OF-WTWI-1984-4

ACTIVE STRESS FIELD IN THE TEXAS PANHANDLE

by

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Prepared for the
U. S. Department of Energy
Office of Nuclear Waste Isolation
under contract no. DE-AC-97-83WM46615

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1984

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The south-central and southwestern United States can be divided into three distinct provinces based on the present distribution of stress: (1) Midcontinent, (2) southern Great Plains, and (3) Basin and Range (fig. 1; Zoback and Zoback, 1980). The Midcontinent province, a tectonically stable region extending from the Appalachians to the Texas Panhandle, is undergoing compressive stress in a NE-SW direction. The Basin and Range province, which includes the area from the Rio Grande Rift in central New Mexico to California and Oregon, is defined by active extension in a WNW-ESE direction. The southern Great Plains province is characterized by NE-SW extension. The Palo Duro Basin lies near the boundary between the southern Great Plains and Midcontinent provinces (fig. 1).

The present distribution of stress within the southern Great Plains province was defined by Zoback and Zoback (1980) on the bases of the NW-SE alignment of Late Cenozoic volcanic centers in northeastern New Mexico and fracture orientations in hydraulically fractured wells in the Permian Basin (fig. 2; Table 1). The orientation of stress in the southwestern part of the Midcontinent province is based on the hydraulic fracturing of a single well in the Anadarko Basin (fig. 2; Table 1). Zoback and Zoback (1980) could not define the location of the boundary between the southern Great Plains and the Midcontinent provinces because of a lack of data in the Texas Panhandle.

The Stone and Webster Engineering Corporation #1 Holtzclaw test well in southern Randall County (fig. 3) was hydraulically fractured to determine the orientation of the present stress field in the Palo Duro Basin. The predominant fracture orientations in the well were N40E and N60E, suggesting that the area is undergoing northeast-southwest compression. This would indicate that the northern part of the Palo Duro Basin is within the Midcontinent stress province. The apparent proximity of the basin to the boundary between the Midcontinent and southern Great Plains provinces, however, raises the possibility that the measurements in the Holtzclaw well are not representative of the entire basin. The closest stress measurement to the southwest of the Holtzclaw well was in Cochran County (fig. 2), approximately 90 miles away. In that well (TX-1; Table 1) the least principal stress direction was N24E. Therefore, additional stress determinations should be made within the Palo Duro Basin before the active stress field is fully characterized.

REFERENCE

Zoback, M. L., and Zoback, M., 1980, State of stress in the conterminous United States: Journal of Geophysical Research, v. 85, no. B11, p. 6113-6156.

FIGURES

Figure 1. Generalized stress map of the conterminous United States (from Zoback and Zoback, 1980). Arrows represent direction of either least (outward directed) or greatest (inward directed) principal horizontal compression. SGP = southern Great Plains; SBR = southern Basin and Range; RGR = Rio Grand Rift; PDB = Palo Duro Basin. Boundary between the Midcontinent and southern Great Plains provinces is not well defined.

Figure 2. Map of conterminous United States, showing least compressive horizontal principal stress direcitons (from Zoback and Zoback, 1980). Physiographic province boundaries are shown for reference. Numbers refer to corresponding state numbers in Table 1.

Figure 3. Map of Texas Panhandle showing outline of the Palo Duro Basin and the location of the Stone and Webster Engineering Corporation #1 Holtzclaw test well.

TABLE

Table 1. Stress data shown in figure 2 (from Zoback and Zoback, 1980).

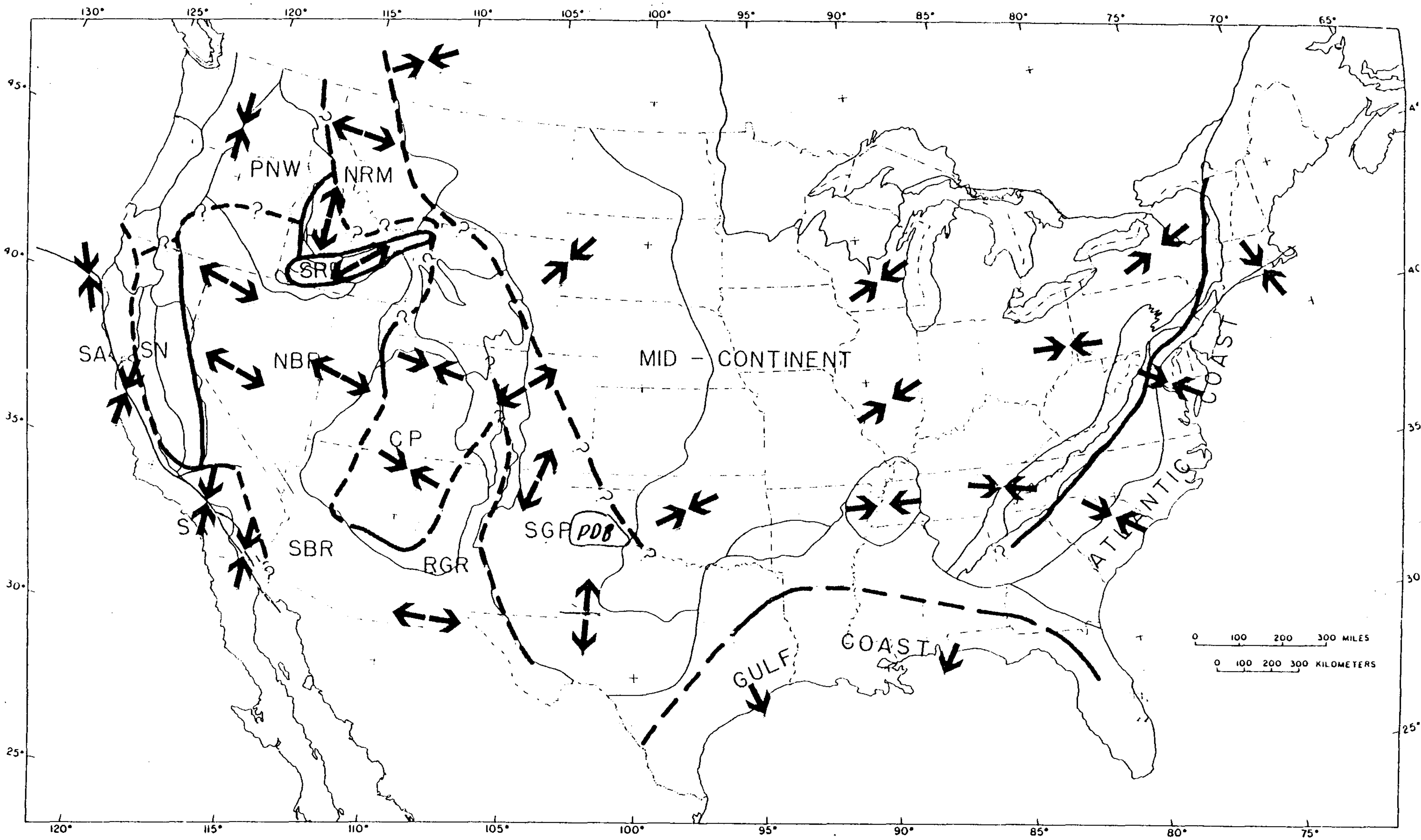
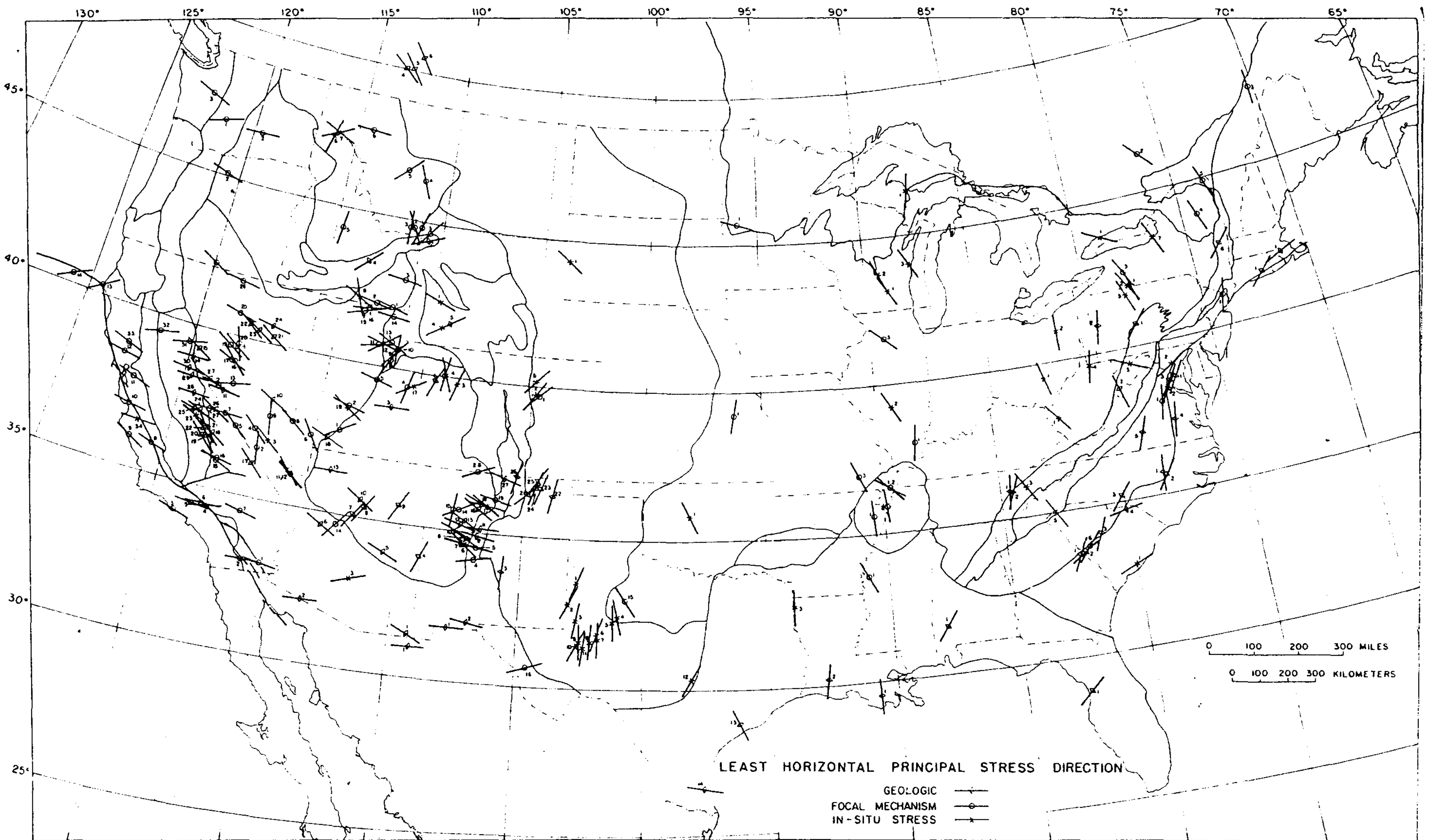


