Is it as mature as you think? Redefining the textural maturity of sediments in Southeast Asia: Implications for Reservoir Quality

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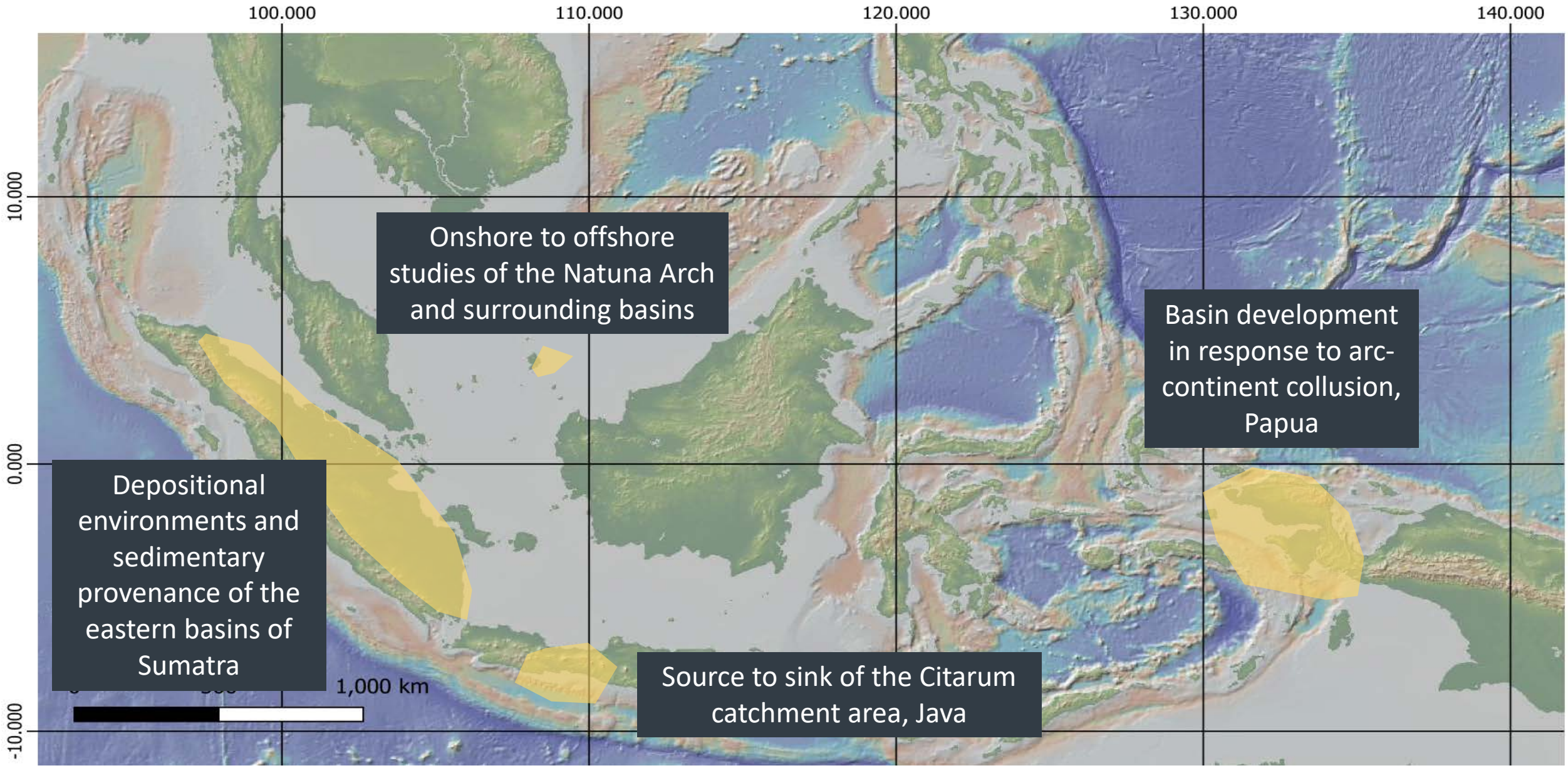
SEARG
SOUTHEAST ASIA RESEARCH GROUP

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Current Research Streams



It is a truth universally acknowledged…

That in terms of sedimentology, the reality of SE Asia is often different from the expectation…

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This in large part due to the complex depositional history causing diverse sedimentation patterns in a range of depositional environments

But boots on the ground fieldwork can address a lot of these uncertainties…

Estimated Sediment Yields

About 25 % of global sediment comes from SE Asian Islands – 2% of land area

- Borneo has provided sediment at about the same rate per unit area as the Himalayas in the last 20-25 Ma
- The Salin Sub-Basin, Myanmar, shows 18 km of subsidence and equal sedimentation just since the Cenozoic
- High present-day and long-term yields must imply prolonged tectonic activity to maintain relief

Mahakam Delta, Borneo

Estimated Sediment Yields

Philippines:
612 Mt / yr

Himalayan Comparison:

Brahmaputra: 1157 Mt / yr
Ganges: 680 Mt / yr
Indus: 300 Mt / yr

Total: 2140 Mt / yr

Malay Peninsula:
388 Mt / yr

Borneo:
581 Mt / yr

Sumatra:
783 Mt / yr

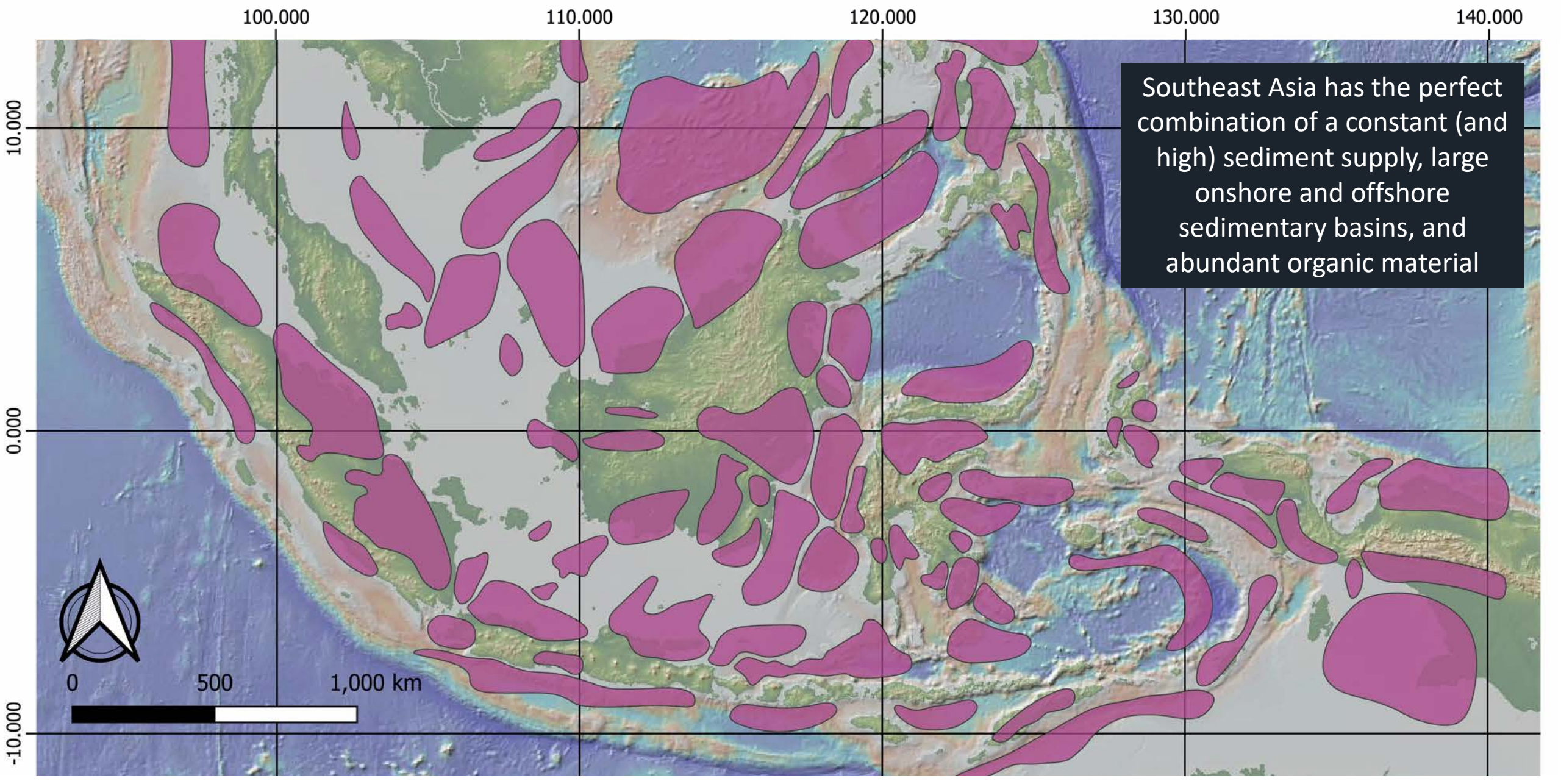
Sulawesi:
454 Mt / yr

New Guinea:
1756 Mt / yr

Java:
323 Mt / yr

Total SE Asia: 5170 Mt / yr = about 25% of total global yield

Sedimentary Basins of SE Asia



Southeast Asia has the perfect combination of a constant (and high) sediment supply, large onshore and offshore sedimentary basins, and abundant organic material

Sediment Yields

Huge sediment yields from high rainfall, short mountainous rivers

Volcanic Quartz

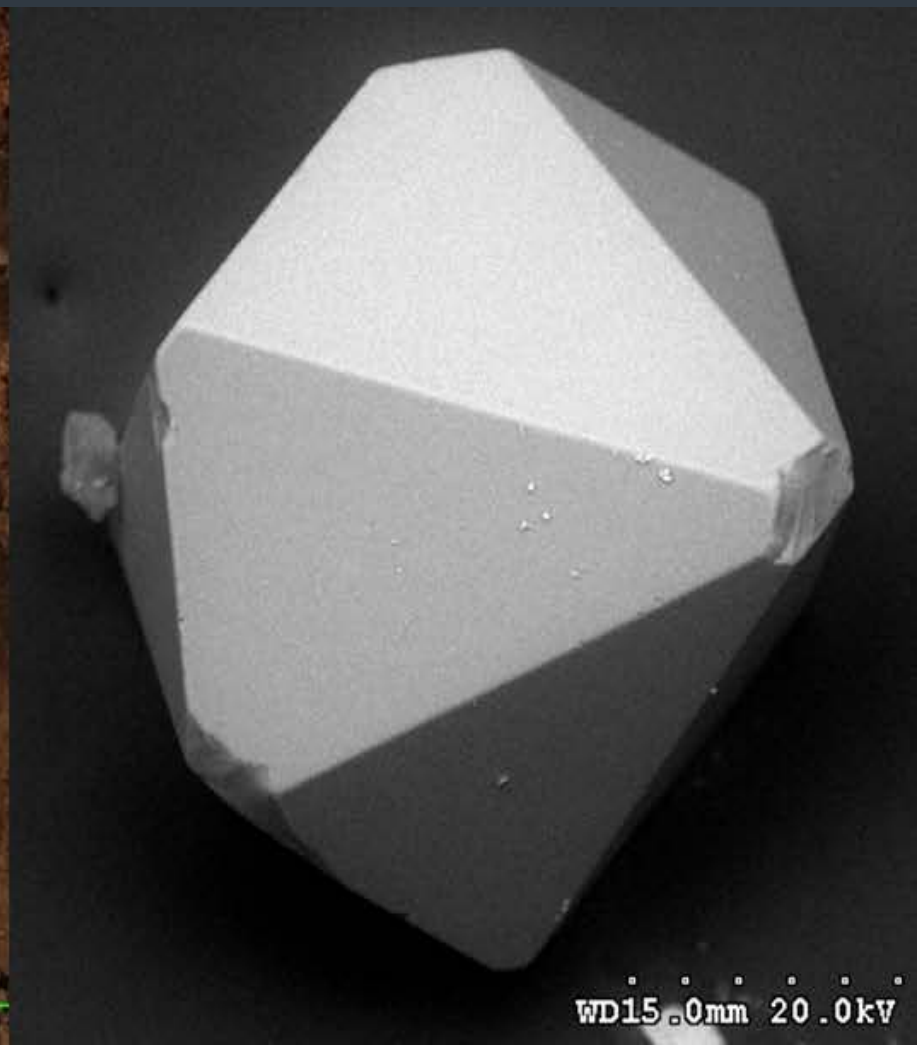
Due to the influx of volcanic material in SE Asia, sediment samples are compositionally mature but texturally *immature*

The key to understanding the nature of the sedimentary fill is to understand the volcaniclastic input into the basins…

