

Tephrochronology of the Monterey and Modelo Formations

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Abstract

The age and correlation of the Monterey and Modelo Formations has been predominantly based on biostratigraphy. Until recently, tephra (volcanic ash beds and tuffs) in the Miocene Monterey and Modelo Formations have been largely ignored. We combine tephrochronology and biostratigraphy to provide more precise numerical age control for eight sedimentary sequences of the Monterey and Modelo Formations from Monterey to Orange Counties in California. We correlate 38 tephra beds in the Monterey and Modelo Formations to 26 dated tephra layers found mainly in non-marine sequences in Nevada, Idaho and New Mexico. We also present geochemical data for an additional 19 tephra layers in the Monterey and Modelo Formations, for which there are no known correlative tephra layers, and geochemical data for another 11 Monterey-age-equivalent tephra layers found elsewhere. Tephra layers in the Monterey and Modelo range in age from 16 to 7 Ma. The majority were erupted from volcanic centers of the Snake River Plain (SRP), northern Nevada to eastern Idaho, and the Southern Nevada volcanic field (SNVF). We identify tephra from five super eruptions deposited as much as 1200 km from the eruptive source: [12.08 Ma Ibex Hollow Tuff (SRP), 11.87 Ma Rainier Mesa (SNVF), 11.31 Ma Cougar Point Tuff XI (SRP), 11.08 Ma Cougar Point Tuff XIII (SRP) and 8.99 Ma McMullen Creek (SRP)]. This initial tephrochronology provides new time-stratigraphic markers that assist with correlation of Monterey Formation deposition (e.g., condensed sequence) with non-marine sequences and events (e.g., Clarendonian mammalian faunal stages) in western North America.

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Bramlette, M. N., 1946, The Monterey Formation of California and the origin of its siliceous rocks: U.S. Geological Survey Professional Paper 212, 57 p.

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NOT AN ENDORSEMENT



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Tephrochronology

- We use the glass shard composition to establish a chemical fingerprint for a tephra bed or tuff
 - Any unknown glass composition is compared to a database of knowns
 - Wide application to sedimentology, basin analysis, volcanic hazards, paleoseismology, etc.
- Advantages over direct dating
 - Volcanic glass transported a greater distance
 - Identifies the volcanic source
 - Budget friendly
- Disadvantages to direct dating
 - No direct date
 - Glass is more susceptible to weathering than minerals



Tephrochronologic Correlation

+ Petrography

- Mineralogy, shard morphology

+ Composition of volcanic glass

- Major and minor oxides (Si, Al, Fe, Mg, Mn, Ca, Ti, K, Na) measured by electron microprobe

+ Relative stratigraphic position

- Lava Creek B/Bishop
- Huckleberry Ridge/Taylor Canyon
- Ibex Hollow/Rainier Mesa

