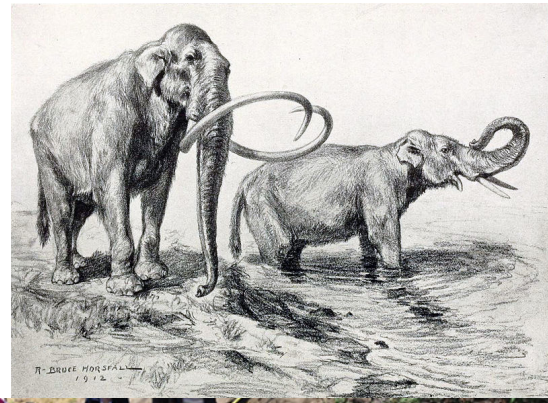
Volcanic stratigraphy of a high-altitude *Mammuthus columbi* excavated in a paleo-ravine on the northern slopes of the Sierra Chichinautzin, Central México

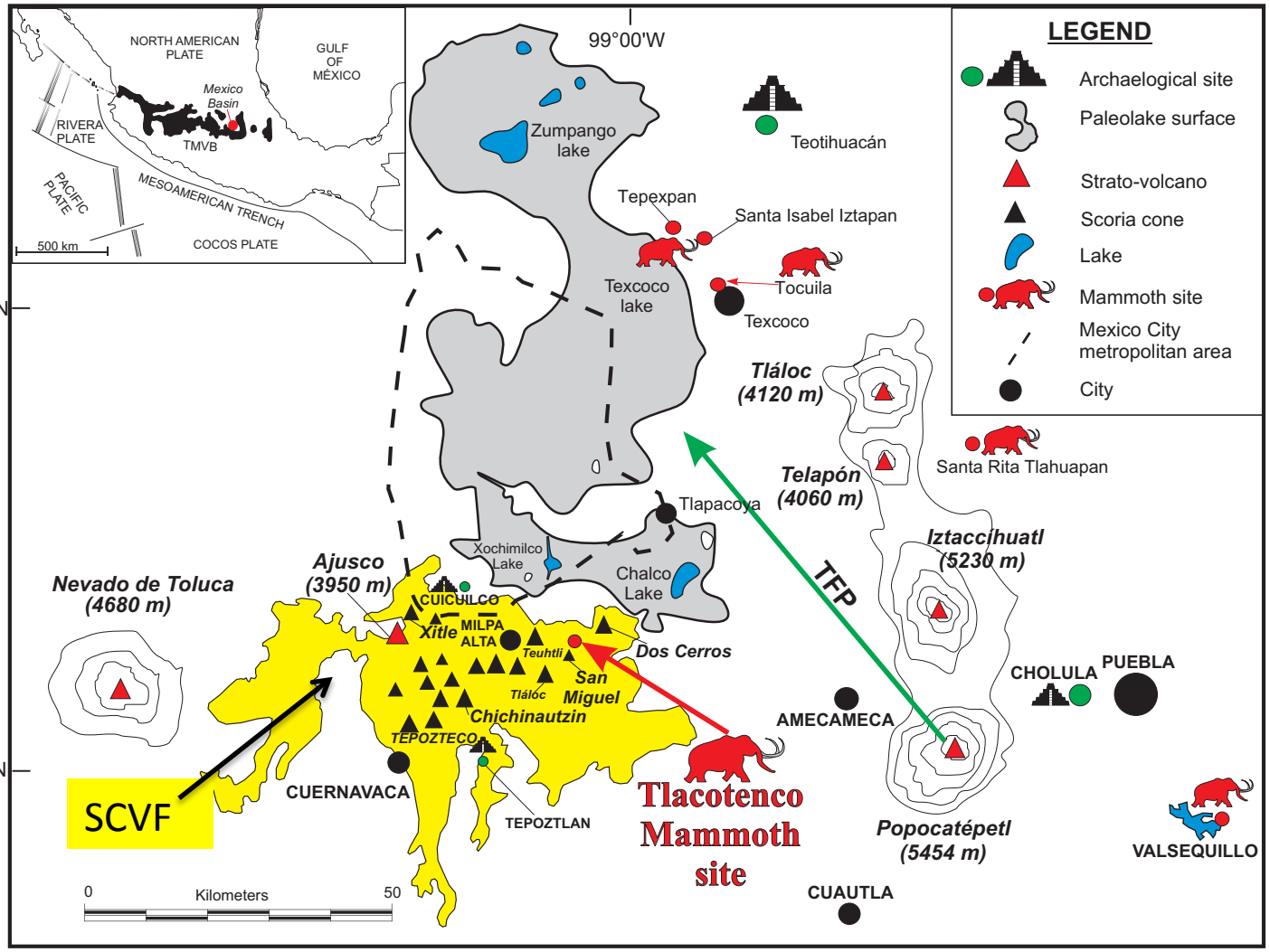
Marie-Noëlle Guilbaud, Lilia Arana, Claus Siebe
Departamento de Vulcanología, Instituto de Geofísica, UNAM

Luis Barba-Pingarrón, Agustín Ortiz Butrón
Laboratorio de Prospección Arqueológica, Instituto de Investigaciones Antropológicas, UNAM



Funded by UNAM-DGAPA IN-109412-3 and RR182312-2, and CONACyT 167231 and 152294 granted to CS and MNG

