State of Nevada

Presentation to the

Technical Review Board

Subject: Tectonic framework of Yucca Mountain

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PURPOSE

1. BRIEFLY OUTLINE TECTONIC FRAMEWORK AND PRINCIPAL TECTONIC FEATURES OF YUCCA MTN AREA

2. CLARIFY STATE'S CONCERNS ABOUT REQUIRED STUDIES AND THE FEASIBILITY OF SITE CHARACTERIZATION
SUMMARY

O Faults at Yucca Mountain are difficult to characterize.

O Exposed faults are neither pure strike-slip nor pure dip-slip.

O Several classes of faults are concealed, and these may contribute to seismic and resource potential.

O Complexity of subsurface structure may make it impossible to develop unique models or to set realistic boundary conditions for groundwater models.
Fig. 0-2: Regional setting of the field trip area with respect to major components of the Cordilleran orogen [from Wernicke et al., 1988].
Figure 1. Generalized geologic map showing the major hydrogeologic units of Winograd and Thordarson (1975) in the region surrounding Yucca Mountain.
Fig. 0–6: Tectonic map of the Basin and Range province at the latitude of Las Vegas showing major Cenozoic fault systems. Areas of relatively minor Neogene tectonism bound two major extensional belts, the Death Valley extensional system to the west and the Las Vegas extensional system to the east. Tick-marked lines, low-angle normal faults; ball-and-bar symbol, high-angle normal faults; arrows, strike-slip faults; GF, Garlock fault; SDF, Southern Death Valley fault zone; HMF, Hunter Mountain fault; NFZ, Northern Death Valley-Furnace Creek fault zone; LVVSZ, Las Vegas Valley shear zone; LMFS, Lake Mead fault system. Note that left-lateral strike-slip faults tend to strike northeastward while right-lateral strike-slip faults strike northwestward [modified from Burchfiel and Davis, 1988 and Wernicke et al., 1988].
FIG. 25-3. Regional structural blocks and major faults in Walker Lane belt. Arrows indicate relative movement on strike-slip faults. Major faults or fault zone listed by structural blocks: PYRAMID LAKE BLOCK: HL, Honey Lake; GV, Grizzly Valley; LC, Last Chance; WSV, Warm Springs Valley; PL, Pyramid Lake. CARSON BLOCK: O, Olinghouse; C, Carson; W, Wabuska. WALKER LAKE BLOCK: G, Genoa; PN, Pine Nut; Y, Yerington; W, Wassuk; AP, Agai Pah Hills; GH, Gumdrop Hills; IH, Indian Head; BS, Benton Spring; PS, Petti- 
field Springs; PM, Pilot Mountains; BW, Bettles Well. EXCELSIOR-COALDALE

 BLOCK: EFZ, Excelsior; CFZ, Coaldale. INYO-MONO BLOCK: KC, Kern Canyon; I, Independence; WM, White Mountain; OV, Owens Valley; FC, 
Furnace Creek; PV, Panamint Valley; DV, Death Valley; G, Garlock; SV, Stewart Valley; P, Pahrump. SPOTTED RANGE-MINE MOUNTAIN BLOCK: 
MM, Mine Mountain; W, Wahmonie; RV, Rock Valley; CS, Cane Spring; YF, 
Yucca-Frenchman. SPRING MOUNTAINS BLOCK: LVV, Las Vegas Valley. 
LAKE MEAD BLOCK: BSV, Bitter Spring Valley; HB, Hamblin Bay; CC, 
Cabin Canyon; BR, Bitter Ridge; LR, Lime Ridge; GB, Gold Butte.
Figure 2. Generalized geologic map of Yucca Mountain. Proposed repository outlined by heavy line. Area of map corresponds to diagonally ruled area on Figure 1. Modified after Scott and Castellanos (1984).
Two cross-sections of the Yucca Mountain region: top one by USGS, bottom one by Center for Neotectonic Studies, UNR.

Key to enlargement only: Pre-13.5 M.y. volcanics [], 13.5 - 11 M. y. volcanics [], post-11.5 M. y. volcanics []. Sediments < 2 M. y. .

Cross-sections are schematic only.