Smyth et al., 2008 – case study from Java

Volcanic Quartz

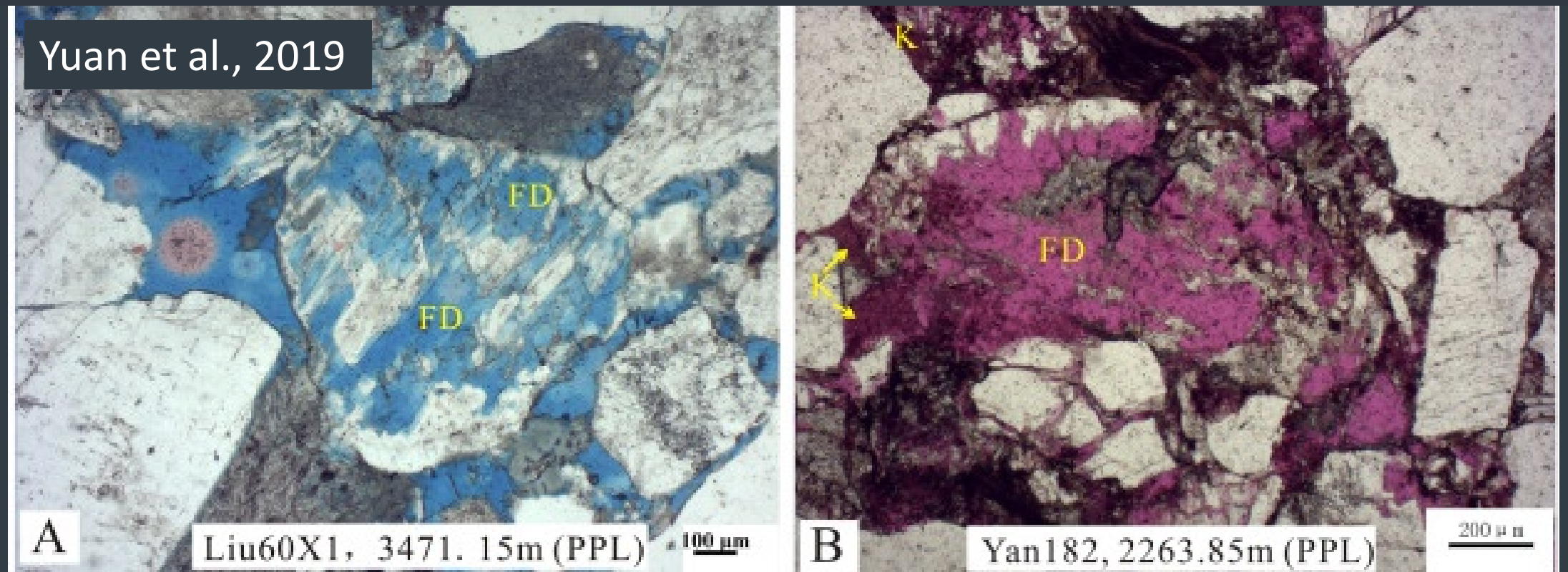
Volcanic quartz-rich sandstones in all areas previously considered to be eroded from old continental regions – misapplication of provenance diagrams derived from temperate North America



Feldspar Dissolution (shallow)

Feldspar undergoes rapid diagenesis during transportation in tropical climates

During shallow burial, feldspar dissolution can increase secondary permeability, and could enhance CCS systems

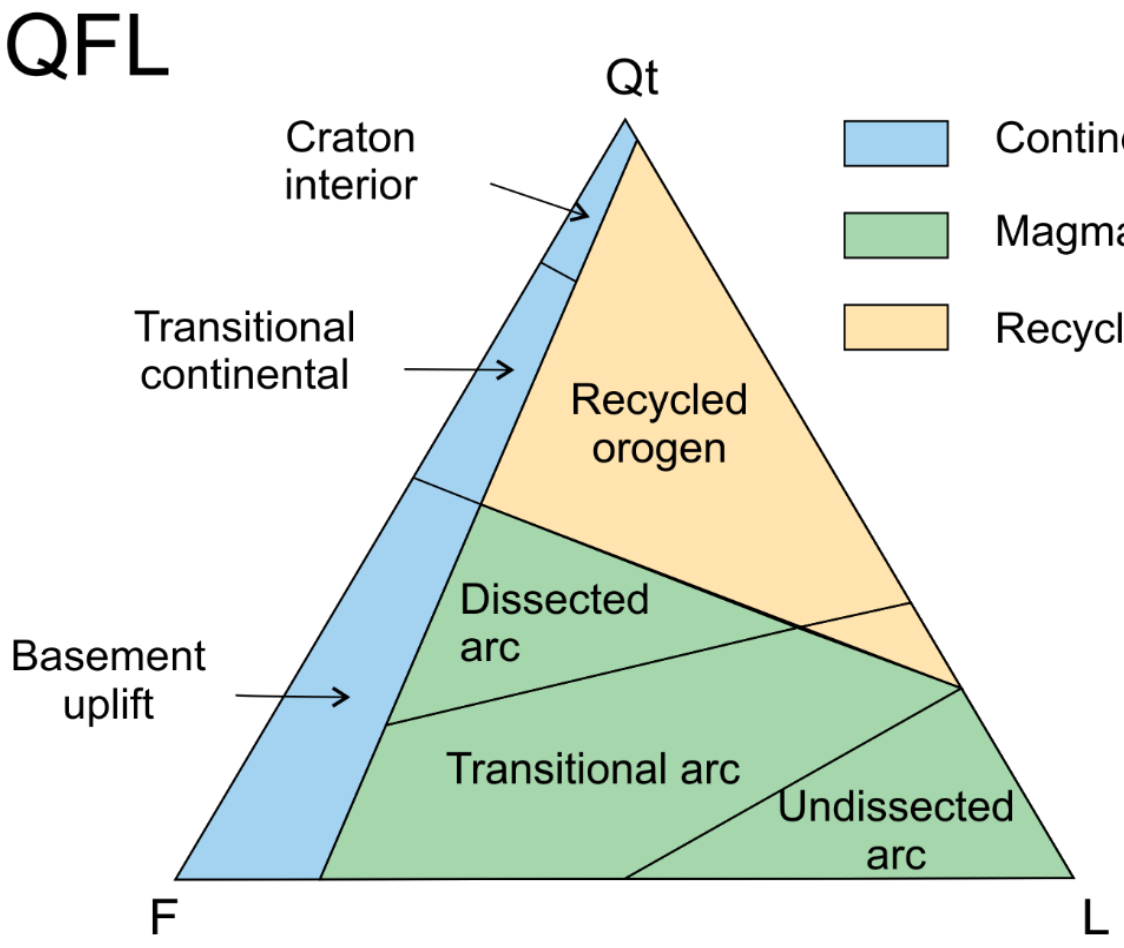


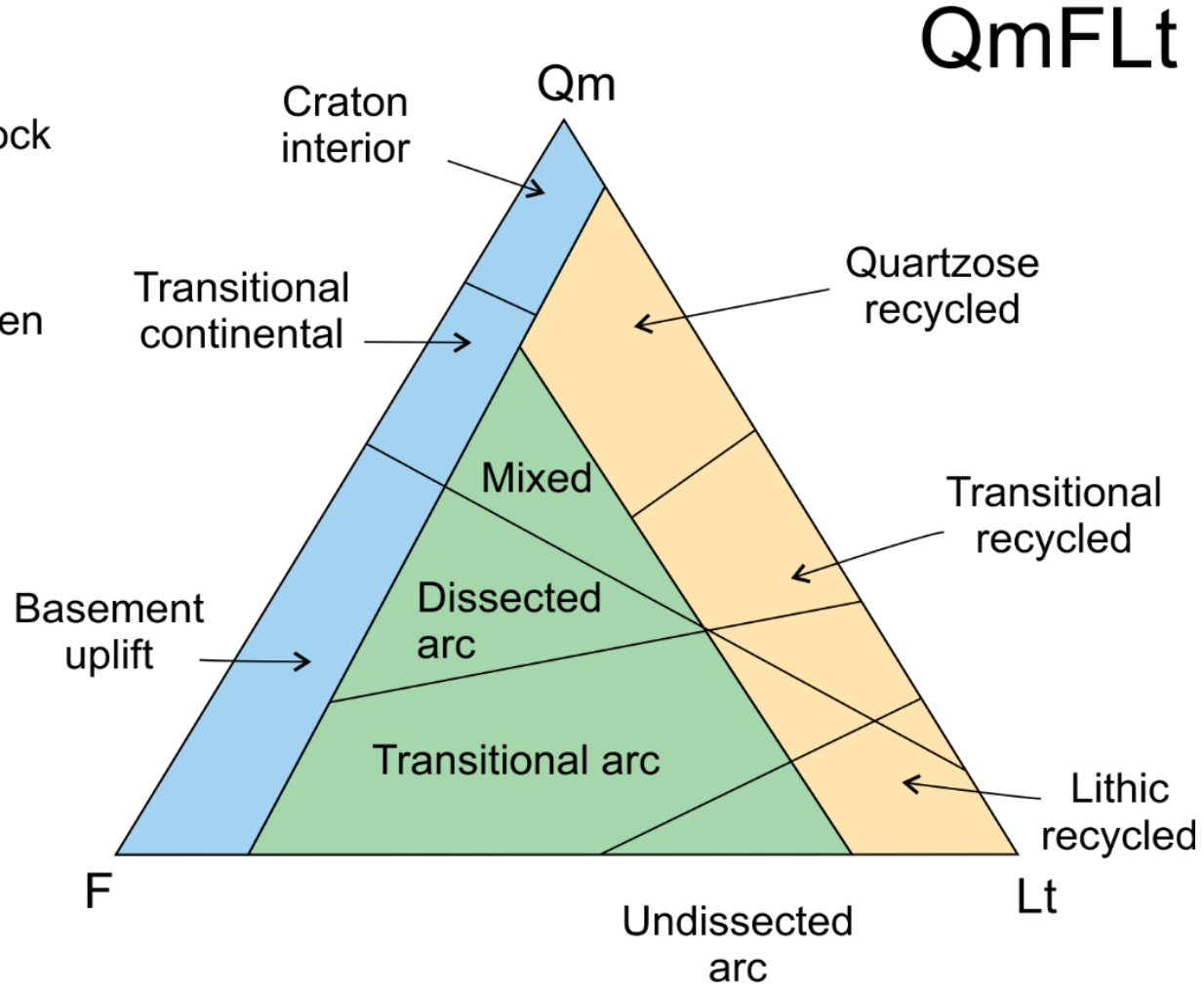
In-Situ Rounding of Clasts

Tropical weather can lead to the appearance of texturally mature sandstones, whereas they could be compositionally immature

This can impact heavily on reservoir quality!