– Trace elements in glass

- INAA and ICP-MS

– Supplemented by

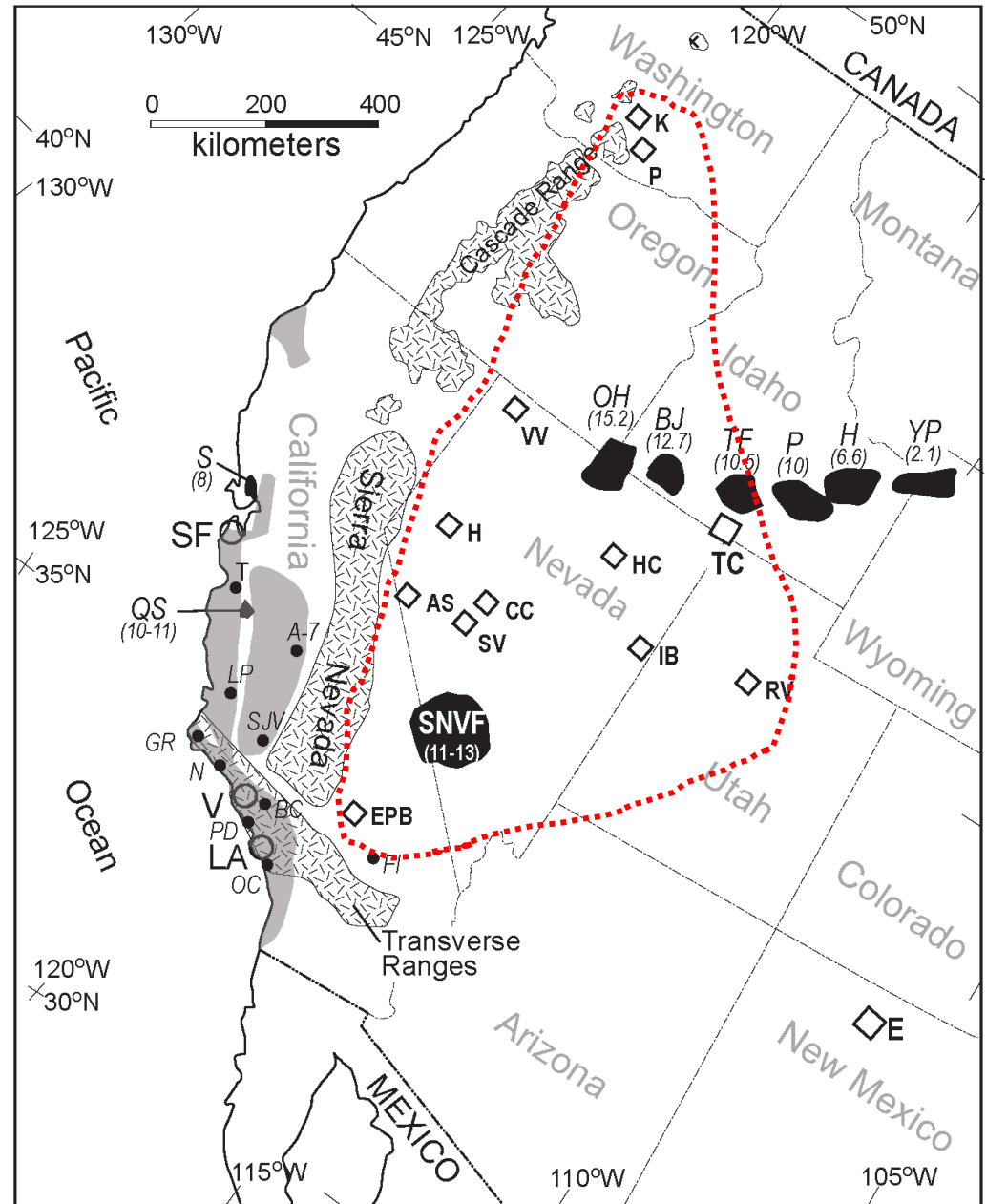
- Paleontology, Paleomagnetism, $^{40}\text{Ar}/^{39}\text{Ar}$



Platy shards from Lava Creek B eruption from Snake River Plain

Why the Monterey?

- Bramlette (1946) described numerous “tuffs” in the Monterey Formation saying these should help make more accurate stratigraphic correlations.
- Biostratigraphy shows that the Monterey Formation is roughly 16 to 7 Ma (Barron, 1981; 1986; 2022).
- Perkins et al identified 69 different tephra layers between 16 and 6 Ma in the Basin and Range.



