Geological and Geophysical Evidence for the Nature, Style, and Age of Faults in Crater Flat, Nevada

John A. Stamatakos and David A. Ferrill
Center for Nuclear Waste Regulatory Analyses,
Southwest Research Institute®
San Antonio, Texas

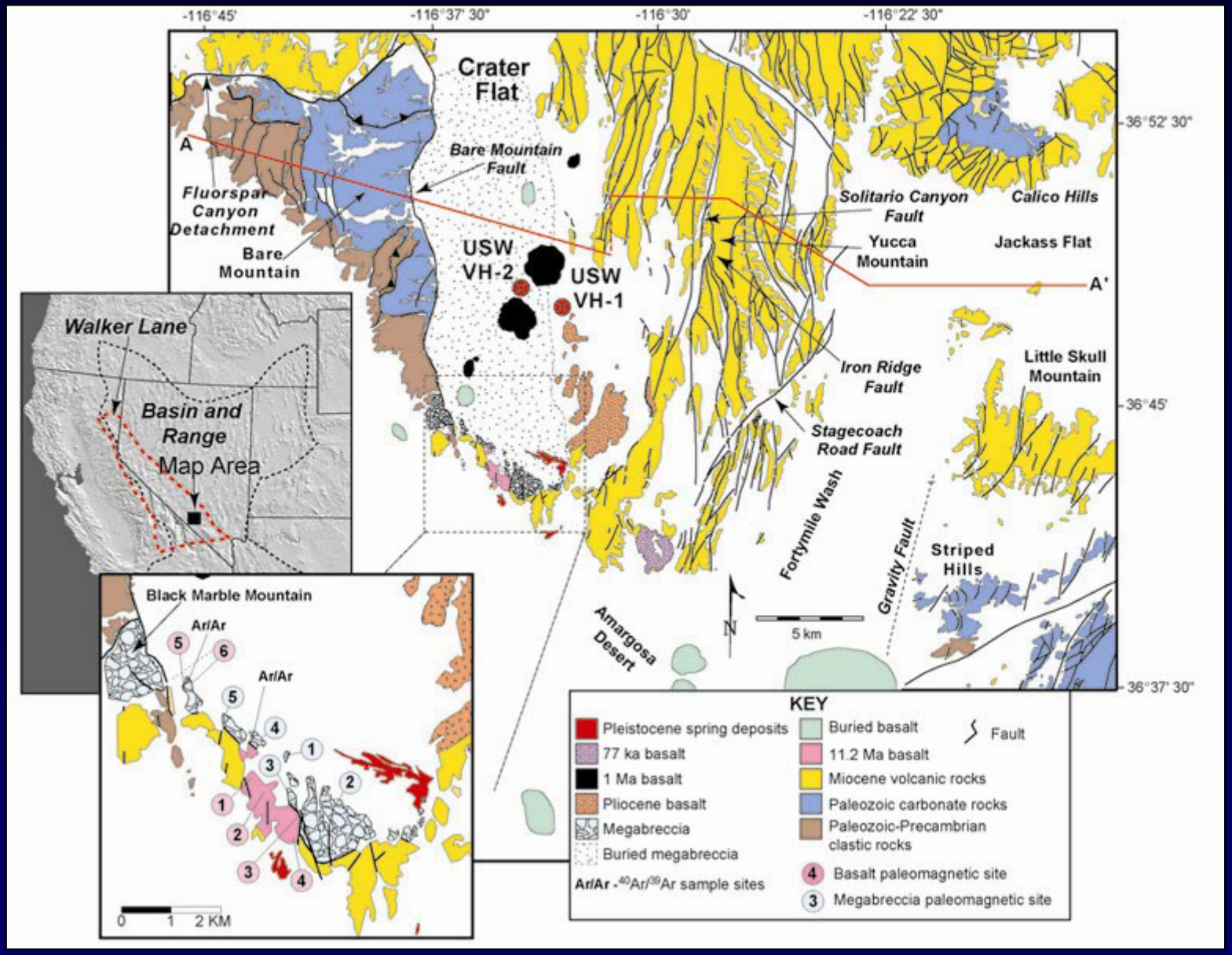
Alan P. Morris
University of Texas at San Antonio, San Antonio, Texas

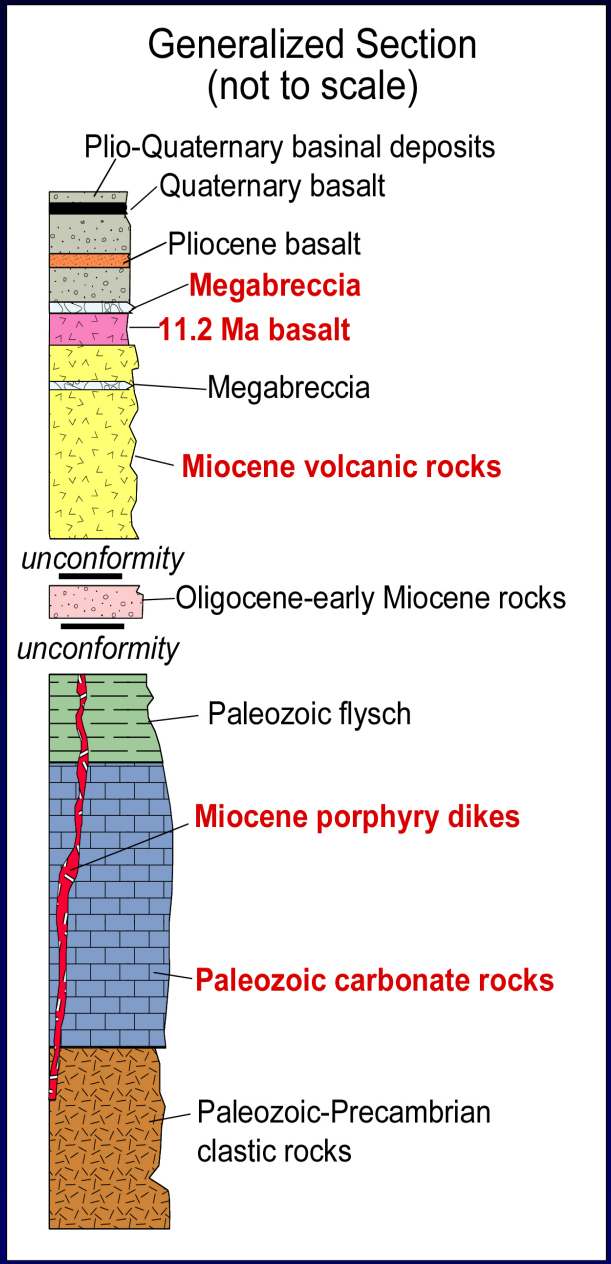
Seismological Society of America Meeting, 2005

Geologic Record of the Faulting Cycle of a Basin and Range Normal Fault

- Geologic record of Crater Flat, Nevada shows that the Bare Mountain fault was active over about a 500 ky period in Miocene.
  - Slip rate of 1–3 mm/yr
  - Basin stratigraphy
  - Geophysical evidence for 3D basin geometry
  - Paleomagnetic evidence for vertical-axis or incline-axis rotations
  - Structural model of hanging wall deformation
  - Timing of tectonic deformation
- Since then, fault activity continued but at a greatly reduced rate
  - Slip rate of 0.01 to 0.06 mm/yr

