

# **CVTS**

**Volcanism**

**A presentation to the Nuclear Waste Technical  
Review Board Panel on Structural Geology  
and Geoengineering**

**September 15, 1992  
Las Vegas, Nevada**

**by**

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 Board Panel on Structural Geology and Geoen지니어ing  
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Purpose of Studies

→ Provide geological data that can be  
 used in risk assessment studies

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*Analog Studies*

- Reville Range
- Fortification Hill
  - » are they appropriate analogs to  
 volcanic systems in the Yucca  
 Mountain area?

*Structural Control of Volcanism*

- Northeast vs. northwest trends.
- Are northeast trends regionally  
 significant?

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*Analog Studies*

- Structural Control of Volcanism
- Vent Geometry
- Estimate:
 
$$\frac{\text{volume of magma erupted}}{\text{volume of magma in subsurface}}$$

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*Analog*

Structural Setting  
 Volume  
 Chemistry

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**Fortification Hill Volcanic Field in  
 northwestern Arizona**

- X Pliocene alkali basalt field with a  
 total volume of about 1 km<sup>3</sup>
- X Total vents = 25
- X Individual volcanoes have volume  
 of less than 0.05 km<sup>3</sup>

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**TECTONIC SETTING**  
**Fortification Hill Volcanic Field**  
**In Northern Colorado River Extensional Corridor**

- ✓ Extension 12-9 Ma
- ✓ north-striking high angle normal faults, northwest and northeast striking strike-slip faults, west dipping detachment faults
- ✓ volcanoes are associated with north-striking faults along west and east margins of Black Mountain horst. Vents also present in range interior.

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**Mantle Boundary**  
 Isotopic compositions of alkali basalts define two mantle domains.  
*The domain to the north is characterized by LM*  
 ( $\epsilon Nd = -3$  to  $-9$ ;  $^{87}Sr/^{86}Sr = 0.706-0.707$ ).  
*To the south mafic lavas have an OIB-mantle signature and appear to have only a minor LM component in their source*  
 ( $\epsilon Nd = 0$  to  $+4$ ;  $^{87}Sr/^{86}Sr = 0.703-0.705$ ).

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**Mantle Boundary**

During thinning and replacement of the lithospheric mantle (LM) in the northern Colorado Extensional Corridor (NCREC), LM to the north remained intact.  
 Contrasting behavior to the north and south of this boundary produced a mantle domain boundary.

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**Passive Rather than Active Rifting**

OIB-type alkali basalt volcanism is focused in a small geographic area for at least 5 Ma.

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**Reveille Range in central Nevada**

- X Pliocene alkali basalt field [5.9 to 3.0 Ma]. Total volume of field is about 9 km<sup>3</sup>.
- X Volcanoes = 72
- X Individual volcanoes have volumes of 0.13 km<sup>3</sup> or less.

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**TECTONIC SETTING**  
**Reveille Range**  
**Axis of Great Basin**

- Miocene and Pliocene extension
- Reveille and Pancake Range next to Railroad Valley, one of the deepest basins in the Great Basin.
- Volcanism occurs along west and east side of Reveille Range and in range interior.

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**Geochemistry**

**Early Episode 1-5.9-5.0 Ma - lithospheric mantle source ( $^{87}\text{Sr}/^{86}\text{Sr}=0.707-0.706$ ,  $\epsilon\text{Nd}=0$  to  $+0.52$ )**

**Late Episode 1 and Episode 2 -5.0-3.0 Ma - asthenospheric mantle source ( $^{87}\text{Sr}/^{86}\text{Sr}=0.703$ ,  $\epsilon\text{Nd}=+3.59$  to  $+5.3$ )**

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**Central Nevada Volcanic Belt**

Originally described by Vaniman, Crowe and Gladney (1982)

Belt of Pliocene volcanoes extending from Crater Flat to Pancake Range

Little or no Pliocene volcanism between belt and margins of Great Basin

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**Central Nevada Volcanic Belt**

*Northern part of belt*

- > Lithospheric mantle source early, asthenospheric mantle late--associated with long period of extension.

*Southern part of belt*

- > Lithospheric mantle between 10.5 and present, extension initiates in late Miocene

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**Central Nevada Volcanic Belt Model**

A Pliocene zone of extension

Zone of extension opening to the south

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**Conclusion**

- Reville range and Crater Flat are in a similar tectonic setting.
- Fortification Hill and Crater Flat have a similar setting.
- Volumes of *individual volcanoes* same order of magnitude (0.05-0.13 km<sup>2</sup>) as those in Yucca Mountain area.
- Chemistry of volcanic rocks in each field is similar.

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**Conclusion**

Reville Range and Fortification Hill fields are suitable analogs to Volcanoes in Crater Flat.

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**Pliocene and Quaternary Volcanism  
 in Great Basin**

**Three Prong Distribution**

- ⊞ Eastern Margin-(e.g., Grand Wash and St. George Fields).
- ⊞ Western Margin-(e.g., Independence field, Clayton Valley centers, Death Valley, Walker Lane).
- ⊞ Central Great Basin-(e.g., Central Nevada Volcanic Belt).

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**Pliocene and Quaternary Volcanism  
 in Great Basin**

**Lunar Crater, Reville, Buckboard,  
 Crater Flat volcanoes (Central  
 Nevada Volcanic Belt) are isolated  
 relative to other volcanic fields of  
 similar age in the Great Basin**

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**Location of Central Nevada Volcanic Belt  
 subparallel to**

- Western margin of Precambrian craton based on Nd data of Farmer and DePaolo (1983) just to west.

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**Location of Central Nevada Volcanic Belt  
 Corresponds to:**

- Concentration of Tertiary calderas
- Pliocene volcanoes
- Deepest basin in central Great Basin (Railroad Valley).

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**Location of Central Nevada Volcanic Belt  
 Corresponds to:**

- A belt of crustal thickening (Sonoman orogeny (late-Permian--early Triassic), Antler orogeny (late Devonian--early Mississippian and Jurassic-Cretaceous thrusting).
- COCORP line across northern Nevada suggests that crust remains thicker in central Great Basin after Tertiary extension.

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**Location of Central Nevada Volcanic Belt  
 Corresponds to:**

*Discontinuities in structural style*

- East of Railroad Valley, Cambrian rocks exposed in thrust sheets. West of Railroad Valley, mid-Paleozoic strata exposed.
- East of Railroad Valley, numerous Tertiary detachment faults. In Pancake and Reville ranges, no detachment structures.

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**Central Nevada Volcanic Belt  
corresponds to an area of the  
Great Basin with a unique  
tectonic and magmatic history**

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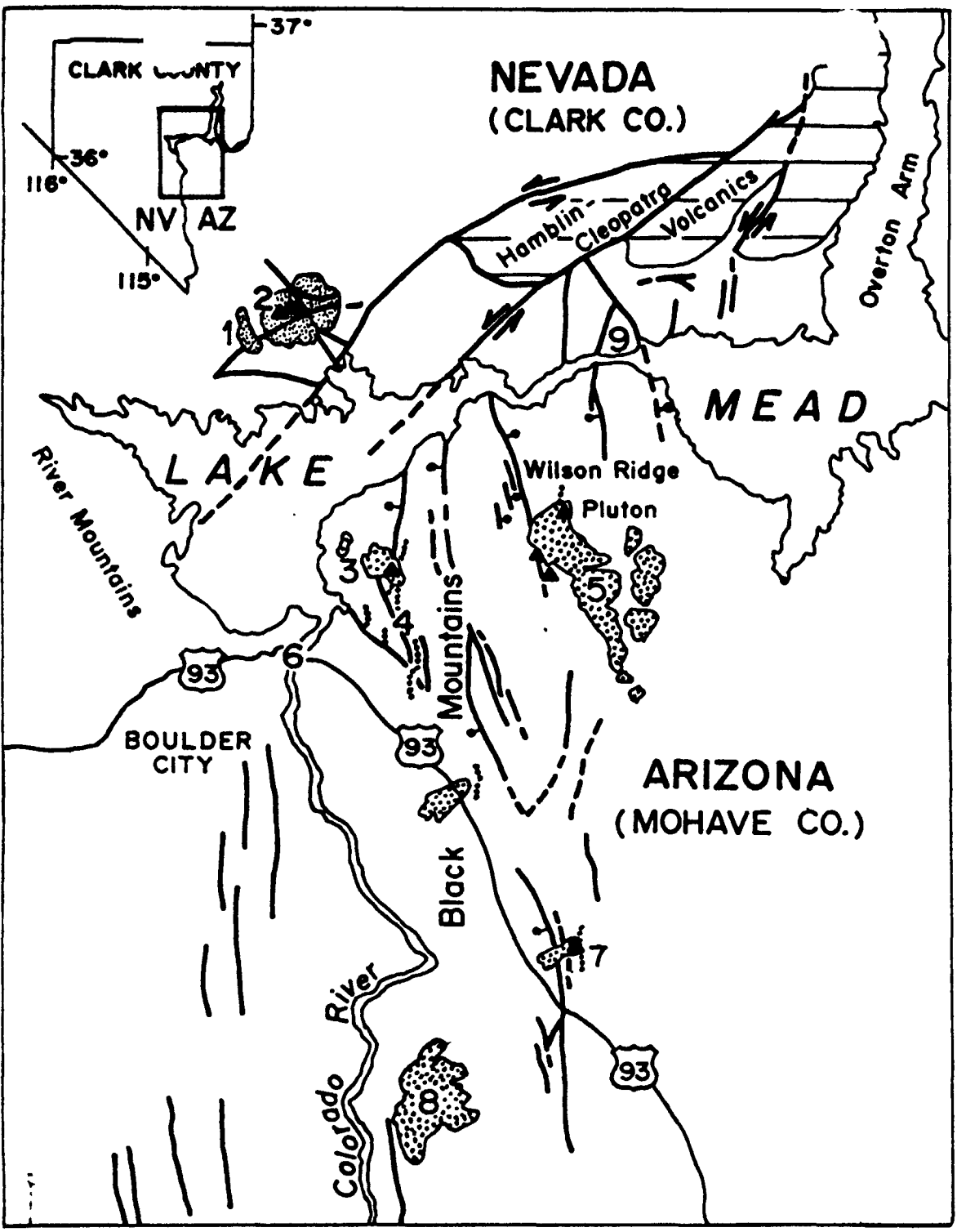
**Why are Pliocene-Quaternary Volcanoes  
found along the axis of the Great Basin?**








