QUATERNARY FAULTING CONCERNS AT YUCCA MOUNTAIN

John W. Bell, Presenter
Alan R. Ramelli
Craig M. dePolo

Nevada Bureau of Mines and Geology
University of Nevada-Reno

PRESENTATION TO
THE NUCLEAR WASTE TECHNICAL REVIEW BOARD

MAJOR CONCERNS

- Existence of Quaternary (potentially active) faults
- Paleoseismic history
- Regional analogues
- Coupled processes
- Interpretation of future events

EXISTENCE OF QUATERNARY (POTENTIALLY ACTIVE) FAULTS

- **Multiple potentially active faults**

  Surface displacements indicate moderate- to large magnitude events recurring on the same fault traces

- **Faults may be difficult to detect**

  Lack of definition; small vertical offsets

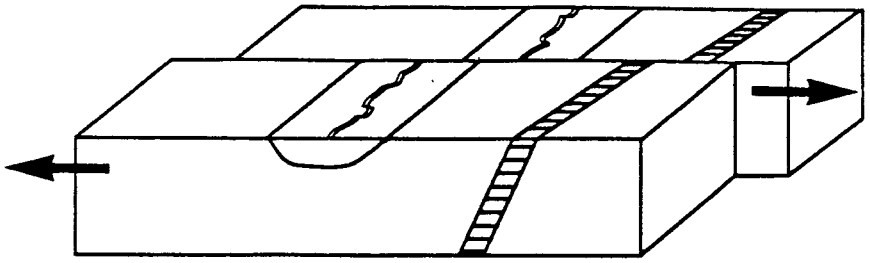
- **Unmapped faults have been identified**

