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Kinematics of Great Basin Intraplate Extension from Earthquake, Geodetic and Geologic Information

by

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KINEMATICS OF GREAT BASIN INTRAPLATE EXTENSION FROM EARTHQUAKE, GEODETIC AND GEOLOGIC INFORMATION

by

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ABSTRACT

Strain rates assessed from brittle fracture, associated with earthquakes, and total brittle-ductile deformation measured from geodetic data have been compared to paleostrain from Quaternary geology for the intraplate Great Basin of the western United States. These data provide an assessment of the kinematics and mode of lithospheric extension that the western U. S. Cordillera has experienced in the last 5-10 million years. Strain and deformation rates were determined by the seismic moment tensor method using historic seismicity and fault plane solutions. By subdividing the Great Basin into areas of homogeneous strain it was possible to examine regional variations in the strain field. Contemporary deformation of the Great Basin occurs principally along the active seismic zones: the southern Intermountain Seismic Belt - 4.7 mm/a maximum deformation rate, along most of the western boundary, the Sierra Nevada front - 28.0 mm/a maximum deformation rate, and along the west central Nevada seismic belt - 7.5 mm/a maximum deformation rate. The earthquake related strain shows that the Great Basin is characterized by regional E-W extension at 8.4 mm/a in the north that diminishes to NW-SE extension of 3.5 mm/a in the south. These results show ~8-10 mm/a deformation associated with earthquakes that compares to ~9 mm/a determined from satellite geodesy and tectonic plate models, implying that modern strain is generally reliant on earthquakes. Zones of maximum extension correspond to belts of shallow crust, high heat flow, and Quaternary basaltic volcanism, suggesting that these parameters are related through an effect such as a stress relaxation allowing bouyant uplift and ascension of magmas.

Contemporary strain and deformation rates have also been determined from geodetic measurements yielding maximum deformation of 11.2 mm/a in the Hebgen Lake por-

tion of the ISB, 3.6 mm/a in the Excelsior area of Nevada, and 2.5 mm/a in the Owens Valley area of the Sierra Nevada front. Paleostrain and deformation rates were determined yielding deformation rate high of 7.4 mm/a along the southern ISB. Geodetically determined strain and deformation rates compare well with rates determined from seismic moments in many areas while paleostrain and deformation rates are ~10 times smaller than contemporary rates except in parts of central and southern California, Wyoming, parts of Utah, and along the Idaho-Wyoming border.

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INTRODUCTION

The Great Basin subprovince of the Basin - Range province, western U. S., is an area of active E-W lithospheric extension (Figure 1). The regime has been well documented [Smith and Sbar, 1974; Eaton et al. 1978; Zoback et al. 1981]; however, quantitative measurements of contemporary deformation and magnitudes of extension rates have been difficult to obtain. Various authors have made estimates of local and regional extension using studies of fault plane geometries, intraplate tectonic models, and geodetic measurements [Proffett, 1977; Minster and Jordan, 1984; Savage, 1983].

Brittle strain release in the lithosphere is primarily expressed by earthquakes that can be used to assess regional strain [see for example Doser and Smith, 1982; Hyndman and Weichert, 1983; and Wesnousky et al. 1982a]. Earthquake magnitudes with stress orientations derived from fault plane solutions can also be used to determine seismic moment tensors, that can be used to calculate strain rate tensors [Kostrov, 1974]. These data can then be used to determine horizontal strain and deformation rates. Earthquake data recorded on modern regional networks were used, along with historic data for large events, in these calculations.

The area of this study includes the Great Basin and surrounding areas of extension in southwestern Montana, western Wyoming, southern Idaho, eastern California, and southeastern Oregon (Figure 1). Figure 1 shows areas of assumed homogeneous seismicity and stress orientation used in this study. Great Basin topography is dominated by north-trending, normal-fault bounded ranges separated at ~25 km intervals by alluvium-filled basins. The region has a generally high elevation of about 1.-1.5 km and is characterized by high heat flow exceeding 90 mW/m^2 [Lachenbruch and Sass, 1978], low Bouguer gravity

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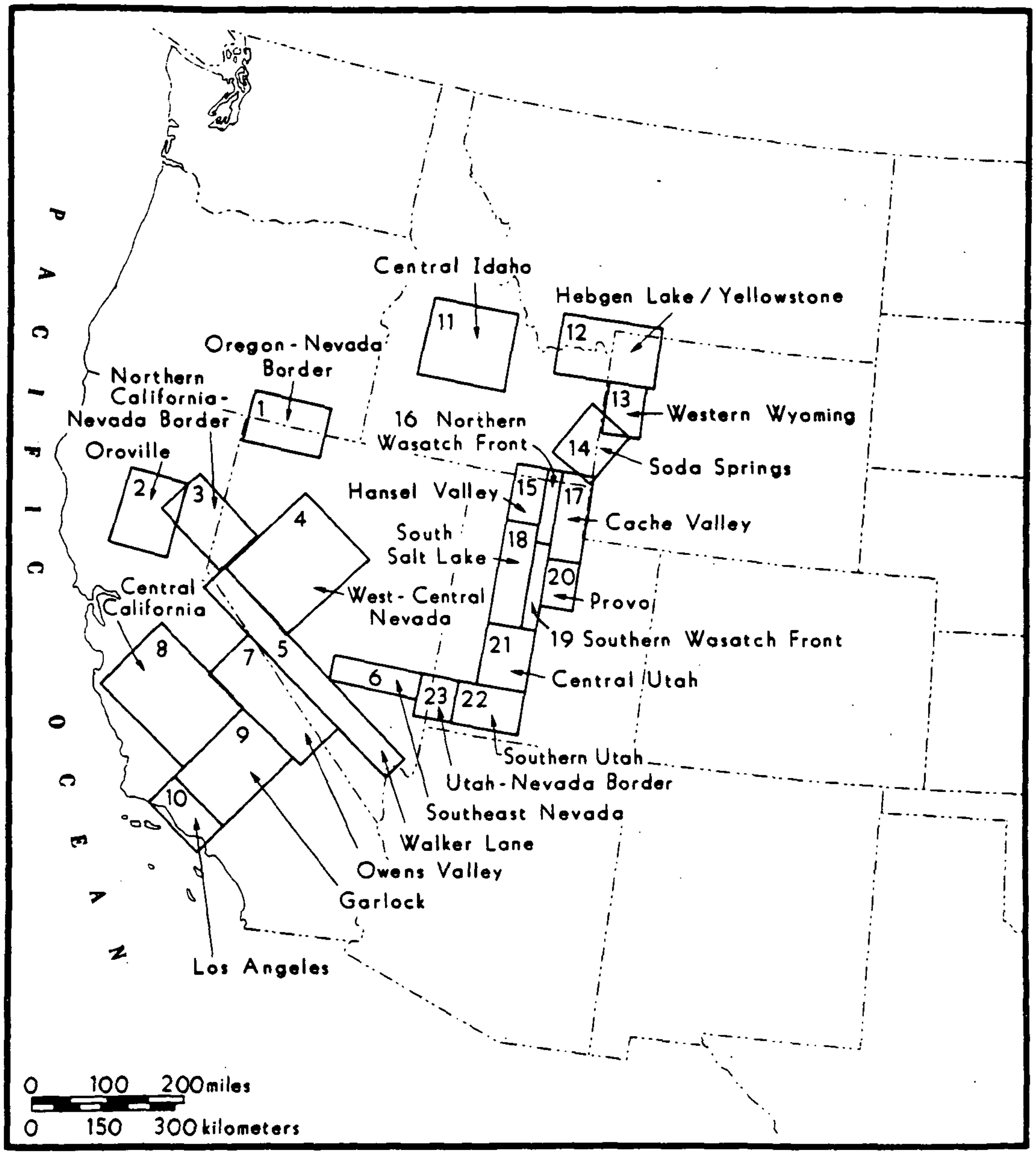
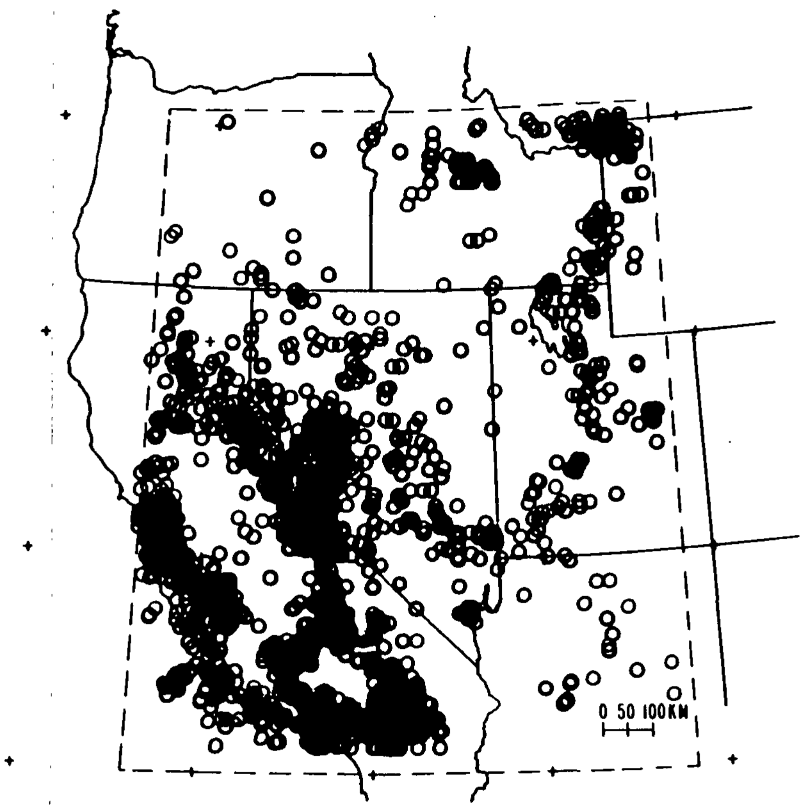


Fig. 1. Homogeneous seismic study area locations

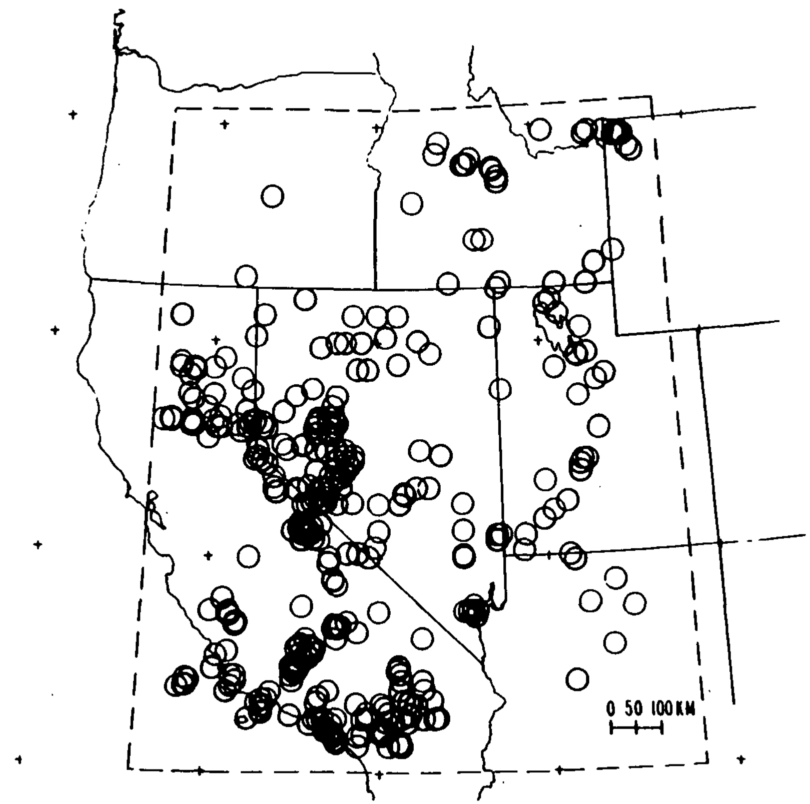
[Eaton et al. 1978], a thin crust, 24-30 km, and low Pn velocities [Smith, 1978]. The seismicity occurs along diffuse N-S bands up to 200 km wide with shallow focal depths (80% of the events were shallower than about 10 km) around the Great Basin's margins [Smith and Sbar, 1974; Wright, 1976; Wallace, 1984] (Figure 2).

Determining contemporary strain rates in the Great Basin using earthquake data fulfilled two objectives; 1) it served as a measure of contemporary brittle strain rates, supplementing fault plane geometry studies and geodetic studies. This is important since fault plane geometry studies determine only paleostrain rates, and geodetic surveys, when available, are limited to small areas; 2) comparing strain rates from earthquake data with strain rates measured using other methods allows an estimation of the relative amount of brittle fracture versus aseismic creep.

In summary, the objectives of the study were: 1) to assess the compiled historical earthquake data set, 2) to determine the contemporary strain and deformation rates both within homogeneous portions of the Great Basin and in surrounding areas using the seismic moment tensor method, and 3) to compare the contemporary strain rates with geologic and geodetic determinations of strain rates.

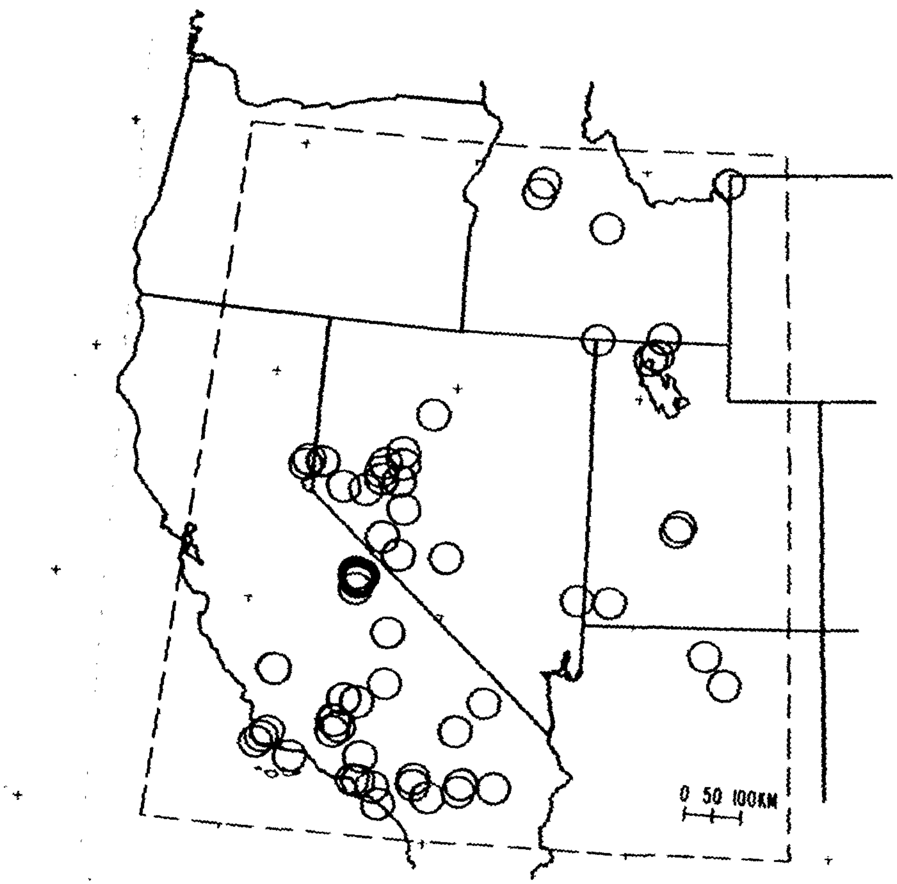


a) Magnitude 4+ Epicenter Map

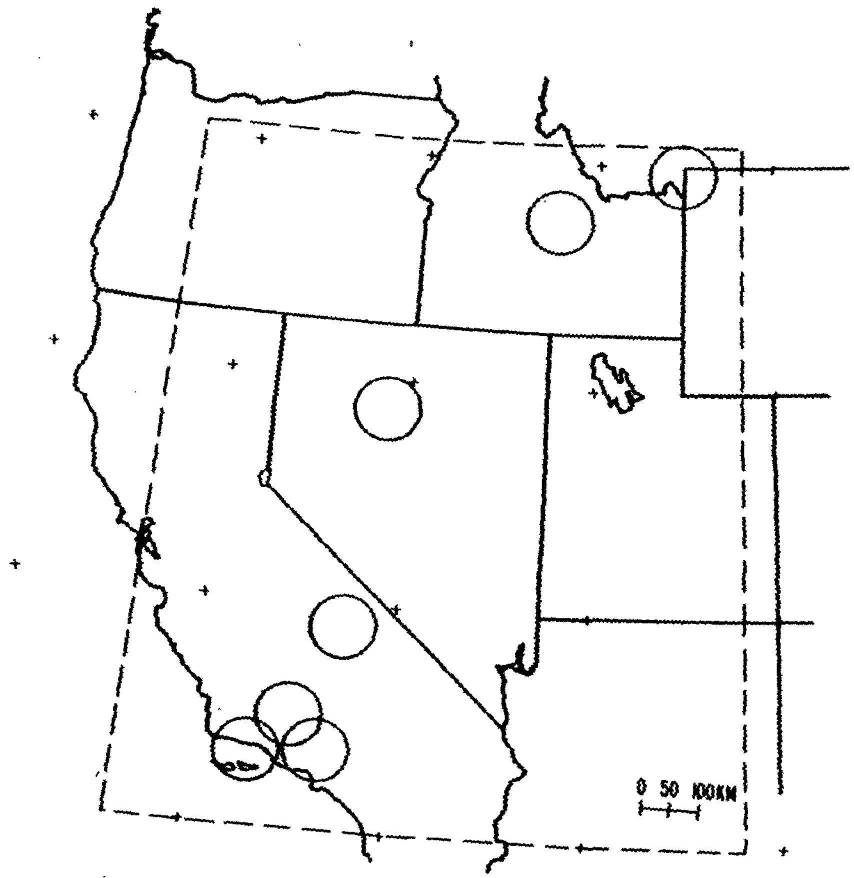


b) Magnitude 5+ Epicenter Map

Fig. 2. Earthquake epicenter maps from data compiled for this study Data covered the period from 1900-1981 including 1983 Borah Peak, Idaho events; a) $M_L > 4$, b) $M_L > 5$, c) $M_L > 6$, d) $M_L > 7$.



c) Magnitude 6+ Epicenter Map



d) Magnitude 7+ Epicenter Map

REGIONAL GEOLOGY AND GEOPHYSICS

Cenozoic History

Extension of the Great Basin began with the cessation of subduction along the west coast of North America about 30 ma. Before this extension regime, Mesozoic volcanism was associated with subduction that produced a calc-alkaline volcanic arc represented by the Sierra Nevada batholith. East of this arc, a foreland belt of folding and thrusting identified as the Sevier - Laramide thrust produced crustal compression and lithospheric shortening.