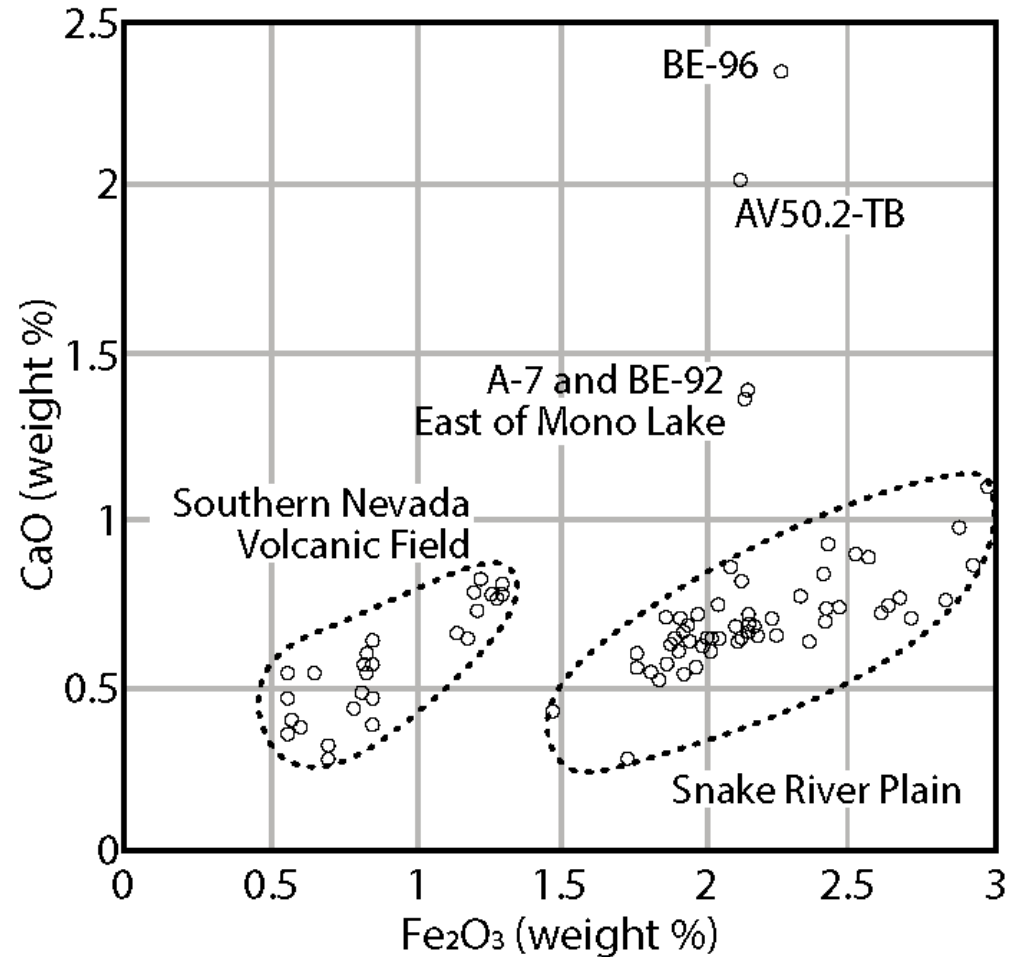
Monterey Application

- Samples collected over ~40 years.
- Sampling
 - Purposeful collection
 - Geotechnical and paleontological consultants from construction sites
- Many samples contained diatoms.
- 38 tephra beds correlated to 26 different tuffs between 16-7 Ma
 - Others characterized, but not correlated



ERUPTIVE SOURCE

- Snake River Plain
 - Higher Fe_2O_3
 - Gray color
 - Platy shards common
- Southern Nevada volcanic field
 - Lower Fe_2O_3
 - White color
 - Bubble-wall junction shards common
 - Sanidine and biotite



Fe_2O_3 vs. CaO for all samples determined by electron microprobe.