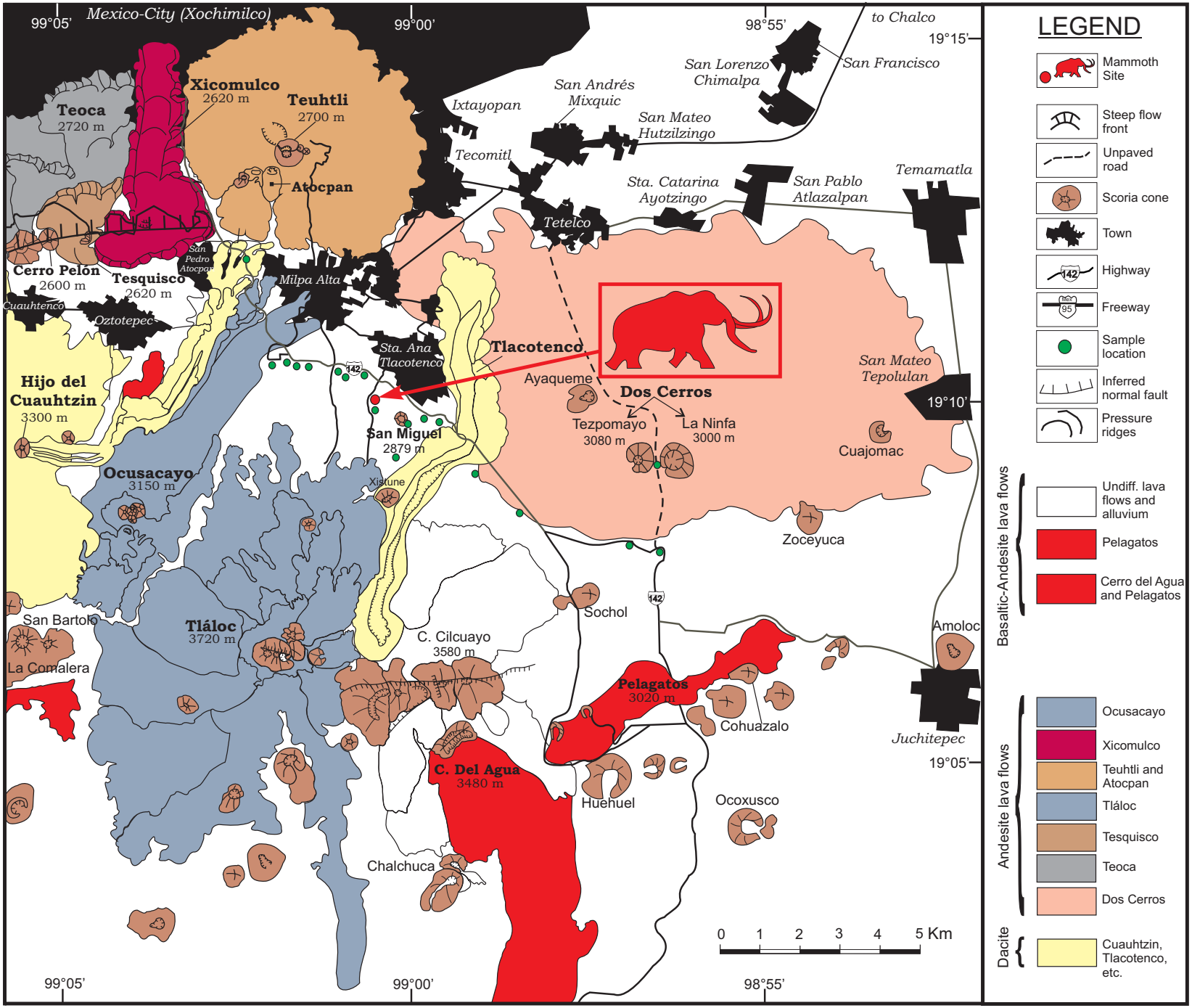
Mammoth sites around Mexico Basin

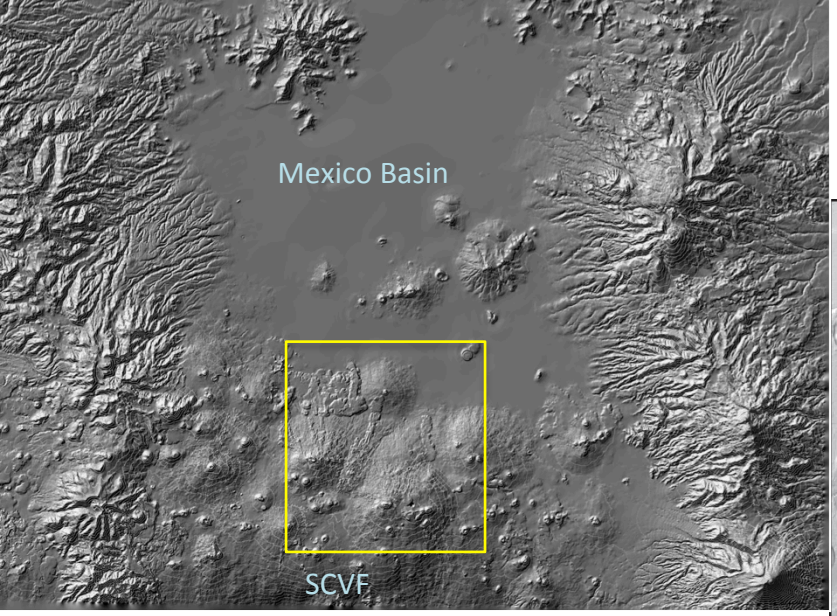


Discoveries of Mammoth bones common around Mexico Basin

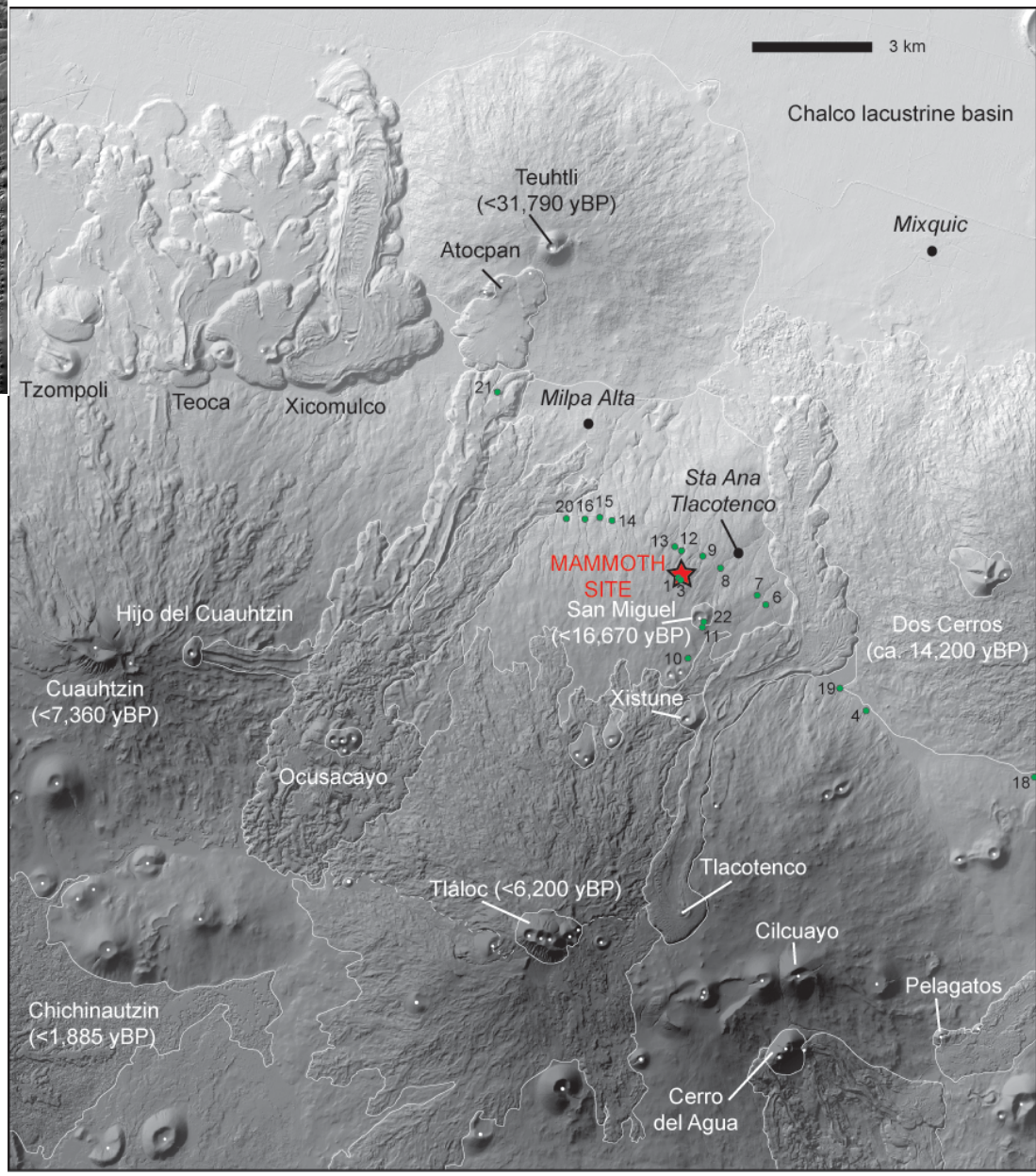
Yet this discovery is the first one yet made on the steep, elevated slopes of the SCVF

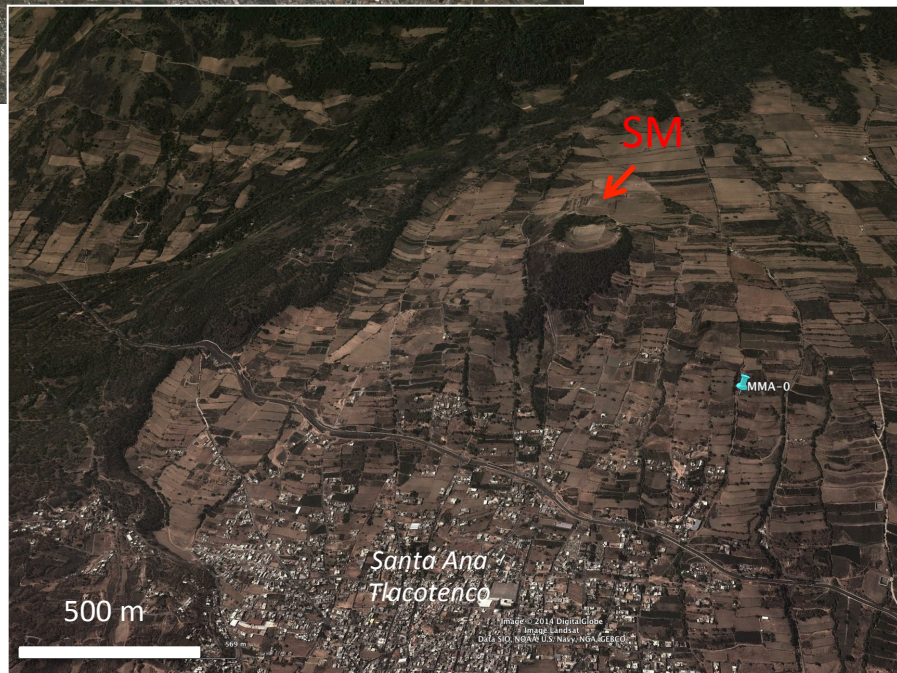
SCVF = monogenetic field, <1 Ma, >10 eruptions in last 14 kyrs. Proximal tephra deposits


99°05'
Mexico-City (Xochimilco)
99°00'
98°55'
to Chalco
19°15'
San Lorenzo Chimalpa
San Francisco
San Andrés Mixquic
Ixtayopan
San Mateo Hutzilzingo
Tecomitl
Sta. Catarina Ayotzingo
San Pablo Atlazalpan
Temamatla
Tetelco
Xicomulco
2620 m
Teuhtli
2700 m
Teoca
2720 m
Atocpan
San Pedro Atocpan
Cerro Pelón
2600 m
Tesquisco
2620 m
Cuauhtenco
