Regional exploration of the Nusa Tenggara Islands, Indonesia, to assess their geothermal energy potential

Ahmad Fauzi Purwandono[1,2], Damien Bonté[1], Agung Harijoko[2], Fred Beekman[1], and Jan Diederik van Wees [1,3]
[1]*Utrecht University,* [2]*Universitas Gadjah Mada,* [3]*TNO Utrecht*

Introduction

Nusa Tenggara Islands are situated at Sunda-Banda Arc transition, that is part of the Indonesian island arc where the tectonic regime changes from oceanic–island arc subduction in western part to continental island arc-subduction to the east.

This unique setting makes an ideal target to study the geodynamic process and associated geothermal systems.

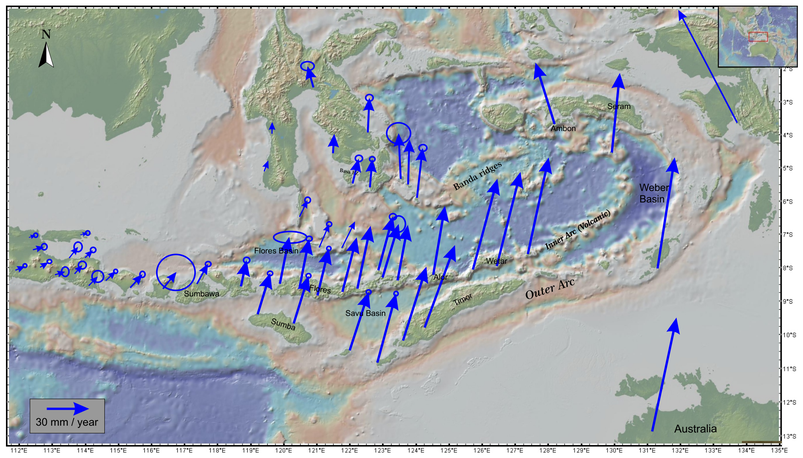


Figure 1: GPS velocities of the Nusa Tenggara and Eastern Indonesia with respect to Sunda Block

Regional Tectonic Setting

Nusa tenggara islands, as part of Eastern Indonesia, which is located at the triple junction between Eurasian, Australian and the Pacific plate, has undergone several geodynamic changes within a convergent tectonic regime.

This region consists of several complex of ocean basin which is separated by ridge or sliver, while on some part of the region is undergoing the effects of collisions in various stages of development. (Vroon, 1992; Ballie, 2004)

Events	NEOGENE: MIOCENE (20–5)	NEOGENE: PLIOCENE (5–2)	QUATERNARY: PLEISTOCENE (2–0.01)	QUATERNARY: HOLOCENE (0.01–0)	References
End of South China Sea Spreading	■				Briais et al, 1993; Fortuin, 1997
Bone Gulf	Extension Begins; Basin Widening; WNW Dextral transform faulting	Steep Normal fault on western edge of basin			Camplin, 2014
North Banda Basin	———				Charlton, 2000; Hinschberger, 2001
South Banda Basin		———			Charlton, 2000; Hinschberger, 2001
Weber Deep			——?		Pownall, 2016; Hall, 2012
Seram & Ambon Island extension		■			Pownall, 2014, 2017
Initial Collision of Australia		■			Tate, 2015
Timor Island		■			Tate, 2015
Cessation of Volcanic Activity					Harris, 2011
Wetar			■		
Romang			■		
Alor				■	
Sumba Rotation 5 CCW		■			Fortuin, 1997; Wensink, 1997

Table 1 : *The timeline of geodynamic events in Eastern Indonesia, (Neogene - Holocene).*

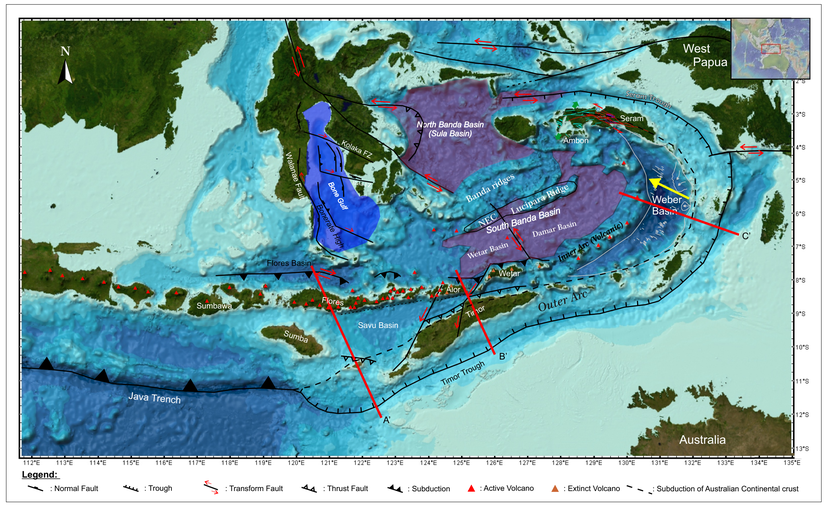
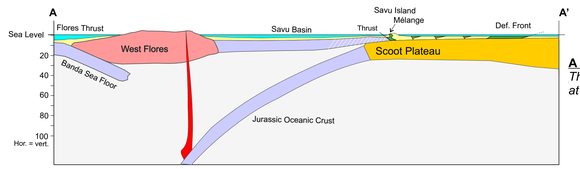
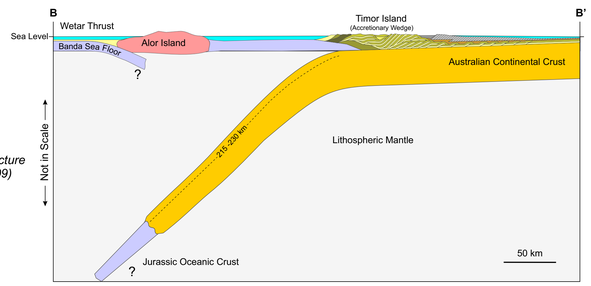