Geologic Setting of Yucca Mountain Region

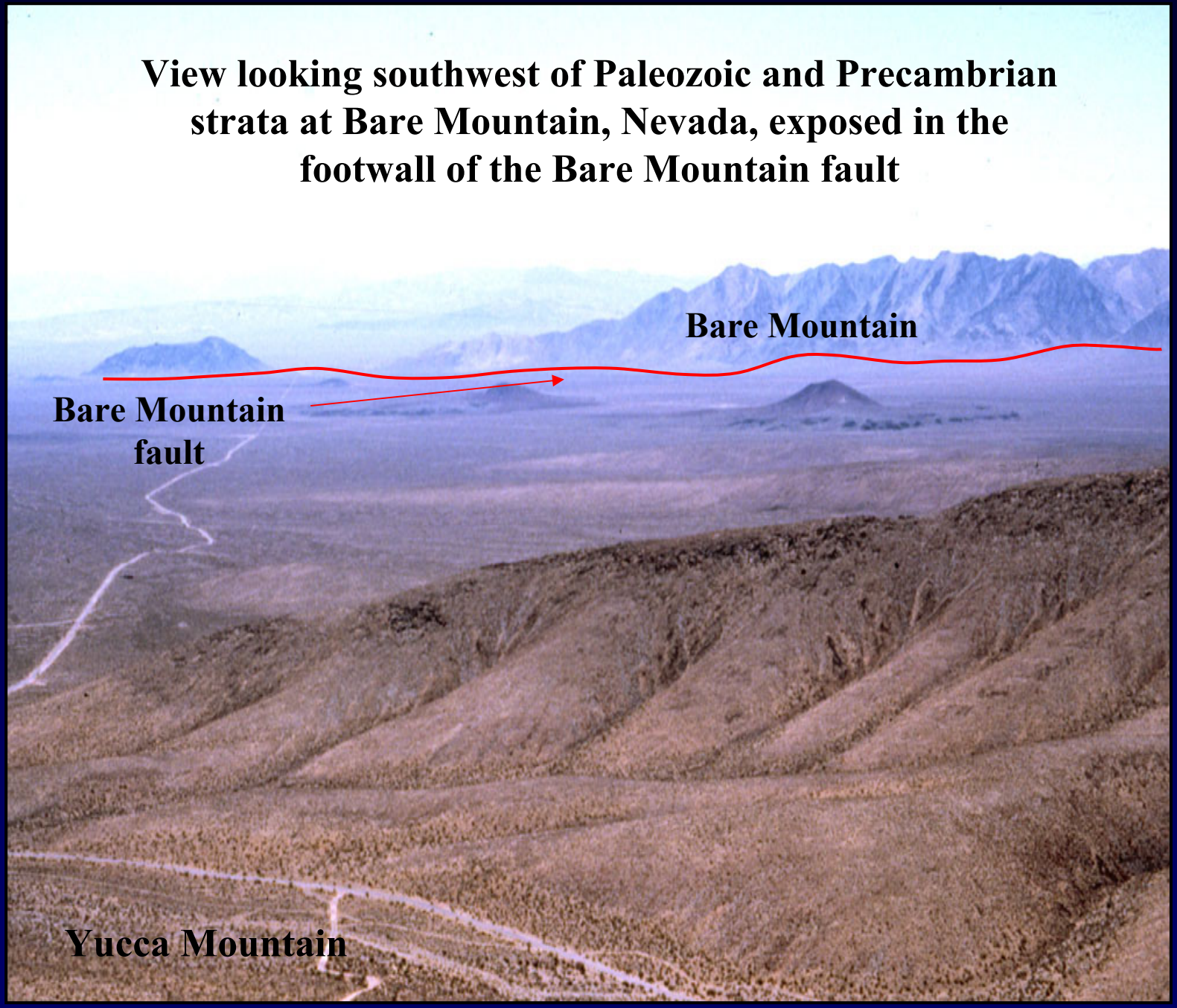




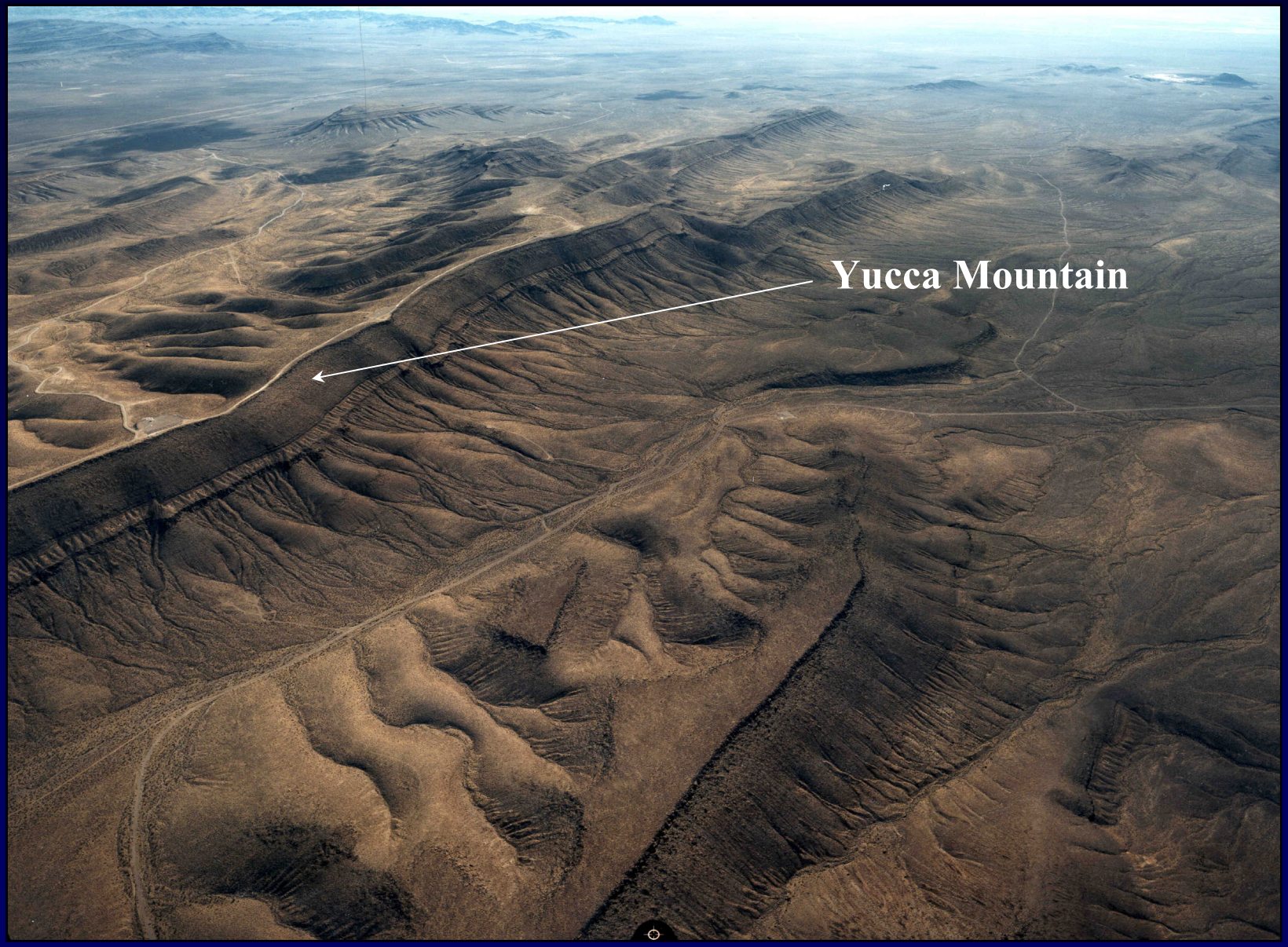
Generalized Stratigraphy of Yucca Mountain Region

Important strata that constrain the timing of faulting on the Bare Mountain fault

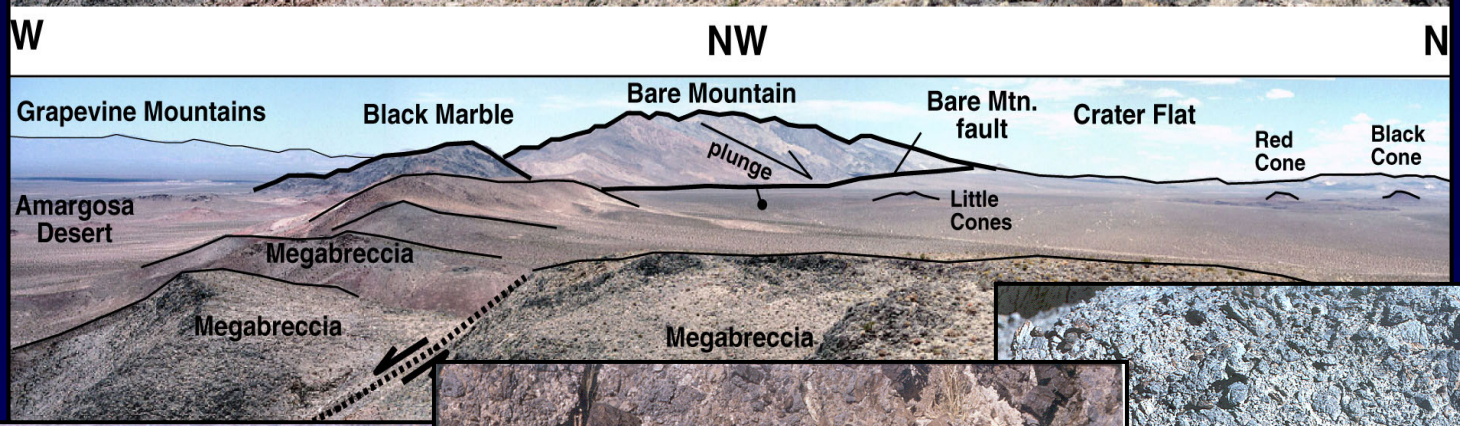
- Precambrian to Paleozoic bedrock
- Miocene (~13–11 Ma) rhyolite tuff strata
- Miocene Basalt (11.2 Ma)
- Miocene carbonate megabreccia
- Quaternary basalt