Oztotepec
Milpa Alta
Sta. Ana Tlacotenco
Tlacotenco
Ayaqueme
Dos Cerros
Tezpomayo
3080 m
La Ninfa
3000 m
San Mateo Tepolulan
19°10'
Cuajomac
Hijo del Cuauhtzin
3300 m
San Miguel
2879 m
Xistune
Ocusacayo
3150 m
Zoceyuca
Sochol
Amoloc
San Bartolo
Tláloc
3720 m
C. Cilcuayo
3580 m
La Comalera
Pelagatos
3020 m
Cohuazalo
Juchitepec
19°05'
C. Del Agua
3480 m
Huehuel
Ocoxusco
Chalchuca
0 1 2 3 4 5 Km
99°05'
99°00'
98°55'
LEGEND
Mammoth Site
Steep flow front
Unpaved road
Scoria cone
Town
Highway
Freeway
Sample location
Inferred normal fault
Pressure ridges
Basaltic-Andesite lava flows
Undiff. lava flows and alluvium
Pelagatos
Cerro del Agua and Pelagatos
Andesite lava flows
Ocusacayo
Xicomulco
Teuhtli and Atocpan
Tláloc
Tesquisco
Teoca
Dos Cerros
Dacite
Cuauhtzin, Tlacotenco, etc.



