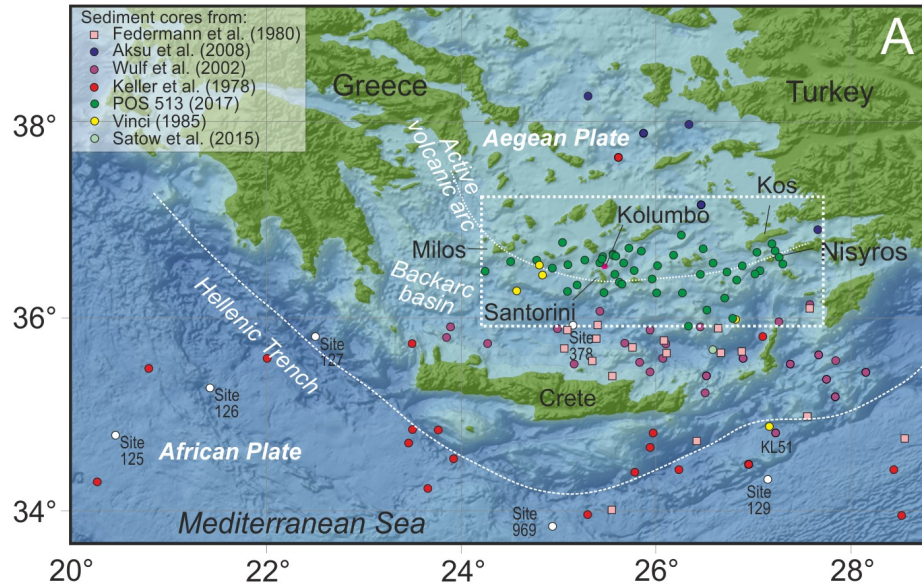


# The medial offshore record of Plinian arc volcanism in the Eastern Aegean Sea: Implications for tephrostratigraphy, correlations, ages and volumes

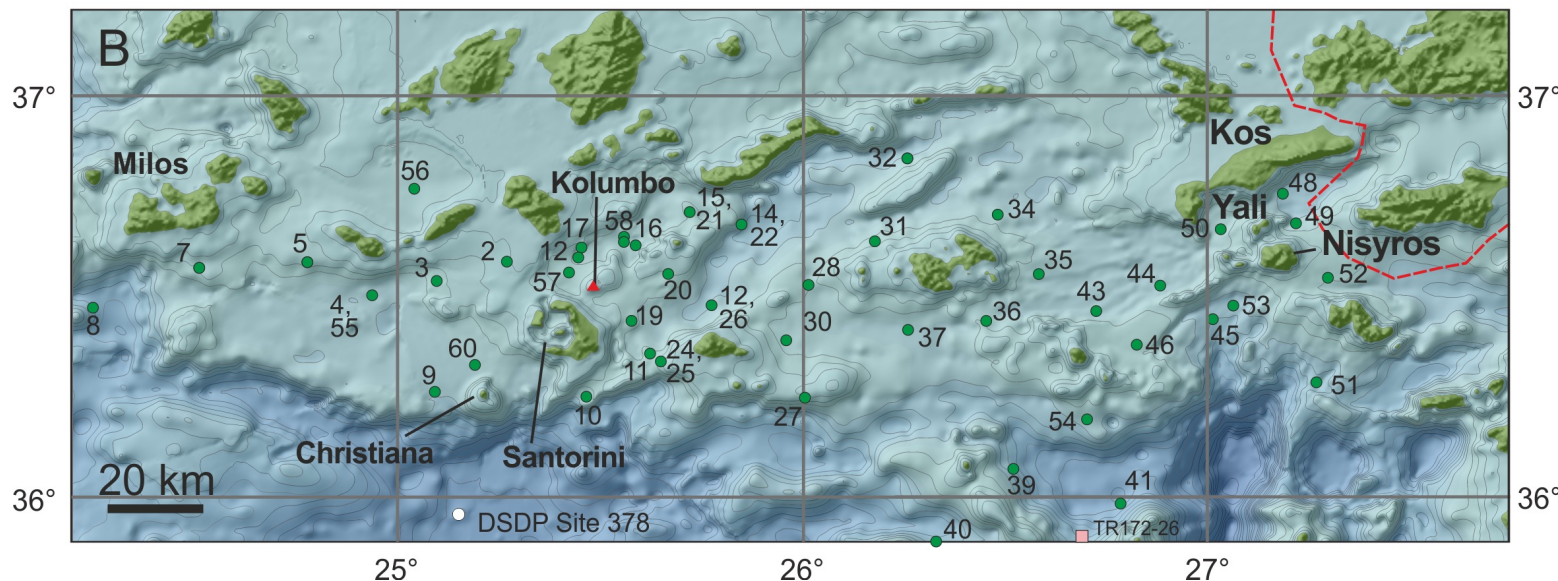
**S. Kutterolf**, A. Freundt, T.H. Hansteen, R. Dettbarn,  
F. Hampel, C. Sievers, C. Wittig, T. Druitt, J. McPhie,  
P. Nomikou, K. Pank, J.C. Schindlbeck-Belo, K.-L.  
Wang, H.-Y. Lee, B.



# 1. Introduction: Regional Setting



- Aegean arc → Christiana-Santorini-Kolumbo & Kos-Yali-Nisyros volcanic complexes
- The past record of VEI 4 to 7 explosive eruptions provides information on frequency, magnitudes and intensities
- The past highly explosive eruptions range from submarine through emergent to subaerial



**Initial objective**  
complementation and  
extension of  
tephrostratigraphy using 47  
medial distant sediment  
cores from 2017's RV  
Poseidon cruise POS 513.



