State of Nevada

Presentation to the

Technical Review Board

Subject: Tectonic framework of Yucca Mountain

Date: June 26, 1989

Presenter: Dr. Richard A. Schweickert

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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

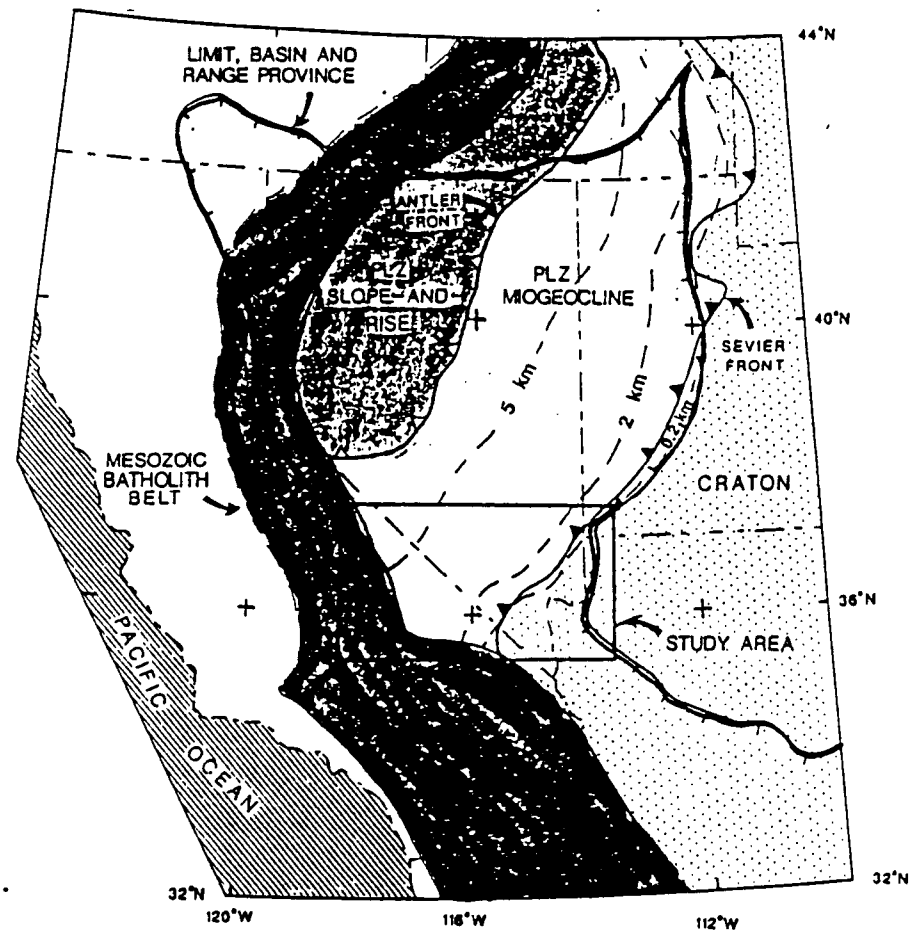
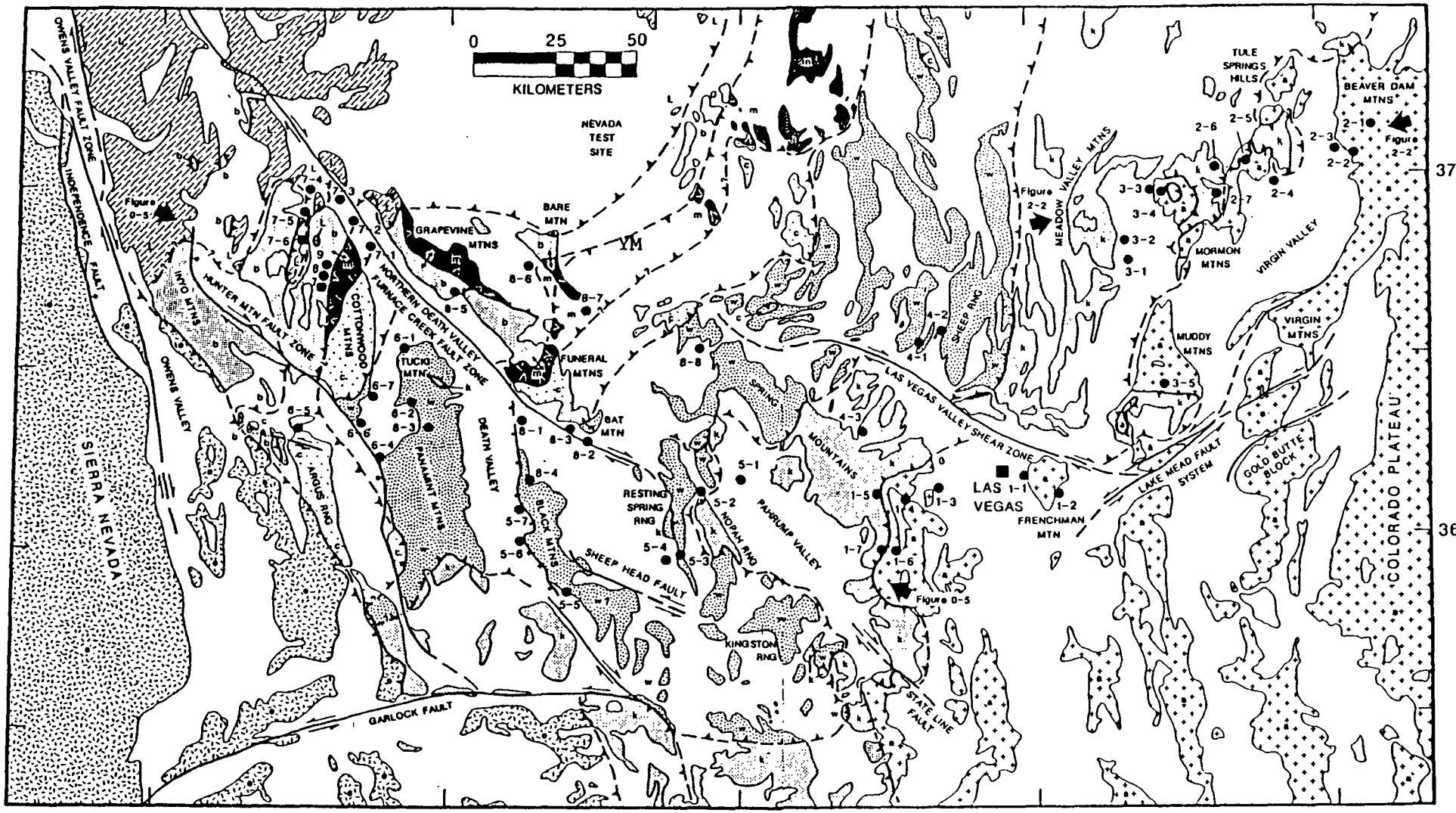