- **Zone of Pliocene extension**
- **Areas of significant changes in crustal thickness**
- **Area where west dipping detachment faults enter middle to lower crust**

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***CONCLUSIONS***

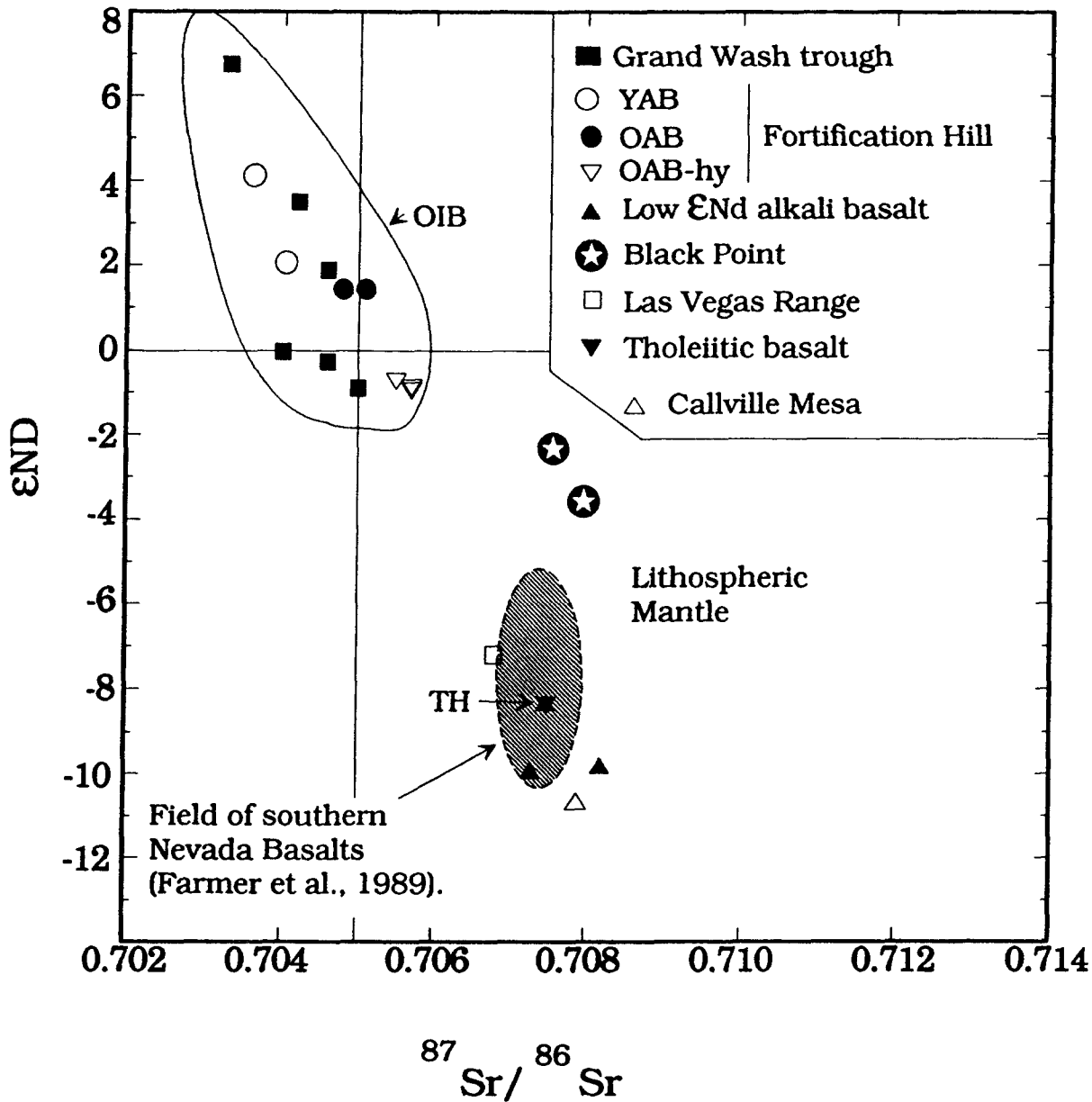
- **Reveille Range and Fortification Hill volcanic field are appropriate analogs to volcanoes near Yucca Mountain**
- **Crater Flat and Lathrop Wells volcanoes are part of the Central Nevada Volcanic Belt**
- **North-northeast fault and vent alignments have regional significance**



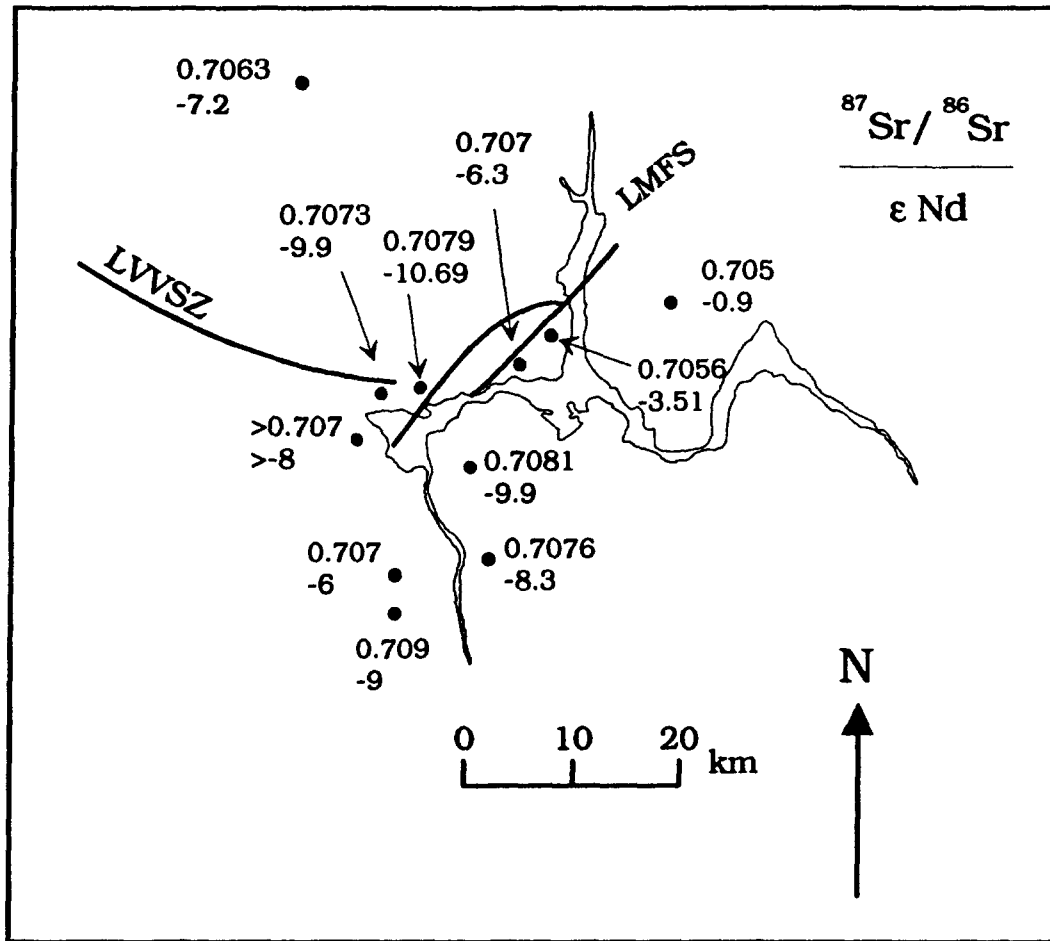
-  FORTIFICATION HILL BASALTS
-  CALLVILLE MESA- WEST END WASH VOLCANICS
-  HAMBLIN - CLEOPATRA VOLCANICS
-  HIGH-ANGLE NORMAL FAULT
-  STRIKE-SLIP FAULT
-  DIKE
-  VOLCANIC CENTER