Significant differences between cross-sections:

- we include more realistic fault geometry, and show the potential distribution of Lower Paleozoic (aquifer) units.
- we include three generations of faulting indicated by field evidence.
- we show one subhorizontal detachment, as opposed to three, for which there is good evidence.
Figure 14.—Location and chronology of the Death Valley-Pancake Range basalt belt. Buried basalt just south of Lathrop Wells has reverse polarity and its age is therefore considered to be roughly that of the Gilbert magnetic epoch. Ages of the Lunar Crater and Reveille basalt fields are based on estimates from reconnaissance by W. J. Carr and two dates: (1) lower flow in Lunar Crater dated at 4.2±0.3 m.y. (R. F. Marvin, U.S. Geol. Survey, written commun., 1981), and (2) flow in the Reveille quadrangle, age reported as 5.7±0.2 m.y. (Ekren and others, 1973).
1. Mesozoic thrusts with west and east vergence - generally place lower Pz carbonates on upper Pz clastics
   Buried

2. pre-Middle Miocene detachment faults - evidence exists for large extension prior to 14 Ma
   Buried

3. pre-Middle Miocene strike-slip faults - evidence exists for large dextral displacement prior to 14 Ma
   Buried

4. ±14 Ma cauldron subsidence faults related to Crater Flat caldera
   Buried

5. exposed faults that postdate Paintbrush Tuff - large normal displacement pre-Timber Mtn Tuff
   Exposed
   - moderate normal and strike-slip displacements post-Timber Mtn Tuff
POTENTIAL SIGNIFICANCE OF OLDER BURIED FAULTS AT YUCCA MOUNTAIN

1. **Seismicity**--They could be reactivated or could be intermittently active under different stress regimes

2. **Hydrogeology**--They could have a significant effect on groundwater flow paths and may be important to boundary conditions for groundwater models

3. **Hydrocarbon potential**--They could be responsible for the formation of hydrocarbon traps

4. **Mineral potential**--They could have formed channelways for hydrothermal fluids during various volcanotectonic events

5. **Volcanic assessments**--They could provide conduits for basaltic magma during volcanic events
SUMMARY

O FAULTS AT YUCCA MOUNTAIN ARE DIFFICULT TO CHARACTERIZE

O EXPOSED FAULTS ARE NEITHER PURE STRIKE-SLIP NOR PURE DIP-SLIP

O SEVERAL CLASSES OF FAULTS ARE CONCEALED, AND THESE MAY CONTRIBUTE TO SEISMIC AND RESOURCE POTENTIAL

O COMPLEXITY OF SUBSURFACE STRUCTURE MAY MAKE IT IMPOSSIBLE TO DEVELOP UNIQUE MODELS OR TO SET REALISTIC BOUNDARY CONDITIONS FOR GROUNDWATER MODELS
Richard A. Schweickert, Professor of Geology

**Born:** Sonora, California

**Social Security No.:** 554-66-1602

**Degrees:**
- B.S. with distinction and honors, Stanford University, Stanford, California, 1967 (major: Geology).
- Ph.D., Stanford University, Stanford, California, 1972 (Geology);
  Dissertation entitled, "Shallow-level intrusions in the eastern Sierra Nevada, California."

**Positions Held:**
- Teaching assistant, Stanford University, 1967-70.
- Acting instructor of geology, Summer Field Geology, Stanford University; Summer, 1968, 1970.
- Assistant Professor of Geology (temporary), California State College, Sonoma, Rohnert Park, California; Fall, 1972-73; courses in mineralogy and introductory geology.
- Lecturer in Geology, California State University, San Jose, California; Spring, 1973: Course in advanced structural geology.
- Visiting Assistant Professor of Geology, California State University, San Francisco, San Francisco, California; Summer, 1973: course in field geology.
- Associate Professor of Geology, Columbia University, New York, N.Y.; July, 1978 - June, 1982: Courses in stratigraphy, tectonics, and field geology.
- Member of Senior Staff, Lamont-Doherty Geological Observatory of Columbia University; September, 1973 - June 1982.
Adjunct Professor of Geological Sciences; Columbia University, New York, N.Y.; July 1982 - present.

Professor of Geology, University of Nevada, Reno, Nevada; July, 1982 - present: Courses in structural geology, stratigraphy, field geology.


**Fellowships and Awards**

1967 Honorary International Minerals and Chemical Corporation - Louis Ware Fellow (stipend turned down to accept NSF Fellowship).

