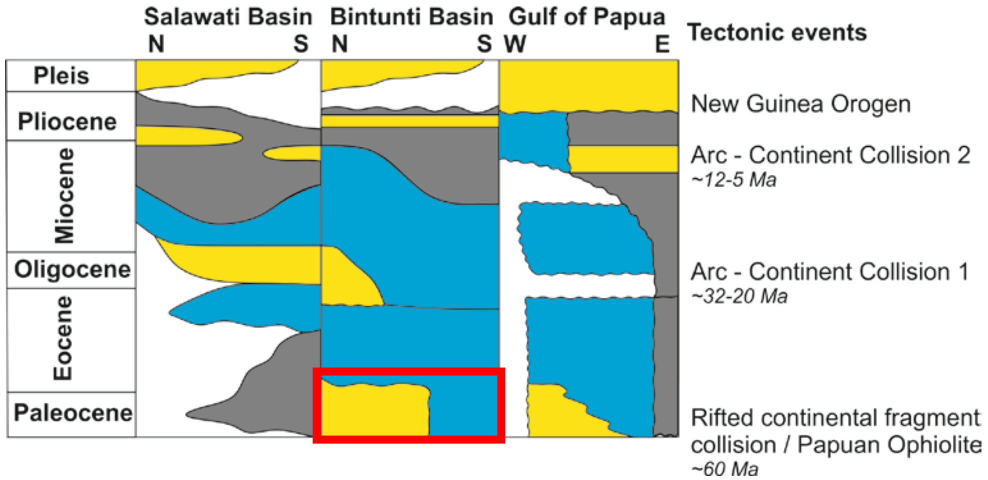


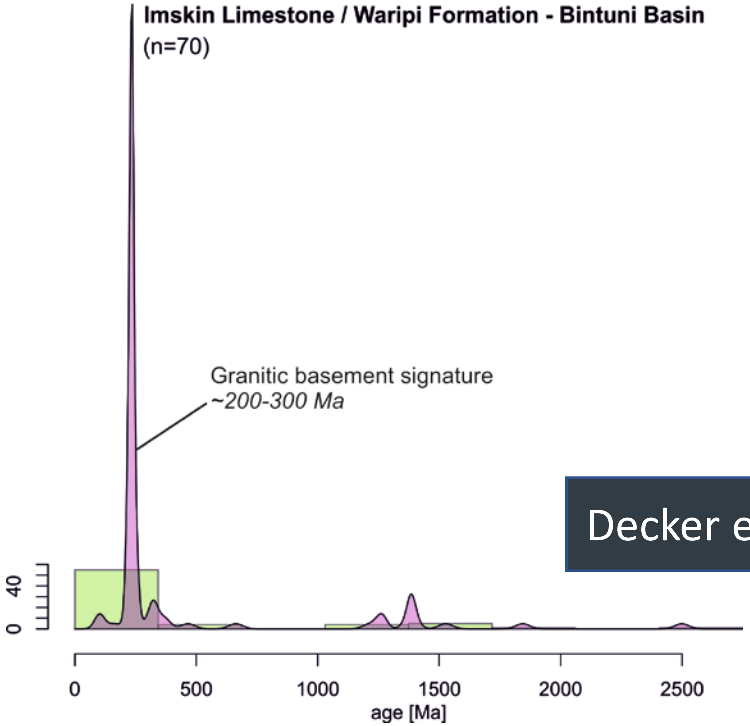
Decker et al., 2009

Bintuni Basin – Response to continental fragment collision

Imskin / Waripi Formation:

- Paleocene age
- Interbedded sandstones and marls
- Tilted post-deposition
- Heavy input from granitic basement shown in detrital record



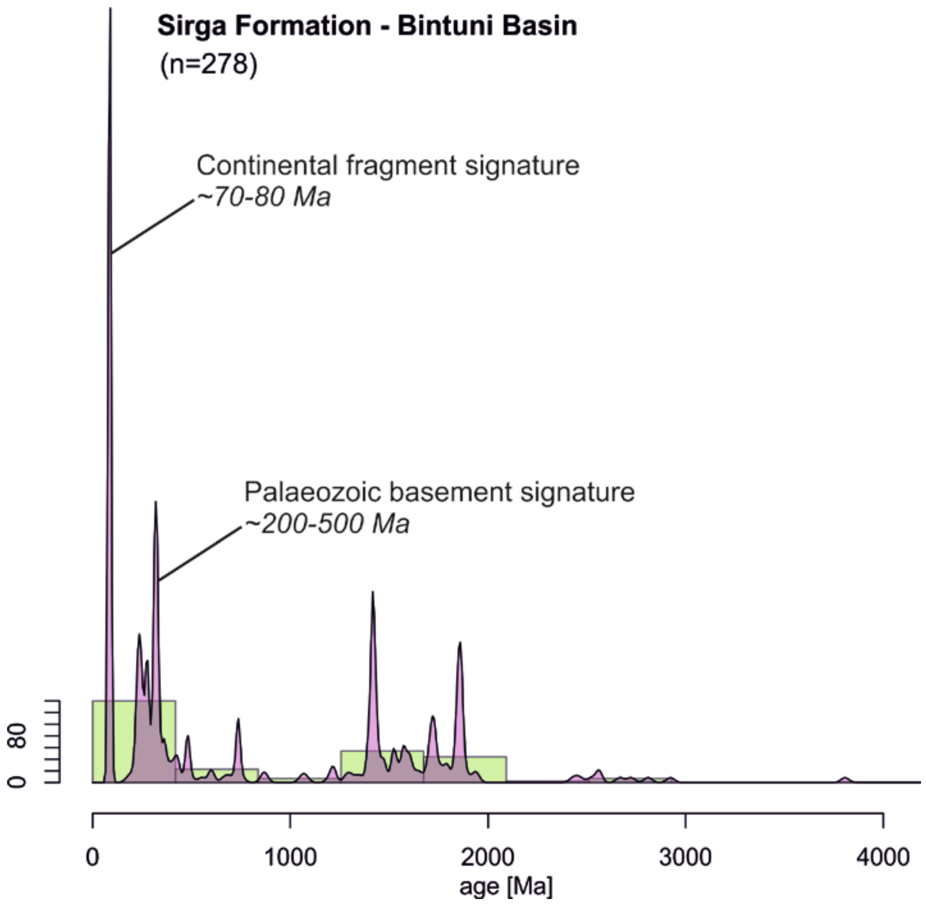


Decker et al., 2017

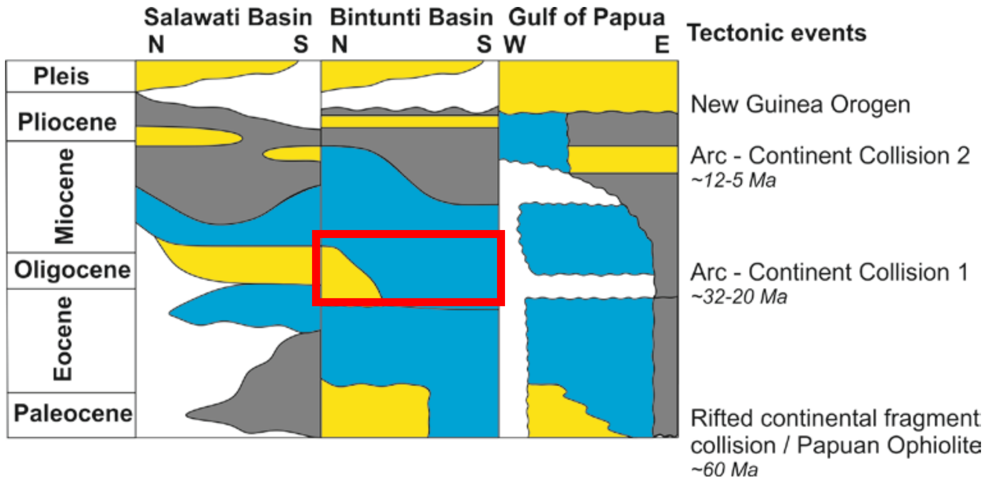
Bintuni Basin – Response to arc-continent collision 1