Fig. 0–2: Regional setting of the field trip area with respect to major components of the Cordilleran orogen [from Wernicke et al., 1988].



MESOZOIC TECTONIC UNITS

- rocks of EAST SIERRAN THRUST plate
- rocks of LAST CHANCE THRUST plate and equivalents
- rocks of MARBLE CANYON THRUST plate and equivalents above
- WHITE TOP MOUNTAIN BACKFOLD and equivalents
- rocks of Marble Canyon thrust plate BELOW backfold and equivalents
- rocks of CLERY THRUST plate and equivalents
- rocks of WHEELER PASS THRUST plate and equivalents
- rocks of KEYSTONE THRUST plate and equivalents
- AUTOCHTHONOUS and parautochthonous rocks below Keystone thrust and equivalents

WERNICKE AND OTHERS, 1989

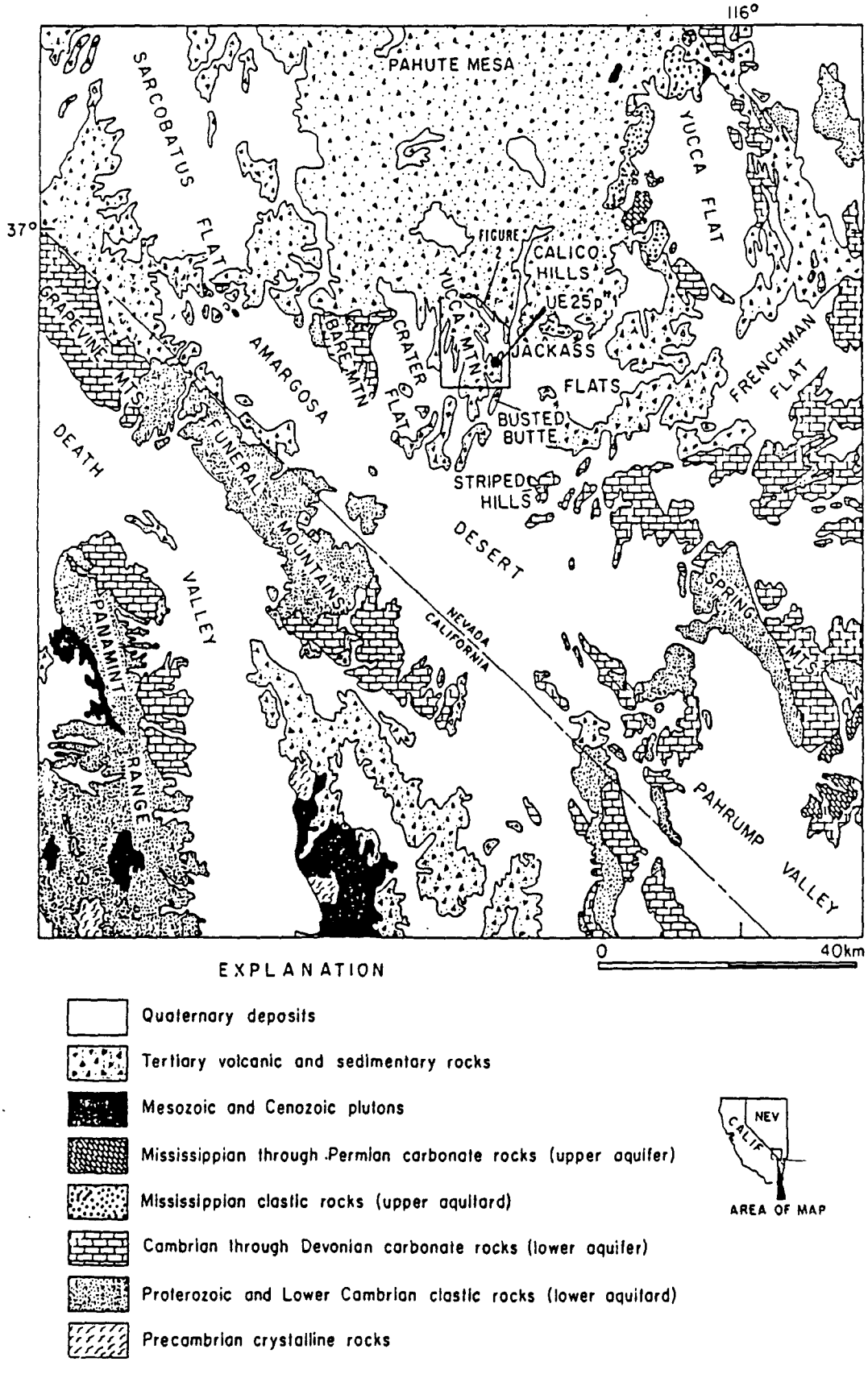


Figure 1. Generalized geologic map showing the major hydrogeologic units of Winograd and Thordarson (1975) in the region surrounding Yucca Mountain.

