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Quaternary caldera-forming eruptions from north to south Sumatra (Indonesia)

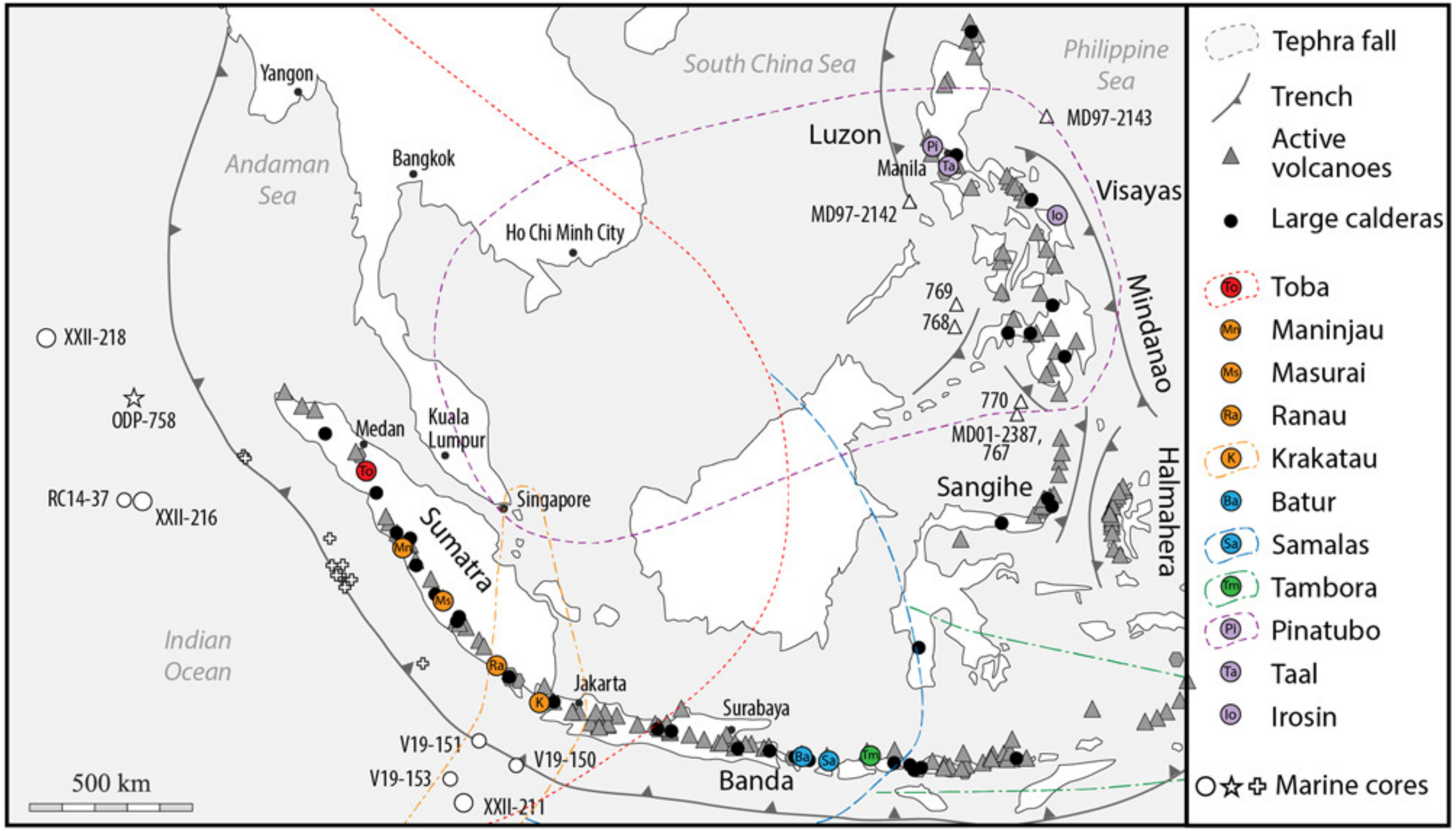
Forni F., Oalmann J.A., Fellin G., Eisele S., Phua M., Guillong M., Rifai H., Bouvet de Maisonneuve C.

ETH zürich

NANYANG TECHNOLOGICAL UNIVERSITY
Asian School of the Environment

UNIVERSITAS NEGERI PADANG
UNP

What do we know about caldera-forming eruptions in SE Asia?