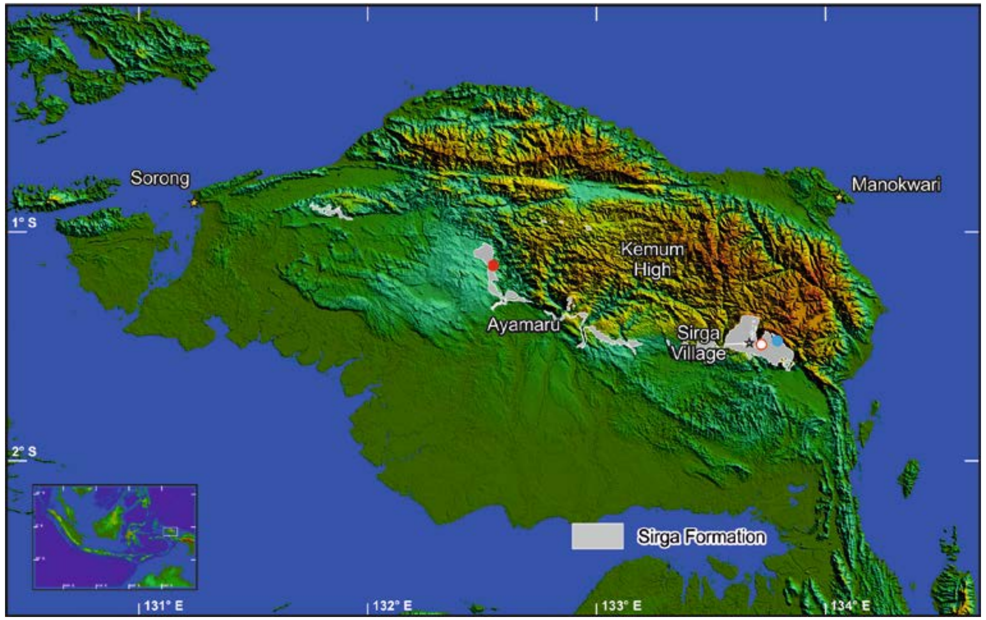
Sirga Formation:

- Oligocene age
- Very poorly exposed
- Significant input from rifted continental fragment source
- Additional input from Palaeozoic basement