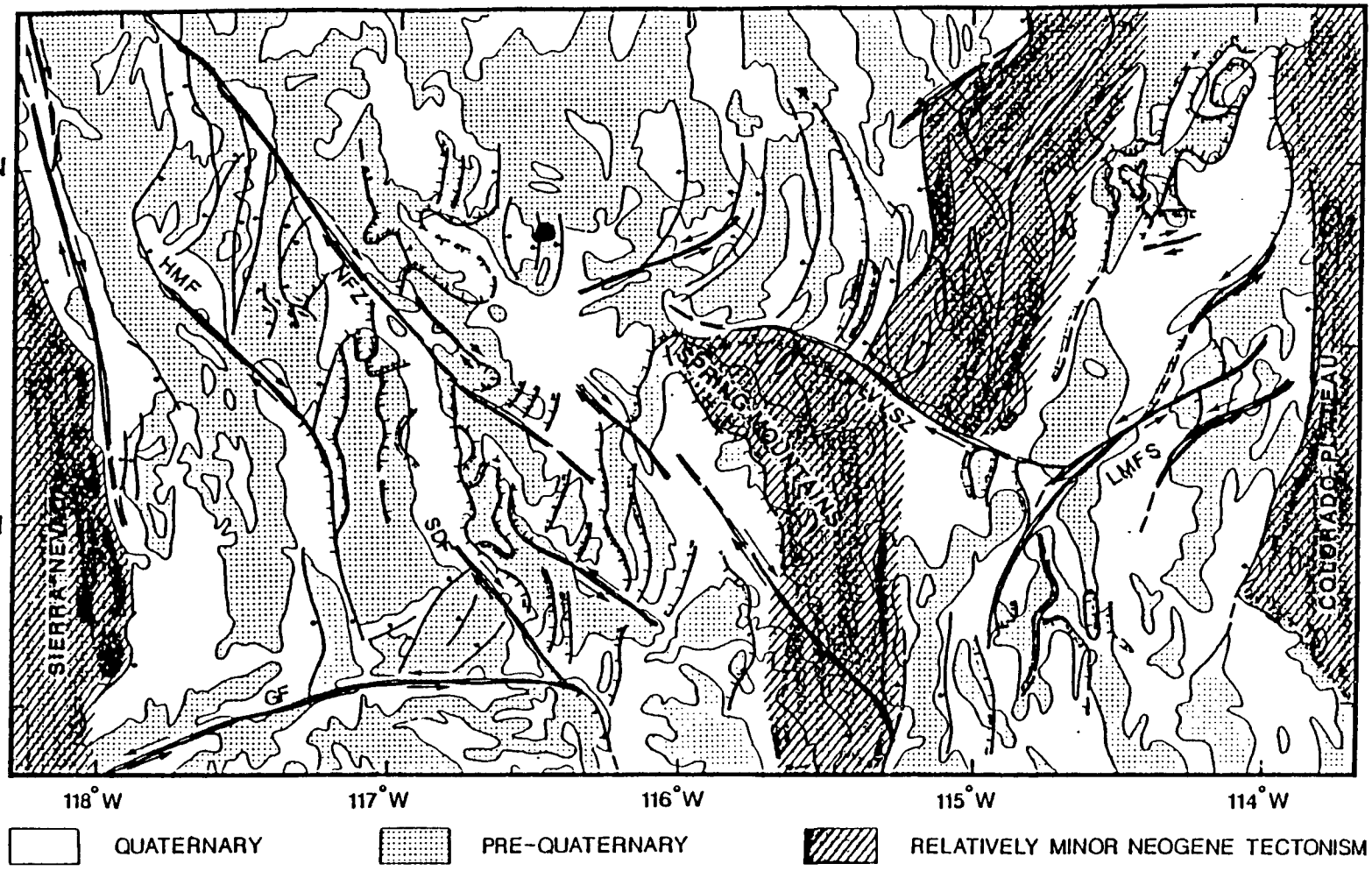


Fig. 0–6: Tectonic map of the Basin and Range province at the latitude of Las Vegas showing major Cenozoic fault systems. Areas of relatively minor Neogene tectonism bound two major extensional belts, the Death Valley extensional system to the west and the Las Vegas extensional system to the east. Tick-marked 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].