Fig 1 Generalized stress map of the conterminous United States. Stress provinces are the same as in Plate 2. Arrows represent direction of either least (outward directed) or greatest (inward directed) principal horizontal compression.

Figure 1



Map of conterminous United States, showing least compressive horizontal principal stress directions. Physiographic provinces are shown for reference. Numbers refer to corresponding state numbers in Table

Figure 2

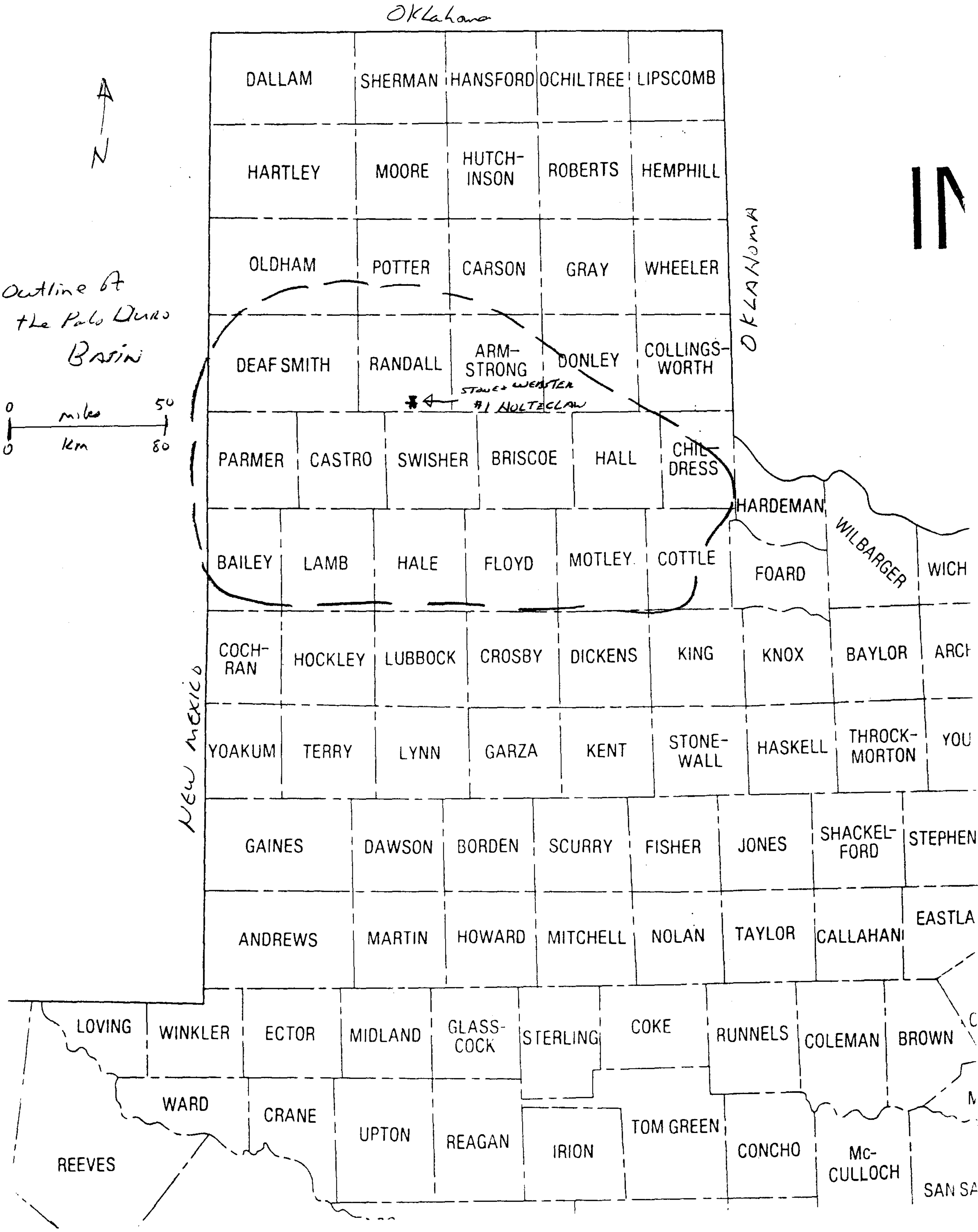

Oklahoma
N
Outline of the Palo Duro Basin
0 miles 50
0 Km 80
Stone & Webster #1 Holtclaw
OKLAHOMA
NEW MEXICO
DALLAM
SHERMAN
HANSFORD
OCHILTREE
LIPSCOMB
HARTLEY
MOORE
HUTCH-INSON
ROBERTS
HEMPHILL
OLDHAM
POTTER
CARSON
GRAY
WHEELER
DEAF SMITH
RANDALL
ARM-STRONG
DONLEY
COLLINGS-WORTH
PARMER
CASTRO
SWISHER
BRISCOE
HALL
CHIL-DRESS
HARDEMAN
WILBARGER
BAILEY
LAMB
HALE
FLOYD
MOTLEY
COTTLE
FOARD
COCH-RAN
HOCKLEY
LUBBOCK
CROSBY
DICKENS
KING
KNOX
BAYLOR
YOAKUM
TERRY
LYNN
GARZA
KENT
STONE-WALL
HASKELL
THROCK-MORTON
GAINES
DAWSON
BORDEN
SCURRY
FISHER
JONES
SHACKEL-FORD
ANDREWS
MARTIN
HOWARD
MITCHELL
NOLAN
TAYLOR
CALLAHAN
LOVING
WINKLER
ECTOR
MIDLAND
GLASS-COCK
STERLING
COKE
RUNNELS
COLEMAN
BROWN
WARD
CRANE
UPTON
REAGAN
IRION
TOM GREEN
CONCHO
Mc-CULLOCH
REEVES