Gunawan, 2013

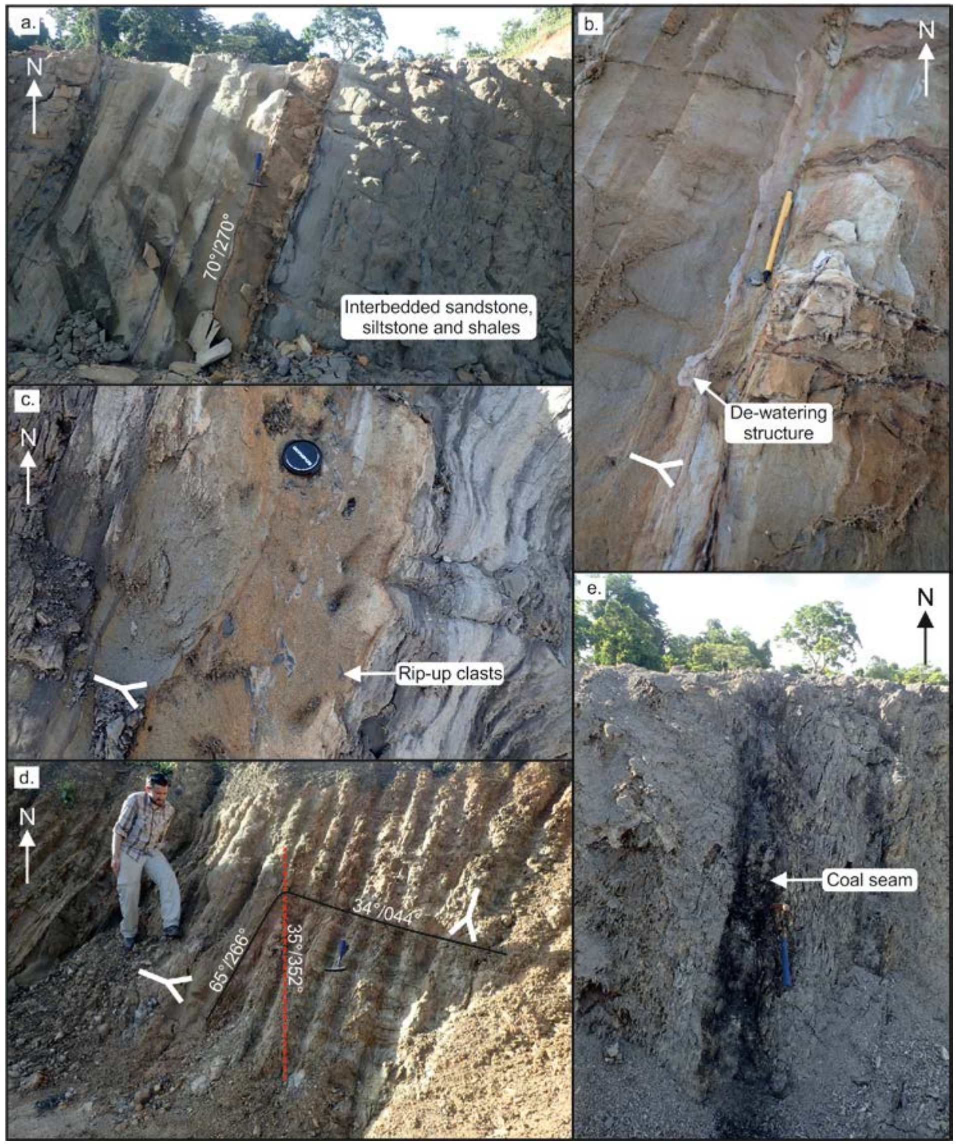


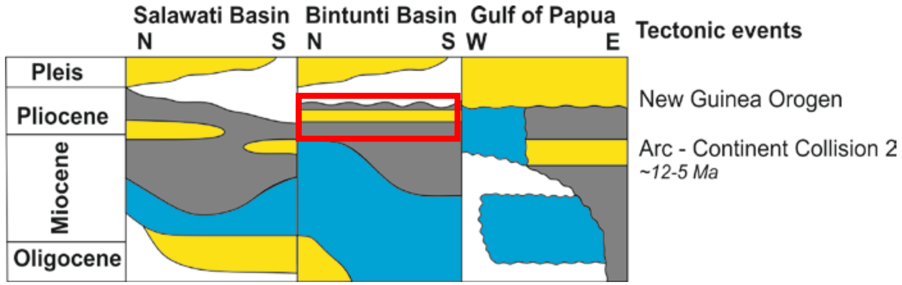


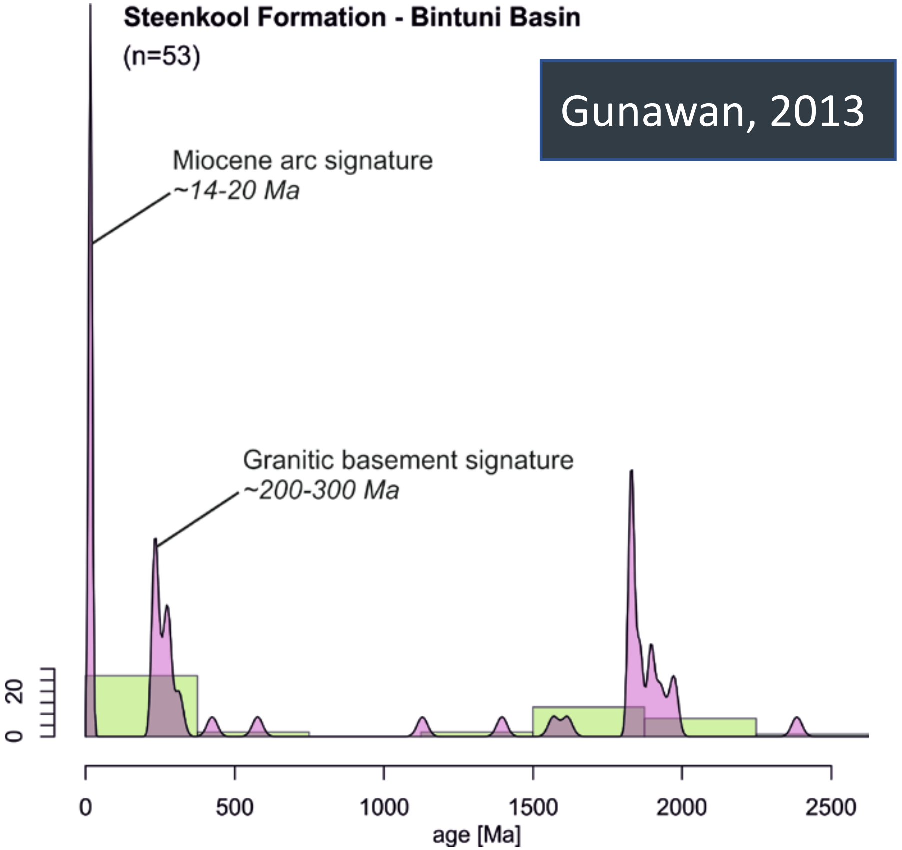
Bintuni Basin – Response to arc-continent collision 2

Steenkool Formation:

- Pliocene age
- Interbedded sands, silts, and shales
- Tilted & folded post-deposition
- Clear volcanic arc signature in the zircon record
- Evidence for additional basement input





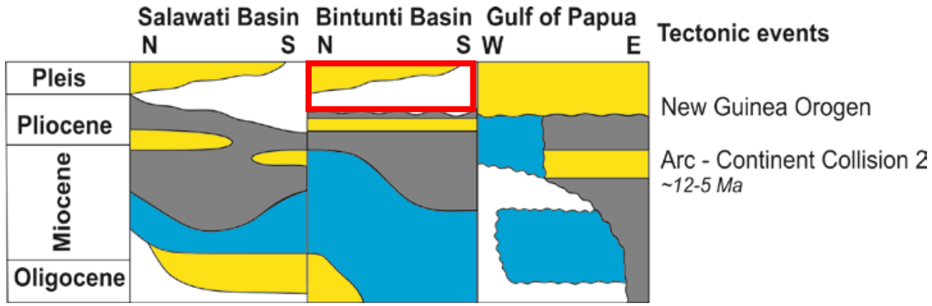


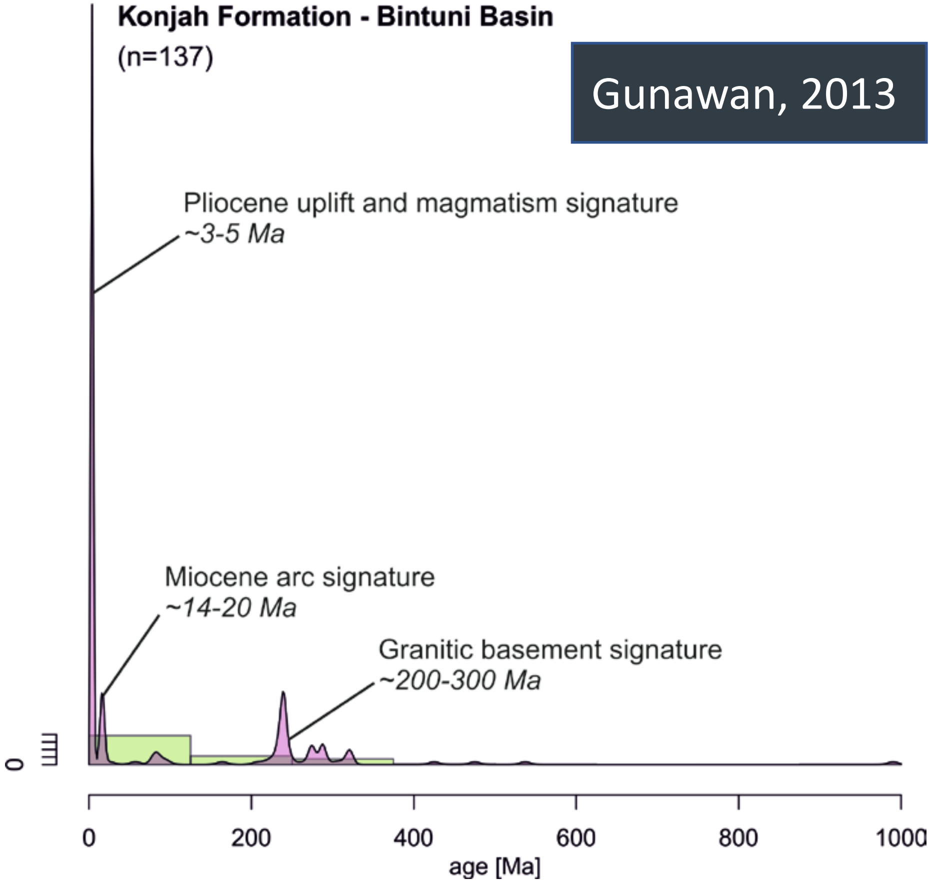
Gunawan, 2013

Bintuni Basin – Response to the New Guinea Orogen

Konjah Formation:

- Pleistocene age
- Conglomeratic sands with volcanic clasts
- Clear volcanic arc signature in the zircon record from two events
- Shows a reduction in basement input