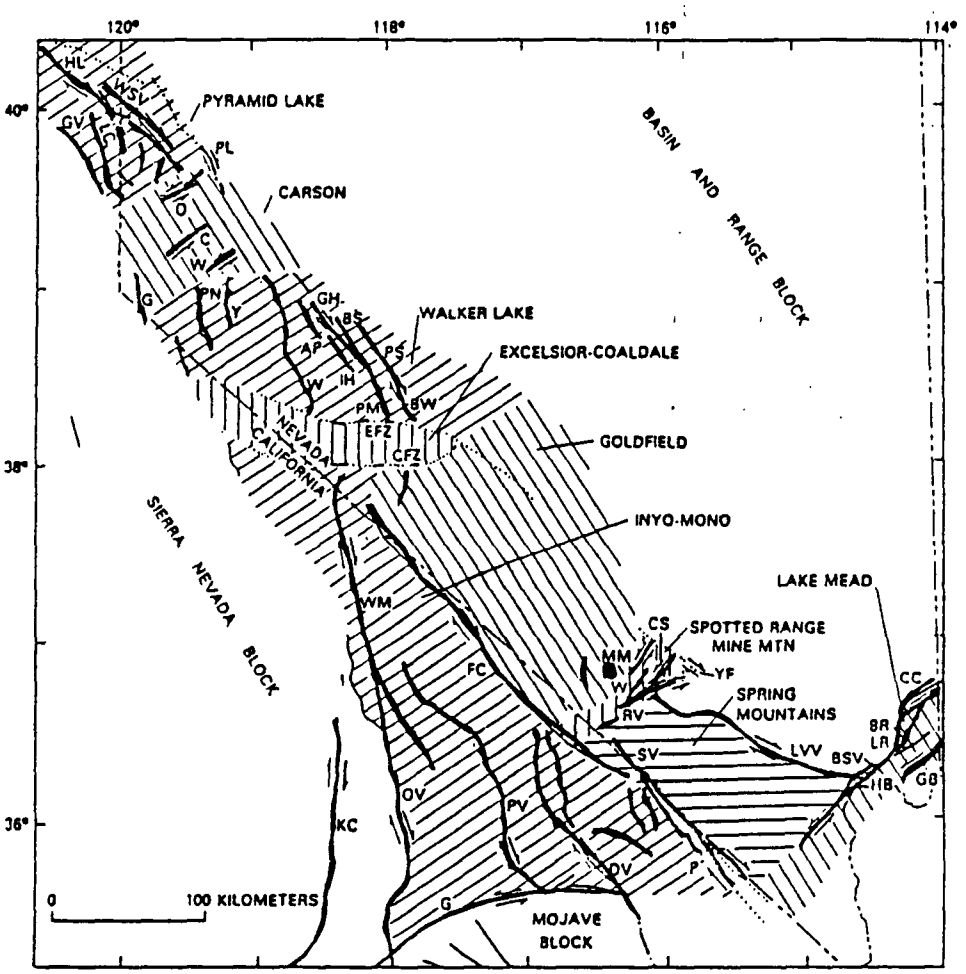


FIG. 25-3. Regional structural blocks and major faults in Walker Lane belt. Arrows indicate relative movement on strike-slip faults. Major faults or fault zone listed by structural blocks: PYRAMID LAKE BLOCK: HL, Honey Lake; GV, Grizzly Valley; LC, Last Chance; WSV, Warm Springs Valley; PL, Pyramid Lake. 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, Petrifield 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.

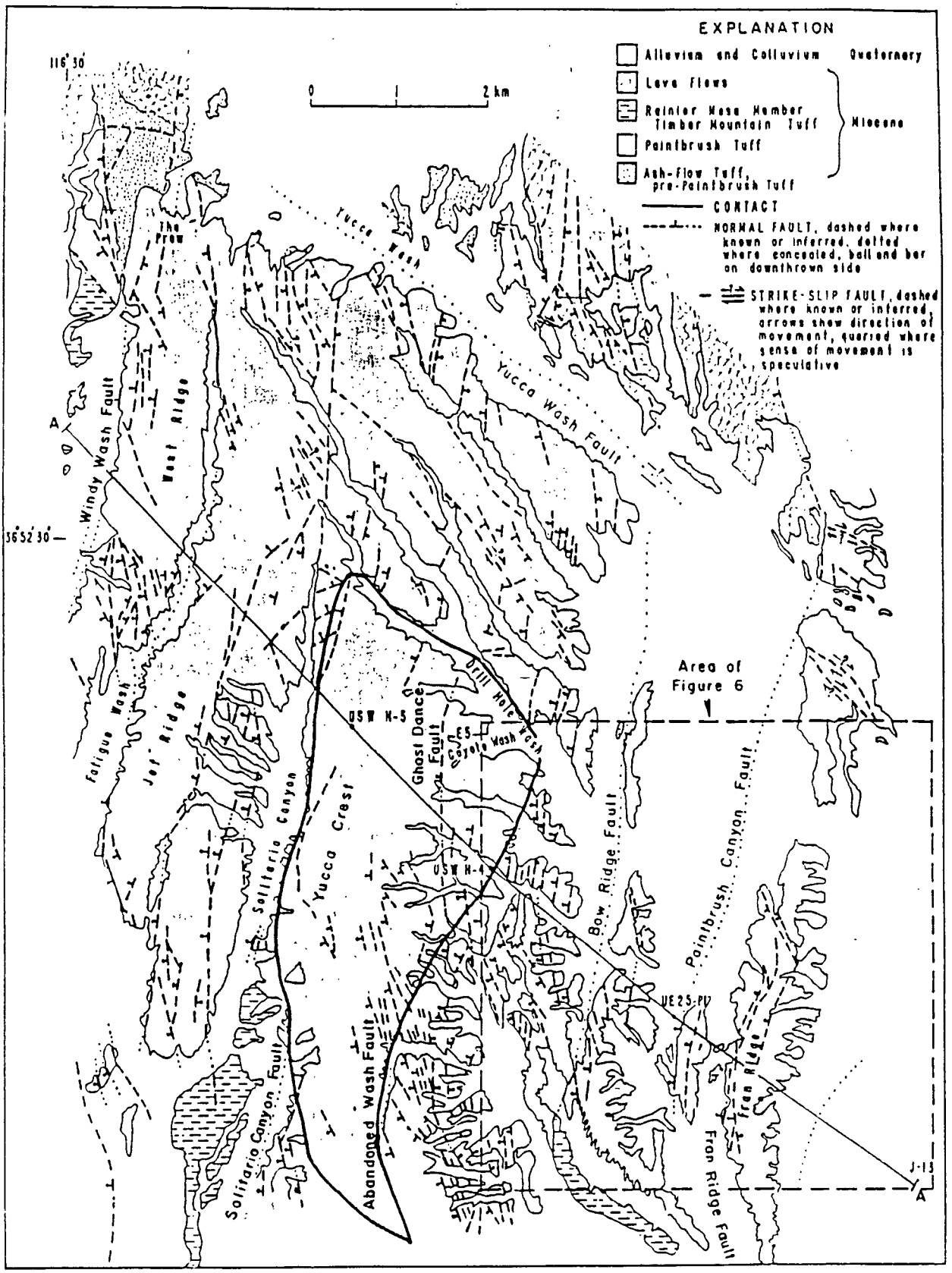
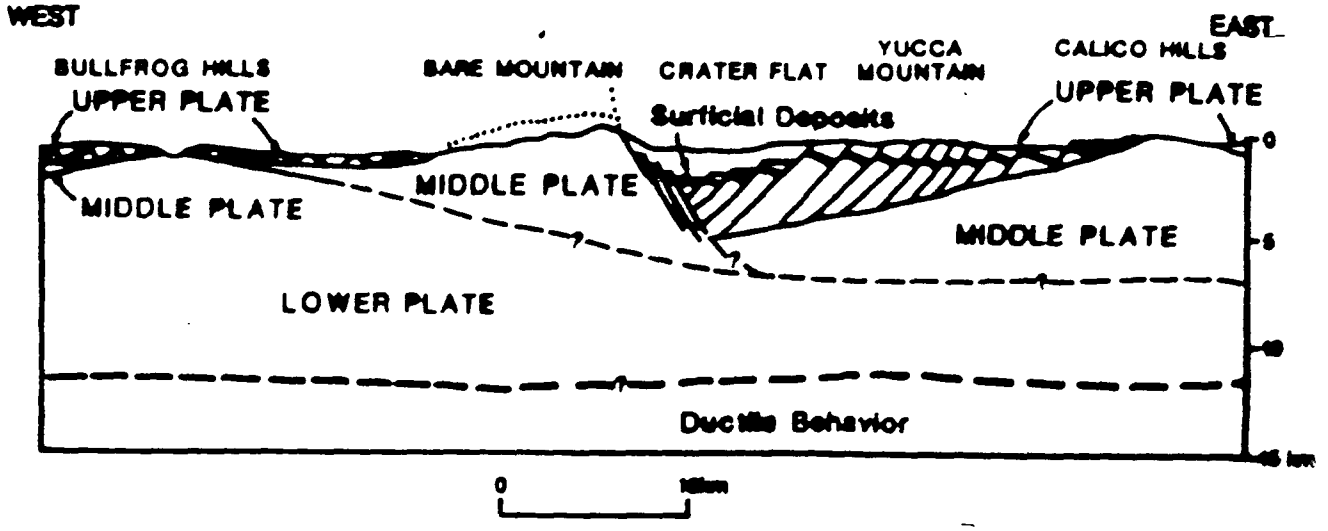
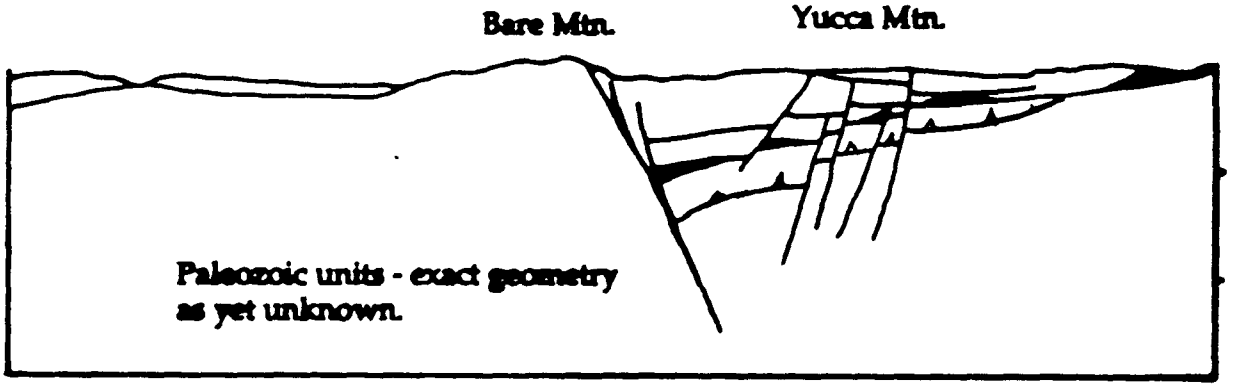