TABLE 1. Stress Data

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					Alabama	
AL-1	Clarke County ~31.65°, 87.91°	N35°E	N	G-FS	average trend of several normal (growth) fault zones that offset lower Tertiary to Miocene-Quaternary beds	*Copeland* [1976]
					Arizona	
AZ-1	San Bernardino volcanic field 31.45°, 109.30°	N62°W	N	G-CC	basaltic cinder cones 0.2 to 3 m.y. old; best alinement on youngest cones	*Luedke and Smith* [1978*a*]
AZ-2	Pinacate volcanic field 32.12°, 113.50°	~E-W	N	G-CC	alinement of three major centers of eruption, <100,000 years old	*Donnelly* [1974]
AZ-3	Lakeshore mine ~33°, 111.7°	N73°E	N	OC	depth, 480 m; $S_{Hmin} \simeq \frac{1}{2} S_v$	*Bickel and Dolinar* [1976]
AZ-4	White Mountains volcanic field ~34°, 109.5°	N25°E	N?	G-CC	alinement of basaltic cinder cones, 2–3 m.y. old	*Luedke and Smith* [1978*a*] and *Merrill and Péwé* [1977]
AZ-5	Chediski quadrangle 34.02°, 110.60°	~N63°W	N?	G-CC	basalt overlies gravel, which overlies rim gravel; age <5 m.y., probably <3 m.y.; orientation based only on two cones	*Finnell* [1966]
AZ-6	Bagdad 34.58°, 113.21°	N58°W	N	G-FS(G)	right-lateral oblique slip on Hawkeye fault, which cuts late(?) Tertiary and Pleistocene(?) Gila(?) conglomerate	*C. A. Anderson et al.* [1955]
AZ-7	Sycamore Canyon primitive area 35.08°, 111.96°	N35°E	N?	G-D, CC	average trend; actual range in strike, N45°–73°W; based on a spatter cone alinement and numerous dikes exposed in canyon	*Huff et al.* [1966]
AZ-8	San Francisco volcanic field (SE) ~35.25°, 111.42°	N30°E	N	G-D, CC	basaltic cinder cones all <1 m.y. old; includes Sunset Crater rift zone (~1000 years old)	*Moore and Wolfe* [1976] and *Colton* [1967]
AZ-9	Hopi Buttes 35.42°, 110.17°	N30°W	?	G-CC, D	numerous dikes and cinder cones; monchiquite volcanism primarily 4–6 m.y. B.P.	*Akers et al.* [1971] and *Hack* [1942]
AZ-10	San Francisco volcanic field (N) 35.55°, 111.42°	N55°W	N	G-CC	basaltic cinder cones less than 1 m.y. old (Dog Knobs) alined parallel to Mesa Butte fault/graben system	*Babenroth and Strahler* [1945] and *Shoemaker et al.* [1978]
AZ-11	Lake Mead 36.0°, 114.7°	N46°W	SS	FM(C)	T axis plunge = 20°SE; P axis azimuth = N43°E, plunge = 20°SW	*R. B. Smith and A. G. Lindh* [1978]
AZ-12	Boulder Dam 36.03°, 114.73°	N54°W	N/SS	OC	overcore at 107-m depth, $S_{Hmax} = S_v >> S_{Hmin}$	*Merrill* [1964]
AZ-13	North Rim of Grand Canyon 36.42°, 113.17°	~E-W	N	G-CC	basaltic cinder cones 0.1–1.0 m.y. old	*Koons* [1945]
AZ-14	Prescott 34.66°, 112.58°	N39°E	N	FM(S)	primarily normal faulting based on surface wave solution, consistent with body wave data; T axis plunge = 5°NE; P axis azimuth = N73°, plunge = 84°W	*Eberhart-Phillips et al.* [1979]
					Arkansas	
AR-1	New Madrid (SW) 35.6[illegible]°, 90.5[illegible]°	N3°W	SS/T	FM(A)	average of two events with similar solutions; both have thrust and strike slip components	*Herrmann and Canas* [1978] and *Herrmann* [1979]
AR-2	New Madrid (NE) [illegible]5.9[illegible]°, 89.9[illegible]°	N4°W	SS	FM(S)	strike slip event, constrained with both body wave and surface wave solutions; T axis plunge = 32°S; P axis azimuth = N88°W, plunge = 9°W	*Herrmann and Canas* [1978] and *Herrmann* [1979]
					California	
CA-1	Brawley 32.92°, 115.5°	N81°W	SS	FM(A)	average stress directions taken from primarily strike slip earthquakes in left-stepping offset of San Andreas fault	*Hill* [1977]
CA-2	Borrego Mountain 33°, 116°	~E-W	SS	FM(A)	average trend of stress orientations based on 72 composite focal mechanisms of aftershocks of the 1968 Borrego Mountain earthquake; predominantly strike slip; a few thrust mechanisms	*Hamilton* [1972]
CA-3	Point Mugu 34.13°, 119.04°	N72°W	T/SS	FM(A)	1973 Point Mugu earthquake; average orientation based on main shock (thrust) and numerous aftershocks (thrust and strike slip)	*Stierman and Ellsworth* [1976]
CA-4	Palmdale 34.45°, 117.87°	N80°E	SS	HF	results from ~200-m depth in two wells adjacent to San Andreas fault; estimated [illegible]	*M. D. Zoback et al.* [1980b]

TABLE 1. (continued)

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					California (continued)	
CA-30	Markleeville quadrangle ~38.625°, 119.875°	N81°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-31	Truckee 39.43°, 120.17°	N78°E	SS	FM(S)	1956 Truckee earthquake; *T* axis plunge = 6°E; *P* axis azimuth = N2°W, plunge = 7°N	*Tsai and Aki* [1966]
CA-32	Oroville 39.5°, 121.5°	N77°E	N/SS	FM(S)	1975 Oroville earthquake; predominantly normal faulting; *T* axis plunge = 16°SW; *P* axis azimuth = N53°W, plunge = 64°SE	*Langston and Butler* [1976]
CA-33	Geysers–Clear Lake area ~38.75°, 122.75°	N70°W	SS	FM(A)	average stress orientations from 13 events, 12 strike slip and 1 dip slip	*Bufe et al.* [1980]
CA-34	Gabilan Range 36.69°, 121.35°	N88°E	SS	HF	average of two hydrofrac orientations at 167- and 185-m depth; accuracy, ±10°	*M. D. Zoback et al.* [1980*b*]
					Canada	
CN-1	Oshawa 43.88°, 78.85°	N65°W	T	HF	depth 230–300 m	*Haimson and Lee* [1979]
CN-2	Maniwaki 46.3°, 76.22°	N40°W	T/SS	FM(S)	predominantly thrust with component of strike slip; *P* axis trends N50°E, plunge = 19°NE	*Horner et al.* [1975] and *Sbar and Sykes* [1977]
CN-3	St. Lawrence region 47.5°, 70.2°	N-S	T/SS	FM(A)	average of six events with mean *P* axis trending E-W and with *T* axes that alternate between horizontal and vertical	*Leblanc and Buchbinder* [1977]
CN-4	southern Alberta 50.1°, 113.4°	N47°W	T/SS?	G-DE	average of mean stress orientations inferred from drill hole ellipticity resulting from breakouts in three wells (N49°W, N51°W, N40°W)	*Bell and Gough* [1979] *Babcock* [1978]
CN-5	southern Alberta 50.1°, 113.0°	N35°W	T/SS?	G-DE	average of mean stress orientations inferred from drill hole ellipticity resulting from breakouts in three wells (N24°W, N44°W, N36°W)	*Bell and Gough* [1979] and *Babcock* [1978]
CN-6	southern Alberta 50.85°, 112.55°	N33°W	T/SS?	G-DE	mean orientation of stress inferred from drill hole ellipticity resulting from breakouts (single well)	*Bell and Gough* [1979] and *Babcock* [1978]
					Colorado	
CO-1	Rocky Mountain Arsenal (Denver) 39.7°, 104.7°	~N45°E	N	FM(A)	earthquakes induced by fluid injection at Rocky Mountain Arsenal; surface wave mechanism, seismicity trend, and pressure required to trigger earthquakes suggest normal faulting on fault striking N45°W	*Healy et al.* [1968] and R. Herrmann (written communication, 1979)
CO-2	Henderson Project 39.77°, 105.83°	N38°E	N?	OC	overcores at different depths in three localities; only shallowest (624 m) had vertical and horizontal stress orientations; deeper two had principal stress axes with large plunge, and so horizontal azimuths not meaningful; shallow measurement, $S_1 = S_v$; in deeper measurements the axis with steepest plunge is S_3	*Hooker et al.* [1972]
CO-3	Piceance Basin 39.83°, 108.38°	N20°E	SS?	HF	average S_3 direction from six wells; at 0.5-km depth, $S_1 = S_v$ in one hole, $S_2 = S_v$ in three holes, and $S_3 < S_v$ in all holes	*Bredehoeft et al.* [1976]
CO-4	Rangely 40.10°, 108.88°	N20°W N12°E	SS SS	HF FM(C)	single hydrofrac measurement at depth of earthquake foci (~1.8 km); focal mechanism consistent with slip on preexisting fault; surface overcoring measurements somewhat scattered, least principal horizontal stress directions range between N27°W and N10°E	*Raleigh et al.* [1972] and *Haimson* [1973]
CO-5	Wattenberg 40.15°, 104.82°	N45°E	?	HF	orientations from seven wells as determined with surface electrical resistivity measurements and tiltmeters; result may be influenced by rock strength anisotropy	*M. B. Smith* [1979]