During the Miocene, about 30-40 ma, subduction was nearing its conclusion and WSW-ENE extension began in the Great Basin region, possibly as a result of back-arc spreading and stress relaxation of the lithosphere [Scholz et al. 1971; Zoback et al. 1981].

A second period of extension followed in the Great Basin region about 10-13 ma [Zoback et al. 1981], initially in the southern Basin - Range of Arizona and northern Mexico [Thompson and Burke, 1974]. Marking the beginning of this extensional episode, the direction of extension rotated counterclockwise ~45° to a WNW-ESE direction [Zoback et al. 1981]. Evidence from palinspastic reconstruction of profiles supports the theory of two separate periods of extension [Von Tish et al. 1985].

The upper crustal structure that developed during the latter period of crustal extension has largely overprinted evidence for the earlier periods of extension and compression [Eaton et al. 1978]. However, in some areas, contemporary strain has been accommodated by movement on preexisting faults developed during the early periods of deformation

[Zoback and Zoback, 1980; Smith and Bruhn, 1984].

The Great Basin is still undergoing E-W extension as evidenced by the regional seismicity and fault plane solution patterns [Smith, 1978; Smith and Lindh, 1978]. Some possible causes of Great Basin lithospheric extension have been suggested, such as lateral crustal loading, active magmatic intrusion, or a combination of these [Lachenbruch and Sass, 1978]. It appears that some mantle upwelling must accompany Great Basin extension to produce the widespread, late Tertiary basaltic volcanism [Best and Hamblin, 1978], high heat flow [Lachenbruch and Sass, 1978], and the high, E-W symmetric elevation of the province [Eaton et al. 1978].

Thompson and Burke [1974] concluded that passive magma intrusion may have occurred because of an onshore extension of the East Pacific rise. Eaton et al. [1978], on the other hand, rejected this passive model in favor of active mantle upwelling and divergence as a driving force for extension. Best and Hamblin [1978] and Stewart [1978] argued that upward movement of mantle material may have occurred to replace the old subducted plate that once existed under the Great Basin province. Smith [1978] coupled the rising mantle idea with the theory of four separate subplates of the the North American plate - namely the Great Basin, Northern Rocky Mountains, and the Sierra Nevada subplates moving away from the Colorado Plateaus subplate.

Atwater [1970] proposed that other factors motivating Great Basin extension were secondary to the region's role as a "soft" boundary of the North American Plate where it intersects the Pacific plate. However, many workers have noted that this model does not account for Great Basin symmetry, nor for the "soft" characteristics of the boundary itself [see for example Eaton et al. 1978; Best and Hamblin, 1978]. From the evidence compiled, it appears that both upward movement of mantle material and proximity of the western Great Basin to the San Andreas fault system have influenced deformation that has occurred in this region.

Earthquake History of The Great Basin

Seismicity within the Great Basin (Figure 2) has been concentrated along the eastern province margin associated with the southern Intermountain Seismic Belt (ISB), along the western province margin, associated with the Sierra Nevada front, and also in central Nevada [Smith, 1978] (Figure 2). Large magnitude earthquakes, M 6.5+ , of the Great Basin have occurred principally in central Nevada, in Owens Valley, California, and at locations of pronounced changes in direction of the trend of the southern ISB (Table 1 and Figure 2c). Not surprisingly, many M6+ earthquakes have also occurred along strike-slip faults associated with the San Andreas system in California. Most faulting associated with the San Andreas was not considered in this study and was removed from the data when possible (Figure 2).

Great Basin seismicity is characterized primarily by dip-slip and oblique-slip events throughout most of the region including M 7+ normal faulting events that produced scarps [Smith, 1978; Smith, 1985; Smith and Lindh, 1978]. Strike-slip and oblique-slip earthquakes have occurred along the region's southern and southwestern borders. According to Greensfelder et al. [1980], the shear zones marked by strike slip earthquakes found in the Walker Lane, the Garlock, and the extreme southern Nevada regions serve to separate zones of contrasting extension rate.

Most earthquakes in the Great Basin occur at depths less than 20 km and 80% are generally less than 10 km [Smith and Bruhn, 1984; Smith and Sbar, 1974]. Hypocenters of the largest earthquakes, M7+ , however, were located at greater depths, e.g. ~15 km [Smith and Richins, 1984; Sibson, 1984] near the hypothesized brittle-ductile transition. Smith and Bruhn [1984] and Sibson [1984] have theorized that large earthquakes nucleate near the brittle-ductile transition where overburden loading can produce large shear stresses and where rocks are still strong enough to support those stresses. For example, three of the largest Great Basin earthquakes and their focal depths (all ~15 km) are shown in Table 2. The large magnitude, M7+ , earthquakes can be clearly correlated with surface-breaking

Table 1. Great Basin M_L 6+ earthquakes

yr	date	orig time	lat-n	long-w	depth	M_L	no	gap	dmn	rms
1857	109	1600 0.	34-48.60	119- 1.20	0.	7.9	0	0	0	0.
1872	326	1030 0.	36-36.60	118- 4.80	0.	7.9	0	0	0	0.
1901	1114	439 0.	38-46.15	112- 5.02	0.	6.3	0	0	0	0.
1902	728	657 0.	34-30.00	120-30.00	0.	6.3	0	0	0	0.
1902	801	330 0.	34-36.00	120-24.00	0.	6.3	0	0	0	0.
1902	1117	1950 0.	37-23.58	113-31.20	0.	6.3	0	0	0	0.
1907	920	154 0.	34- 6.00	117-18.00	0.	6.0	0	0	0	0.
1909	1006	250 0.	41-46.00	112-40.00	0.	6.4	0	0	0	0.
1910	924	405 0.	36- 0.	111- 6.00	0.	6.4	0	0	0	0.
1910	1121	2323 0.	38- 0.	117- 0.	0.	6.3	0	0	0	0.
1910	1121	2323 0.	38- 0.	118- 0.	0.	6.0	0	0	0	0.
1912	818	2112 0.	36-30.00	111-30.00	0.	6.4	0	0	0	0.
1914	218	1817 0.	39-30.00	119-48.00	0.	6.0	0	0	0	0.
1914	424	834 0.	39-30.00	119-48.00	0.	6.4	0	0	0	0.
1915	112	431 0.	34-42.00	120-18.00	0.	6.3	0	0	0	0.
1915	112	431 0.	34-30.00	120-30.00	0.	6.3	0	0	0	0.
1915	1003	149 0.	40-30.00	117-30.00	0.	6.0	0	0	0	0.
1915	1003	653 0.	40-30.00	117-30.00	0.	7.8	0	0	0	0.
1916	1023	244 0.	34-54.00	118-54.00	0.	6.0	0	0	0	0.
1916	1110	911 0.	35-30.00	116- 0.	0.	6.1	0	0	0	0.
1918	421	2232 25.00	33-48.00	117- 0.	0.	6.8	0	0	0	0.
1920	622	248 0.	34- 0.	118-30.00	0.	6.3	0	0	0	0.
1920	622	249 45.00	34- 0.	118-24.00	0.	6.3	0	0	0	0.
1921	929	1412 0.	38-40.97	112- 8.98	0.	6.3	0	0	0	0.
1921	930	230 0.	38-40.97	112- 8.98	0.	6.4	0	0	0	0.
1921	1001	1532 0.	38-40.97	112- 8.98	0.	6.3	0	0	0	0.
1922	310	1121 20.00	35-48.00	120-18.00	0.	6.9	0	0	0	0.
1923	723	730 26.00	34- 0.	117-18.00	0.	6.3	0	0	0	0.
1925	629	1442 16.00	34-18.00	119-48.00	0.	7.6	0	0	0	0.
1927	918	207 7.00	37-30.00	118-48.00	0.	6.0	0	0	0	0.
1929	708	1646 6.70	33-54.00	118- 6.00	0.	6.3	0	0	0	0.
1932	1221	610 4.00	38-48.00	117-58.79	0.	6.9	0	0	0	0.
1933	311	154 7.80	33-36.95	117-57.95	16.0	6.3	0	0	0	0.
1933	625	2045 0.	39- 6.00	119-18.00	0.	6.0	0	0	0	0.
1934	130	2016 35.00	38-16.79	118-22.20	0.	6.0	0	0	0	0.
1934	312	1505 48.00	41-42.00	112-48.00	0.	6.6	0	0	0	0.
1934	312	1820 0.	42- 0.	114- 0.	0.	6.1	0	0	0	0.
1934	312	1820 12.00	41-42.00	112-48.00	0.	6.1	0	0	0	0.
1934	608	447 0.	35-48.00	120-19.79	0.	6.0	0	0	0	0.

Table 1. cont.

yr	date	orig time	lat-n	long-w	depth	M_L	no	gap	dmn	rms
1940	518	721 32.70	34- 3.96	116-19.97	16.0	7.0	0	0	0	0.
1941	914	1643 31.80	37-33.95	118-43.97	16.0	6.0	0	0	0	0.
1941	914	1839 11.90	37-33.95	118-43.97	16.0	6.0	0	0	0	0.
1944	712	1930 23.00	44-30.00	115-30.00	0.	6.1	0	0	0	0.
1945	214	301 15.00	44-42.00	115-24.00	0.	6.0	0	0	0	0.
1946	315	1349 35.90	35-42.95	118- 3.00	22.0	6.0	0	0	0	0.
1947	410	1558 6.00	34-58.97	116-33.00	0.	6.2	0	0	0	0.
1948	1204	2343 17.00	33-55.97	116-22.97	0.	6.5	0	0	0	0.
1948	1229	1253 27.00	39-30.00	120- 6.00	0.	6.0	0	0	0	0.
1949	502	1125 47.00	34- 1.10	115-40.97	0.	6.1	0	0	0	0.
1952	721	1152 14.00	35- 0.	119- 0.95	16.0	7.7	0	0	0	0.
1952	721	1205 31.00	35- 0.	119- 0.	16.0	6.0	0	0	0	0.
1952	723	38 32.00	35-21.95	118-34.97	16.0	6.0	0	0	0	0.
1952	729	703 47.00	35-22.97	118-51.00	16.0	6.0	0	0	0	0.
1954	706	1113 20.00	39-25.20	118-31.79	0.	6.0	0	0	0	0.
1954	706	2207 41.00	39-18.00	118-30.00	0.	6.0	0	0	0	0.
1954	824	551 32.50	39-34.79	118-27.00	0.	6.0	0	0	0	0.
1954	1216	1107 11.00	39-16.79	118- 7.19	0.	6.9	0	0	0	0.
1954	1216	1111 34.00	39-48.00	118- 6.00	0.	6.0	0	0	0	0.
1959	323	710 20.00	39-36.00	118- 4.19	0.	6.0	0	0	0	0.
1959	623	1435 2.00	39- 4.80	118-49.20	0.	6.3	0	0	0	0.
1959	818	637 15.00	44-49.97	111- 4.98	0.	7.6	0	0	0	0.
1966	816	1802 36.60	37-24.00	114-12.00	33.0	6.0	0	0	0	0.
1966	912	1641 1.10	39-25.20	120- 9.00	0.	6.0	0	0	0	0.
1968	426	1500 0.10	37-18.00	116-30.00	0.	6.3	0	0	0	0.
1971	209	1400 41.80	34-24.65	118-24.50	0.	6.4	0	0	0	0.
1973	606	1300 0.10	37-14.69	116-20.76	0.	6.1	0	0	0	0.
1975	328	231 5.99	42- 3.77	112-31.48	5.0	6.2	0	0	0	0.
1975	603	1420 0.20	37-20.39	116-31.37	0.	6.0	0	0	0	0.
1975	626	1230 0.20	37-16.73	116-22.13	0.	6.1	0	0	0	0.
1975	1028	1430 0.20	37-17.39	116-24.71	0.	6.3	0	0	0	0.
1975	1120	1500 0.10	37-13.50	116-22.70	0.	6.0	0	0	0	0.
1976	103	1915 0.20	37-17.81	116-19.97	0.	6.2	0	0	0	0.
1976	212	1445 0.20	37-16.26	116-29.28	0.	6.3	0	0	0	0.
1976	314	1230 0.20	37-18.36	116-28.26	0.	6.2	0	0	0	0.
1980	525	1633 44.80	37-36.47	118-49.27	3.7	6.4	0	0	0	0.
1980	525	1944 48.10	37-19.86	118-49.79	0.	6.1	0	0	0	0.
1980	525	1944 52.15	37-33.37	118-47.43	6.4	6.5	0	0	0	0.
1980	527	1450 57.12	37-27.82	118-49.40	2.4	6.3	0	0	0	0.
1980	527	1451 56.70	37-26.87	118-47.90	0.	6.2	0	0	0	0.
1983	1028	1406 6.79	43-58.07	113-53.94	16.0	7.3	19	106	70	0.32

Table 2. Nucleation depths of large Great Basin earthquakes

Date	Location	Magnitude	Depth (Km)
1954	Dixie Valley, Nevada	6.9	~15
1959	Hebgen Lake, Montana	7.5	15± 3
1983	Borah Peak, Idaho	7.3	16± 4

Adapted from Smith and Richins [1984]

faults. However, for smaller earthquakes, generally less than M 6.5, there is a lack of surface faulting [Smith, 1982].

History of Strain Study

Quantifying deformation in the Great Basin has been a natural culmination of studies of Great Basin Cenozoic history. The amount and rate of extension in the Great Basin have been estimated by many workers with disparate results (percentage of extension ranging from 10-300 %). Some of the estimates (Table 3) are as follows: Thompson and Burke [1974] have estimated extension of 100 km or 10% based on fault geometries, amounts of slip on Quaternary faults, and Pleistocene Lake shorelines in Dixie Valley, Nevada. Strain rates derived from seismicity in the paper by Greensfelder et al. [1980] agreed with this 10% extension rate in this area. Jordan et al. [1985] calculated a deformation rate of less than 9 mm/a (or less than 10-15% extension) based on the theory that the relative velocity of the Pacific and North American plates, up to 55 mm/a, was not totally accounted for by motion along the San Andreas fault. Thus a deficit must be made up in Great Basin and offshore California deformation.

Lachenbruch and Sass [1978] used thermal properties and reduced heat flow to estimate a total Great Basin extension rate of 10-20%. This estimate is equivalent to a deformation rate of 5-10 mm/a.

Other fault geometry/slip-rate studies have suggested higher estimates of crustal extension, depending largely on inferred fault dip at depth. There is evidence that some Great Basin faults become listric at depth [Smith, 1977; Smith and Bruhn, 1984] and the resulting shallower dips may yield higher extension estimates.