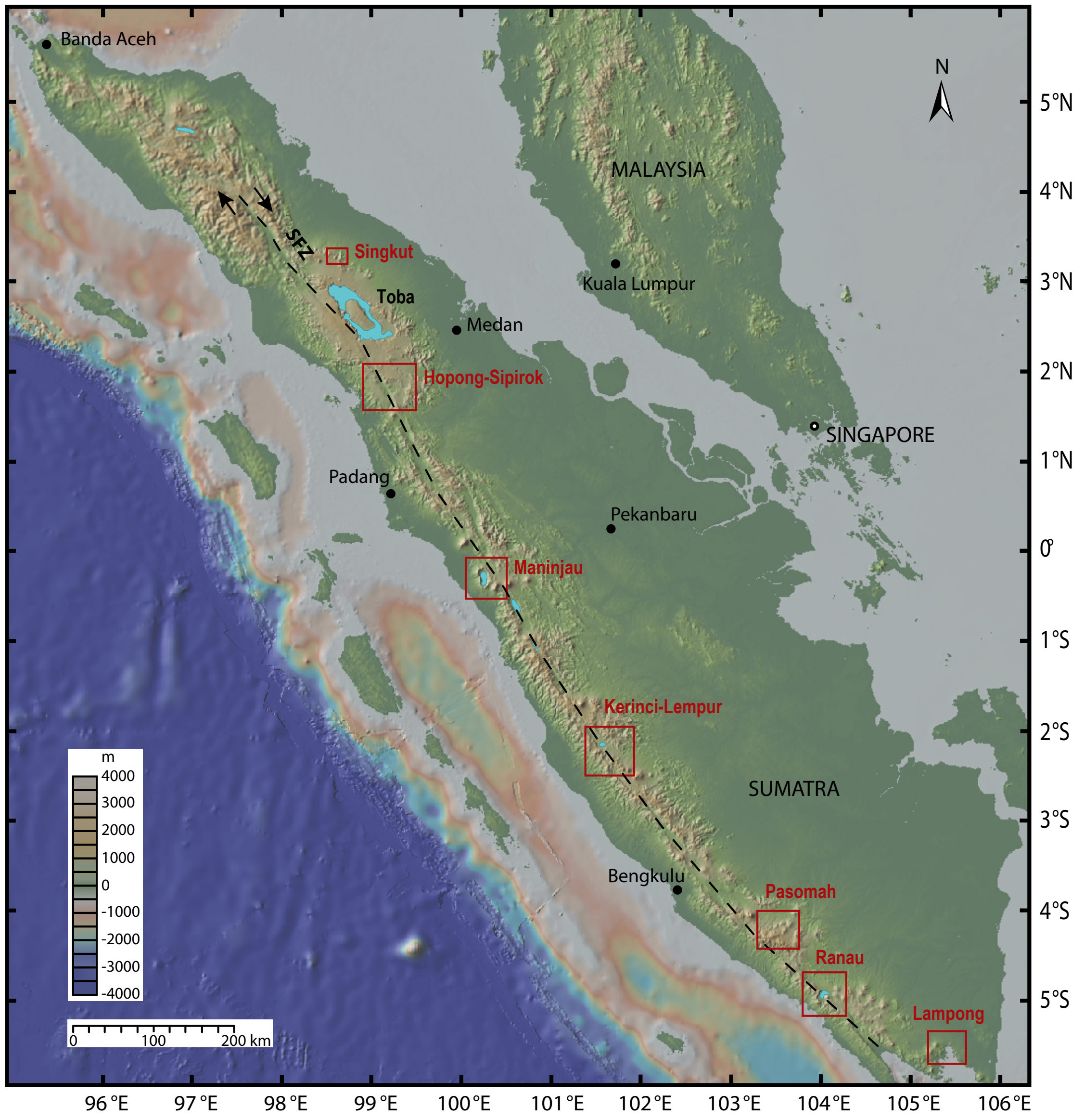


Map of SE Asia showing with colour-coded symbols the Holocene VEI 6-8 caldera-forming eruptions for which geochemical data and/or ages are available in the literature (Bouvet De Maisonneuve and Bergal-Kuvikas, 2020).

- At least **41 large calderas** (> 5km) in SE Asia, that produced VEI 6-8 explosive eruptions (Whelley et al., 2015)
- Geochemical data and/or ages are available in the literature only for 11 caldera-forming systems, 5 of which are in Sumatra
- Silicic tuffs are widespread all over Sumatra suggesting a **much higher frequency of large explosive eruptions**

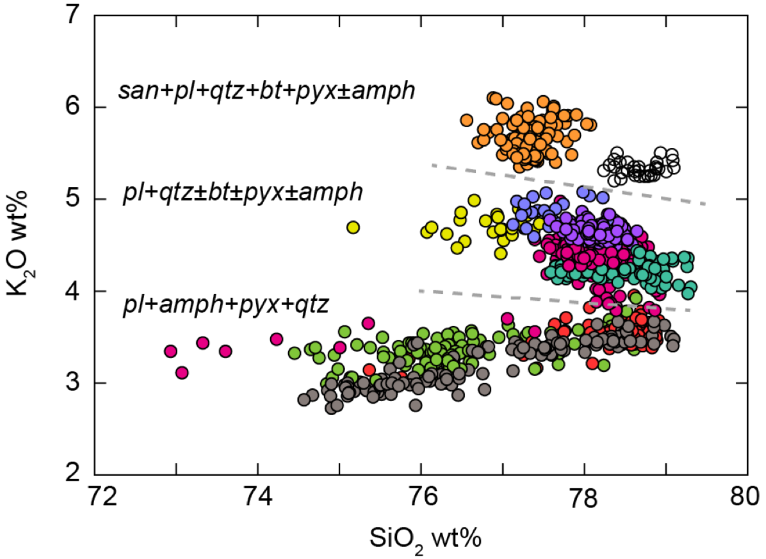
Our survey in Sumatra

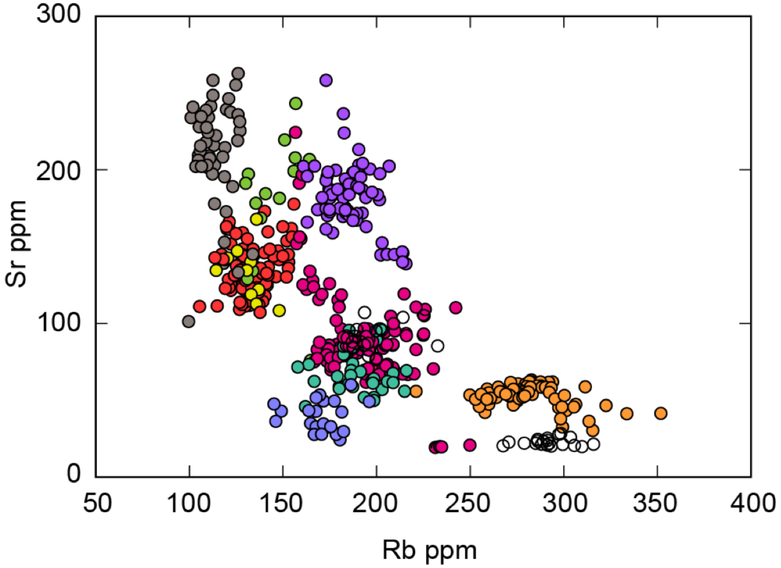
- **7 source areas** of caldera-forming eruptions and associated silicic tuffs have been identified
- Some of these sources have experienced multiple caldera-forming eruptions
- Caldera diameters vary between ~5 and 30 km
- Erupted volumes are in the order of tens to hundreds of km^3 (VEI 6-7)



Map of Sumatra showing the location of the investigated sources of caldera-forming eruptions. SFZ = Sumatran Fault Zone.