1968-71 National Science Foundation Fellow, Stanford University.

1971 Recipient of Roy Angus MacDiarmid Award of Stanford University presented by Geology Faculty.

**Geological Field Experience:**


Summer, 1966 and 1968 (latter half): Mapping of plutonic, volcanic, and metamorphic rocks in the eastern Sierra Nevada, California.

Summer, 1967: Detailed mapping and economic evaluation of pegmatites, anorthosites, and nepheline syenites in North Carolina, Virginia, Ontario (Canada), and South Dakota.

1968-71: Detailed mapping of key areas and reconnaissance mapping of a larger region in the eastern Sierra Nevada, California; study of shallow-level plutons and metamorphosed Mesozoic pyroclastic rocks in roof pendants.

Summer, 1972: Reconnaissance mapping and measurement of stratigraphic sections in an 80 by 250 mile segment of Alaska Peninsula.


August, 1974 and August, 1975: Field study of Dunnage melange and associated intrusive rocks, Newfoundland.


Summer, 1986: Structural and neotectonic study of faults in Santa Maria basin, California

1988-1989: Tectonic study of Yucca Mountain region, southern Nevada

Field Courses Taught:

Summer, 1983: Snake Range, Nevada.

May 1975: Northern Scotland.


Invited Lectures:
1976 Cornell University; SUNY Albany.
1978 Caltech; Cornell University; U.C. Berkeley; UCLA; Princeton University; Lamont-Doherty Geological Observatory.
1979 Franklin and Marshall College; U.C. Davis; Rice University.
1980 Skidmore College; U.C. Davis; University of South Carolina.
1983 University of Kansas; Geological Society of Nevada.
1984 University of California, Santa Barbara; San Diego State University.
1985 Stanford University.
1986 UCLA; University of Nevada--Reno.
1987 Humboldt State University.
1988 UCLA, California Division of Mines and Geology, USC.
1989 University of Washington, University of California, Davis

Publications:

A. Published papers.

1. Refereed Journals.


2. Invited, refereed papers in symposia.


Schweickert, R.A., 1981, Tectonic evolution of the Sierra Nevada range in


3. Field Trip Guides.


Schweickert, R.A., and Hanson, R.E., in press, Geologic map of the Sierra City 15' quadrangle, Sierra County, California: U.S. Geological Survey Map.

5. Other.
Contributor to: Northern California Region, Correlation of stratigraphic units of North America (COSUNA) Project, AAPG, 1984.

B. PAPERS IN PRESS.

ABSTRACTS.
Schweickert, R.A., and Wright, W.H., III, 1975, Preliminary evidence of the tectonic evolution of the Calaveras Formation, Sierra Nevada, California:


Society of America Abstracts with Programs, v. 18, p. 181.
terranes of the northern Sierra Nevada, California with airborne Thermal
Infrared Multispectral Scanner data: ERIM Fifth Thematic Conference:
Mount, C., and Schweickert, R.A., 1986, Early Paleozoic orogeny in the Shoo Fly:
Evidence from clastic rocks in the Sierra City Melange, California:
Geological Society of America Abstracts with Programs, v. 18, p. 162.
Klamath Mountains, California: A new hypothesis: Geological Society of
America Abstracts with Programs, v. 18, p. 742.
Cambrian miogeoclinal rocks in Snow Lake pendant (SNLP), northern
Yosemite National Park, Sierra Nevada, California: Geological Society of
Yosemite-Emigrant Wilderness, Sierra Nevada, California: Evidence for
major Early Cretaceous dextral translation of a continental crustal sliver:
belt in eastern Sierra Nevada (ESN) and White-Inyo Mountains (WIM): A new
hypothesis: Geological Society of America Abstracts with Programs, v. 20,
Caskey, S. J., and Schweickert, R. A., 1989, Mesozoic west-vergent thrust in
the CP Hills, Nevada Test Site, Nye County, NV (abs.): Geological Society of
America Abstracts with Programs, v. 21, p. 64.
Greene, D. C., Schweickert, R. A., and Strobel, R. J., Possible westward
continuation of the Roberts Mountains thrust in the northern Ritter Range
pendant (NRP), eastern Sierra Nevada, California (abs.): Geological Society
of America Abstracts with Programs, v. 21, p. 86-87.
Yosemite National Park, CA: Structural relations and significance (abs.):
Geological Society of America Abstracts with Programs, v. 21, p. 141.