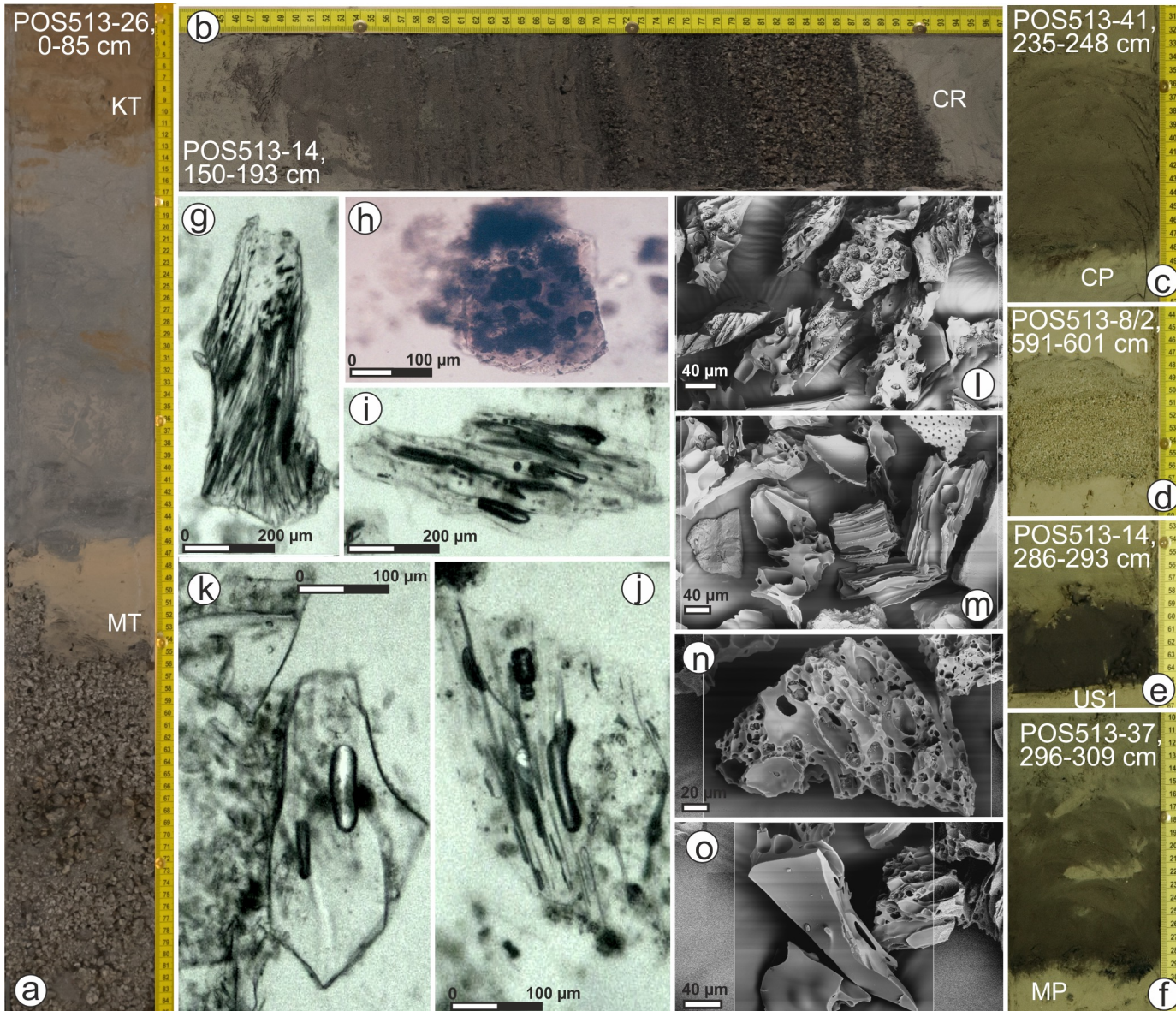
# 1. Introduction: tephra occurrence, methods

## Methods:

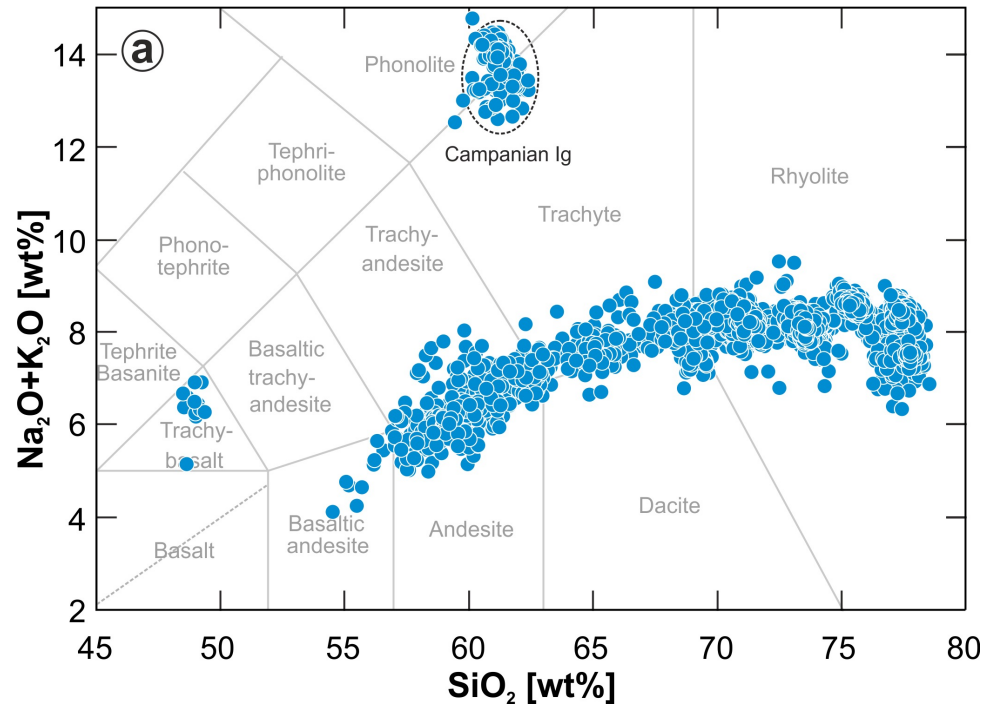
- petrographical and stratigraphical criteria
- major elements of glasses (EMP)
- trace element data (LA-ICP-MS).

## Correlation:

- compositional fields of terrestrial units
- chemical fingerprinting of marine ash layers.
- statistical methods (principal component analysis, hierarchical cluster analysis)