CA-5	San Fernando 34.41°, 118.40°	N85°E	T/SS	FM(A)	average of both main shock and aftershocks of 1971 San Fernando earthquake; includes strike slip and thrust events	*Whitcomb et al.* [1973]
CA-6	central Transverse Ranges 34.5°, 118°	E-W	T/SS	FM(A)	average stress orientation from 22 mechanisms for small events; predominantly thrusting on E-W planes; some strike slip on NE and NW planes	*Pechmann* [1980]
CA-7	Galway Lake 34.52°, 116.48°	N75°W	SS	FM, G-FS	right-lateral slip on vertical fault striking N25°W to N, on basis of first motion data, distribution of aftershocks, and ground breakage	*R. L. Hill and D. J. Beeby* [1977] and *Kanamori and Fuis* [1976]
CA-8	Parkfield 35.92°, 120.42°	N70°W	SS	FM(S)	1966 Parkfield earthquake, nearly pure strike slip event; *T* axis plunge = 13°E, *P* axis azimuth = N13°E, plunge = 14°S	*McEvilly* [1966]
CA-9	central coastal California ~36°, 121.5°	~N60°W	SS/T	FM(A)	average of 30 events; approximately equal number of strike slip and thrust events; range of *P* axes = N10°W–N60°E	*Gawthrop* [1977]
CA-10	San Francisco Bay area/central San Andreas fault ~37°, 121.5°	~N80°W	SS	FM(A)	average of 40 events, predominantly strike slip and some thrust; range of *T* axes N67°E–133°E, standard deviation ±33°	W. L. Ellsworth (written communication, 1979)
CA-11	Livermore Valley 37.83°, 121.67°	~N70°W	SS	FM(A)	average of 70 events representing seismicity from 1969–1979; predominantly strike slip with some thrust events; *T* axes azimuth range = N44°–96°W; *P* axes range = N7°W–N48°E with nearly all plunges ≤ 15°	*Ellsworth and Marks* [1980] and *Weaver and Hill* [1979]
CA-12	Santa Rosa 38.48°, 122.68°	N77°W	SS	FM(A)	average composite solution for aftershocks of 1969 Santa Rosa earthquake; *T* axis plunge = 2°W; *P* axis azimuth = N13°E, plunge = 11°N	*R. B. Smith and A. G. Lindh* [1978]
CA-13	Cape Mendocino 40.30°, 124.50°	N59°E	SS	FM(S)	purely strike slip event in 1962	*Bolt et al.* [1968]
CA-14	offshore Cape Mendocino 40.34°, 125.84°	N63°E	SS	FM(S)	purely strike slip event on Mendocino fracture zone	*Tobin and Sykes* [1968]
CA-15	China Lake 35.92°, 117.80°	N66°W	SS	FM(S)	purely strike slip solution	*R. B. Smith and A. G. Lindh* [1978]
CA-16	Coso Hot Springs 36.0°, 117.83°	N80°W	N/SS	FM(A) G-CC, D	both strike slip and normal fault events with consistent *T* axes; also consistent with Quaternary volcanic feeder trends	*Weaver and Hill* [1979] and *Duffield* [1975]
CA-17	Death Valley 36.1°, 116.8°	~N45°W	N	G-FS(G)	trend of striated surfaces on 'turtlebacks'	*Wright et al.* [1974]
CA-18	Owens Valley 36.75°, 118.2°	N57°W	N	G-FS(H)	1872 Owens Valley earthquake; oblique slip on NNW trending fault; used maximum vertical and right-lateral offsets (which occurred very close to one another) and average fault trend	*Bateman* [1971]
CA-19	Mount Whitney quadrangle ~36.625°, 118.275°	N34°W	SS	G-FS(G)	strain pattern deduced from near-conjugate sets of microfaults, stress direction taken as appropriate bisector of the angle between intersecting trends of right-lateral and left-lateral faults	*Lockwood and Moore* [1979]
CA-20	Triple Divide Peak quadrangle ~36.625°, 118.625°	N46°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-21	Mount Pinchot quadrangle ~36.875°, 118.375°	N43°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-22	Marion Peak quadrangle ~36.875°, 118.625°	N49°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-23	Dinkey Creek ~37.15°, 119°	N65°W	SS	HF	hydrofrac at 160 and 320 m; at deeper interval $S_{Hmax} \gtrsim S_v > S_{Hmin}$	*Haimson* [1976]
CA-24	Mount Abbott quadrangle ~37.375°, 118.875°	N68°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-25	Kaiser Peak quadrangle ~37.375°, 119.125°	N74°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-26	White Mountains 37°5°, 118.3°	N60°W	N	G-FS(G)	grooves and slickensides on fault bounding White Mountains	*Russell* [1977]
CA-27	Mono Lake area 37.5°, 118.5°	~E-W	SS	FM(C)	composite focal mechanism for strike slip events in Mono Lake–northern Owens Valley area	*Pitt and Steeples* [1975]
CA-28	Tuolumne Meadows quadrangle ~37.875°, 119.375°	N87°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]
CA-29	Sonora Pass quadrangle ~38.375°, 119.625°	N88°W	SS	G-FS(G)	see CA-19	*Lockwood and Moore* [1979]

					Connecticut	
CT-1	Colchester 41.5°, 72.25°	N32°E	T	G-FS	offset core holes indicate modern thrust motion on preexisting fault; grooves and slickenslides measured on slip surfaces	*Block et al.* [1979]
					Florida	
FL-1	Crystal River 28.85°, 82.53°	N47°E	N	G-FS	normal fault offsets Eocene strata ≈10 m	*Vernon* [1951]
					Georgia	
GA-1	Augusta 33.5°, 82.22°	N27°E	T	G-FS	late Cenozoic (possibly Holocene) age beds offset by high-angle reverse fault in Belair fault system	*Prowell et al.* [1975]
					Idaho	
ID-1	Cache Valley 42.05°, 111.8°	N77°W	N	FM(S)	1962 Cache Valley earthquake; nearly pure normal fault; *T* axis plunge = 13°W; *P* axis azimuth = N51°W, plunge = 76°SE	*R. B. Smith and M. L. Sbar* [1974]
ID-2	Pocatello 42.2°, 112.5°	N76°W	N	FM(S)	1975 Pocatello Valley earthquake; nearly pure normal fault	*Bache and Lambert* [1977] and *Arabasz et al.* [1979]
ID-3	Caribou Range 43.0°, 111.4°	N81°W	N	FM(C)	predominantly normal faulting, small strike slip component; *T* axis plunge = 10°W; *P* axis azimuth = N 10°W, plunge = 75°S	*Sbar et al.* [1972]
ID-4	central snake river Plain ~43.42°, 113.21°	~N48°E	N	G-CC	rift zone crossing plain marked by normal faults, open fissures, and cinder cones; age of associated basaltic volcanism is late Pleistocene (100,000–12,000 years B.P.)	*Kuntz* [1978]
ID-5	Salmon River Mountains 44.3°, 114.7°	N9°E	N	FM(S)	virtually a purely normal fault; *T* axis plunge = 1°N; *P* axis azimuth = N85°W, plunge = 83°W	*R. B. Smith and M. L. Sbar* [1974]
ID-6	Kellogg 47.33°, 116.06°	N15°E	N	HF	hydrofrac measurement at 2285-m depth; $S_3/S_1 = 0.42$	*Haimson* [1977*b*]
ID-7	Coeur d'Alene district 47.47°, 116.0°	N65°W N63°E	SS T	OC OC	depth, 1670 m; $S_{Hmax} >> S_v > S_{Hmin}$; depth, 1616 m, all stresses approximately equal in magnitude; measurements made in separate mines only 3 km apart	*Chan and Crocker* [1972] and *Skinner et al.* [1974]
ID-8	Raft River ~42.2°, 113.3°	N61°W N18°W	N	HF	hydrofracs determined from two different wells within geothermal field; more northerly fracture orientation that corresponds to N61°W stress direction, adjacent to north trending normal fault; nearly east-west fracture orientation near northeast lineament interpreted as fault	W. S. Keys (written communication, 1980)
					Illinois	
IL-1	southern 37.95°, 88.48°	N7°E	T	FM(S)	well-constrained single-event solution; *P* axis azimuth = N83°W, plunge = 1°E; *T* axis plunge = 82°	*Stauder and Nuttli* [1970]
IL-2	central 39.3°, 89.35°	N30°W	SS/T	HF	depth, 100 m; $S_1 > S_v = S_3$	*Haimson* [1974*a*]
IL-3	northern 41.6°, 89.4°	N51°W	SS	FM(S)	based on both surface wave and body wave solutions; *T* axis plunge = 28°SE; *P* axis azimuth = N38°E, plunge = 1°NE	*Herrmann* [1979]
					Kansas	
KS-1	northeastern 39.14°, 96.30°	N10°E	T	FM(S)	microearthquake solution, *P* and *T* axes constrained to ±10°	D. W. Steeples (written communication, 1979)
					Louisiana	
LA-1	southeastern ~29.6°, 90.75°	N	N	G-FS	active growth faults, general regional trend	*Howard et al.* [1978]
LA-2	southern ~30.2°, 92.8°	N8°E	N	G-FS	active growth faults, general regional trend	*Howard et al.* [1978]
LA-3	Caddo-Pine Island 32.67°, 94°	N	N/SS?	HF	depth, 425 m; maximum horizontal stress not measured; $S_v > S_3$	*Strubhar et al.* [1975]
					Maryland	
MR-1	Brandywine fault system 38.70°, 76.92°	~N32°E	T	G-FS	reverse fault indicated by drill hole and geophysical data	*Jacobeen* [1972]
MR-2	Sunshine 39.25°, 77.17°	N55°E	T	HF	depth, 417 m, in gneiss; at depths below 420 m, S_{Hmax} and $S_{Hmin} > S_v$, and were found to increase with depth	H. R. Pratt (written communication, 1980)