Mineralogy and geochemistry of tuffs

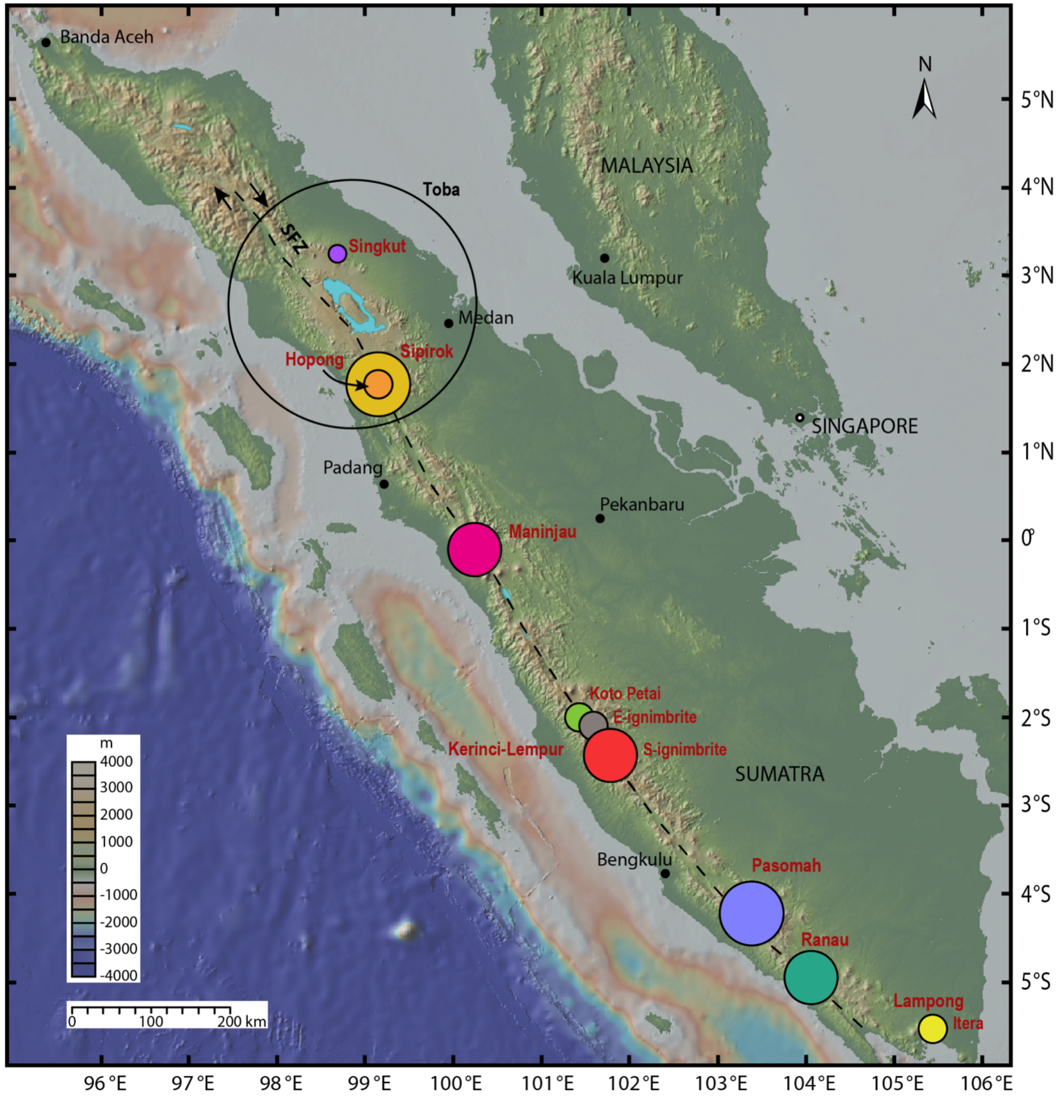




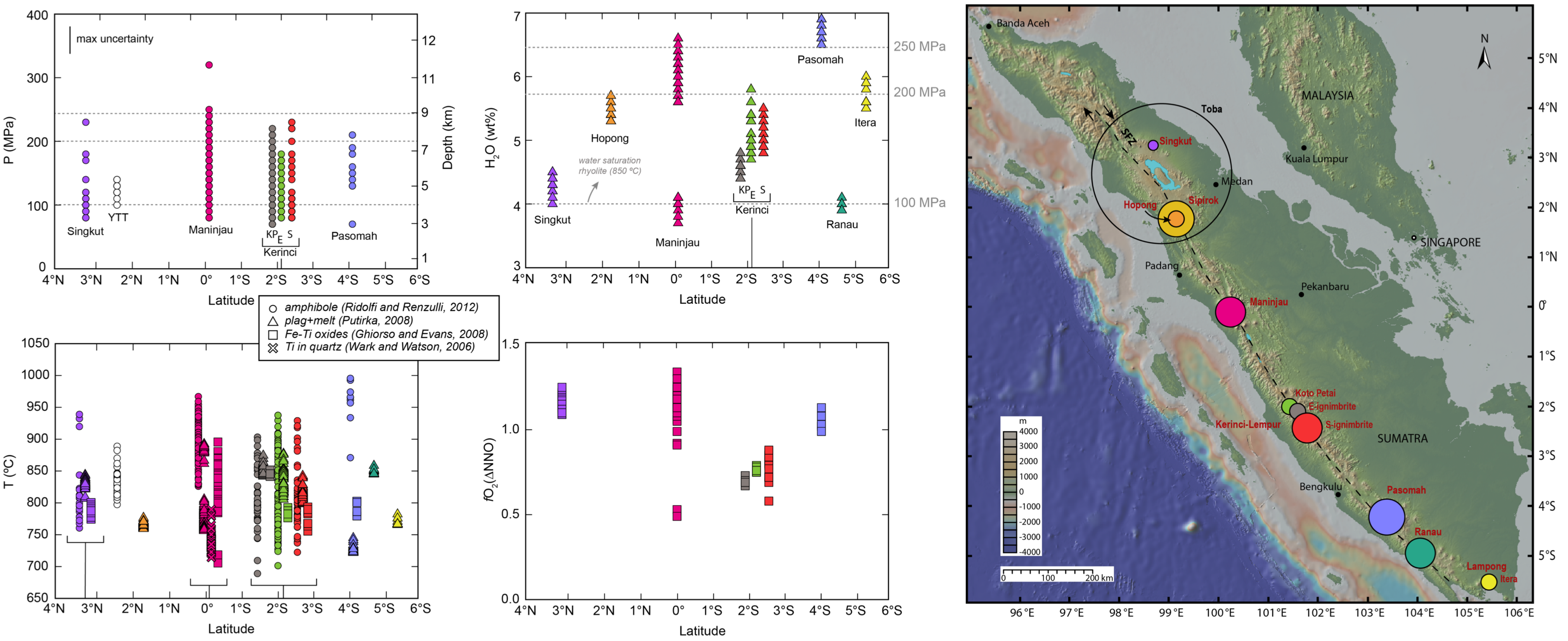
The tuffs are all rhyolitic in composition but show differences in their mineralogy and major and trace element composition of matrix glasses

Composition of matrix glasses from the tuffs and their main mineral phases. Colours are the same as on the map (no glass data available for the Sipirok tuff).

Location of the investigated silicic tuffs. Colours identify the pyroclastic units, symbol size is scaled to the diameter of the associated calderas with Toba for comparison.



Magma storage conditions



Intensive parameters derived from matrix glass and mineral chemistry for the investigated tuffs, ordered according to their latitude. The data indicate that the small differences in the magma storage conditions are independent from latitude and eruption size. Overall, magmas are stored between 50 and 250 MPa (3-9 km) and their water contents are close to or above saturation.