NAPLES BEACH TEPHROCHRONOLOGY

• McMullen Creek

- Diatom zones
- Snake River Plain
- Correlative to Modelo Fm tephra

• Ibex Hollow/Rainier Mesa

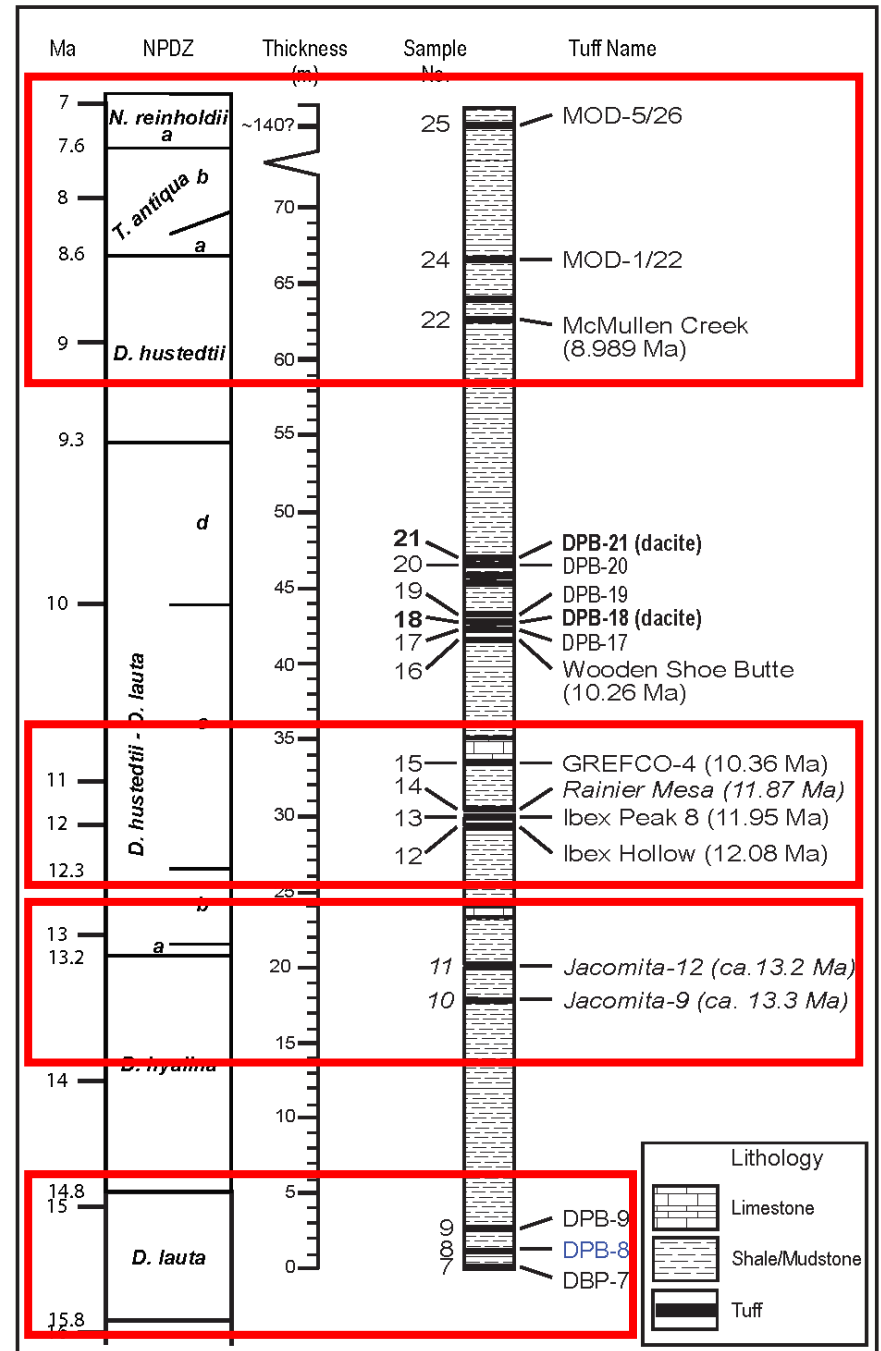
- Lower 12.3-9.3 Ma *D. hustedtii*-*D. lauta*
- Sequence with Snake River and Southern Nevada tuffs