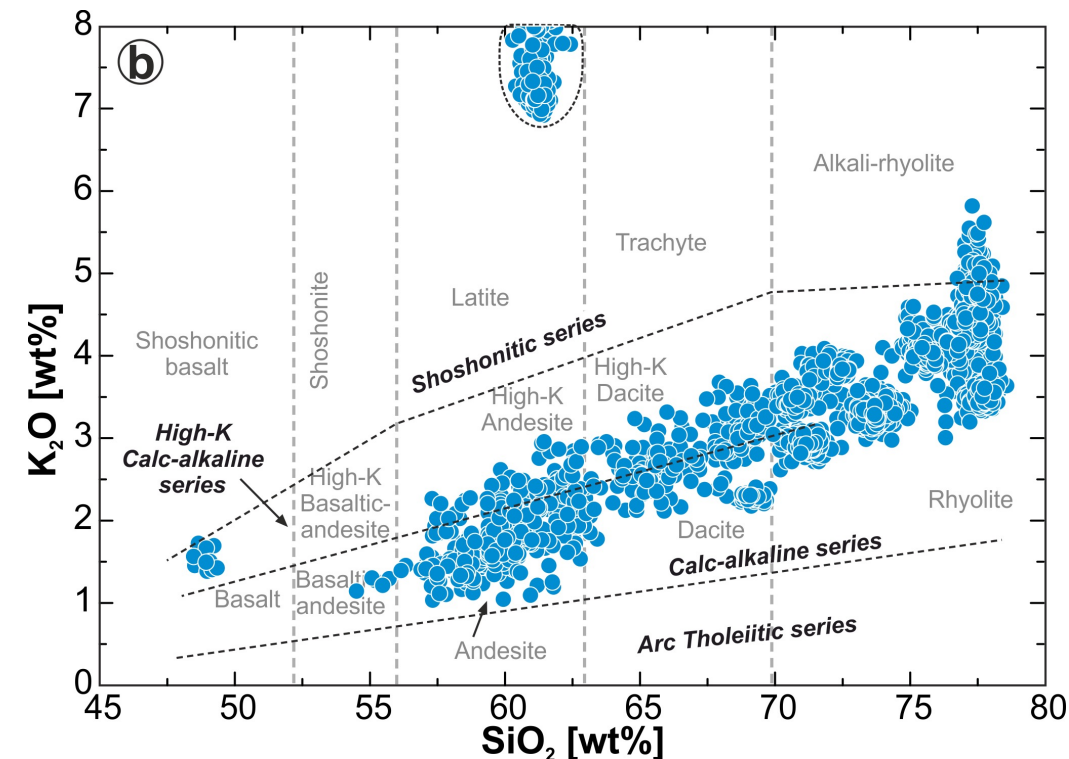


## 2. Tephra Compositions: General Classification



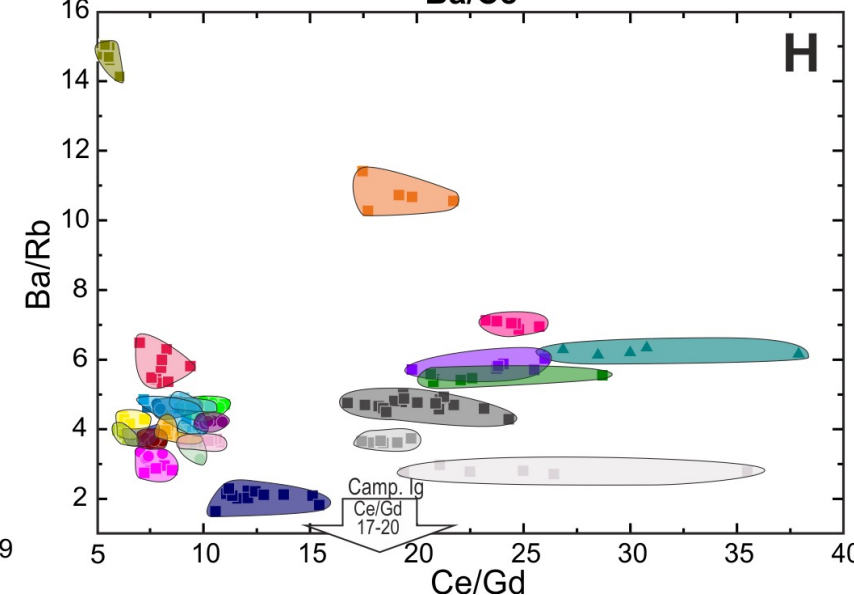
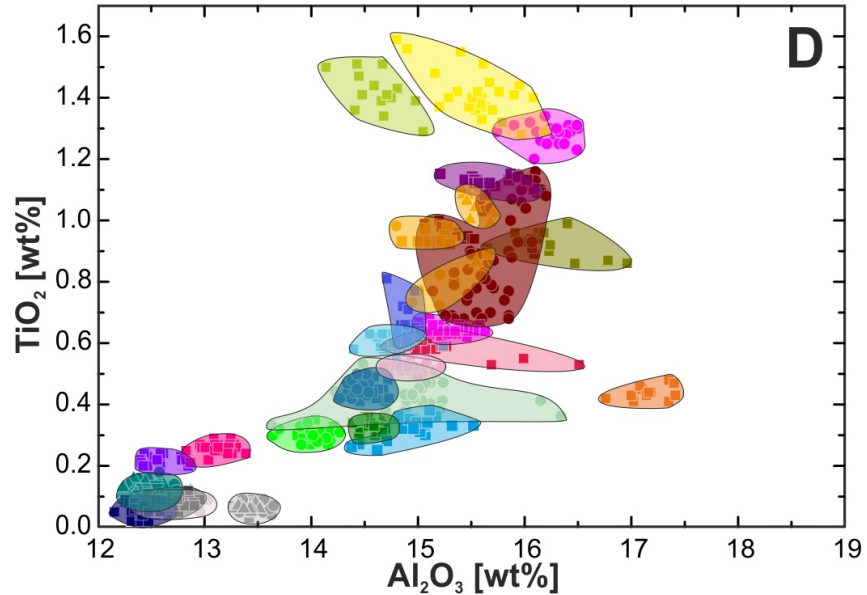
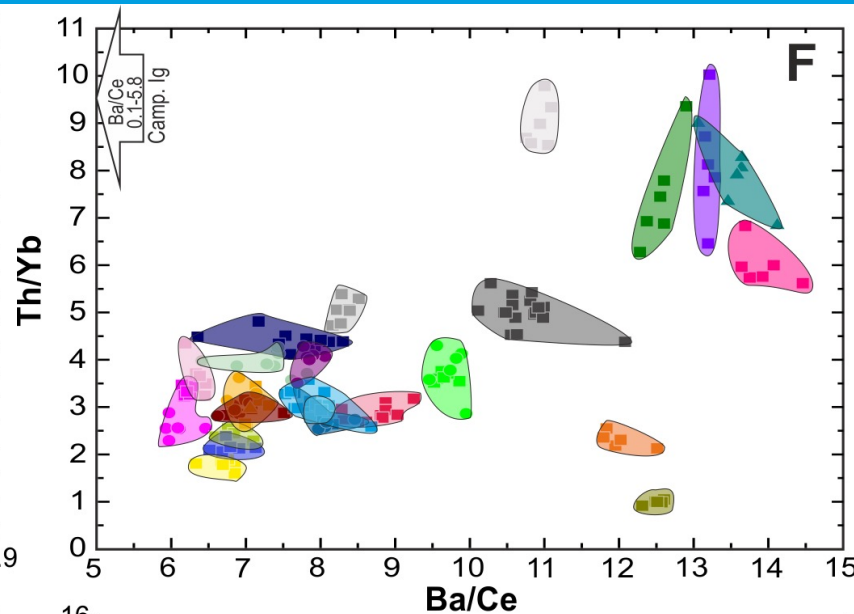
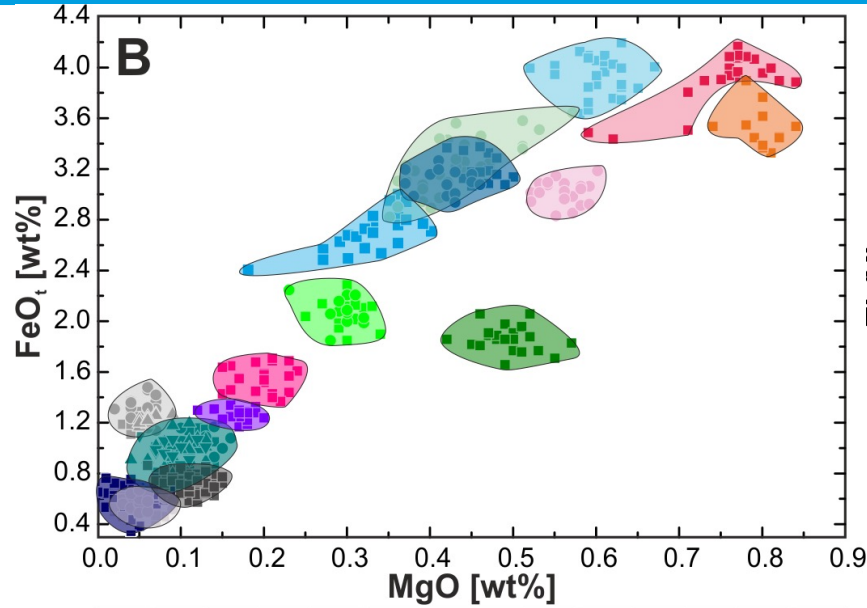
- 47 gravity cores (< 7.4 m)
- 377 tephra horizons; <60 cm thick
- transparent and dark to light brown
- blocky, cusped, tubular glass shards
- plag > amph/pyrox > biotite >> ol

- 7000 EMP and 1500 La-ICPMS analysis
- 229 primary layers (fine ash to fine lapilli)
- andesitic to rhyolitic
- phonolithic/trachytic exception → Campanian IG