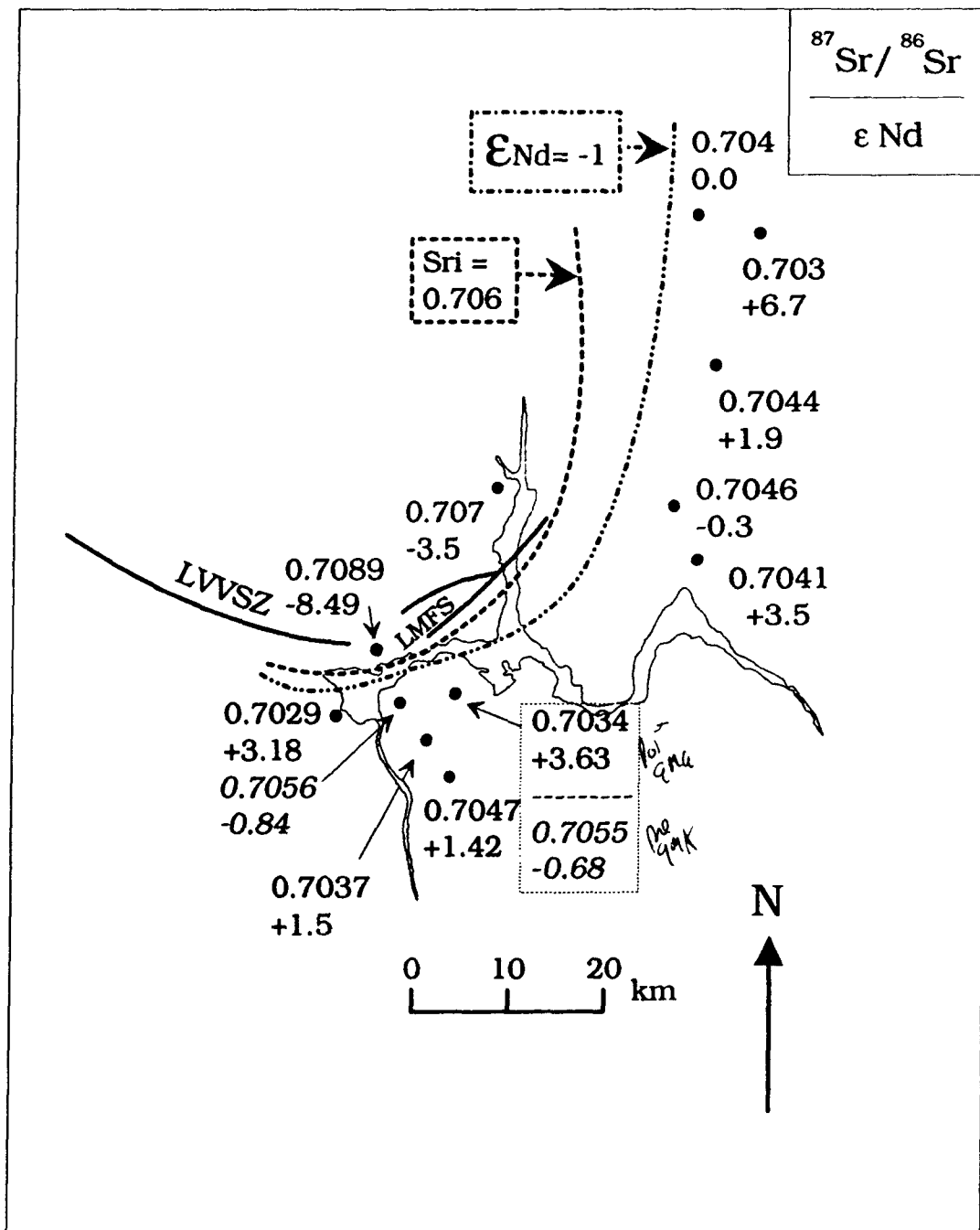
*2.18 Apr 2000  
Fortification Hill*



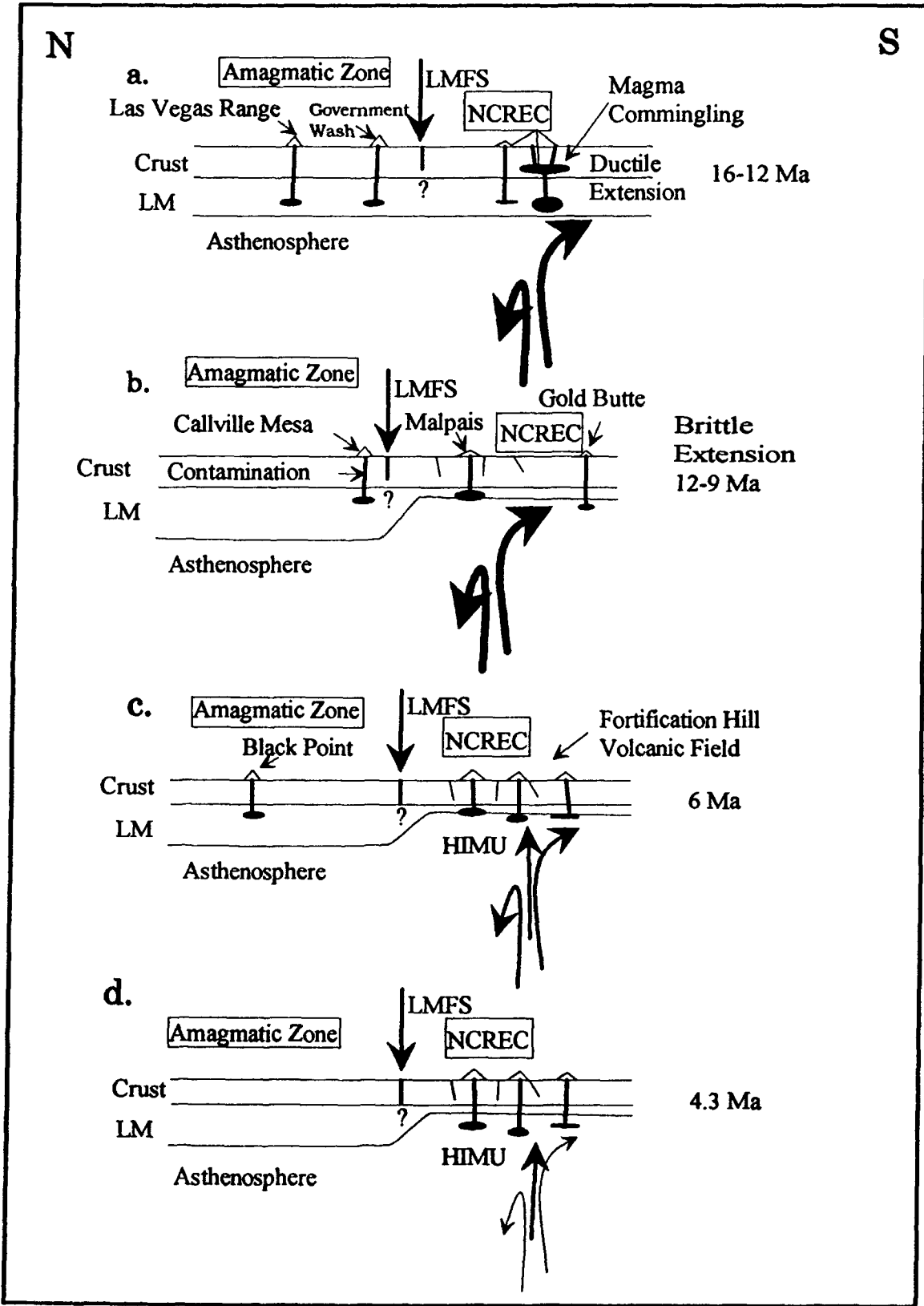




**Fortification Hill Volcanic Field**  
**Pre 9-Ma Mafic Volcanism**



**Fortification Hill Volcanic Field  
Post 9-Ma Volcanism**