  Low-sun-angle aerial photography highlights subtle features

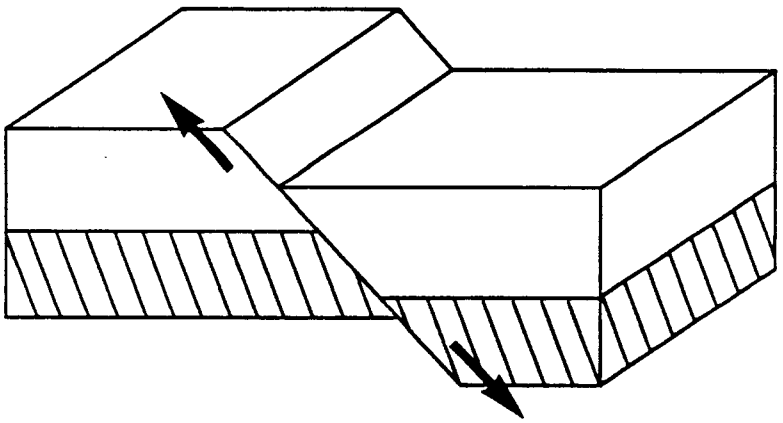
- **Other unrecognized faults likely**

  Additional aerial photography and ground investigation required

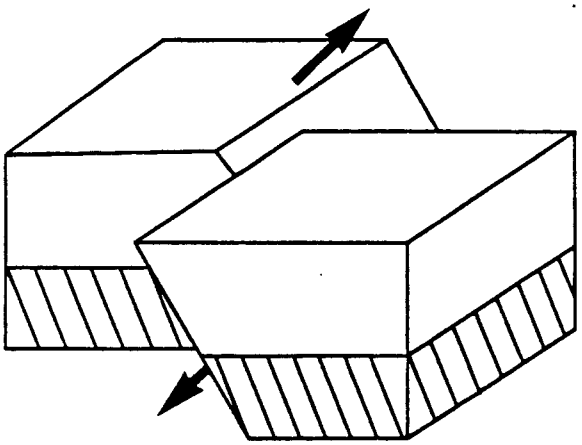
STRIKE-SLIP FAULT



NORMAL-SLIP FAULT

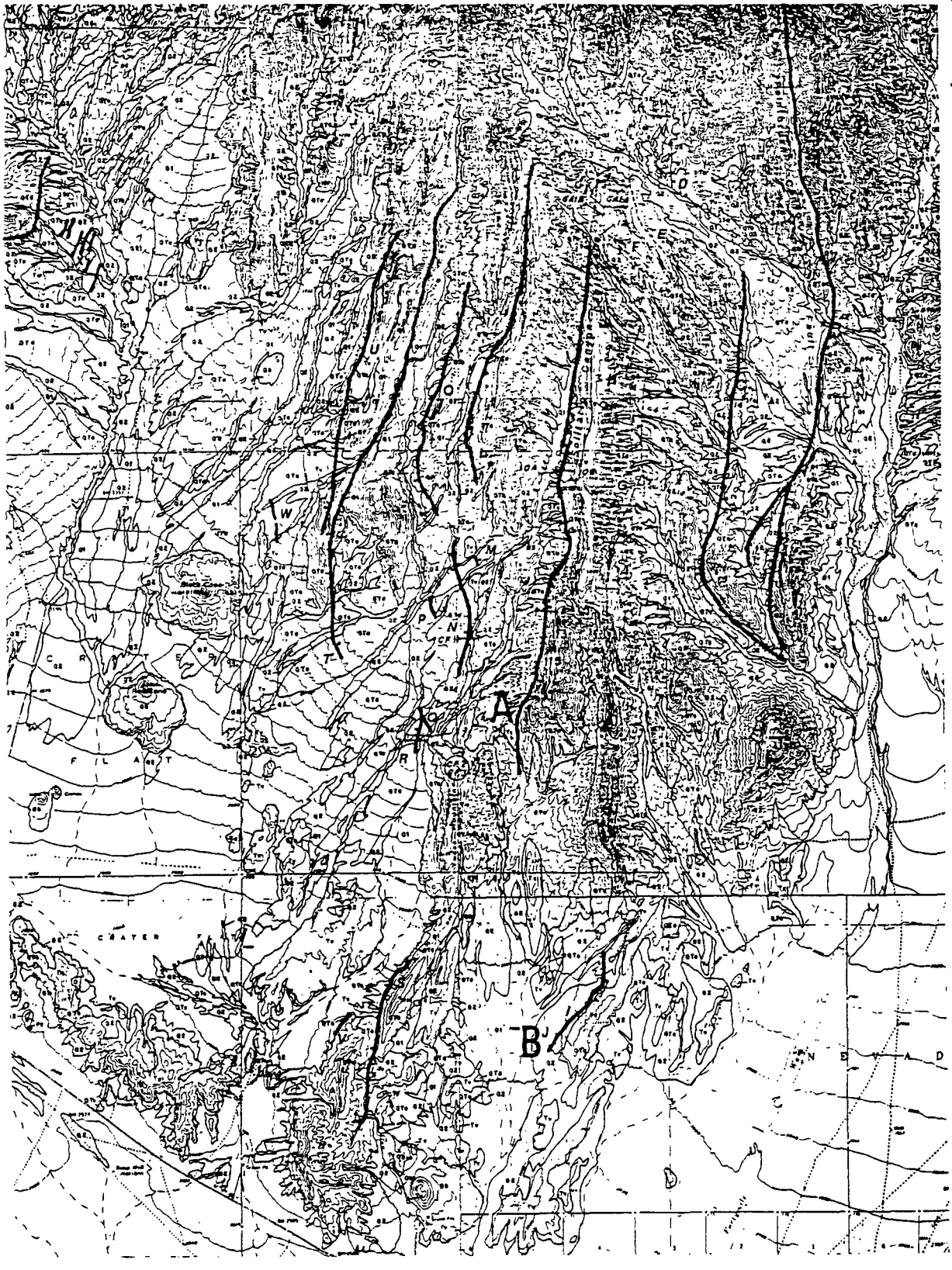


OBLIQUE-SLIP FAULT

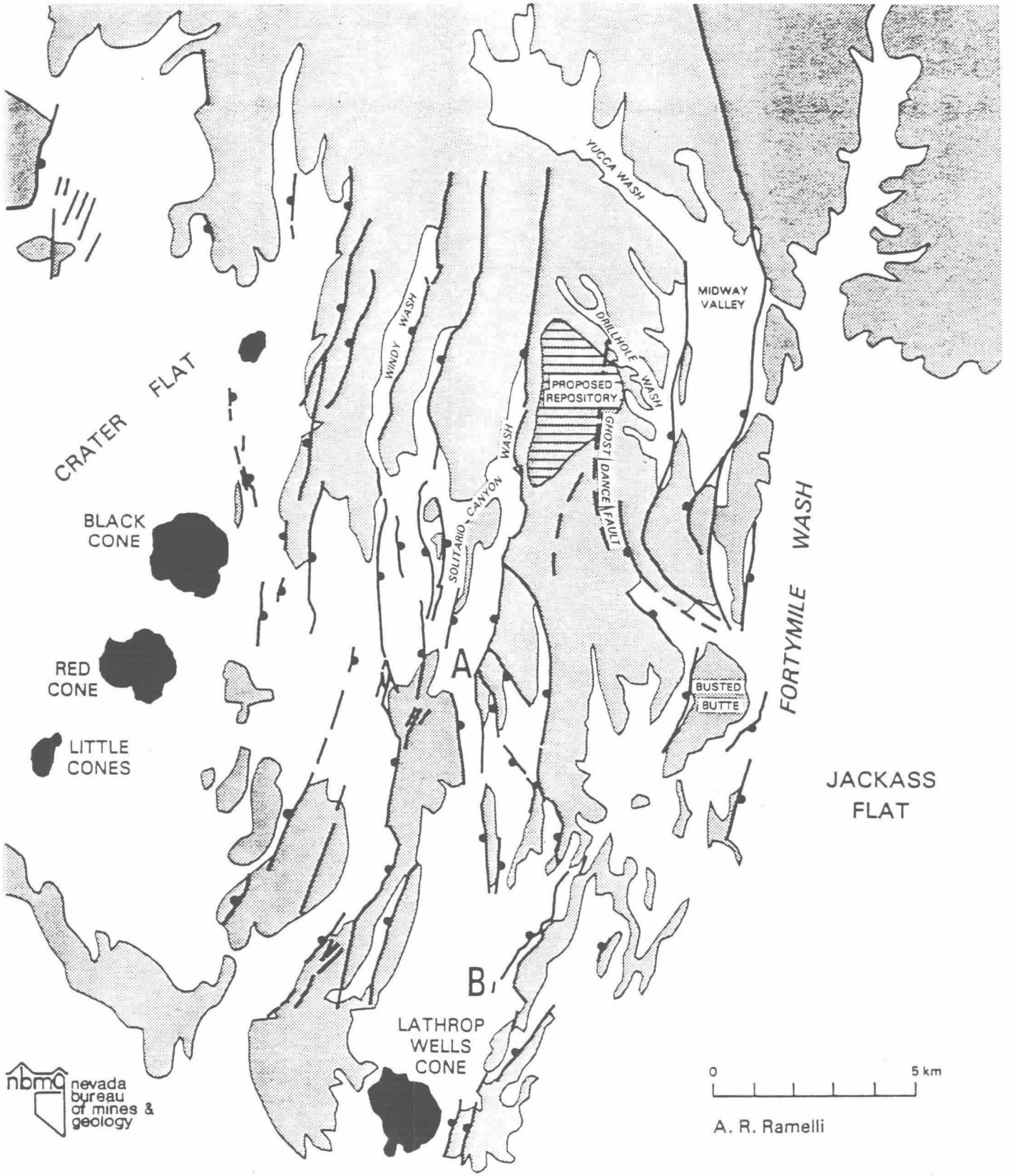


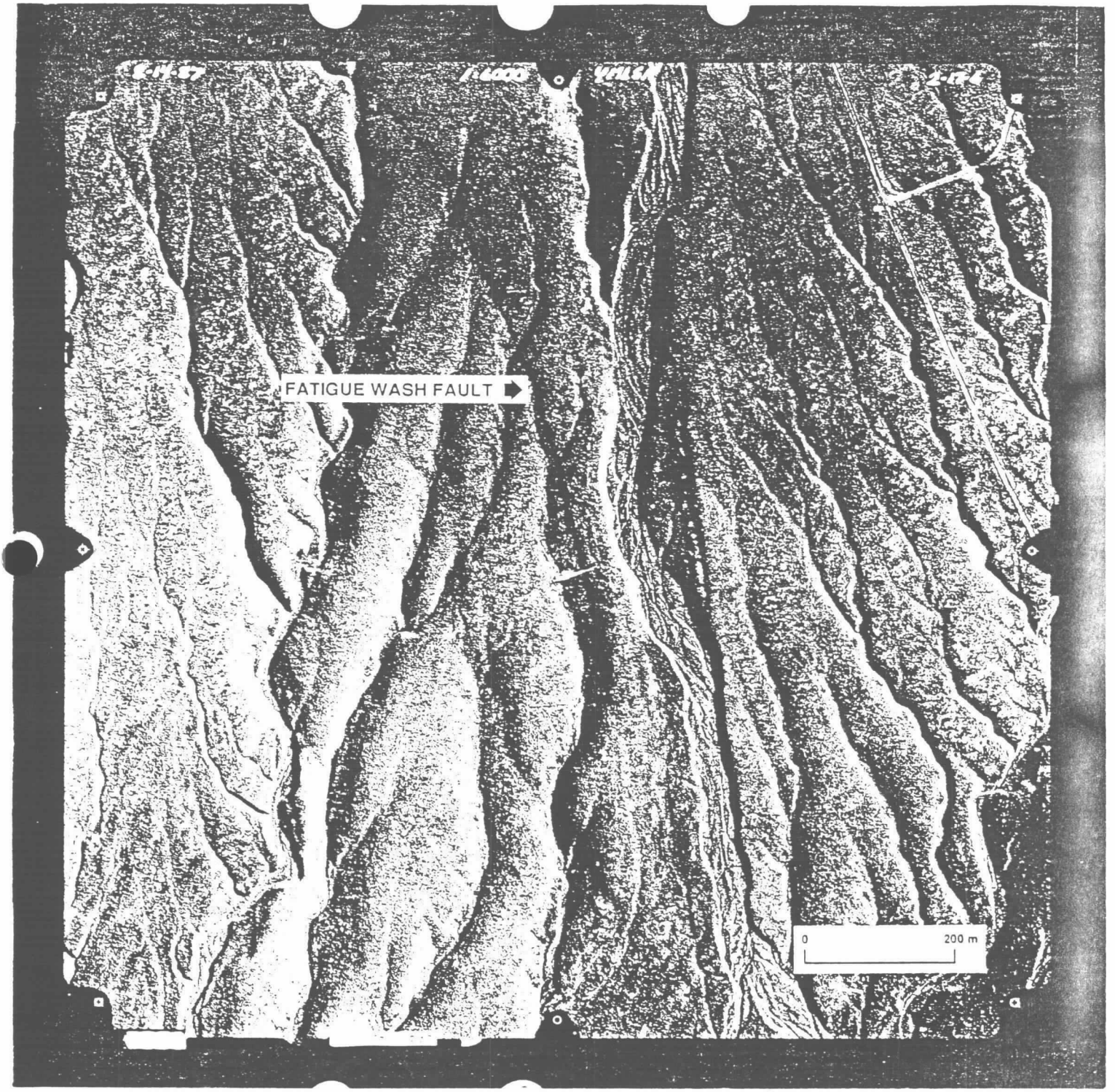
nbmg nevada bureau of mines & geology

CURRENT DOE FAULT REPRESENTATION (Swadley and others, 1984)