Figure 2. Generalized geologic map of Yucca Mountain. Proposed repository outlined by heavy line. Area of map corresponds to diagonally ruled area on figure 1. Modified after Scott and Castellanos (1984).

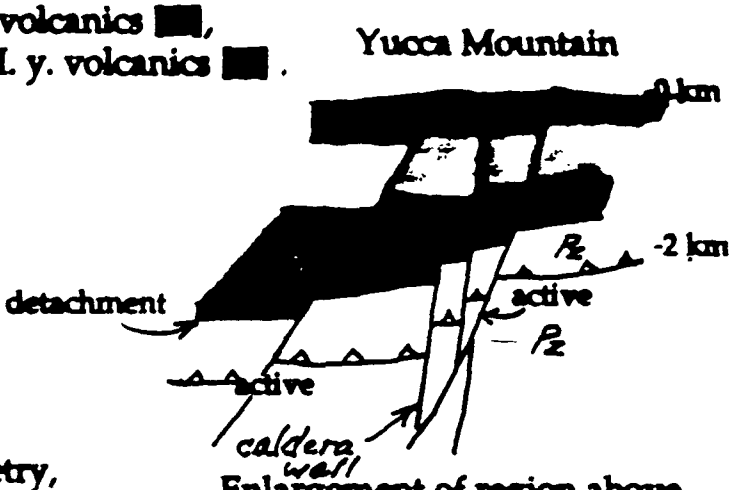
Two cross-sections of the Yucca Mountain region: top one by USGS, bottom one by Center for Neotectonic Studies, UNR.





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.



Enlargement of region above, showing three generations of extensional faulting and displacement of volcanic units and older detachment.

<u>Significant differences between cross-sections:</u>

- 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.