Geochronology

<u>Dating methods</u>

U/Pb*
(U-Th)/He*
^{14}C**

U/Pb*
^{39}Ar/^{40}Ar***

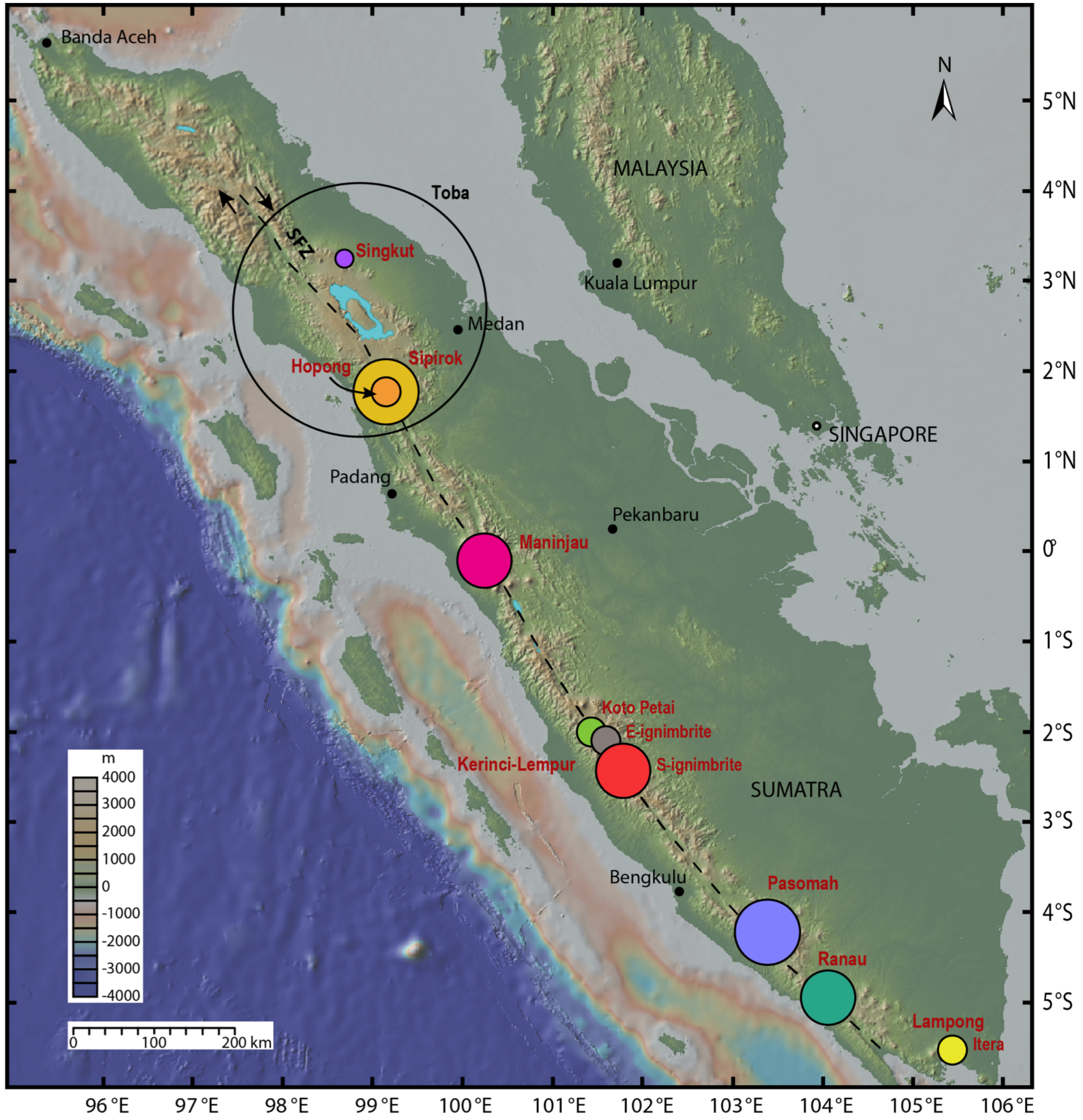
U/Th*

U/Pb*
(U-Th)/He*

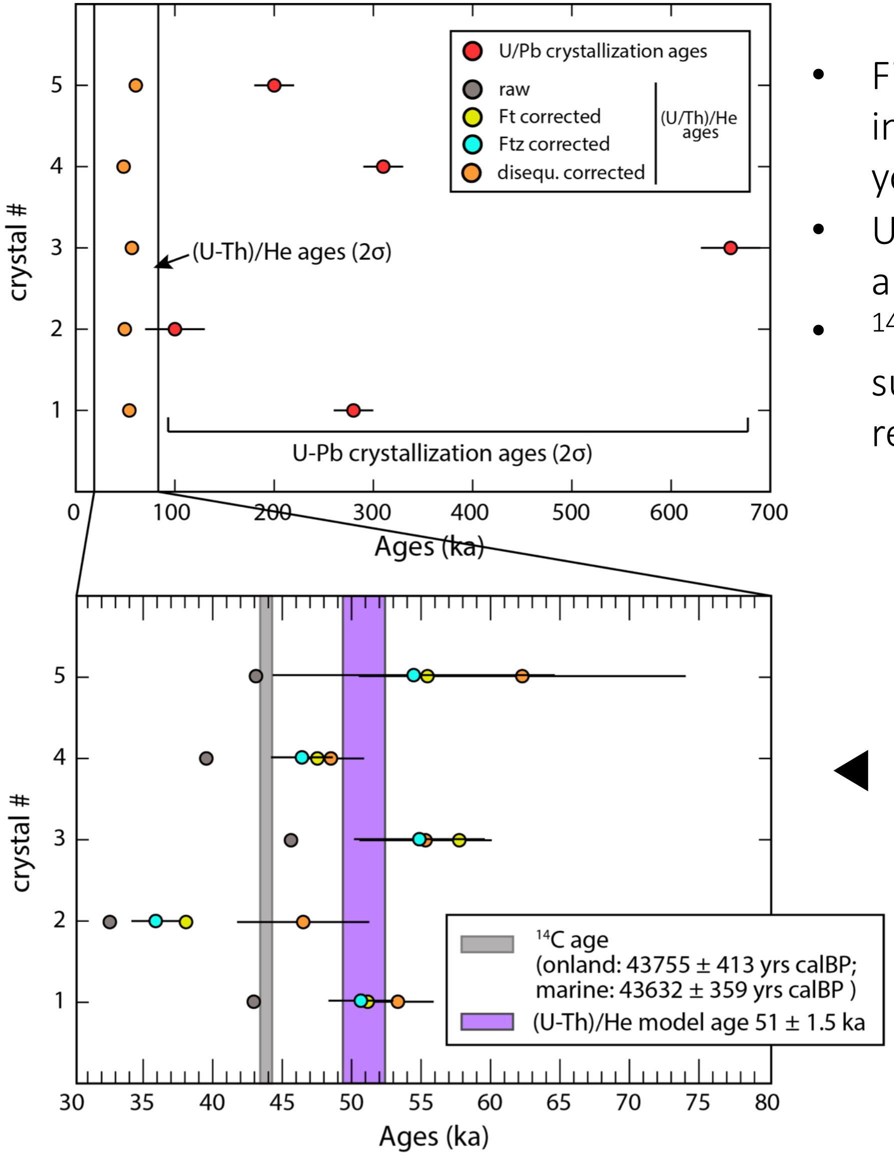
U/Th*
(U-Th)/He*
^{14}C**

U/Pb*
(U-Th)/He*

* zircon
** charcoal (onland deposits)
/forams (marine cores)