TABLE 1. (continued)

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					Massachusetts	
MS-1	Attleboro 41.94°, 71.32°	N67°E	T	G-FS(G)	postglacial vertical offsets on high-angle reverse faults	*Woodworth* [1907] and *Oliver et al.* [1970]
					Mexico	
MX-1	northern Sonora 31.08°, 109.17°	E-W	N	G-FS(H)	Sonoran earthquake ($M \sim 7.8$); generally N trending normal fault (±10°) with vertical slickensides	*Natali et al.* [1979]
					Michigan	
MC-1	Ishpenning 46.50°, 87.63°	N8°E	SS	OC	depth, 976 m	*Aggson* [1972]
					Minnesota	
MN-1	west-central 45.7°, 96.0°	N77°W	SS	FM(S)	strike slip event with thrust component; based on surface wave and body wave data; *T* axis plunge = 14°W; *P* axis azimuth = N17°E; plunge = 14°N	*Herrmann* [1979]
					Mississippi	
MI-1	west-central 33.6°, 90.9°	N25°W	SS	FM(S)	primarily strike slip event, constrained with both surface wave and body wave data; *T* axis plunge = 21°SE; *P* axis plunge = 7°NW	*Herrmann* [1979]
					Missouri	
MO-1	New Madrid area 36.5°, 89.7°	N47°W	SS/N	FM(S)	primarily strike slip with normal component; based on surface and body wave solutions; *T* axis plunge = 8°NW; *P* axis azimuth = N49°E, plunge = 34°NE	*Herrmann* [1979]
MO-2	New Madrid area 36.5°, 89.6°	N59°W	SS/T	FM(S)	primarily strike slip with thrust component; based on surface wave and body wave solutions; *T* axis plunge = 28°NW; *P* axis azimuth = N43°E, plunge = 19°NE	*Herrmann* [1979]
MO-3	Ozark uplift 37.5°, 91.0°	N24°W	N	FM(S)	primarily normal fault; based on surface wave and body wave solutions; *T* axis plunge = 7°SE; *P* axis azimuth = N87°W, plunge = 76°W	*Herrmann* [1979]
					Montana	
MT-1	Hegben Lake 44.75°, 111.18°	N18°E	N	FM(S+A)	1959 Hegben Lake earthquake, primarily normal faulting; *T* axis plunge = 19°S; *P* axis azimuth = N3°E, plunge = 70°N; consistent stress orientation obtained from a number of recent microearthquakes in the area	*Ryall* [1962] and *Bailey* [1976]
MT-2	southeastern Madison Valley 44.8°, 111.43°	N26°W	N	FM(C)	nearly purely normal faulting; *T* axis plunge = 8°N; *P* axis azimuth = N24°E, plunge = 82°S	*Trimble and Smith* [1975]
MT-3	Madison Valley 44.8°, 111.6°	N2°E	SS	FM(S)	predominantly strike slip event; *T* axis plunge = 30°N; *P* axis azimuth = N88°E, plunge = 7°W	*R. B. Smith and M. L. Sbar* [1974]
MT-4	southeast of Helena 46.4°, 111.3°	N21°W	SS	FM(S)	1925 Montana earthquake ($M = 6.7$), predominantly strike slip; poorly constrained; from one of Byerly's first determinations of first motion patterns; *T* axis plunge = 8°N; *P* axis azimuth = = N71°E, plunge = 7°W	*Byerly* [1926] and *R. B. Smith and M. L. Sbar* [1974]
MT-5	Helena ~46.67°, 112.17°	N45°E	N/SS	FM(A)	average of composite solutions for three swarms; two solutions were primarily normal faulting, one mostly strike slip, all have comparable *T* axes (±10°)	*Friedline et al.* [1976]
MT-6	Flathead Lake 47.8°, 114.3°	N86°W	N/SS	FM(A)	average of two composite focal mechanisms, one strike slip and one normal, with *T* axes trending ~N85°W and ~N87°W, respectively; $S_{vert} \approx S_{Hmax}$	*Sbar et al.* [1972] and *Stevenson* [1976]

					Nevada	
NV-1	Lake Mead area 36.08°, 114.74°	N38°W	N/SS	FM(A)	average of two composite mechanisms, one is a strike slip and one normal, with similar *T* axes	*A. M. Rogers and W. H. K. Lee* [1976]
NV-2	northwest of Las Vegas 36.60°, 116.27°	N6°W	N	FM(S)	predominantly normal event with a small strike slip component; *T* axis plunge = 3°N; *P* axis azimuth = N77°E, plunge = 66°SE	*R. B. Smith and A. G. Lindh* [1978]
NV-3	Nevada Test Site (NTS) 37°, 116°	N50°W	N/SS	G, HF, OC, FM	based on trends of Quaternary faulting, strain measurements, tectonic cracking, focal mechanisms (including both strike slip and normal events), overcoring, and hydrofrac measurements	*Carr* [1974], *Fischer et al.* [1972], and *Haimson et al.* [1974]
NV-4	northwest of NTS 37.2°, 116.5°	N45°W	N/SS	FM(A)	consistent *T* axis orientation from two composite events, one pure strike slip, the other normal	*Hamilton and Healy* [1969]
NV-5	California-Nevada border 37.13°, 117.32°	N50°W	N	FM(S)	predominantly normal event with strike slip component; *T* axis plunge = 30°NW; *P* axis azimuth = N85°W, plunge = 45°E	*R. B. Smith and A. G. Lindh* [1978]
NV-6	southern Utah-Nevada border 37.4°, 114.2°	N30°W	SS	FM(S)	nearly purely strike slip mechanism; *T* axis plunge = 16°SE; *P* axis azimuth = N59°E, plunge = 0°	*R. B. Smith and M. L. Sbar* [1974]
NV-7	Silver Peak Range 37.47°, 117.87°	N88°W	N	FM(S)	predominantly normal event with small strike slip component; *T* axis plunge = 3°W; *P* axis azimuth = N15°E, plunge = 63°N	*R. B. Smith and A. G. Lindh* [1978]
NV-8	Northern Pahroc Range 37.73°, 115.05°	N51°W	N	FM(S)	predominantly normal event with strike slip component; *T* axis plunge = 30°SE; *P* axis azimuth = N16°W, plunge = 81°N	*R. B. Smith and A. G. Lindh* [1978]
NV-9	Southern Quinn Canyon Range 37.75°, 116.0°	N6°W	SS	FM(C)	predominantly strike slip, *T* axis plunge = 15°S; *P* axis azimuth = N87°E, plunge = 2°W	*R. B. Smith and A. G. Lindh* [1978]
NV-10	Lunar Crater volcanic field 38.25°, 116.0°	N60°W	N	G-CC	average trend of alinements of basaltic craters, cones, mounds, and fissure vents; basalts tentatively Quaternary, possibly Holocene	*Scott and Trask* [1971]
NV-11	Candelaria Hills 38.2°, 118.15°	N82°W	N/SS	G-FS(G)	large component of left-lateral slip on an ~E-W trending fault	*Speed and Cogbill* [1979]
NV-12	Excelsior Mountains 38.3°, 118.4°	N75°W	N	FM(C)	predominantly normal event with strike slip component; *T* axis plunge ≃ 0°; *P* axis azimuth ≃ N10°E, plunge ≃ 60°S	*Ryall and Priestley* [1975]
NV-13	Cedar Valley 38.5°, 117.8°	~N80°E	N	FM(C)	predominantly normal event with strike slip component; *T* axis plunge = 21°W; *P* axis azimuth = N33°E, plunge = 59°N	*Gumper and Scholz* [1971]
NV-14	Genoa 39.0°, 119.8°	~E-W	N	G-FS(G)	well-exposed bedrock scarp	*Thompson and Burke* [1973]
NV-15	Comstock–Virginia City 39.3°, 119.6°	N60°W	N	G-FS(G)	based on surface and subsurface observations	*Thompson and Burke* [1973]
NV-16	Fairview Peak, south zone 39.2°, 118.0°	~N44°W	N	FM(C)	pure normal faulting; *T* axis plunge = 5°NW; *P* axis azimuth = N44°W, plunge = 85°SE	*Ryall and Malone* [1971]
NV-17	Fairview Peak, central zone 39.2°, 18.1°	N65°W	N/SS	FM(A)	average of similar composite mechanisms and single mechanism for 1954 earthquake, combination normal and strike slip component; *T* axes plunge 2°–3°, *P* axes plunge 40°–45°	*Romney* [1957] and *Ryall and Malone* [1971]
NV-18	Dixie Valley 39.7°, 118.0°	N55°W	N	G-FS(G)	mean extension direction based on 55 measurements along fault zone on west side of Dixie Valley	*Thompson and Burke* [1973]
NV-19	Rainbow Mountain 39.7°, 118.4°	N56°W	N	FM(C)	purely normal faulting; *T* axis plunge = 5°NW; *P* axis azimuth = N56°W, plunge = 85°SE	*Ryall and Malone* [1971]
NV-20	Fairview Peak, north zone 39.8°, 118.0°	~N14°W	N	FM(C)	predominantly normal with strike slip component; *T* axis plunge = 1°N; *P* axis azimuth = N53°E, plunge = 59°SW	*Ryall and Malone* [1971]
NV-21	Cortez 40.2°, 116.5°	N55°W	N	G-FS(G)	well-exposed Holocene bedrock scarp; mean extension direction based on 56 measurements along 8-km length of fault	*M. L. Zoback* [1978] and *Muffler* [1964]
NV-22	Pleasant Valley 40.3°, 117.6°	N50°–70°W	N	G-FS(H)	based on offsets on scarps formed during 1915 Pleasant Valley earthquakes	*Wallace* [1979]
NV-23	Buffalo Valley 40.37°, 117.33°	N60°W	N	G-CC	trend of zone of basaltic cinder cones 1.35 ± 0.15 m.y. old	*Trexler et al.* [1978]
NV-24	Argenta Rim 40.6°, 116.75°	N77°W	N	G-FS(G)	average of five directions measured in one locality	*M. L. Zoback* [1978]
NV-25	Black Rock Desert 40.75°, 119.25°	N75°W	N	FM(A), G-FS	average of several microearthquake focal mechanisms, also based on trends of "tectonic" cracks and Quaternary faulting	*Grose* [1978] and *Kumamoto* [1978]
NV-26	Denio 41.83°, 118.48°	~N80°W	N	FM(C)	normal faulting event with strike slip component; *T* axis plunge = 0°; *P* axis azimuth = ~N45°E, plunge ≃ 45°SW	*Richins* [1974] and *R. B. Smith and A. G. Lindh* [1978]
NV-27	Wassuk Range ~38.5°, 118.75°	N70°W	N	G-FS(G)	slip in shear zones along range front fault; average direction from 58 measurements	R. C. Bucknam (written communication, 1979)