## 2. Tephra Compositions: terrestrial tephras



### Santorini-Kolumbo-Milos

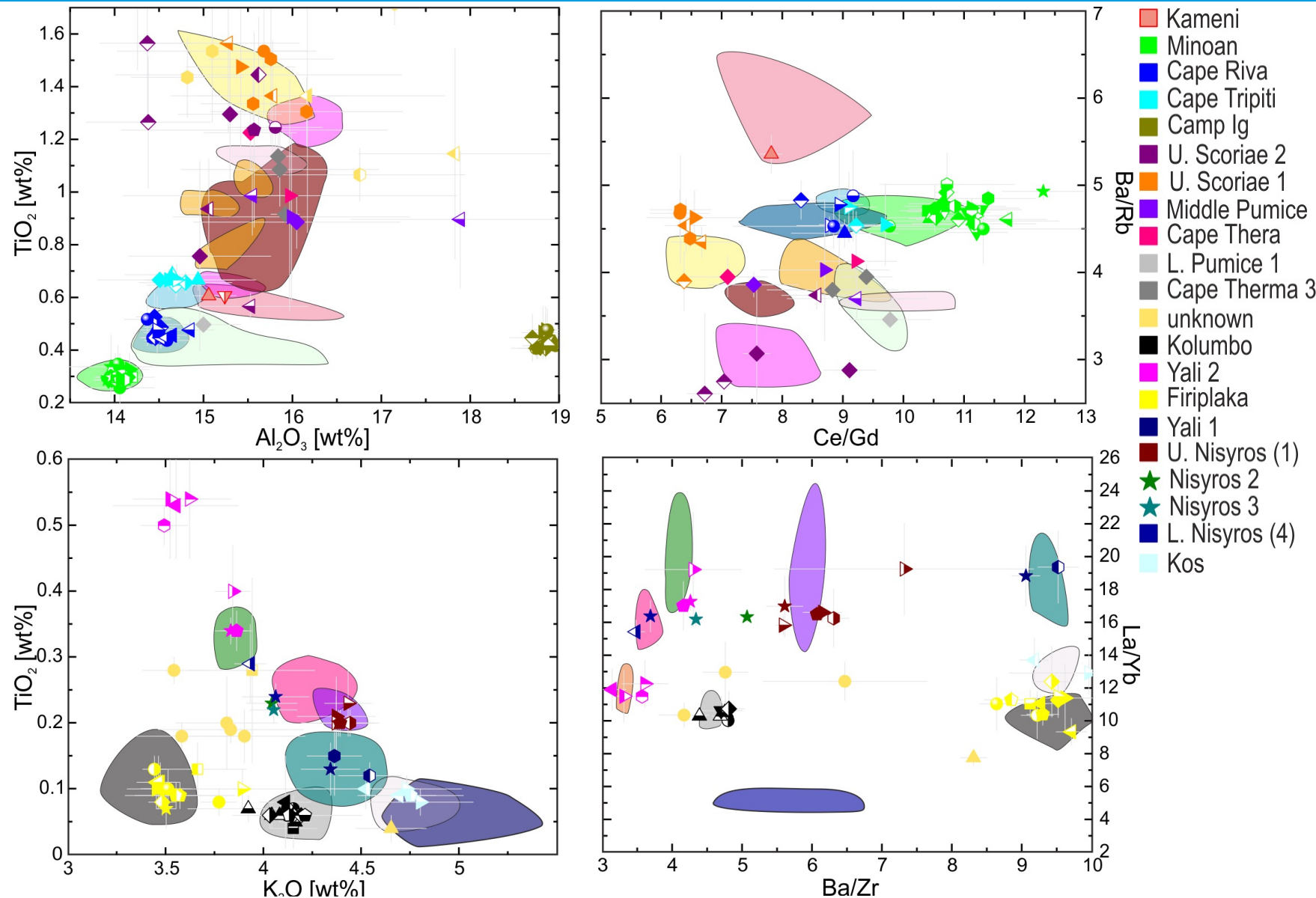
- Kameni (<3 ka)
- Minoan (3.6 ka)
- Cape Riva (22 ka)
- Cape Tripiti (26 ka)
- Upper Scoriae 2 (54 ka)
- Cape Thera (145 - 172 ka)
- Lower Pumice 2 (172 ka)
- Lower Pumice 1 (184 ka)
- Cape Therma 3 (196 ka)
- Cape Therma 2 (>225 ka)
- Upper Scoriae 1 (80 ka)
- Megalo Vouno (50 - 100 ka)
- Vourvoulos (?)
- Main Scoria Fall (?)
- Middle Pumice (145 ka)

### Kolumbo-Milos

- Kolumbo 1650
- Trachillas
- Firiplaka
- Nisyros-Kyra (38 ka)
- Nisyros Upper Pum (46 ka)
- Nisyros Lower Pum (>47 ka)
- Kos Plateau tephra (161 ka)
- Yali 1 (?)
- Yali 2 (31-35 ka)

- correlation fields for major tephras
- Comparison to literature data (e.g. interplinian eruptions by Wulf et al. 2020)

## 2. Tephra Correlations: Major and traces



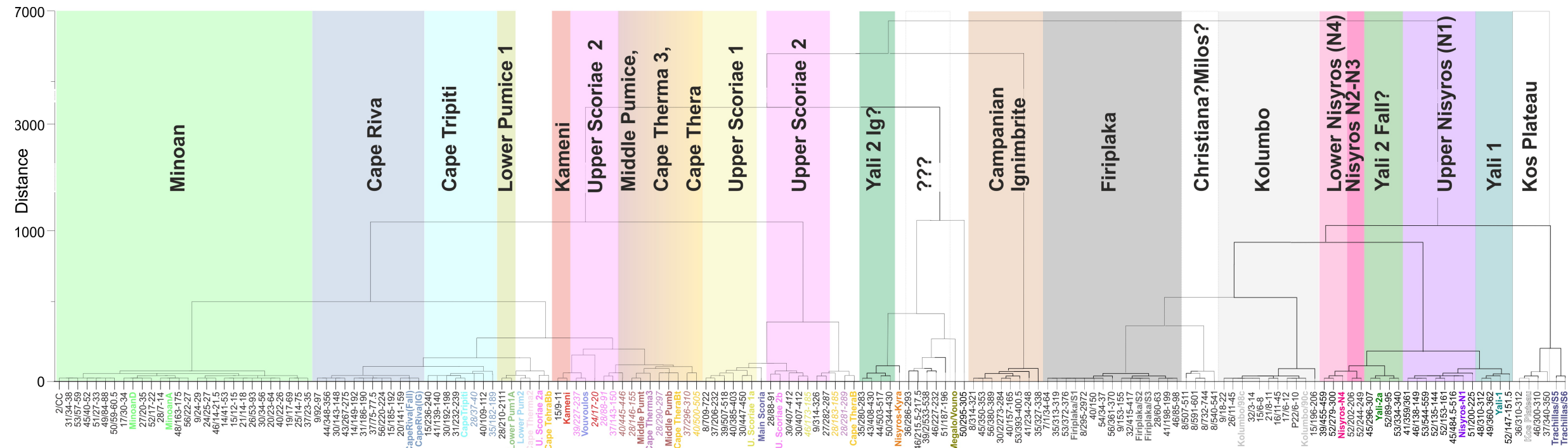
### Santorini

- Correlations to Minoan, Cape Riva, Cape Tripiti, Upper Scoriae 2 & 1, Cape Thera, Lower Pumice 1, Cape Thera 3
- No correlation to interplinian ?
- Correlation to Camp. IG
- 7 uncorrelated tephras

### Kos-Nisyros-Yali-Milos-Kolumbo

- Correlations to Yali 2, Yali 1, Nisyros Lower & Upper, Kos; Kolumbo Tephra; Firiplaka tephra
- 2nd facies Yali 2?
- 2 Interplinian Nisyros events ?