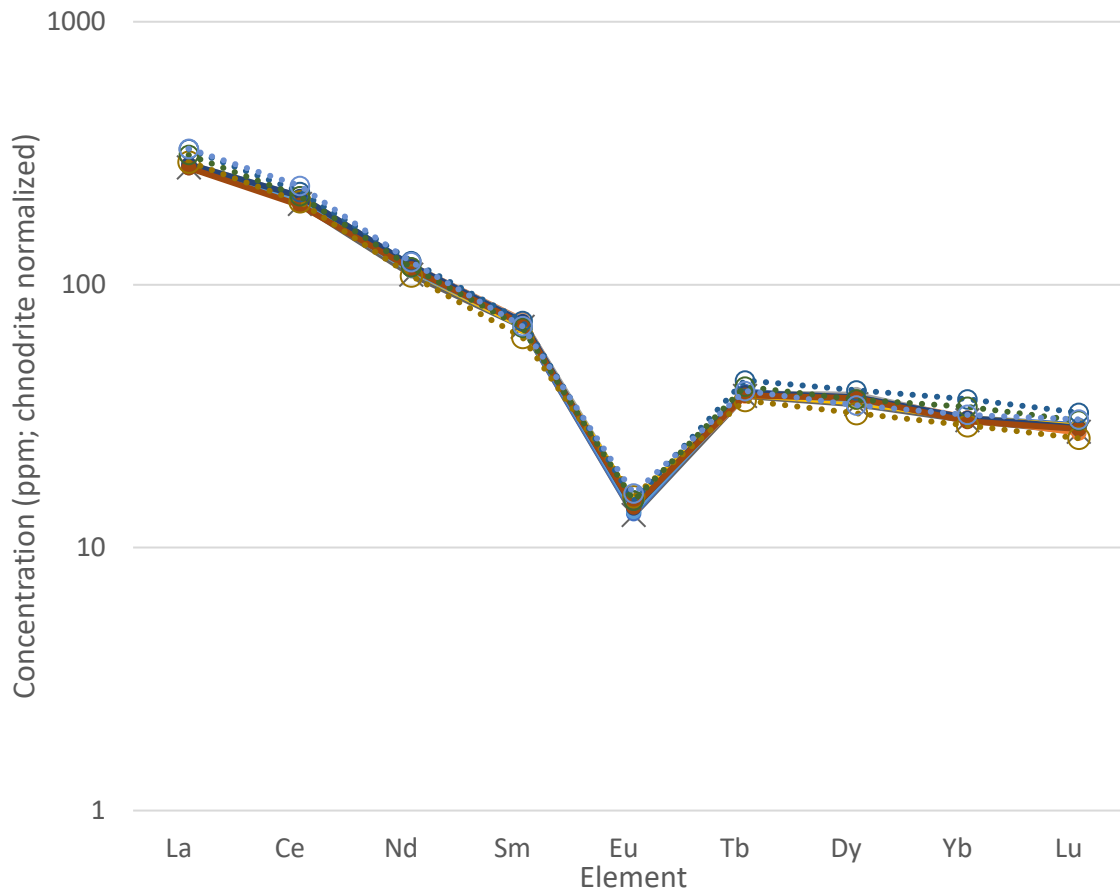
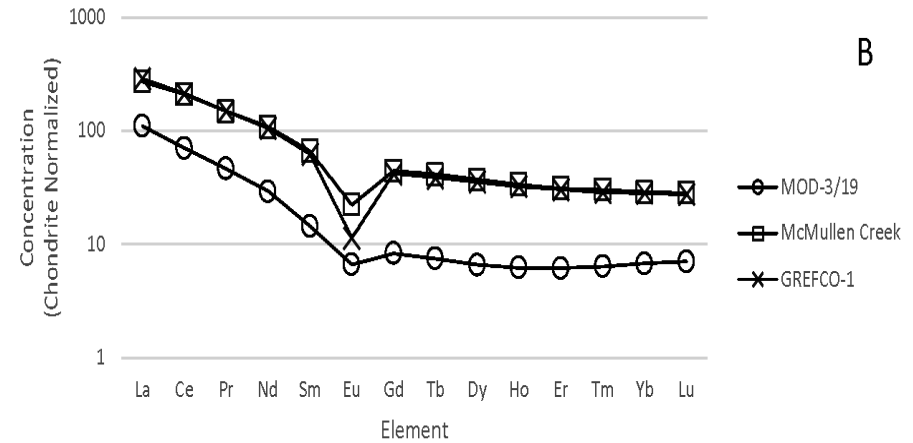
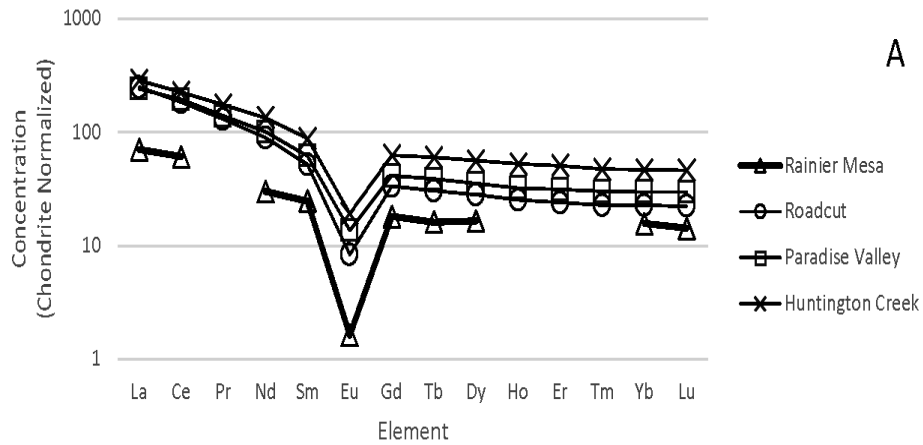
• Jacomita 9 & 12