TABLE 1. (continued)

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					New Jersey	
NJ-1	Ramapo fault 41.0°, 74.25°	~N10°E	T(SS)	FM(A)	modern slip on reactivated Triassic normal fault (Ramapo fault); predominantly thrust events, some strike slip; average *P* axis trends N80°W ± 20°	*Aggarwal and Sykes* [1978]
					New Mexico	
NM-1	Tres Hermanas Mountains 31.83°, 107.80°	~E-W	N	G-D,CC	basaltic volcanism, latest Tertiary-Quaternary	*Balk* [1962]
NM-2	Potrillo volcanic field ~32°, 107°	~N80°W	N	G-CC	basaltic volcanism about 100,000 years old	*Luedke and Smith* [1978*a*] and *Hoffer* [1976]
NM-3	north of Carrizozo 33.8°, 105.83°	~N5°E	N?	G-D,CC	Broken Back Carter and Little Black Peak, Pleistocene and Holocene in age	*C. T. Smith* [1964] and *Weber* [1964]
NM-4	Socorro 34.12°, 106.92°	N80°E	N	FM(A)	average *T* direction taken from three composite solutions; all normal events	*Sanford et al.* [1979]
NM-5	Belen 34.5°, 106.85°	N81°W	N/SS	FM(A)	average *T* direction taken from four composite solutions, two events nearly pure normal faulting and two strike slip	*Sanford et al.* [1979]
NM-6	northern Socorro County 34.55°, 107.33°	~N50°W	N	G-FS(G)	normal faults striking N10°W with consistent right-lateral components of motion	*Jicha* [1958]
NM-7	Valencia, Socorro, and Catron Counties 34.62°, 107.53°	N80°W	N	G-CC	basaltic volcanism 1–5 m.y. B.P.	*Luedke and Smith* [1978*a*] and *Winchester* [1920]
NM-8	west of Los Lunas 34.80°, 107.35°	N61°W	N	G-D	trend of single basaltic dike, Quaternary in age	*Wright* [1946]
NM-9	Cat Hills 34.88°, 106.87°	N79°W	N	G-CC	basaltic volcanism 140,000 years old	*Luedke and Smith* [1978*a*]
NM-10	Grants 35°, 48.81°	N67°W	N	G-D	basaltic dike (latest Pliocene or Quaternary) adjacent to Mal Pais volcanic field, which is marked by a prominent NNE trending gravity high	*Thaden et al.* [1967] and L. Cordell (written communication, 1979)
NM-11	Albuquerque 35.15°, 106.77°	N87°W	N	G-CC	spectacular alinement of 18 basaltic cones, 190,000 years old	*Kelley* [1969]
NM-12	Mount Taylor volcanic field 35.33°, 107.63°	N70°–75°W	N	G-CC, D	basaltic volcanism, Pliocene to Holocene	*Hunt* [1938] and *Moench and Schlee* [1967]
NM-13	southeastern McKinley County 35.37°, 107.48°	N60°W	N	G-CC	based on several cinder cone alinements and trends of numerous parallel faults, 2–3 m.y. old	*Cooper and John* [1968]
NM-14	northwest of Mount Taylor 35.7°, 107.73°	N63°E	SS	FM(S)	predominantly strike slip event, no information on plunge of *P* and *T* axes	*Sanford et al.* [1979]
NM-15	northwest of Mount Taylor 35.7°, 107.98°	N7°E	SS	FM(S)	predominantly strike slip event, no information on plunge of *P* and *T* axes	*Sanford et al.* [1979]
NM-16	Bernillo 35.83°, 106.83°	N55°W	N	G-FS(G)	normal fault striking N5°W with a component of right-lateral slip in addition to dip slip	*Woodward* [1977]
NM-17	Jemez Mountains 35.92°, 106.83°	N55°W N80°W	N N?	HF G-D, CC	Hydrofrac measurements to depths of 2.93 km; average trend of Quaternary dikes and cinder cones, also Vallez caldera elongation	*Haimson* [1977*b*] and *R. L. Smith et al.* [1970]
NM-18	Naciemento uplift 36.0°, 106.88°	N62°W	N	FM(C)	predominantly normal with strike slip component; no information given on plunge of *P* or *T* axes	*Sanford et al.* [1979]
NM-19	Espanola 36.14°, 106.27°	N75°W	N	FM(C)	predominantly normal event; no information on plunge of *P* or *T* axes	*Sanford et al.* [1979]
NM-21	Western Raton volcanic field 36.42°, 104.92°	N48°E	N?	G-D	basaltic dikes generally 3–5 km long, late Tertiary or Quaternary in age	*Griggs* [1948]

NM-22	southeast of Raton 36.53°, 103.25°	N14°E	N?	G-CC	based on several basaltic cinder cone alinements, (>5 m.y. old); longest alinement Don Carlos Hills, contains 16 cones within 22 km	*Baldwin and Muehlberger* [1959]
NM-23	Raton volcanic field 36.62°, 104.33°	N23°E	N?	G-D	well-exposed basaltic dike swarm with average trend of N67°W; probably 2–3 m.y. old on basis of nearby flows	*Wood et al.* [1953]
NM-24	Raton volcanic field 36.67°, 104.57°	N20°E	N?	G-D	several well-exposed basaltic dike swarms with average trend ~N70°W; late Tertiary or Quaternary in age	*Griggs* [1948]
NM-25	Mora County 36.87°, 104.5°	N36°E	N?	G-D	basaltic dike ~8 km long; probably 3–4 m.y. old on basis of nearby flows	*Wanek* [1962]
NM-26	Sangre de Cristo Mountains 36.98°, 105.40°	N74°W	N?	G-D	basaltic dike which intrudes Quaternary fan gravels	*McKinlay* [1956]
NM-27	Taos plateau 36.84°, 105.95°	N73°W	N	G-CC, FS	basaltic volcanism 3–4 m.y. B.P.; Lambert mentions transform-style near-vertical faults that trend nearly E-W and have horizontal slickensides	*Luedke and Smith* [1978*a*] and *Lambert* [1966]
NM-28	Dulce 37.0°, 107.0°	N73°E	N	FM(S)	normal fault solution well constrained by surface wave data and by body wave waveforms; T axis plunge = 1°E; P axis plunge = 83°; focal depth = 3 km	R. B. Herrmann (written communication, 1980)
					New York	
NY-1	Alma Township 42.08°, 78°	N15°W	SS/T	HF	depth, 510 m; $S_{Hmax} > S_v = S_{Hmin}$	*Haimson* [1974*a*]
NY-2	Allegany County 42.08°, 78°	N30°W	?	HF	only orientation given, no information on magnitudes or depth	*Overbey and Rough* [1968]
NY-3	Attica 42.8°, 78.2°	N29°W	SS/T	FM(S)	based on surface wave and body wave solutions; T axis plunge = 28°W; P axis azimuth = N62°E, plunge = 1°NE	*Herrmann* [1979]
NY-4	Blue Mountain Lake 43.88°, 74.33°	N19°W	T	FM(A)	average of numerous thrust events	*Sbar et al.* [1972]
NY-5	Altona 44.90°, 73.67°	N17°W	T	FM(S)	predominantly thrust event; P axis azimuth = N73°E, plunge = 8°E; T axis plunge = 84°	*Aggarwal et al.* [1977]
NY-6	Pumpkin Hollow 42.83°, 73.66°	~N40°E	T	G-FS	reverse faults cutting Pleistocene gravels; average strike and dip of faults is N40°E, 65°SE	*Oliver et al.* [1970]
NY-7	Oswego 43.45°, 76.52°	N23°W	T	OC	depth, 810 m	N. Tillman (oral communication, 1980)
					North Carolina	
NC-1	Flowers 35.66°, 78.27°	~N7°E	T	G-FS	reverse fault offsetting Pleistocene or Pliocene deposits; significant lateral offsets may have occurred	*Daniels and Gamble* [1972]
NC-2	Stancils Chapel 35.57°, 78.18°	~N35°E	T	G-FS	reverse fault offsetting Tertiary deposits	*Prowell* [1980]
NC-3	Mount Gilead 35.17°, 80.08°	~N39°E	T	G-FS	reverse fault offsetting lower Tertiary deposits	*White* [1952]
					Ohio	
OH-1	Hocking County/Falls Township 39.5°, 82.5°	N25°W	SS	HF	depth, 810 m	*Haimson* [1974*a*]
OH-2	Barberton 41.01°, 81.64°	N-S	SS/T	OC	depth, 701 m; $S_{Hmax} >> S_v \simeq S_{Hmin}$	*Obert* [1962]
					Oklahoma	
OK-1	Kingsfisher County 35.9°, 97.9°	N25°W	?	HF	depth and magnitudes of stresses not given	*von Schonfeldt et al.* [1973]