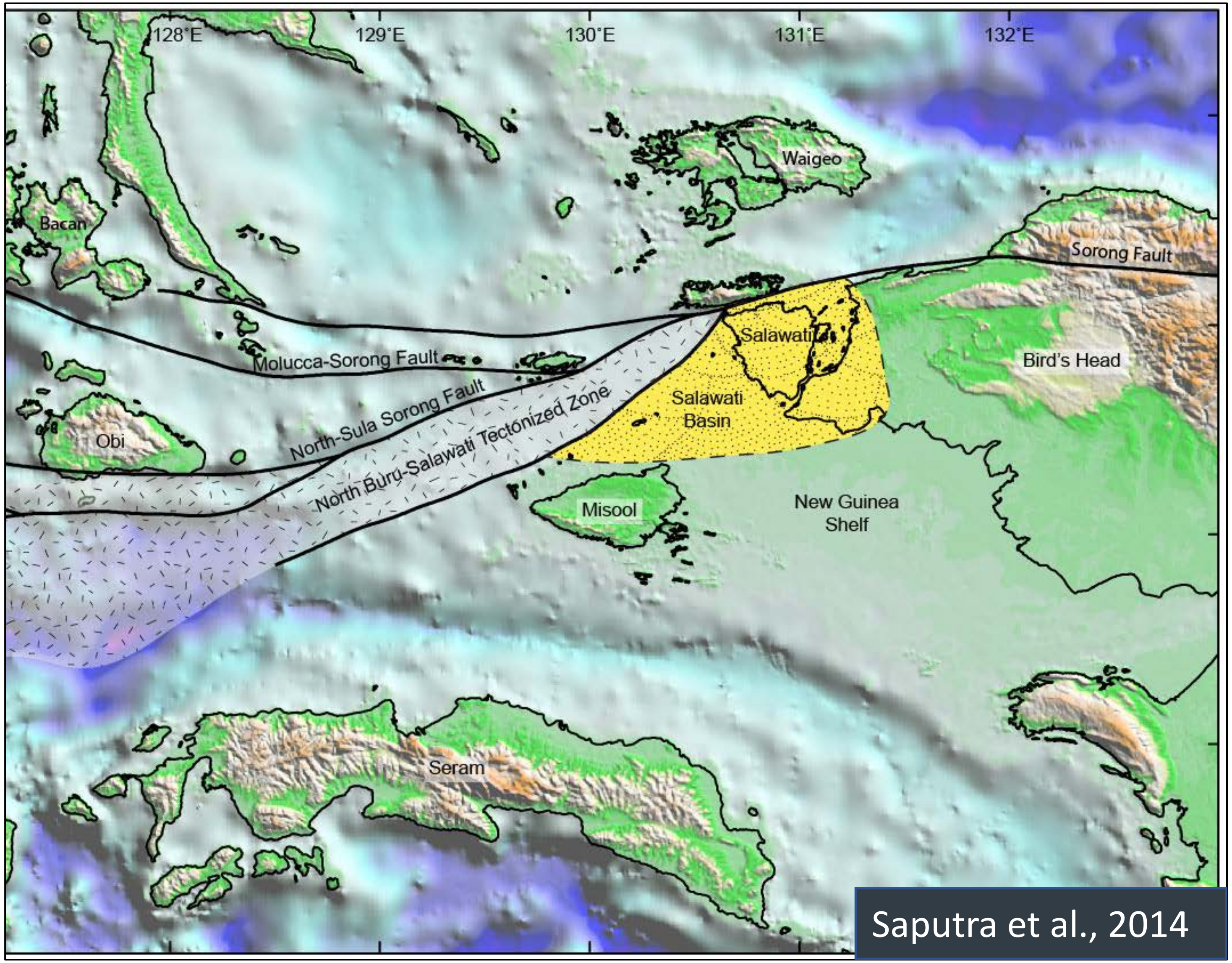




Gunawan, 2013

Salawati Basin - Overview

- Younger hydrocarbon system with source rocks in the Miocene Klasafet Formation and Kais Limestone.
- Bound by Sorong Fault Zone to north and west – this has driven basin development since mid-Pliocene.
- SFZ movement has resulted in a basin polarity reversal – the depocenter has switched from the south to north.
- Alternating carbonate and siliciclastic deposition throughout the Cenozoic.

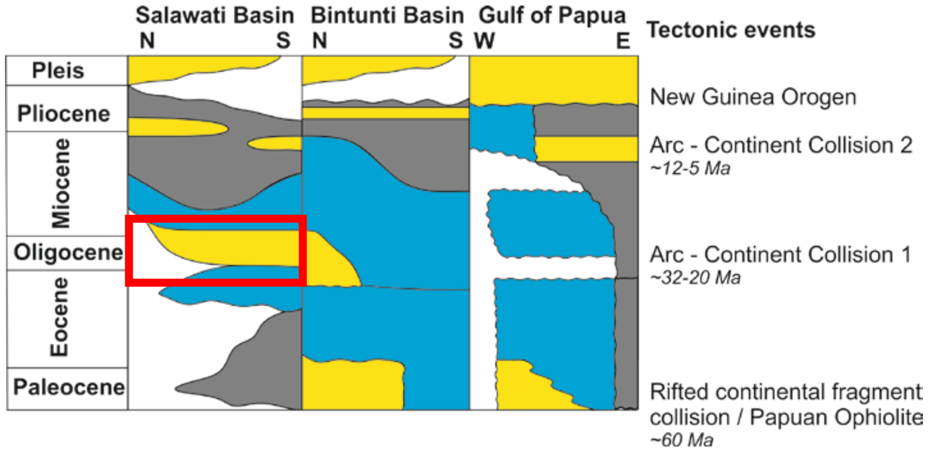


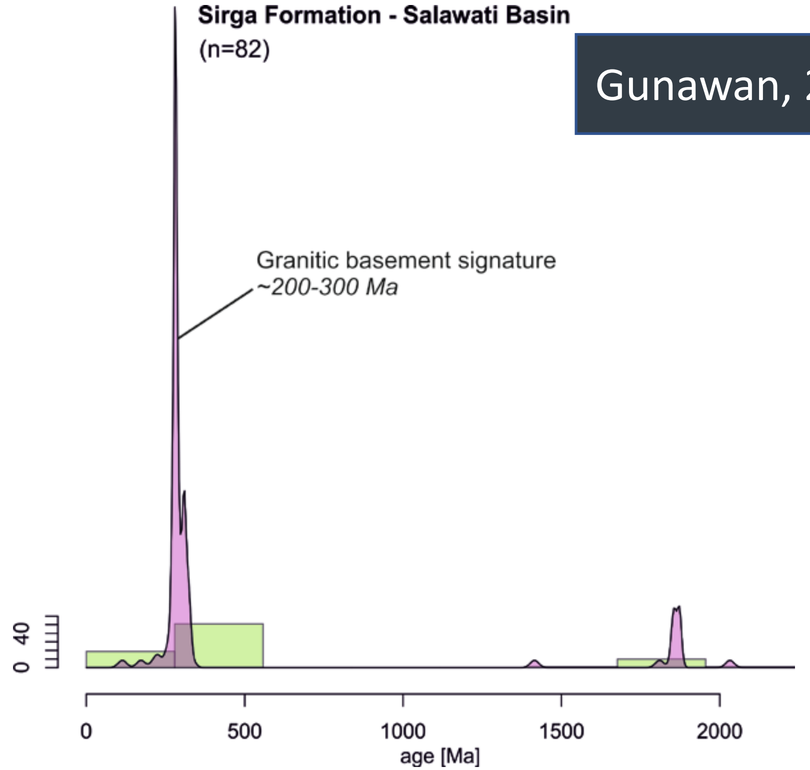
Saputra et al., 2014

Salawati Basin – Response to arc-continent collision 1

Sirga Formation:

- Oligocene age
- Calcareous sands, laminated muds and silts with coal fragments
- Very strong granitic basement signature in detrital record
- Granitic source general indicative of clean sands