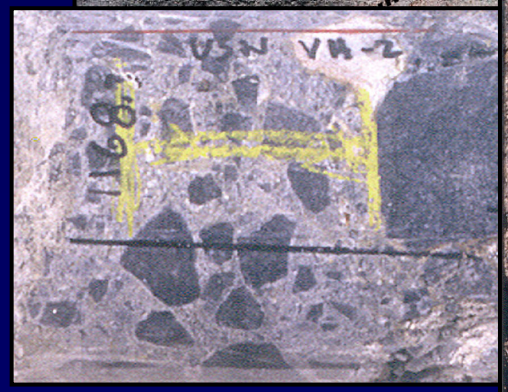

View looking southwest of Paleozoic and Precambrian strata at Bare Mountain, Nevada, exposed in the footwall of the Bare Mountain fault
Bare Mountain
Bare Mountain fault
Yucca Mountain

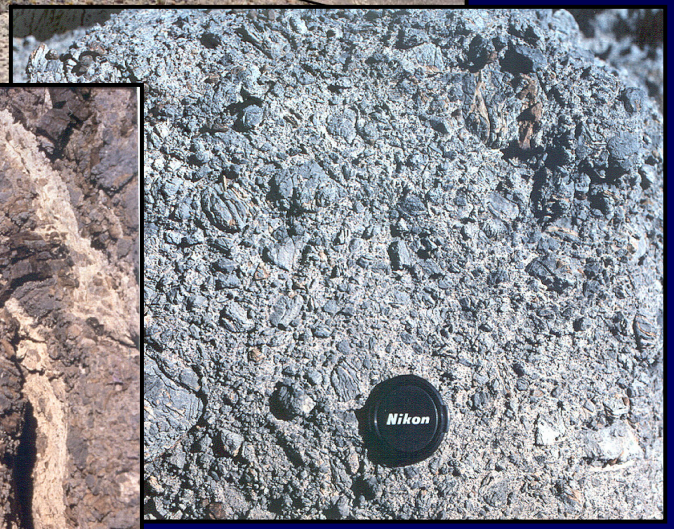
Aerial View looking south of Miocene Tuff Strata at Yucca Mountain