Zoback et al. [1981] have estimated Great Basin total extension in the last 10 ma to be 15-30%. Wright [1976] has subdivided the region by primary faulting style into northern and southern parts (normal faults to the North and strike-slip and oblique-slip faults to the south) and calculated 10% extension for the northern section and 50% extension in the

Table 3. Great Basin extension estimates from other workers

Author	Percent Extension	Method
Thompson and Burke [1974]	10	fault geometries/ slip rates
Greensfelder [1980]	10	seismicity
Jordan et al. [1985]	10-15	tectonic plate interaction
Zoback et al. [1981]	15-30	fault geometries/ slip rates
Wright [1976]	10 northern region	fault geometries/ slip rates
	50 southern region	fault geometries/ slip rates
Proffett [1977]	10-15 central region	fault geometries/ slip rates
	50-100 east and west margins	fault geometries/ slip rates
	30-35 entire Great Basin	fault geometries/ slip rates
Lachenbruch and Sass [1978]	10-20	heat flow
Hamilton and Meyers [1966]	100-300	palinspastic reconstruction
Von Tish et al. [1985]	~60 for Sevier Desert, Utah	palinspastic reconstruction/ reflection seismology

south. Proffett [1977] studied the highly faulted Yerrington, Nevada district and used his results to infer 10-15% extension in the central Great Basin where faults are less dense and appear to dip more steeply. Along the east and west boundaries where faulting is more pervasive and fault planes appear to have shallow dips at depth, Proffett estimated crustal extension to be from 50-100%. His study concluded a total Great Basin extension of 30-35% and included extension back to 17-18 ma.

Palinspastic reconstructions have been carried out assuming extension back to the Mesozoic by Hamilton and Meyers [1966, as reported by Zoback et al. 1981] resulting in total extension of 100-300%. Zoback et al. [1981] postulated that some of the variation in total crustal deformation results stems from a failure to recognize and differentiate between the two different extensional episodes discussed above. Von Tish et al. [1985] have recently shown from reflection profiles in the eastern Great Basin that these two episodes have produced up to 60% local extension. Consequently, workers who failed to recognize the different extension episodes would have averaged over both phases and calculated higher total extension for the Great Basin.

STRAIN DETERMINATION FROM EARTHQUAKE DATA

Brittle Fracture and Crustal Structure

Earthquakes result from strain released through brittle fracture in the lithosphere. The lithosphere's mechanical properties change with depth according to rock composition, temperature, and strain rate [Sibson, 1984; Smith and Bruhn, 1984; Caristan and Brace, 1980]. The uppermost crust experiences brittle deformation under stress while deeper crustal rocks of the same composition deform more ductily as temperature increases. Based on Byerly's brittle behavior law and power law for creep, Smith and Bruhn [1984] concluded that the Great Basin can be modeled with an upper brittle layer (about 8 km thick) underlain by a quasi-plastic layer, a second brittle layer (approximately 2 km thick) at a depth of about 15 km, and a third brittle layer, also about 2 km thick at 25 km depth (Figure 3). Changes in rock composition with depth account for the three different brittle layers.

The maximum depth of brittle behavior controls the depth at which earthquakes nucleate. Stresses in the crust increase with depth in the brittle layers because of overburden loading, and then decrease at still greater depths as the rocks become increasingly ductile, primarily from increased temperature. The greater the degree of quasi-plasticity in rocks, the more they deform aseismically instead of supporting high deviatoric stresses. The result is that high deviatoric stresses needed to generate large earthquakes develop in the deepest of the brittle layers. Historically, large earthquakes in the Great Basin have nucleated at depths of about 15-20 km while smaller earthquakes typically nucleate at shallower depths [Smith et al. 1984b; Smith and Richins, 1984; Smith, 1985]. The brittle strain release that causes these earthquakes can be calculated using the method described below.

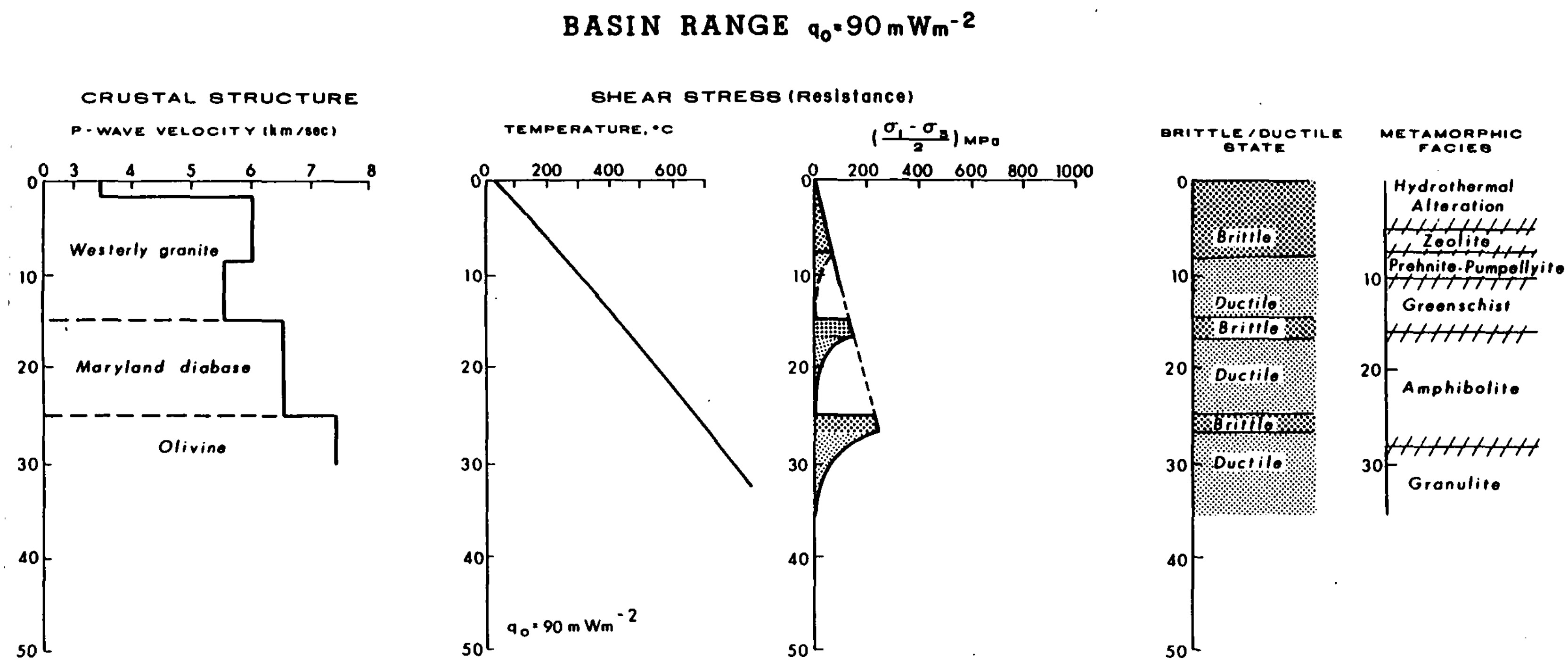


Fig. 3. Great Basin crustal composition and mechanical property profiles. Profiles are from Smith and Bruhn [1984].

Strain Rate Calculations From The Seismic Moment Tensor

The seismic moment method described here was used to calculate stress, strain and seismic moment information from earthquake magnitudes and fault plane solutions following the work of Kostrov [1974], Anderson [1979], Molnar [1979], and Doser and Smith [1982]. The process involves the following steps. First, earthquake magnitudes for given areas of homogeneous strain were converted to scalar moments, and average stress orientations were determined from fault plane solutions. Second, moment tensors were calculated for each earthquake and then summed; then the eigenvalues and eigenvectors of the summed moment tensor were determined. A synthetic fault-plane solution was then calculated for the summed events in each area. Finally, strain rates and deformation rates were determined from the summed moment tensors using Kostrov's [1974] formula:

$$\dot{\varepsilon}_{ij} = \frac{\Sigma m_{ij}}{(2\mu \Delta V \Delta t)} \quad (1) \qquad (1)$$

where $\dot{\varepsilon}_{ij}$ are the strain rate tensor components, m_{ij} are the components of the moment tensor. The summation represents the component summation of moments mentioned above, ΔV is the volume of the block we are considering, Δt is the time difference between first and last events, and μ is the shear modulus taken to be $3.3\text{x}10^{11}$ dynes/cm^2 [Molnar, 1979]. The moment tensor is defined by the equation:

$$m_{o\ ij} = M_o(b_j n_i + b_i n_j) \qquad (2)$$

where $\bar{b}$ is the unit vector in the displacement direction and and $\bar{n}$ is the unit vector perpendicular to the fault plane [Gilbert, 1970].

Kostrov [1974] assumed that deformation occurs on many separate dislocations (Figure 4). Consequently, it is not necessary to study individual fault geometries if stress orientations can be established by other means.

Let us examine each of the major steps mentioned above (hereafter A, B, and

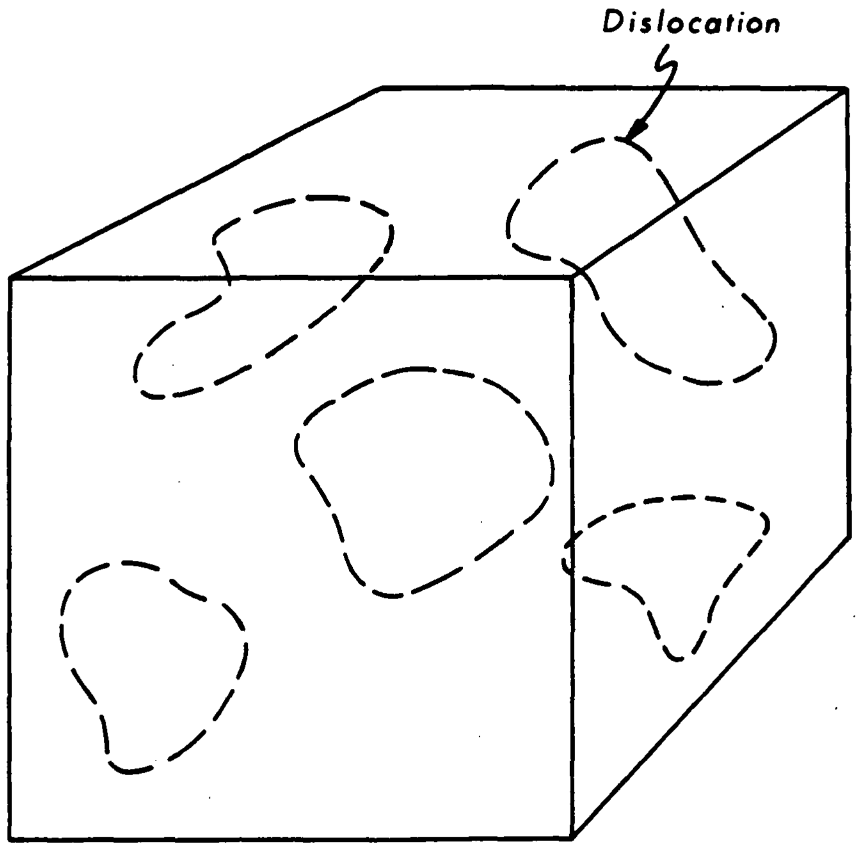


Fig. 4. Unit volume brittle flow diagram. Closed dotted lines represent dislocations [Kostrov, 1974].

C) in more detail using a sample case to illustrate. The program 'nstrain' which incorporates most of the following calculations is included in Appendix B along with other programs used in this study. Also, Files 1-5, input and output files associated with a test case in the Oregon-Nevada border area (area 1) of this study, are included in Appendix A. The Oregon-Nevada area files are considered because that area experienced only 71 earthquakes of $M_L > 2.5$ during the study period and so the files are small enough to be conveniently included in the text. The programs are marked with the capital letters that correspond to the part of this text that explains them. All computer programs referred to in this text will be denoted with single quotes ('example').

A) Conversion of magnitudes to seismic moments - The seismic moment and seismic moment rates of a single fault are given by:

$$M_o = \mu A u \qquad (3a)$$

$$\dot{M}_o = \mu A \dot{u} \qquad (3b)$$

where u = slip, A = fault plane area, μ = shear modulus, and $\dot{u}$ and $\dot{M}_o$ = slip rate and moment rate respectively [after Aki, 1966].

When possible, seismic moments for large ($M_L > 7$) earthquakes were taken from the results of other workers [e.g., Hanks et al. 1975; Sieh, 1977; Doser, 1985]. Seismic moments for smaller events were estimated using empirical moment-magnitude relations. Some examples of moment-magnitude relations for indicated areas and types of deformation are:

$$\log(Mo) = 1.1M_L + 18.4, \qquad 3.7 \le M_L \le 6.6; \qquad (4a)$$

Utah (extension) [Doser and Smith, 1982]

$$\log(Mo) = 1.2m_b + 18.0, \qquad 3.7 \le M_L \le 6.6; \qquad (4b)$$

Utah (extension) [Doser and Smith, 1982]

$\log(Mo) = 1.09 M_L + 17.46, \qquad 3.0 \leq M_L \leq 6.3;$ (4c)

Mammoth Lakes, California (extension) [Archuleta et al. 1982]

$\log(Mo) = 1.5 M_L + 16.0, \qquad 2.0 \leq M_L \leq 6.8;$ (4d)

California (compressive strike-slip) [Thatcher and Hanks, 1973].

Equation (4a) was applied to the Great Basin extensional events and equation (4d) was used for California oblique-slip and strike-slip events. The magnitudes were converted to the local magnitude (Richter magnitude), M_L, scale in this study.

The next step is to associate a regional stress field orientation with each region of homogeneous strain (defined later in this chapter, see Figure 1). The stress orientations from observed fault plane solutions for a given area were weighted and averaged providing the resulting average stress orientation. This direction was assumed for all earthquakes in a given area. This "average" stress orientation was found by calculating an average synthetic fault plane solution using the moment tensors of those earthquakes with known fault plane solutions.

For example, File 1 is the earthquake summary file for area 1. File 2 lists the three focal mechanisms available for that area taken from Smith and Lindh [1978], and C. F. Kienle and R. W. Couch (unpublished data, 1977). 'Nstrain' was used to process these three earthquakes resulting in the synthetic fault plane solution listed in File 3. This 'synthetic fault plane solution' gives the average stress orientation mentioned above. The last two lines of File 3 list the two strikes and dips of the synthetic fault plane solution nodal planes. The rest of the file gives the positions of the principal stress axes for plotting. Rakes for the two nodal planes were determined, then strikes, dips and rakes were applied to each earthquake in the 'nstrain' input file (File 4) in lieu of the unavailable fault plane solutions.

Also included in this input file (File 4) were the name of the synthetic fault plane solution output file (called "fmalin" for area 1), the region name ("Nevada - Oregon border" in this example) and the number of events to be considered (71 here). These three sources of information constitute the first three lines of the input file. The last four lines contain the coefficient of friction to be used in constructing the synthetic fault plane solution, the area dimensions, the time period considered and the rotation of the area box with respect to North. This information completed the 'nstrain' input file. The remaining steps of the analysis, steps B) and C) were carried out with 'nstrain'.

B) Calculate, sum and diagonalize moment tensors - The strike, dip and rake of the assumed fault plane of each earthquake were used to find its moment tensor. The conventions and symbols from Aki and Richards [p. 106, 1980] used for these values are

ϕ = strike - measured clockwise from north

δ = dip - measured in a plane perpendicular to both
the horizontal and the nodal planes,
from horizontal down to the nodal plane

λ = rake - measured in the nodal plane down from the
horizontal to the slip vector

See Figure 5 for an illustration of these conventions.

The data for the auxiliary plane were used only to determine the slip vector on the fault plane for printout using these equations:

slip vector trend, $\phi_{s1} = \phi_{n2} - 90^\circ$ (5a)

slip vector plunge, $\delta_{s1} = 90^\circ - \delta_{n2}$ (5b).