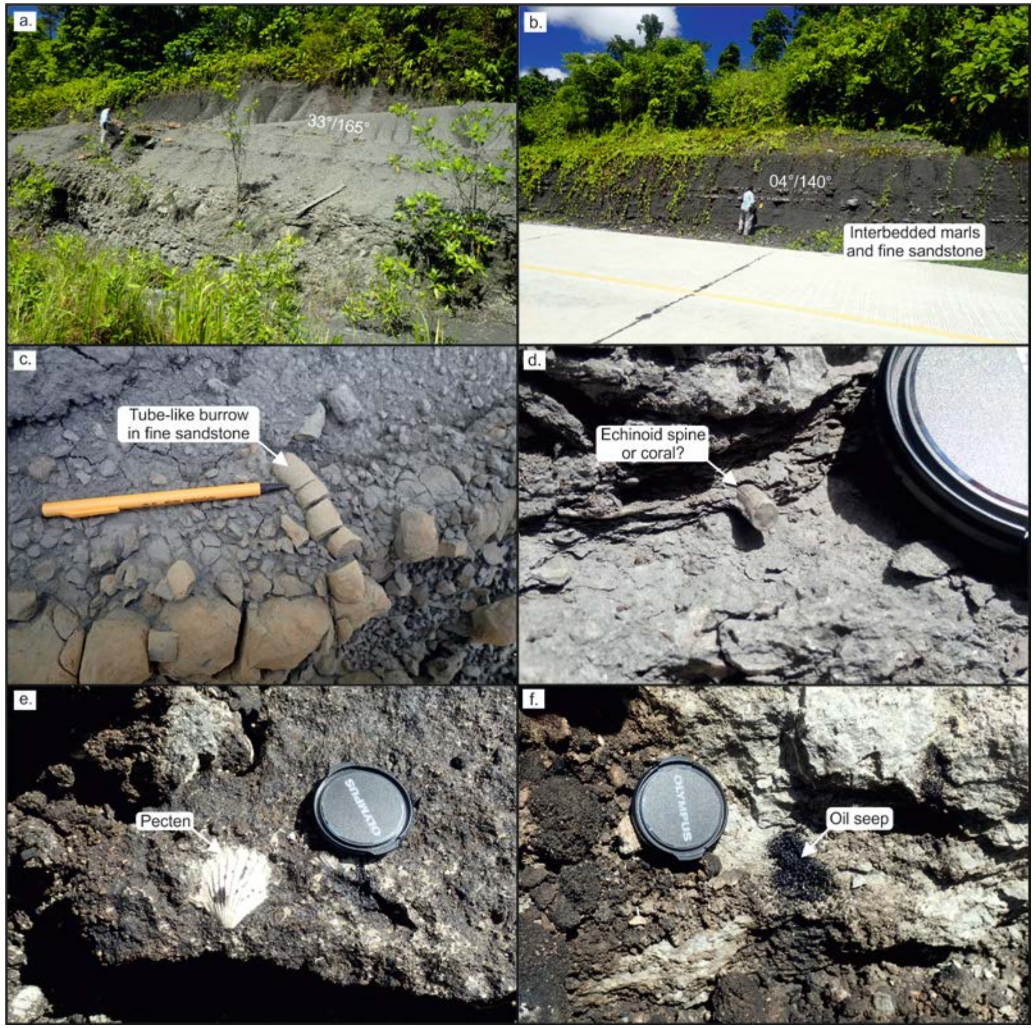


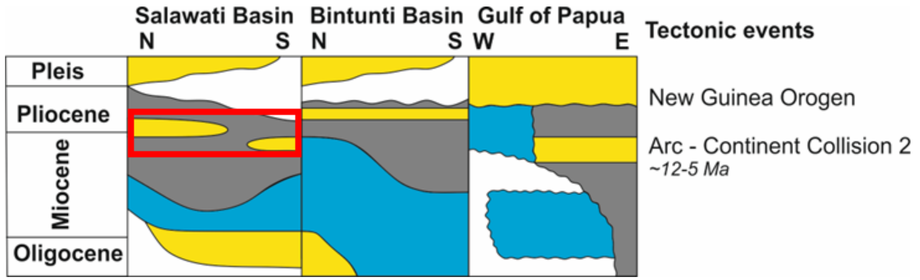
Gunawan, 2013

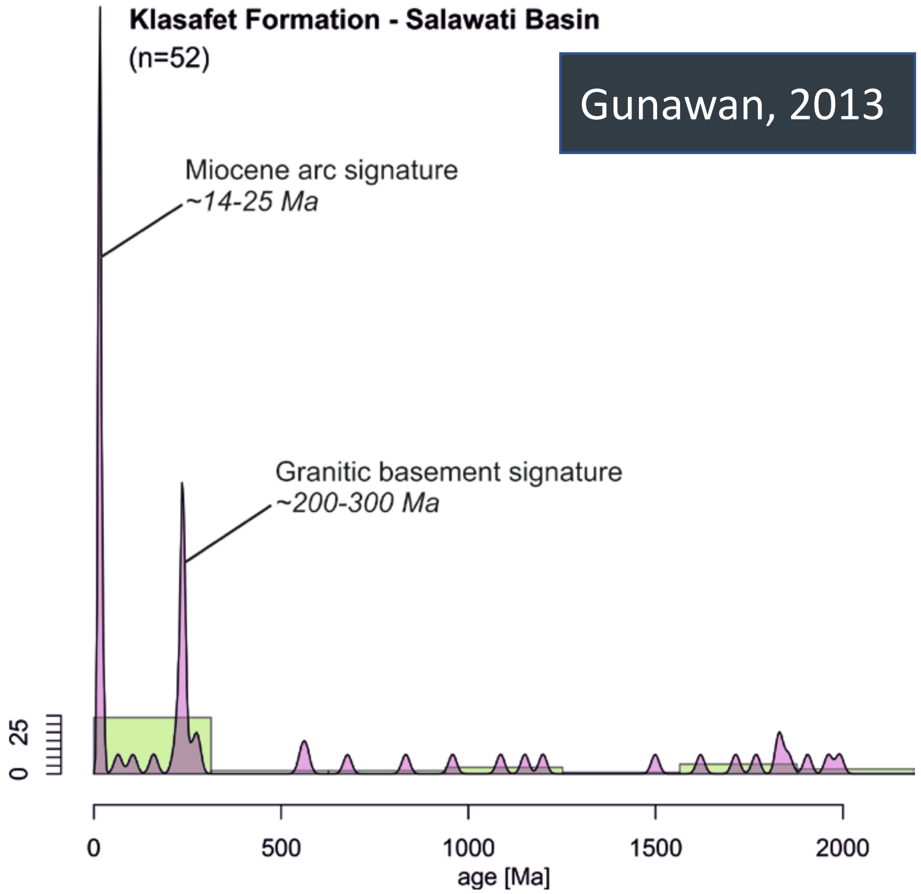
Salawati Basin – Response to arc-continent collision 2

Klasafet Formation:

- Pliocene age
- Interbedded marls and sands
- Relatively undeformed
- Clear volcanic arc signature in the zircon record
- Evidence for additional basement input