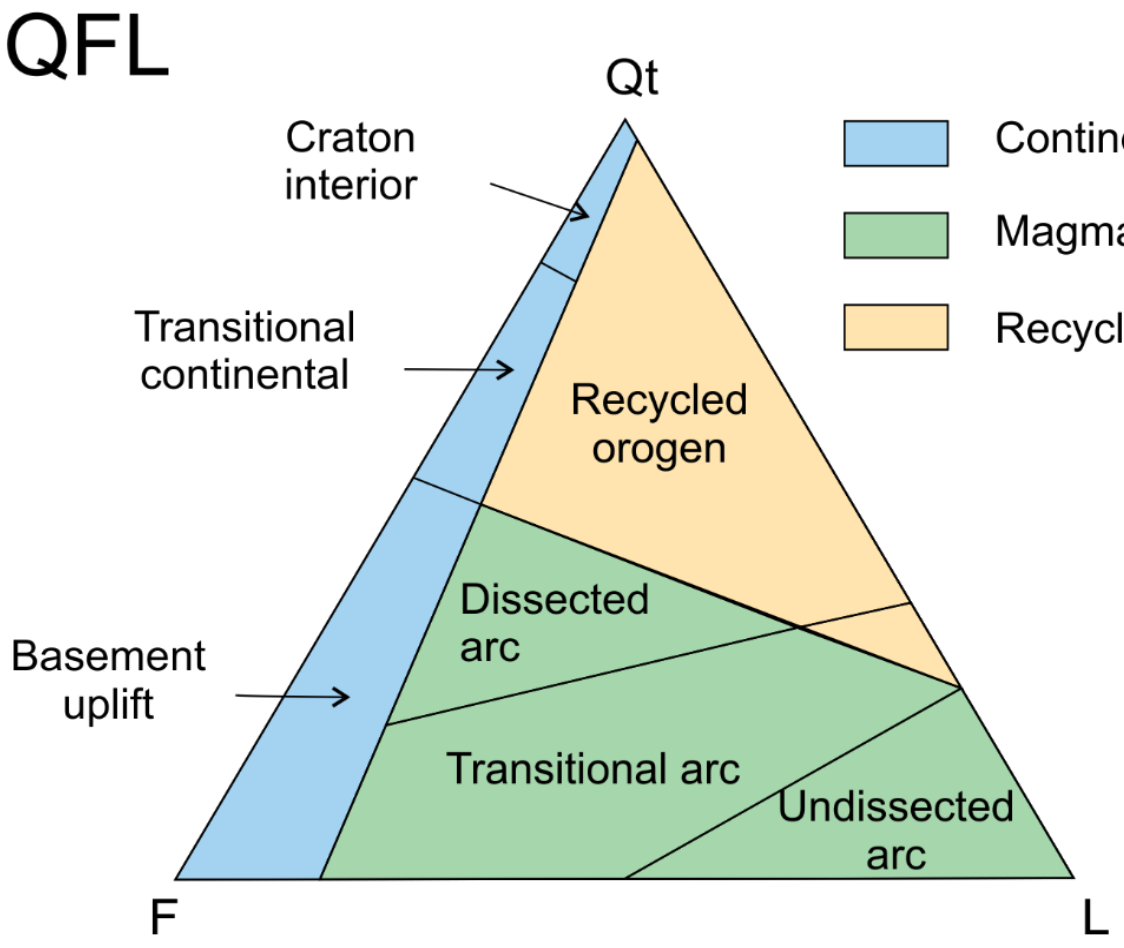
Gazzi-Dickinson Plots

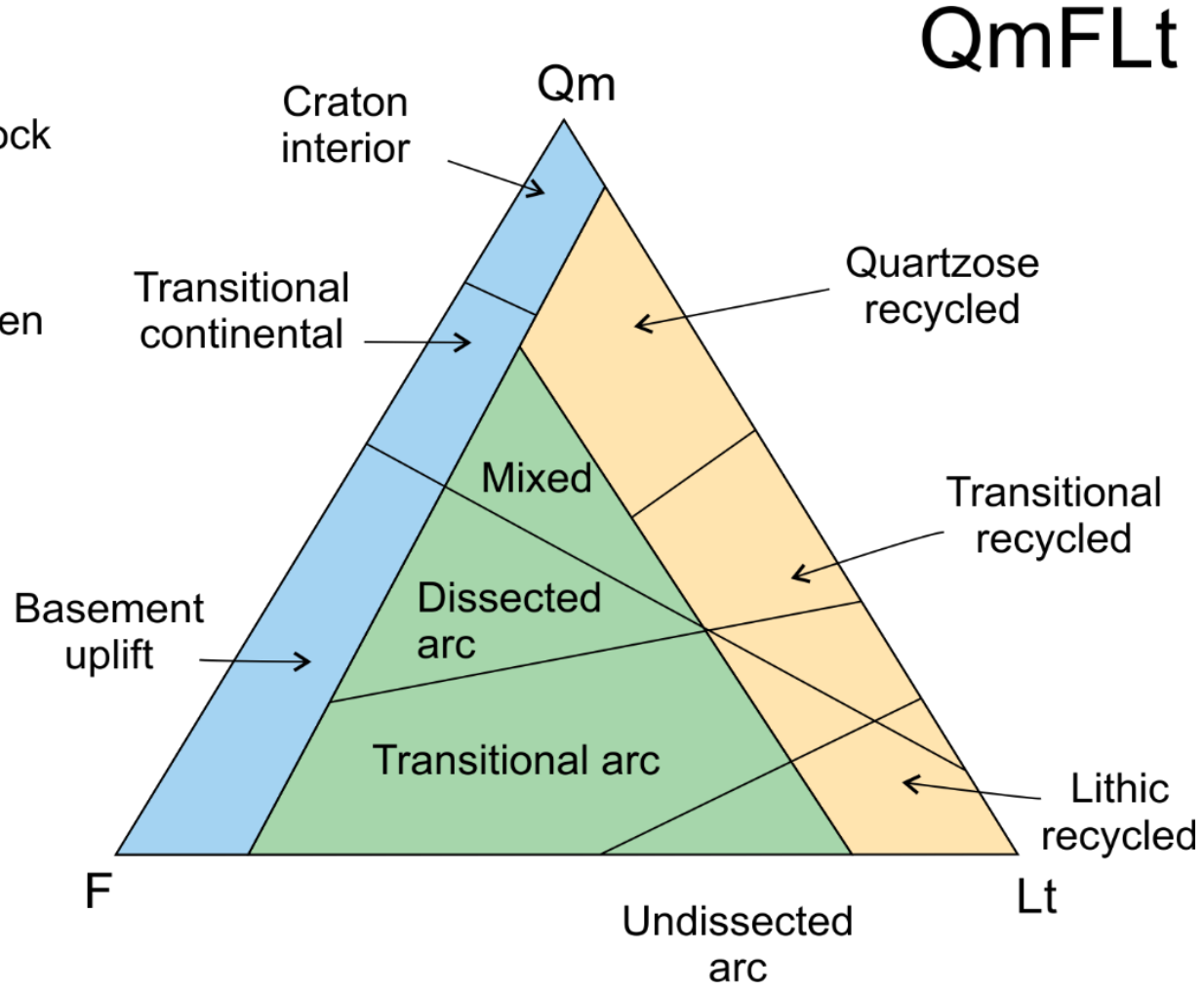




Developed in temperate North America – a GREAT model – but with many limitations

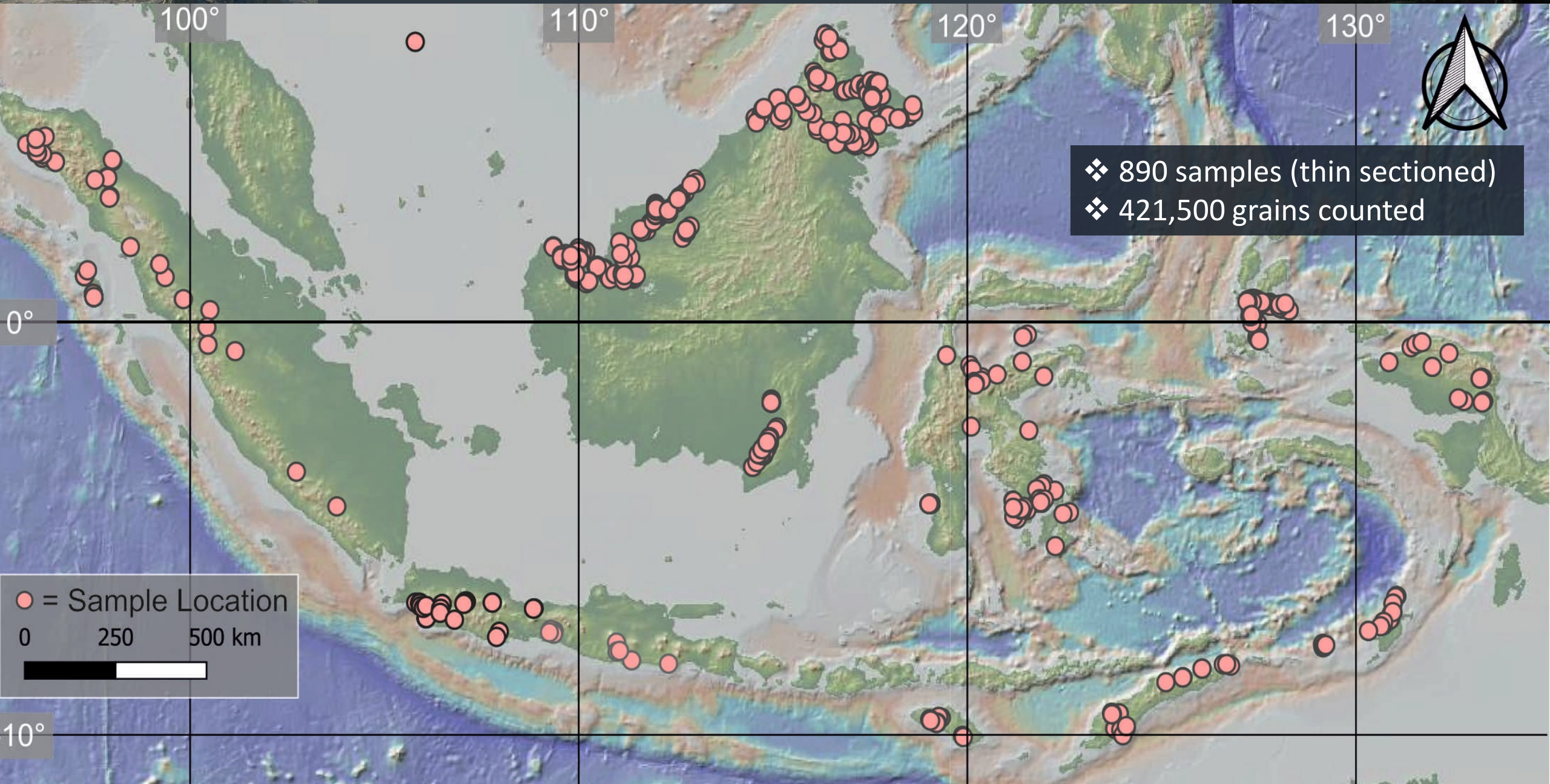
Gazzi-Dickinson Plots



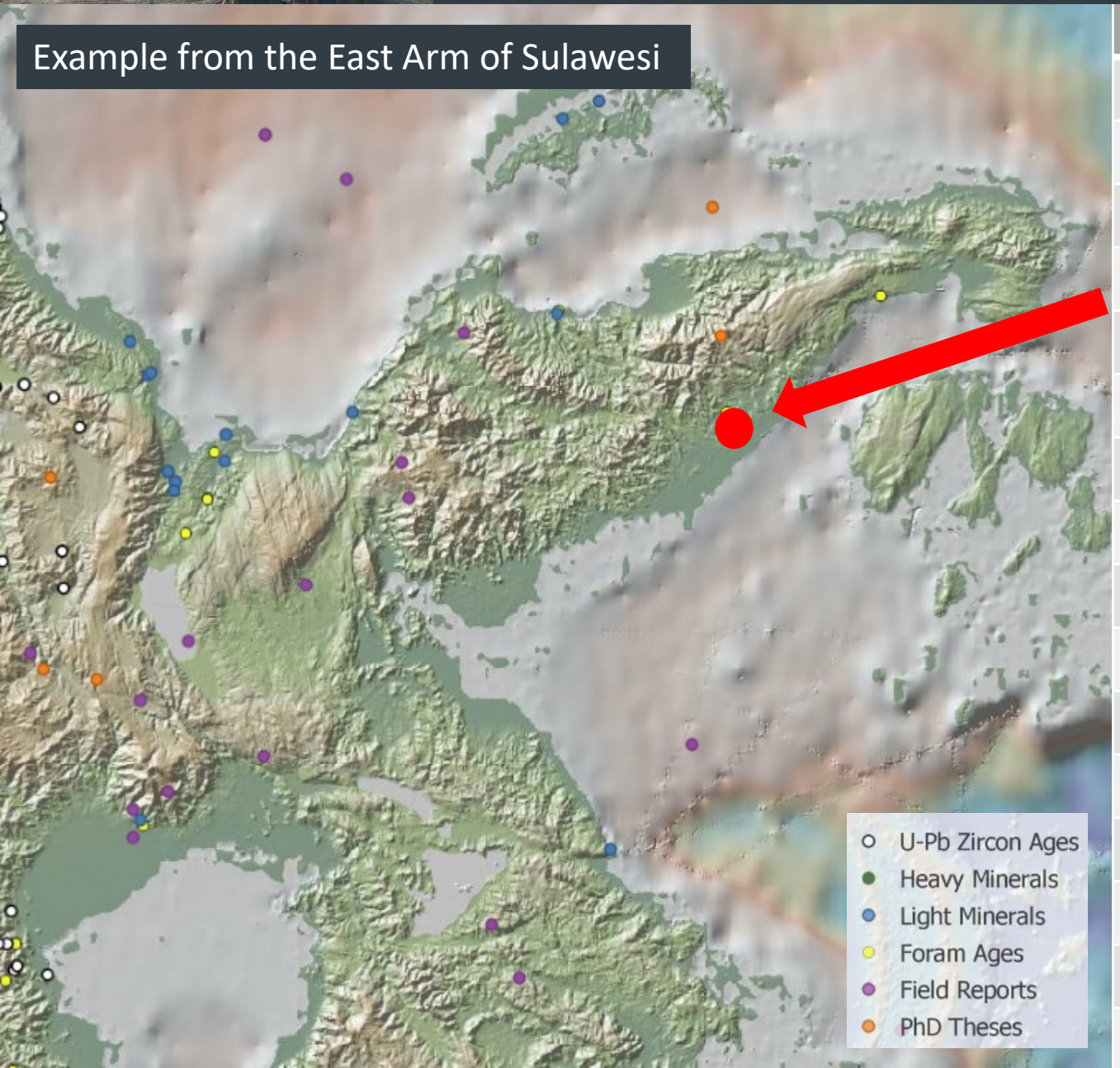


The main sediment sources in the equatorial Southeast Asia region are volcanic arcs, exposed basement terranes, and ophiolites.