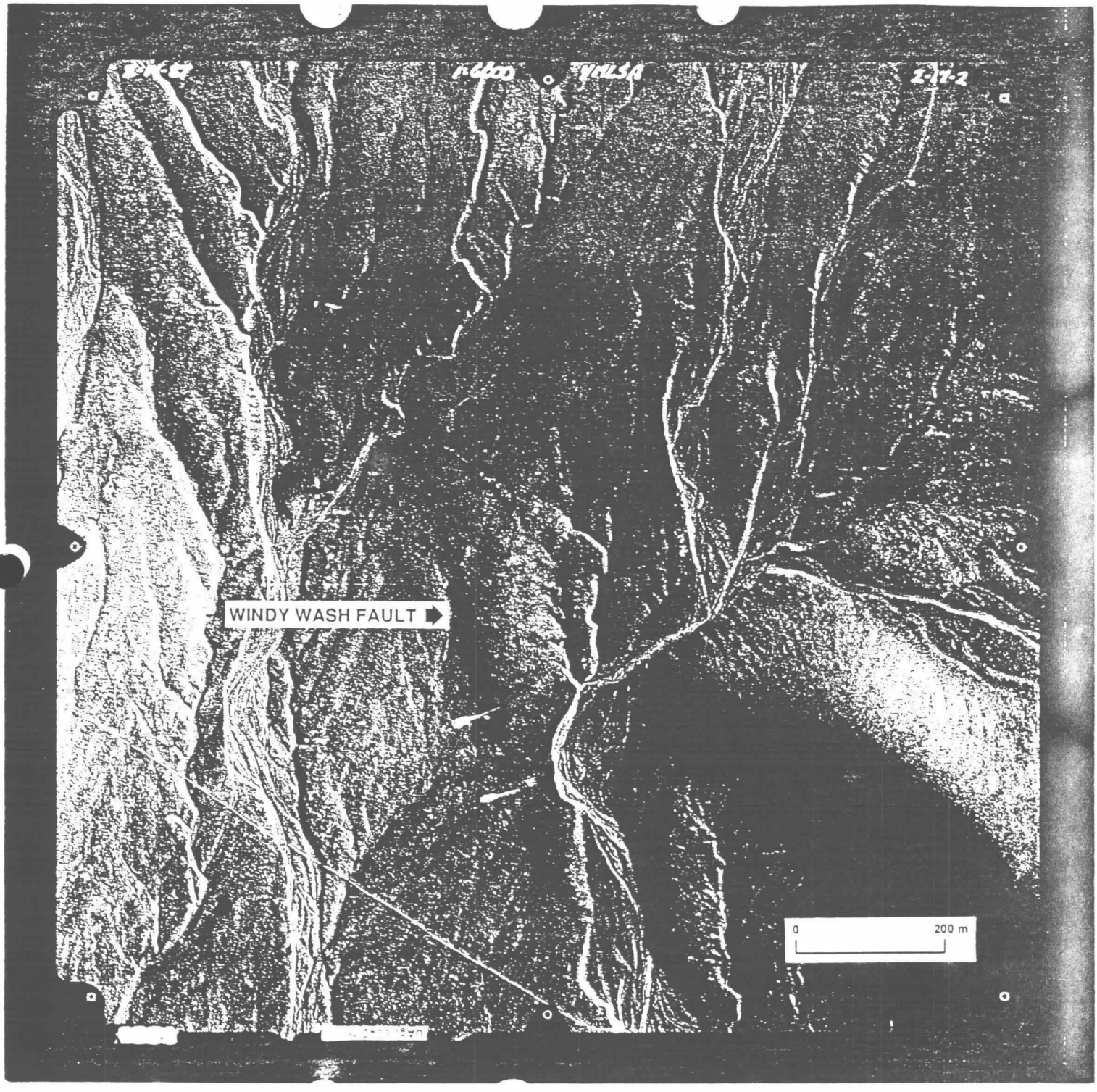


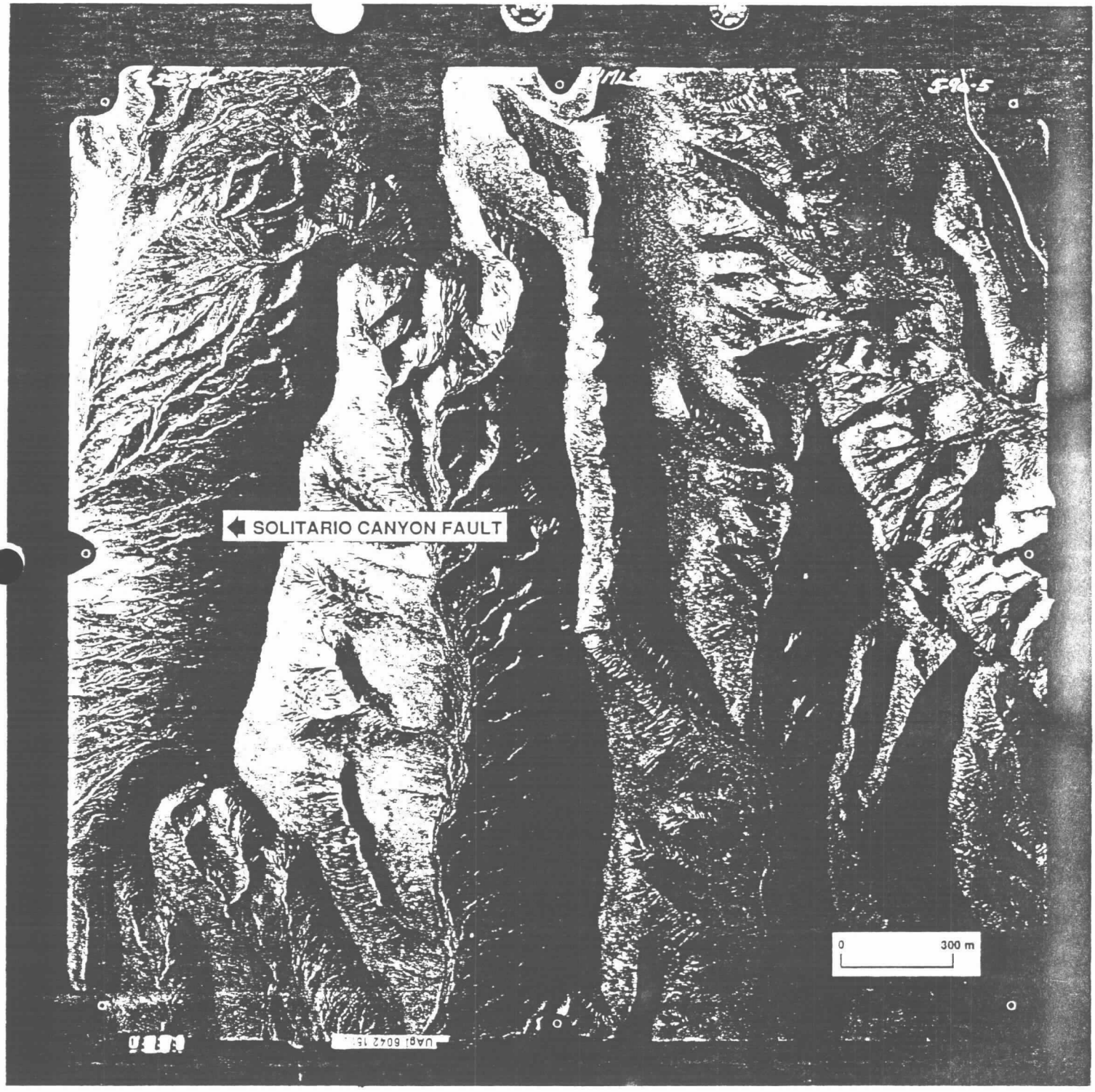
QUATERNARY FAULTS AT YUCCA MOUNTAIN

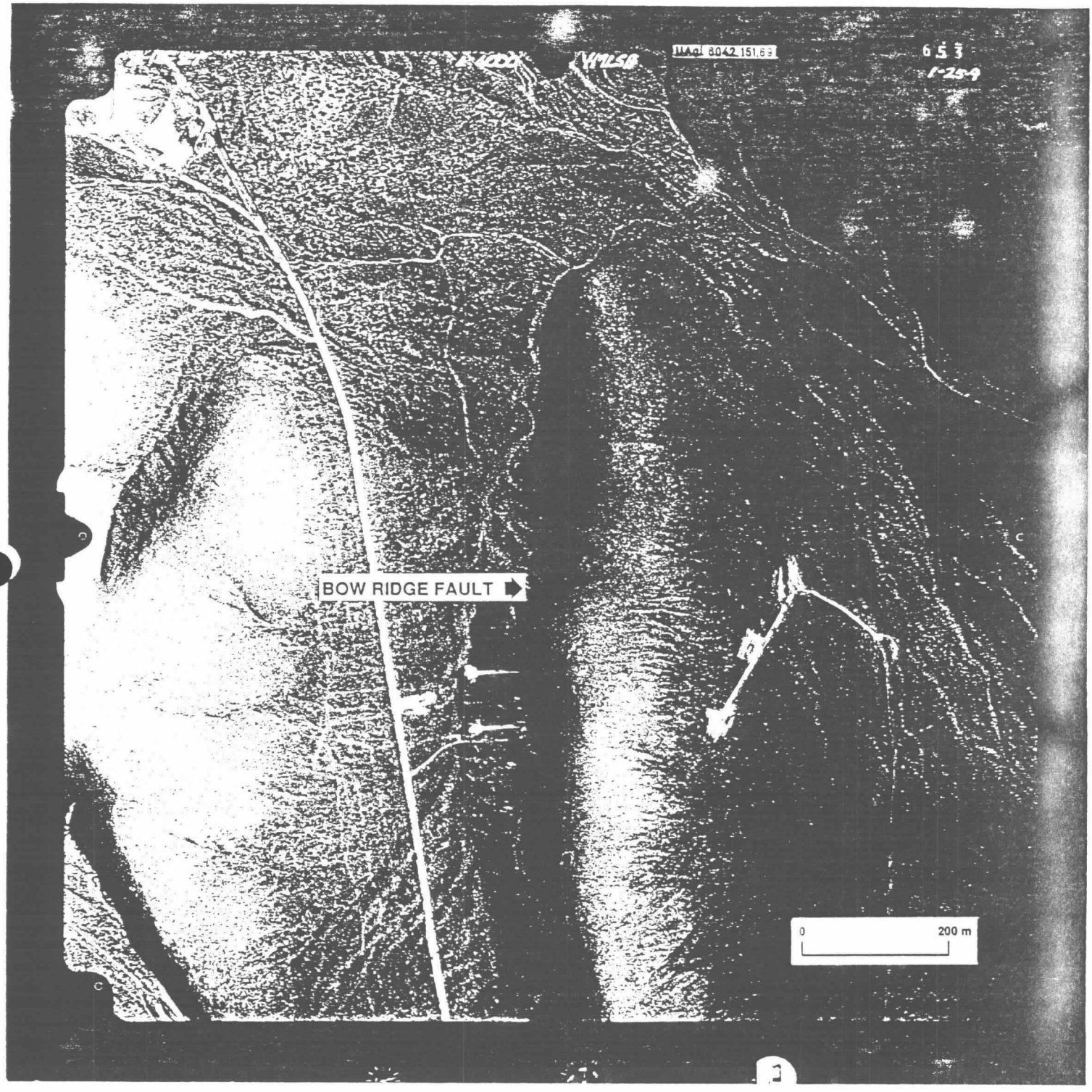


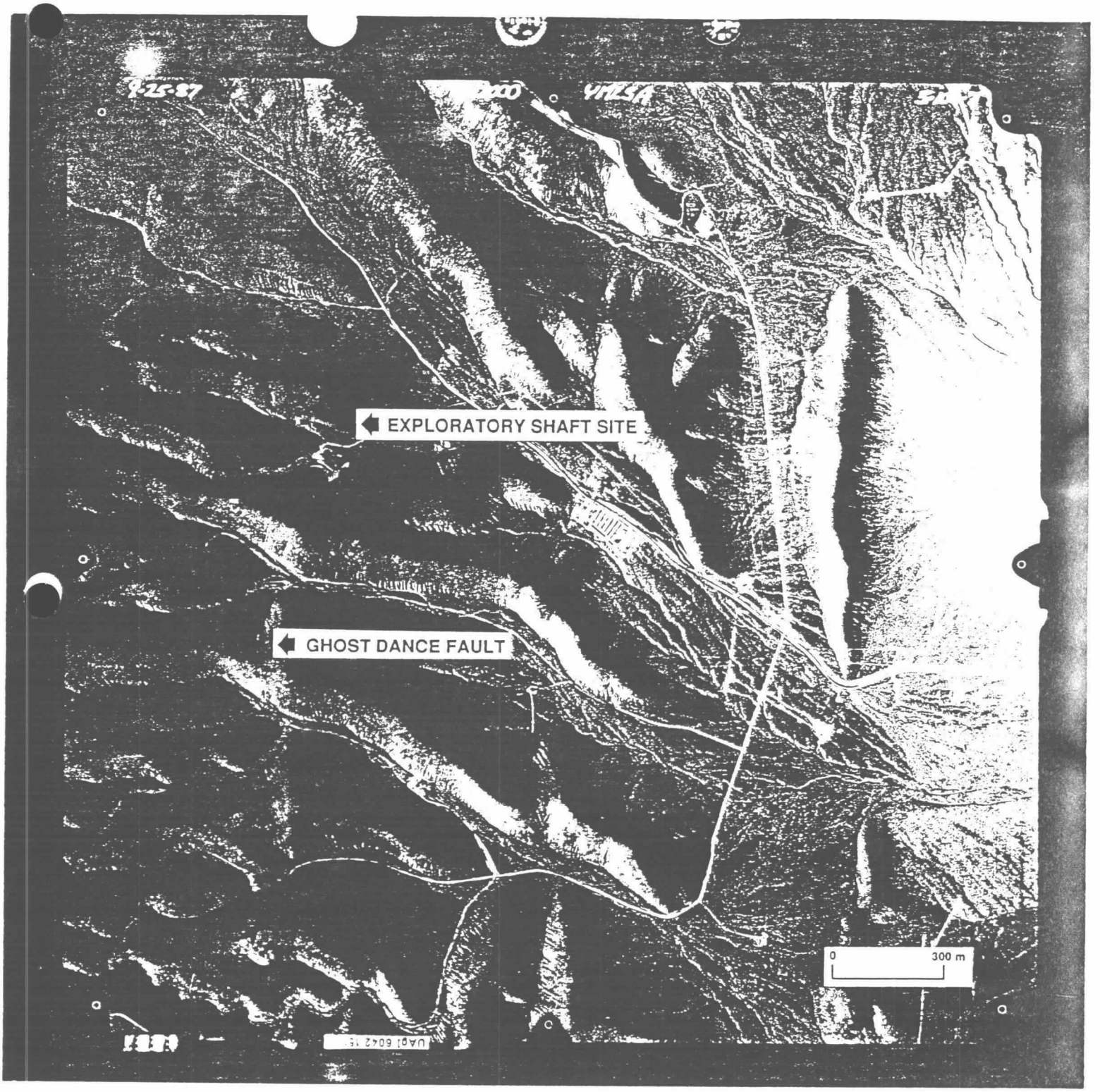

FATIGUE WASH FAULT
0
200 m


WINDY WASH FAULT
FATIGUE WASH FAULT
0
300 m


WINDY WASH FAULT
0
200 m


SOLITARIO CANYON FAULT
0
300 m


BOW RIDGE FAULT
0
200 m


EXPLORATORY SHAFT SITE
GHOST DANCE FAULT
0
300 m

PALEOSEISMIC HISTORY

●Complex, distributive faulting