**Fortification Hill Volcanic Field**

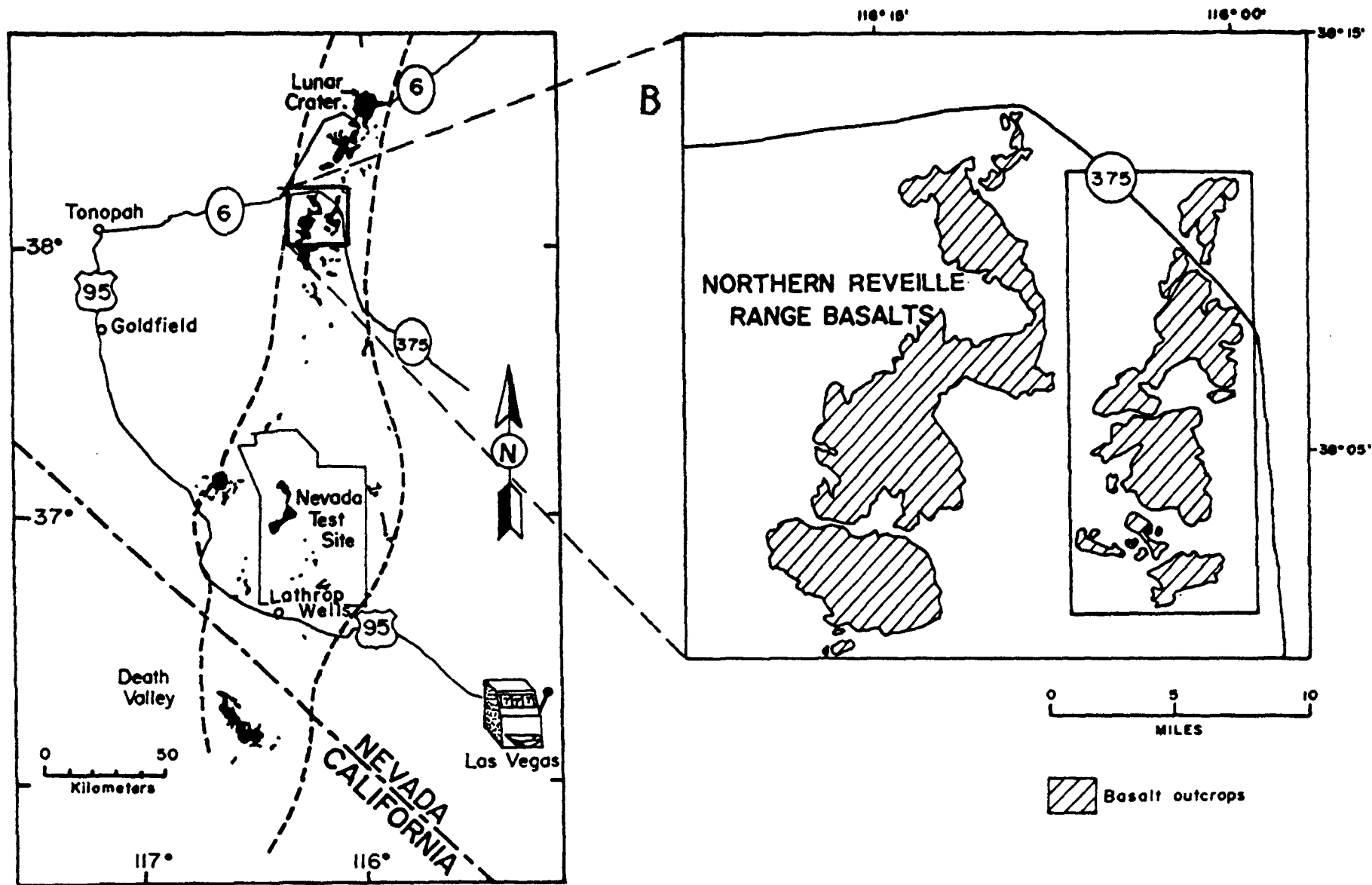
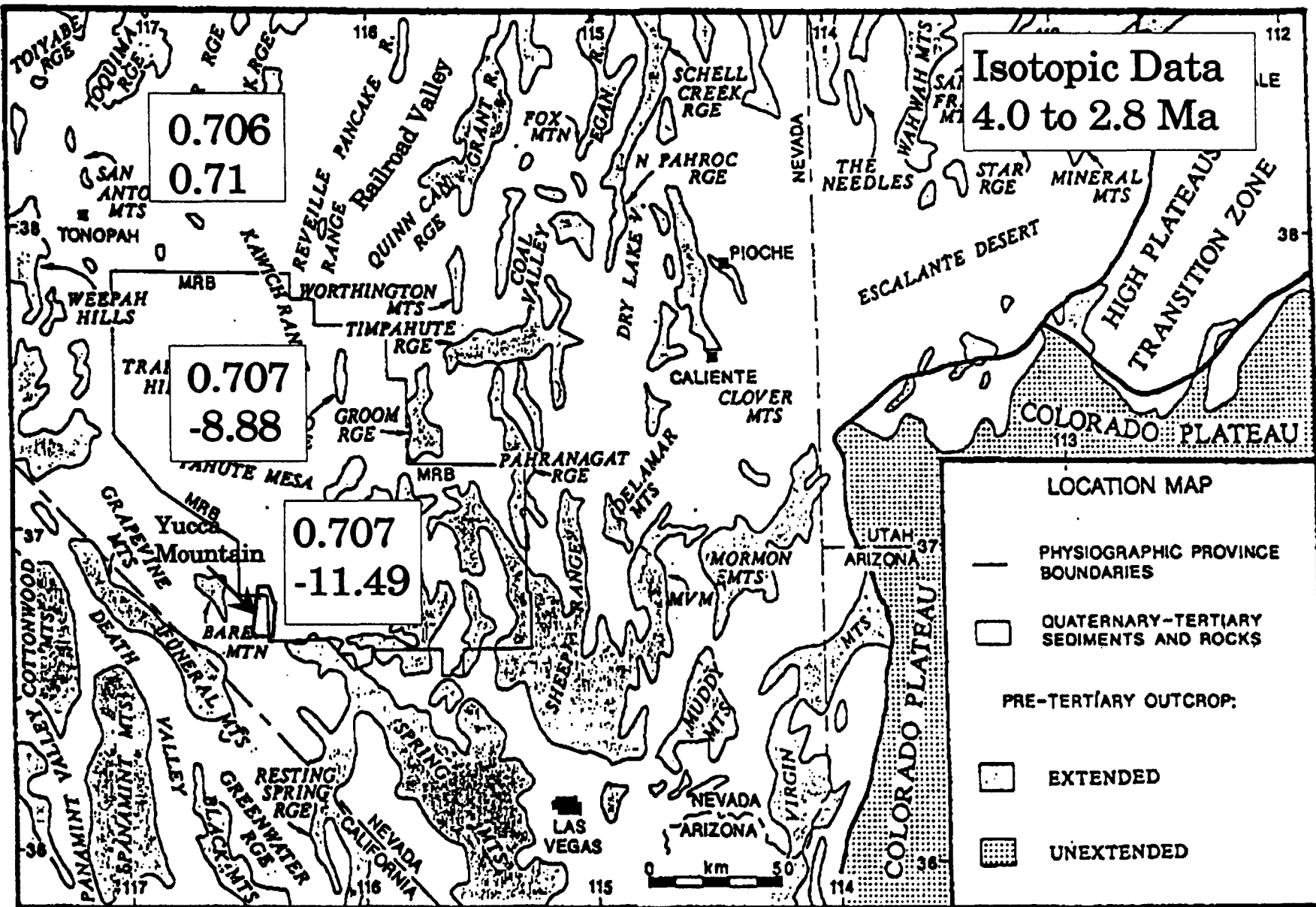
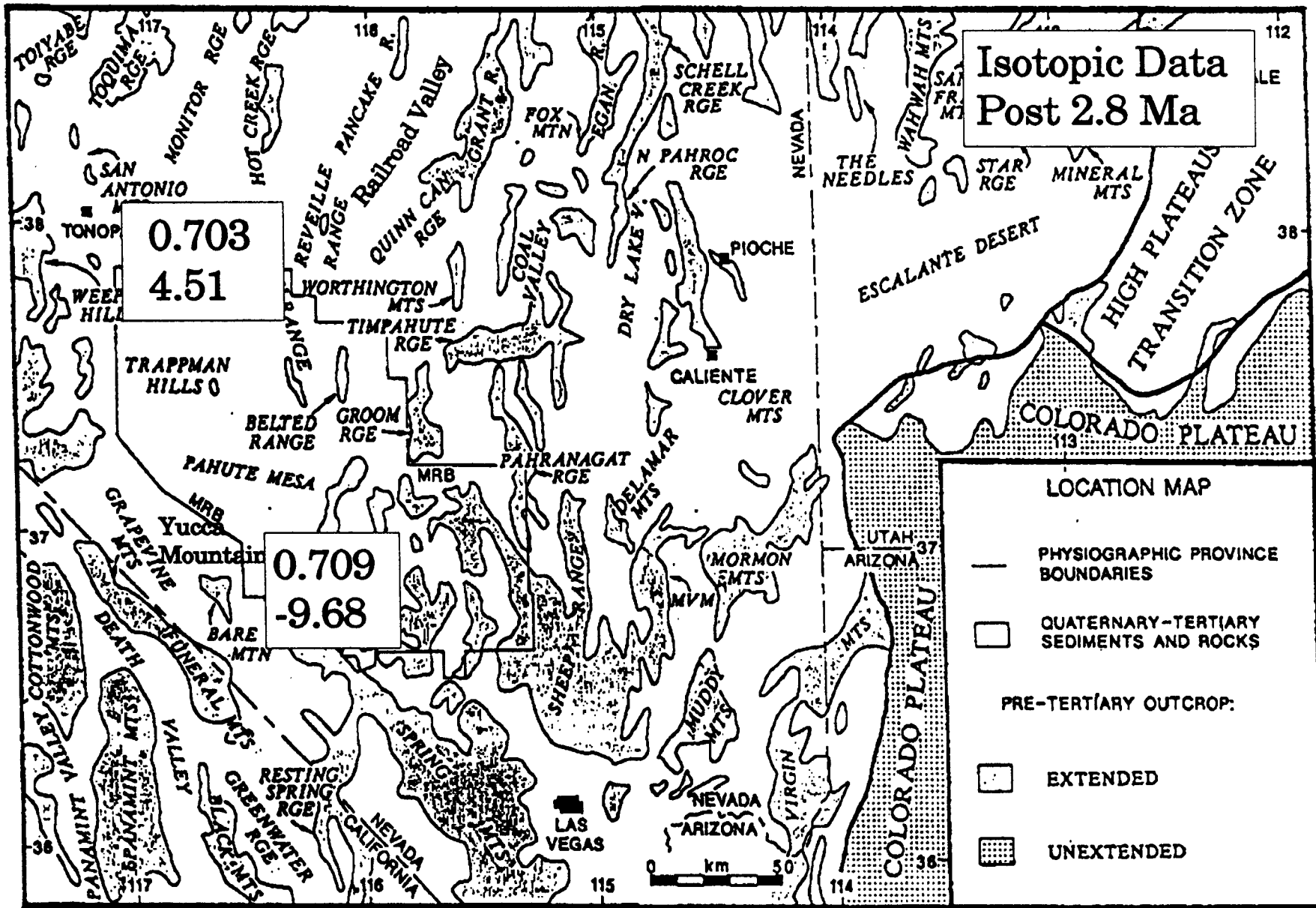
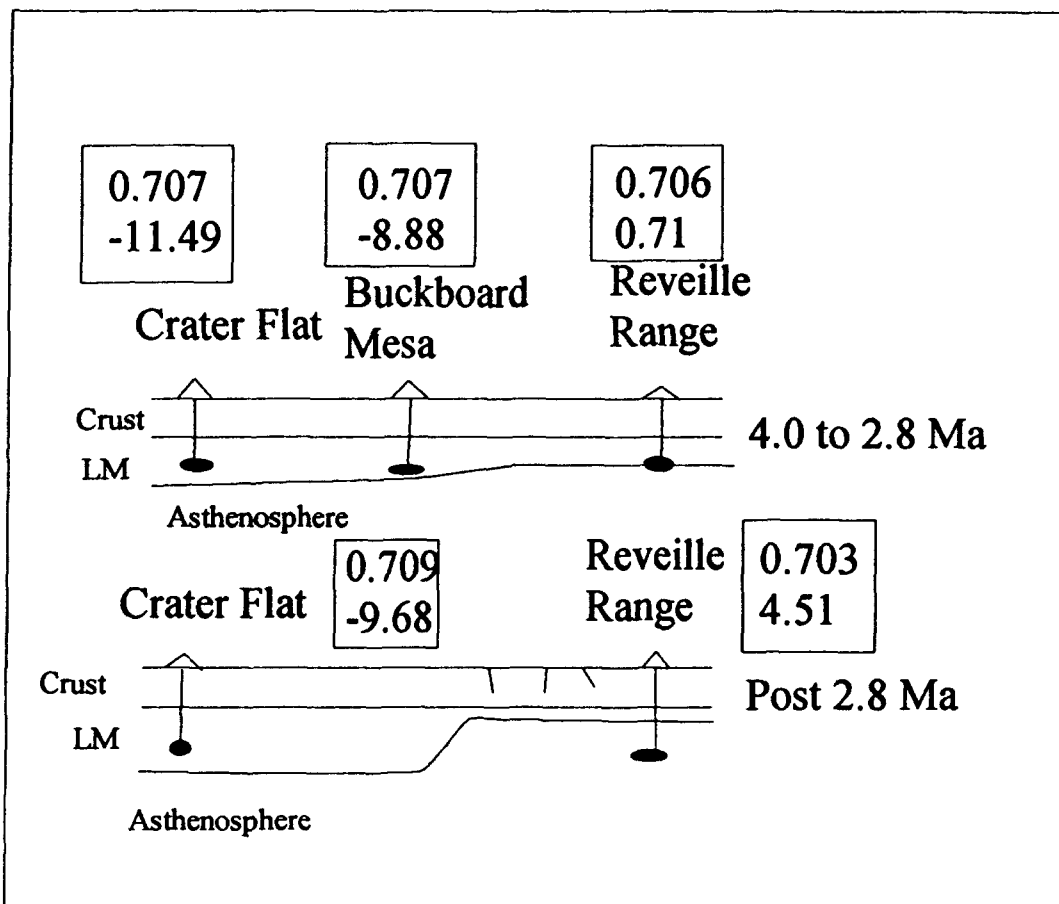