Miocene Carbonate Megabreccia in Southern Crater Flat

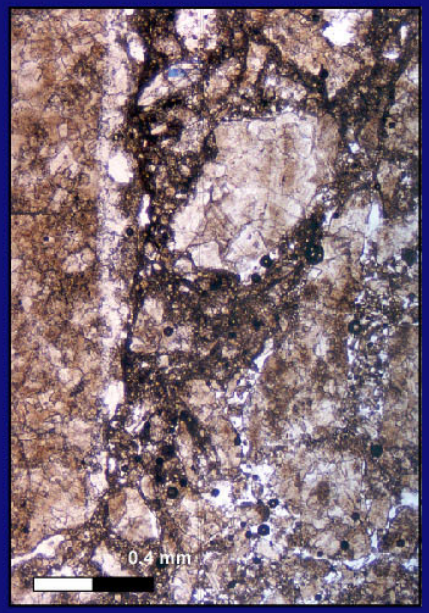




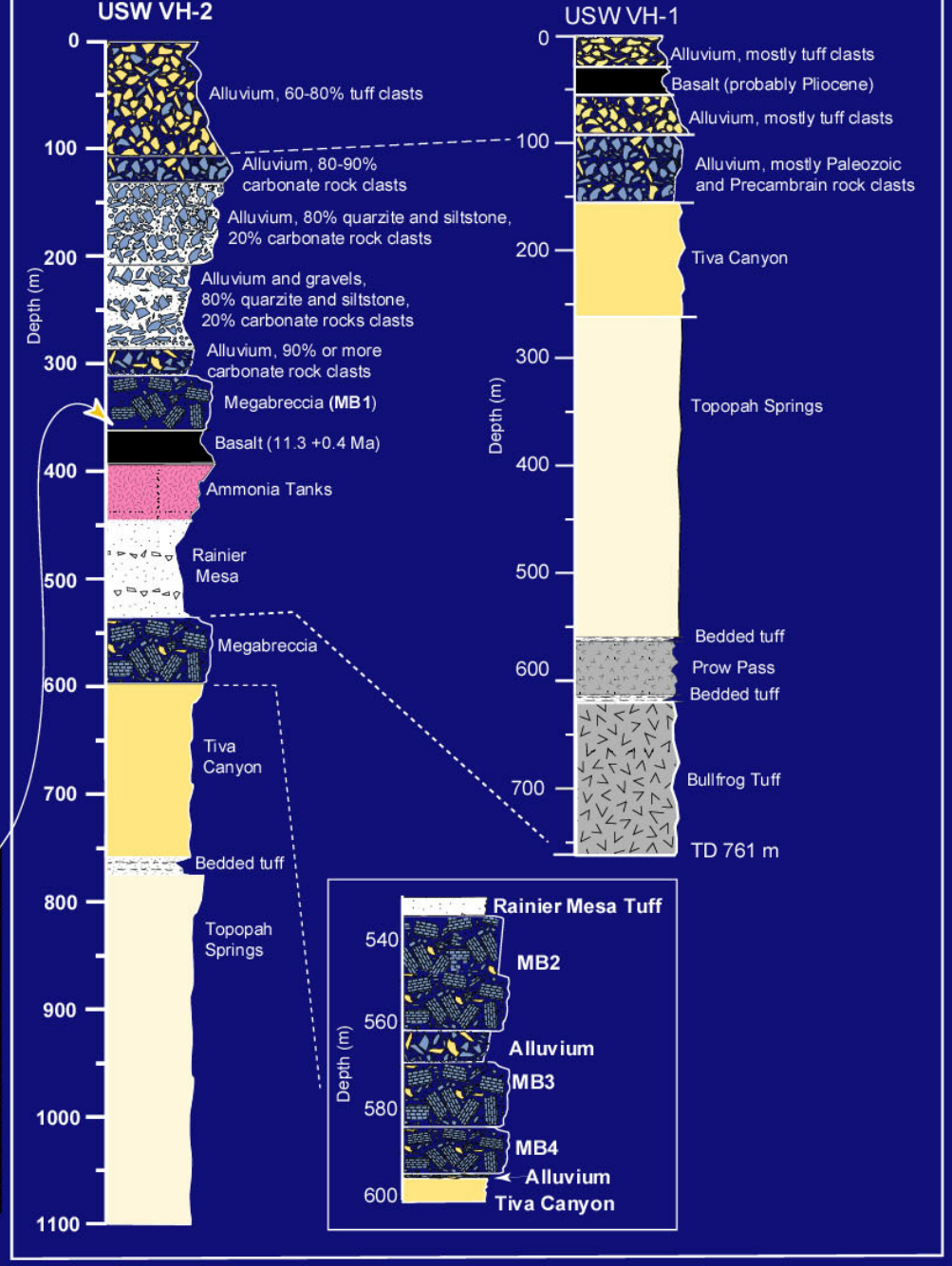


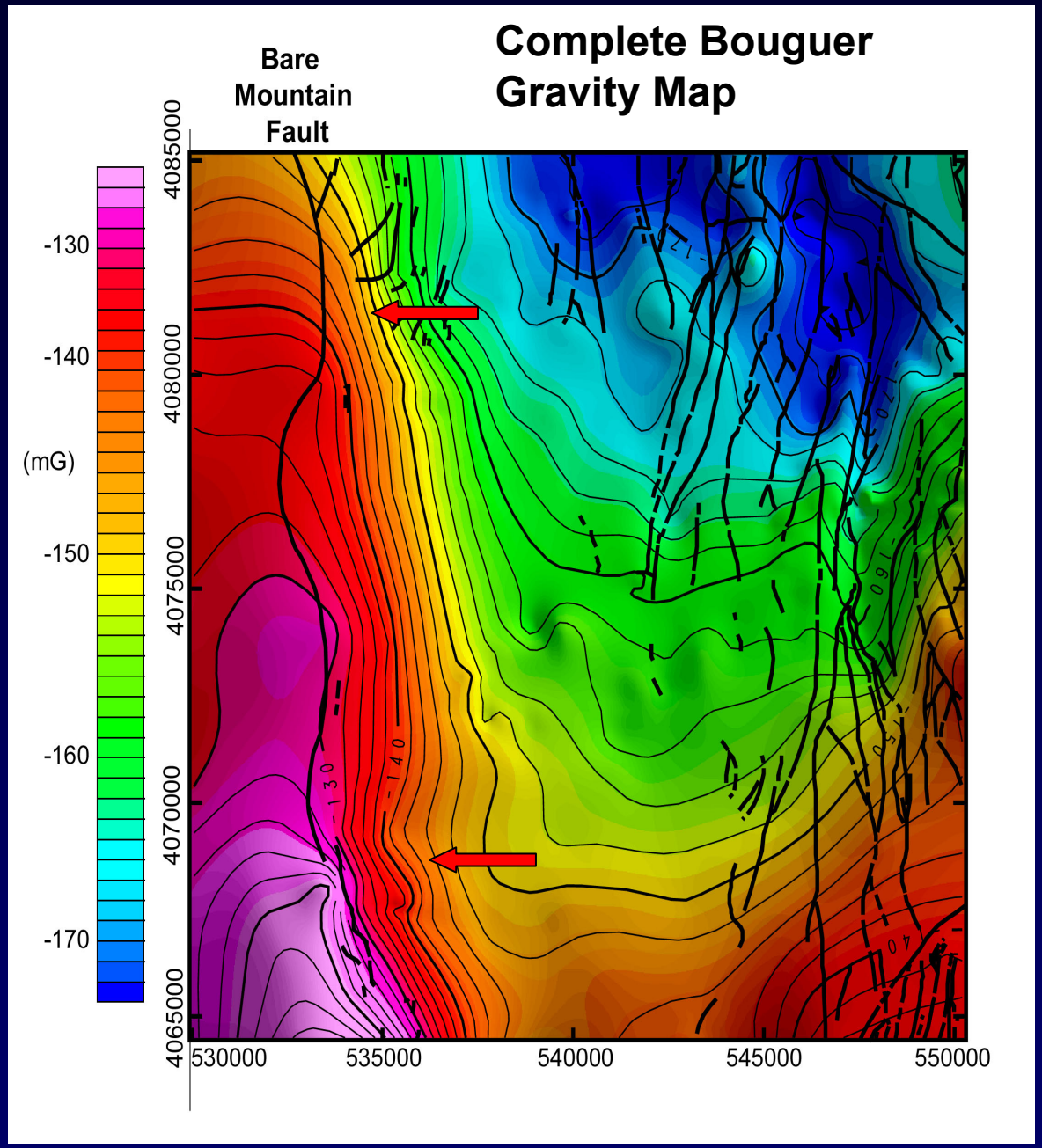
Megabreccia Deposits in Well USW-VH-2