Map and field evidence suggests faults are interconnected

●Recency of faulting
Geologic evidence suggests recent activity

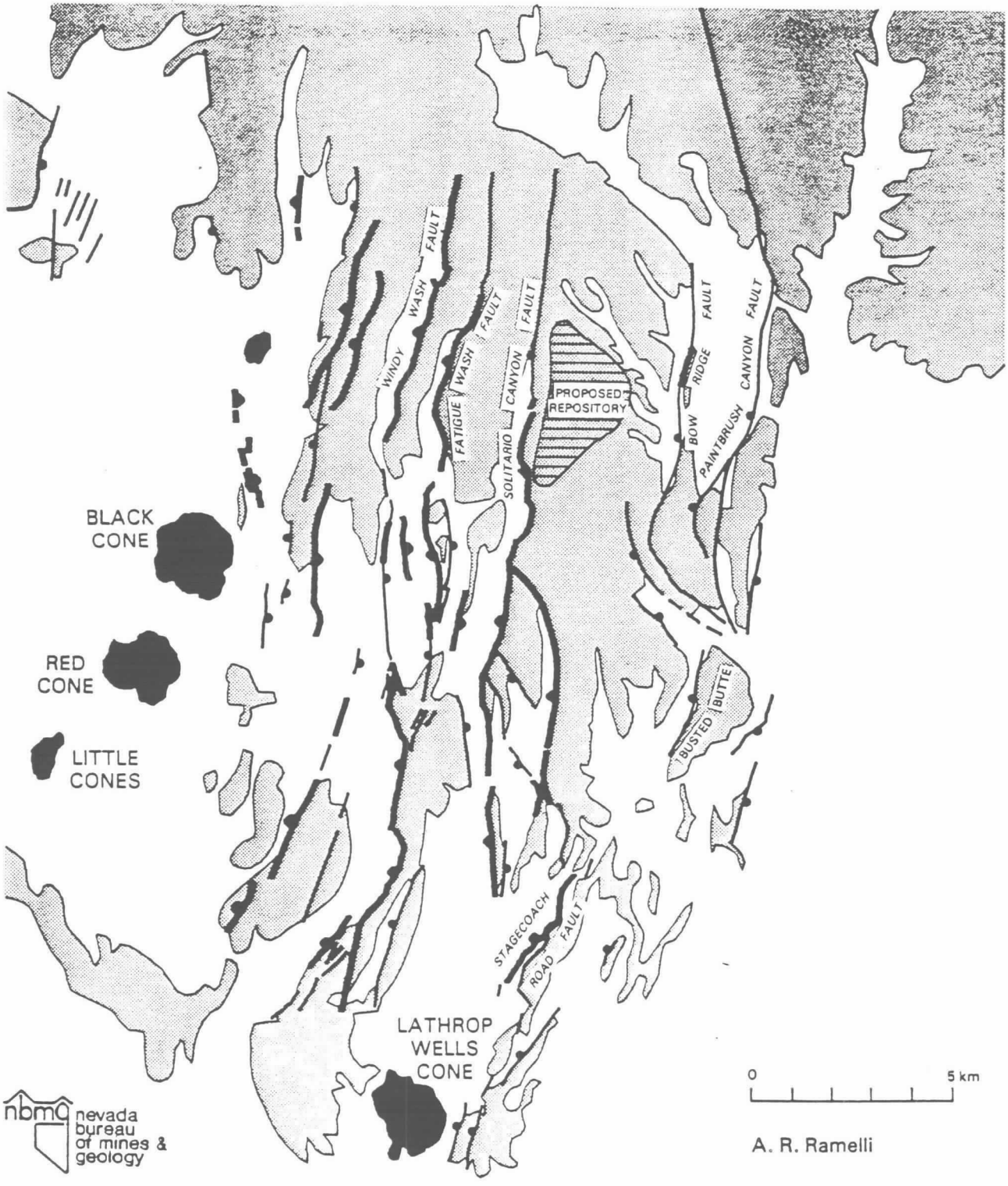
●Ages of faulted and faulted deposits
Timing of Quaternary events is poorly constrained

●Magnitudes of paleoevents
Magnitudes may be 7 or greater

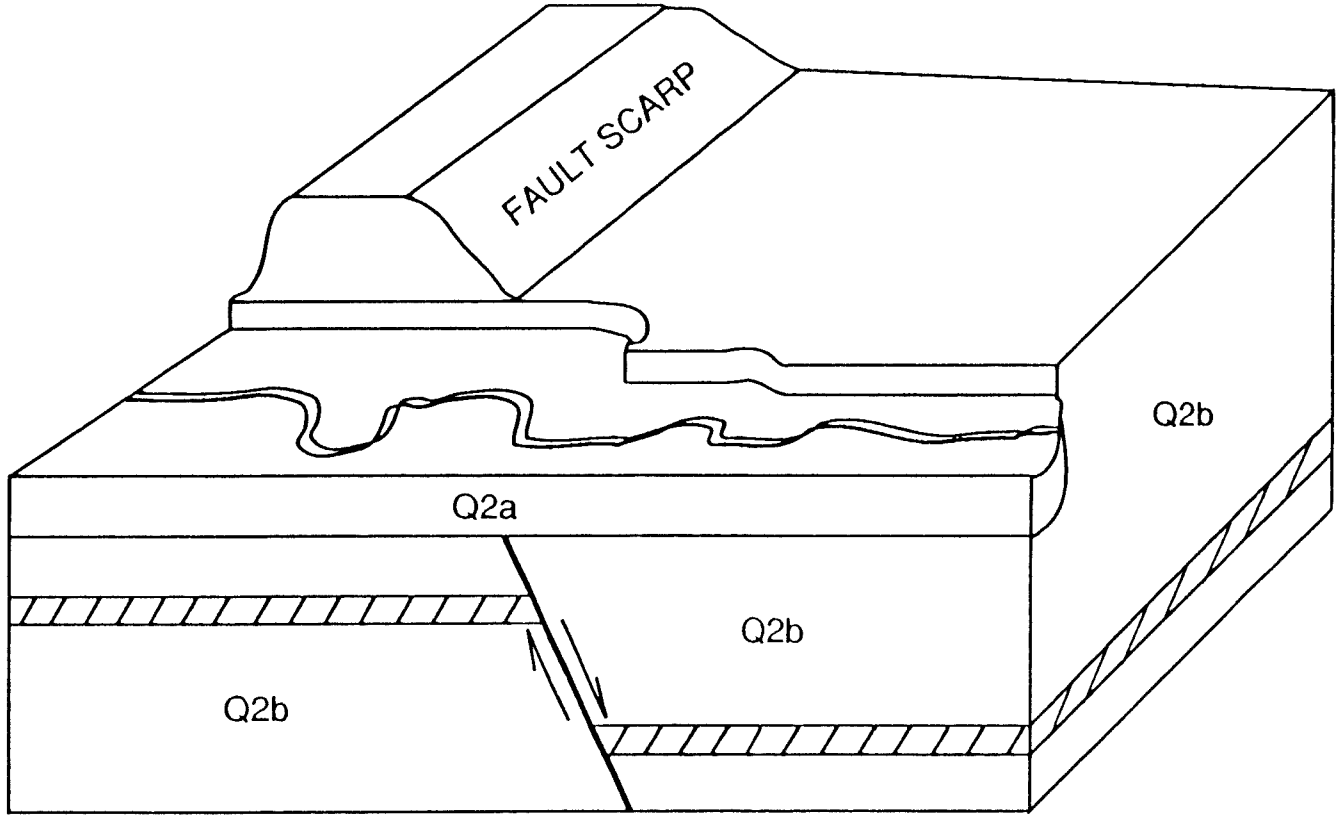
●Strike-slip displacement
Geologic and seismologic evidence suggests strike-slip component