Figure 13. Location map of the northern Reville Range. (A) Post 6 Ma belt of basaltic volcanism. (B) Northern Reville Range and area of Figure 14.

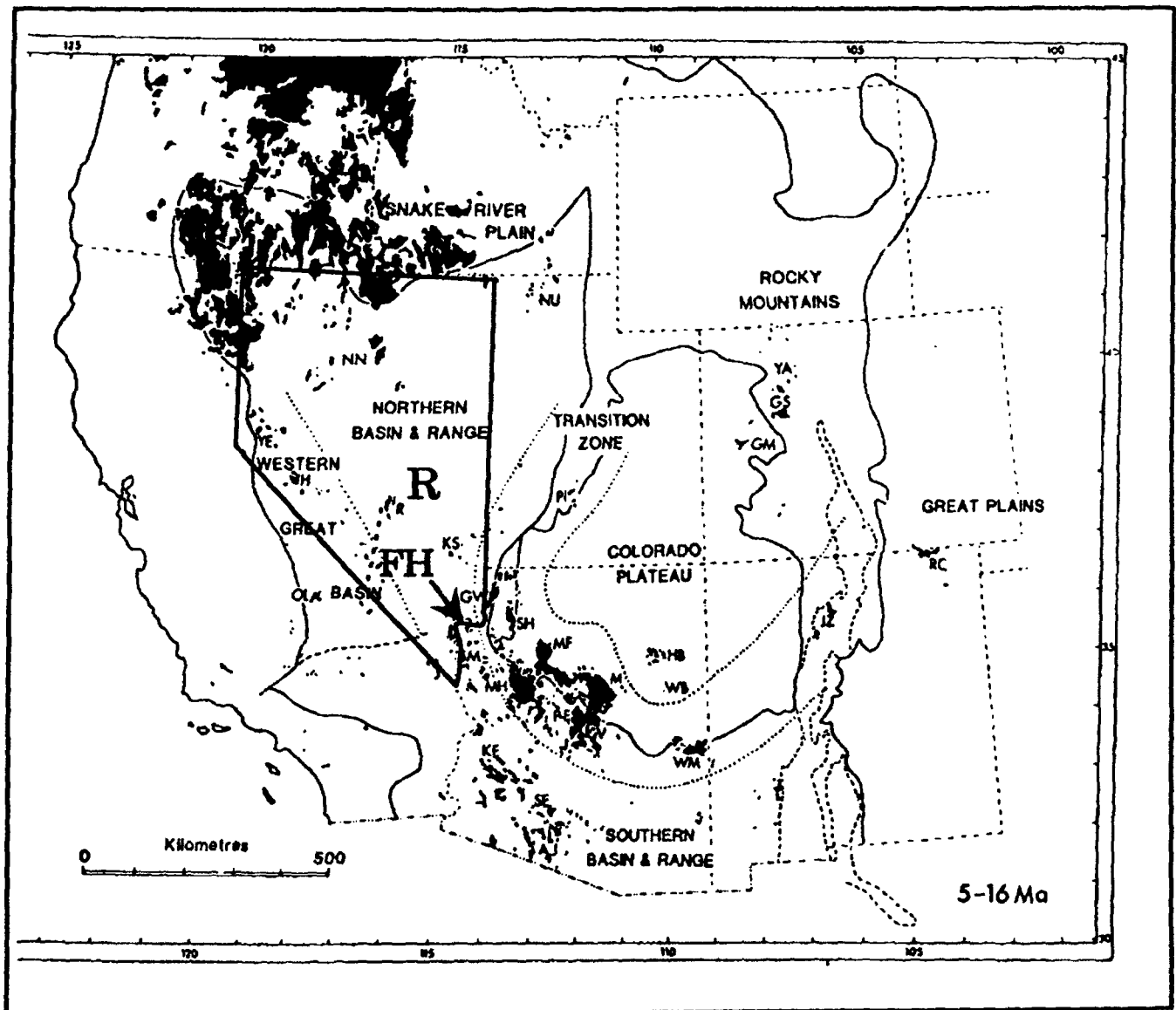






Interpretive Cross Section from Reville Range to Crater Flat, Nevada showing changes in lithospheric thickness with time.