Megabreccia



Base of Megabreccia



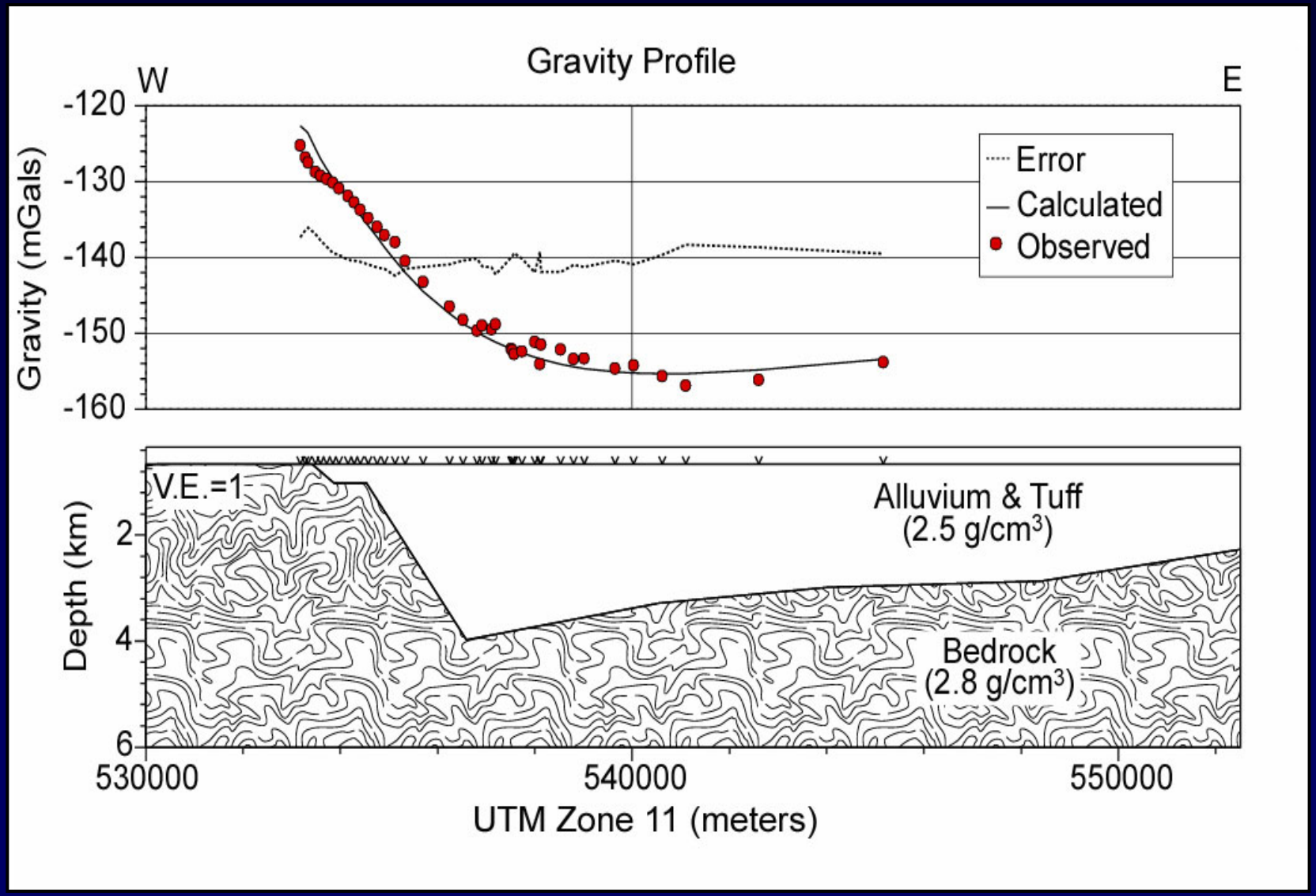


Dip of the Bare Mountain Fault from Gravity Data:

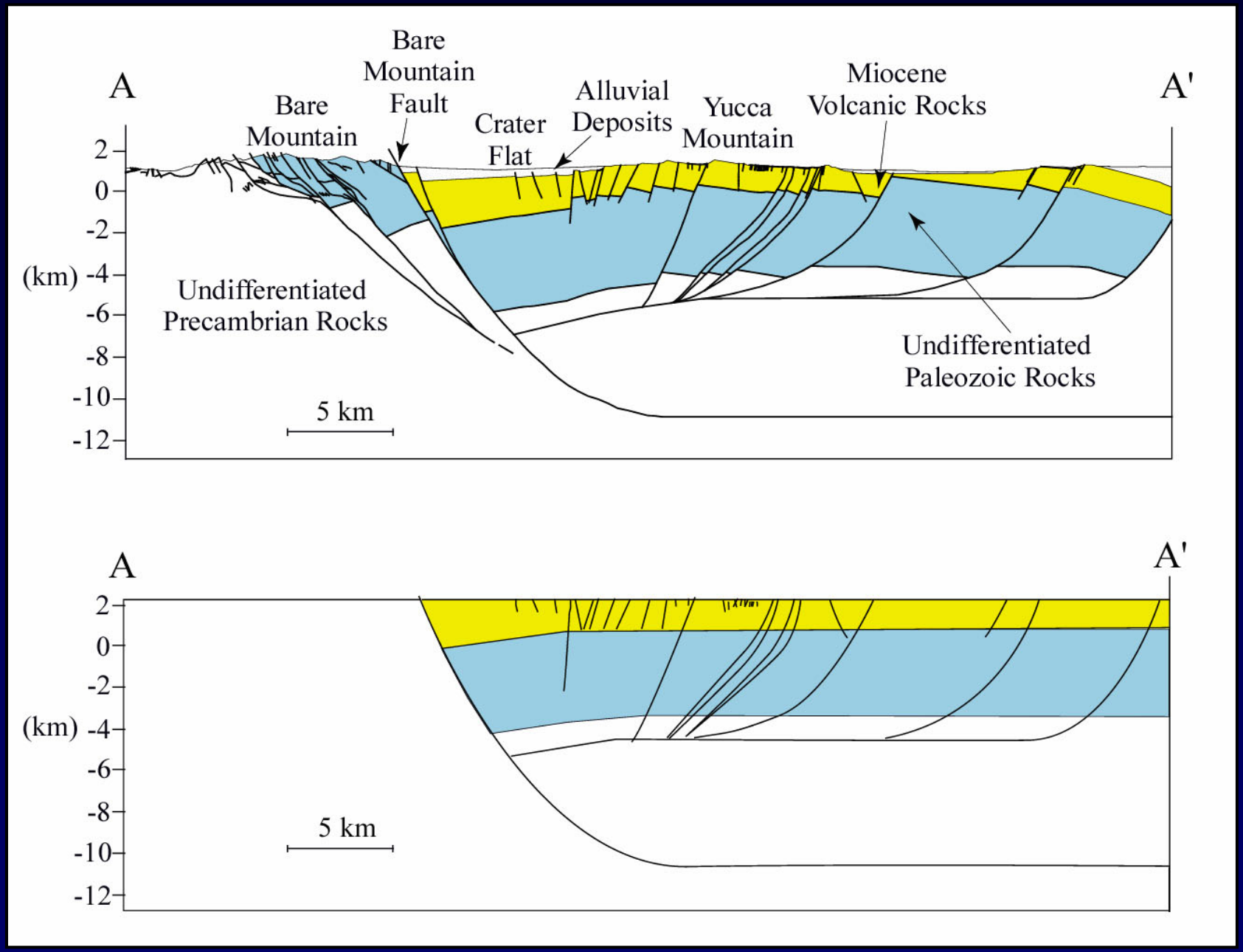
Shallower in Northern Crater Flat (~45°)