The data for the fault plane, along with the scalar moment, Mo, are used to find the moment tensor according to Aki and Richards' [p. 117, 1980] equations:

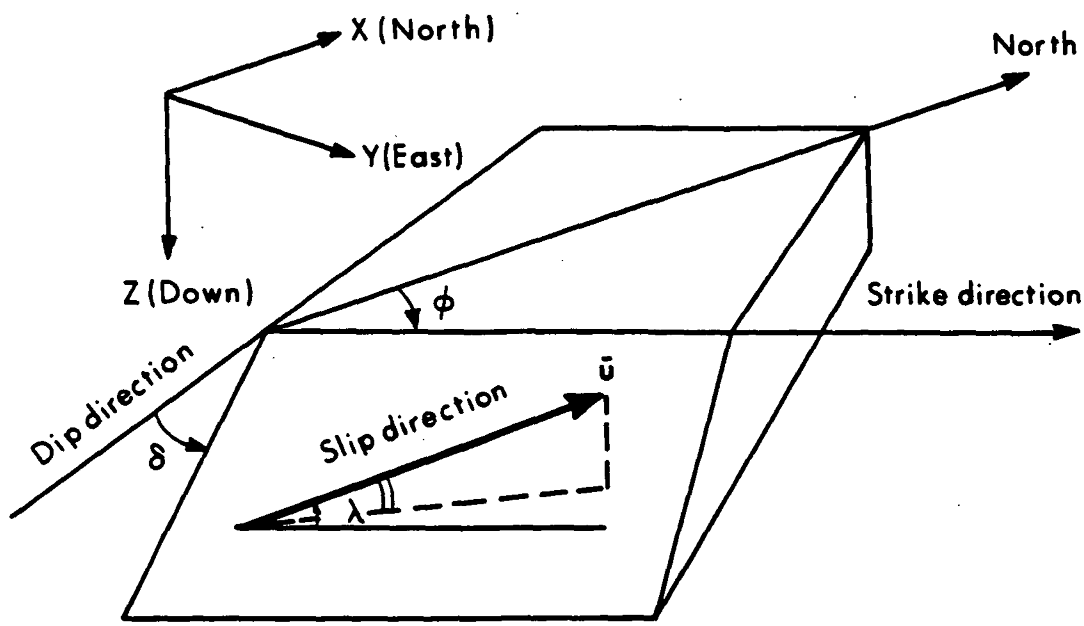


Fig. 5. Fault geometry conventions diagram. Conventions are from Aki and Richards [1980].

$$m_{xx} = -Mo(\sin\delta\cos\lambda\sin 2\phi + \sin 2\delta\sin\lambda\sin^2\phi) \quad (6a)$$

$$m_{xy} = m_{yx} = Mo(\sin\delta\cos\lambda\cos 2\phi + (1/2)\sin 2\delta\sin\lambda\sin 2\phi) \quad (6b)$$

$$m_{xz} = m_{zx} = -Mo(\cos\delta\cos\lambda\cos\phi + \cos 2\delta\sin\lambda\sin\phi) \quad (6c)$$

$$m_{yy} = Mo(\sin\delta\cos\lambda\sin 2\phi - \sin 2\delta\sin\lambda\cos^2\phi) \quad (6d)$$

$$m_{yz} = m_{zy} = -Mo(\cos\delta\cos\lambda\sin\phi - \cos 2\delta\sin\lambda\cos\phi) \quad (6e)$$

$$m_{zz} = Mo(\sin 2\delta\sin\lambda). \quad (6f)$$

Next, the eigenvalues and the eigenvectors of the moment tensor, m_{ij}, are calculated using a math library subroutine 'eign' which uses a solution algorithm for cubic equations [Forsythe, Malcolm and Moler , p. 49, 1977]. We arrive at the cubic equation via the following system of equations

$$\begin{bmatrix} m_{xx} & m_{xy} & m_{xz} \\ m_{yx} & m_{yy} & m_{yz} \\ m_{zx} & m_{zy} & m_{zz} \end{bmatrix} \begin{bmatrix} l \\ m \\ n \end{bmatrix} = \Gamma \begin{bmatrix} l \\ m \\ n \end{bmatrix} \quad (7)$$

that reduce to

$$\det \begin{bmatrix} (m_{xx} - \Gamma) & m_{xy} & m_{xz} \\ m_{yx} & (m_{yy} - \Gamma) & m_{yz} \\ m_{zx} & m_{zy} & (m_{zz} - \Gamma) \end{bmatrix} = 0 \quad (8)$$

where l, m, and n are the direction cosines of the principal axis associated with each principal value, Γ_i.

Equation (8) can be reduced to a cubic equation in Γ, and then solved by 'eign'. The resulting three eigenvalues, Γ_i, and their associated eigenvectors are not only the principal moment values and axes, but are also the primary stress values and axes [Kostrov, 1974; Aki and Richards, p. 117, 1980].

From this point, the moment tensors of individual events can be summed by component and the resulting regional moment tensor can be diagonalized as above.

Referring to File 5) which contains the Oregon Nevada Border area 'nstrain' results as an example, note that the bulk of the output from 'nstrain' consists of the echoed input information, moment tensor, eigenvalues and eigenvectors for each event. After these are listed, the regional moment tensor is presented along with its eigenvalues and eigenvectors.

C) Strain and deformation rates - Assuming linear elasticity, the moment tensor can be converted to the strain rate tensor using Kostrov's [1974] equations:

$$\dot{\varepsilon}_{ij} = \frac{\Sigma\, m_{ij}}{(2\mu \Delta V \Delta t)} \tag{1}$$

To find the maximum strain rates in the horizontal plane, the two-by-two strain rate matrix (9) was then diagonalized.

$$\begin{bmatrix} \dot{\varepsilon}_{xx} & \dot{\varepsilon}_{xy} \\ \dot{\varepsilon}_{yx} & \dot{\varepsilon}_{yy} \end{bmatrix} \tag{9}$$

From this point, finding the deformation rate in the direction of the maximum horizontal strain rate is a simple matter of trigonometrically calculating the distance, L, across the study area in that direction and then multiplying that distance, L, by the strain-rate as in

deformation rate (mm/a) = $(\dot{\varepsilon}_{max}) \times L$ (10).

The strain and deformation rates for the Oregon-Nevada border area are listed in the last section of File 5) entitled "Determination of the Strain Rate." The area dimensions as well as the time span considered are also listed there.

Homogeneous Seismic Areas

One goal of this study was to determine detailed local as well as more regionalized strain rates. To determine local strain rates, Kostrov's method was applied to the smaller areas of more homogeneous strain release shown in Figure 1.

The boundaries of the areas in Utah were established previously by C. Renggli and R. B. Smith (unpublished data, 1983) based on area seismicity and geology. The choice of other area boundaries was similarly based on: 1) fault types and orientations shown in the paper by Greensfelder et al. [1980]; 2) similarities derived from fault plane solutions' P and T axes (maximum and minimum principal stress axes); and 3) similarities in Quaternary geology. The three criteria were usually compatible, although an occasional fault plane solution would display P and T axes inconsistent with area surface geology and other area fault plane solutions.

Limits and Accuracy

The accuracy of the method described above is limited primarily by discretization approximations, by incompleteness and vagueness in the earthquake catalogs and fault plane solution data, and by incorrect magnitude-moment conversions.

First, recall that to find strain, Kostrov's equation (1) requires a reference volume, V. The discrete area subdivisions described above, with an assumed brittle zone depth of 15km, define this volume term. Although the area boundaries were chosen to enclose geologically and geophysically homogeneous regions, it is obvious that no real strain field is completely homogeneous in discrete blocks, nor will it change magnitude and orientation discontinuously at block boundaries. Consequently, the area boundaries shown in Figure 1 could be misplaced 10-20 km. (For example, see the discussion of the Central Utah area in the "STRAIN RATES FROM SEISMICITY" section). This introduces an error of ± 5 % in strain magnitude and and ± 15° in strain direction.

Completeness of the earthquake data, particularly the percentage of events for which fault plane solutions have been determined, is a second limitation. The seismic moment tensor method requires both a magnitude and a fault plane solution for each earthquake. Unfortunately, less than 1% of the earthquakes used were accompanied by fault plane solutions; however, most events of M 6+ in each area had solutions.

Averaging the stress orientations of the available fault plane solutions and applying the resulting "average fault plane solution" to each earthquake alleviated the lack of fault plane solutions for each event, but required an assumption of uniform strain release for all magnitude earthquakes. I know that, in many areas of the Great Basin, M< 4 events produce a variety of fault plane orientations, sometimes not the same as the larger, M6+ , events. Since fault plane solutions for larger magnitude events were usually available and since larger events account for most of the moment in any area (an increase of 1 in magnitude is approximately equal to multiplying the moment by 10), the effect of this assumption on the accuracy of the strain rates is less than 5%.

Another limitation arises from variations in type of magnitude used M_L, m_b, or M_s. The earthquake data in some catalogs did not specify which magnitude scale was used. The main earthquake data file was a combination of several independently compiled catalogs. Simply treating all the magnitudes the same would introduce significant error when magnitudes were converted to moments. For example, if one were to assume that all the earthquakes in an 'nstrain' input file were given in M_s, but all were really in m_b (the worst case) the resulting error in strain and deformation rates could be as great as 25 - 30%.

Fortunately, there were several independent sources available which gave magnitude scales for many of these events. The U.S. Geological Survey Great Basin Study provided a carefully prepared earthquake file that covered the period from 1900 to 1977 [Askew and Algermissen, 1983]. Using the magnitude data of the University of Utah Seismograph Stations, and correlating with the USGS file and with published data on specific events (for example the work by Hanks et al. [1975] on California earthquakes), helped minimize the error caused by incorrect magnitude scale assumptions to 10%.

Error can also be introduced in the magnitude-moment conversion even if proper magnitude scales are assumed. Hanks and Boore [1984] suggested that different magnitude scales established for different parts of California are not really characteristic of different areas, but are dependent on the range of the earthquake magnitudes used to create them. Their assertion is that log(moment) vs. magnitude is not a linear relationship, but that the magnitude of the slope of the curve increases with increasing earthquake magnitude (Figure 6). Thus, if only large magnitude earthquakes were used to establish a linear moment-magnitude relation, the slope of that line would be too steep and moments for small earth-quakes would be underestimated. Conversely, if only smaller magnitude events were used, the slope would be to small and the moments for larger earthquakes would be underestimated.

The primary moment-magnitude relation used in this study, equation (4a), by Doser and Smith [1982] was based on spectral analyses of extensional earthquakes in Utah with magnitudes in the range M_L 3.7-6.6. Thus, the moments of $3.7 < M_L < 6.6$ events would be accurately predicted by equation (4a). An earthquake magnitude outside this range might be converted inaccurately to a seismic moment. However, since smaller earth-quakes have orders of magnitude less impact on the total moment than larger events and since moments for most $M_L > 7$ earthquakes were taken from independently determined results in the literature, possible nonlinearity of the moment-magnitude relation contributed less than 5 % underestimation of moment in any given area.

Relation (4d) of Thatcher and Hanks [1973] used to determine the moments of California strike-slip events was based on 138 events with magnitudes between M_L 2.0 - 6.8, almost all being M_L 3+ and most M_L 4+ . Thus, the argument supporting equation (4a) applies almost exactly to equation (4d) (which was used to determine moments in the Central California, Garlock, and Los Angeles areas).

Another important limitation in moment-magnitude conversions is the variation

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in published seismic moment determinations for earthquakes. For example, Hanks et al. [1975] determined a moment for the 1952 Fort Tejon, California earthquake of 9.0x 10^{17} dyne-cm while Sieh [1977] gave a moment range of 5.0 x 10^{17} - 8.7 x 10^{17} dyne-cm for the same event. Variation in recorded seismic moments can vary by a factor of three. This corresponds to possible error of ± 300 % in strain rate results.

Seismic moments were taken from the results of other workers for 12 earthquakes ranging in magnitude from M_L 6.1 to M 7.9 (M is moment magnitude, Hanks and Kanamori [1979]) (Table 4). However, independent moments were not found for the large central Nevada earthquakes. The error in seismic moment determinations for large earthquakes using moment-magnitude relations is also a factor of three because of scatter in moment-magnitude curves. Hence, a ± 300 % error is possible whether the moment came from the literature or from a moment-magnitude relation.

Wesnousky et al. [1982b] also suggested that earthquake frequency distributions for single faults are not characterized exactly by equation

$$log(N) = a - bm \qquad (11)$$

but instead aftershocks and foreshocks follow such a pattern while the main shocks achieve anomalously high magnitudes. That is, on a log(N) vs. M plot, as log(N) approaches zero, a main shock will have a magnitude 1-1.5 units higher than equation (11) predicts.

Hyndman and Weichert [1983], Schwartz and Coppersmith [1984], Anderson and Luco [1983], and Wesnousky et al. [1982b] have also theorized that log(N) versus M is not linear. They have shown that the number of earthquakes falls off from the linear rate at high magnitudes. Schwartz and Coppersmith argued that an impulse in the number of M_{max} earthquakes then occurs. Hyndman and Weichert [1983] used nonlinear recurrence relations to estimate seismic moment rates and strain rates in the Pacific Northwest. In this study, empirical moment-magnitude relations were applied only to real events, not to events predicted by recurrence relations. Hence, nonlinear recurrence relations did not affect strain

Table 4. Seismic moments for large earthquakes from published studies.

Earthquake		M_L	Moment dyne-cm	Reference
California	Jan 9, 1857	M_s 8.3	$5.3\text{-}8.7 \times 10^{27}$	Sieh [1977]
			9.0×10^{27}	Hanks et al. [1975]
	March 26, 1872	M_s 8.3	5.0×10^{26}	Hanks et al. [1975]
	March 15, 1946	6.0	1.0×10^{25}	Hanks et al. [1975]
	July 21, 1952	7.7	2.0×10^{27}	Hanks et al. [1975]
	July 21, 1952	6.0	3.0×10^{25}	Hanks et al. [1975]
	July 29, 1952	6.0	3.0×10^{25}	Hanks et al. [1975]
	Feb 9, 1971	6.4	1.0×10^{26}	Hanks et al. [1975]
Utah	1934	6.6	7.7×10^{25}	Doser and Smith [1982]
Hebgen Lake	1959	7.6	1.0×10^{27}	Doser [1985]
Idaho	1975	6.2	1.5×10^{25}	Doser [1985]
Yellowstone	1975	6.1	7.5×10^{24}	Doser [1985]
Borah Peak	1983	7.3	3.3×10^{26}	Doser [1985]

rate calculations.

The fact that smaller earthquakes, with magnitudes M< 4, have not been included from earlier periods of recording also adds to moment underestimation. However, because the large magnitude earthquakes contribute most of the moment, underestimation from both incorrect magnitude-moment conversions and incomplete small earthquake listings was less than 5 %.

A more fundamental limitation of determining strain rates from earthquake data is the assumption of an idealized, brittle medium. There is evidence that at some time around 10-20Ma, the Great Basin stress field rotated ~45° in the horizontal plane from WSW-ENE to WNW-ESE [Zoback et al. 1981]. Reactivation of preexisting faults by the present stress field could have introduced error into the results of this study. However, Kostrov's [1974] method, equation (1), assumes statistical distributions and orientations of dislocations in the deforming material. Hence, fault plane orientations of all events were not necessary for the calculations.

The total error in strain and deformation rate calculations because of these limitations is ± 325% in magnitude and ± 15% in direction. The error in strain magnitude is almost entirely from uncertainty in seismic moment determination for large earthquakes, which overshadows all other sources of error.

EARTHQUAKE DATA

Earthquake Catalog

The primary earthquake data used in this study were from a compilation by R. B. Smith and co-workers of data principally from the University of Utah, University of Nevada, National Earthquake Information Service (NEIS), United States Geological Survey (USGS), California Institute of Technology, University of California at Berkeley, and other sources. A complete listing of the earthquake summary files used in this study is given in Appendix C.

The earthquake catalog produced for this study contains a listing of the felt and instrumentally recorded earthquakes from the western U. S. Cordillera during the 19th and 20th centuries up to and including most of 1981. Before 1962, earthquake recording was hampered by a lack of seismograph network coverage. Consequently, only earthquakes recorded after 1900 were considered accurate enough and the files sufficiently complete for use in this study. Because of their large size and impact on the calculations, the 1857 Ms 8.3 Fort Tejon, California and the 1872 Ms 8.3 Owens Valley, California earthquakes were included in this study. All events within the Nevada Test Site were removed from the catalogs studied. No attempt was made to distinguish between manmade and natural events.

The record of M4+ earthquakes was considered to be reasonably complete post 1900 since the number of events of M4+ recorded in this century varies little from year to year. The M4+ earthquakes, shown in Figure 2a, contributed most of the moment and corresponded to the areas of maximum deformation.

For example, in the Walker-Lane, Nevada area (area # 5 in Figure 1) the maximum horizontal deformation rate including all the events totaled 2.9 mm/a. The same area with only M4+ earthquakes included yielded a 2.7 mm/a deformation rate. Earthquakes with magnitudes less than M4 were responsible for only about 6 % of the brittle deformation during this century in that area, so some incompleteness for small magnitude events was not critical to the interpretation.

Table 5 shows the total scalar moment produced by M4+ , M5+ , M6+ , and M7+ Great Basin and southern California earthquakes. These data show that the 3630 earthquakes with magnitudes $4 \leq M < 7$ accounted for only 18 % of the seismic moment released in all M4+ earthquakes; whereas the seven M7+ earthquakes produced 82% of the moment.