*** sanidine

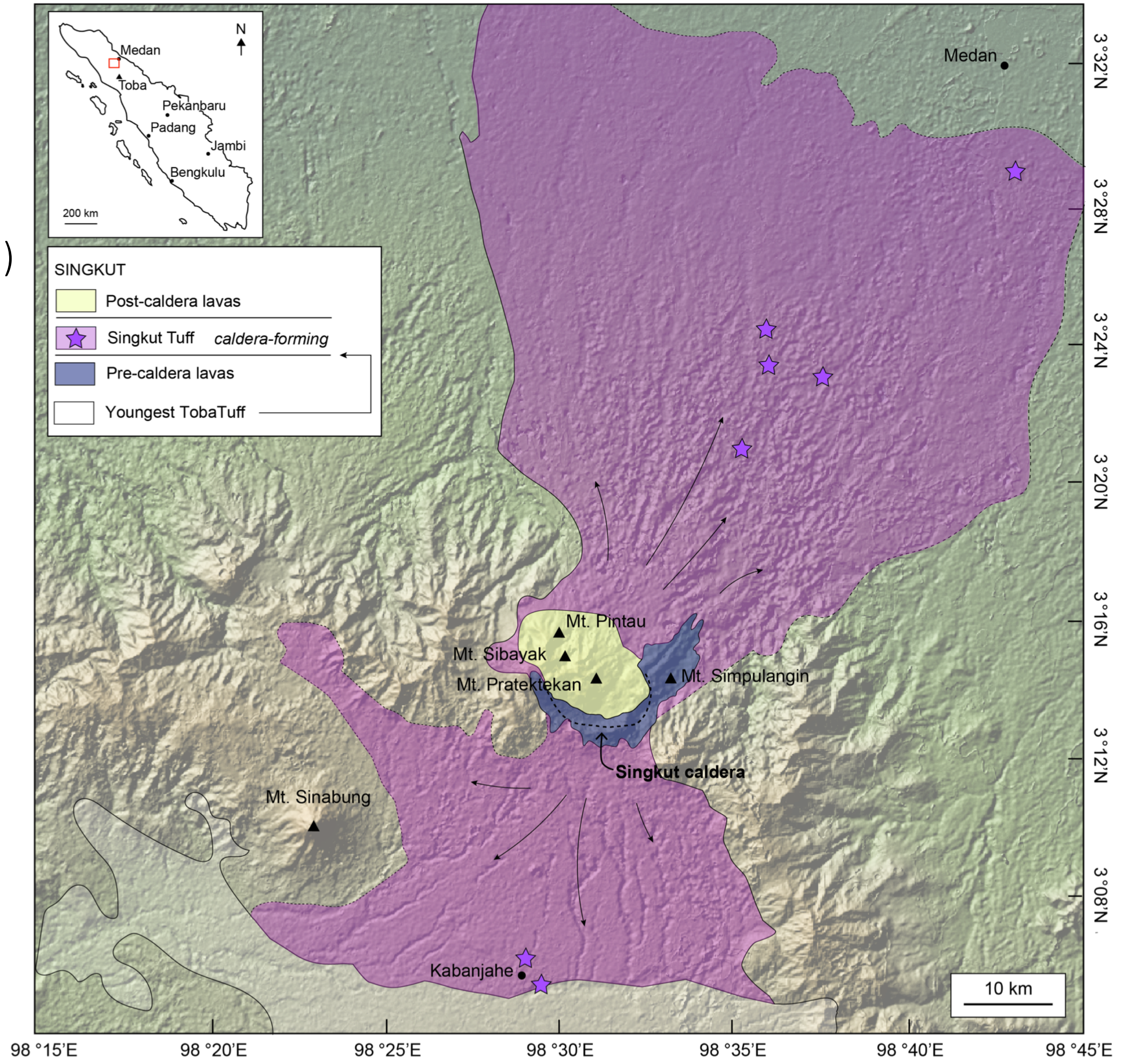


SINGKUT TUFF (N-Sumatra)



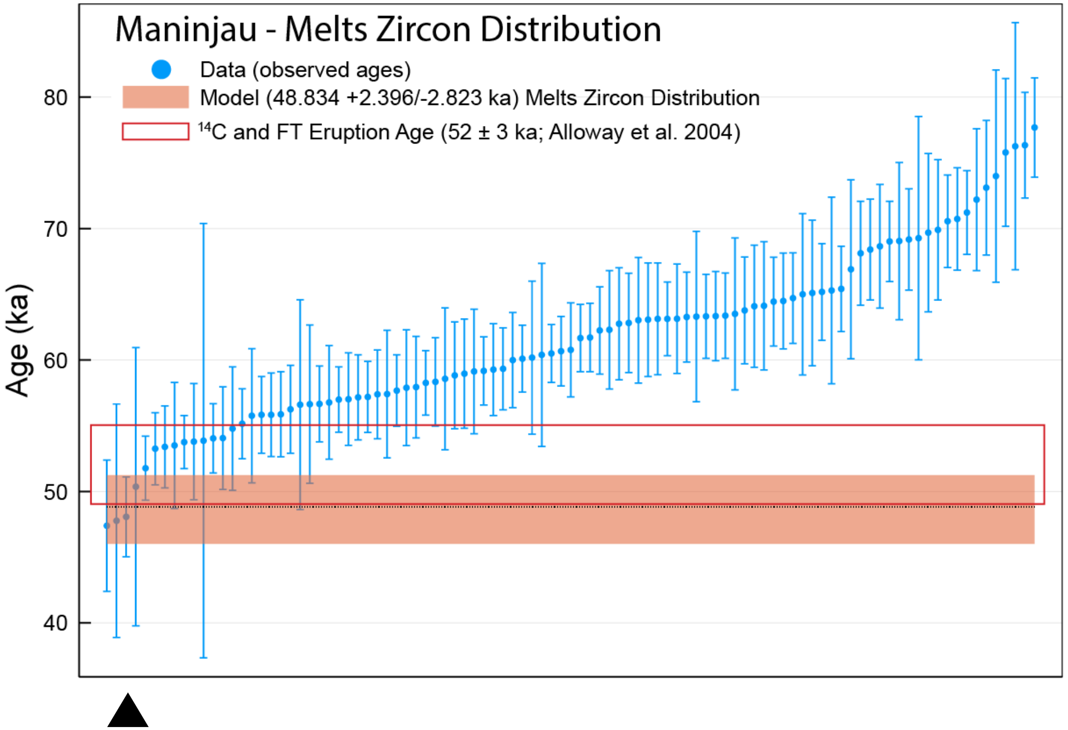
- Field observations indicate that Singkut is younger than YTT (<74 ka)
- U/Pb zircon ages (n=72) are > 100 ka
- ^{14}C and (U-Th)/He ages support the stratigraphic relationships