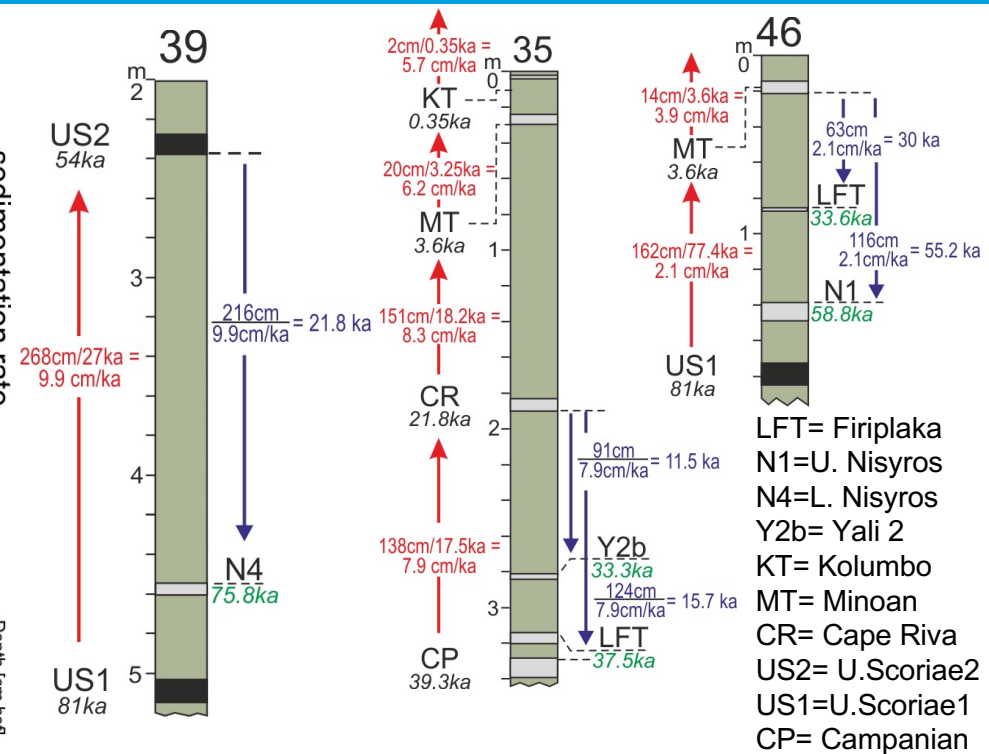
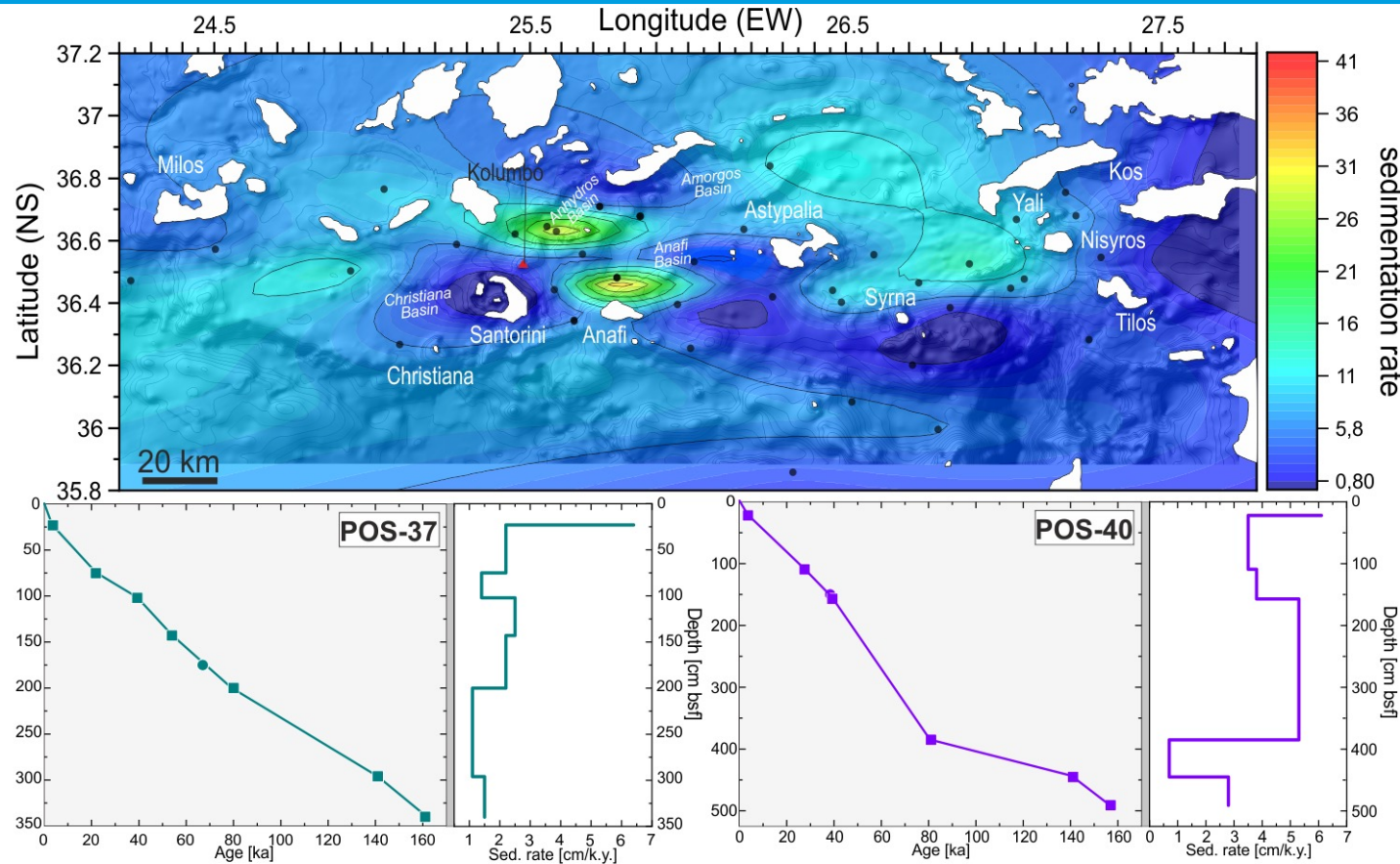
## 2. Tephra Correlation: Cluster analysis



- Principal component analysis (88 elements and ratios condensed to 10 principal components) and cluster analysis (Ward method, squared euclidian distance) of terrestrial and marine data confirm most correlations
- Cluster Middle pumice, Cape Therna 3, Cape Therna is difficult to distinguish but constrained by stratigraphic order in the cores