High resolution elevation data (Lidar)





Oblique view in satellite image (Google Earth) of excavation site and nearby volcanoes

The discovery site

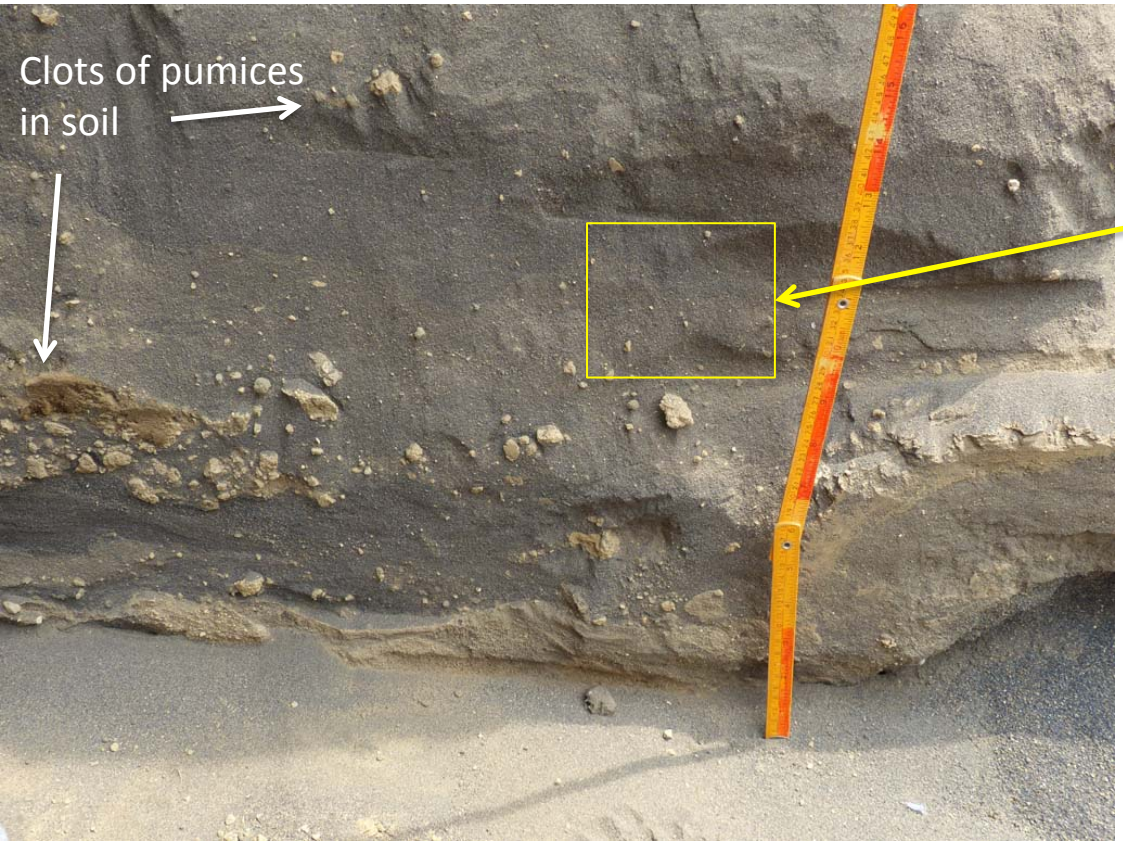
60% of entire skeleton of Mammuthus columbia found in 40 m^2 excavation site on side of terraced cornfield.

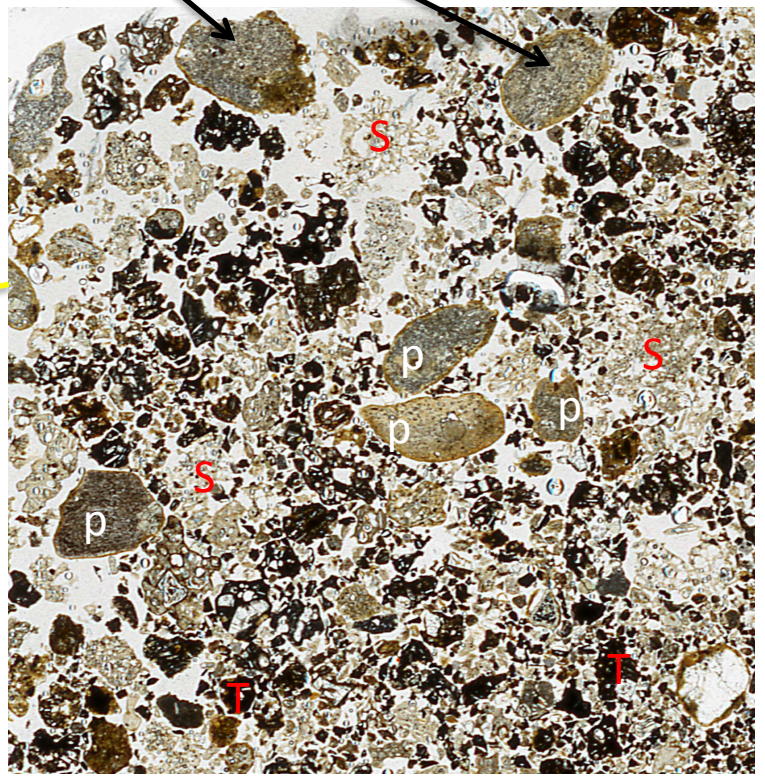
Site located on the side of a ravine filled with water after torrential summer rains

Ash deposit not primary but reworked; Indurated ashy paleosol

The “mammoth ash”