Papers in preparation.
Sharp, W., Saleeby, J.B., Schweickert, R.A., Merguerian, C., Kister, R.W., Tobisch,
O.T., and Wright, W.H., 1987, Age and tectonic significance of Paleozoic
orthogneisses of the Sierra Nevada foothills belt.
Saddlebag Lake pendant, eastern Sierra Nevada, California: in preparation.
Lahren, M.M., and Schweickert, R.A., in prep., Structure, metamorphism, and
tectonic implications of Snow Lake pendant, Yosemite-Emigrant
Wildernesses, Sierra Nevada, California.
Holocene strike-slip faulting within the Sierra Nevada batholith, Snow
Lake pendant, central Sierra Nevada, California.

Activities Related to Professional Development.

a. Member of professional organizations:
   - Geological Society of America
   - American Geophysical Union
   - Society of Economic Paleontologists and Mineralogists
c. Reviewer of manuscripts for:
   - Geology
   - Geological Society of America Bulletin
   - Tectonics
   - Journal of Geophysical Research
   - Nature
   - Journal of Geology
d. Reviewer of research proposals to:
   - National Science Foundation
   - Department of Energy
   - American Chemical Society-Petroleum Research Fund
e. Member of National Science Foundation Advisory Panel in Crustal
   Structure and Tectonics, and Petrogenesis and Mineral Resources,
   1989-1991
f. Research grants received:

   NSF-EAR-89-03963
   Timing, magnitude of displacement, and implications of a major
   intrabatholithic crustal shear zone in eastern California and western
   Nevada, Schweickert, 7/1/89 - 6/30/91.
   $101,000

   STATE OF NEVADA-AGENCY FOR NUCLEAR PROJECTS
   Tectonic and neotectonic framework of the Yucca Mountain region,
   southern Nevada, Schweickert, 7/1/88 - 6/30/89.
   $190,000

   NSF-EAR-87-07312
   Truncation of Antler and Sonoma orogenic belts: Tectonic
   significance of prebatholithic structural breaks, eastern Sierra
   Nevada, California, Schweickert, 7/15/87 - 7/15/89.
   $104,976

   NSF-EAR-84-18338
   Possible extensions of the Antler and Sonoma orogenic belts in the
   Saddlebag Lake pendant, eastern California, Schweickert, 11/30/84 -
   12/1/86.
   $95,634
Tectonic significance of Paleozoic basement terranes in the west-central Sierra Nevada: Continuation and transect across the central Sierra, Schweickert, 6/1/82 - 5/30/84. $38,889

Tectonic evolution of a late Paleozoic island arc and its basement, northern Sierra Nevada, California, Schweickert, R.A., Snyder, W.S., Schreiber, B.C., 11/1/78 - 12/31/81. $55,900, year 1; $54,418, year 2; $46,569, year 3


Tectonic significance of Paleozoic basement terranes in the west-central Sierra Nevada, California, Schweickert, 2/1/79 - 4/30/81. $46,810

Tectonic evolution of the Havallah sequence, a late Paleozoic marginal sea, northern Nevada, Snyder, W.S., Brueckner, H.B., Schweickert, R.A., 6/1/80 - 11/30/81. $29,800

Rb-Sr dating of chert: A potential geochronological tool, Brueckner, H.B., Snyder, W.S., Schweickert, R.A., 6/1/80 - 11/30/81. $29,800

Movement and deformation on the southern part of the foothills fault system, Sierra Nevada, California, Schweickert, R.A., Engelder, J.T., Kent, D., 11/1/78 - 10/31/79. $30,209

The origin, deformation, and metamorphism of chaotic rocks of the Calaveras Formation, western Sierra Nevada, California, Schweickert,
R.A., 8/15/76 - 1/31/78.
$51,100

**NSF-EAR-76-84320**
$40,000

**NSF-DES 73-06663 A01**
The original pattern and subsequent fragmentation of the Alpine orogenic belt, Alvarez, W., Schweickert, R.A., 4/1/77 - 9/30/78.

**NSF-EAR-74-17854**
$17,778

**Other Indications of Merit:**
Listed in American Men and Women in Science; Who's Who in American Science.