### 3. Sedimentation rates and ages

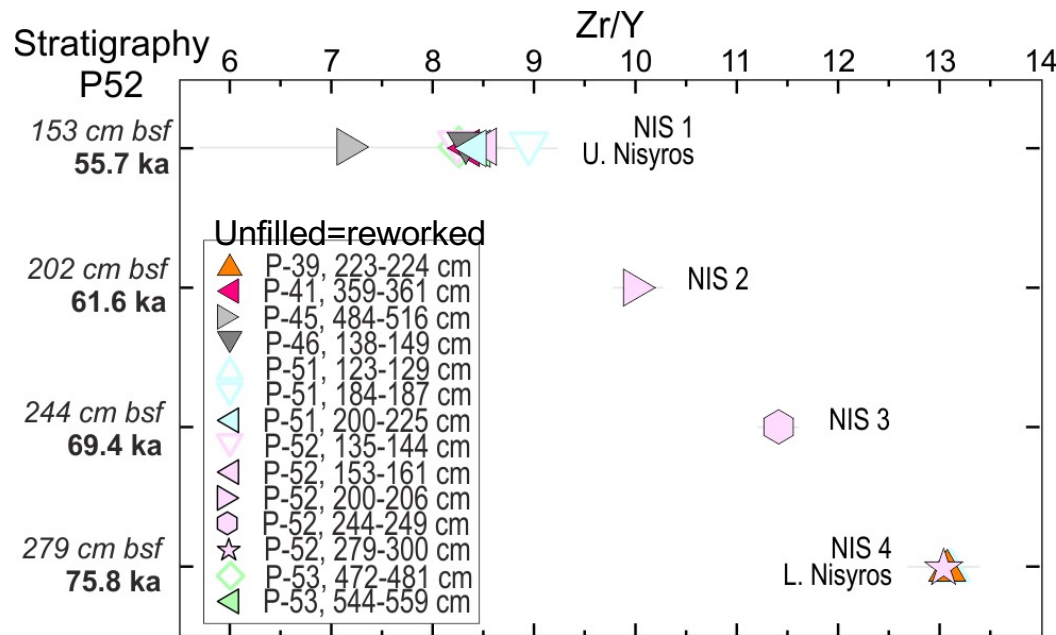


- Mostly homogenous sedimentation rates with time, regional differences
- Decrease in sedimentation rate ~80 ka close to some islands
- High sedimentation rates in basins affected by PDC deposits

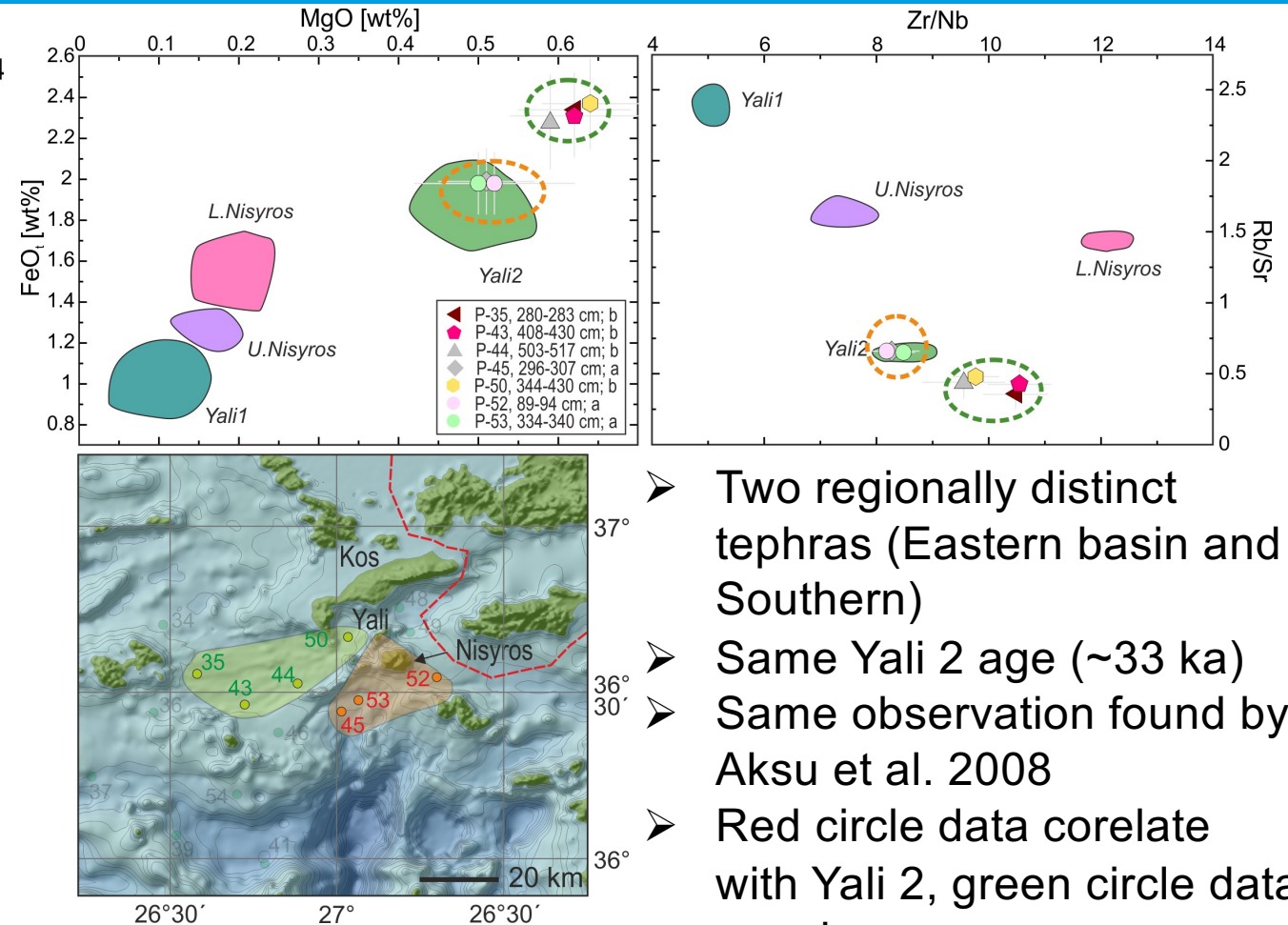
- 7 new ages: Firiplaka (~37ka), Yali 2 (~33ka), Yali 1 (~54ka), N1 (~56ka), N2 (~62ka), N3 (~69ka), N4 (~76ka)
  - Firiplaka, N1, Yali 2 constrained by multiple cores
- ➔ Resulting errors of  $\pm 0.9$  to 2.6 ka