Light Mineral Database

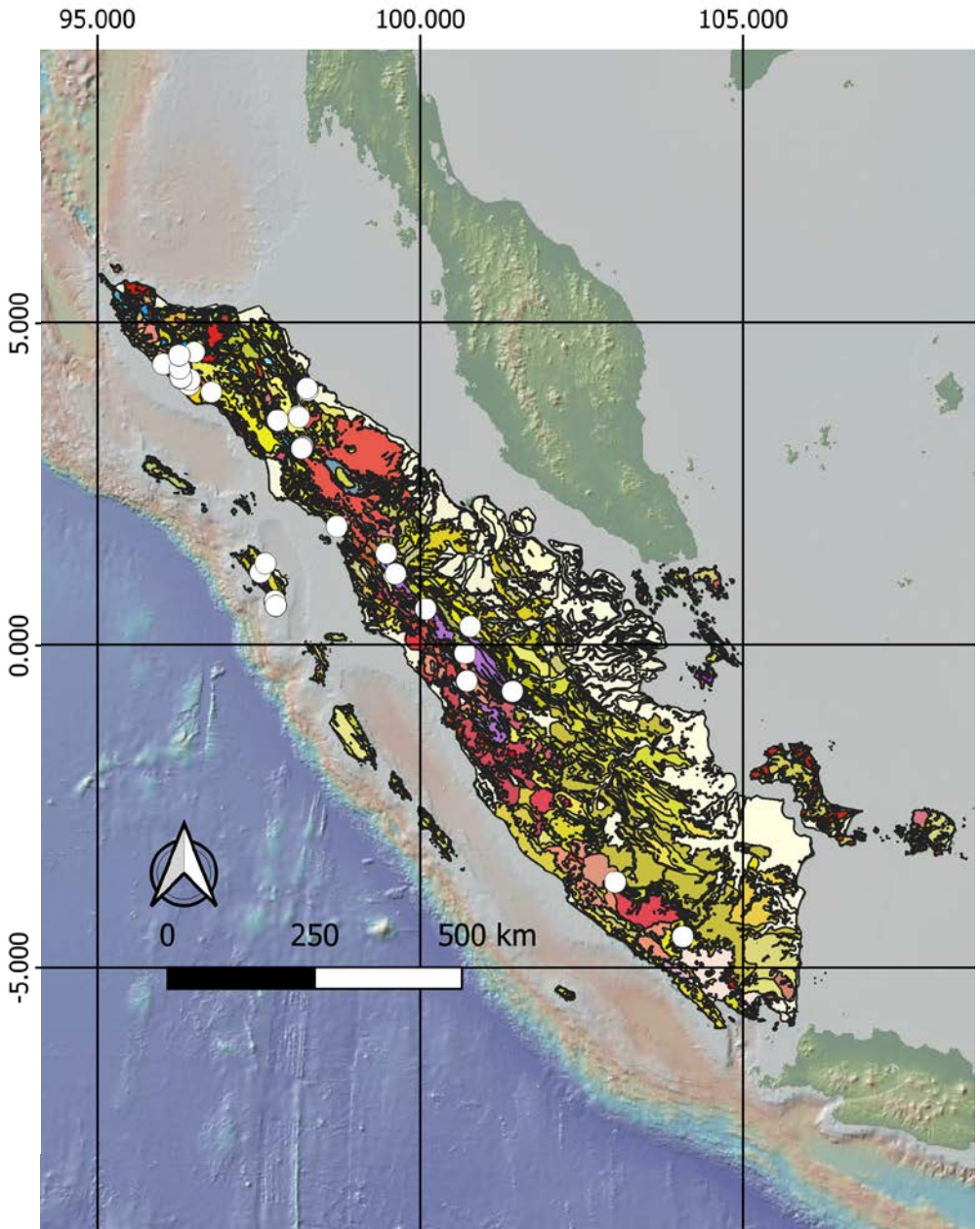


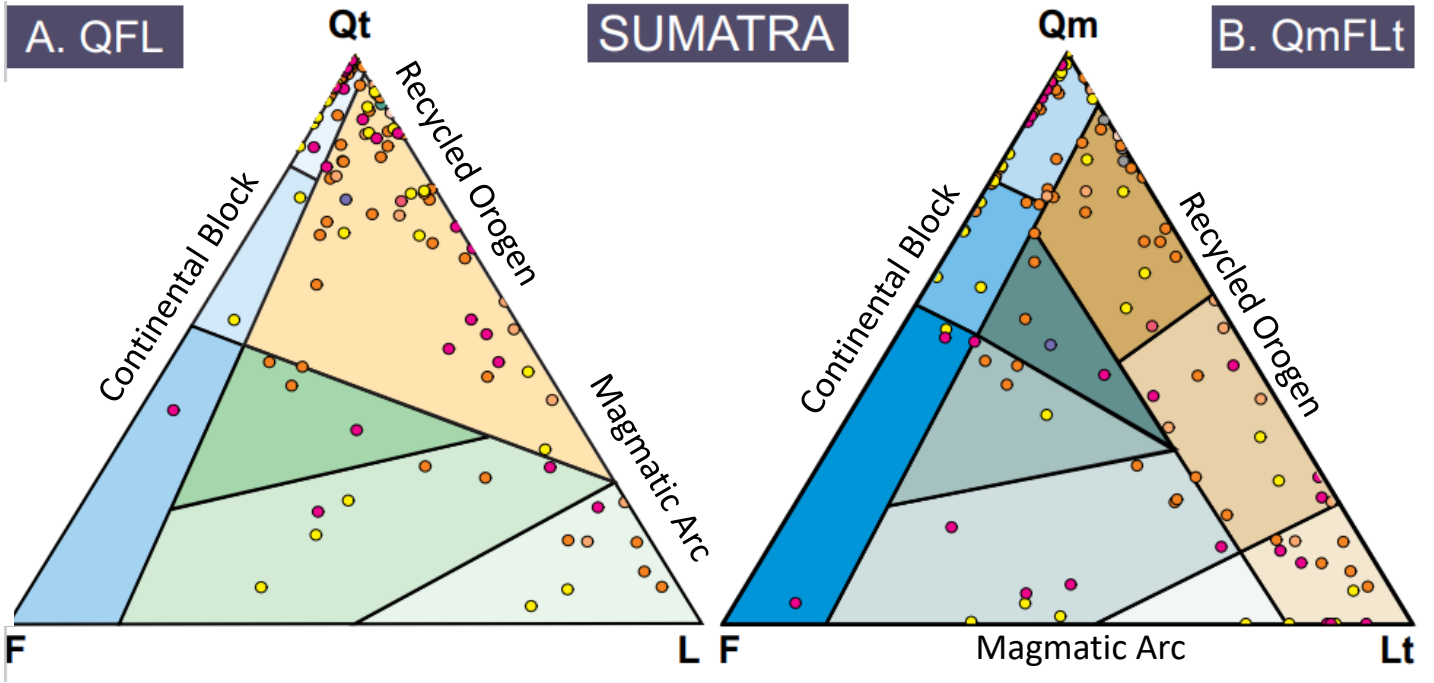
Light Mineral Database



Light Mineral Database (Data in GIS)	
Sample Number	ES13-287
Latitude	-1.33257
Longitude	122.40862
Region	Sulawesi
Sampling Area	Celebes Molasse
Formation	Bongka Formation
Rock Classification	Sedimentary
Rock Type	Litharenite
Grainsize	Fine – coarse grained
Stratigraphic Age	Miocene to Pleistocene
Thin Section Stored?	Yes
Total Accepted Analyses	500
Technique	Point Counting
Laboratory	RHUL
Publication Reference	Surya Nugraha, 2016 (Thesis)
Last Checked	11/09/2020

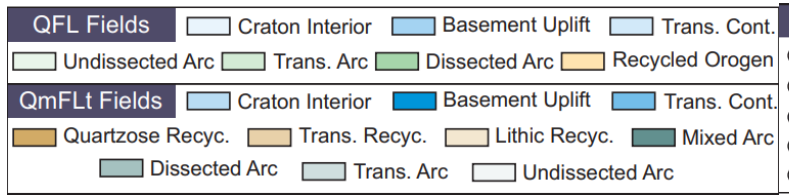
Sumatra

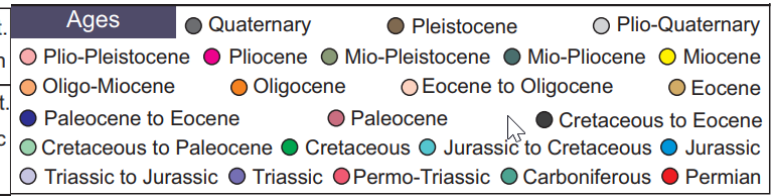




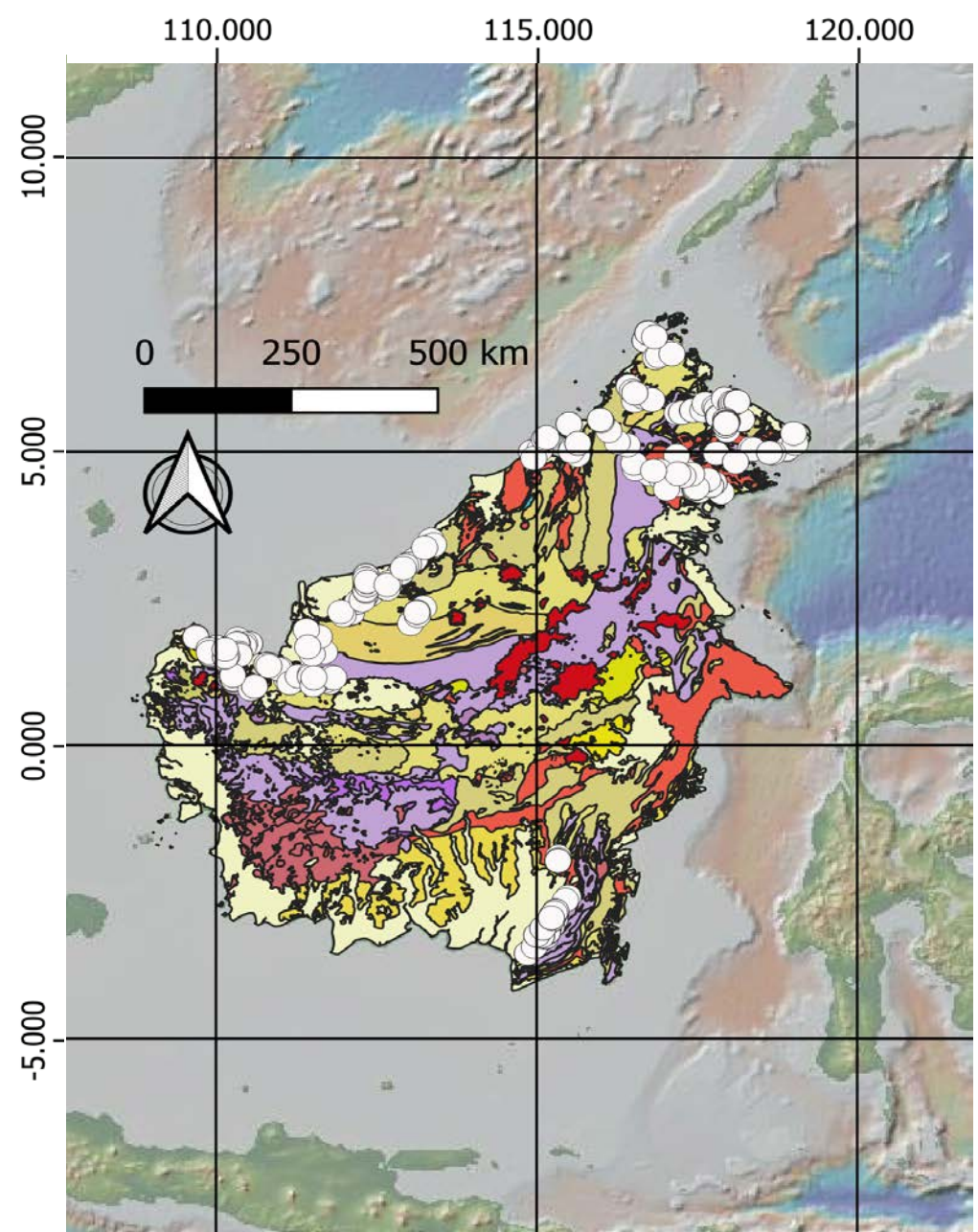
129 Samples; 32,640 data points

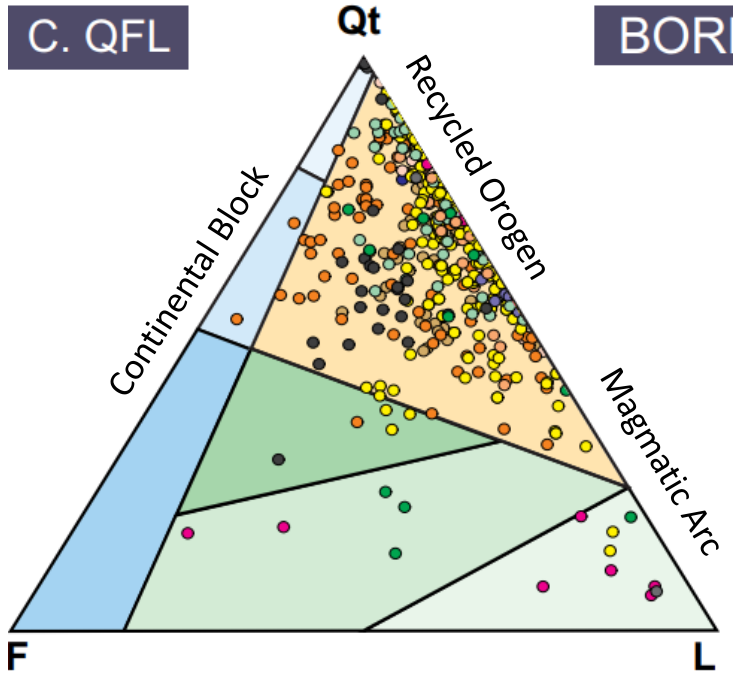
Expected Sources: Metamorphic basement (purples); Barisan Arc (reds); Tin Belt Granites (oranges)