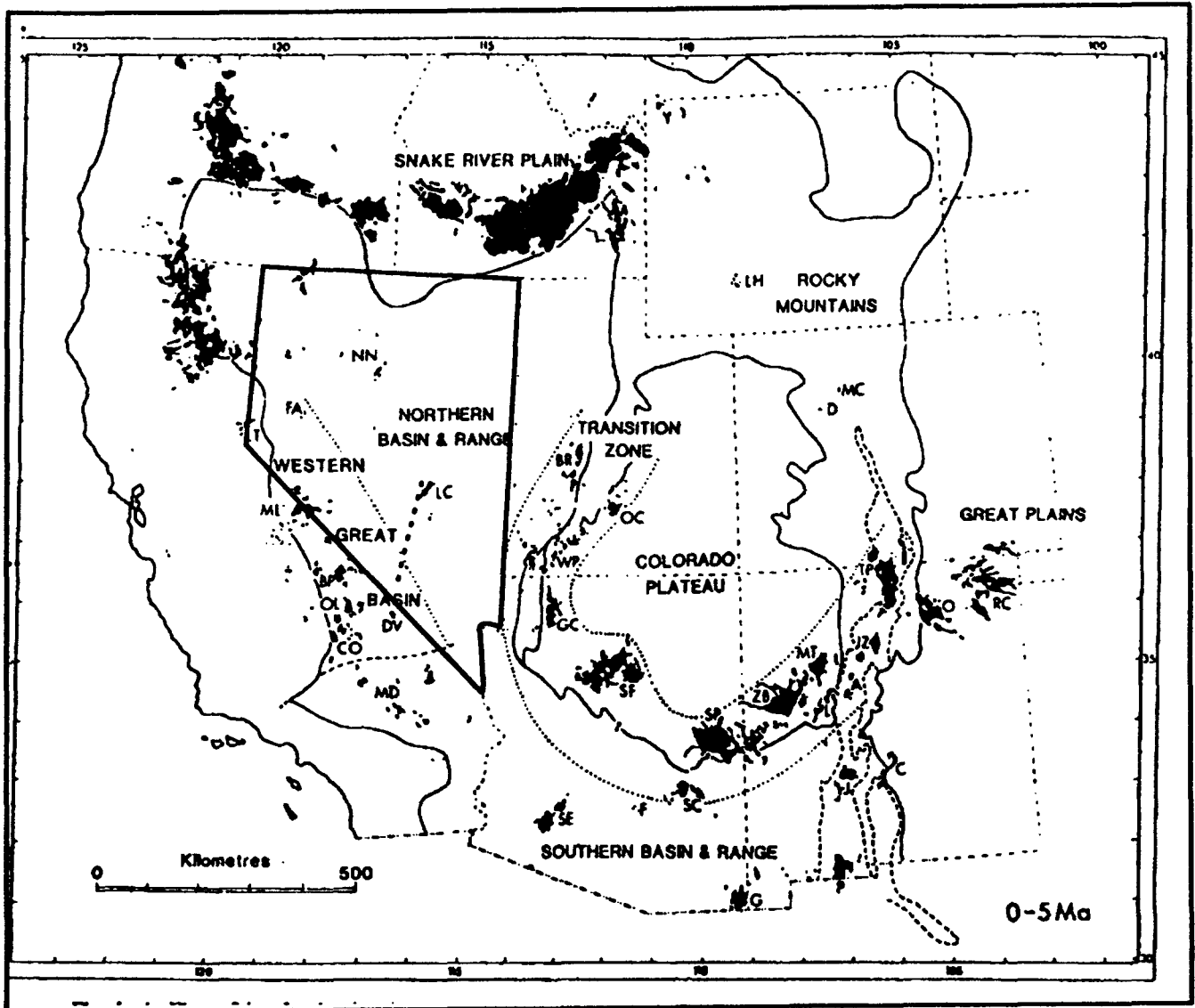
# Mafic Volcanic Rocks in the Western USA 16-5 Ma