In addition to the University of Utah main file discussed above, two additional sources of earthquake summary listings were used. First, a newer USGS earthquake file for the Great Basin area including earthquakes from 1803 - 1977 [Askew and Algermissen, 1983] was used to correlate and correct the magnitudes of all M4+ earthquakes common to the main file and the new USGS file (most of the earthquakes found in the main file that were recorded before 1977 are included in the new USGS file). About 20 earthquakes listed only in the new USGS file were added to the primary file. Second, the University of Utah file of the 1983 Borah Peak, Idaho earthquake and its aftershocks [Richins et al. 1985] was added to the Central Idaho area listing.

Cordilleran Seismicity

The data used in this study included ~50,000 earthquakes out of the ~120,000 events summarized in the various catalogs. The area covered by the main earthquake file extended from longitude 100°- 130° W and from latitude 30°–50° N; Figure 2 shows the seismicity confined primarily to the study area ~longitude 109°30′–125° West and latitude 33°30′–46°.

The areas of most active seismicity occurred at or near changes in direction of

Table 5. Effect on moment of study area earthquakes above different minimum magnitudes

M_{min}	No. of Earthquakes	Moment (dyne-cm)
4	3637	$2.2x10^{28}$
5	572	$2.1x10^{28}$
6	80	$2.0x10^{28}$
7	7	$1.8x10^{28}$

the ISB; along the Great Basin's western border; in Central Nevada; and along the San Andreas fault and its associated system. Almost half of the earthquakes studied were located in the San Andreas, Garlock, and White Wolf fault zones (areas 8, 9 and 10 in central and southern California). Figure 2d shows that, of the seven M7+ earthquakes that occurred in the study area, three were located in the Los Angeles, and Garlock areas; one M7+ event each occurred in the Owens Valley, California, West Central Nevada, Hebgen Lake/Yellowstone Park, and Central Idaho areas.

Fault Plane Solutions

The fault plane solution data used in this study were compiled by C. Renggli and R. B. Smith (unpublished data, 1983) primarily from the data of Smith and Lindh 's [1978] Table 5-1. These were augmented by fault plane solutions for the 1959 Hebgen Lake, Montana earthquakes [Doser,1984], for the 1983 Borah Peak earthquake sequence [Doser,1985], and by focal mechanisms for Great Basin earthquakes based on surface wave analyses by Patton [1984].

Information taken from fault plane solutions include the strike, dip, and rake of each nodal plane (following the Aki and Richards' conventions (Figure 5). Typically, rakes would be missing (with only the two nodal plane strikes and dips given) or incorrect, so rakes were calculated from the strikes and dips of the two nodal planes. The updated tabulation of all focal mechanisms is summarized in Appendix C and 'T' axes are presented in Figure 7. These axes show that extension across the Great Basin is generally N-S in Idaho, Montana and Wyoming, and E-W throughout the rest of the Great Basin.

*Next the USGS file of Askew and Algermissen [1983] was sorted into the homo-*geneous areas mentioned earlier, and then sorted according to magnitude scale. Since many of the events in the Askew and Algermissen USGS file had magnitudes listed in more than one scale, the order of preference for scale used was M_L first, then M_s, and finally m_b if a given event was listed under neither of the other scales. Next, the primary file for each area

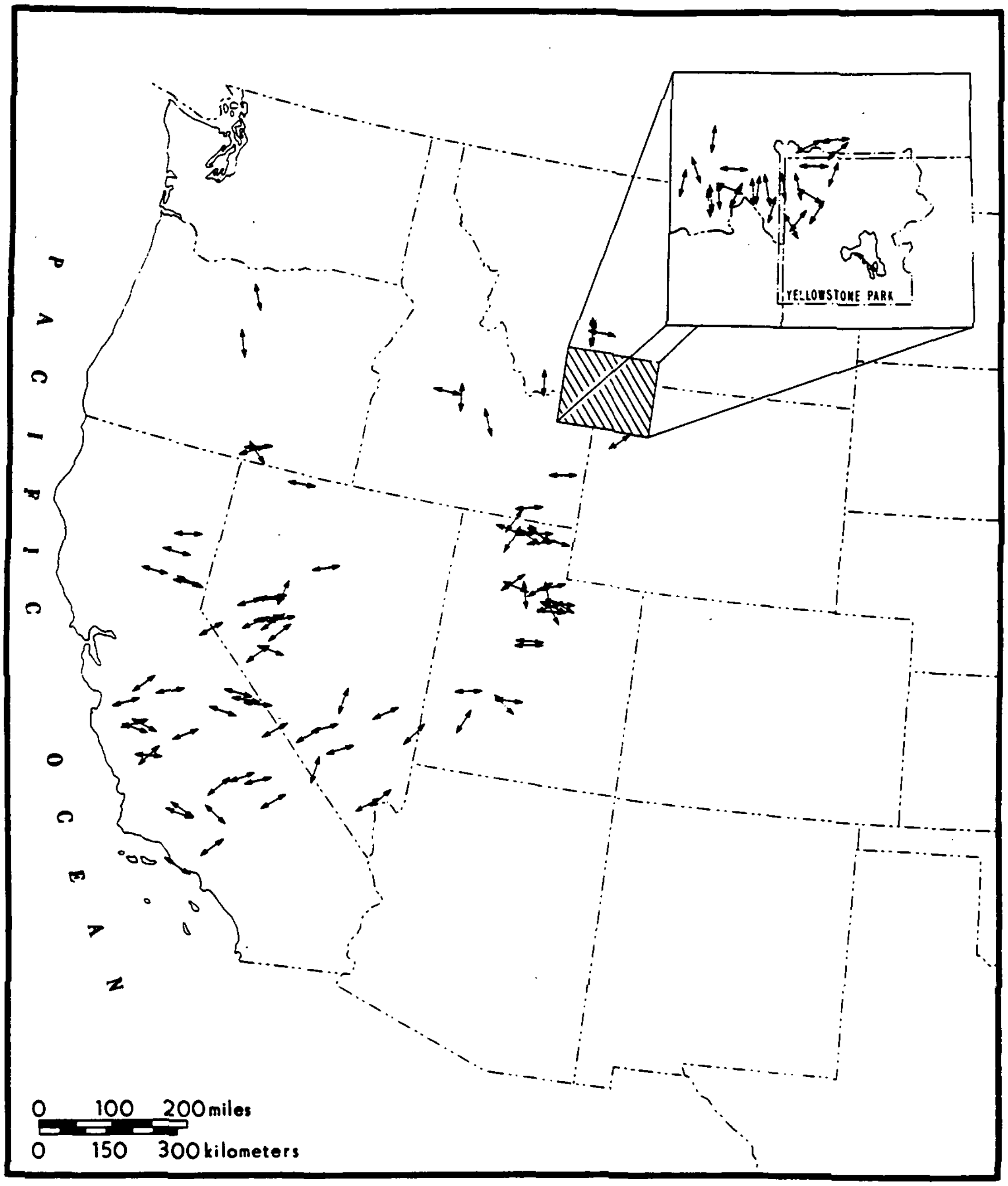

Fig. 7. Tension axes from fault plane solutions. Those used in this study were from Smith and Lindh [1978], Doser [1984], Kienle and Couch (unpublished data, 1977), and Patton [1984].

was compared to each of the three newly created USGS files for that area. USGS magnitudes were assumed in case of contradiction and all m_b and M_s magnitudes were converted to M_L using Gutenberg and Richter's [1956] equations:

$$M_L = 1.4m_b - 2.4 \tag{12a}$$

$$M_L = 0.76M_s + 1.6) \tag{12b}$$

so that equation (4a), or (4d) could be used for magnitude-moment conversions. If the primary file contained duplicates of an event found in a USGS file, the event which most closely matched the USGS version was retained.

After the primary area file was brought into conformity with the USGS file, it was sorted into chronological order (occasionally events were out of sequence) and all detectable duplicates not already eliminated were deleted according to the criteria that any two events that occurred within 10 seconds and 15km of each other were considered to be the same event. The original primary file contained about 1% duplicates. Finally magnitudes were converted to moments in an input file for 'nstrain' so that strain and deformation rates could be calculated.

STRAIN RATES FROM SEISMICITY

Regional Strain Pattern

Strain and deformation rates calculated from the earthquake data are given in detail in Appendix D. Note that results for the Northern Utah areas were calculated previously by Smith et al. [1984a]. A summary of the results for each area is presented in Table 6 and in Figure 8. Time periods for given areas vary according to the data available but were generally from 1900 to 1981. Figure 8 also includes for comparison some of Anderson's [1979] results for southern California and Hyndman and Weichert's [1983] results for the Pacific Northwest.

The general results show a principal east - west direction of extension for the seismically active parts of the Great Basin. E-W extension was especially prevalent on the west edge of the Great Basin; in Idaho, Montana, and Wyoming, extension was more N-S; and in Utah, extension trended more NW-SE. Some exceptions were in central Utah and along the Utah-Nevada border (areas 18, 20, 21 and 23) where the principal horizontal strain corresponded to compression rather than extension.

The central Wasatch front region (area 18) has had little earthquake activity in historic time and so has a low deformation rate of only 0.001 mm/a - too small to be reliable.

The Colorado Plateaus-Great Basin transition zone (area 20) may be influenced by the neighboring N-S compression. The central Utah area would seem geographically to be more closely associated with the Great Basin; however, here, the stress orientation of the area was determined primarily from a single event with a near-vertical nodal plane on the extreme eastern edge of the area. The stress orientation for the Utah-Nevada border area

Table 6. Number of earthquakes, maximum magnitude (M_{max}), principal moment tensor component (M1), horizontal deformation rates, and maximum horizontal strain rates for homogeneous areas of the Great Basin

area no.	area name	number of earthquakes	M_{max}	M_1 (dyne-cm/a)	horizontal deformation (mm/a)	strain rate (sec^{-1})	
1	Oregon-Nevada Border	71	5.0 M_s	$2.3x10^{23}$	0.2	$2.4x10^{-17}$	N65°W
2	Oroville	590	6.0 M_s	$7.6x10^{23}$	0.5	$8.6x10^{-17}$	N87°W
3	Northern California - Nevada Border	1429	6.4 M_L	$1.7x10^{24}$	1.6	$2.1x10^{-16}$	N90°W
4	West-Central Nevada	2533	7.8 M_L	$1.9x10^{25}$	7.5	$1.0x10^{-15}$	N69°W
5	Walker Lane	2237	6.0 M_L	$1.8x10^{24}$	2.9	$1.3x10^{-16}$	N46°W
6	Southeast Nevada	118	6.0 m_b	$5.5x10^{23}$	0.22	$9.6x10^{-17}$	N22°W
7	Owens Valley	3809	8.3 M_s	$4.9x10^{25}$	28.0	$3.7x10^{-15}$	N83°E
8	Central California	20827	6.9 M_L	$3.3x10^{24}$	1.1	$-1.8x10^{-16}$	N19°E
9	Garlock	5647	8.3 M_s	$8.9x10^{25}$	59.	$-6.8x10^{-15}$	N13°W
10	Los Angeles	4175	6.3 M_L	$2.4x10^{24}$	1.2	$-1.8x10^{-16}$	N27°W
11	Central Idaho	918	7.3 M_L	$4.5x10^{24}$	2.0	$3.3x10^{-16}$	N29°E
12	Hebgen Lake Yellowstone Park	1332	7.6 M_L	$1.3x10^{25}$	4.7	$1.1x10^{-15}$	N11°E
13	Western Wyoming	1159	4.5 M_L	$6.7x10^{22}$	0.07	$1.4x10^{-17}$	N41°W
14	Soda Springs	242	5.0 M_L	$1.9x10^{23}$	0.12	$2.7x10^{-17}$	N81°W
15	Hansel Valley	1944	6.8 M_L	$1.8x10^{24}$	1.5	$6.3x10^{-16}$	N67°E
16	Northern Wasatch Front	166	5.7 M_L	$7.9x10^{22}$	0.04	$3.8x10^{-17}$	N78°E
17	Cache Valley	789	5.9 M_L	$41.0x10^{23}$	0.29	$1.3x10^{-16}$	N79°W
18	South Salt Lake	141	5.4 M_L	$3.7x10^{21}$	0.001	$-4.1x10^{-19}$	N66°W
19	Southern Wasatch Front	520	5.7 M_L	$1.7x10^{23}$	0.13	$1.3x10^{-16}$	N76°E
20	Provo	249	5.7 M_L	$3.2x10^{22}$	0.06	$-1.5x10^{-17}$	N37°E
21	Central Utah	962	6.9 M_L	$2.2x10^{24}$	1.3	$-2.6x10^{-16}$	N35°W
22	Southern Utah	234	5.5 M_L	$1.5x10^{23}$	0.23	$4.5x10^{-17}$	N59°E
23	Utah - Nevada Border	94	6.3 M_L	$5.8x10^{23}$	1.0	$-4.5x10^{-16}$	N64°E

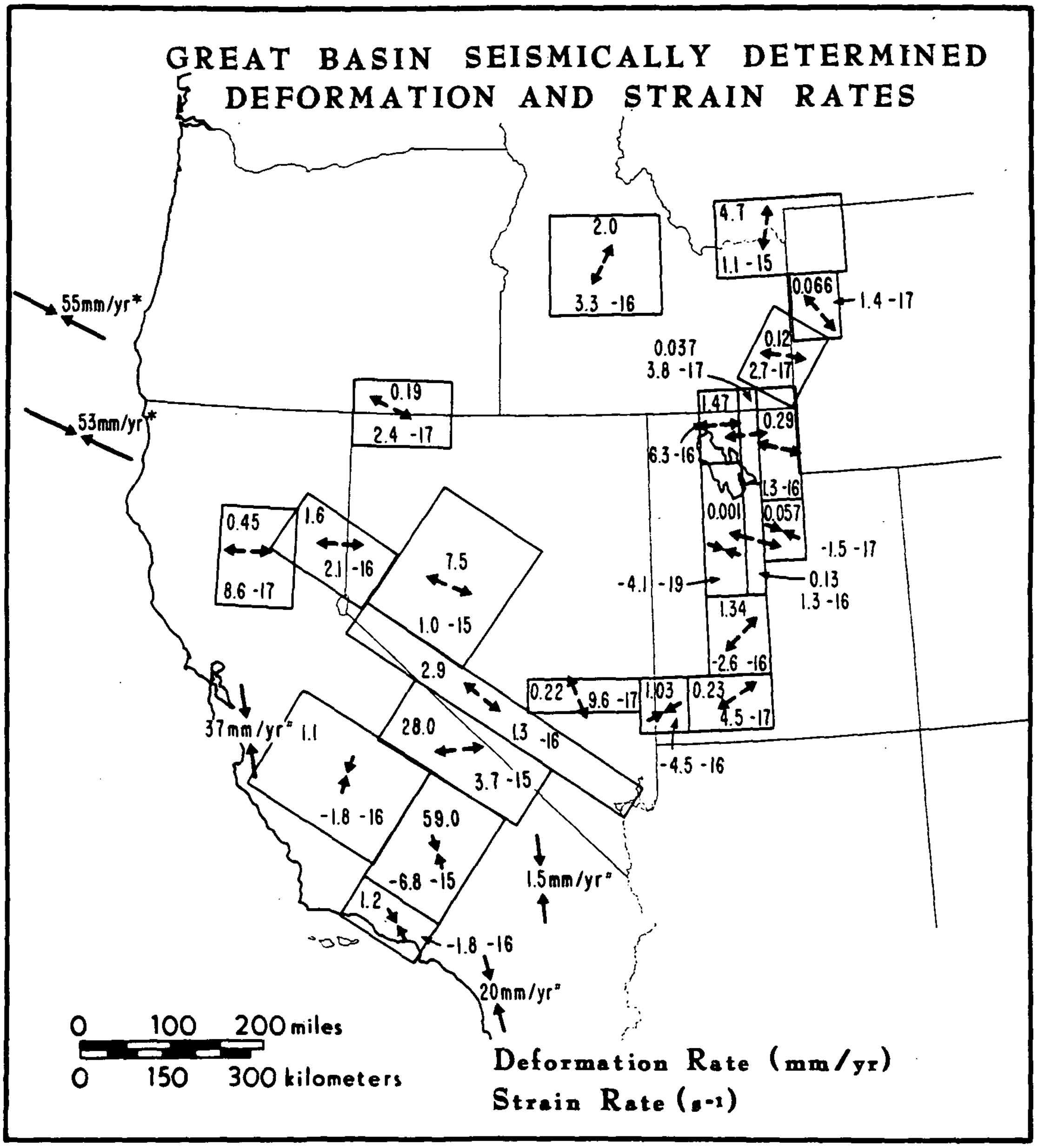

Fig. 8. Great Basin seismically determined strain/deformation rates. In each area, top value is deformation rate in mm/a, bottom value is strain rate in $s^{-1}r$ (second number is power of 10); * from Hyndman and Weichert [1983], # from Anderson [1979].

was determined from a single large strike-slip event, M6.1, 1966. This solution is anomalous, hence the stress orientation was not adequately accounted for. However, this strike-slip earthquake is the first of many that extend westward across southern Nevada.