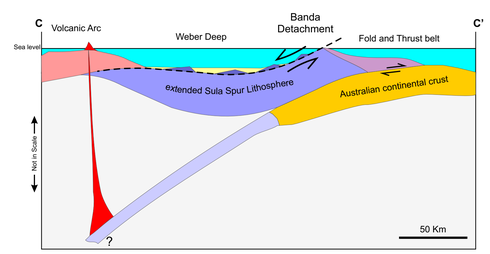
Figure 2: Simplified tectonic setting of the Nusa Tenggara and Eastern Indonesia



A - A' Cross Section :
The initial closure stage of island arc - continent at Savu Island (modified from Harris, 2009)



B - B' Cross Section :
The cross section across Timor island as accretionary wedge with duplex stacks structure (modified from Tate, et al, 2015; Harris, 2009)



C - C' Cross Section :
Configuration of the Weber Deep extension (Banda Detachment; modified from Pownall, 2016)

Volcanic and Geothermal energy Occurrences

- The volcanic flux vary from west to east, with average spacing of volcanic centres from 68 - 72 km, with an anomaly in East Nusa Tenggara which only has 21 km. (Ely, 2009)
- The geothermal systems in Nusa Tenggara are mostly related and located in the vicinity of volcanoes. All the geothermal field has been identified from the presence of surface evidences (fumaroles and hot springs), and were generally found in high altitude on the volcanic system. (Johnstone, 2005)
- There are currently 15 occurrences of geothermal resource in Nusa Tenggara, of which 2 have already power plant installed and are producing electricity (Ulumbu and Mataloko Geothermal Field in west Flores).

Conclusion

The Nusa Tenggara islands shows change of trends from its morphology, tectonic and volcanism, related with the transition of subduction - collision of Indo-Australian Continental crust from the south.

Further study is needed to investigate how the geothermal systems in Nusa Tenggara, particularly in Flores Island, is affected by this change of tectonic settings.

References

Baillie, P., Fraser, T., Hall, R., and Myers, K., 2004, Geological development of Eastern Indonesia and the northern Australia collision zone: A review, In: Ellis, G. K., Baillie, P. W., and Munson, T. J. (eds), Timor Sea Petroleum Geoscience: Proceedings of the Timor Sea Symposium, Darwin, Northern Territory, Australia, June 2003, Northern Territory Geological Survey, Special Publication, 1, 539-550.

Camplin, D. J., Hall, R., 2014. Neogene history of Bone Gulf, Sulawesi, Indonesia, Mar. Petrol. Geol., 57, 88–108.

Charlton, T.R., 2000. Tertiary evolution of the Eastern Indonesia collision complex. J. Asian Earth Sci. 18, 603–631.

Ely, K.S., 2009. Geochronology of Timor-Leste and seismo-tectonics of the southern Banda Arc (Doctoral dissertation).

Fortuin, A.R., van der Werff, W., Wensink, H., 1997. Neogene basin history and paleomagnetism of a rifted and inverted forearc region, on- and offshore Sumba, Eastern Indonesia. Journal of Asian Earth Sciences 15, 61– 88.

Harris, R.A., Vorkink, M.W., Prasetyadi, C., Zobell, E., Roosmawati, N., 2009. Transition from subduction to arc-continent collision: geological and neotectonic evolution of Savu, Indonesia. Geosphere 5, 1–20.

Hinschberger, F., Malod, J.-A., Réhault, J.-P., Villeneuve, M., Royer, J.-Y., and Burhanuddin, S., 2005. Late Cenozoic geodynamic evolution of eastern Indonesia: Tectonophysics, v. 404, p. 91–118,

Johnstone, R.D., 2005. Contrasting geothermal fields along the magmatic Banda Arc, Nusa Tenggara, Indonesia. In Proceedings.

Koulali, A., Susilo, S., McClusky, S., Meilano, I., Cummins, P., Tregoning, P., Lister, G., Efendi, J., Syafi'I, M.A., 2016. Crustal strain partitioning and the associated earthquake hazard in the eastern Sunda–Banda Arc. Geophys. Res. Lett.

Pownall, J.M., Hall, R. & Lister, G.S. 2016. Rolling open Earth's deepest forearc basin. Geology, 44, 947–950.

Silver, E.A., Breen, N.A., Prasetyo, H., and Hussong, D.M., 1986. Multibeam study of the Flores Backarc Thrust Belt, Indonesia. Journal of Geophysical Research, 91, 3489–3500.

Tate, G.W., McQuarrie, N., van Hinsbergen, D.J.J., Bakker, R.R., Harris, R., Haishui, J., 2015. Australia going down under: quantifying continental subduction during arc-continent accretion in Timor-Leste. Geosphere.

Vroon, P. Z. (1992). Subduction of continental material in the Banda Arc, Eastern Indonesia: Sr–Nd–Pb isotope and trace-element evidence from volcanics and sediment. Ph.D. dissertation, University of Utrecht.

Acknowledgements

The project is part of GEOCAP, the Indonesia-Netherlands joint collaboration in geothermal development. The author also expresses his gratitude to Indonesian Endowment Fund for Education (LPDP).

EGU2018-16496
Poster presented: EGU General Assembly, 8-13 April, Vienna

Contact: Ahmad Fauzi Purwandono
a.f.purwandono@uu.nl