- Top of 14.8-13.2 Ma *D. hyalina* zone
- Southern Nevada source
- <13.7 Ma by vertebrate paleontology in Espanola basin, NM

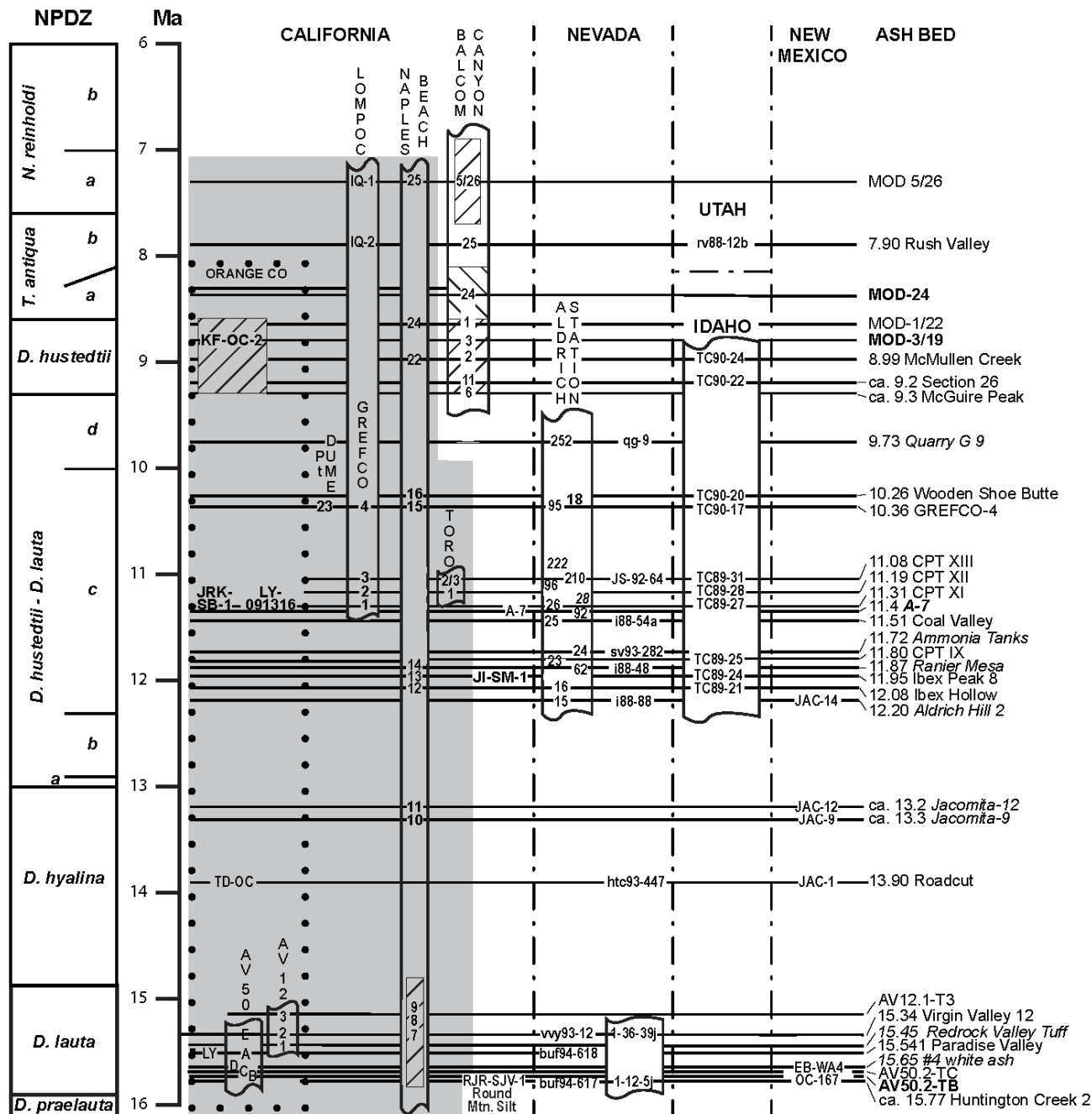
• DPB 7, 8 & 9

- 15.7-14.9 Ma *D. lauta* subzone
- Snake River Plain source
- No correlative tephra