◀ *(U-Th)/He ages of 5 zircons with different U/Pb ages (2σ uncertainties) and ^{14}C ages (1σ). The plots show the effect of the various corrections. The final eruption age (U-Th/He model age) is calculated using MCHeCalc (Schmitt et al., 2010).*

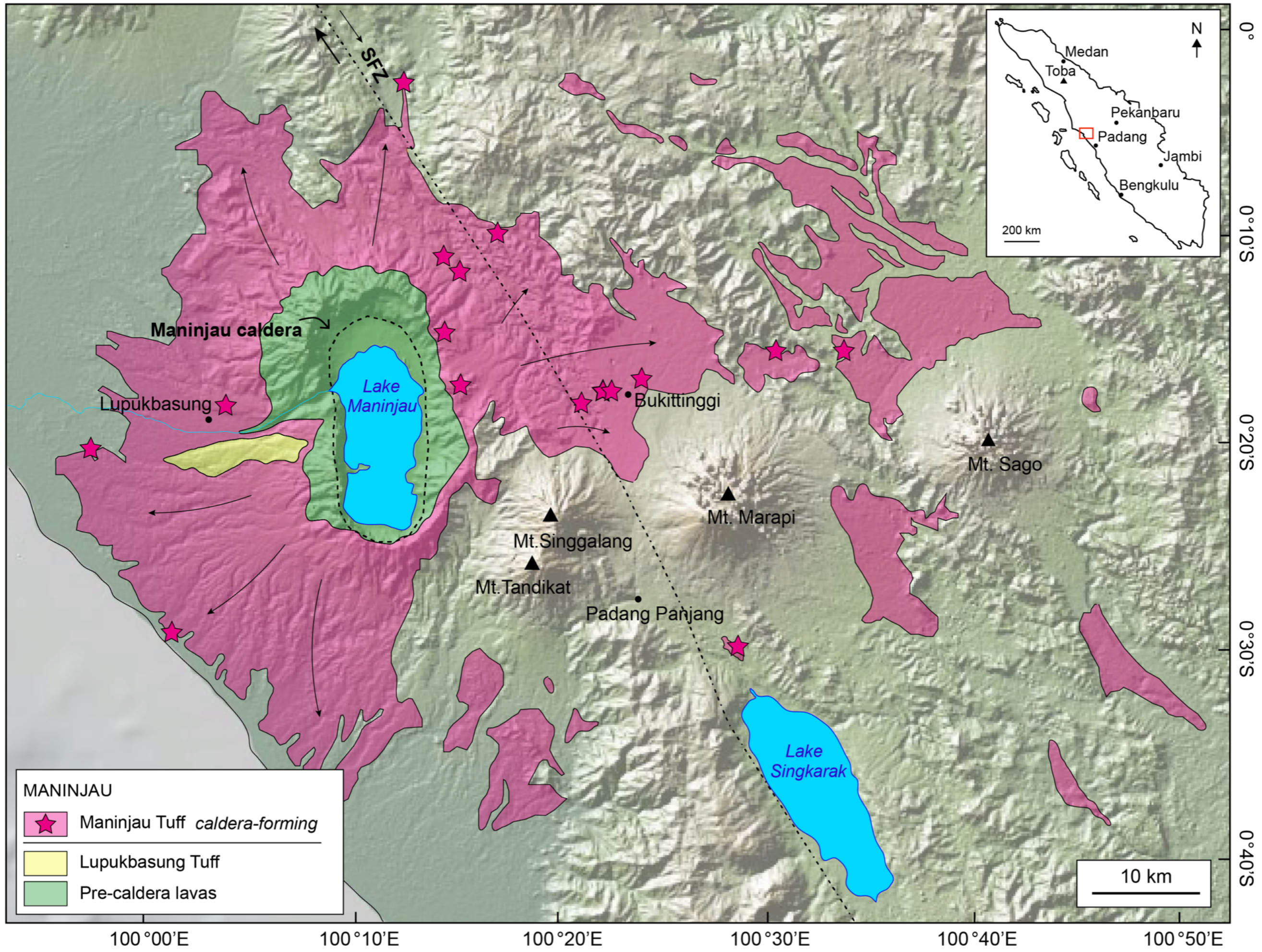


Map of the Singkut caldera showing the extension of the Singkut Tuff, sampling localities (stars), contacts with the the pre- and post-caldera units and the 74 ka Youngest Toba Tuff (YTT).

MANINJAU TUFF (central Sumatra)