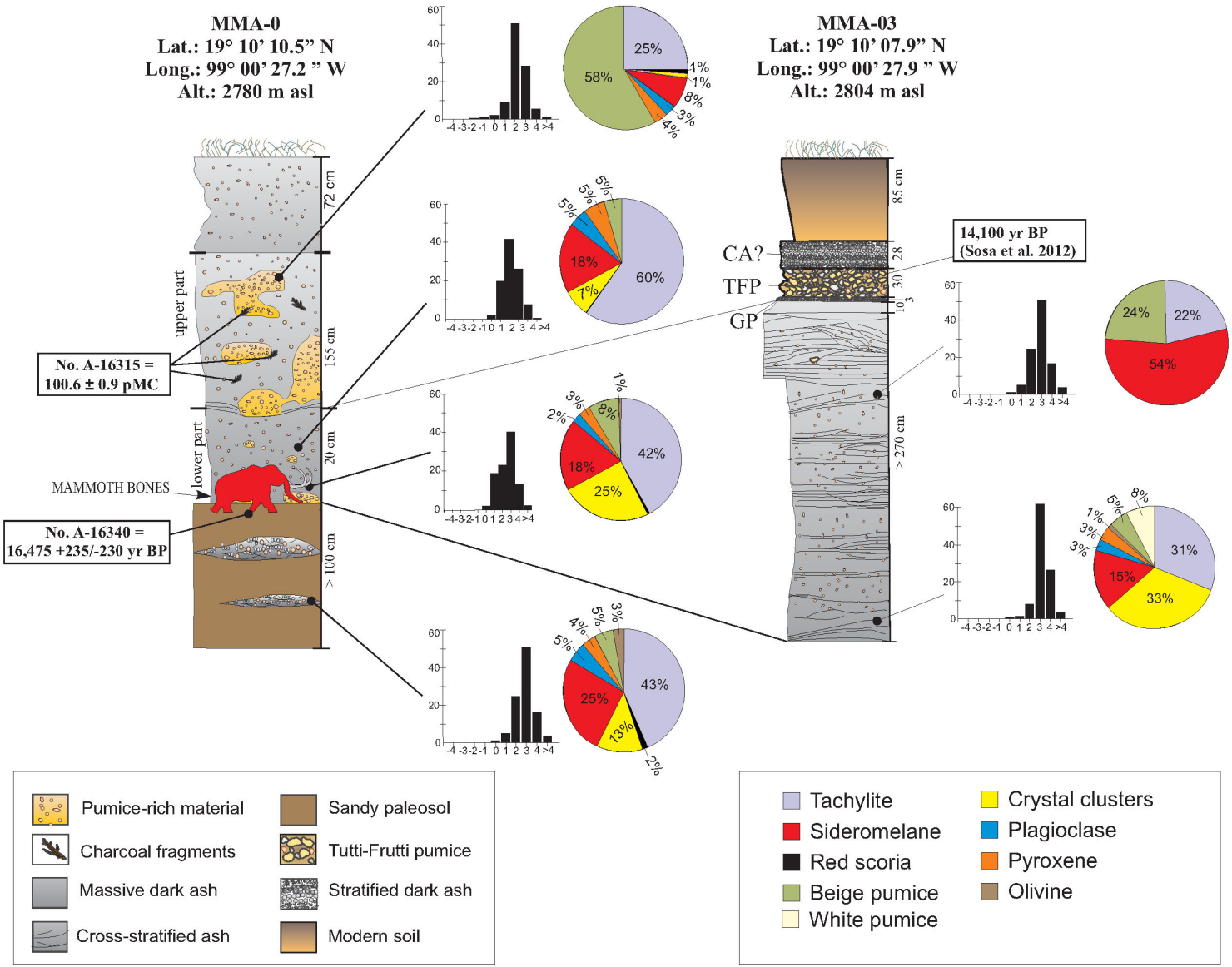
<10% altered pumices with Hbl+Plag+Cpx pheno (p)