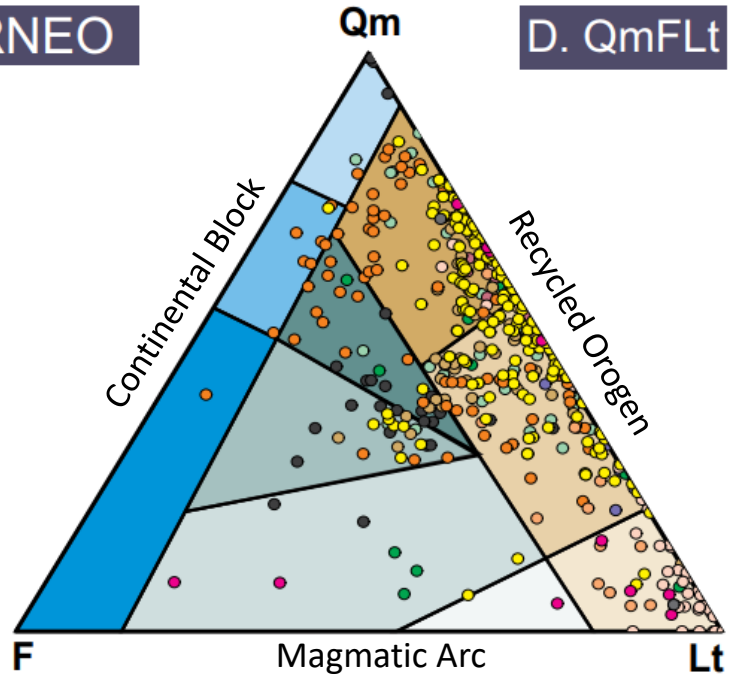




Borneo

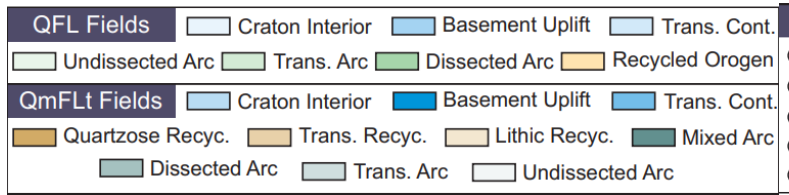


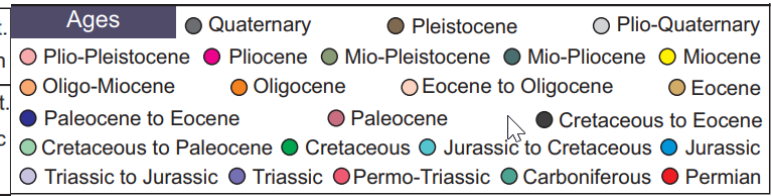




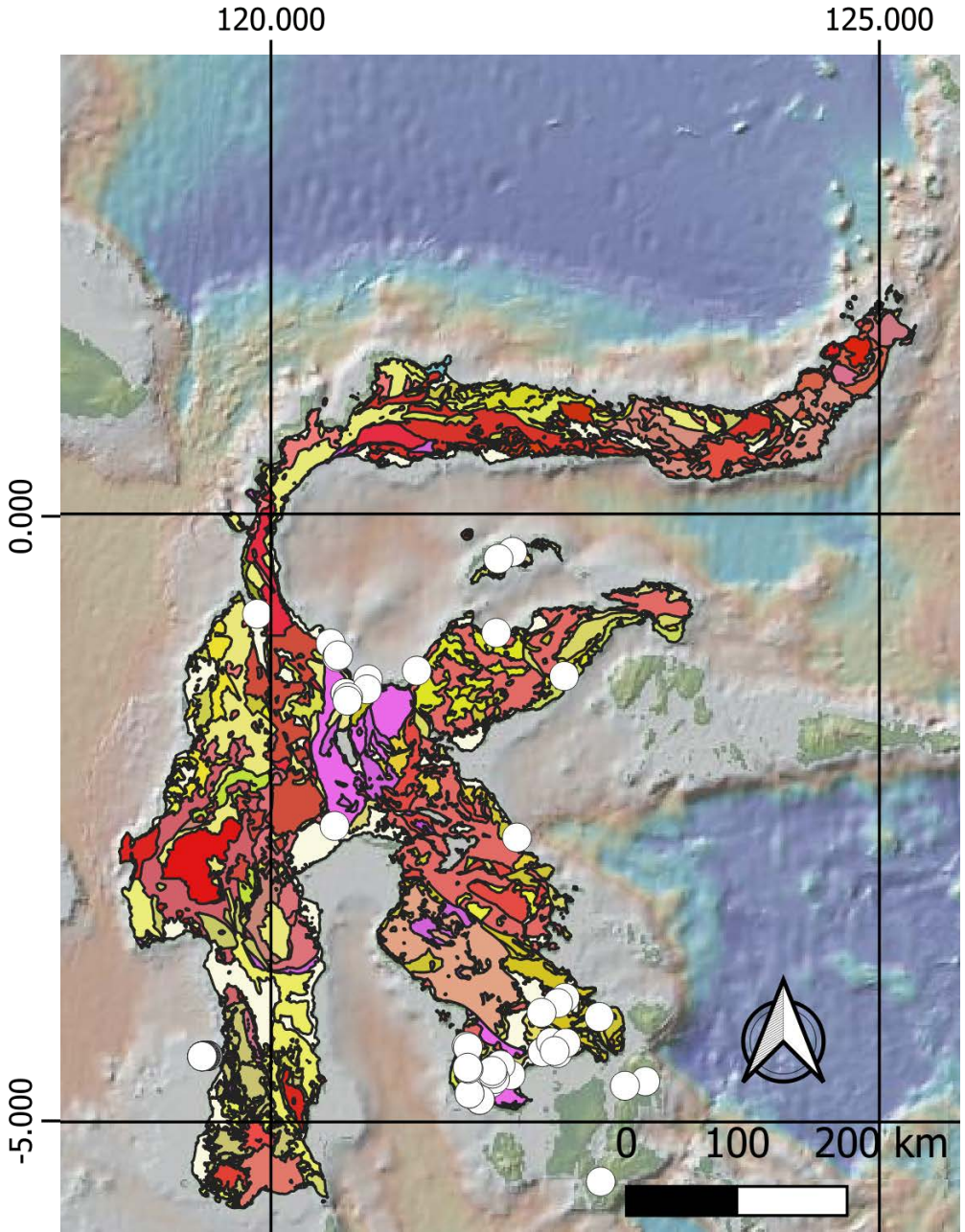
454 Samples; 167,780 data points

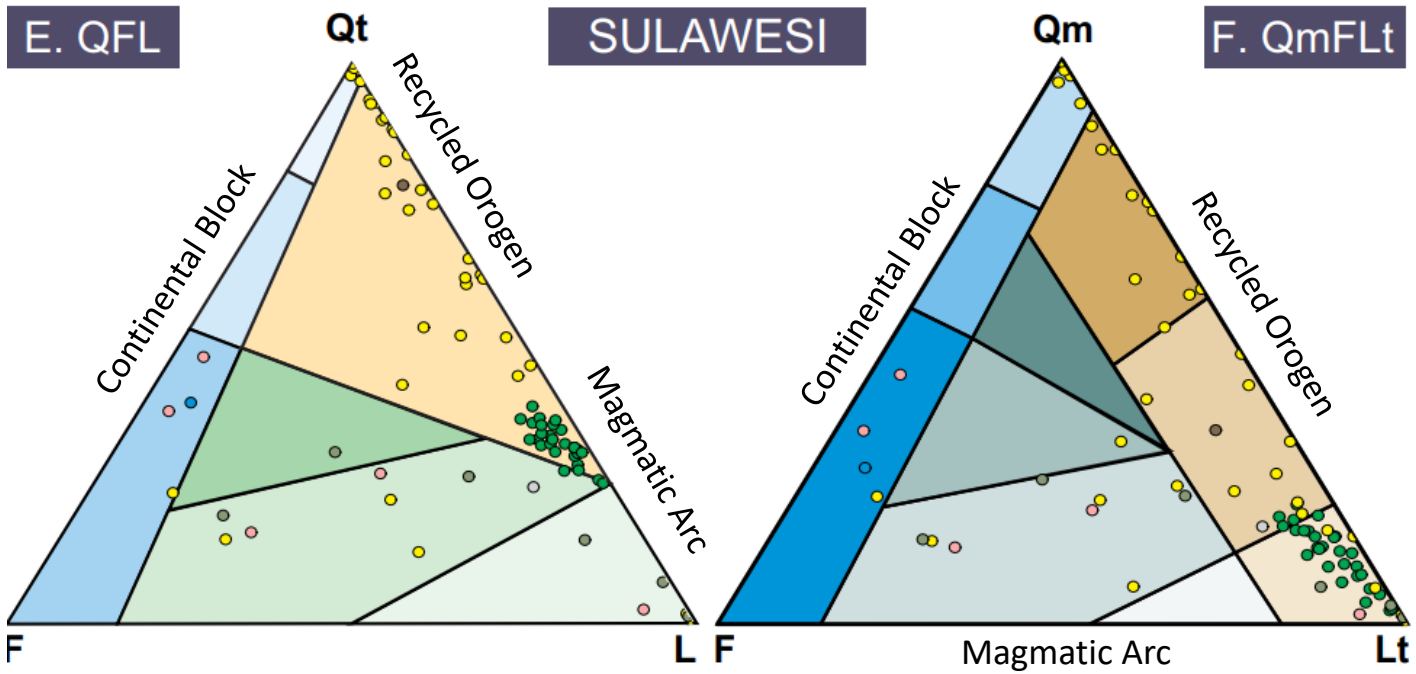
Expected Sources: Metamorphic basement (purples); Schwarner Granite (reds); ophiolites (bright red); and minor cratonic material (yellows)





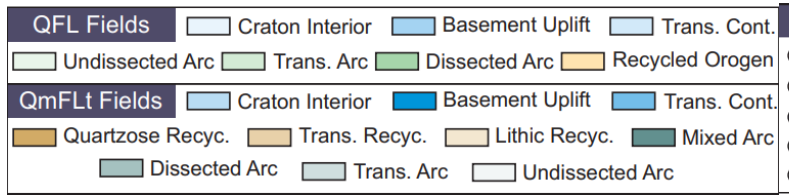
Sulawesi

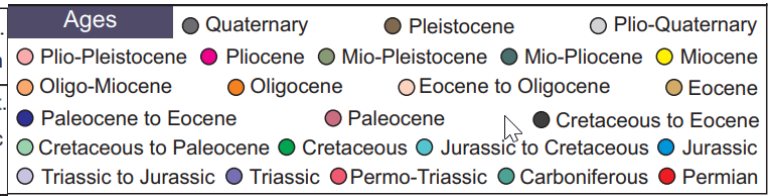




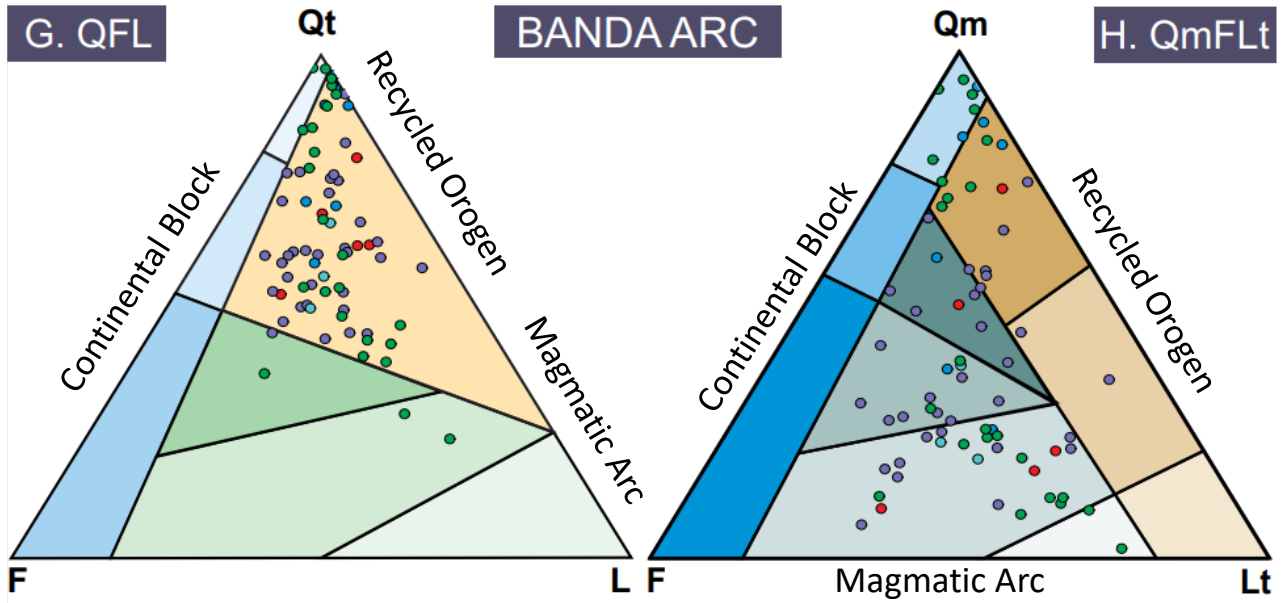
77 Samples; 32,822 data points

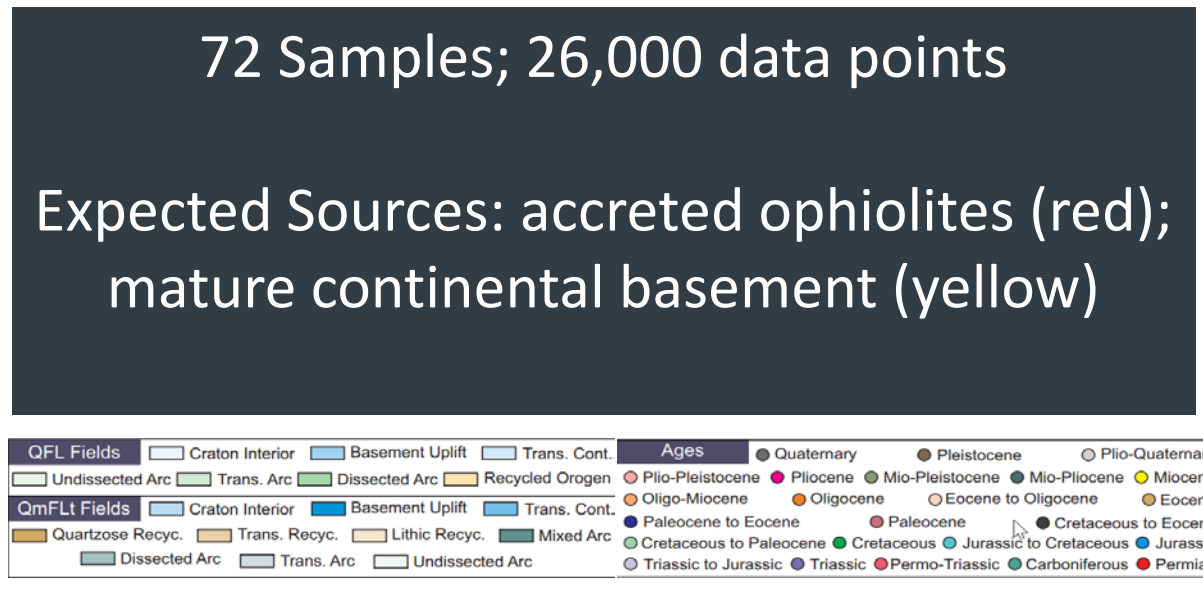
Expected Sources: Metamorphic basement (purples); the Western Sulawesi Volcanic Arc and the Eastern Sulawesi Ophiolite Belt (reds)