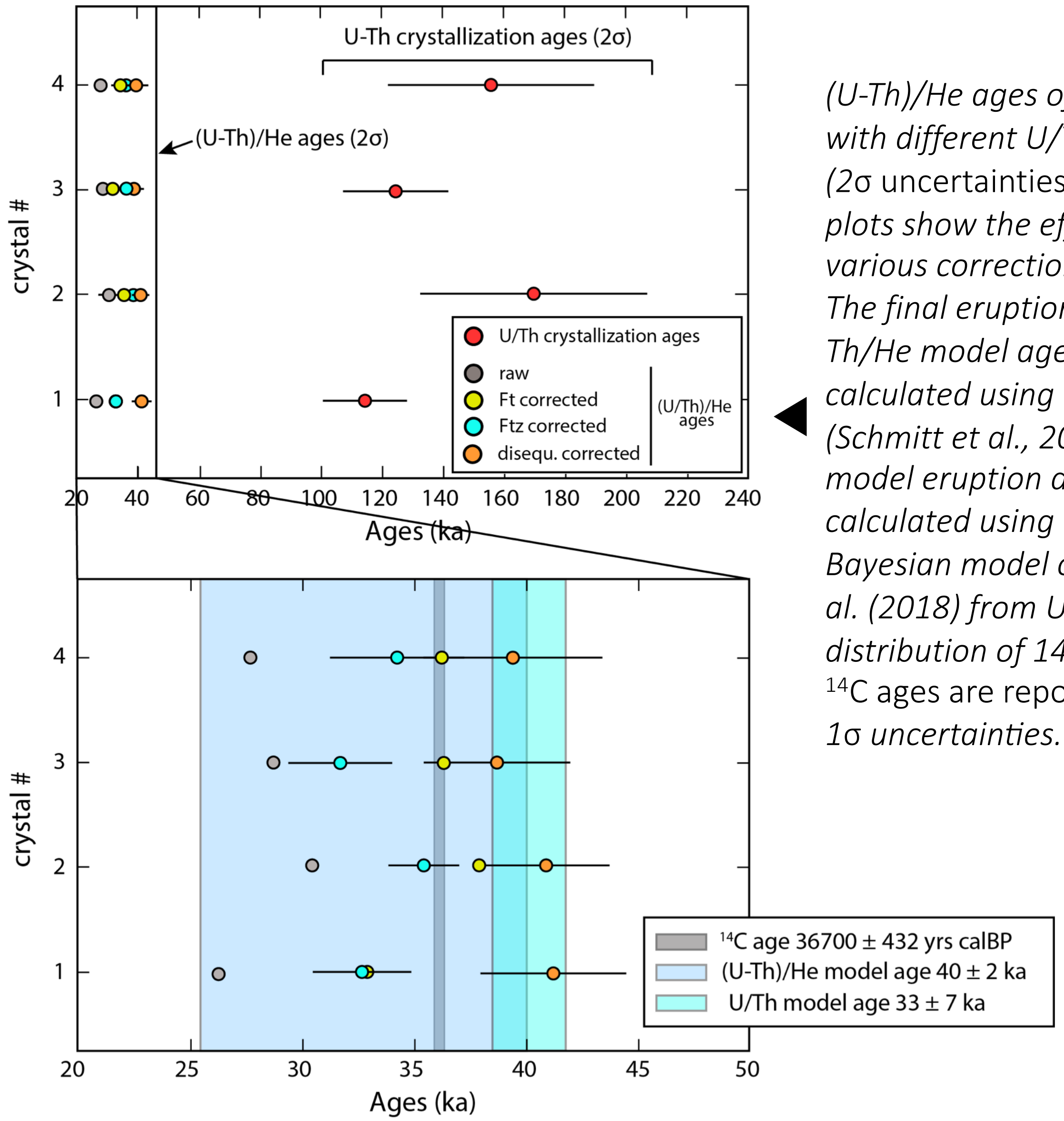


U/Th age distribution of 97 zircons in the Maninjau Tuff and eruption age interpretation obtained using the Bayesian model of Keller et al. (2018) (orange box). ^{14}C and FT eruption age from Alloway et al. (2004) for comparison (red outline). All uncertainties in 1σ.

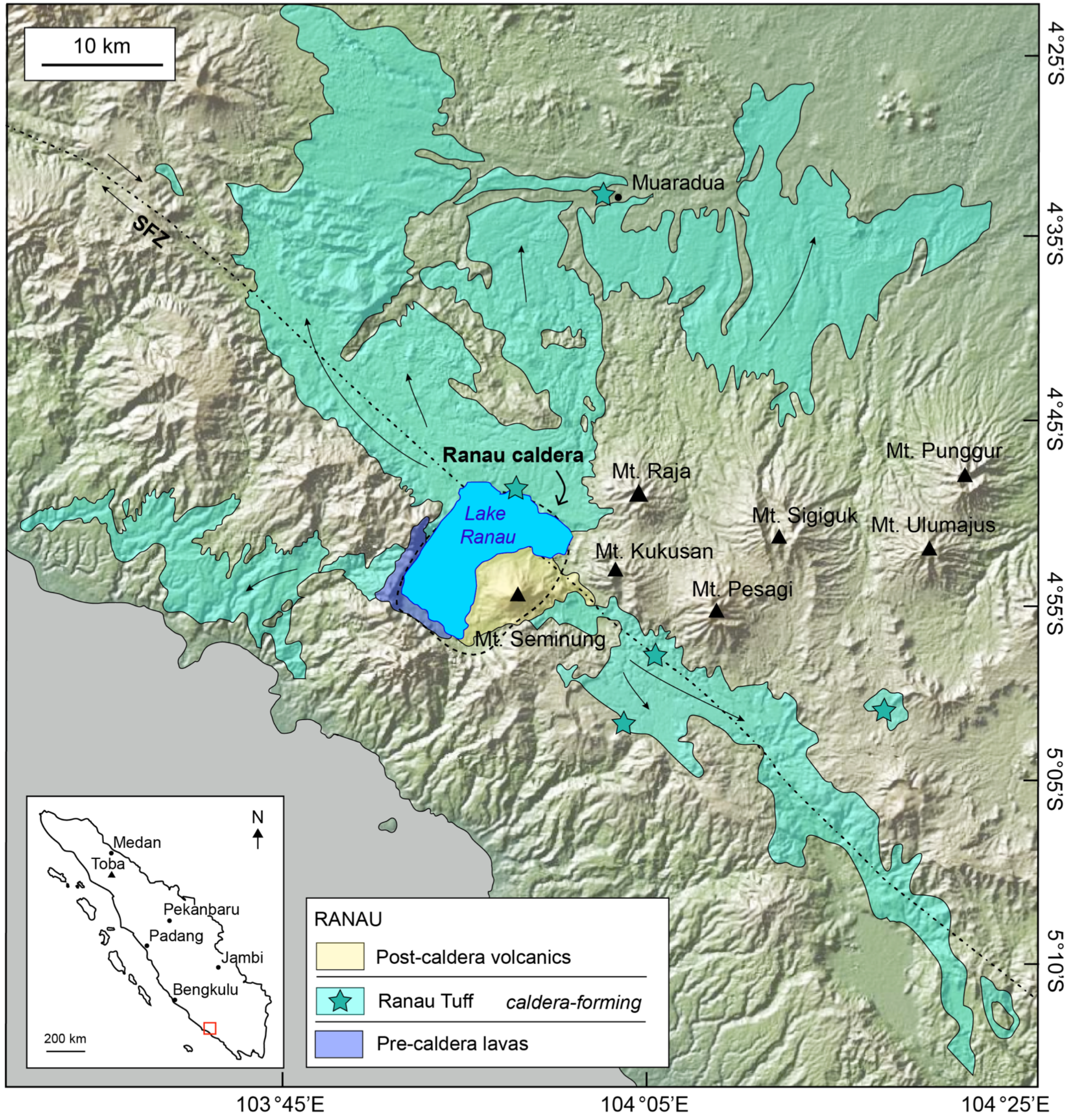


Map of the Maninjau caldera showing the extension of the Maninjau Tuff, sampling localities (stars) and contacts with the pre-caldera units.