## 4. Aegean teprostratigraphic problems



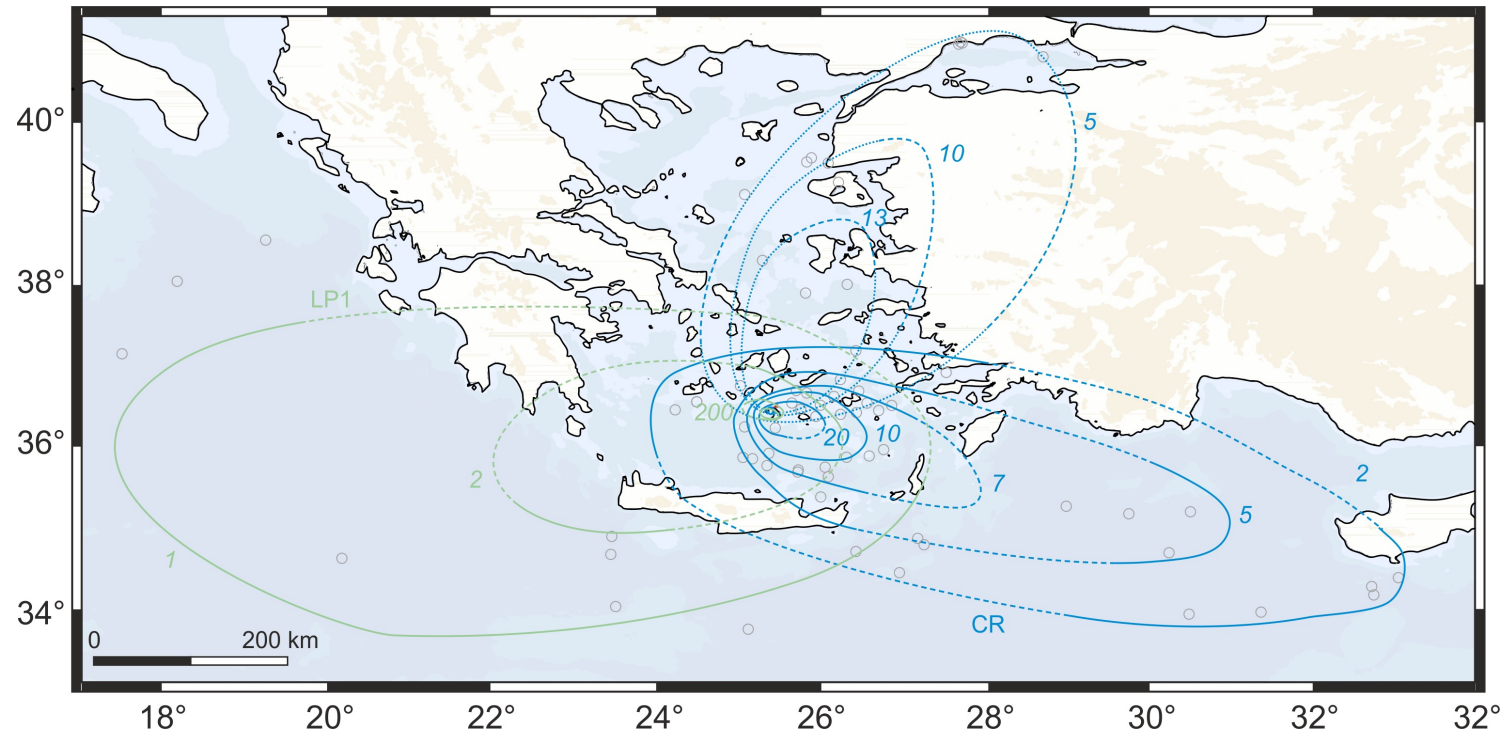
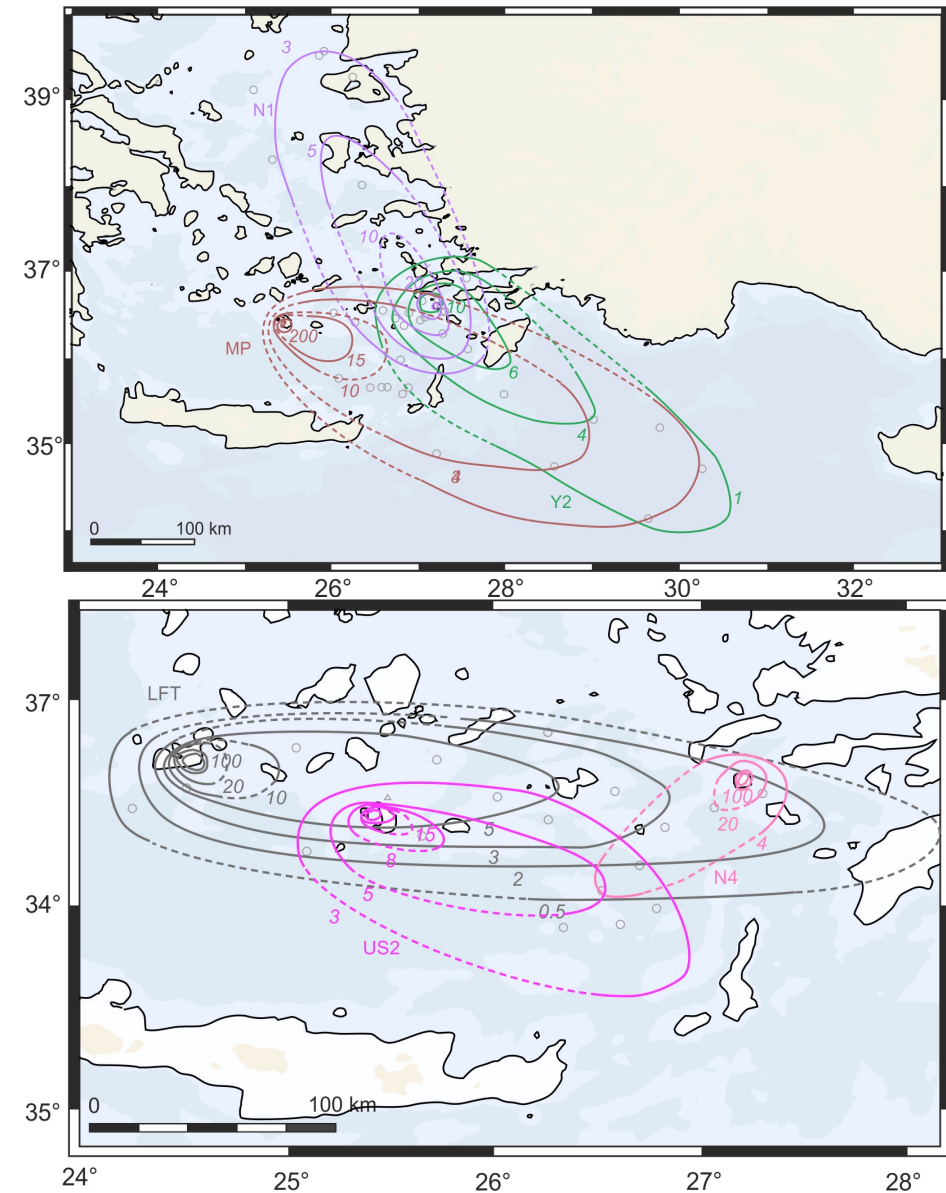
- Clear distinction between marine tephras in P52 → ~12km from vent
- Trend from N4 to N1
- Hemipelagic sedimentation in between → Individual events
- 6 to 7 ka break between events
- ➔ 2 interplinian eruptions between Lower and Upper Nisyros pumice



➔ two facies: a PDC related eastern and a fall dominated southern??

- Two regionally distinct tephras (Eastern basin and Southern)
- Same Yali 2 age (~33 ka)
- Same observation found by Aksu et al. 2008
- Red circle data correlate with Yali 2, green circle data are close
- contemporaneous eruptions? Or two facies?