Steeper in Southern Crater Flat (~70°)

Gravity Model for Crater Flat Shows Basin Geometry

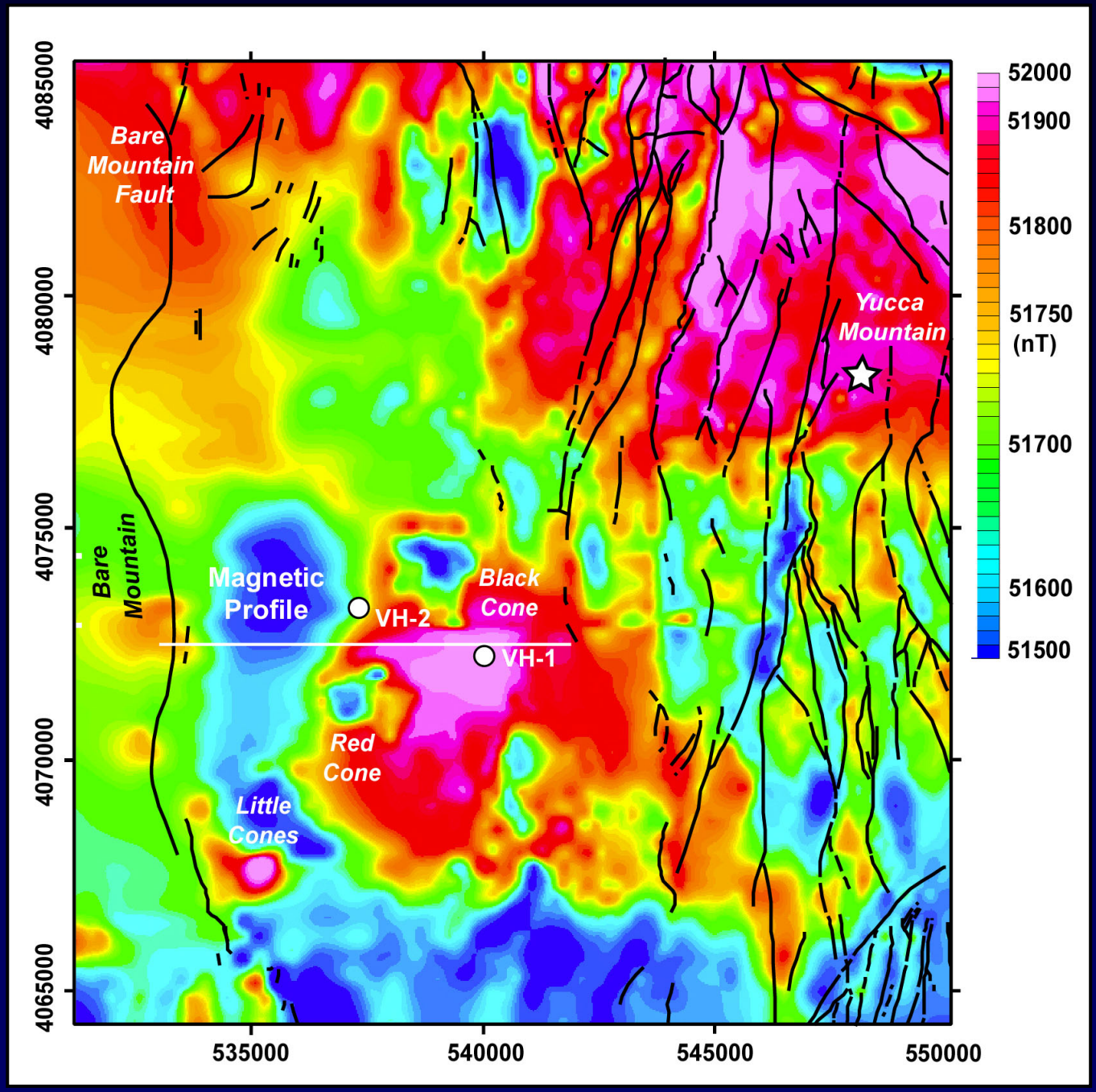


Cross-Section of Crater Flat Showing Rift Basin Geometry



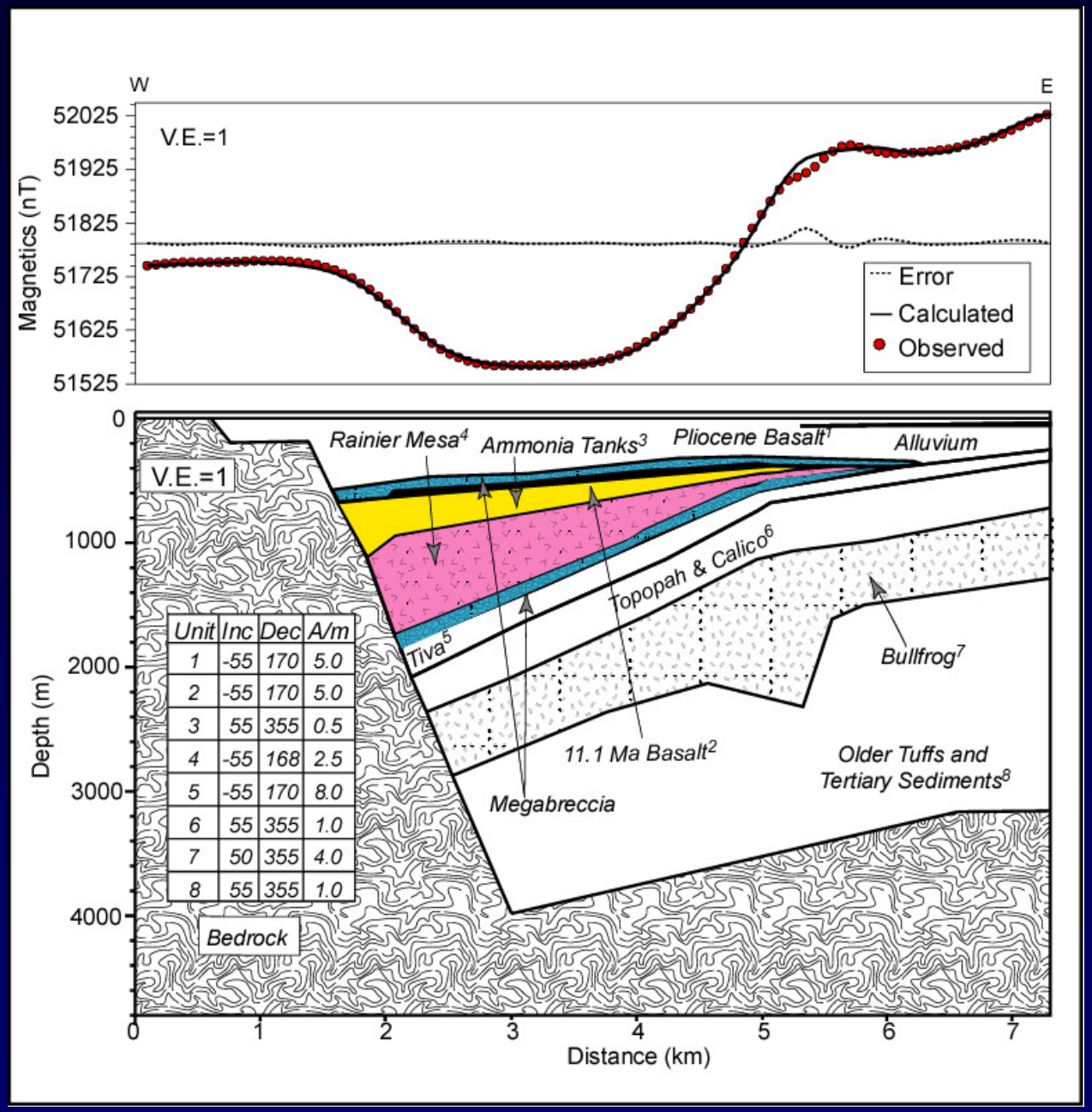
Aeromagnetic Data

Large positive-negative anomaly pair in Crater Flat is interpreted to reflect highly magnetic tuff deposited during basin extension



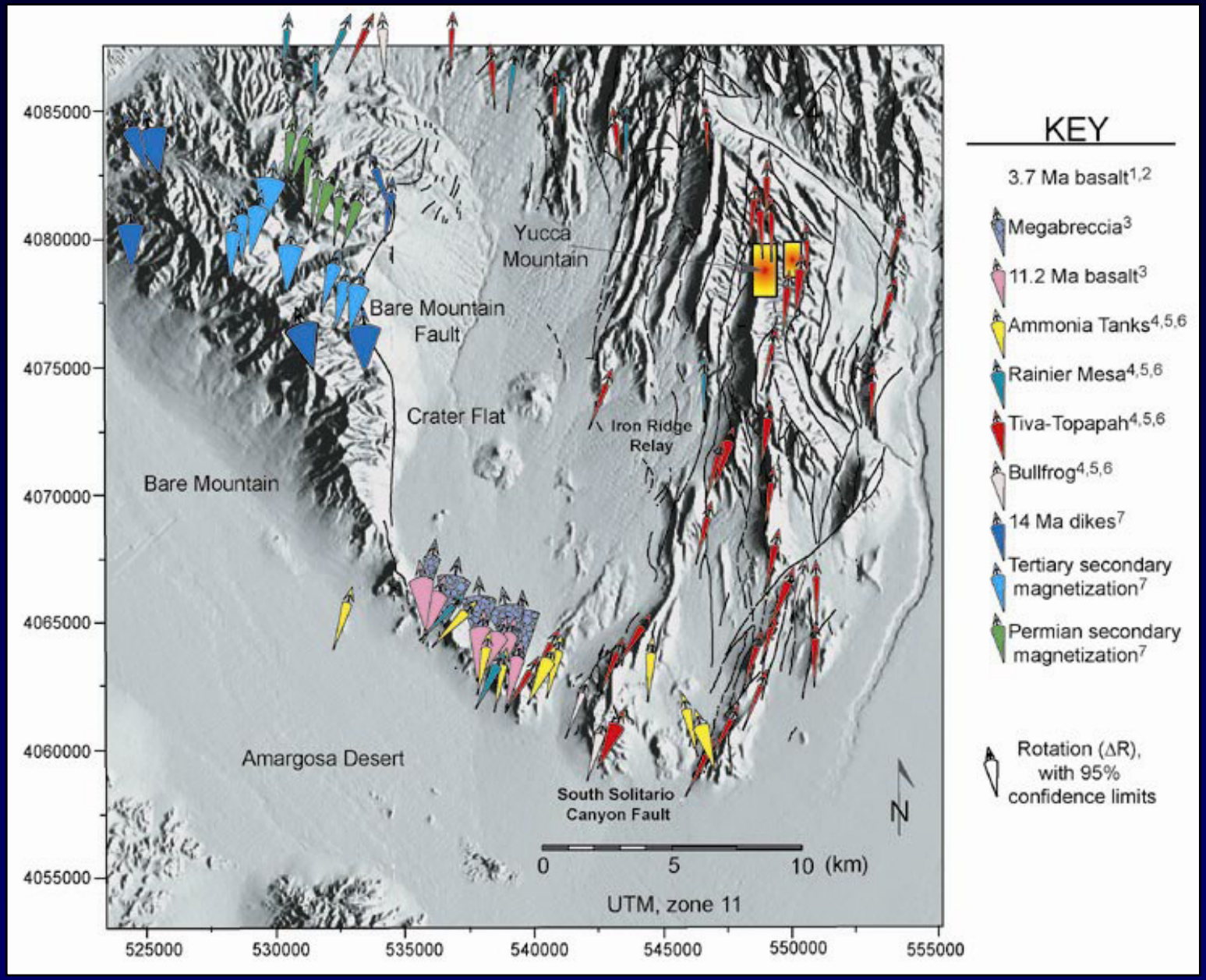
Magnetic Model for Crater Flat

Model shows wedge of Rainier Mesa Tuff adjacent to Bare Mountain fault

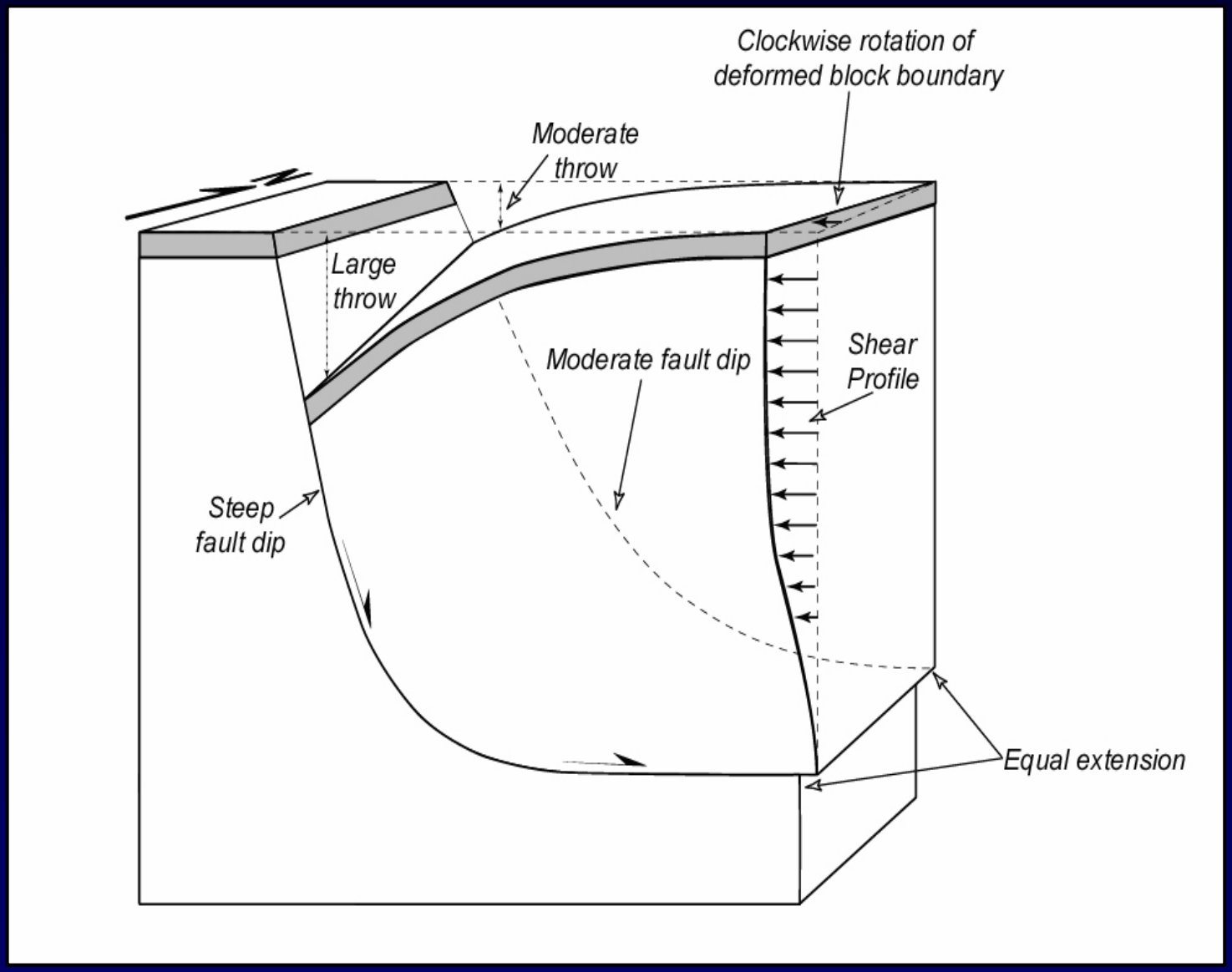


Unit	Inc	Dec	A/m
1	-55	170	5.0
2	-55	170	5.0
3	55	355	0.5
4	-55	168	2.5
5	-55	170	8.0
6	55	355	1.0
7	50	355	4.0
8	55	355	1.0