●Synthesis of data
Reasonable conservatism should be used to define paleoseismic history

FAULTS WITH YOUNG SCARPS

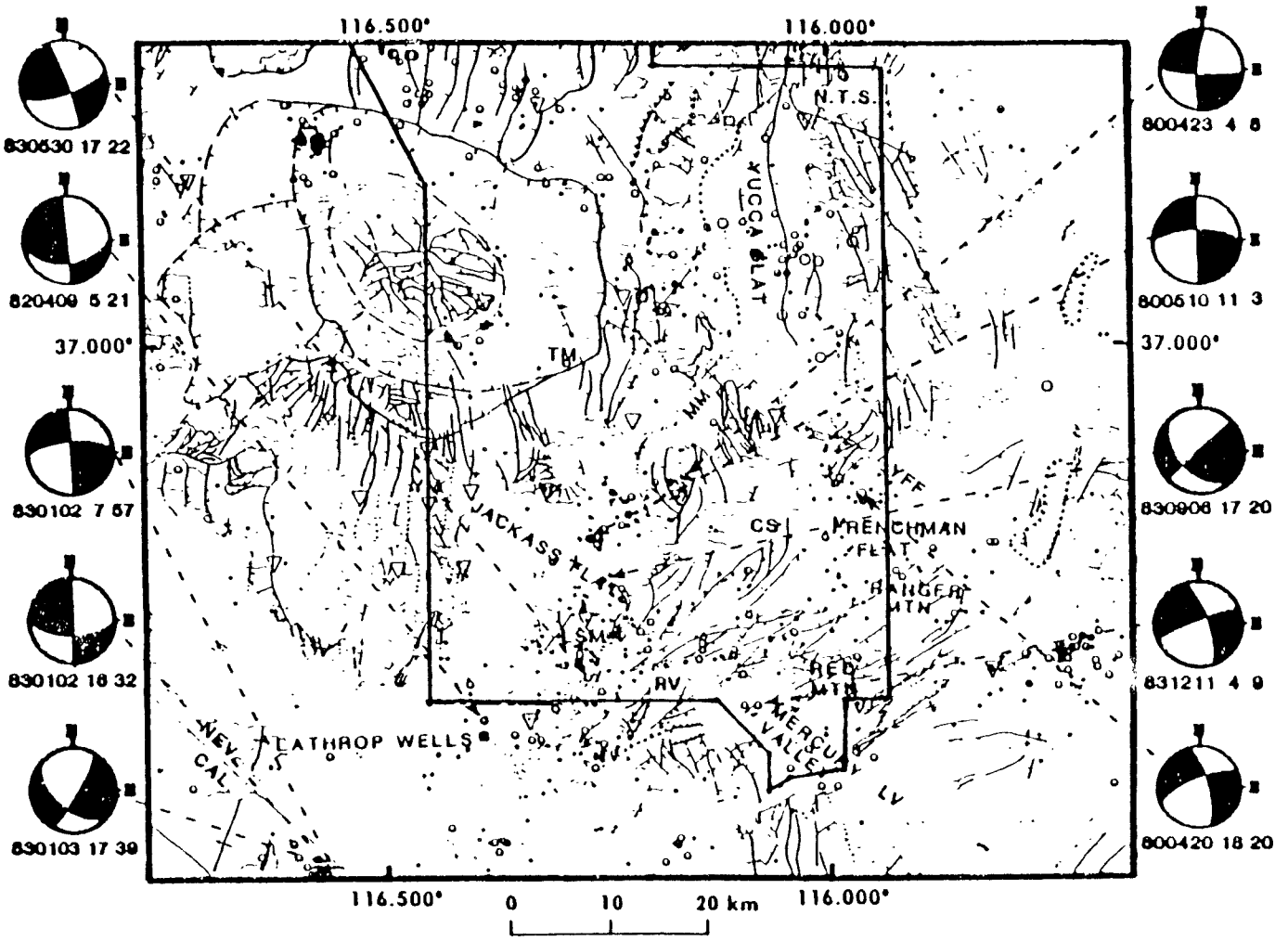


FAULTED AND UNFAULTED DEPOSITS



nbmg nevada bureau of mines & geology

FOCAL MECHANISMS IN THE NTS REGION (Rogers and others, 1987)



REGIONAL ANALOGUES

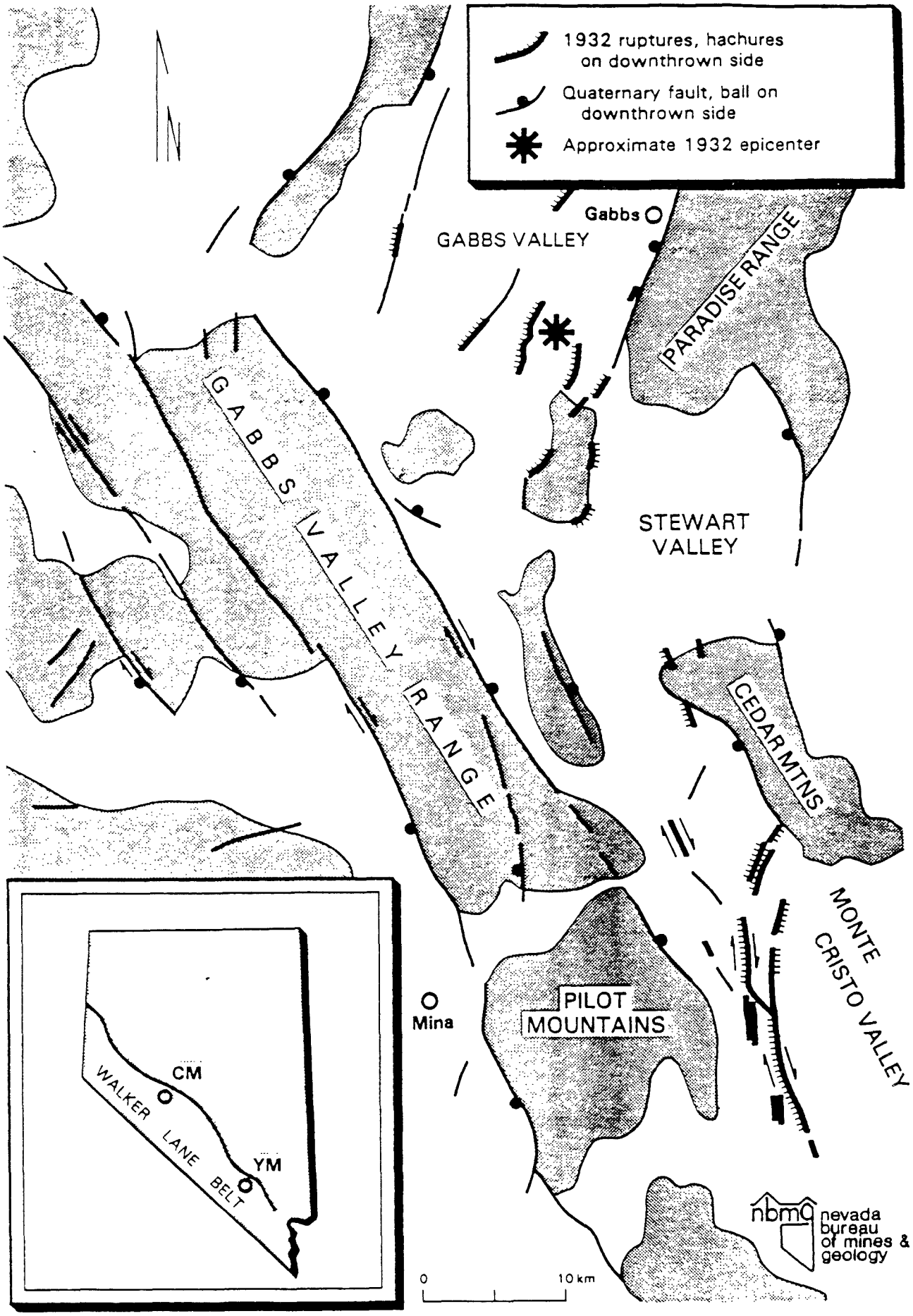
- **1932 Cedar Mountain earthquake should be used as a principal analogue**