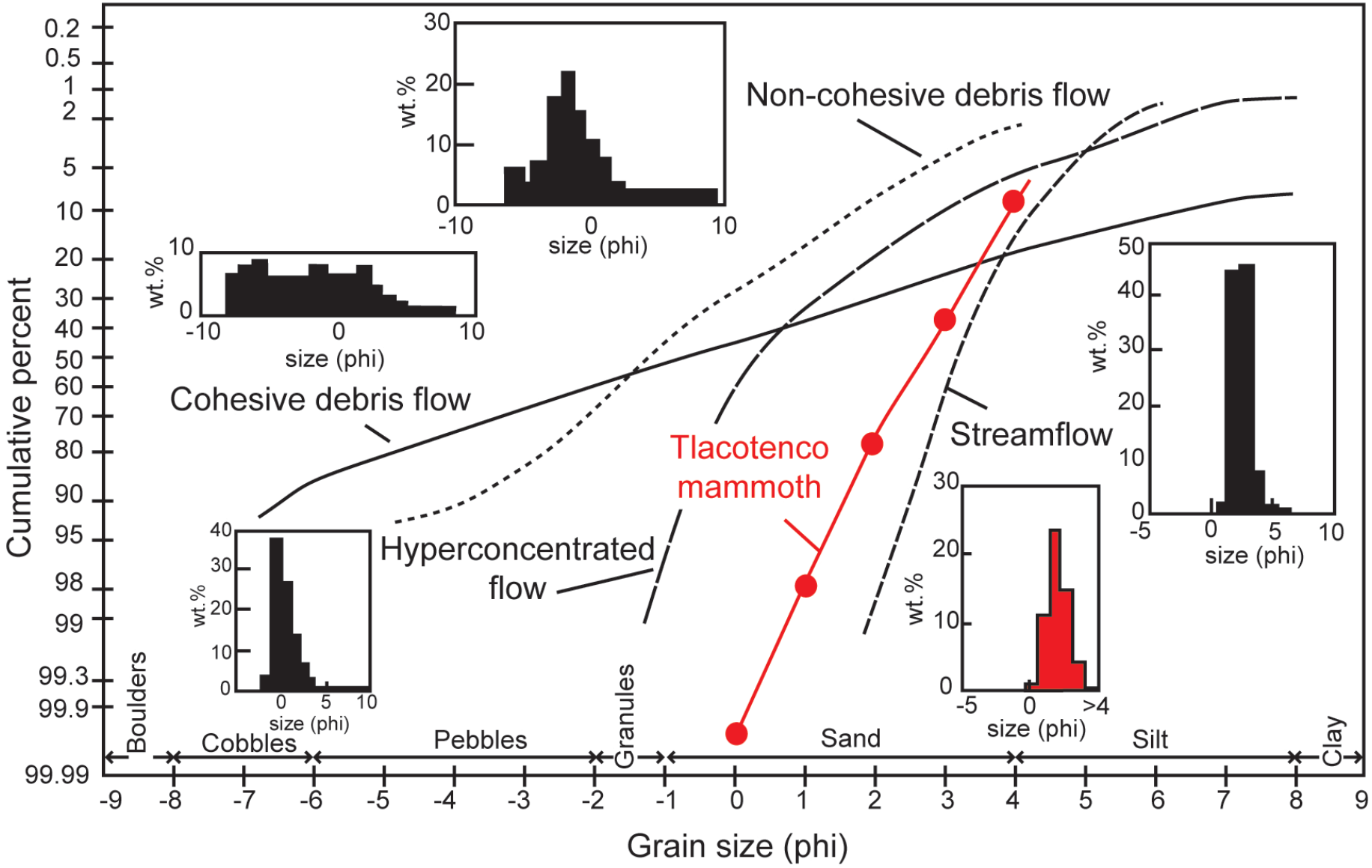


Ca. 60% ol-bearing scoria:
Vesicular (Sideromelane) + denser (Tachylite)

Tlacotenco Mammoth excavation site



Cumulative grain size distribution of Tlacotenco mammoth deposit



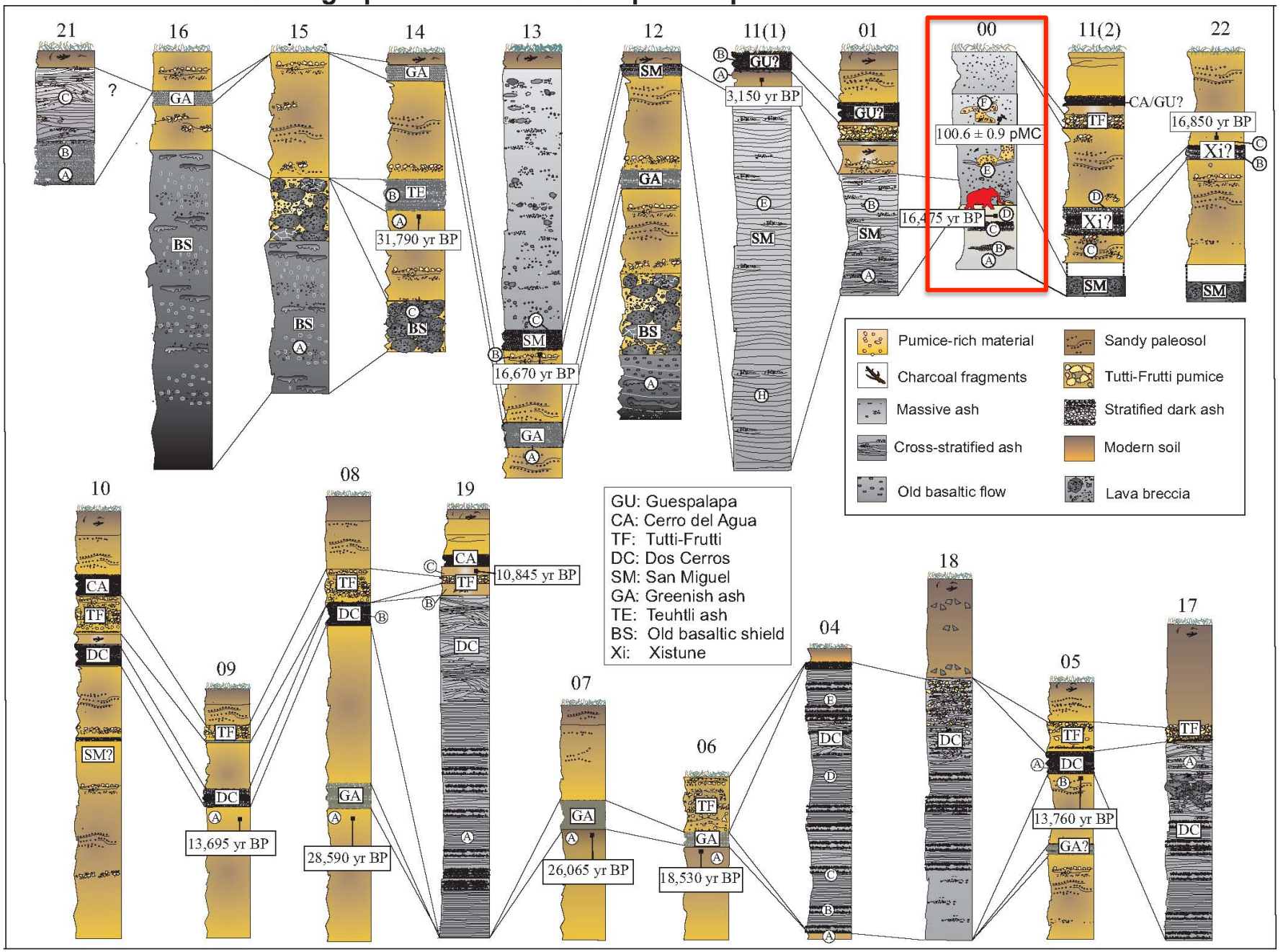
Grain size analyses: indicator of type of lahar that buried skeleton.