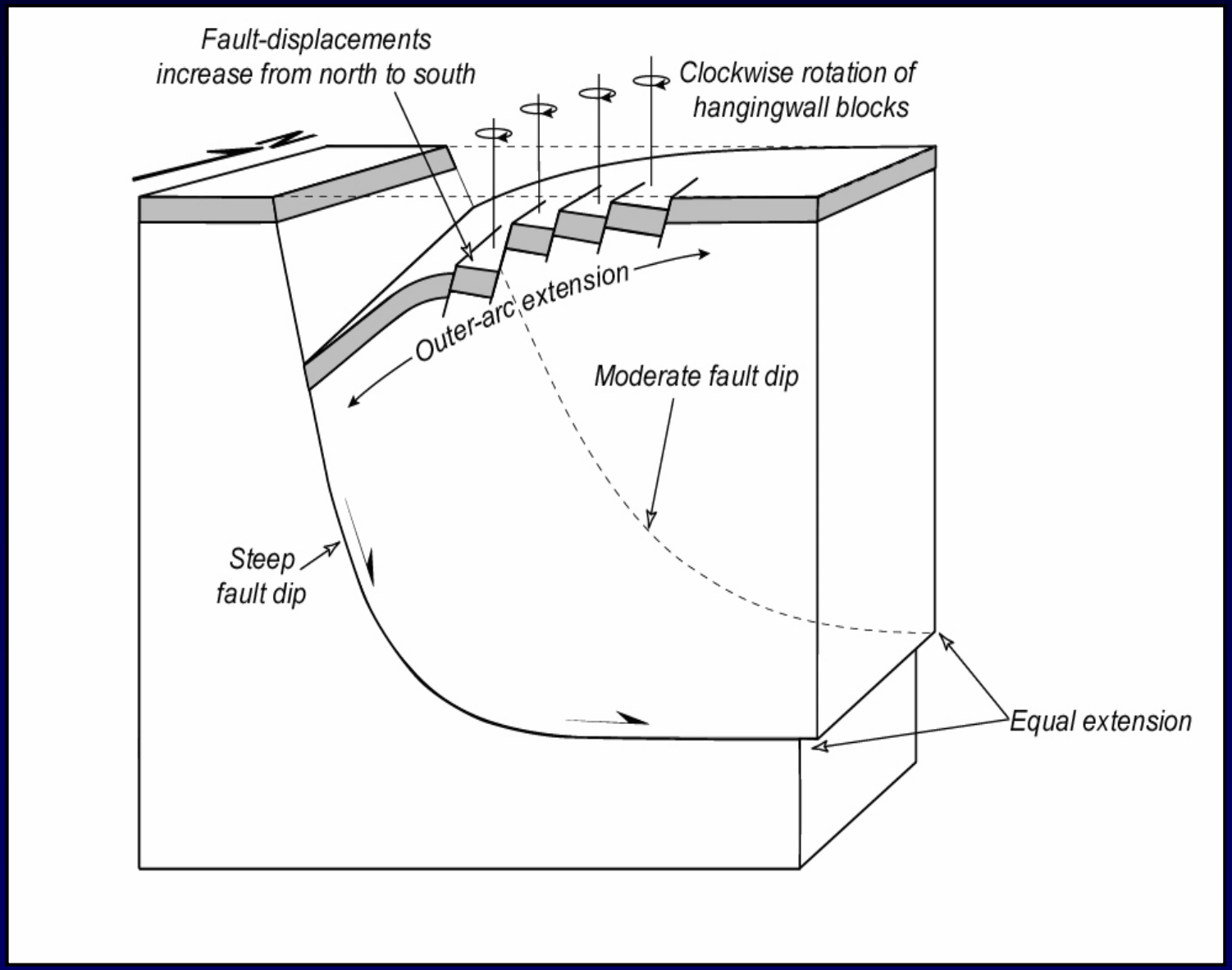
Summary of Paleomagnetic Vertical-Axis Rotation Data



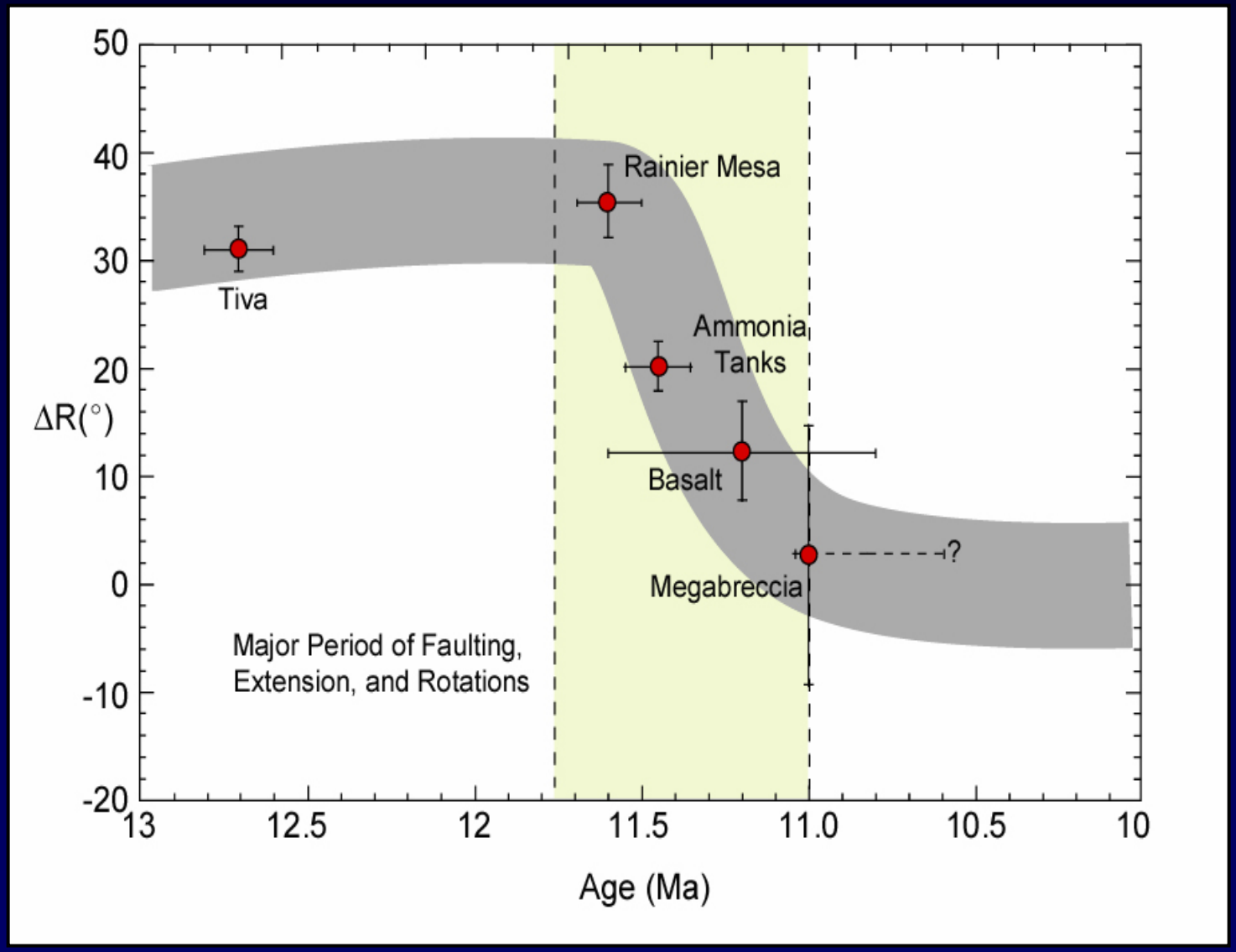
Model of Hanging Wall Deformation Above Listric Bare Mountain Fault