RANAU TUFF (S-Sumatra)

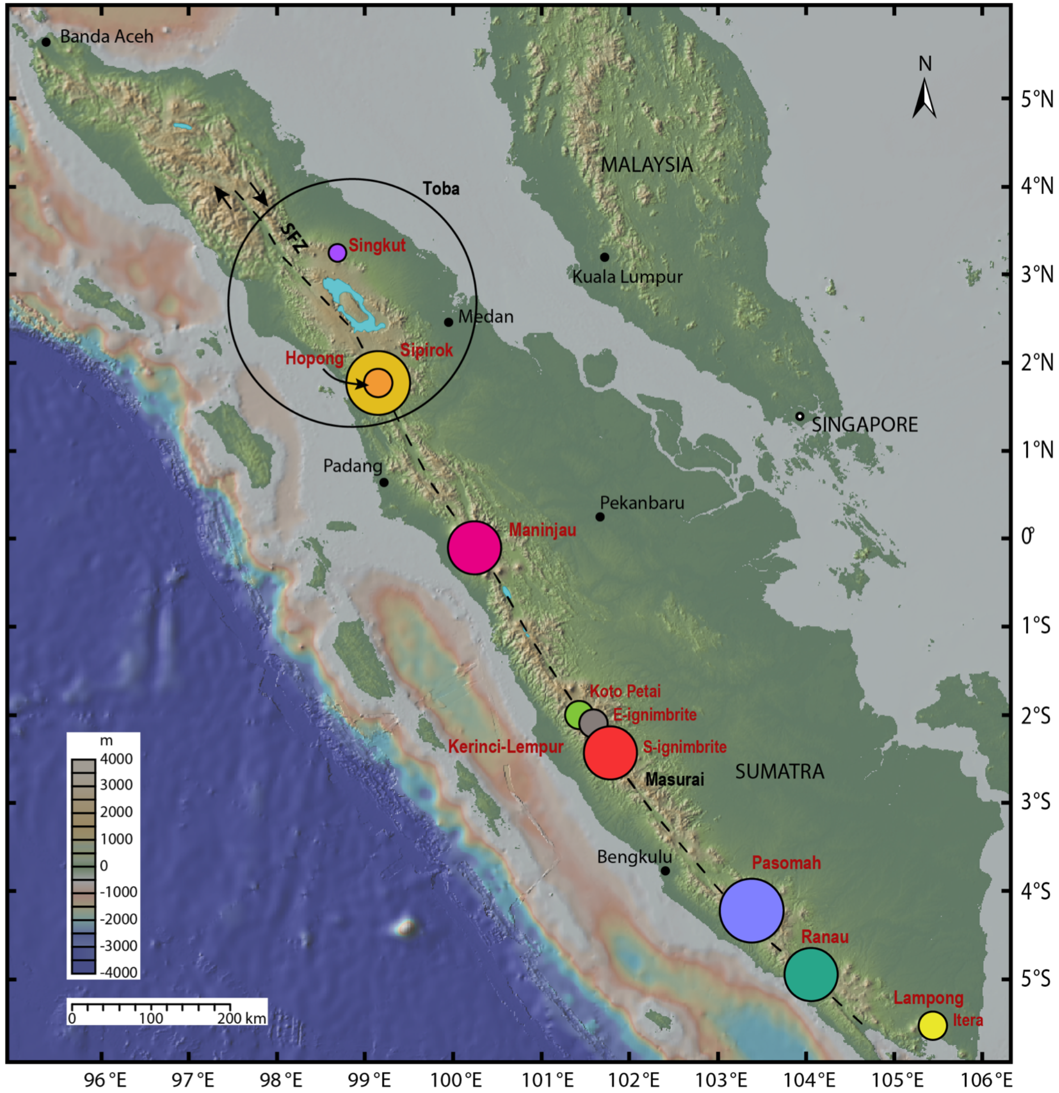


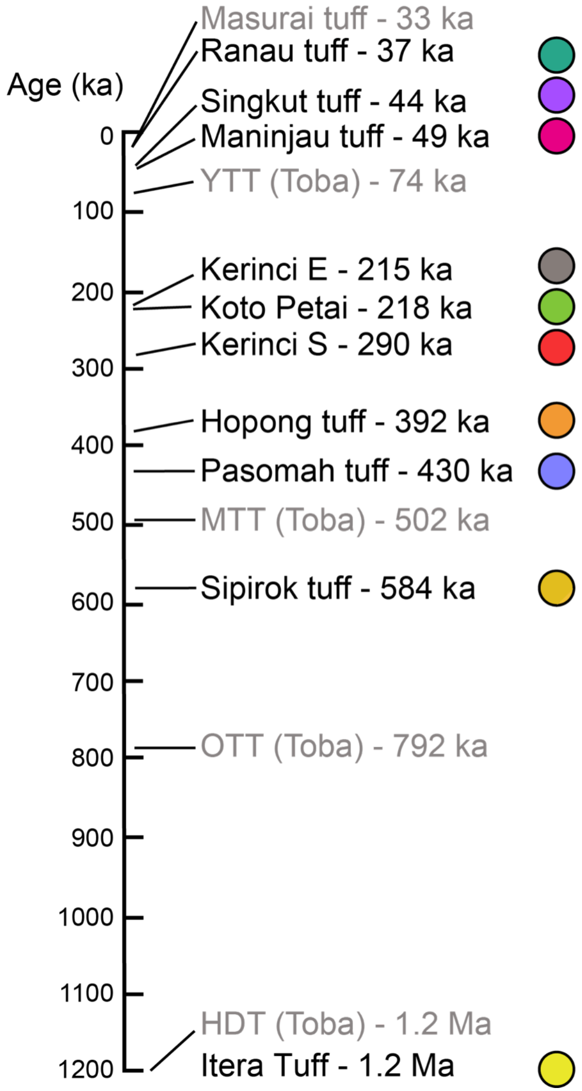
(U-Th)/He ages of 4 zircons with different U/Th ages (2σ uncertainties). The plots show the effect of the various corrections. The final eruption age (U-Th/He model age) is calculated using MCHeCalc (Schmitt et al., 2010). U/Th model eruption age (2σ) is calculated using the Bayesian model of Keller et al. (2018) from U/Th age distribution of 143 zircons. ^{14}C ages are reported with *1σ uncertainties.*



Map of the Ranau caldera showing the extension of the Ranau Tuff, sampling localities (stars) and contacts with the pre- and post-caldera units.

Conclusions





- We redefine the number of caldera-forming eruptions in Sumatra from 7 (previously dated) to 15 over the last 1.2 Myr
- A significant number of eruptions, potentially better preserved in the marine record, might still be missing from our reconstruction

References

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