  Walker Lane tectonic setting

  Predominantly strike-slip event

  Distributive fault pattern with small vertical displacements

1932 CEDAR MTN. EARTHQUAKE RUPTURES



COUPLED PROCESSES

- **Volcano-tectonic events**

  Volcanic ash found in four faults

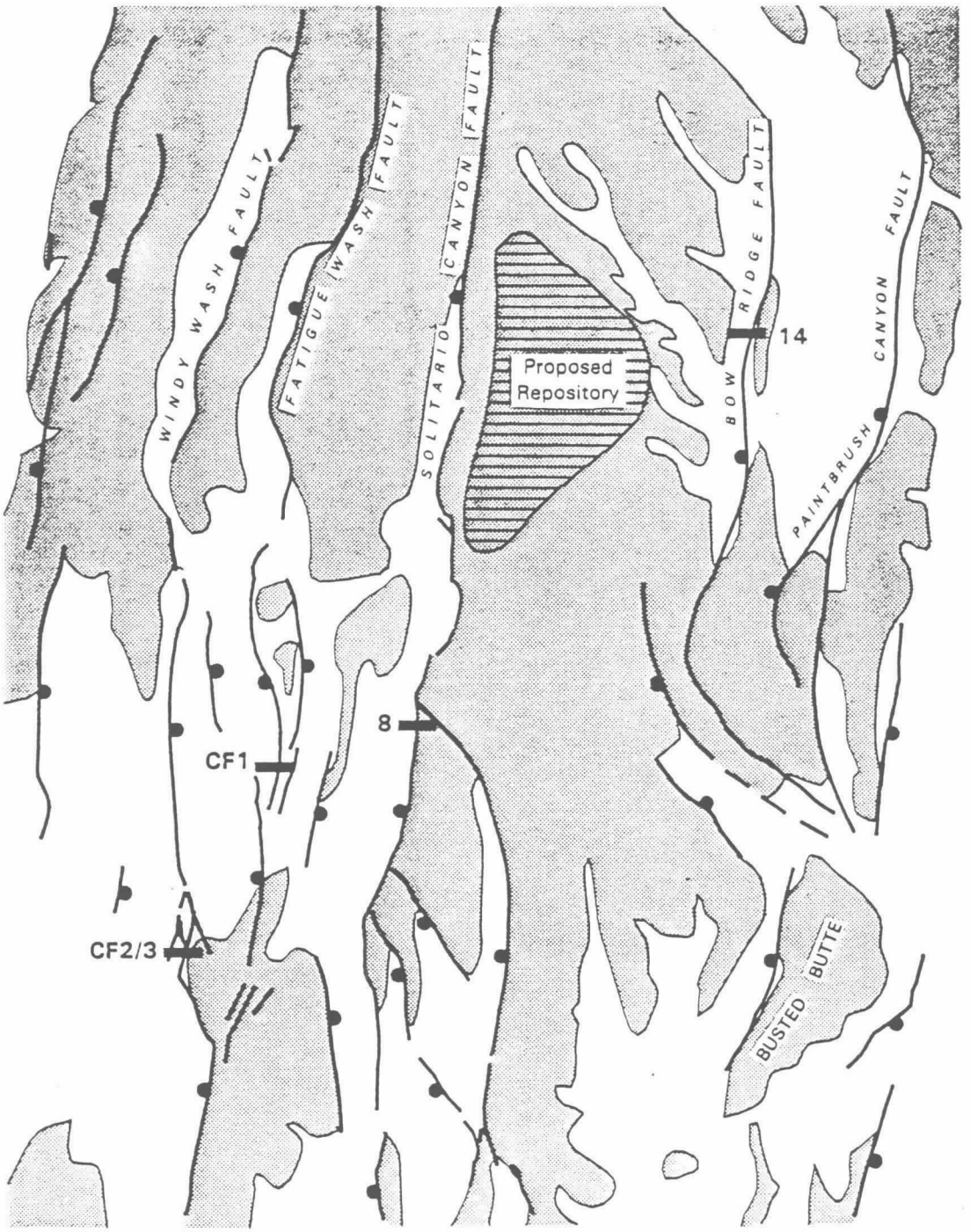
  Suggestive of simultaneous volcanic and faulting events