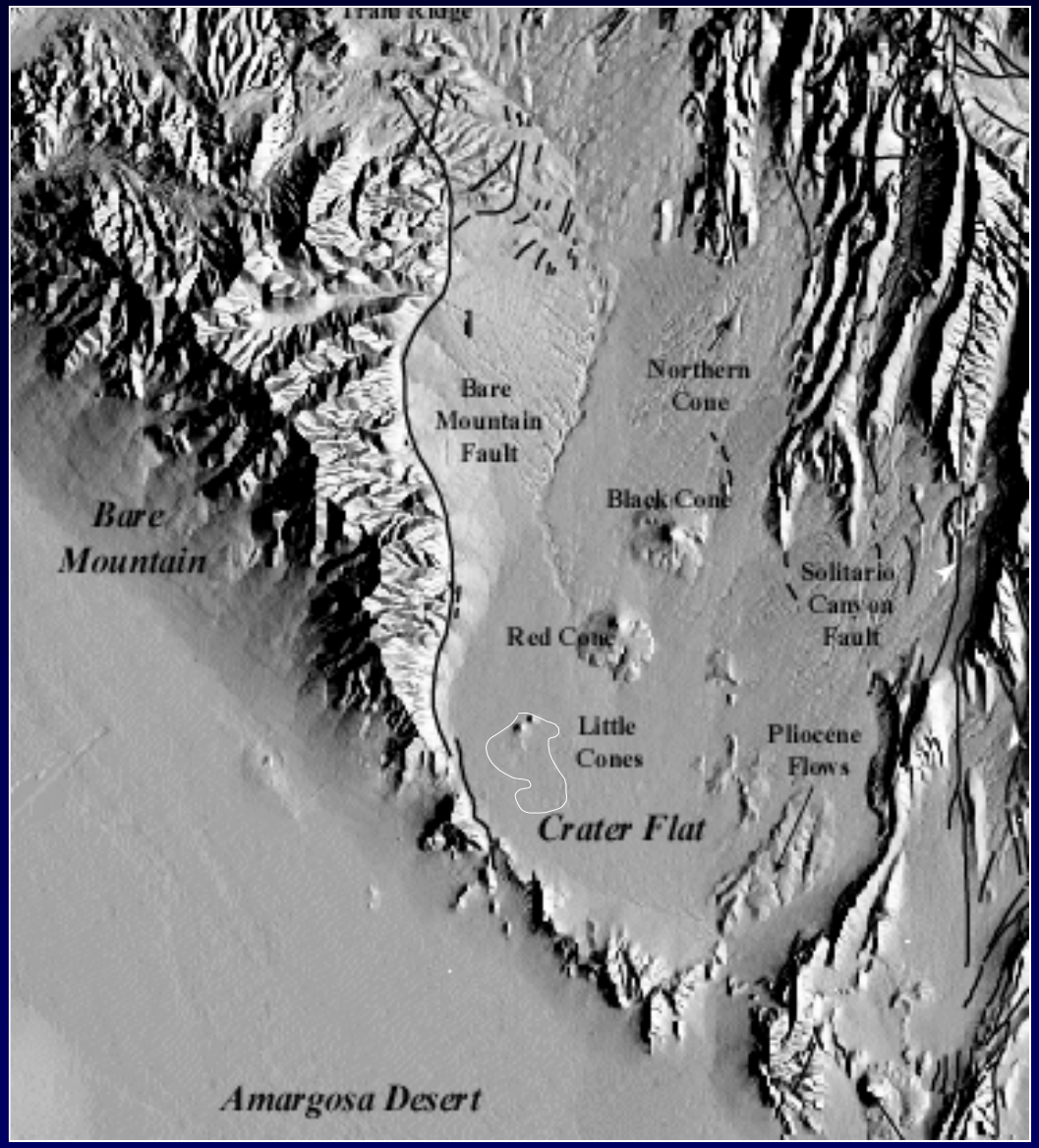


Model of Hanging Wall Deformation Above Listric Bare Mountain Fault



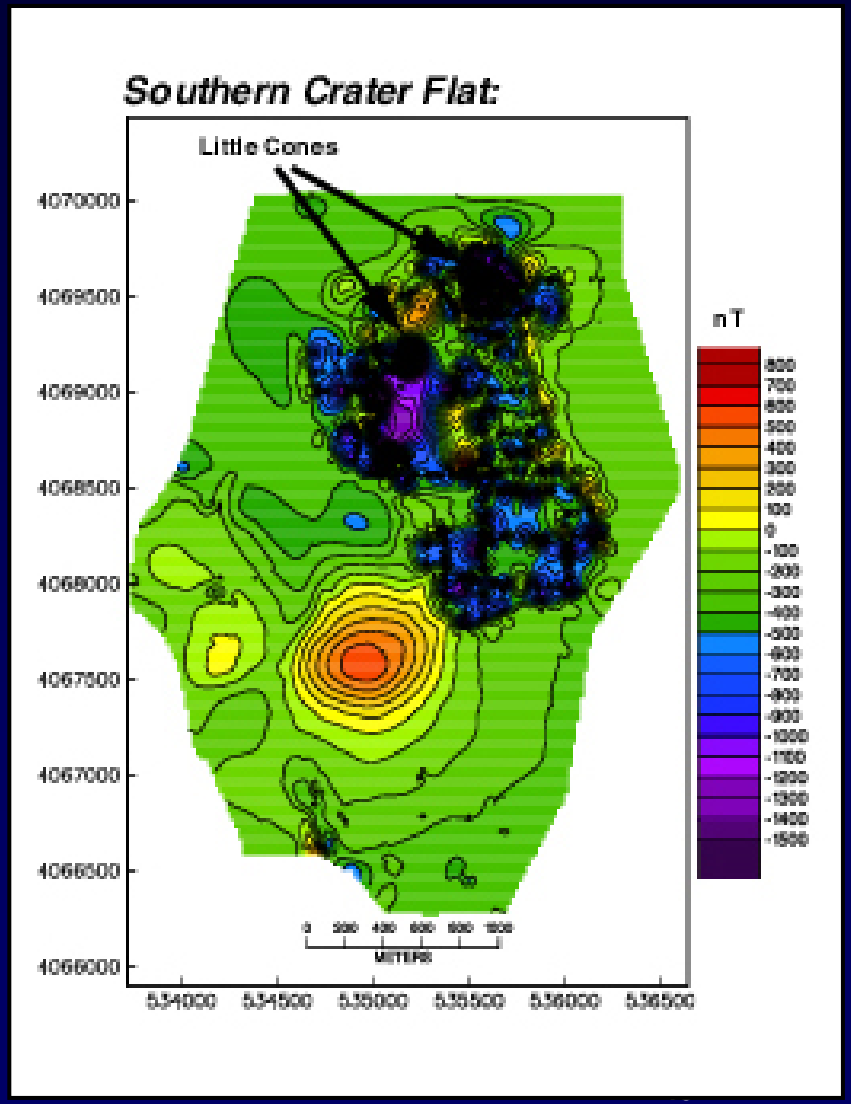
Paleomagnetic Rotations (ΔR) Constrain Age of Faulting





Little Cones (~1 Ma) Basalt Buried by 30 m of Quaternary Alluvium

(Slip Rate = 0.06 mm/yr)



Conclusions

- **Bare Mountain Fault is a typical range front fault in the Basin and Range**
  - dip slip extension
  - 2–3 km of total slip
- **Geophysical data shows change in fault dip along strike**
  - fault steepens from north to south
  - steeper fault segments are less efficient at accommodating extension (shear in hanging wall)
- **Extension of hanging wall above fault results in vertical axis rotations**
  - age and timing of extension constrained by age of vertical-axis rotations
  - paleomagnetic data show rotations occurred between ~11.5 and 11 Ma.,
  - inferred slip rates 1–3 mm/yr during this 500 ky period
  - Quaternary slip rates based on Little Cones' magnetic data is 0.06 mm/yr
- **Geologic data also indicates rapid basin growth ~11.5–11 Ma**
  - wedge of Rainier Mesa tuff adjacent to Bare Mountain
  - megabreccia younger than 11.2 Ma from over-steep Bare Mountain footwall

Acknowledgements

"This presentation was prepared to document work performed by the Center for Nuclear Waste Regulatory Analyses (CNWRA) and its contractors for the Nuclear Regulatory Commission (NRC) under Contract No. NRC–02–02–012. The activities reported here were performed on behalf of the NRC Office of Nuclear Material Safety and Safeguards, Division of High-Level Waste Repository Safety. This presentation is an independent product of the CNWRA and does not necessarily reflect the view or regulatory position of the NRC."