TABLE 1. (continued)

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					Oregon	
OR-1	Adel 42.17°, 119.92°	N60°W	N/SS	FM(S)	1968 Adel (Warner Valley) earthquake; combination normal and strike slip faulting; P axis azimuth = N65°E, plunge = 35°NE; T axis plunge = 13°SE	*Schaff* [1976]
OR-2	Deschutes Valley 45.15°, 120.86°	N72°W	T	FM(C)	1976 Deschutes Valley earthquake; composite mechanism using foreshocks, mainshock, and aftershocks; P axis azimuth = N18°E, plunge = 13°S; T axis plunge = 77°	*Couch et al.* [1976]
					Pennsylvania	
PA-1	Port Matilda 40.78°, 78.07°	N50°E	T	G-FS(C)	modern offset of core holes exposed in road cut, motion on preexisting reverse fault	*Schäfer* [1979]
PA-2	Millerstown 40.55°, 77.58°	N10°E	T	G-FS(C)	modern offset of core holes exposed in road cut, motion on preexisting reverse fault	*Schäfer* [1979]
PA-3	McKean County 41.8°, 78.6°	N20°W	?	HF	depth and stress magnitudes not reported	*Overbey and Rough* [1968]
					South Carolina	
SC-1	Summerville 32.60°, 80.32°	N65°E	N?	HF	average of two impression orientations in depth range 100–340 m; estimated accuracy of orientation, ±20°	*M. D. Zoback et al.* [1978]
SC-2	Langley 33.53°, 81.85°	N55°E	N	G-FS	post-Eocene motion on normal faults with average trend of N35°W ±5°	*Inden and Zupan* [1975]
SC-3	west of Columbia 34.00°, 81.00°	N23°E	?	G-D	orientation of post-Eocene(?) clastic dikes	*Zupan and Abbot* [1975]
SC-4	Cheraw 34.75°, 80.0°	N78°E	T	G-FS	post-Eocene motion on reverse faults with average trend of N78°E	*Howell and Zupan* [1974]
SC-5	Lake Jocassee 35.0°, 82.87°	N30°W	T	HF	depth, 185–255 m; stress orientation subparallel to topography; $S_{Hmax} > S_{Hmin} > S_v$	*Haimson*, 1976
SC-6	Trenton 33.74°, 81.71°	N55°E	T	FM(S)	poorly constrained pure reverse fault body wave mechanism; faults striking N18°E also allowable; in either case, P axes plunge <10°; T axes plunge ≈85°	A. Tarr and P. Talwani (written communication, 1980)
					South Dakota	
SD-1	Lead 44.35°, 103.80°	N40°W	N	OC	depth, 1890 m; $S_v > S_{Hmax} > S_{Hmin}$	*Aggson and Hooker* [1980]
					Tennessee	
TN-1	Rockwood-Harriman 35.90°, 84.67°	N10°E	T	G-FS(C)	modern offset of core holes exposed in road cut, motion on preexisting reverse fault	*Schäfer* [1979]
TN-2	Rockwood-Harriman 35.9°, 84.53°	N20°E	T	G-FS(C)	average horizontal component of shortening on core hole offsets; N70°W; range in values E-W to N50°W	*Schäfer* [1979]
TN-3	Knoxville 36.0°, 83.95°	~N32°W	T	OC	overcore at 282-m depth	*Aggson and Hooker* [1980]
					Texas	
TX-1	Morton ~33.65°, 102.7°	N24°E	?	HF	average of fracture orientations in three wells, 5° range in values; depth range, 1.52–1.55 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-2	Denver City ~32.92°, 103.05°	N29°E	?	HF	average of fracture orientations in three wells, 4° range in values; depth, 2.32 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-3	Andrews ~32.3°, 102.75°	N6°E	?	HF	average of fracture orientations in four wells, 33° range in values; depth range, 1.3–1.4 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]

TX-4	west of Snyder ~32.5°, 101.12°	N12°W	?	HF	average of fracture orientations in two wells, 18° range in values; depth, 915 m; no information on relative magnitude of stresses.	*Zemanek et al.* [1970]
TX-5	Big Spring ~32.3°, 101.2°	N6°W	?	HF	average of fracture orientations in three wells, 22° range in values; depth range, 820–915 m; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-6	southeast of Midland ~31.87°, 101.85°	N17°E	?	HF	one well; depth, 2.13 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-7	southeast of Midland ~31.7°, 101.9°	N3°E	?	HF	one well; depth, 2.59 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-8	southwest of Odessa ~31.62°, 102.15°	N4°E	?	HF	average of fracture orientations in two wells, 3° range in values; depth, 2.38 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-9	Monahans ~31.62°, 102.6°	N5°E	?	HF	average of fracture orientations in four wells, 29° range in values; depth 1.04 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-10	south of Monahans ~31.5°, 102.67°	N29°E	?	HF	one well; depth, 1.43 km; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-11	southeast of Monahans ~31.42°, 102.45°	N9°E	?	HF	one well; depth, 975 m; no information on relative magnitude of stresses	*Zemanek et al.* [1970]
TX-12	Marble Falls 30.57°, 98.27°	N23°E	SS(T)	HF	depth, 346 m; $S_{Hmax} >> S_v \gtrsim S_{Hmin}$	*Roegiers and Fairhurst* [1973]
TX-13	southeastern 28.9°, 96.30°	N26°W	N	G-FS	active growth faults, general regional trend	*Howard et al.* [1978]
TX-14	southern 26.75°, 97.72°	N81°W	N	G-FS	active growth faults, general regional trend	*Howard et al.* [1978]
TX-15	Snyder 33.0°, 100.7°	N31°W	N	FM(S)	predominantly normal with strike slip component; based on surface wave and body wave solutions; *T* axis plunge = 9°NW; *P* axis azimuth = N36°E, plunge = 60°S; depth ≃ 3 km	*Voss and Herrmann* [1980]
TX-16	Valentine 30.69°, 104.57°	N74°E	SS	FM(S)	1931 Valentine earthquake, nearly purely strike slip event; *T* axis plunge = 12°W; *P* axis azimuth = N16°W, plunge = 12°S	*Dumas et al.* [1980]
					Utah	
UT-1	Cedar City 37.8°, 113.03°	N60°E	N	FM(S)	normal fault event, *T* axis plunge = 10°E; *P* axis plunge = 76°	*R. B. Smith and M. L. Sbar* [1978]
UT-2	Cove Fort 38.58°, 112.83°	N75°W	N	FM(C)	predominantly normal with strike slip component; *T* axis plunge = 34°W; *P* axis azimuth = N54°W, plunge = 54°SE	*R. B. Smith and A. G. Lindh* [1978]
UT-3	west of San Rafael swell 38.75°, 111.0°	E-W	N?	G-D	basaltic dikes, latest Pliocene in age	P. T. Delaney (oral communication, 1979)
UT-4	Price 39.5°, 110.5°	N15°E	T	FM(C)	predominantly thrust event; *T* axis plunge = 65°; *P* axis azimuth = N75°W, plunge = 25°W	*R. B. Smith et al.* [1974*a*]
UT-5	Nephi 39.6°, 111.9°	N74°W	N/SS	FM(S)	approximately equal components of strike slip and normal faulting; *T* axis plunge = 20°E; *P* axis azimuth = N40°E, plunge = 48°S	*R. B. Smith and M. L. Sbar* [1974]
UT-6	Uinta basin 39.83°, 109.25°	N25°E	?	G-D	Gilsonite dikes, post-Eocene in age; mapped as cutting Quaternary alluvium	*Untermann and Untermann* [1964]
UT-8	Heber City (south) 40.4°, 111.4°	N27°E	T	FM(C)	motion on very high-angle reverse fault (dip = 80°) or low-angle thrust; *T* axis plunge = 55°, least horizontal stress taken as null axis: N27°E, plunge = 0°	*Arabasz et al.* [1979]
UT-9	Heber City (central) 40.52°, 111.31°	N41°E	N	FM(C)	predominantly normal event; *T* axis plunge = 17°NE; *P* axis plunge = 67°	*Langer et al.* [1979]
UT-10	Heber City (north) 40.6°, 111.2°	N3°E	T	FM(C)	motion on very high angle reverse fault (dip = 80°) or low-angle thrust (dip = 10°); *T* axis plunge = 55°, least horizontal stress direction taken as null axis: N3°E, plunge = 2°N	*Arabasz et al.* [1979]
UT-11	Salt Lake City 40.72°, 112.04°	N98°W	N	FM(C)	predominantly normal fault event; *T* axis plunge = 14°SW; *P* axis plunge = 72°	*Arabasz et al.* [1979]
UT-12	Salt Lake City 40.78°, 111.88°	N72°W, N125°W	N	G-FS(G)	two consistent groove sets found on two faults whose strike varied by nearly 90°	*Pavlis and Smith* [1980]