after Fitton et al., 1991

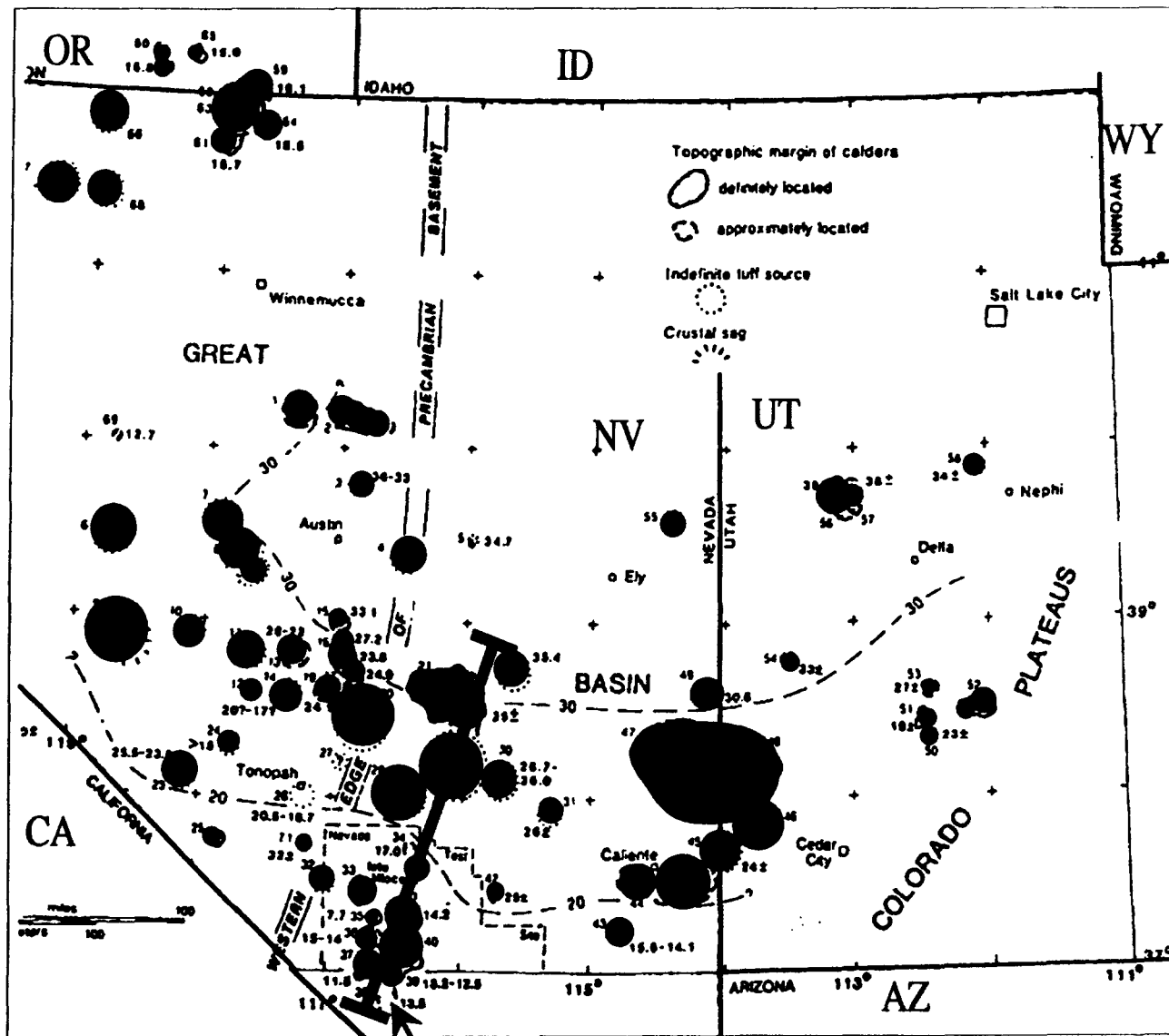


# Distribution of Mafic Volcanic Rocks in the Western USA 0-5 Ma



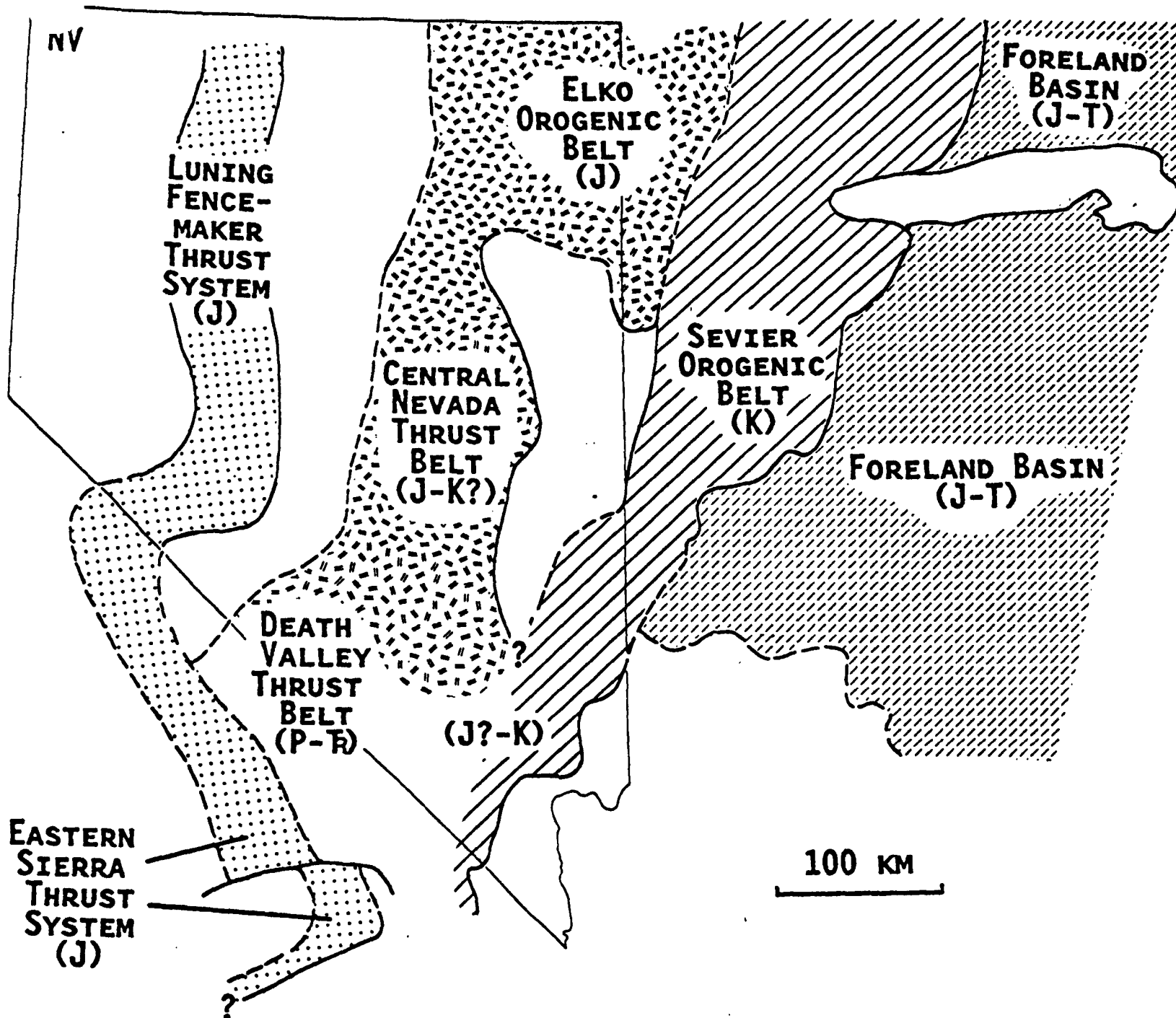
after Fitton et al., 1991

## Distribution of Known or Suspected Calderas in the Great Basin and Adjacent Areas

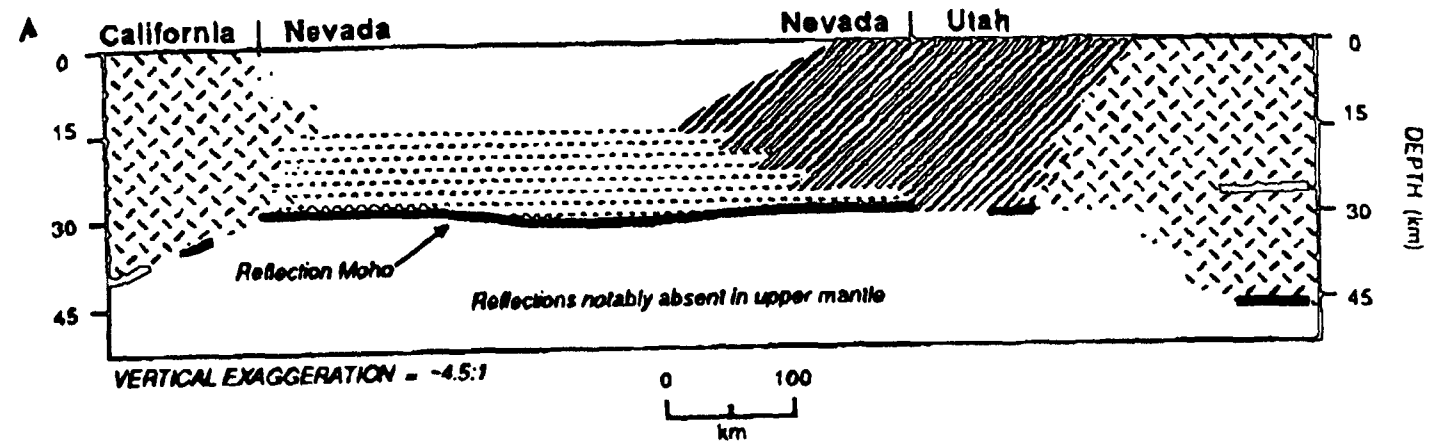


Yucca Mountain

from Best et al., 1989

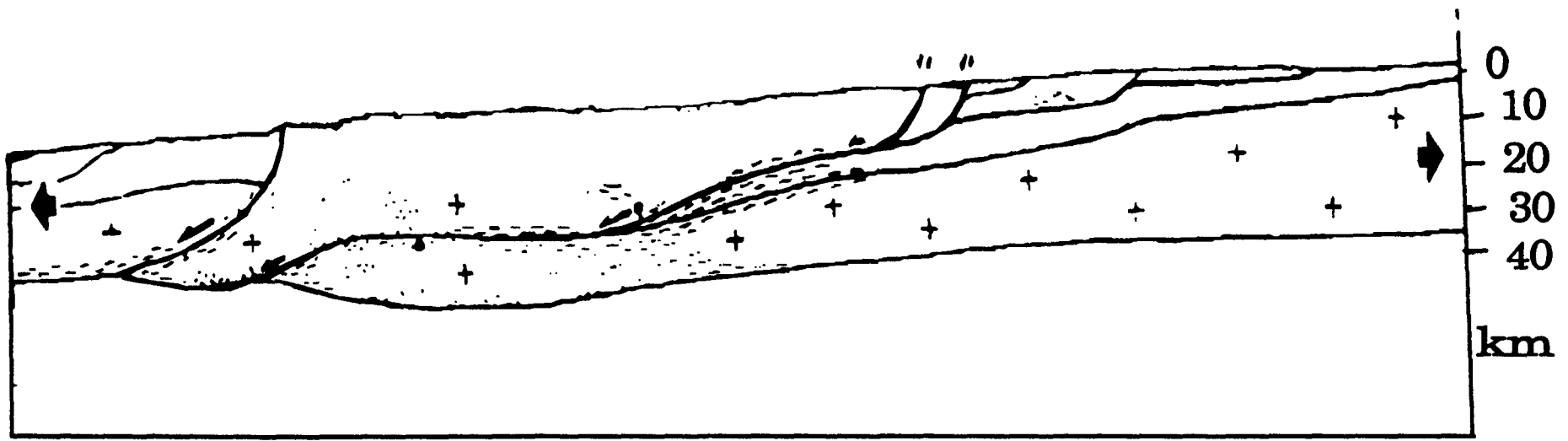


Sierra Nevada ← BASIN AND RANGE → Transition Zone Colorado Plateau