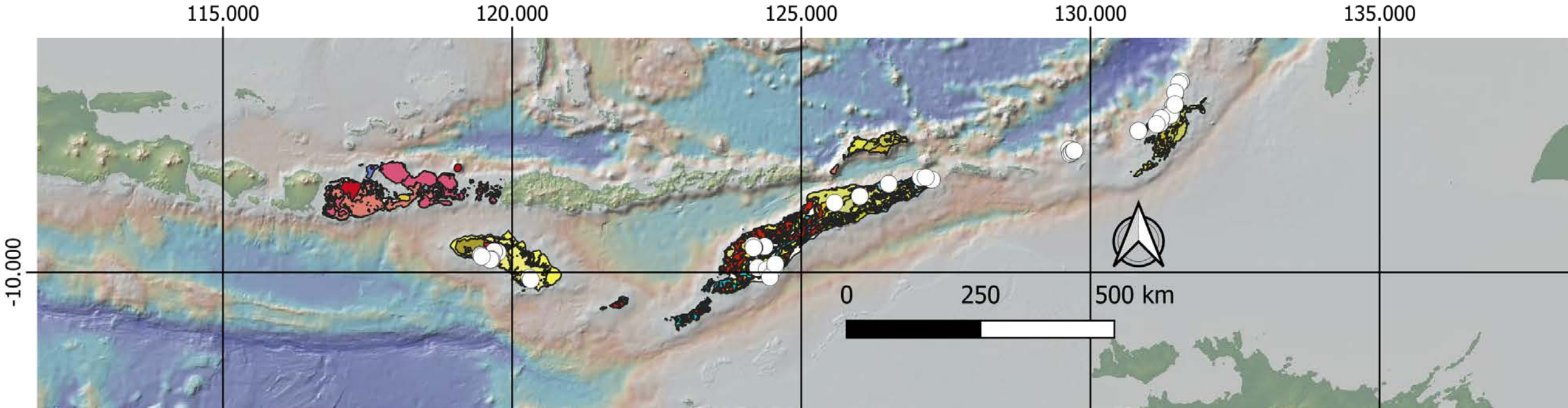
Banda Arc



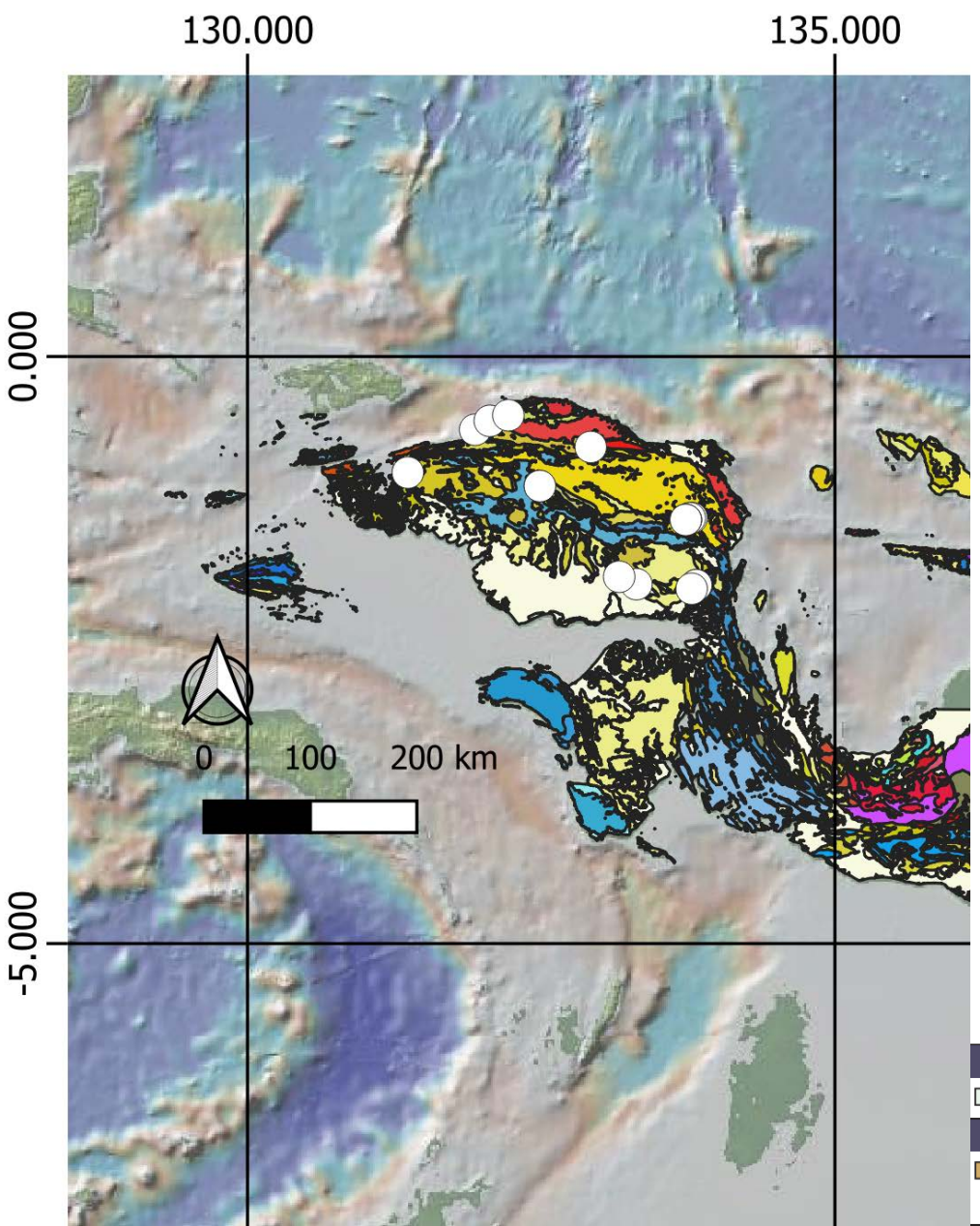


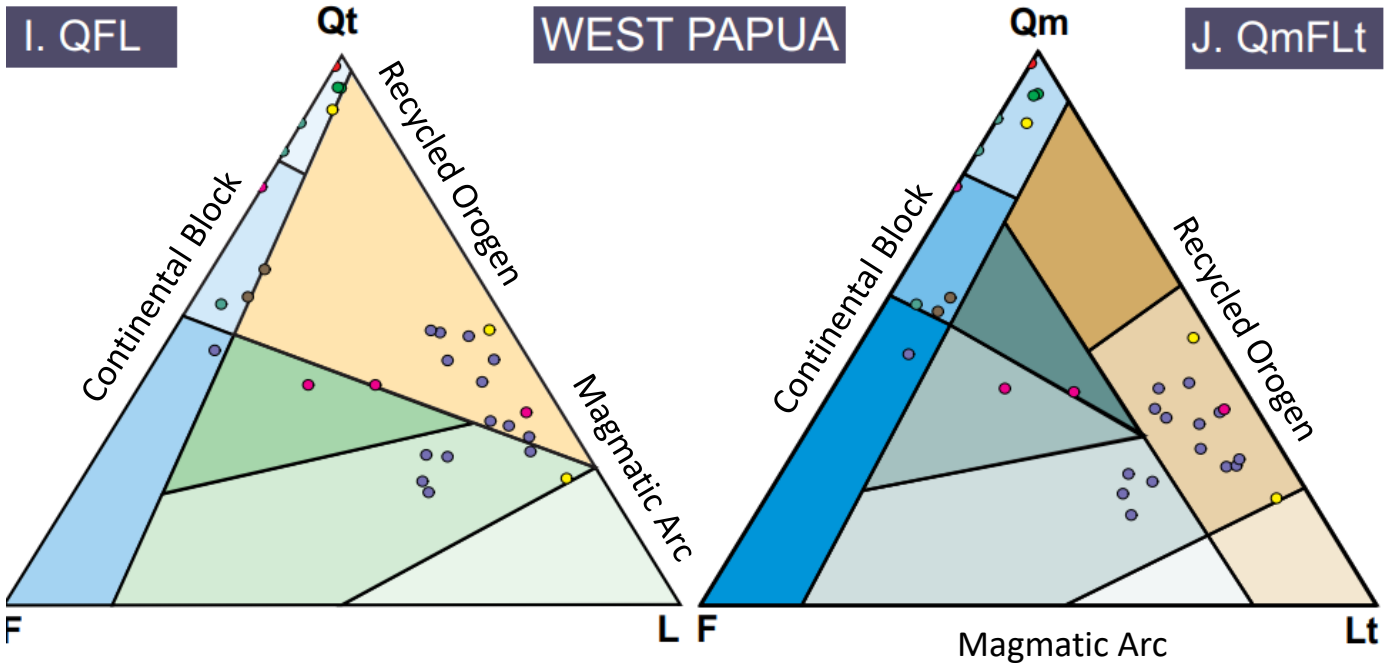
72 Samples; 26,000 data points

Expected Sources: accreted ophiolites (red); mature continental basement (yellow)



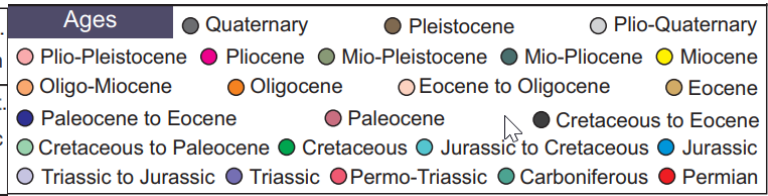
West Papua



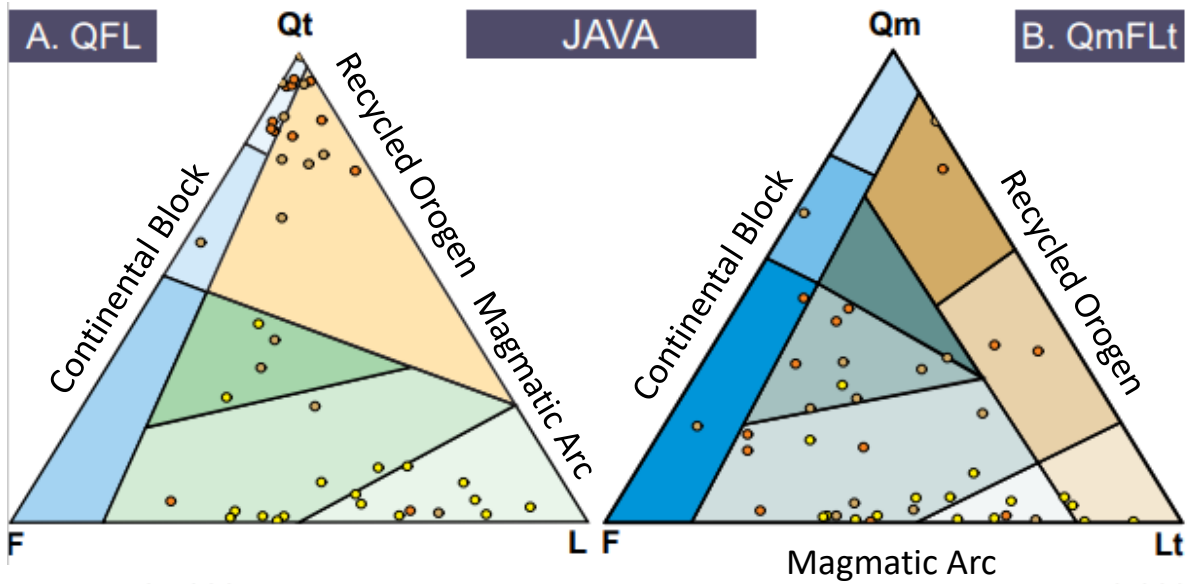


26 Samples; 12,778 data points

Expected Sources: arc material (red); metamorphic (purple), and granitic (red)