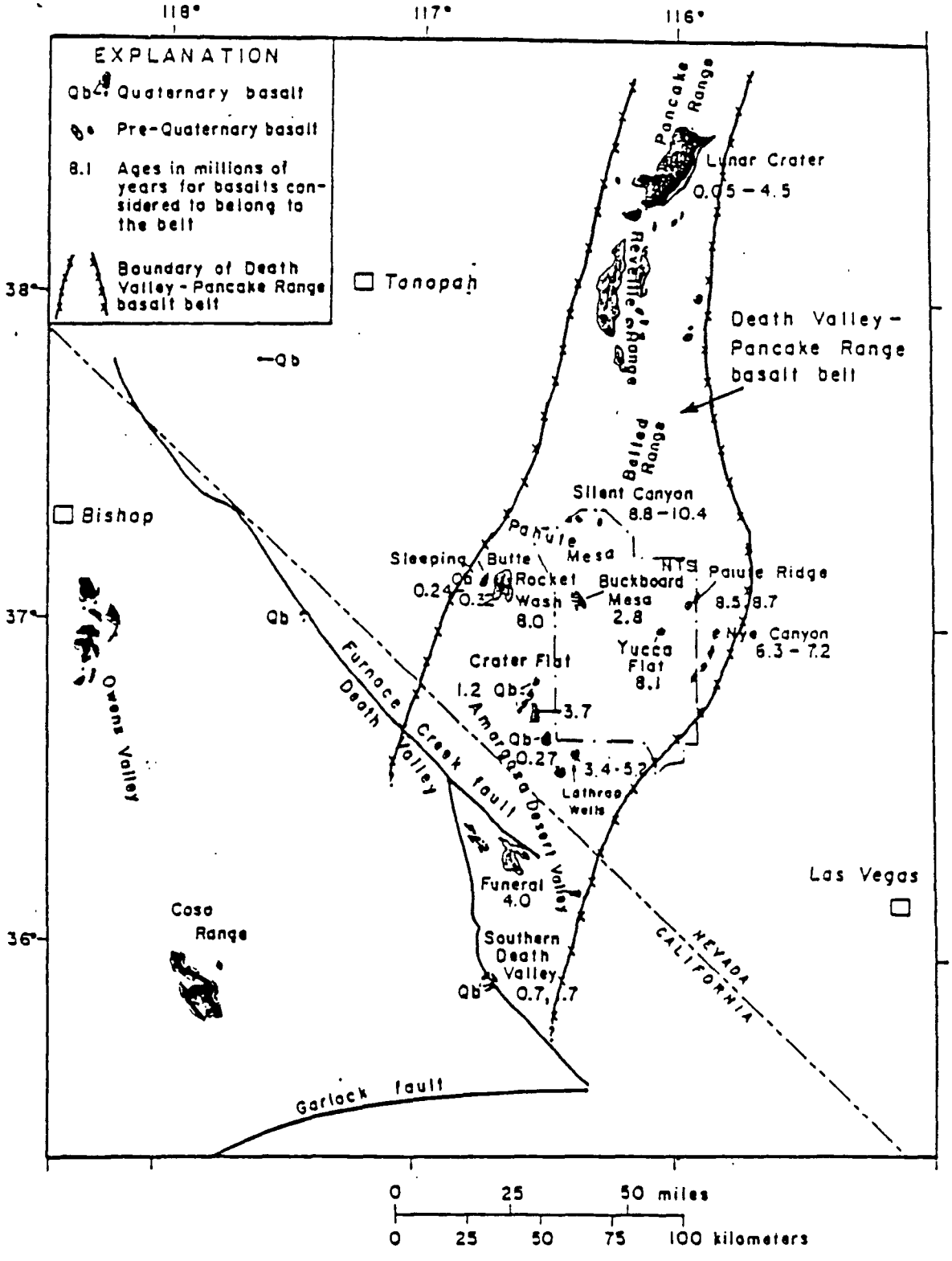


Figure 14.--Location and chronology of the Death Valley-Pancake Range basalt belt. Buried basalt just south of Lathrop Wells has reverse polarity and its age is therefore considered to be roughly that of the Gilbert magnetic epoch. Ages of the Lunar Crater and Reveille basalt fields are based on estimates 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).

CNS YM PROJECT TASK 5: June 26, 1989

TYPES OF FAULTS AT YUCCA MOUNTAIN	Exposed/Buried
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 -moderate normal and strike-slip displacements post-Timber Mtn Tuff	Exposed

CNS YM PROJECT TASK 5: June 26, 1989

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

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- O COMPLEXITY OF SUBSURFACE STRUCTURE MAY MAKE IT IMPOSSIBLE TO DEVELOP UNIQUE MODELS OR TO SET REALISTIC BOUNDARY CONDITIONS FOR GROUNDWATER MODELS

VITAE

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:

Surveying aid, U.S., Forest Service, Stanislaus N.F., California; summer, 1964, 1965, 1966; Party chief, 1966.

Field geologist, International Minerals and Chemical Corporation, Skokie, Illinois; summer 1967.

Teaching assistant, Stanford University, 1967-70.
Acting instructor of geology, Summer Field Geology, Stanford University; Summer, 1968, 1970.

Exploration geologist, Texaco, Inc., Los Angeles, California, 1971-72.

Assistant Professor of Geology (temporary), California State College, Sonoma, Rohnert Park, California; Fall, 1972-73; courses in mineralogy and introductory geology.
Geologist, U.S. Geological Survey, Menlo Park, California; Spring, 1973.

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.

Assistant Professor of Geology, Columbia University, New York, N.Y.; July, 1973 - June, 1978.

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.

Geologist, U.S. Geological Survey, WAE, Summer, 1984, 1985.

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; winter, 1969: Mapping of Eocene-Miocene marine and nonmarine sedimentary rocks in Transverse Ranges of California.

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.

Summer, 1974, 1975: Mapping of blueschist terrane, northern Sierra Nevada.

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

Summer, 1973, 1974, 1975, 1976, 1977, 1978, 1979, 1980, 1981, 1982, 1983: Detailed mapping of Paleozoic island-arc sequence and its basement, northern Sierra Nevada; reconnaissance of Paleozoic rocks of Sierran belt; structural and tectonic study of Calaveras Complex, central Sierra Nevada, California.

December-January, 1975-1976: Structural study of metamorphosed basement rocks in the South Shetlands, Antarctica.

May, 1978, September, 1978: Reconnaissance and structural study of Schistes Lustres terrane, Corsica.

Summer, 1982, 1983, 1984, 1985, 1986, 1987, 1988: Structural study of high Sierra roof pendants, eastern Sierra Nevada, California.

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 1973, 1976, 1979, 1981: Northern Sierra Nevada, California.

Summer, 1983: Snake Range, Nevada.

May 1975: Northern Scotland.

August, 1978: Swiss Alps.

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.
1981	Stanford University; University of Nevada--Reno; University of Washington; U.C. Santa Cruz; U.S. Geological Survey, Menlo Park.
1982	New Jersey Gem and Mineral Society.
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.