Surrounding sites: Stratigraphic markers

Tutti-Frutti pumice fallout with underlying grey pumice horizon: products of V. Popocatepetl dated at 14,100 yBP

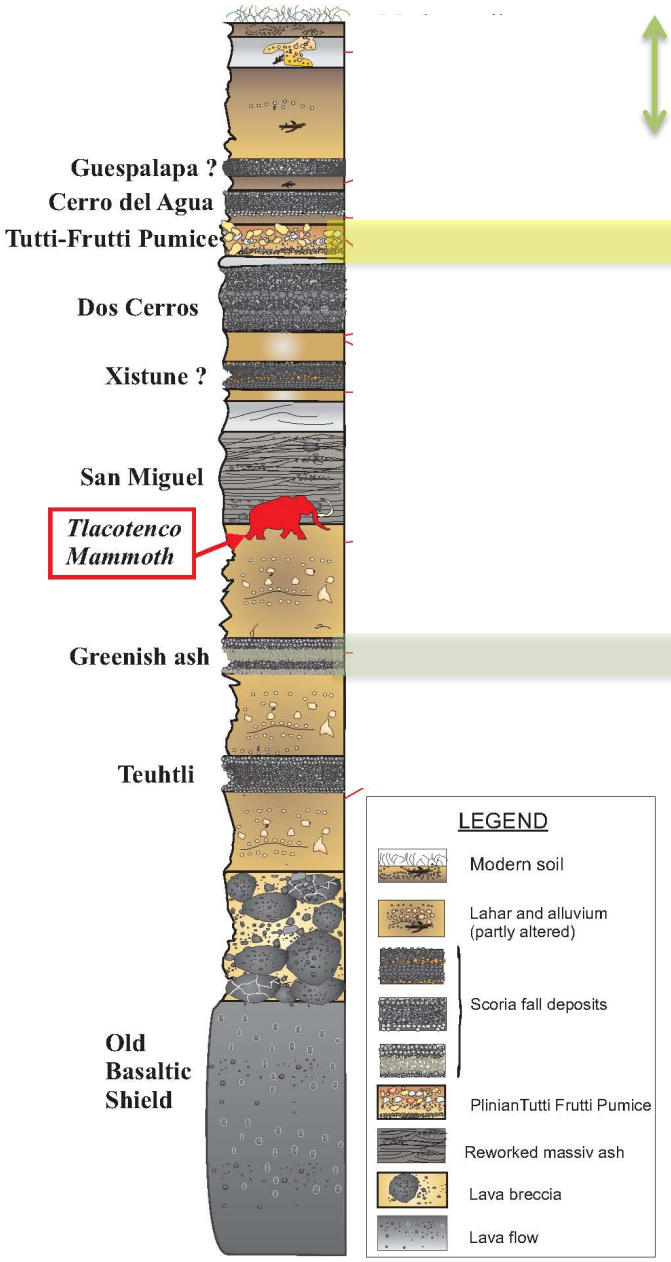
Greenish ash: Previous unreported distinct pale ash fallout dated here at ca. 18,000 yBP, unknown origin