- **Hydrologic effects**

  Water level fluctuations

  Extensive fracturing associated with faulting

TRENCHES EXPOSING BASALTIC ASH IN FAULTS

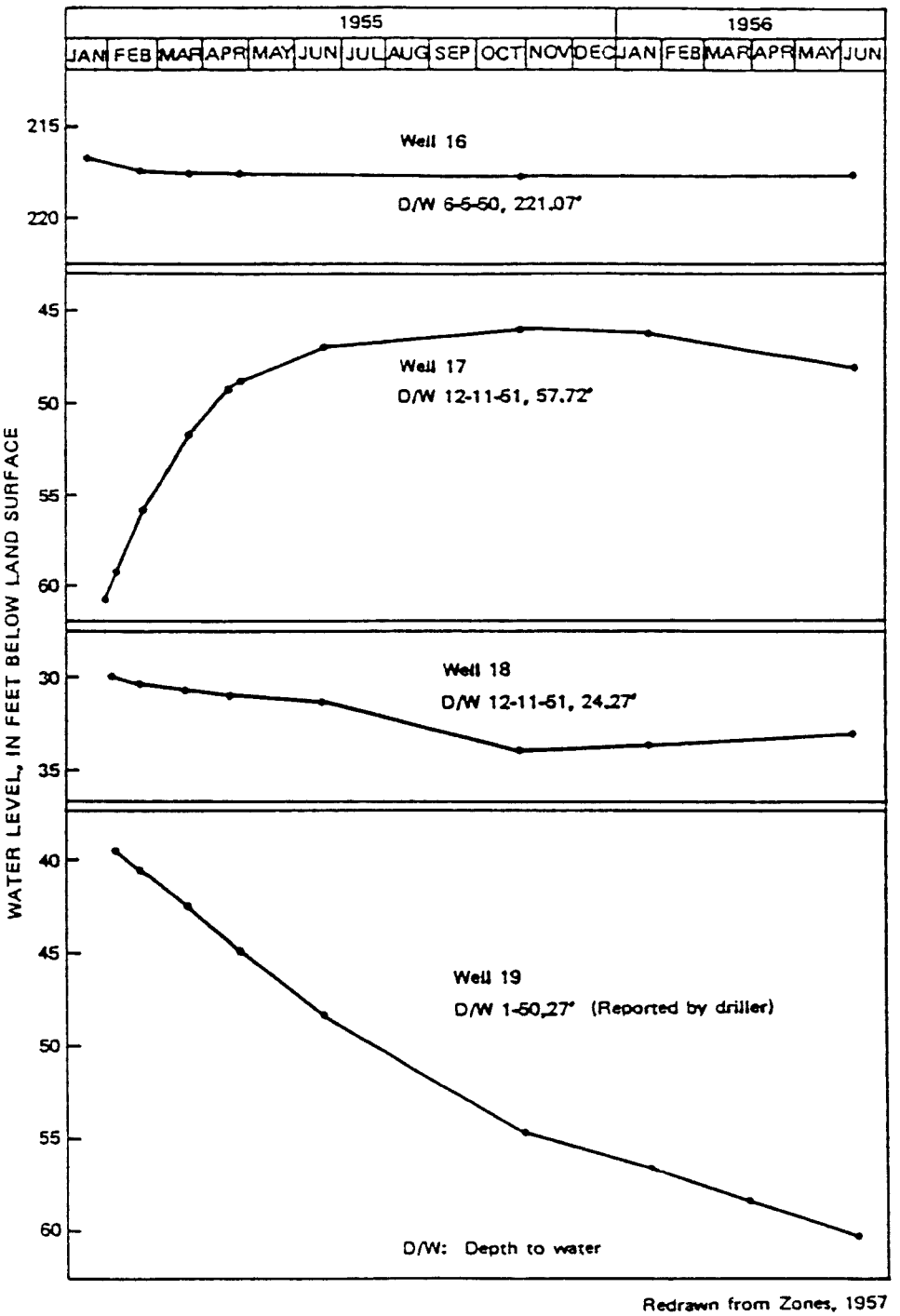


nbmg nevada bureau of mines & geology

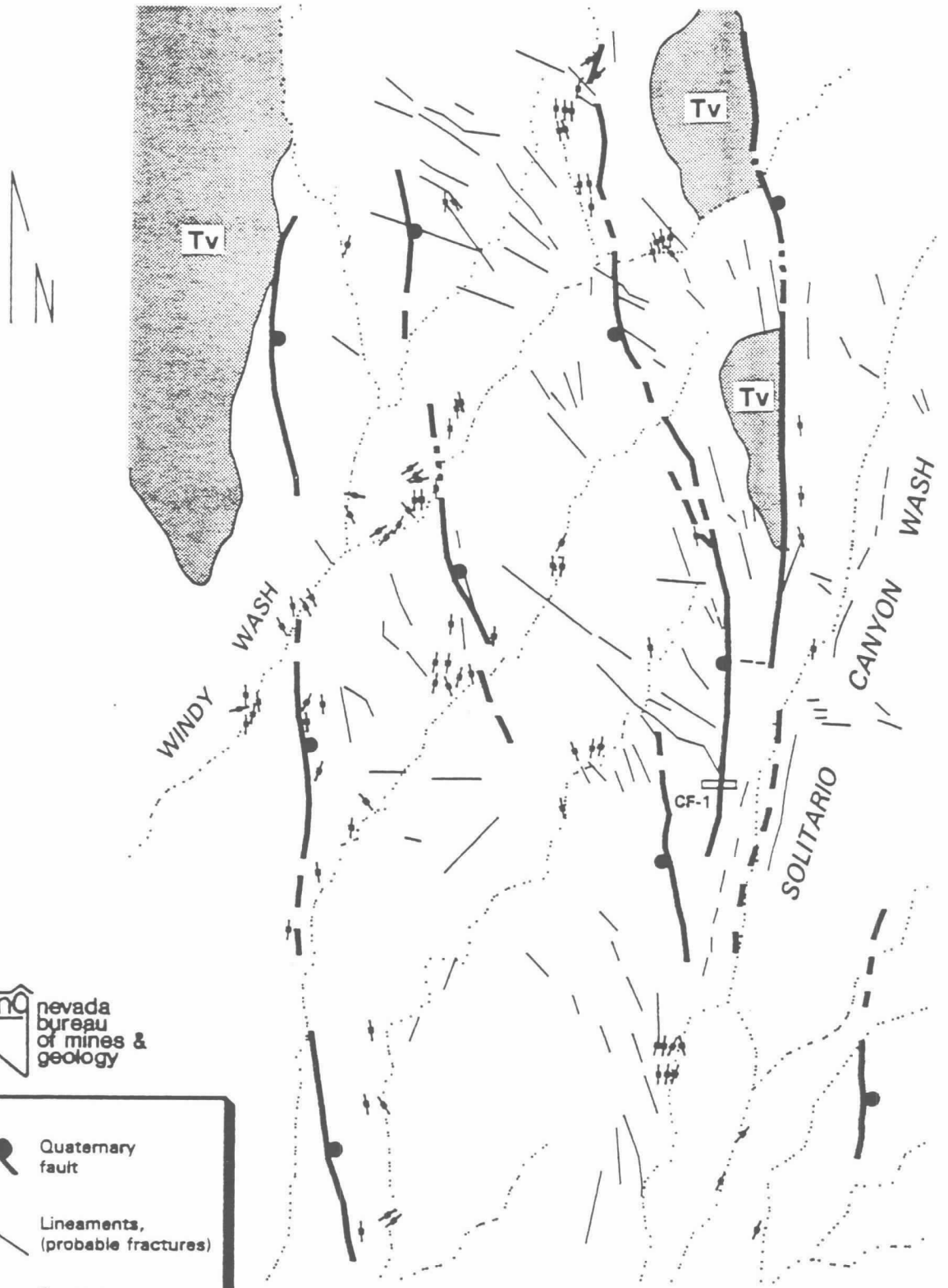
0 1 2 3 km

A. R. Ramelli

HYDROGRAPHS OF SELECTED WELLS IN FAIRVIEW VALLEY AFFECTED BY THE 1954 DIXIE VALLEY-FAIRVIEW PEAK EARTHQUAKES (Raney, 1988, for the N.R.C.)



Redrawn from Zones, 1957



nbmg nevada bureau of mines & geology

Quaternary fault

Lineaments, (probable fractures)

Fracture orientation

0 300 m

QUATERNARY FAULTS AND FRACTURES IN ALLUVIUM IN THE VICINITY OF TRENCH CF-1

SUMMARY OF QUATERNARY FAULTING CONCERNS

- Distribution of Quaternary faults
- Style, age and magnitude of faulting
- Regional analogues
- Coupled processes
- Interpretation of future events

JOHN W. BELL

Professional Summary

PERSONAL

Born January 24, 1946, Berwyn, Illinois

Business address: Nevada Bureau of Mines and Geology
University of Nevada-Reno
Reno, NV 89557-0088

Business telephone: (702) 784-6691
Home telephone: (702) 972-1804
FAX: (702) 784-1709

EDUCATION

B.A. Geology, Augustana College, 1968
M.S. Geology, Arizona State University, 1974

REGISTRATION

Registered Geologist, State of California

AREAS OF EXPERTISE

Quaternary geology; alluvial and soil stratigraphy
Neotectonics
Earthquake hazards
Engineering and urban geology

PROFESSIONAL WORK EXPERIENCE

A. Research Faculty, Nevada Bureau of Mines and Geology
Mackay School of Mines, University of Nevada-Reno
(1976-present)

Assistant Engineering Geologist (1976-1979)
Associate Engineering Geologist (1979-1988)
Engineering Geologist (1988-present)
Tenured 1981

Responsible for basic and applied research in Quaternary and surficial geology as related to engineering geology; specialized in neotectonics.

B. Geologist, Earth Resources Technology, Inc. (formerly Fugro, Inc.), Long Beach, California
(1973-1976)

Conducted Quaternary and engineering geology studies for nuclear power plant sites in Arizona and California.

C. Geologist (WAE), U.S. Geological Survey, Alaskan Geology Branch, Menlo Park, California
(1972-1974).

Conducted environmental geology research in the Fairbanks area, Alaska.

D. Consulting Geologist, Arizona Atomic Energy Commission, Phoenix, Arizona
(1972)

Conducted Quaternary geology study for proposed nuclear power/desalinization plant.

E. U.S. Army
(1969-1971)

Surveyor; included service in Vietnam.

PROFESSIONAL SOCIETIES

Geological Society of America
Association of Engineering Geologists
International Association of Engineering Geologists
Seismological Society of America

HONOR SOCIETIES

Society of Sigma Xi

PUBLICATIONS

Peer-Reviewed Reports Published by Geological Surveys

Bell, J.W., and Bonham, H.F., Jr., 1987, Geologic map, Vista quadrangle: Nevada Bureau of Mines and Geology Map 4Hg.

Bell, J.W., and Garside, L.J., 1987, Geologic map, Verdi quadrangle: Nevada Bureau of Mines and Geology Map 4Gg.

Bell, J.W., and Katzer, T.L., 1987, Surficial geology, hydrology, and late Quaternary tectonics of the IXL Canyon area, Nevada, as related to the 1954 Dixie Valley earthquake: Nevada Bureau of Mines and Geology Bulletin 102, 52 p.

Matti, J.C., Bachhuber, F.W., Morton, D.M., and Bell, J.W., 1987, Geologic map, Las Vegas NW quadrangle: Nevada Bureau of Mines and Geology Map 3Dg.

Bell, J.W., 1984, Quaternary fault map of Nevada--Reno sheet: Nevada Bureau of Mines and Geology Map 79.

Bell, J.W., 1981, Subsidence in Las Vegas Valley, Nevada: Nevada Bureau of Mines and Geology Bulletin 95, 84 p.

Bell, J.W., and Trexler, D.T., 1980, Earthquake hazards map, New Empire quadrangle: Nevada Bureau of Mines and Geology Map 1Bi.

Bell, J.W., and Smith, E.I., 1980, Geologic map, Henderson quadrangle: Nevada Bureau of Mines and Geology Map 67.

Trexler, 1980, Earthquake hazards map, South Lake Tahoe quadrangle: Nevada Bureau of Mines and Geology Map 2Ai.

Trexler, D.T., and Bell, J.W., 1980, Earthquake hazards map, Carson City quadrangle: Nevada Bureau of Mines and Geology Map 1Ai.

Bell, J.W., 1978, Geologic constraints map, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Map 3am.

Papke, K.C., and Bell, J.W., 1978, Energy and mineral resources map, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Map 3Ah.

Pewe, T.L., Bell, J.W., Williams, J.R., and Paige, R.A., 1976, Geologic map of the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map I-949.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map I-942.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 SW quadrangle, Alaska: U.S. Geological Survey Map I-829A.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map I-950.

Pewe, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1975, Geologic map of the Fairbanks D-2 NW quadrangle, Alaska: U.S. geological Survey Map I-907.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671B.

Pewe, T.L., and Bell, J.W., 1975, Map showing distribution of permafrost in the Fairbanks D-1 SW quadrangle, Alaska: U.S. Geological Survey Map 671A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669B.

Pewe, T.L., and Bell, J.W., 1975, Map showing permafrost in the Fairbanks D-2 SE quadrangle, Alaska: U.S. Geological Survey Map 669A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670B.

Pewe, T.L., and Bell, J.W., 1975, Map showing distribution of permafrost in the Fairbanks D-2 NE quadrangle, Alaska: U.S. Geological Survey Map 670A.

Pewe, T.L., and Bell, J.W., 1975, Map showing foundation conditions in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map 668D.

Pewe, T.L., and Bell, J.W., 1975, Map showing construction materials in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map 668C.

Pewe, T.L., and Bell, J.W., 1975, Map showing ground water conditions in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map 668B.

Pewe, T.L., and Bell, J.W., 1975, Map showing distribution of permafrost in the Fairbanks D-2 NW quadrangle, Alaska: U.S. Geological Survey Map MF-668A.

Pewe, T.L., and Bell, J.W., 1974, Map showing distribution of permafrost in the Fairbanks D-2 SW quadrangle, Alaska: U.S. Geological Survey Map I-829B.