The largest deformation rates were associated with the western margins of the Great Basin along the northern California-Nevada border (1.6 mm/a), in West-Central Nevada (7.5 mm/a), along the Walker Lane (2.9 mm/a), and in the Owens Valley (28.0 mm/a), areas 3, 4, 5 and 7. Deformation in the Owens Valley area was exceptionally high because of the 1872 M_s 8.3 Owens Valley earthquake.

Another region of high strain occurred along the Great Basin's eastern border. Deformation rates of 1.0 to 4.7 mm/a were found in areas where the trend of the ISB changes: for example at the Hebgen Lake/ Yellowstone Park; Hansel Valley, northern Utah; Central Utah; and Utah-Nevada border areas (areas 12, 15, 21 and 23).

The deformation in the Central Idaho area was due principally to the 1983, M7.3, Borah Peak, Idaho sequence and does not fit either of the two trends mentioned above. The central Idaho area is associated with a northwest extension of the Great Basin eastern margin.

Note that Askew and Algermissen [1983] assigned some large earthquakes in central Nevada lower magnitudes than usually found in the literature. The Dixie Valley and Fairview Peak, Nevada earthquakes were given magnitudes of M 7.1 and M 6.8 by Tocher [1957]. Askew and Algermissen [1983], however, listed values of M_L 6.9 and M_L 6.0. As stated earlier, Askew and Algermissen's catalog was considered the standard. When the larger magnitudes were considered, the West-Central Nevada area yielded a deformation rate of 9.1 mm/a and a strain rate of 1.2×10^{-15}/sec.

Except for the Owens Valley area, deformation rates in these rapidly deforming areas ranged from 1 to 9 mm/a - about 10 times greater than in other areas of the Great Basin. However, they were 10 times less than the ~60 mm/a deformation rate found in the Garlock area (note that most of the Garlock area moment came from the 1857 M_s 8.3 Fort

Tejon earthquake produced by fracture on the San Andreas fault along the south edge of the Garlock area).

In addition to spatial variations in strain and deformation magnitudes, it is also interesting to note spatial variations in the orientation of the maximum horizontal strain and deformation rates. Figure 9 shows just the maximum horizontal extension vectors associated with each area. The dotted arrows represent the minimum horizontal strain rate axes in areas that displayed compressive maximum strain rates. The south Salt Lake and Provo areas (areas 18 and 20) were not included in Figure 9 since the south Salt Lake area displays insignificant strain rates and the Provo area is associated with Colorado Plateaus stresses. Figure 9 shows that in the extreme northern Great Basin, across central Idaho and the Yellowstone Park area, the maximum extension direction was NNE-SSW. In the southern study area, principally across southern Utah and southern Nevada, the direction of maximum extension was NNW-SSE. Throughout the central Great Basin, comprised of Nevada, Utah, and northwestern California, extension is oriented almost exclusively E-W.

Great Basin Deformation And Strain Rates

Deformation and strain rates were also calculated across the entire Great Basin to estimate intraplate-wide deformation rates (along profiles B-B', B-B'' and C-C', Figure 10) The components of the deformation rates along each profile were summed to give the overall values.

Profile B-B', a line across northern California, Nevada, and northern Utah had a 10.0 mm/a deformation rate. Profile B-B'' is an east-west line with an 8.4 mm/a rate. The southern profile, C-C', is an east - west line across southeastern California, southern Nevada, and southern Utah. Here, the deformation rate was 3.5 mm/a; however, if Owens Valley deformation is projected up to C-C', the deformation rate increases to 29.2 mm/a. (The extension rates found along these profiles are listed in Table 7 and are shown in Figure 10). The deformation and strain rates along line B-B'' are considered the most

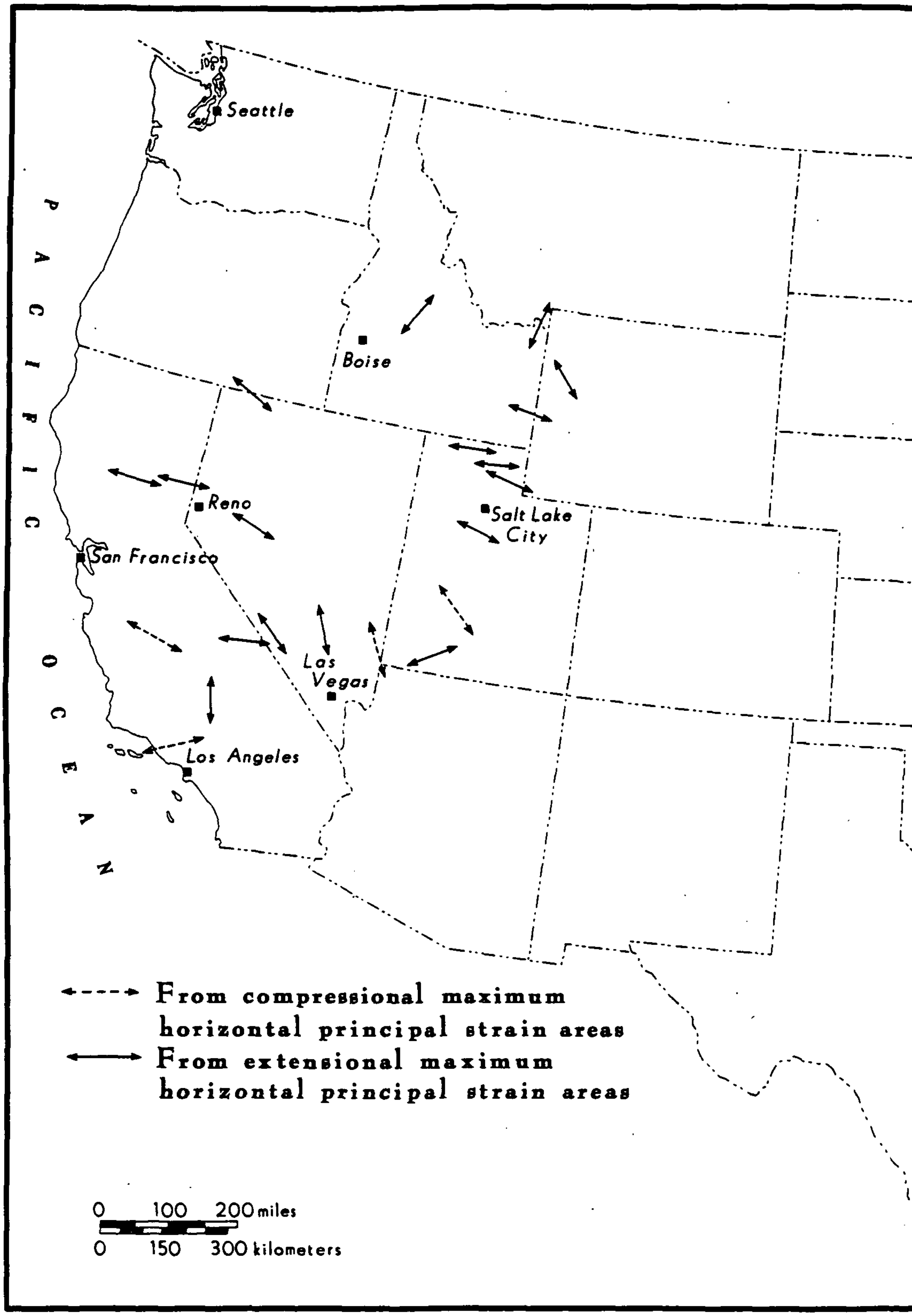

Fig. 9. Seismically determined maximum horizontal extension directions. Dotted arrows indicate compressive maximum horizontal strain.

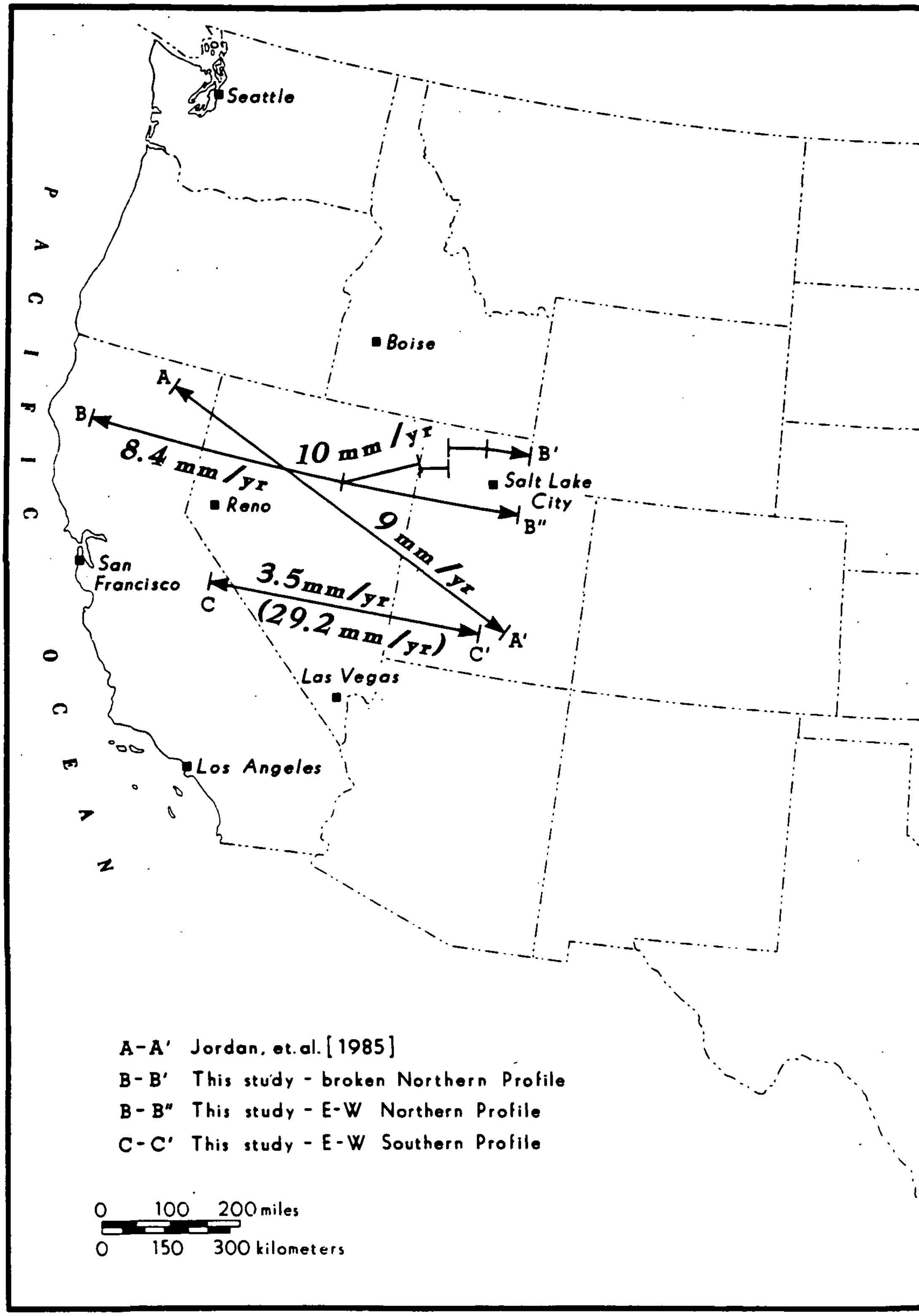

Fig. 10. Great Basin regional extension. A-A' is from Jordan et al. [1985]; B-B', B-B'', and C-C' from this study. Value in parentheses below C-C' includes deformation from Owens Valley, California.

Table 7. Maximum horizontal Great Basin strain rate, deformation rate, and total extension from this and other studies

Reference - Method	Strain Rate (sec^{-1})	Deformation Rate (mm/yr)	Total Extension %
Seismic Results			
B-B'	2.6×10^{-16}	10.0	~10
B-B"	2.2×10^{-16}	8.4	~10
C-C'	1.3×10^{-16}	3.5	~10
Jordan et al. [1985] - satellite geodesy			
A-A'		< 9	
Wright [1976] - geology			
north		5.8-7.5	~10
south		3.7-10.1	10-50
Proffett [1977] - geology		200	30-35
Thompson and Burke [1974] - geology	3.2×10^{-16}	8	10
Eaton et al. [1978] - geology	3.2×10^{-16}	8	10
Zoback et al. [1981] - summary			15-39
Minster and Jordan [1984] - summary			
Geology[1]		3-20	
heat flow[2]		3-12	
paleoseismicity[3]		1-12	
seismicity[4]		5-22	

1 Hamilton and Meyers [1966], Stewart [1978], Davis [1980], Proffett [1977]

2 Lachenbruch [1979]

3 Wallace [1978], Thompson and Burke [1974], Greensfelder et al. [1980]

4 Greensfelder et al. [1980], Anderson [1979]

representative for the Great Basin because of its central location and since the absence of line bends makes its strain and deformation rate calculations the most straightforward. A-A' results are from Jordan et al. [1985] for later comparison.

Note that the deformation rate is more than twice as high in the northern Great Basin than it is in the southern Great Basin if the Owens Valley area is not considered. When strain rates were considered, it was found that B-B' experienced 2.7×10^{-16} /sec, B-B'' yielded 2.2×10^{-16} /sec and C-C' yielded 1.4×10^{-16} /sec; the northern profiles displayed almost twice the strain rate of the southern profile, consistent with deformation rate results.

COMPARISON OF CONTEMPORARY AND PALEOSTRAIN RATES

To clarify the role of the seismically determined strain rates discussed previously, comparisons with strain rates found with other methods are useful. Two methods to be addressed here are geologic and geodetic determinations of strain rates. These, with Great Basin extension rates calculated by other workers, give insight into contemporary versus paleostrain rates in this region.

Paleostrain Rate Calculations From Geologic Data

Strain rates from geologic data (slip rates on faults) were determined using a conversion of fault slip rates to seismic moment. Mapped slip rates and fault plane geometries were used to determine only the scalar moment following the equation:

$$M_o = \mu A u. \tag{3a}$$

From this seismic moment and the age of the fault displacement, strain rate can be found using:

$$\dot{\varepsilon} = \frac{\dot{M}_o\, k}{2\,\mu\, l_1\, l_2\, l_3} \quad [\textit{Anderson}, 1979] \tag{13}$$

where l_1, l_2 and l_3 = *volume*

$k = 0.75\ (0.75 \le k \le 0.96)$

$\dot{\varepsilon}$ = *scalar strain rate.*

$\dot{M}_o$ = *scalar moment rate.*

Moments for faults in the western U. S. were calculated previously by R. B. Smith et al. (unpublished data, 1984) assuming average fault dip of 60° on some of the western U. S. faults shown in Figure 11. Smith also made these calculations assuming 40° fault dips that gave increased horizontal extension rates by a factor of ~1.5. The 60° dip assumption was used in this study. Ages of the faulting ranged from ~10,000 a to 10 ma. Moments and strain rates for the Wasatch front were determined from fault segmentation and slip rates by Schwartz and Coppersmith [1984]. Paleodeformation rates calculated for some areas in southern California by Anderson [1979] were also included in Figure 4. Geologic results for the Borah Peak, Idaho area are from Scott et al. [1984].

The faults were grouped for this study into the same areas as used in the seismic strain rate determination where possible. Figure 12 shows the centers of some the faults from Figure 11 on a map of the western U. S. The seismic moment rates were determined using equation (3a) and then summed. The direction of extension was assessed to be east-west for most of the Great Basin. North-south compression was assumed for areas associated with the San Andreas fault system (the Central California and Los Angeles areas) and in Idaho and Montana.

The primary drawbacks of the geologic data lie in their interpretation and lack of completeness. First, in order for the results to be complete, all major faults must be included and assigned accurate slips, areas, and displacement ages. While there are numerous references to Holocene and Quaternary faults throughout the region, less than 30% had slip rates. Fault dips at depth must also be accurately estimated since low-angle normal fault dips yield higher horizontal extension rate estimates. Second, even if surface exposures of faults are adequate and all major faults have been studied in an area, only large earthquakes, M6.5+, will have produced any surface displacement in the first place. Consequently, underestimation of paleostrain in a given area is almost certain.