Dickinson, W. R., Cowan, D.S., and **Schweickert, R.A.**, 1972, Test of new global tectonics: American Association of Petroleum Geologists Bulletin, v. 56, p. 375-384.

Schweickert, R.A., and Cowan, D.S., 1975, Early Mesozoic tectonic evolution of the western Sierra Nevada, California: Geological Society of America Bulletin, v. 86, p. 1329-1336.

Schweickert, R.A., 1976, Early Mesozoic rifting and fragmentation of the Cordilleran orogen: Nature, v. 272, p. 586-591.

Schweickert, R.A., 1976, Shallow-level plutonic complexes in the eastern Sierra Nevada, California, and their tectonic implications: Geological Society of America Special Paper 176, 58 p.

Schweickert, R.A., Armstrong, R.L., and Harakal, J.E., 1980, Lawsonite blueschist in the northern Sierra Nevada: Geologic relations, age, and tectonic significance: Geology, v. 8, p. 27-31.

Alvarez, W., Kent, E.V., Premoli-Silva, I., **Schweickert, R.A.**, Larson, R.L., 1980, Franciscan Complex limestone deposited at 17 degrees south paleolatitude: Geological Society of America Bulletin, v. 91, p. 476-484.

Cohen, C., **Schweickert, R.A.**, and Odom, A.L., 1981, Structural and geochronological constraints on the timing of emplacement of the Schistes Lustres nappe, Alpine Corsica: Tectonophysics, v. 73, p. 267-282.

Hanson, R.E., and **Schweickert, R.A.**, 1982, Chilling and brecciation of a Devonian rhyolite sill intruded into wet sediments, northern Sierra Nevada, California: Journal of Geology, v. 90, p. 717-724.

Schweickert, R.A., Bogen, N.L., Girty, G.H., Hanson, R.E., and Merguerian, C., 1984, Timing and structural expression of the Nevadan orogeny, Sierra Nevada, California: Geological Society of America Bulletin, v. 95, p. 967-979.

Girty, G.H., and **Schweickert, R.A.**, 1984, The Culbertson Lake allochthon, a newly identified structural unit in the Shoo Fly Complex, northern Sierra Nevada, California: Modern Geology, v. 8, p. 181-198.

Girty, G.H., Wardlaw, M.S., **Schweickert, R.A.**, Hanson, R.E., and Bowring, S.A., 1984, Timing of pre-Antler deformation in the Shoo Fly Complex, Sierra Nevada, California: Geology, v. 12, p. 673-676.

Bogen, N.L., and **Schweickert, R.A.**, 1985, Magnitude of crustal extension across the northern Basin and Range province: Constraints from paleomagnetism: Earth and Planetary Science Letters, v. 75, p. 93-100.

Bogen, N.L., Kent, D.V., and **Schweickert, R.A.**, 1985, Paleomagnetism of Jurassic rocks in the western Sierra Nevada metamorphic belt and its bearing on the structural evolution on the Sierra Nevada block: Journal of Geophysical Research, v. 90, p. 4627-4638.

Schweickert, R.A., Bogen, N.L., Girty, G.H., Hanson, R.E., and Merguerian, C., 1985, Timing and structural expression of the Nevadan orogeny, Sierra Nevada, California: Reply: Geological Society of America Bulletin, v. 96, p. 1349-1352.

Nelson, K.D., Zhu, T.F., Gibbs, A., Harris, R., Oliver, J.E., Kaufman, S., Brown, L., and **Schweickert, R.A.**, 1986, COCORP deep seismic reflection profiling in the northern Sierra Nevada mountains, California: Tectonics, v. 5, p.

321-334.
Ingersoll, R.V., and **Schweickert, R.A.**, 1986, A plate-tectonic model for Late Jurassic ophiolite genesis, Nevadan orogeny and forearc initiation, northern California: Tectonics, v. 5, p. 901-912.
Hanson, R.E., and **Schweickert, R.A.**, 1986, Stratigraphy of mid-Paleozoic island-arc rocks in part of the northern Sierra Nevada, Sierra and Nevada Counties, California: Geological Society of America Bulletin, v. 97, p. 986-998.
Merguerian, C., and **Schweickert, R.A.**, 1987, Paleozoic gneissic granitoids in the Shoo Fly Complex, central Sierra Nevada, California: Geological Society of America Bulletin, v. 99, p. 699-717.
Schweickert, R.A., and Lahren, M.M., 1987, Continuation of Antler and Sonoma orogenic belts to the eastern Sierra Nevada, California, and Late Triassic thrusting in a compressional arc: Geology, v. 15, p. 270-273.
Lahren, M.M., **Schweickert, R.A.**, and Taranik, J.V., 1987, Analysis of accreted terranes of the northern Sierra Nevada, California with airborne Thermal Infrared Multispectral Scanner data: Environmental Research Institute of Michigan, Proceedings of the Fifth Thematic Conference on Remote Sensing for Exploration Geology, v. 1 p; 13-14.
Hanson, R.E., Saleeby, J.B., and **Schweickert, R.A.**, 1988, Composite Devonian island-arc batholith in the northern Sierra Nevada, California: Geological Society of America Bulletin, v. 100, p. 446-457.
Lahren, M.M., **Schweickert, R.A.**, and Taranik, J.V., 1988, Analysis of the northern Sierra accreted terrane, California, with airborne thermal infrared multispectral scanner data: Geology, v. 16, p. 525-528.
Lahren, M.M., and **Schweickert, R.A.**, 1989, Proterozoic and Lower Cambrian miogeoclinal rocks of Snow Lake pendant, Yosemite-Emigrant Wilderness, Sierra Nevada, California: Evidence for major Early Cretaceous dextral translation: Geology, v. 17, p. 156-160.
Schweickert, R.A., and Irwin, W.P., 1989, Extensional faulting in southern Klamath Mountains, California: Tectonics, v. 8, p. 135-149.