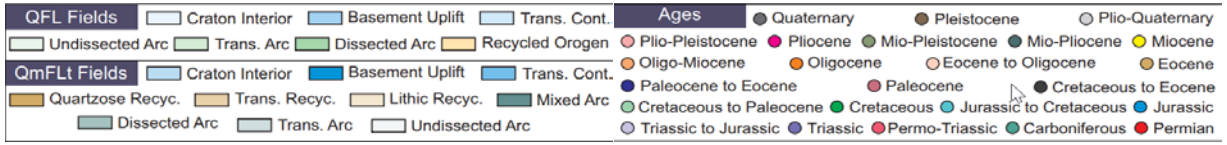


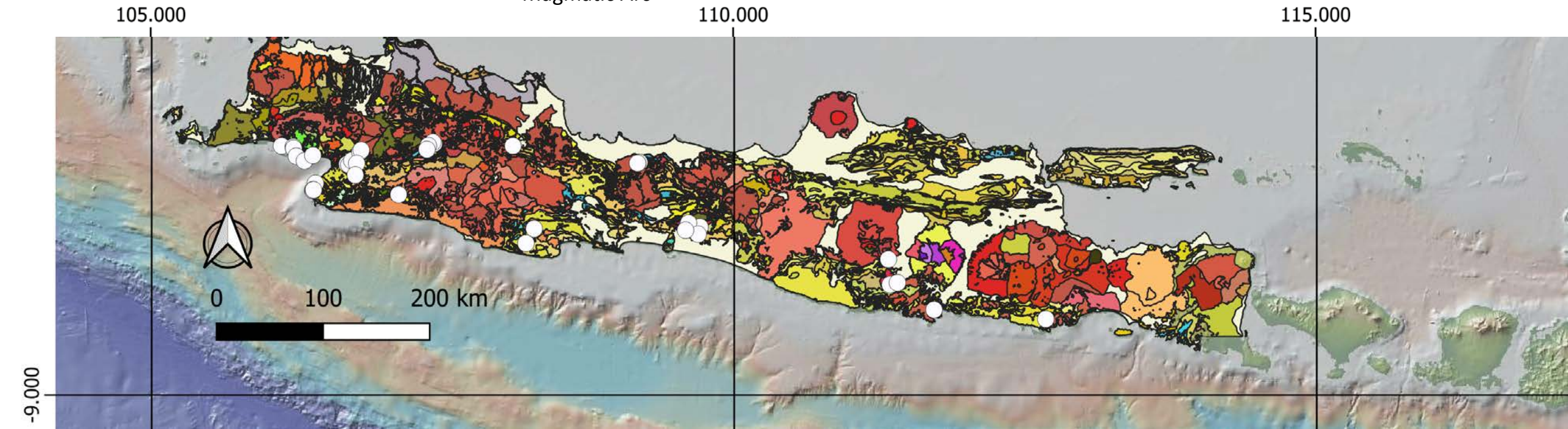
Java



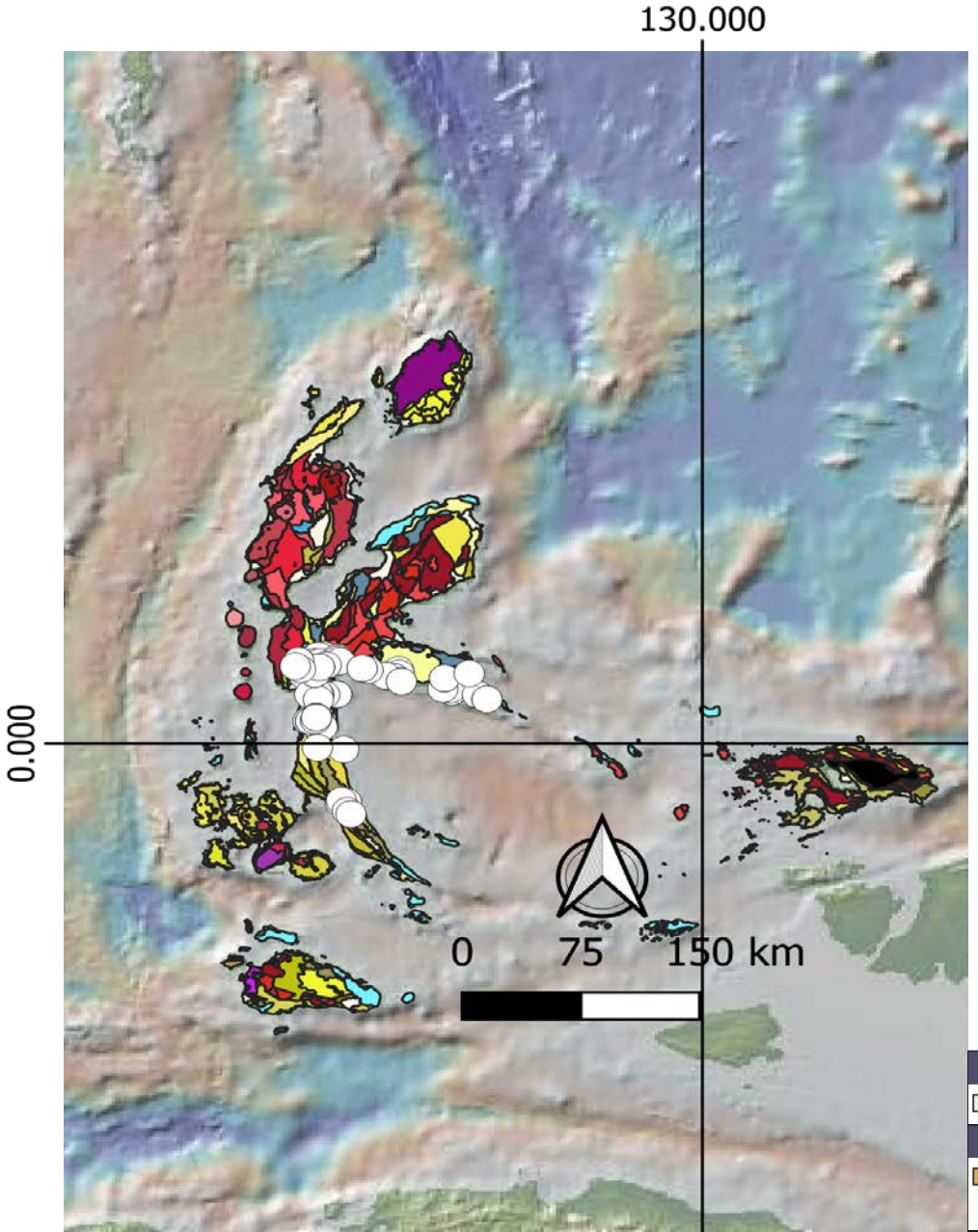
43 Samples; 12,900 data points

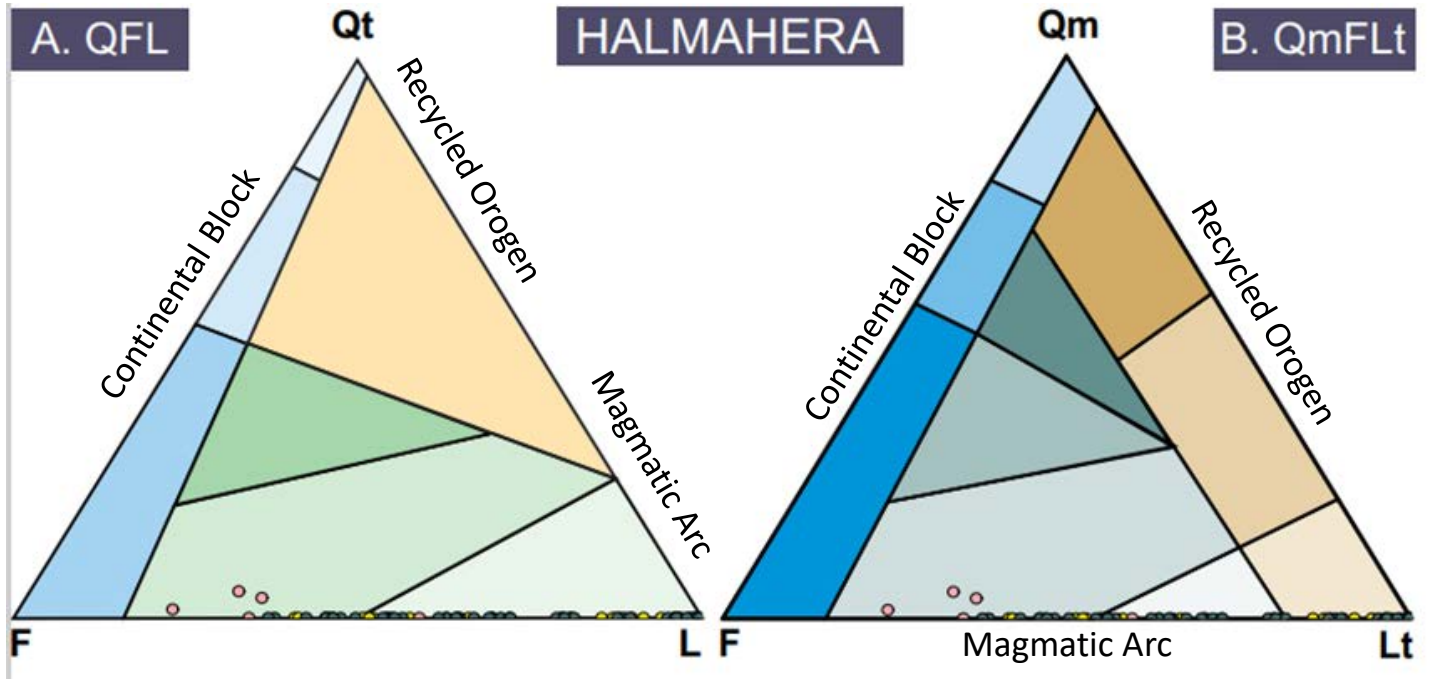
Expected Sources: arc material (red); some cretaceous basement (purple)





Halmahera





84 Samples; 8400 data points

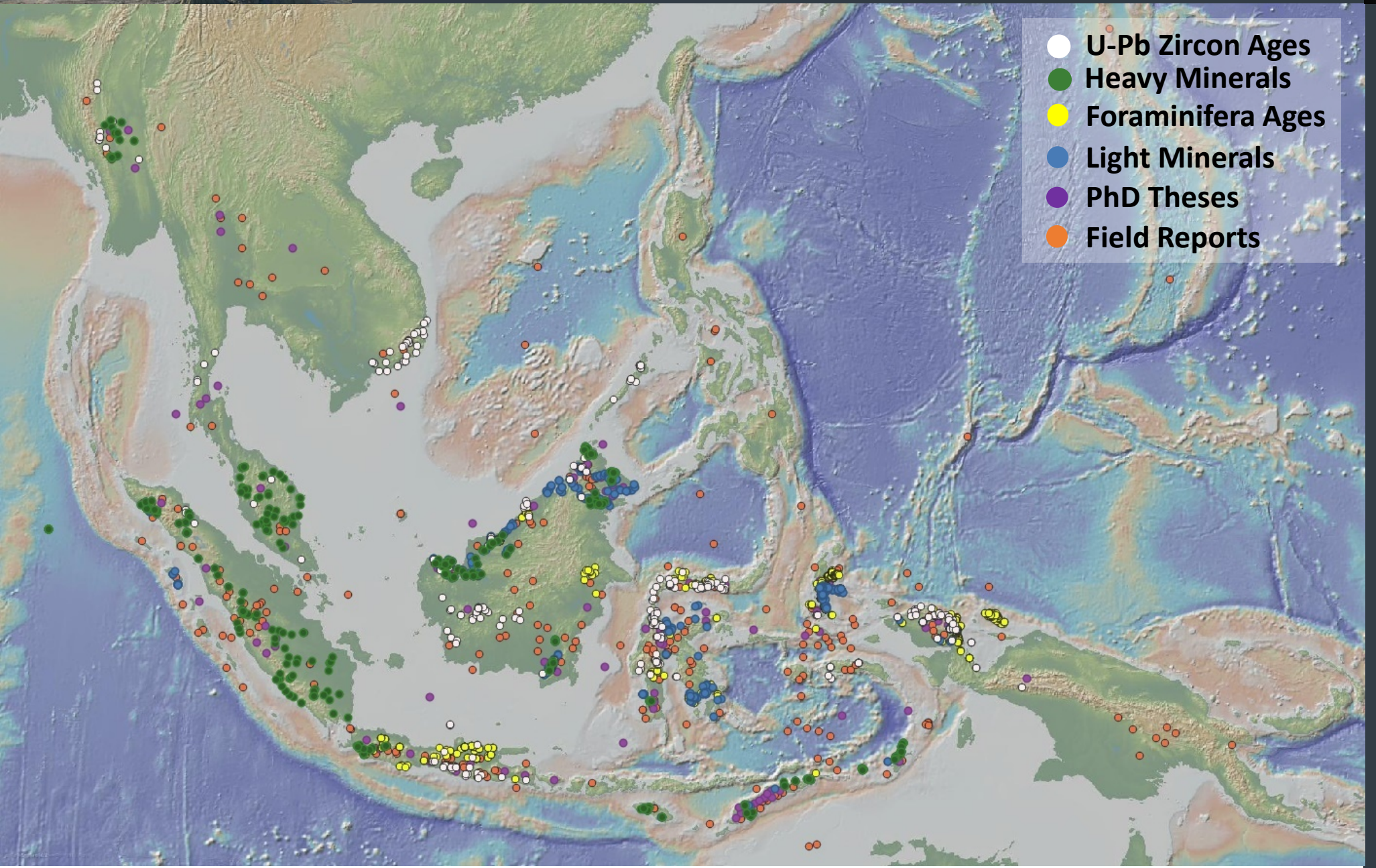
Expected Sources: evolving arc material (red), plus ophiolites and early volcanic basements

QFL Fields: Craton Interior; Basement Uplift; Trans. Cont.; Undissected Arc; Trans. Arc; Dissected Arc; Recycled Orogen

QmFLt Fields: Craton Interior; Basement Uplift; Trans. Cont.; Quartzose Recyc.; Trans. Recyc.; Lithic Recyc.; Mixed Arc; Dissected Arc; Trans. Arc; Undissected Arc

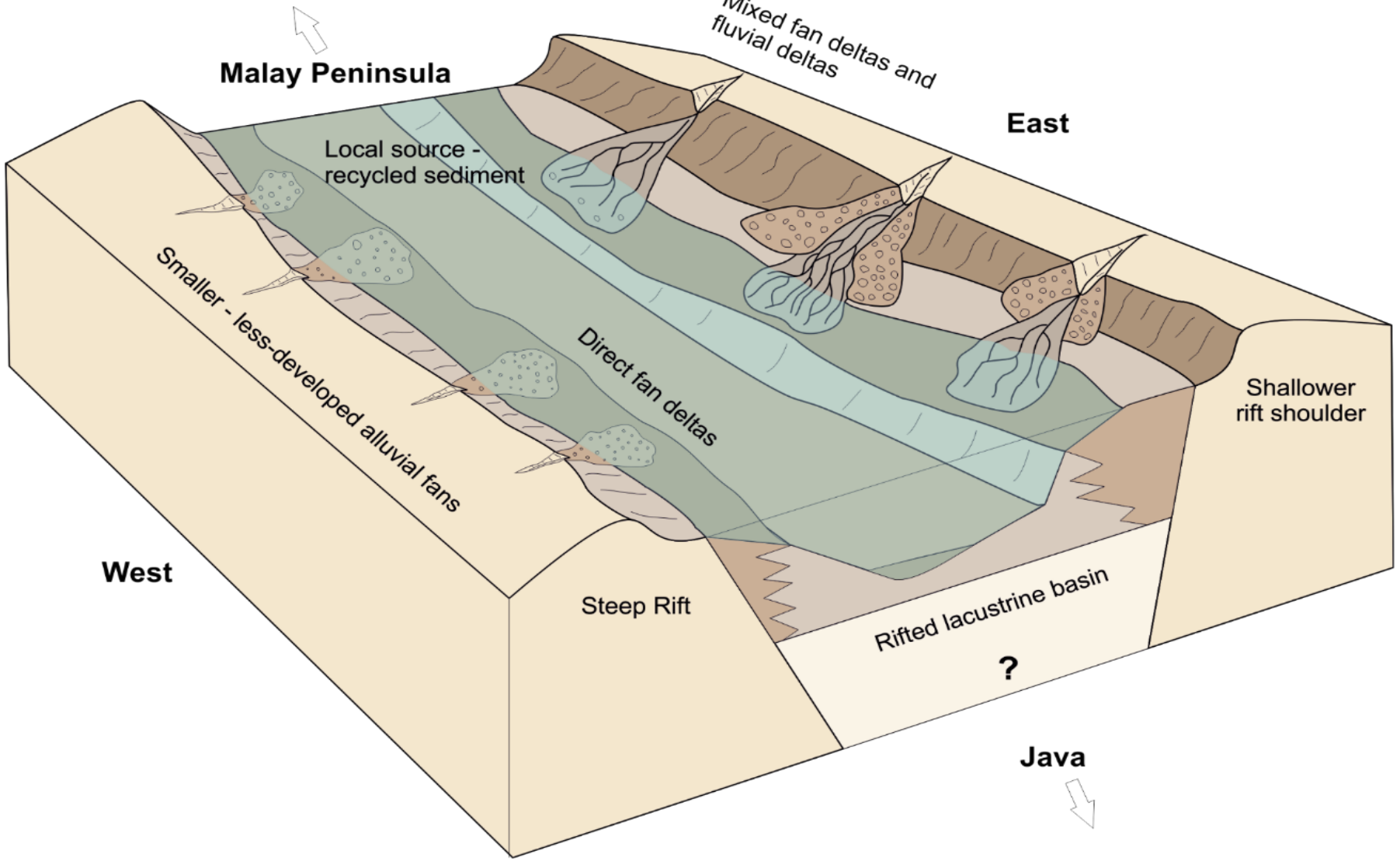
Ages: Quaternary; Pleistocene; Plio-Quaternary; Plio-Pleistocene; Pliocene; Mio-Pleistocene; Mio-Pliocene; Miocene; Oligo-Miocene; Oligocene; Eocene to Oligocene; Eocene; Paleocene to Eocene; Paleocene; Cretaceous to Eocene; Cretaceous to Paleocene; Cretaceous; Jurassic to Cretaceous; Jurassic; Triassic to Jurassic; Triassic; Permo-Triassic; Carboniferous; Permian