TABLE 1. (continued)

Site	Location*	Least Principal Horizontal Stress Orientation	Stress Regime†	Type of Indicator‡	Comments	References
					Utah (continued)	
UT-13	east of Salt Lake City 40.8°, 111.5°	N60°W	N	FM(C)	predominantly normal fault event; *T* axis plunge *P* axis plunge = 64°	*Arabasz et al.* [1979]
UT-14	Logan ~41.7°, 111.7°	N84°W	N	FM(C)	nearly purely normal fault event; *T* axis plunge = 15°E; *P* axis plunge = 75°	*Arabasz et al.* [1979]
UT-15	near Idaho-Utah border 41.8°, 112.9°	N105°W	N	FM(S)	1934 Hansel Valley earthquake, predominantly normal event; *T* axis plunge = 30°NE; *P* axis azimuth = N60W, plunge = 50°W	*Dewey et al.* [1972]
UT-16	Idaho-Utah border 41.9°, 112.66°	N103°W	N	FM(C)	predominantly normal with strike slip component; *T* axis plunge = 2°W; *P* axis azimuth = N19°W, plunge = 57°S	*Richins* [1979]
UT-17	Sunnyside 39.57°, 110.40°	N59°E	T	OC	depth, 323 m; $S_{Hmax} > S_{Hmin} >> S_v$	*Aggson and Hooker* [1980]
UT-18	St. George 37.40°, 113.55°	~N65°W	N	G-CC	basaltic cinder cone <5 m.y. old	*Luedke and Smith* [1978*b*]
UT-19	Roosevelt Hot Springs 38.51°, 112.85°	~N55°W	N	HF	drilling induced hydrofrac in geothermal area	*Keys* [1979]
					Virginia	
VA-1	North Anna 38.03°, 77.73°	N10°E	T	FM(A)	average of composite predominantly thrust mechanisms; *P* axes range from N80° to 120°E	*Dames and Moore* [1976]
VA-2	Stafford fault zone 38.40°, 77.37°	N33°E	T	G-FS	latest Tertiary, possibly Quaternary reverse slip on fault trending N33°E	*Mixon and Newell* [1977]
VA-3	Falls Church 38.92°, 77.23°	~N35°E	T	G-FS	reverse fault offsetting Miocene(?) alluvial deposits	*Prowell* [1980]
VA-4	Dutch Gap 37.32°, 77.37°	~N10°E	T	G-FS	reverse fault offsetting Paleocene age sediments	*Prowell* [1980]
VA-5	Waynesboro 37.03°, 78.78°	~N20°E	T	G-FS	reverse fault offsetting Miocene (or younger) sediments	*Nelson* [1962]
					Washington	
WA-1	Mount Rainier National Park 46.76°, 121.52°	N70°E	SS	FM(S)	nearly purely strike slip event	*Crosson and Lin* [1975]
WA-2	Columbia River basin 46.75°, 119.58°	N85°E	T	FM(A)	based on composites from three separate swarm events and from a nearby single event solution; predominantly thrust mechanisms with *T* axes scattered about vertical	*Malone et al.* [1975] and *R. B. Smith and A. G. Lindh* [1978]
WA-3	Puget Sound 47.5°, 122.5°	~N70°W	SS/T	FM(A)	three composite mechanisms with *P* axis azimuths N36°W, N14°E, N22°E, all plunges ≤ 15°; all show combination reverse and strike slip movement; *T* axes plunge between 12° and 70°; stress orientation consistent with best constrained mechanism	*Crosson* [1972]
					West Virginia	
WV-1	Wayne 38.14°, 82.00°	N30°W	SS/T	HF	depth, 835 m; $S_{Hmax} >> S_v \geq S_{Hmin}$	*Haimson* [1977*a*] and *Abou-Sayed et al.* [1978]
WV-2	Franklin 38.65°, 79.35°	N15°W	T	G-FS(C)	modern offset of core holes exposed in road cut, motion on preexisting reverse faults	*Schäfer* [1979]
WV-3	Berkeley County 39.55°, 78.75°	N65°W	T	HF	depth, 25 and 135 m; $S_{Hmax} >> S_{Hmin} \approx S_v$; depth of orientation measurement not given	*Haimson* [1977*b*].
WV-4	northwestern 39.75°, 80.42°	N6°E	T	HF	average stress orientation from four localities several miles apart	*Parsons and Dahl* [1972]

					Wisconsin	
WS-1	Waterloo 43.18°, 89.00°	N33°W	T	HF	average of deeper measurements in two wells; measurements at 17–238 m in one well and 2–74 m in another well; found decoupling between surface stresses and tectonic stresses at depth; accuracy of orientations ± 15°	*Haimson* [1978*a*]
WS-2	Montello 43.78°, 89.33°	N25°W	SS	HF	measurements at 75 and 190 m; $S_{Hmax} > S_v >> S_{Hmin}$ at 190 m	*Haimson* [1976]
WS-3	Valders 44.07°, 87.85°	N30°W	T	HF	depth, 300 m; stress orientations consistent with depth, vertical stress is minimum stress at all depths	*Haimson* [1978*b*]
					Wyoming	
WY-1	Green River basin ~42.5°, 109°	N65°W	SS	HF	depth, 2775 m	*Power et al* [1976]
WY-2	Yellowstone caldera 44.47°, 110.65°	WSW	N	FM(C)	based on alinement of rhyolite domes, thermal zones, trend of young faults, and a composite normal fault focal mechanism for Yellowstone Lake.	R. L. Christiansen (manuscript in preparation, 1980) *R. B. Smith et al.* [1977] and *Weaver et al.* [1979]
WY-3	north rim Yellowstone caldera 44.68°, 110.62°	N40°E	N/SS	FM(A)	average of several single-event solutions and foreshock/main event composites; predominantly normal faulting, some strike slip events	*Pitt et al.* [1979]
WY-4	Green River 41.55°, 109.45°	N60°E	SS	OC	average of two overcore measurements at separate localities, both in Green River; one measurement depth 259 m, S_{Hmin} = N52°E; the other 488 m, S_{Hmin} = N67°E	*Aggson and Hooker* [1980]
WY-5	Leucite Hills ~41.75°, 109°	N60°E	N?	G-D, CC	high-potash leucite volcanic assemblage ~1 m.y. old	*Schultz and Cross* [1912], *Kemp and Knight* [1903], and *McDowell* [1971]

Data arranged by state (within each state, data are generally numbered from south to north).

* Site locations given in °N latitude, °W longitude.

† Stress regimes indicated are N, normal faulting (S_1 vertical), SS, strike slip faulting (S_2 vertical), and *T*, thrust or reverse faulting (S_3 vertical).

‡ For a mixed mode of deformation or for data in which one stress magnitude is unknown, a slant separates the two possible stress states. The types of indicators are (1) Geologic: G-CC, cinder cone alinement; G-D, dike trends; G-DE, drill hole ellipticity; G-FS, fault slip on basis of trend of fault and primary type of offset; G-FS(G), fault slip indicated by grooves and slickensides; G-FS(H), fault slip on basis of measured offsets in historic earthquakes; and G-FS(C), fault slip determined from offset core holes, (2) focal mechanisms: FM(S), single-event mechanism; FM(C), composite mechanism; and FM(A), average stress direction from several mechanisms, and (3) in situ stress: HF, hydrofrac, and OC, overcore.