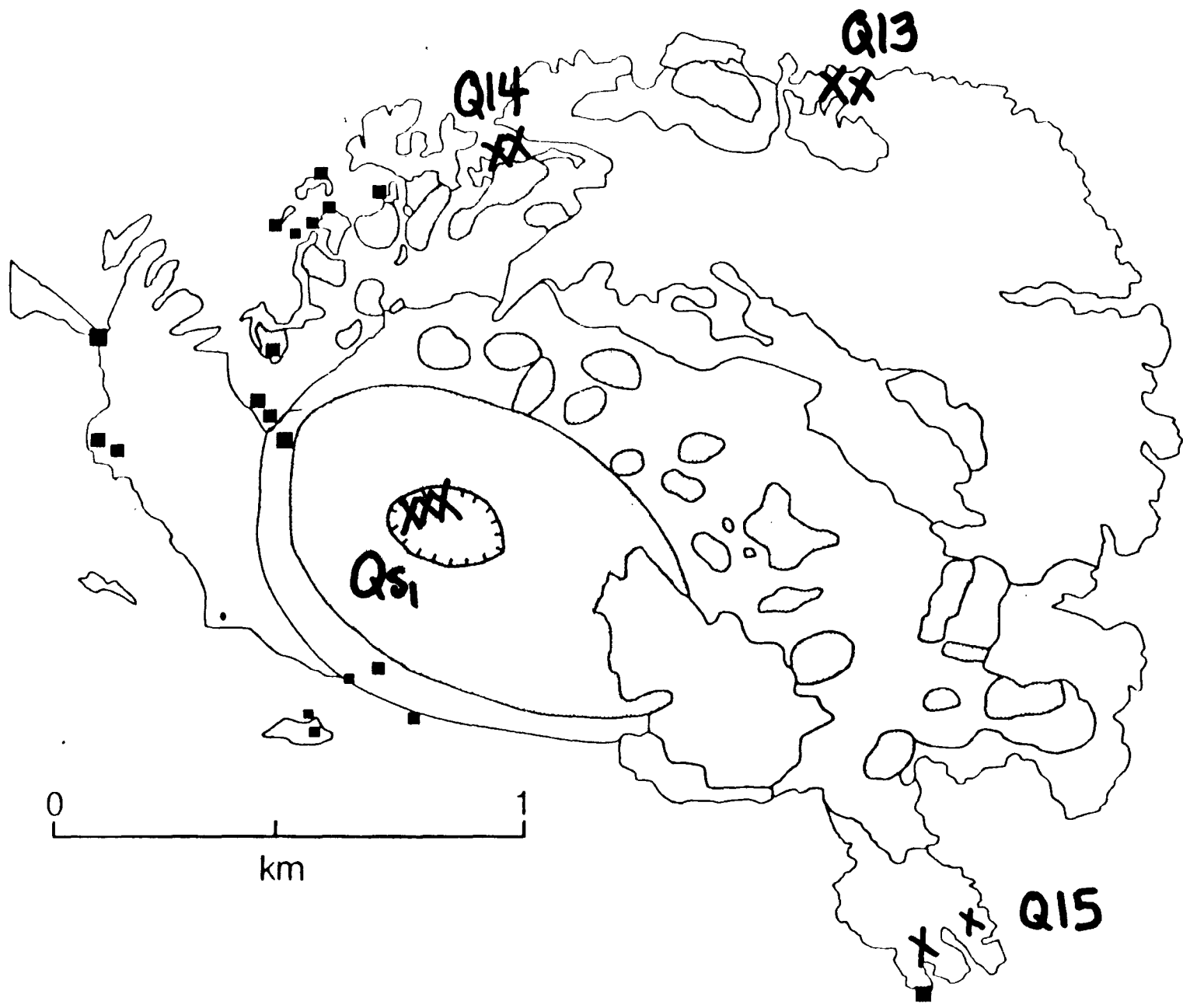


# Central Great Basin

E



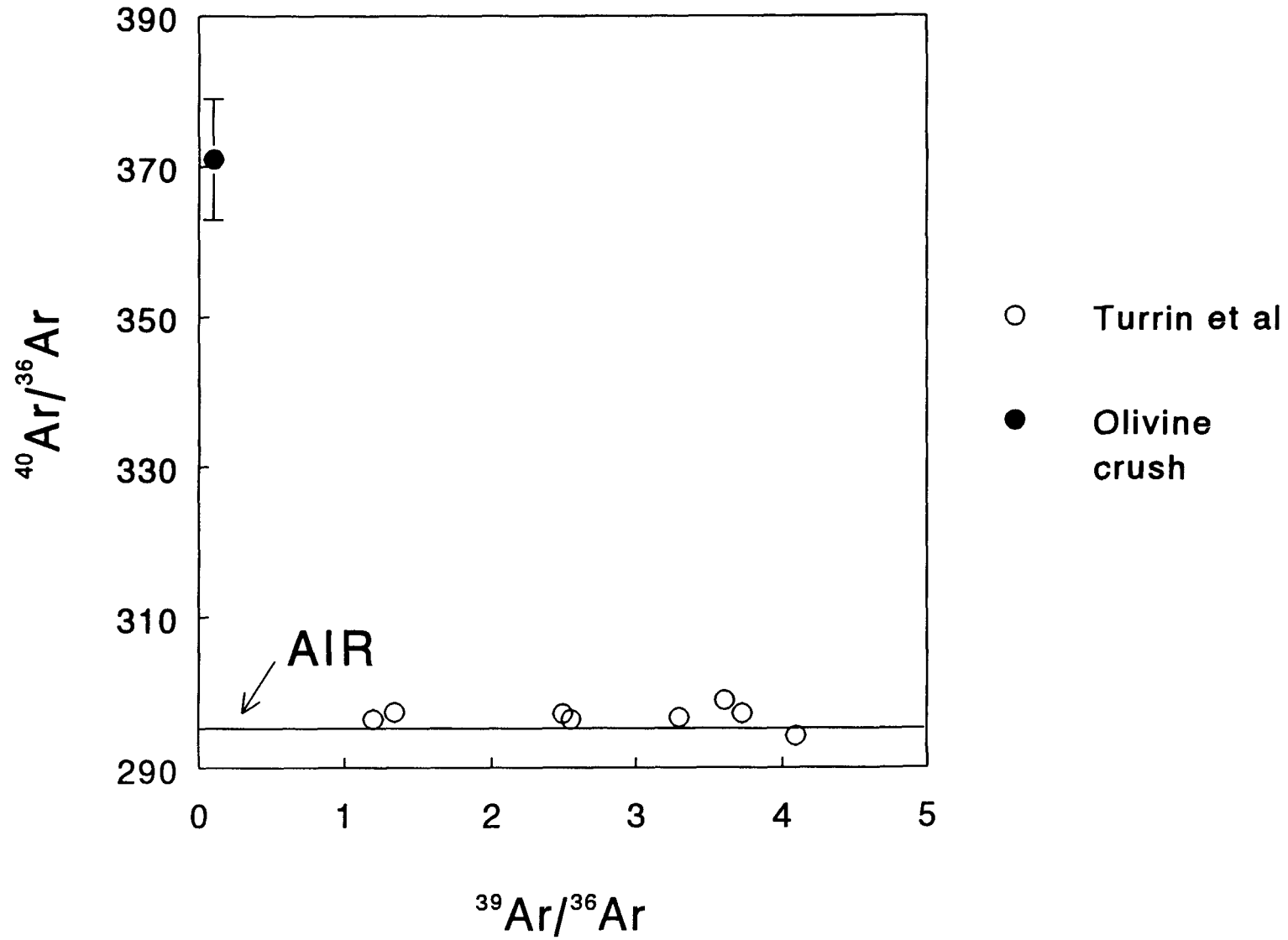
Detachment faults extending into the middle to lower crust Beneath the central Great Basin (cartoon sketch after Malavielle (1987)).



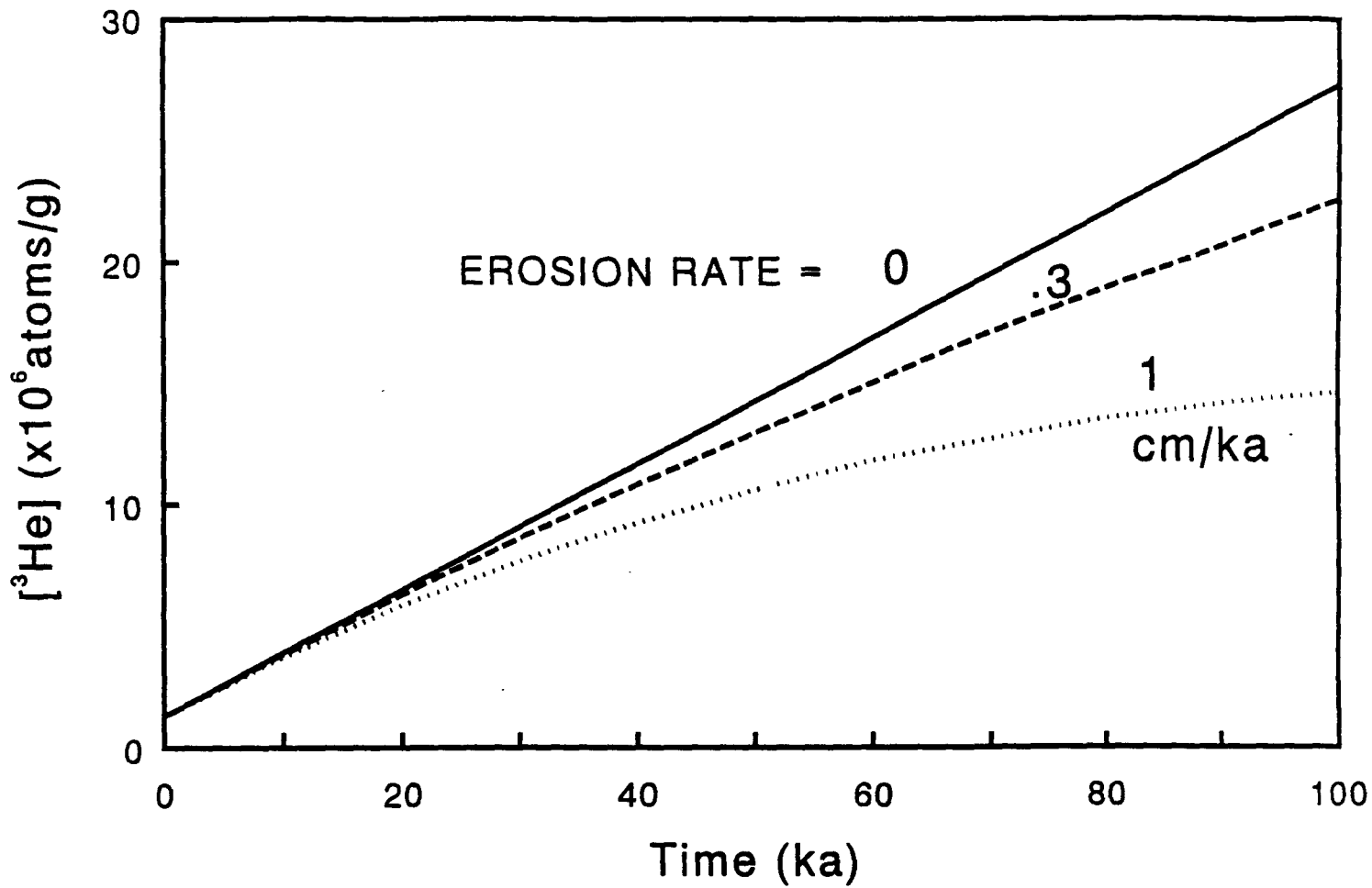
Lathrop Wells Volcanic Center: Trench Sites

X He sites

# ARGON FROM Q15



# Buildup of Cosmogenic He-3





# Surface Exposure Ages