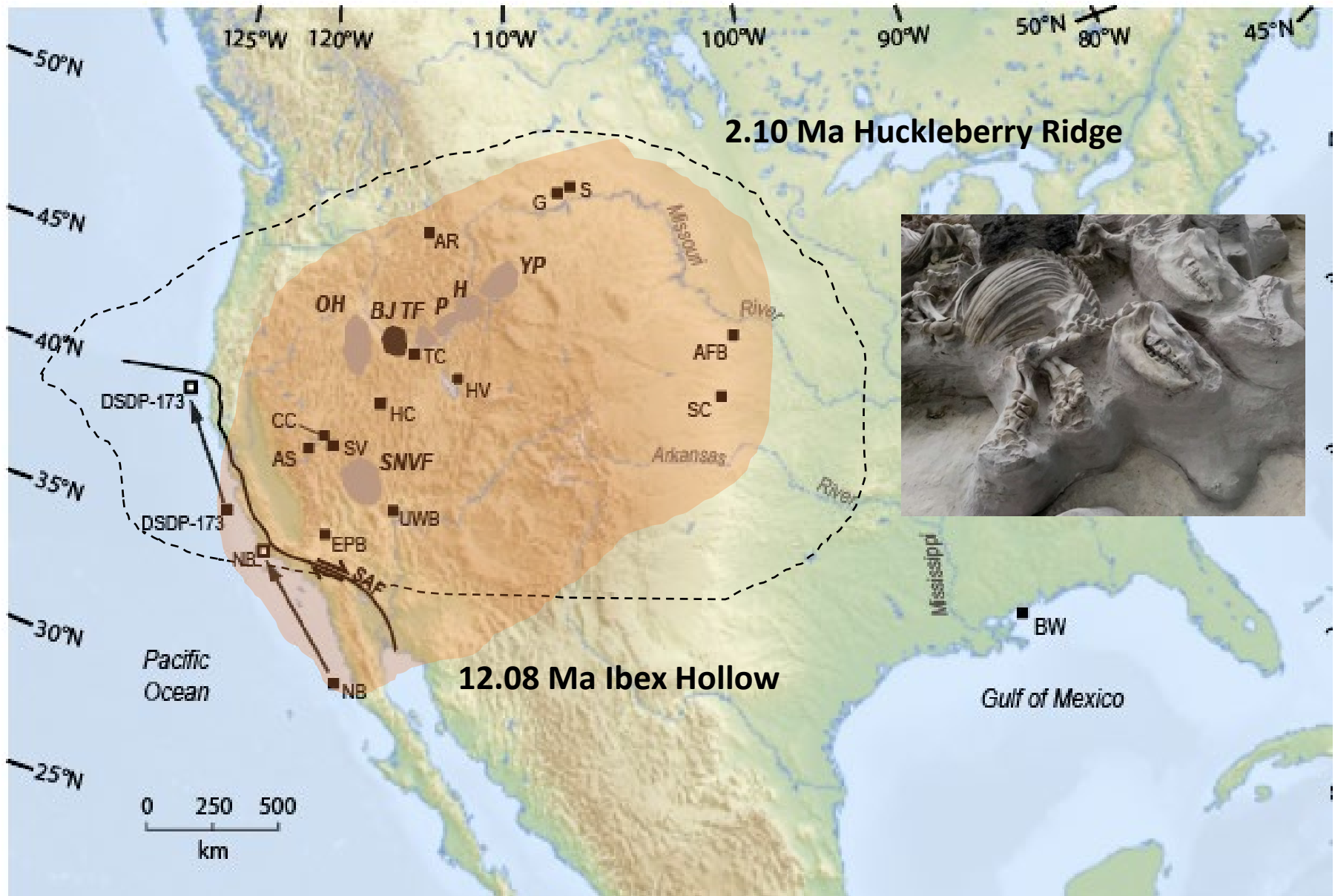




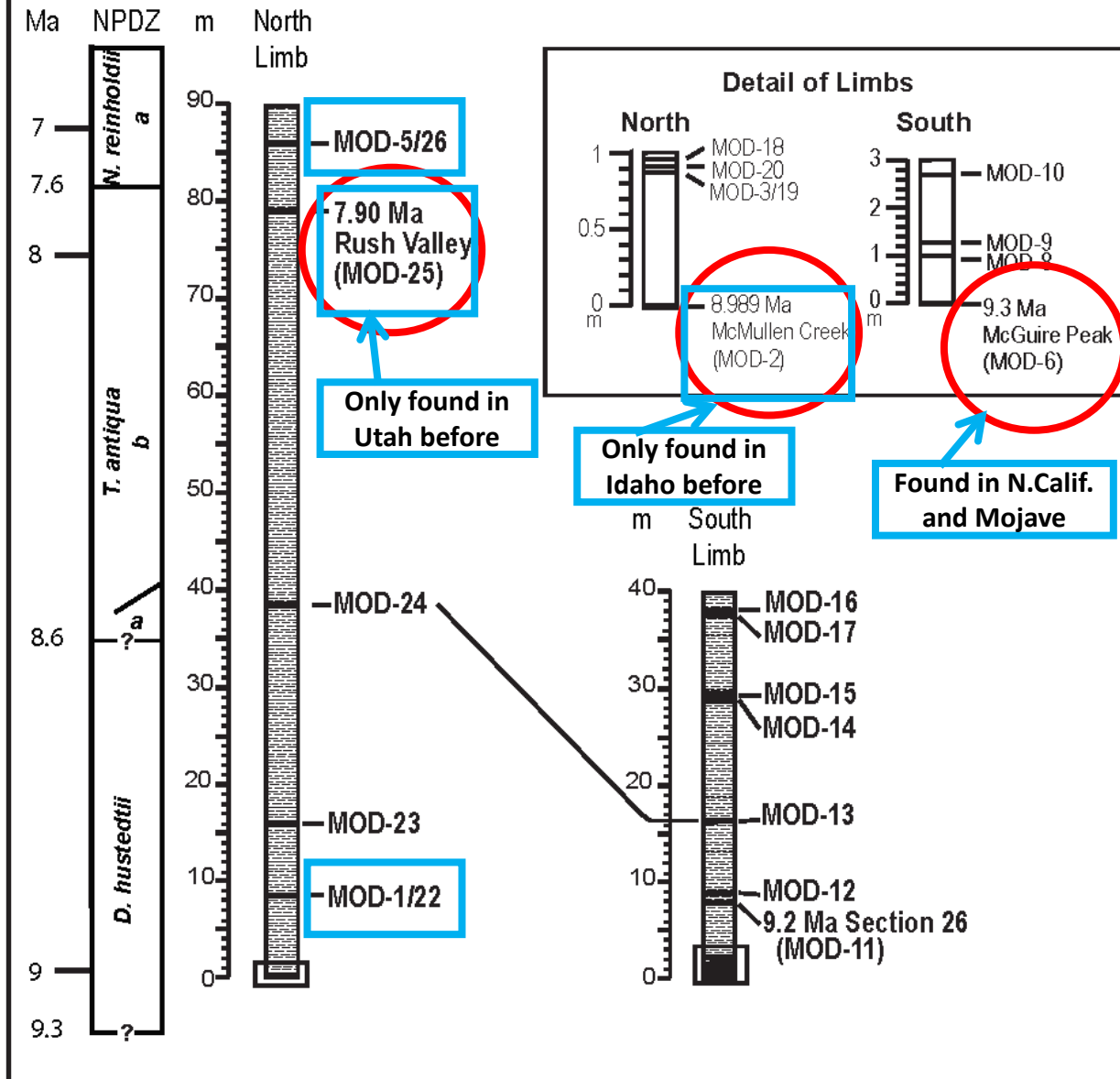
- Trace element composition allows distinguishing tuffs from the same volcanic center.
- Trace elements are consistent.



SUPER ERUPTIONS?



MEASURED SECTION FROM MODELO FORMATION AT BALCOM CANYON, VENTURA, CA



SUMMARY

- Correlation by
 - Major, minor and trace elements
 - Paleontology
- Connections among different sedimentary sequences
- Initial results



13.90 Ma Roadcut Ash, Newport Beach, CA

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- Bramlette, M. N., 1946, The Monterey Formation of California and the origin of its siliceous rocks: U.S. Geological Survey Professional Paper 212, 57 p.
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