Symposium Proceedings

Watters, R.J., Bell, J.W., and Reno, R., 1988, Engineering geology constraints on the preservation and distribution of Sherpa cultural sites, Khumbu Himal, Nepal, in, Marinos, P.G., and Koukis, G.C., eds., Proceedings: International Association of Engineering Geologists Annual Meeting, Athens, Greece, p. 1385-1391.

Bell, E.J., Trexler, D.T., and Bell, J.W., 1978, Computer-simulated composite earthquake hazard model for the Reno, Nevada, area: Proceedings of Second International Conference on Microzonation, San Francisco, California, p. 471-483.

Other Articles

Bell, J.W., Glancy, P.A., and Watters, R.J., 1989, Engineering geology of the Reno-Lake Tahoe area, Nevada, in, Keaton, J.R., and Morris, R., Engineering geology of western United States urban centers: American Geophysical Union Field Trip Guidebook T181, 28th International Geological Congress, p. 41-50.

dePolo, C.M., Bell, J.W., and Ramelli, A.R., 1989, The use of the relative comparison approach at Yucca Mountain and similarities between Yucca Mountain and the 1932 Cedar Mountain earthquake area, in, Late Cenozoic evolution of the southern Great Basin: Nevada Bureau of Mines and Geology Open-File Report 89-1.

Slemmons, D.B., and Bell, J.W., 1987, 1954 Fairview Peak earthquake, Nevada: Geological Society of America Centennial Field Guide-Cordilleran Section, p. 73-76.

Bell, J.W., 1984, Guidebook for selected Nevada earthquake areas: Western Geological Excursions, Guidebook for 1984 Annual Meeting, Geological Society of America, v. 4, p. 387-472.

Bell, J.W., 1984, Holocene faulting in western Nevada and recurrence of large-magnitude earthquakes, in Bell, J.W., ed., Guidebook for selected Nevada earthquake areas: Western Geological Excursions, Guidebook for 1984 Annual Meeting, Geological Society of America, v. 4, p. 388-402.

Bell, J.W., Slemmons, D.B., and Wallace, R.E., 1984, Roadlog, Reno to Dixie Valley-Fairview Peak earthquake areas: Western Geological Excursions, Guidebook for 1984 Annual Meeting, Geological Society of America, v. 4, p. 425-472.

Bell, J.W., 1981, Quaternary fault map of the Reno 1° x 2° quadrangle: U.S. Geological Survey Open-File Report 81-982, 62 p.

Bell, J.W., 1981, Results of leveling across fault scarps in Las Vegas Valley, Nevada, April, 1978-June, 1981: Nevada Bureau of Mines and Geology Open-File Report 81-5, 21 p.

Bell, J.W., 1980, Results of leveling across fault scarps in Las Vegas Valley, April, 1978-June, 1980: Nevada Bureau of Mines and Geology Open-File Report 80-7, 15 p.

Bell, J.W., and Pease, R.C., 1980, Soil stratigraphy as a technique for fault activity assessment in the Carson City area, Nevada: Proceedings of Conference X, Earthquake Hazards of the Wasatch and Sierra Nevada Frontal Fault Zones: U.S. Geological Survey Open-File Report 80-801, p. 577-600.

Bell, J.W., 1979, Results of leveling across fault scarps in Las Vegas Valley, Nevada, April 1978-April, 1979: Nevada Bureau of Mines and Geology Open-File Report, 12 p.

Bell, J.W., 1977, Geologic constraints, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 20 p.

Bell, J.W., 1977, Engineering geologic aspects, Las Vegas SE quadrangle: Nevada Bureau of Mines and Geology Open-File Report, 34 p.

Bell, J.W., and Scott, J.D., 1975, Age and correlation of fluvial terraces in San Juan and Bell Canyons, Orange County, California, in Ross, A., and Dowlen, R., eds., Studies on the geology of Camp Pendleton and western San Diego County, California: San Diego Association of Geologists, p. 33-35.

Abstracts

Bell, J.W., Ramelli, A.R., dePolo, C.M., Maurer, D.K., and Prudic, D.E., 1989, Extensional cracking along an active normal fault: a case for creep on a basin and range fault?: Seismological Society of America Seismological Research Letters, v. 60, no. 1, p. 30.

Bell, J.W., 1988, Quaternary geology studies in the 1954 Dixie Valley and 1932 Cedar Mountain earthquake areas, central Nevada: Geological Society of America Abstracts with Program, v. 20, no. 3, p. 142.

Dorn, R.I., Bell, J.W., and Peterson, F.F., 1988, Implications of rock varnish dating at Crater Flat, near Yucca Mountain, Nevada: Geological Society of America Abstracts with Program, v. 20, no. 7, p. 54.

Ramelli, A.R., Bell, J.W., and dePolo, C.M., 1988, Evidence for distributive faulting at Yucca Mountain, Nevada: Geological Society of America Abstracts with Program, v. 20, no. 7, p. 383.

Bell, J.W., dePolo, C.M., and Ramelli, A.R., 1987, The 1932 Cedar Mountain earthquake and its relationship to Yucca Mountain: Late Cenozoic evolution of the southern Great Basin--a workshop: University of Nevada-Reno.

dePolo, C.M., Bell, J.W., and Ramelli, A.R., 1987, Geometry of strike-slip faulting related to the 1932 Cedar Mountain earthquake, central Nevada: Geological Society of America Abstracts with Program, v. 19, no. 6, p. 371.

Bell, J.W., and Katzer, T.L., 1984, Quaternary tectonic history of the IXL Canyon quadrangle, Dixie Valley, Nevada: Geological Society of America Abstracts with Program, v. 16, no. 6, p. 442.

Bell, J.W., and Pewe, T.L., 1983, Mapping of permafrost in the Fairbanks area, Alaska, for urban planning purposes: Abstracts and program, Fourth International Permafrost Conference, Fairbanks, Alaska, p. 72.

Bell, J.W., 1982, Quaternary faulting in western Nevada: Geological Society of America Abstracts with Program, v. 14, no. 4, p. 149.

Bell, J.W., 1979, Origin of prehistoric faulting in Las Vegas Valley, Nevada: Geological Society of America Abstracts with Program, v. 11, no. 3, p. 69.

Bell, J.W., Ku, T.L., and Kukla, G.J., 1978, The Chemehuevi formation of Nevada, Arizona, and California: An examination of its distribution, facies, and age: Geological Society of America Abstracts with Program, v. 10, no. 3, p. 95.

Bell, J.W., and Lee, G.K., 1976, Description and age of pediment terraces along the lower Colorado River: America Quaternary Association, Abstracts of the fourth biennial meeting, p. 126.

Murray, K.S., and Bell, J.W., 1976, Northwest-trending structure in the Chocolate Mountains, southeastern California: Association of Engineering Geologists Abstracts of the 19th annual meeting, p. 25.

Lee, G.K., and Bell, J.W., 1975, Late Cenozoic geology along the Gila River near Gillespie Dam, central Arizona: Geological Society of America Abstracts with Program, v. 7, no. 3, p. 340-341.

Contract Reports and Unpublished Reports

Bell, J.W., dePolo, C.M., and Ramelli, A.R., 1988, Review of site characterization plan--consultation draft, Yucca Mountain site--Quaternary tectonics comments: Report submitted to the Nevada Nuclear Waste Project Office, 30 p.

Bell, J.W., Ramelli, A.R., and dePolo, C.M., 1988, Review of draft NRC generic technical position on guidance for determination of anticipated processes and events and unanticipated processes and events: Report submitted to Nevada Nuclear Waste Project Office, 7 p.

Bell, J.W., Ramelli, A.R., dePolo, C.M., Bonham, H.F., Jr., Fleming, K.L., and Varnum, N., 1988, Final report, Task 1, Quaternary geology and active faulting at and near Yucca Mountain: Center for Neotectonic Studies Report to Nevada Nuclear Waste Project Office, 235 p. with maps.

Bell, J.W., dePolo, C.M., and Ramelli, A.R., 1987, Final report, Task 1, Review of Quaternary geology and evaluation of potential for undetected Quaternary faults at and near Yucca Mountain, in Evaluation of the geologic relations and seismotectonic stability of the Yucca Mountain area, Nevada Nuclear Waste Site Investigation (NNWSI), Center for Neotectonic Studies Report to Nevada Nuclear Waste Project Office, 214 p.

Bell, J.W., 1986, Review of tectonics issue, Department of Energy environmental assessment, Yucca Mountain site: Report to State of Nevada Nuclear Waste Project Office, 12 p.

Bell, J.W., 1985, Review of draft environmental assessment, Yucca Mountain tectonics, in State of Nevada comments on the U.S. Department of Energy draft environmental assessment for the proposed high-level nuclear waste site at Yucca Mountain: Nevada Nuclear Waste Project Office Report, v. II, p. 13-43.

Murray, K.S., Bell, J.W., and Crowe, B.M., 1976, Stratigraphy and structure of the Orocopia, Chocolate, and Cargo Muchacho Mountains, southeastern California: Appendix 2.5L, Early Site Review Report, Sundesert Nuclear Power Project, 30 p.

Lee, G.K., and Bell, J.W., 1975, Depositional and geomorphic history of the lower Colorado River: Appendix 2.5D, Early Site Review Report, Sundesert Nuclear Power Project, 25 p.