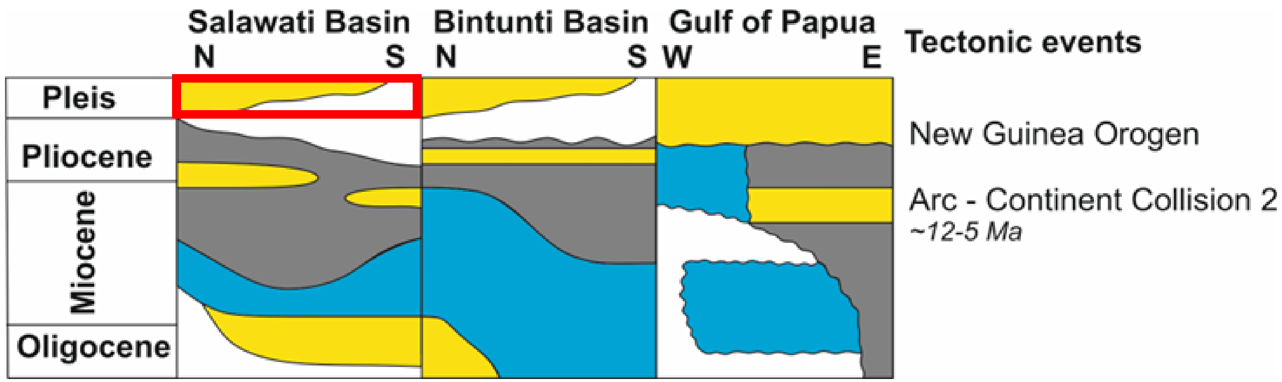


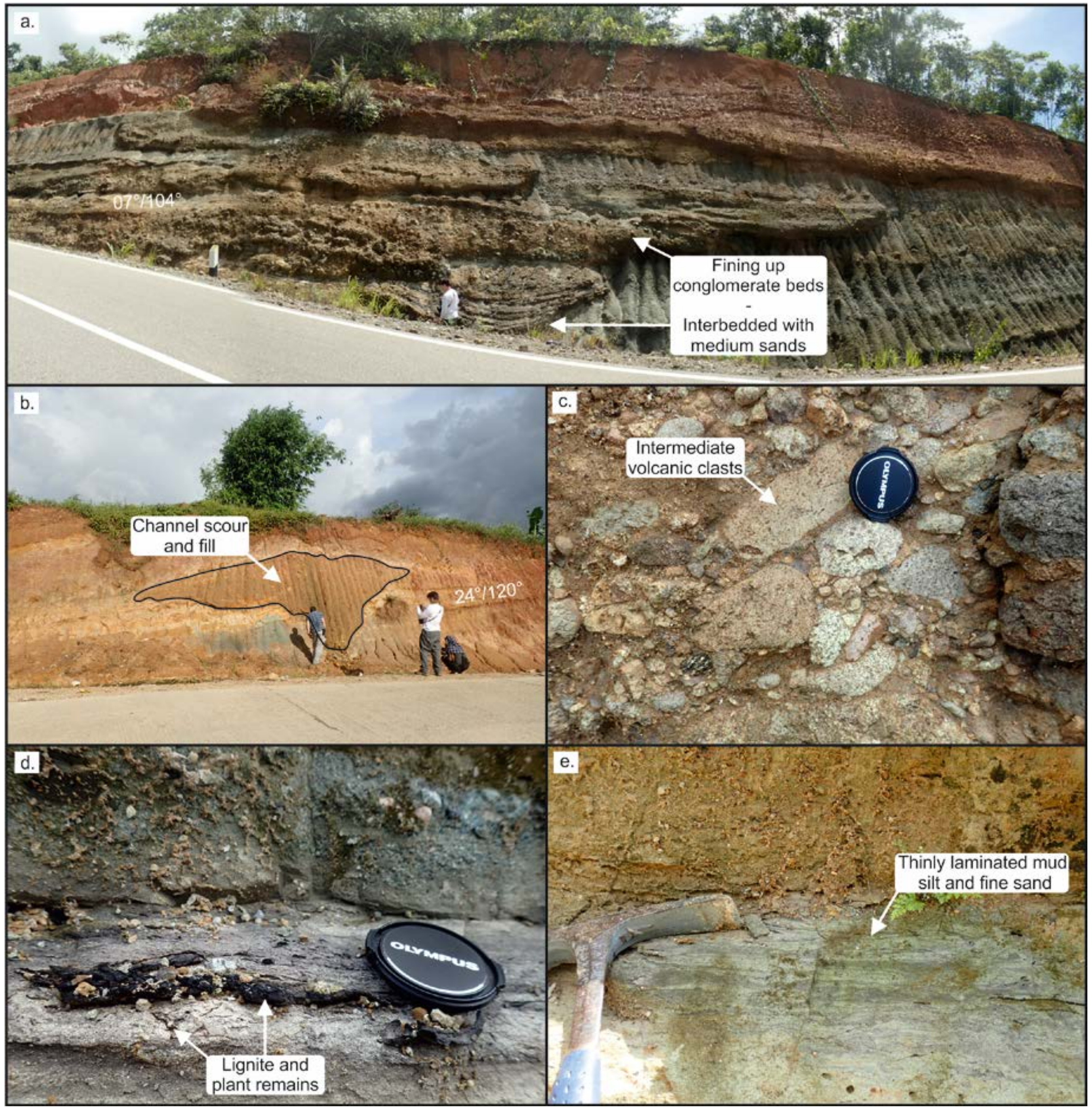




Gunawan, 2013

Salawati Basin – Response to the New Guinea Orogen



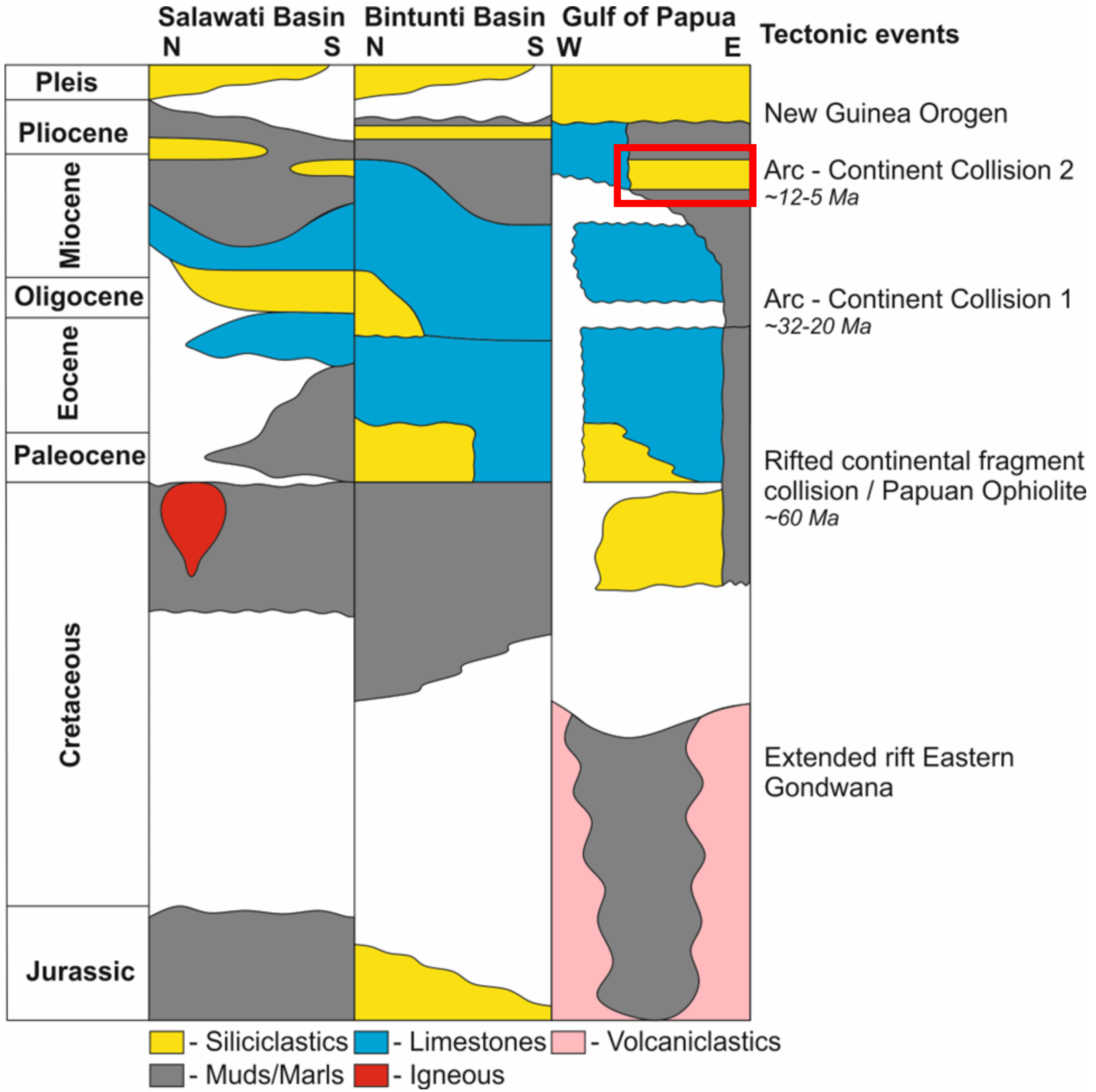


Sele Conglomerate:

- Pleistocene age
- Interbedded medium sands and conglomerates
- Channel scours, plant remains, and laminated muds and sands
- Abundant intermediate volcanic clasts (arc material)
- No zircon data yet

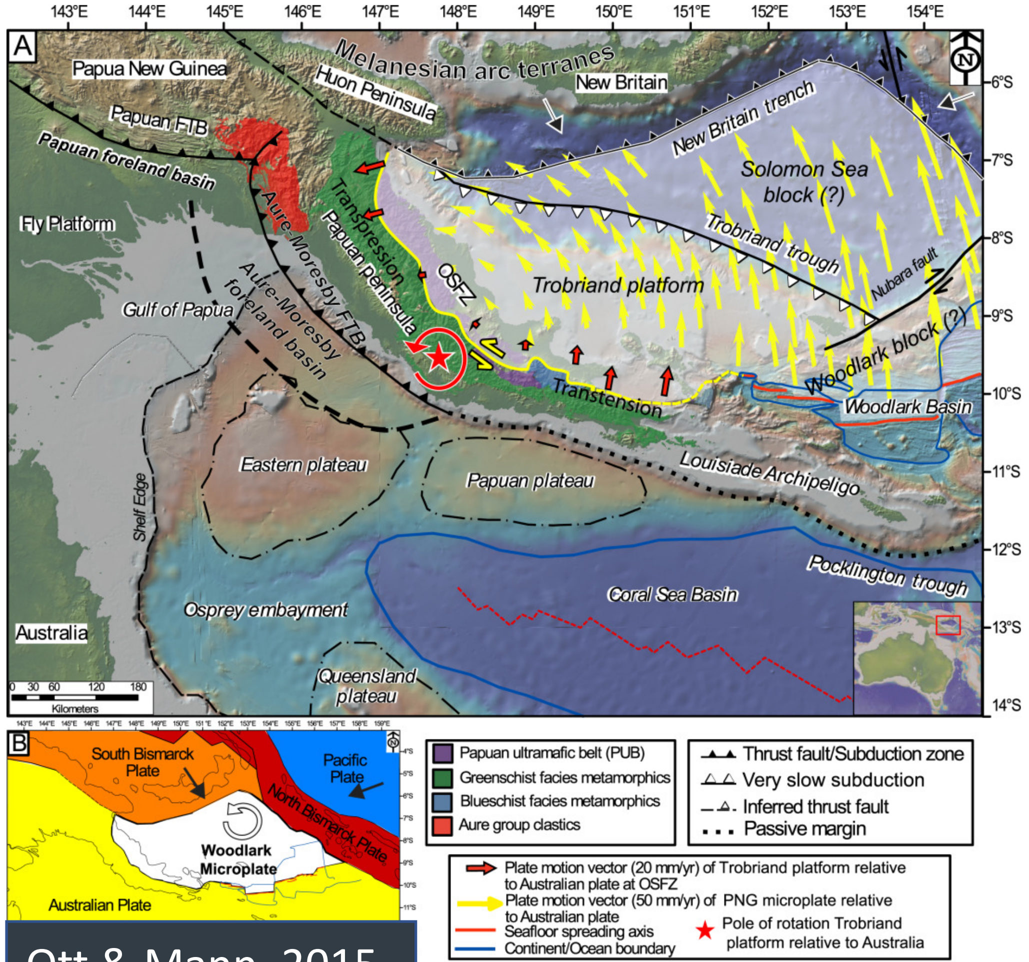
Implications for the Gulf of Papua

- Shared tectonic and sedimentation history with the Salawati and Bintuni Basins.
- Arc-continent collision 1 is marked by a regional unconformity.
- Mesozoic sections dominated by volcaniclastics within the extended rift zone.
- Emerging plays within Mid-Miocene turbidites and Pliocene sands of the Aure-Moresby Fold and Thrust Belt.
- New field campaigns could provide insight into uplift history, sediment sourcing, and routing pathways.

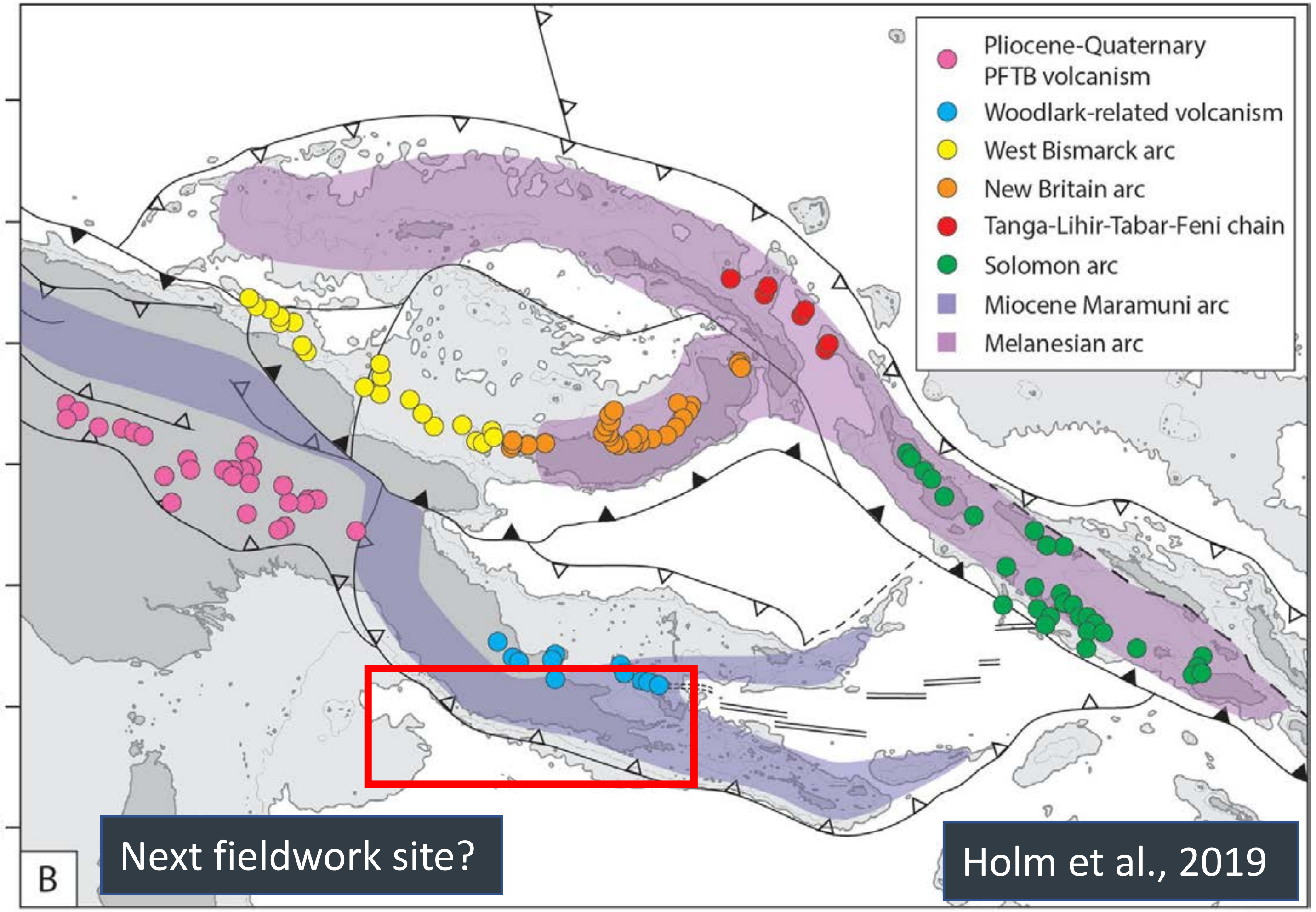


Implications for the Gulf of Papua

- Uplift and related sedimentation driven by microplate rotation and terminal arc-continent collision since ~10-7 Ma.
- Quartz-rich sands likely fed by felsic volcanics (Maramuni Arc) and rifted continental fragment (Owen Stanley Ranges)