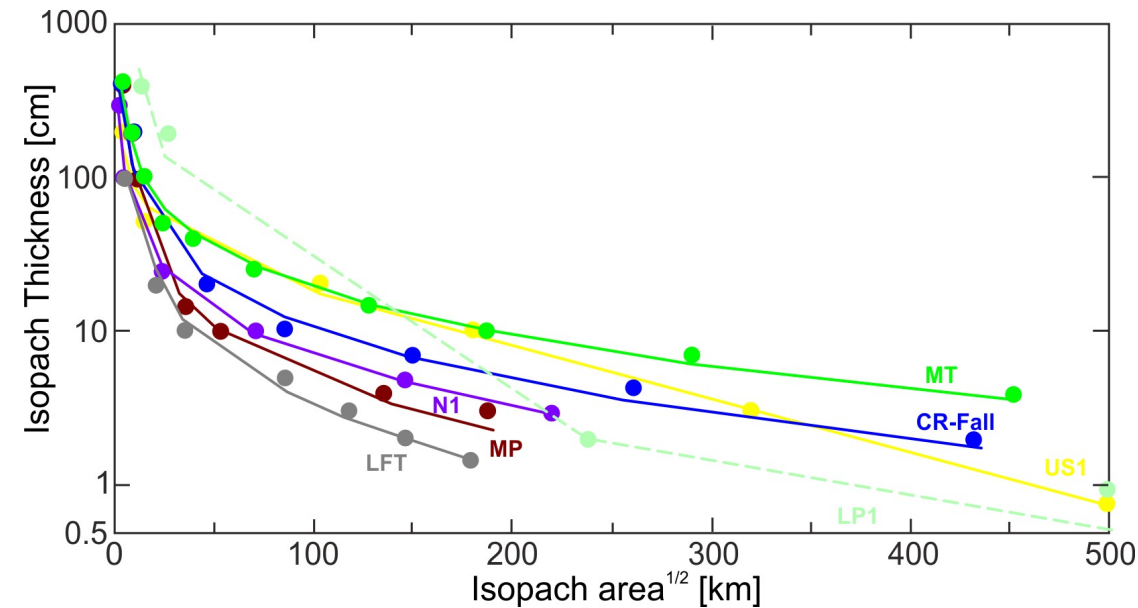
## 5. Distribution



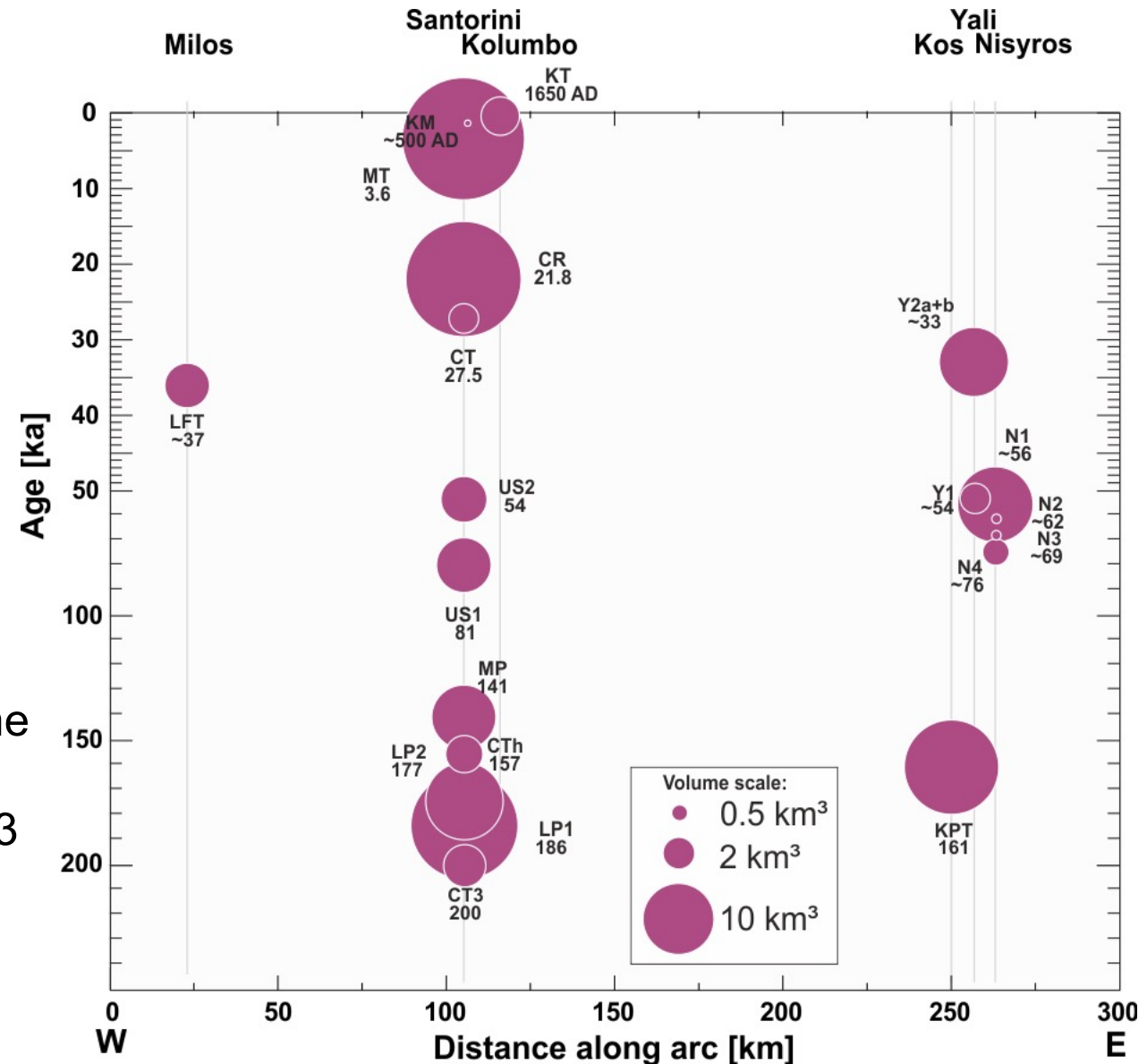
- Using 1 to 68 core locations including literature data
- Aegean arc tephras cover areas up to  $10^5 \text{ km}^2$
- Different dispersal axis, but mostly in direction of prevailing stratospheric wind direction (west to east); exceptions due to column height? Bi-annual QBO? Co-IG?
- Combined co-ignimbrite and fall isopachs, exception Cape Riva where distinction is possible



## 6. Volumes



- <1 to 48 km<sup>3</sup> tephra volume without PDC's
- 0.1 to 30 km<sup>3</sup> DRE volume
- Cumulative minimum explosive eruptive volume of Santorini = 110 km<sup>3</sup> DRE; Kos, Yali, Nisyros = 11 to 18 km<sup>3</sup> DRE; Milos, Kolumbo = 4 and 3 km<sup>3</sup> DRE
- Overall 7 to 14 kg/s eruptive magma flux per eruptive center; exception Santorini (38 kg/s)



## 7. Summary

- 47 gravity cores, 377 tephra horizons, 229 primary tephra layers
- 19 correlations to eruptions from Santorini, Milos, Kolumbo, Kos, Nisyros, Yali
- 1 correlation to Campanian Ignimbrite
- Regional variable sedimentation rates often constant within cores; some exceptions with decreasing sedimentation rate around 80 ka close to islands
- 7 new ages assisting former age estimates or establishing new ages in the region
- Small, possibly sub-Plinian, eruptions between Upper and Lower Nisyros pumice with recurrence rates of 6 to 7 ka
- Two facies for Yali 2 eruptions in the marine depositional area, one probably associated with PDC's and one with fallout
- Tephra distribution of  $10^5$  km<sup>2</sup> predominantly within prevailing wind direction
- <1 to 48 km<sup>3</sup> tephra volume (0.1 – 30 km<sup>3</sup> DRE)
- Ø 7 to 14 kg/s explosive eruptive magma flux; exception Santorini (38 kg/s)