2. Invited, refereed papers in symposia.

Schweickert, R.A., Saleeby, J.B., Tobisch, O.T., and Wright, W.H., III, 1977, Paleotectonic and paleogeographic significance of the Calaveras Complex, western Sierra Nevada, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, Symposium on Pacific Coast Paleozoic Paleogeography, P. 381-394.
Schweickert, R.A., 1978, Triassic and Jurassic paleogeography of the Sierra Nevada and adjacent regions, California and western Nevada *in* Howell, E.G., ed., Mesozoic paleogeography of the western United States: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 361-384.
Schweickert, R.A., 1981, Tectonic evolution of the Sierra Nevada range *in*

Ernst, W.G., ed., The geotectonic development of California, Rubey Vol. 1: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 87-131.

Schweickert, R.A., and Snyder, W.S., 1981, Tectonic evolution of the Sierra Nevada range *in* Ernst, W.G., ed., The geotectonic development of California, Rubey Vol. 1: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 182-203.

Batten, R.L., and **Schweickert, R.A.**, 1981, The lost Pacifica continent: A mobilistic speculation: Discussion: Vicariance Biogeography Symposium, American Museum of Natural History, Columbia University Press, p. 359-366.

Schweickert, R.A., 1981, The relative importance of plate movement, eustasy and climate in controlling major biogeographic changes since the early Mesozoic: Discussion: Vicariance Biogeography Symposium, American Museum of Natural History, Columbia University Press, p. 331-334.

Snyder, W.S., Brueckner, H.K., and **Schweickert, R.A.**, 1983, Deformational styles in the Monterey Formation and other siliceous sedimentary rocks *in* Isaacs, C., and others, eds., Petroleum generation and occurrences in the Miocene Monterey Formation, California: Society of Economic Paleontologists and Mineralogists, Pacific Section, p. 151-170.

Schweickert, R.A., Merguerian, C., and Bogen, N.L., 1988, Deformational and metamorphic history of Paleozoic and Mesozoic basement terranes in the western Sierra Nevada metamorphic belt *in* Ernst, W.G., ed., Metamorphism and crustal evolution of the western United States, Rubey Vol. VII: Prentice-Hall, Inc., Englewood Cliffs, New Jersey, p. 789-822.

3. Field Trip Guides.

Schweickert, R.A., and Wright, W.H., III, 1975, Structural studies of the Calaveras Formation along the Stanislaus River and their tectonic implications: Geological Society of Sacramento, Annual Field Trip Guidebook, p. 38-47.

Wright, W.H., III., and **Schweickert, R.A.**, 1977, Tectonics and stratigraphy of the Calaveras Complex, Sierra Nevada foothills: Geological Society of America, Cordilleran Section, Field Trip Guidebook,17 p.

Schweickert, R.A., 1981, The Sierra Nevada magmatic arc *in* Graham, S.A., ed., Field guide to the Mesozoic-Cenozoic convergent margin of northern California: American Association of Petroleum Geologists, Pacific Section, v. 50, p. 15-24.

Schweickert, R.A., and Graham, S.A., 1981, Field trip road log: Sierra Nevada arc complex, Reno to Sacramento *in* Graham, S.A., ed., Field guide to the Mesozoic-Cenozoic convergent margin of northern California: American Association of Petroleum Geologists, Pacific Section, v. 50, p. 25-39.

Schweickert, R.A., and Hanson, R.E., 1982, A transect of the northern Sierra along the North Yuba River: Field trip guidebook, Second Annual Peninsula Geological Society Field Trip, p. 1-12.

Schweickert, R.A., and Bogen, N.L., 1983, Tectonic transect of Sierran Paleozoic through Jurassic accreted belts: Pacific Section, Society of Economic Paleontologists and Mineralogists, 22 p.

Schweickert, R.A., Harwood, D.S., Girty, G.H., and Hanson, R.E., 1984, Tectonic development of the northern Sierra terrane: An accreted late Paleozoic island arc and its basement: Description and road logs *in* Lintz, Jr., J., ed., Western Geological Excursions, Volume 4: Department of Geological Sciences, Mackay School of Mines, Reno, Nev., p. 1-65.

Ingersoll, R.V., **Schweickert, R.A.**, Kleist, J.R., Graham, S.A., and Cowan, D.S., 1984, Field guide to the Mesozoic-Cenozoic convergent margin of northern California *in* Lintz, Jr., J., ed., Western Geological Excursions, Volume 4: Department of Geological Sciences, Mackay School of Mines, Reno, Nev., p. 304-353.

4. Maps.

Schweickert, R.A., Harwood, D.S., Girty, G.H., and Hanson, R.E., in press, Geologic map of the Emigrant Gap 15' quadrangle, Sierra County, California: U.S. Geological Survey Map.

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.

Noble, D.C., McKee, E.H., and **Schweickert, R.A.**, 1973, K-Ar ages on post-Lower Jurassic granodiorite form the southern Pine Nut Range, western Nevada: Isochron West, v. 3.

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

B. PAPERS IN PRESS.

Schweickert, R. A., and Lahren, M. M., 1989, Speculative reconstruction of a major Early Cretaceous(?) dextral fault zone in the Sierra Nevada: Implications for Paleozoic and Mesozoic orogenesis in the western United States: Geol. Soc. America Spec. Paper.

ABSTRACTS.

Schweickert, R.A., 1971, Shallow-level intrusions in the eastern Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 3. p. 190-191.

Schweickert, R.A., 1974, Probable late Paleozoic thrust fault near Sierra City, California: Geological Society of America Abstracts with Programs, v. 6, p. 251.

Schweickert, R.A., and Cowan, D.S., 1974, Pre-Tithonian magmatic arcs and subduction zones, Sierra Nevada, California: Geological Society of America Abstracts with Programs, v. 6, p. 251-252.

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Lahren, M.M., and Schweickert, R.A., in prep., Small scale Tertiary and possibly 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
b. Associate Editor, Geological Society of America Bulletin, 1981-88.
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
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$30,209

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R.A., 8/15/76 - 1/31/78.
$51,100

NSF-EAR-76-84320
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$17,778

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