Paleodeformation rates yield the highest values in two regions (Figure 13 and

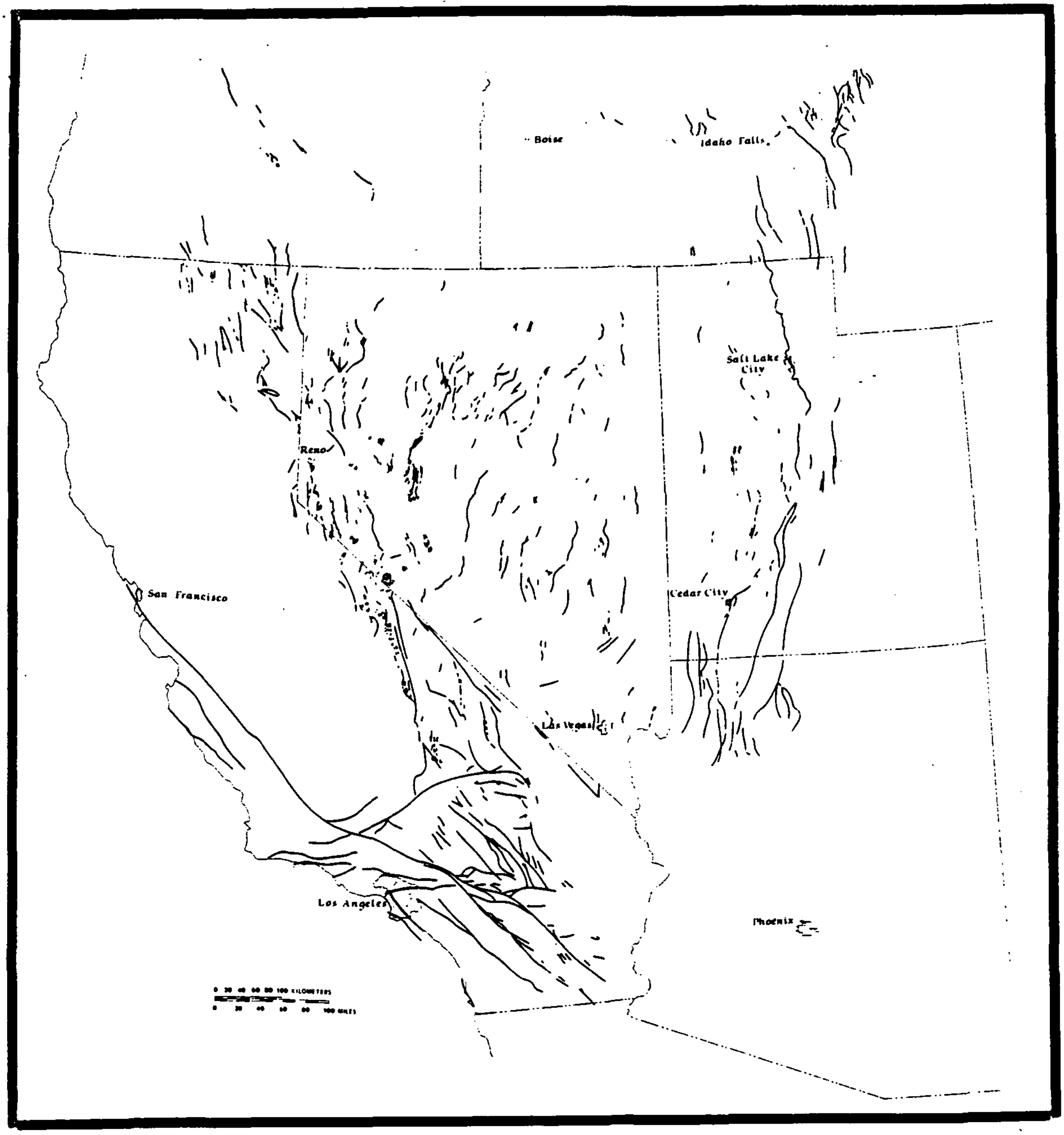

Fig. 11. Western U. S. fault map. Data from Smith et al. (unpublished data, 1982)

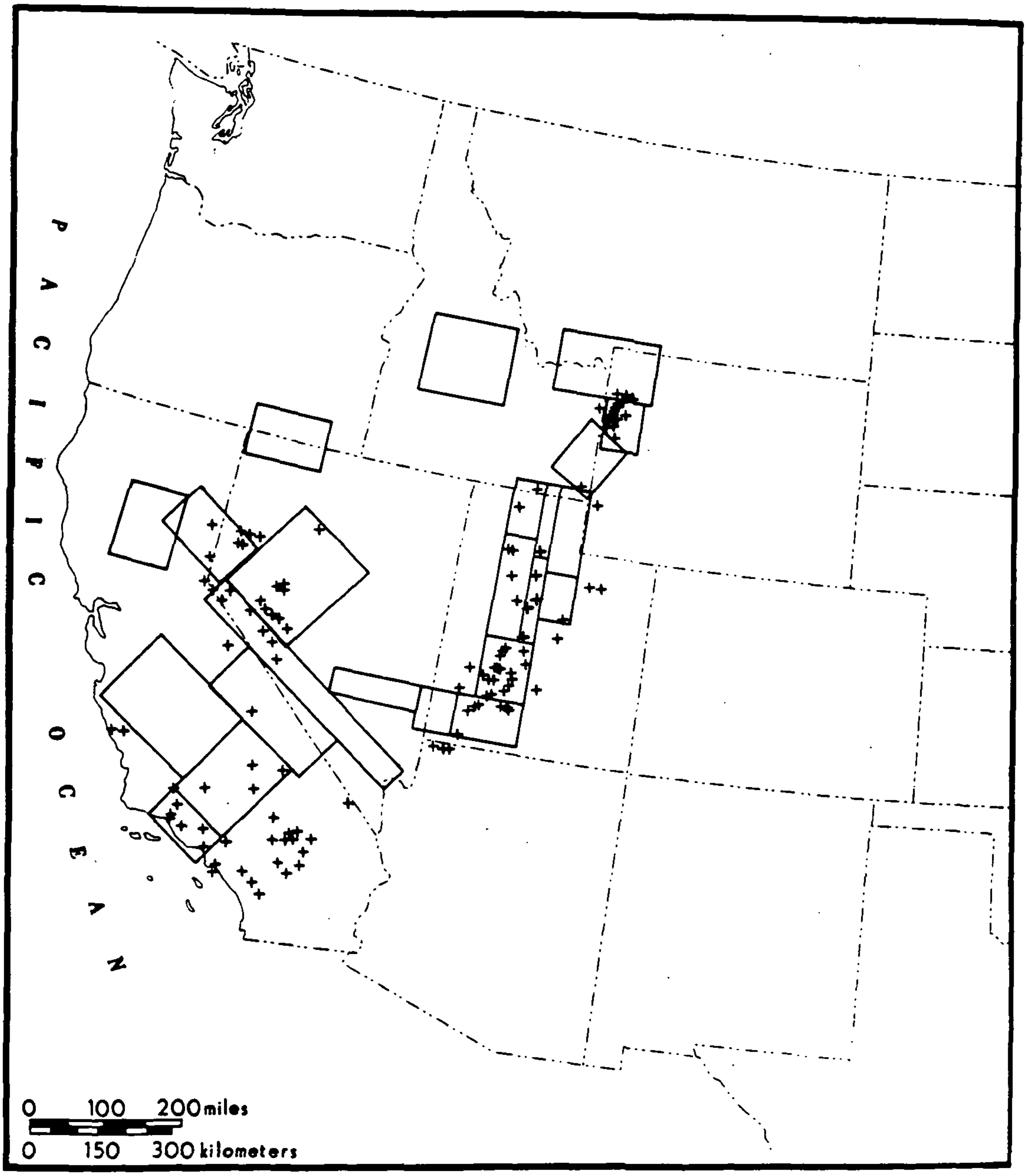

Fig. 12. Locations of study area fault centers. Study areas are superimposed.

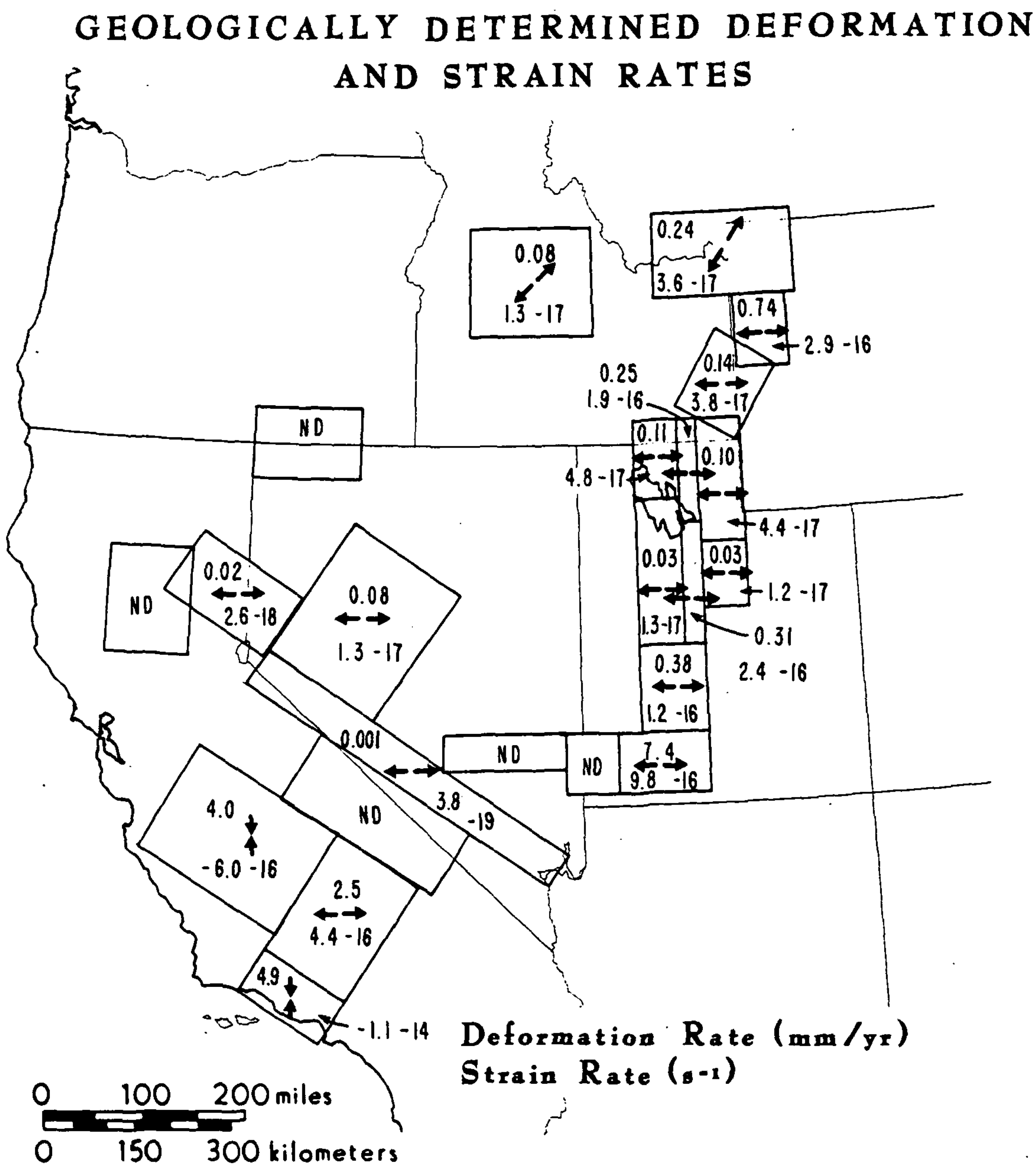

Fig. 13. Great Basin paleostrain and deformation rates from geologic data. Top value is deformation rate in mm/a, bottom value is strain rate in s^{-1} (second number is power of 10).

Table 8). High deformation rates were determined for Hebgen Lake/Yellowstone Park, 0.24 mm/a; and in Wyoming, 0.74 mm/a. Here, the ISB changes from a N-S trend in Utah to a NNE-SSW trend in southeast Idaho and western Wyoming. High deformation rates were also calculated for the Central and southern Utah areas (0.38 and 7.4 mm/a) where the ISB changes trend from N-S in most of Utah to E-W in southeast Nevada. Concentration of deformation in these regions is much less pronounced in paleostrain results than it is in seismically determined results.

Data for the west side of the Great Basin were considered incomplete resulting in either unavailable or low deformation rates. Figure 14 shows that both the east and west margins of the Great Basin have experienced M > 7 earthquakes that produce high deformation. This map was determined using geologic data [Thenhaus and Wentworth, 1982; R. B. Smith et al. unpublished data, 1983], so incomplete fault study was the problem, not inadequate fault exposures.

Contemporary Strain Rate

Geodetic trilateration and triangulation networks have been used by several workers to determine strain rates - primarily J. Savage (USGS) and R. Snay (NGS) and co-workers. For purposes of comparison, Savage's [1983] summary of strain rates of different USGS trilateration networks was used along with modifications and additions taken from Savage et al. [preprint, 1985] and Snay et al. [1984].

Some problems associated with geodetic determinations are inaccurate measurements because of inconsistent location of measurement stations and inconsistent measuring technique. Also a factor in the usefulness of geodetic measurements is the sparseness of measurements throughout the western U. S. with the exception of California. The available geodetic data are presented in Figure 15 and Tables 8 and 9.

Geodetic strain rates are only available in about half of the areas considered in the seismic strain rate determination. In many areas where geodetic strain measurements

Table 8. Strain and deformation rates measured using geologic, seismic, and geodetic data

Area	Geologic Def. Rate (mm/a)	Geologic Strain Rate (sec^{-1})	Seismic Def. Rate (mm/a)	Seismic Strain Rate (sec^{-1})	Geodetic Def. Rate (mm/a)	Geodetic Strain Rate (sec^{-1})
Oregon - Nevada Border			0.19	$2.4x10^{-17}$		
Oroville			0.5	$8.6x10^{-17}$		
Northern California - Nevada Border	0.02	$2.6x10^{-18}$	1.6	$2.1x10^{-16}$		
West-central Nevada	0.08	$1.3x10^{-17}$	7.5	$1.0x10^{-15}$	2.0	$1.6x10^{-15}$
Walker Lane	0.001	$3.8x10^{-19}$	2.9	$1.3x10^{-16}$	3.6	$1.9x10^{-15}$
Southeast Nevada			0.22	$9.6x10^{-17}$		
Owens Valley			28.0	$3.7x10^{-15}$	2.5	$2.5x10^{-15}$
Central California	4.0	$-1.9x10^{-16}$	1.1	$-1.8x10^{-16}$	1.8	$-2.9x10^{-15}$
Garlock	2.5	$4.4x10^{-16}$	59.0	$-6.8x10^{-15}$	11.2	$-5.1x10^{-15}$
Los Angeles	49.3	$-1.1x10^{-14}$	1.2	$-1.8x10^{-16}$	13.5	$-4.8x10^{-15}$
Central Idaho*	0.08	$1.3x10^{-17}$	2.0	$3.3x10^{-16}$		
Hebgen Lake/ Yellowstone Park	0.24	$3.5x10^{-17}$	4.7	$1.1x10^{-15}$	11.2	$8.9x10^{-15}$
Western Wyoming	0.74	$2.9x10^{-16}$	0.07	$1.4x10^{-17}$		
Soda Springs	0.14	$3.8x10^{-17}$	0.12	$2.7x10^{-17}$		
Hansel Valley	0.11	$4.8x10^{-17}$	1.5	$6.3x10^{-16}$		
Northern Wasatch Front	0.25	$1.9x10^{-16}$	0.04	$3.8x10^{-17}$	0.6	$3.2x10^{-16}$
Cache Valley	0.10	$4.4x10^{-17}$	0.29	$1.3x10^{-16}$		
South Salt Lake	0.03	$1.3x10^{-17}$	0.001	$-4.1x10^{-19}$		
Southern Wasatch Front	0.31	$2.4x10^{-16}$	0.13	$1.3x10^{-16}$		
Provo	0.03	$1.2x10^{-17}$	0.06	$-1.5x10^{-17}$		
Central Utah	0.38	$1.2x10^{-16}$	1.3	$-2.6x10^{-16}$		
Southern Utah	7.4	$9.8x10^{-16}$	0.23	$4.5x10^{-17}$		
Utah - Nevada Border			1.0	$-4.5x10^{-16}$		

* from Scott et al. [1984].