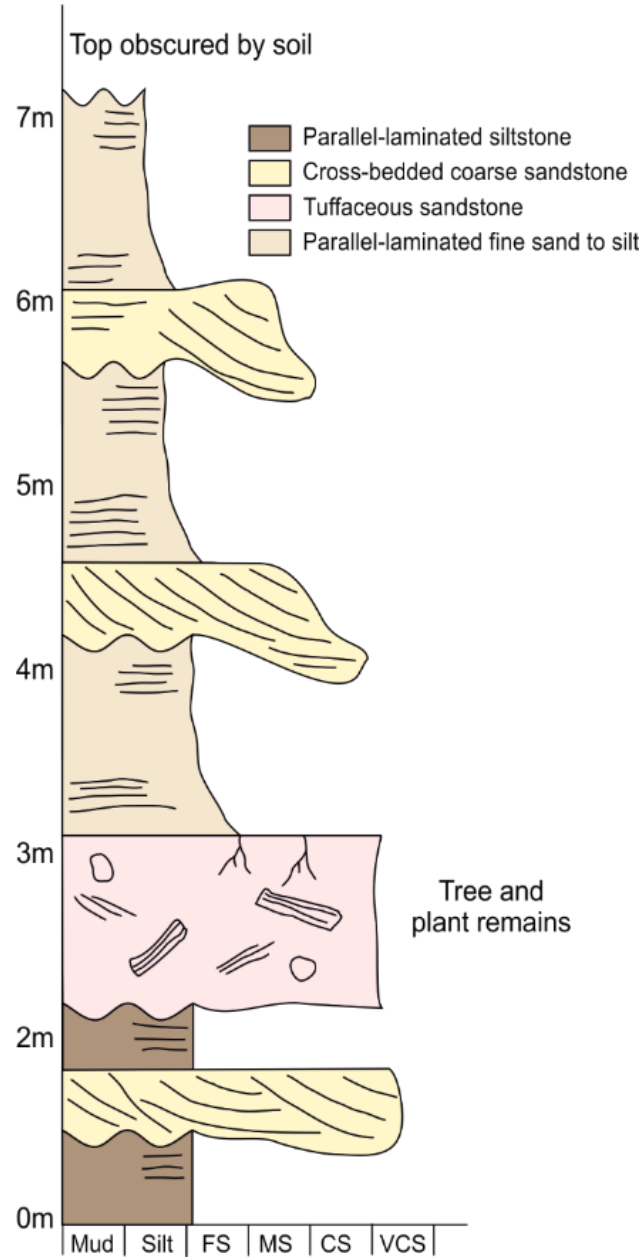
Multi Proxy Studies



- SEARG has 40 years worth of onshore data from SE Asia
- All analytical data is housed in large databases
- Data shown: light minerals, heavy minerals, forams, U-Pb zircon ages
- Data not shown: sedimentology (e.g., palaeocurrents, samples, thin sections (etc…).

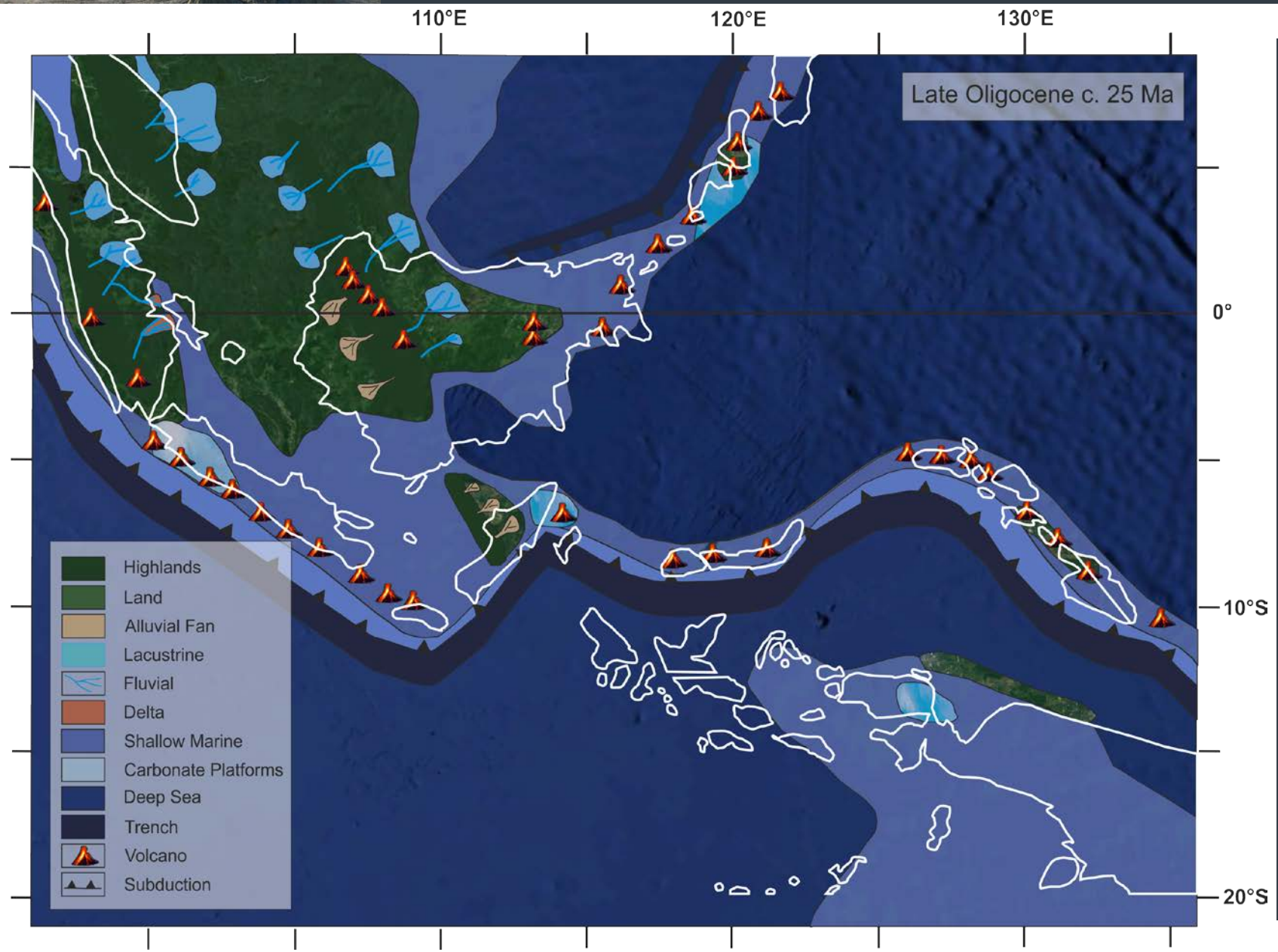
Reconstructing Past Environments





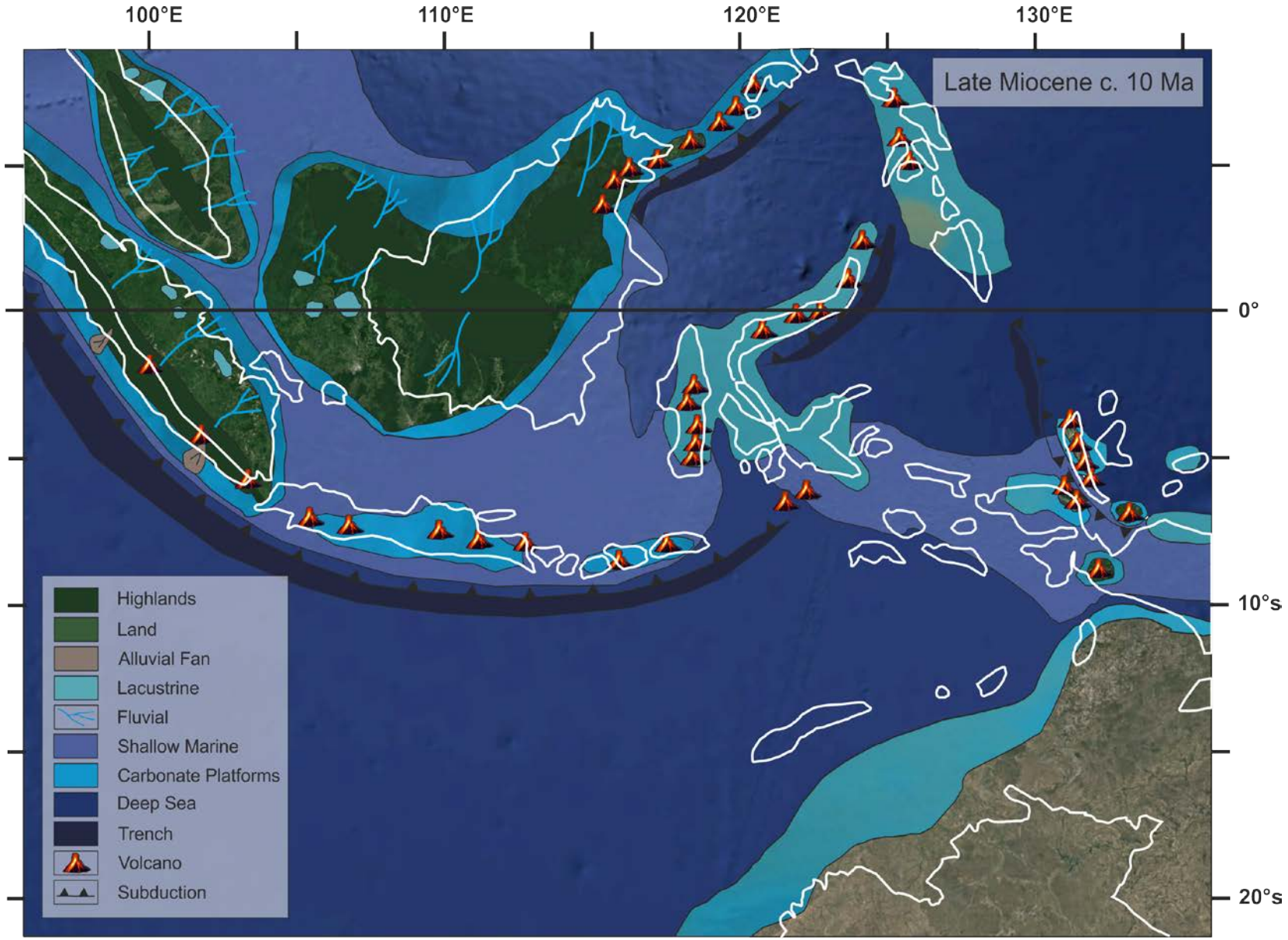
Example from the Lehat and Lemat Formations, Central Sumatra Basin

Multi-proxy Palaeogeographies



- A combination of tectonic reconstructions, provenance studies, and biostratigraphy allows for the reconstruction of palaeogeographies around Southeast Asia.
- These can be used to interrogate what sediment is expected in the offshore basins, by looking at spatial data onshore (mapping, provenance, etc).

Multi-Proxy Palaeogeographies



- These palaeogeographies can be reconstructed for any specific time periods due to comprehensive age data contained in the SEARG databases
- Whilst sediments behave differently in equatorial climates, big datasets can be used to overcome a lot of the limitations of alternative models

Conclusions

- Equatorial Southeast Asia has abundant and unique sedimentary systems
- A combination of sediment supply, continuous tectonic uplift, and a humid climate leads to sediment modification both prior to and during burial
- Many more traditional techniques have limitations when applied to SE Asia
- This can be solved by using a multi proxy approach to understanding sediment routing, deposition, and burial

Thank You

SEARG
SOUTHEAST ASIA RESEARCH GROUP

Thank you for listening

And thank you to all past and present members of SEARG

ROYAL HOLLOWAY UNIVERSITY OF LONDON