Ott & Mann, 2015



Next fieldwork site?

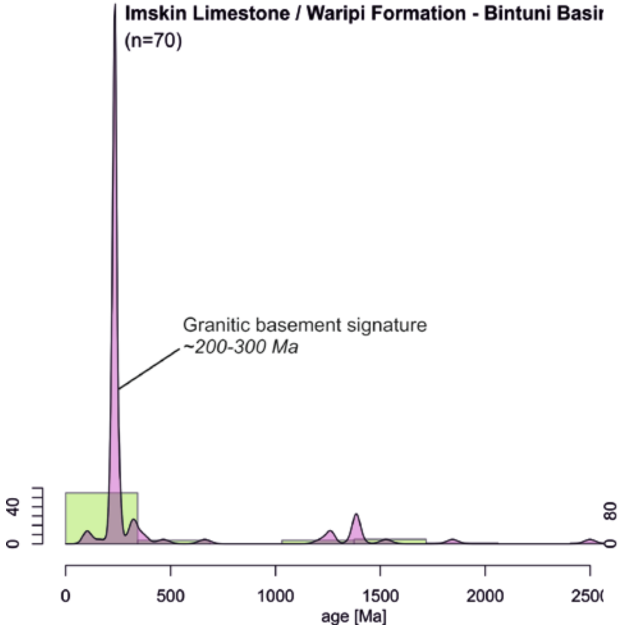
Holm et al., 2019

Impact of arc collision on sedimentary provenance and routing pathways

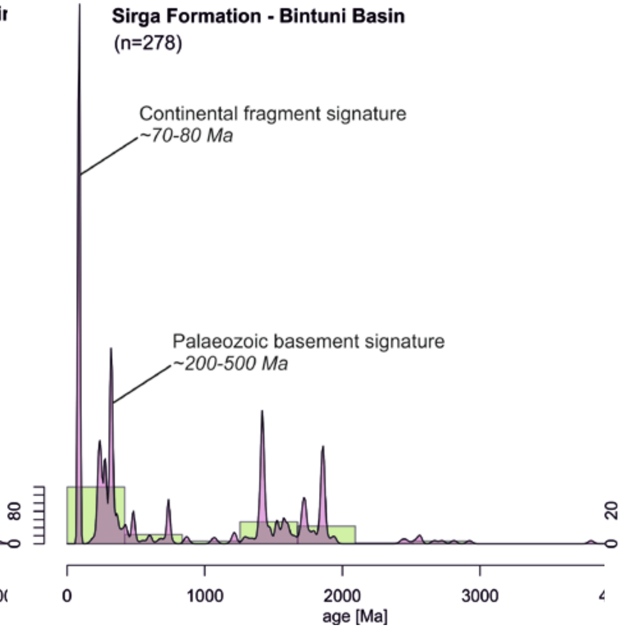
- **Progressive collisional events in New Guinea have allowed different sources of sediment to become available for erosion and deposition at different times.**

- **Understanding the overall tectonic history allows us to link specific sediment packages to key collisional events and understand when and how sediment has occurred in basins along the margin of collision.**

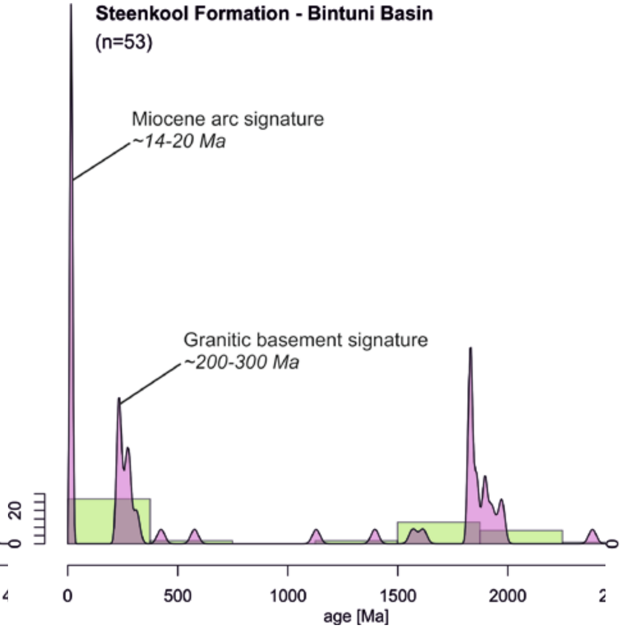
Continental fragment collision



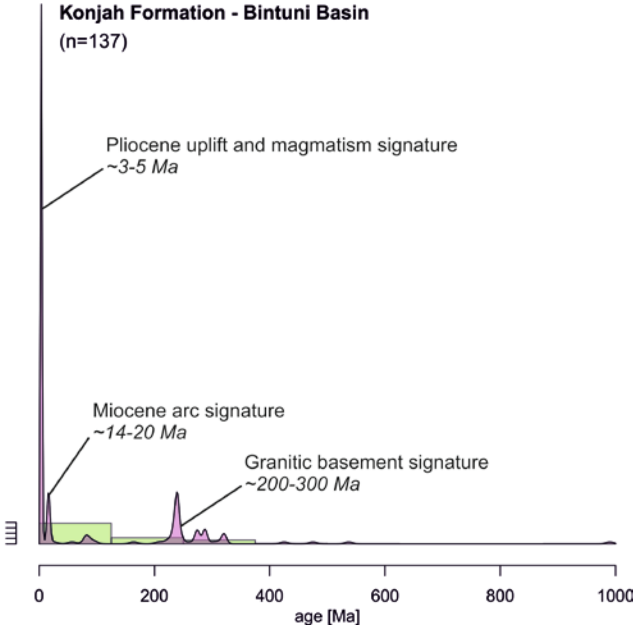
Arc-continent collision 1



Arc-continent collision 2



New Guinea Orogen



Conclusions and future work

Conclusions:

- The collisional history of New Guinea has driven siliciclastic sedimentation during three separate events throughout the Cenozoic:
  - **Continental fragment collision - 60 Ma**
  - **Arc-continent collision 1 – 32 to 20 Ma**
  - **Arc-continent collision 2 – 12 to 5 Ma**
- Sandy sediment deposition is observed during these three intervals within the Salawati Basin, Bintuni Basin, and the Gulf of Papua
- Fieldwork is important, zircon geochronology and provenance is important, more that just the sediment.

Future work:

- Upcoming expedition to the understudied Cyclops Mountains in June 2023.
- More onshore studies of the collisional history surrounding the Gulf of Papua is necessary.

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