Stratigraphic correlation of tephra deposits in the Tlacotenco area



Tephrochronology

Composite stratigraphic section



Recent reworking processes

2 events after TFP

TFP: 14,100 yBP

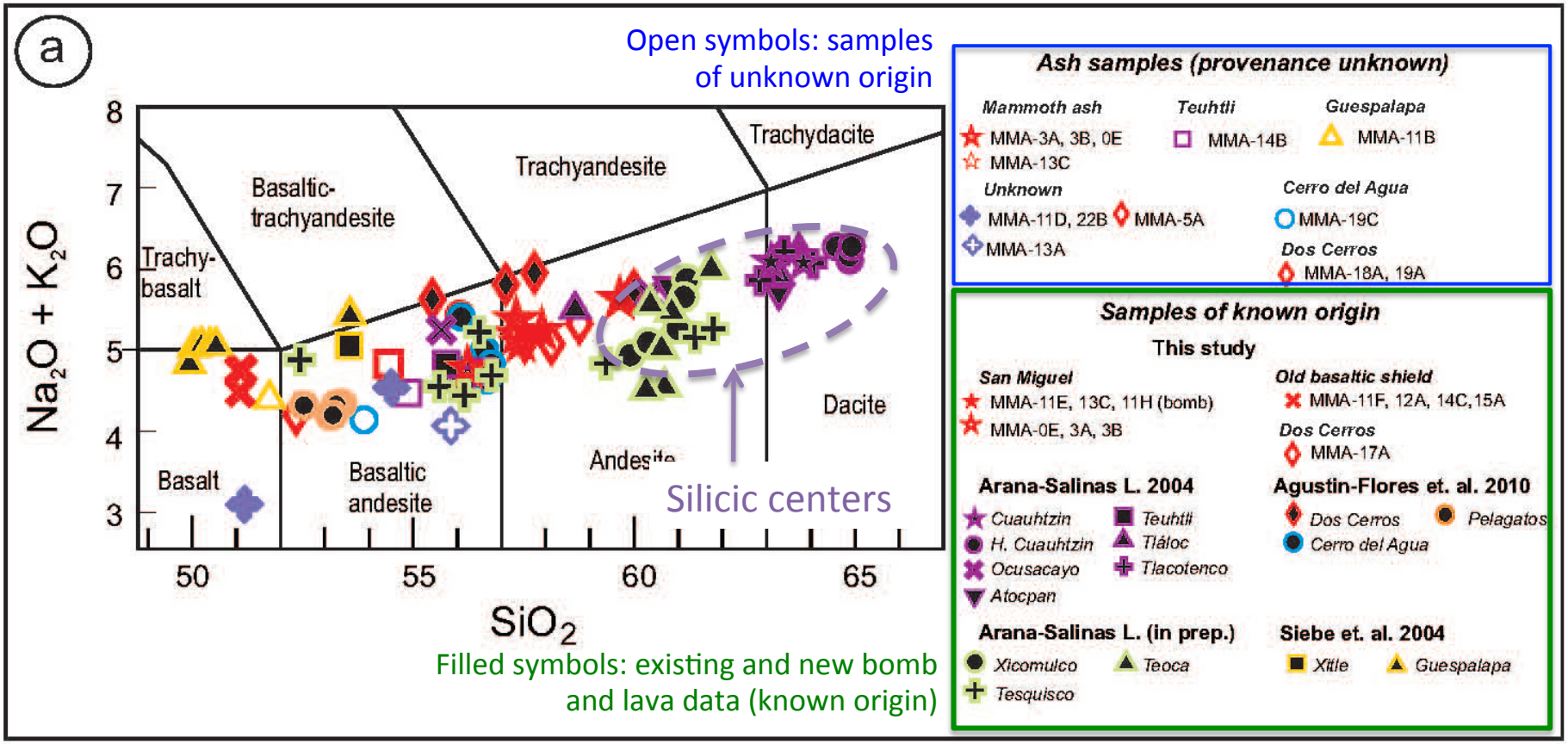
>3 events between GA and TFP

GA: 18,500 – 28,000 yBP

1 event (Teuhtli) between shield (basement) and GA

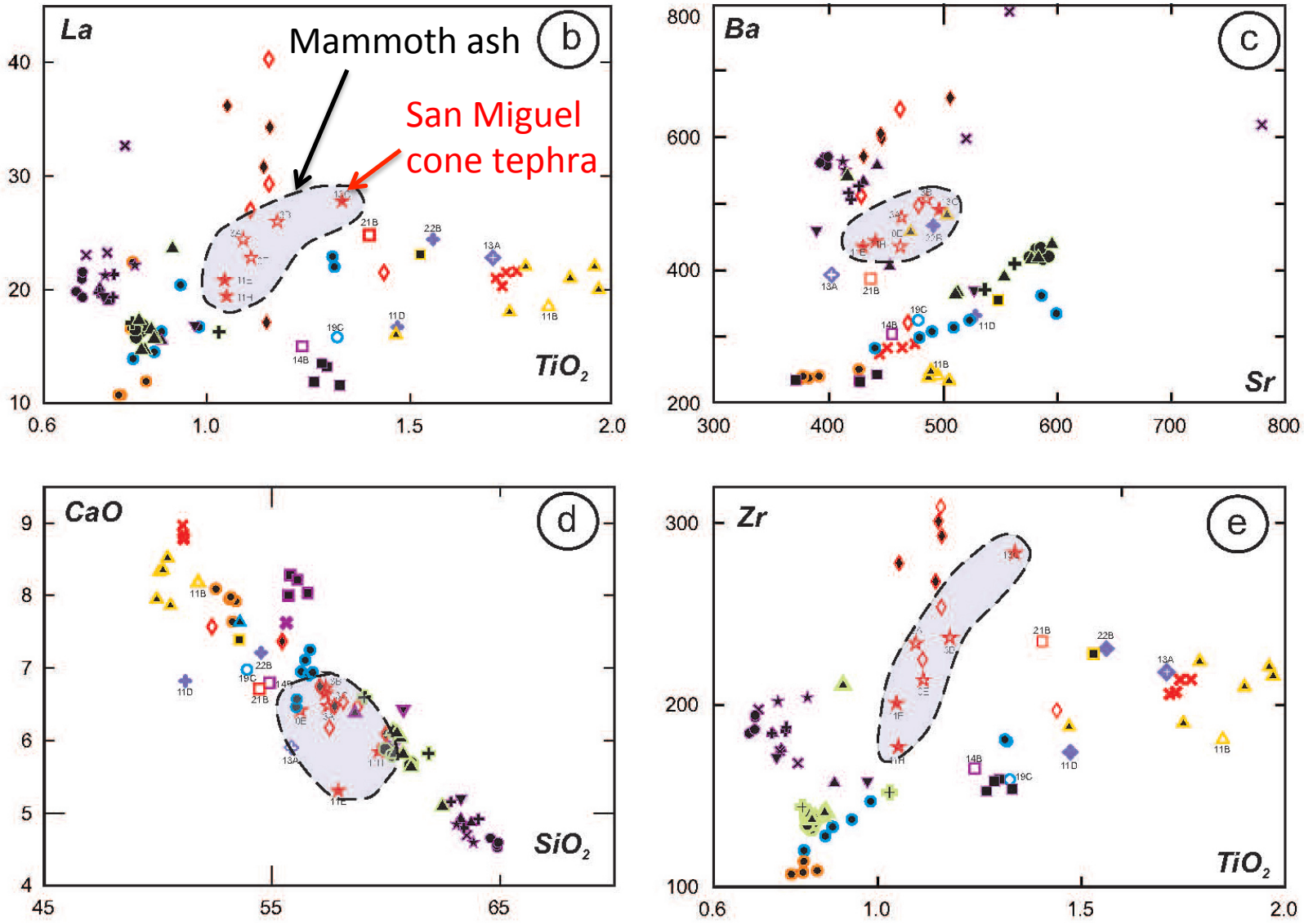
Basement: sloping shield of basaltic lavas (>32,000 yBP)

Bulk Rock Geochemistry (ICPMS and INAA on largest scoria fragments)



Silicic centers: small compositional range but non ash producers

Basaltic to andesitic (<60% SiO_2), mayor ash producers and wide compositional range not resulting from simple fractionation processes (mantle source heterogenety and/or crystal contamination involved)



Same general pattern as for mayor elements but some volcanoes with distinct though variable compositions in trace elements. Stratigraphy and age data remain alsolutely necessary for determining sources. Some unknowns remain due to uncomplete record. San Miguel best candidate for mammoth scoria.

Conclusions

- Mammoth buried after its death in a ravine by reworked ash from a lahar some time after 17,000 yrs BP (radiocarbon dating of a paleosol underlying the animal) but prior to 14,100 yrs BP (TF pumice above).
- Grain-size distribution of reworked material points towards mobilization by diluted flow of water and ash (stream-flow)
- The ash in which most of bones were embedded is compositionally similar to products of nearby San Miguel scoria cone whose eruption also occurred close to 17,000 yrs BP.
- This suggests that pluvial precipitations following eruption of cone removed thick loose ash accumulated nearby, creating water-rich lahars that eroded older pumice deposits and deposited sediment load downstream, covering the mammoth bones lying on the margin of the ravine.

Use of data for correlating with cores in Mexico basin?

Turning this into tool for tephrochronology?

- Microprobe work on volcanic glasses?
- LA-ICPMS on single shards? Problems with microlites, vesicularity etc
- Improve stratigraphy, more radiocarbon ages
- -> necessary for estimating recurrence intervals of eruptions in this area
- -> improve understanding on crustal-level differentiation or contamination processes during monogenetic eruptions in continental arcs