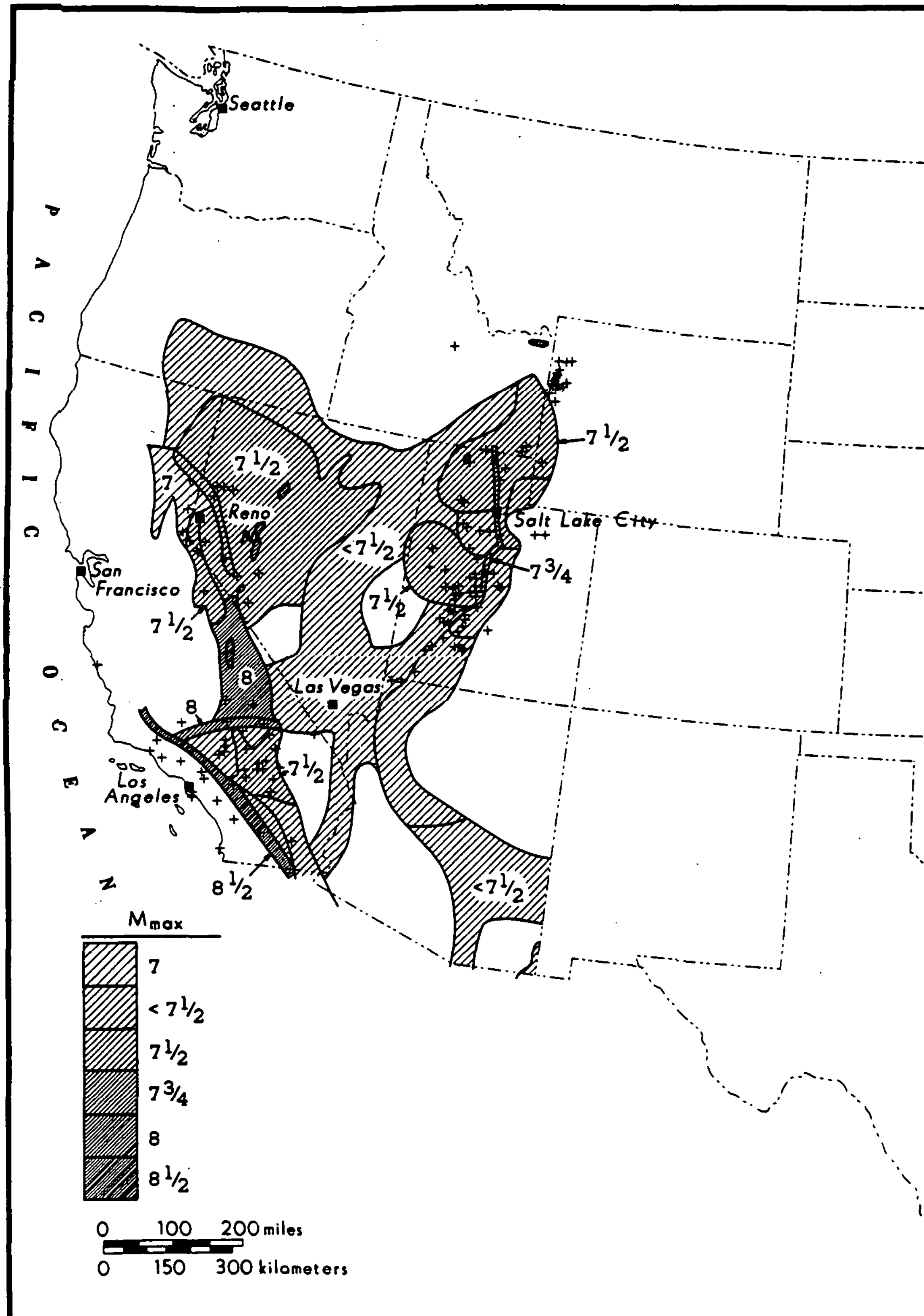

Fig. 14. Maximum magnitude capabilities of the western U. S. Data from Smith (unpublished data, 1982), and Thenhaus and Wentworth [1982]. Crosses, + , indicate centers of mapped faults.

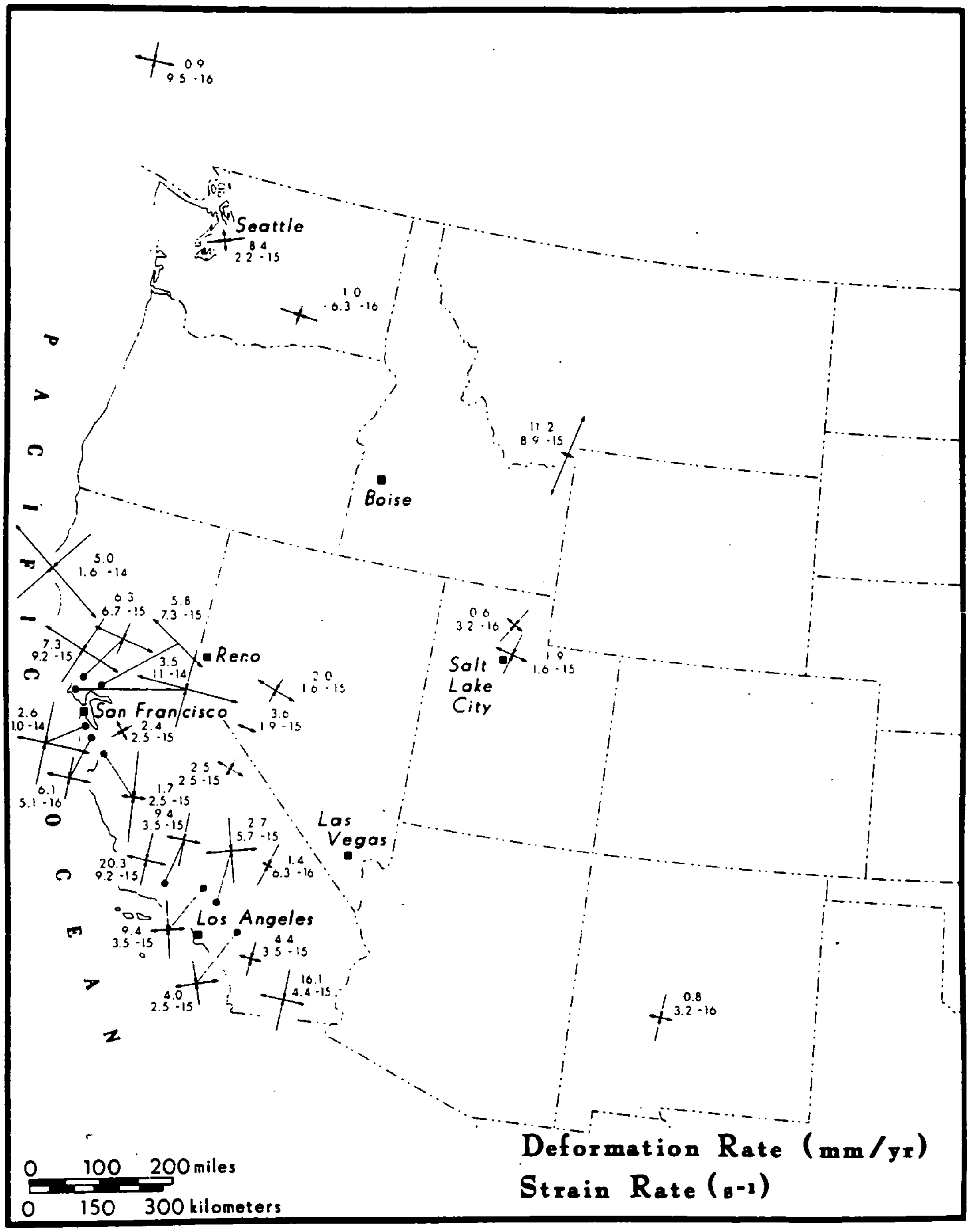

Fig. 15. Western U. S. geodetically determined extensional deformation and strain rates. The top number is deformation rate (mm/a) and the bottom is strain rate (s^{-1}). The second number is power of 10 from Savage [1983], Savage et al. [1984], and Snay et al. [1984].

Table 9. Geodetically measured strain and deformation rates

Network	Period (yr)	Principal Extension direction	ε_1 Def. Rate (mm/a)	ε_1 Strain Rate (sec^{-1})	ε_2 Def. Rate (mm/a)	ε_2 Strain Rate (sec^{-1})	Reference
Johnstone	1914-66	N87°E± 15°	0.9	9.5×10^{-16}	1.2	-9.5×10^{-16}	1
Seattle	1972-79	N20°W± 6°	8.4	2.2×10^{-15}	7.7	-3.8×10^{-15}	1
Hanford	1972-81	N5°E± 14°	1.0	-6.3×10^{-16}	1.6	-1.3×10^{-15}	1
Hebgen	1973-84	N14°E± 1°	11.2	8.9×10^{-15}	2.6	-1.6×10^{-15}	2
Ogden	1972-84	N57°W± 13°	0.6	3.2×10^{-16}	1.1	-6.3×10^{-16}	2
Shelter Cove	1930-76	~N58°W°	5.0	1.6×10^{-14}	5.0	-1.6×10^{-14}	1
Geyser	1972-79	N74°W± 2°	7.3	9.2×10^{-15}	2.8	-8.9×10^{-15}	1
Santa Rosa	1972-81	N81°W± 2°	6.3	6.7×10^{-15}	2.2	-3.5×10^{-15}	1
Napa	1976-80	N63°W± 8°	5.8	7.3×10^{-15}	0.3	3.2×10^{-16}	1
Point Reyes	1972-80	N88°W± 3°	3.5	1.1×10^{-14}	2.0	-8.9×10^{-15}	1
Fairview	1973-79	N74°W± 11°	2.0	1.6×10^{-15}	13.2	-3.8×10^{-15}	1
Peninsula	1970-80	N88°W± 7°	2.6	1.0×10^{-14}	1.4	-8.9×10^{-15}	1
Mocho	1973-81	N43°W± 4°	2.4	2.5×10^{-15}	2.0	-2.5×10^{-15}	1
Excelsior	1972-79	N81°W± 7°	3.6	1.9×10^{-15}	0.	0.	1
Loma Prieta	1972-80	N87°W± 4°	6.1	5.1×10^{-15}	3.0	-4.8×10^{-15}	1
Pajaro	1973-81	N98°W± 2°	1.7	2.5×10^{-15}	4.8	-1.0×10^{-14}	1
Carrizo	1977-81	N89°W± 4°	20.3	9.2×10^{-15}	1.8	-2.9×10^{-15}	1
Los Padres	1973.8-81.4	~N89°E	9.4	3.5×10^{-15}	13.5	-4.8×10^{-15}	1
Palmdale	1971.6-80.9	~N76°E	2.7	5.7×10^{-15}	3.8	-6.0×10^{-15}	1
Garlock	1973.2-80.9	~N74°E	1.4	6.3×10^{-16}	11.2	-5.1×10^{-15}	1
Tehachapi	1973.7-80.9	~N77°E	9.4	3.5×10^{-15}	10.8	-3.8×10^{-15}	1
Cajon	1974.3-81.3	~N80°E	4.4	3.5×10^{-15}	6.4	-5.1×10^{-15}	1
Anza	1974.0-81.2	~N87°W	4.0	2.5×10^{-15}	6.6	-3.8×10^{-15}	1
Salton	1972.9-81.1	~N89°E	16.1	4.4×10^{-15}	24.2	-7.0×10^{-15}	1
Socorro	1972-84	N84°E± 15°	0.8	3.2×10^{-16}	0.8	-6.3×10^{-16}	2
Owens Valley	1975-79	N69°W± 11°	2.5	2.5×10^{-15}	2.1	-2.2×10^{-15}	1
Salt Lake City	1962-74	N76°W± 15°	1.9	1.6×10^{-15}	4.0	2.5×10^{-15}	3

References: 1) Savage [1983], 2) Savage et al. [preprint, 1985], 3) Snay et al. [1984]

were available, these values were close to the values measured seismically; however, sometimes the geodetic rates were 10-20 times larger (Table 8).

Geodetically determined strain rates were probably higher than seismically determined counterparts owing to spatial sampling differences. Geodetic networks were usually three to five times smaller than the areas used in this study and focussed on the most actively deforming regions. Consequently, higher strain rates would be expected for geodetic network results.

The Walker Lane area (area 5) was an apparent example of different areal coverage with different contemporary strain rates. The seismically and geodetically determined strain rates for this area differ by almost an order of magnitude (1.3 x 10^{-16}/sec and 1.9 x 10^{-15}/sec respectively). However, the seismic and geodetic deformation rate results for the area were 2.9 mm/a - from earthquake data and 3.6 mm/a measured geodetically [Savage, 1983]. The Excelsior fault was probably the source of most deformation in this area and was sampled in both methods. Thus, when area size discrepancies are eliminated, the resulting deformations are almost identical.

Summary of Strain Rates

Table 8 shows that paleostrain rates are generally one to two orders of magnitude lower than contemporary strain rates. The exceptions to this pattern were: 1) the Los Angeles, Wyoming, south Salt Lake, southern Utah, and northern Wasatch front areas where the paleodeformation rates of 49.3, 0.74, 0.03, 7.4, and 0.25 mm/a were significantly larger than seismically determined rates of 1.2, 0.07, 0.001, 0.23, 0.04, and 0.13 mm/a; and 2) in the Idaho-Wyoming, 0.14 versus 0.12 mm/a; central California, 4.0 versus 1.1; Cache Valley, Utah, 0.1 versus 0.3 mm/a; and the southern Wasatch front, 0.31 versus 0.13 mm/a areas where paleo- versus seismically determined deformation rates were within a factor of four. These results suggest that historic seismicity and deformation in the areas named above have been lower than average levels, since the seismic values are no larger that the underestimated paleodeformation values. It is also possible that these areas have more complete geologic data than other areas.

Paleostrain rates in Figure 13 also show that deformation along the ISB, up to 7.4mm/a in the Southern Utah area, was greater than along the western margins of the Great Basin with up to 0.08 mm/a in the West-Central Nevada area). This result is the opposite of the results determined using earthquake data where deformation rates along the ISB were as high as 2.8 mm/a, in the Hebgen Lake/Yellowstone area, and deformation rates in the western half of the Great Basin were as high as 7.5 mm/a in the West-Central Nevada area. This difference is probably the result of lack of geologic data and temporal variation in seismic activity.

Anderson [1979] calculated values of 2.0 mm/a deformation rate in the Los Angeles area compared to 1.2 mm/a from the earthquake contribution. Likewise, he estimated deformation rates of 8.0 and 1.5 mm/a in the Garlock and Owens Valley areas where seismicity rates were 59.0 mm/a in the Garlock area and 28.0 mm/a in Owens Valley.

Contemporary and paleodeformation comparisons also support the existence of an anomalous Wasatch front seismic gap. The northern Wasatch Front area (area 16) contains the Wasatch fault - the primary surface breaking fault of the eastern Great Basin. Area 16 is also bordered on the east and west by seismically active areas (the Cache Valley and Hansel Valley areas). In contrast, the northern Wasatch front area has been quiet. Less than 200 earthquakes have been recorded there in the last 78 years. The maximum magnitude earthquake to be recorded in the area during this time period was M_L 5.7.

Smith [1978] suggested that this "seismic gap" along the northern Wasatch fault is temporary and might be seismically filled on a longer time scale. The deformation rate from seismicity for the northern Wasatch front was 0.04 mm/a and for the southern Wasatch front was 0.13 mm/a. In contrast, the geologic rates were 0.25 mm/a and 0.31 mm/a north and south. The higher paleodeformation values suggest that contemporary seismic quiescence is indeed anomalous.

Comparisons of Great Basin Extension Rate

Earthquake induced deformation rates of 10.0 mm/a on B-B' and 8.4 mm/a on B-B'' determined along the two northern profiles in Figure 10 compare well with deformation rates determined from other studies. For example, Lachenbruch and Sass [1978] determined 5-10 mm/a extension for the Great Basin using heat flow constraints and thermal models of extension (Table 7). Also, Jordan et al. [1985] estimated a deformation rate across the Great Basin of less than 9 mm/a from North American-Pacific intraplate tectonic models, while the seismically determined deformation rate along line B-B'' was 8.4 mm/a (Table 7) - close for two different methods. This implies that the North American/Pacific plate interaction modeled by Jordan et al. [1985] may contribute a component to Great Basin extension. This comparison also leads to the conclusion that most of the extension in the Great Basin is expressed as earthquake generated brittle fracture.

The strain rates found along the profiles mentioned above can also be compared to results from other workers (Table 7). For example, Thompson and Burke [1974] arrived at a deformation rate estimate of 8 mm/a from geologic data. Wright [1976] used geologic data to determine a deformation rate across the northern Great Basin of 5.8 - 7.8 mm/a. Also, Minster and Jordan's [1984] Table 3 (included in Table 7) listed deformation rates in the range 1-22 mm/a derived from various workers' results. All these deformation rates are compatible with the 8.4 mm/a results obtained in this study for profile B-B''. Also, Wright's [1976] southern area results were 3.7-10.1 mm/a - comparable with the deformation rate of 3.5 mm/a found in this study for profile C-C' across the southern Great Basin.

These comparisons suggest that since geologically inferred and contemporary strain rates are similar, the mechanism that facilitates Great Basin extension today probably operated throughout Quaternary times as well. Had the mechanism changed, we would expect to see greater differences in deformation rates between contemporary and paleo-estimations.

Also, contemporary versus paleostrain rate comparisons in the Great Basin suggest that the seismic record, though perhaps experiencing short-term, local variability, is probably a reasonable indicator of future seismicity on a regional scale. This conclusion is analogous to the findings of Wesnousky et al. [1982a] for Japanese seismicity. In their study, contemporary variations in seismic activity were determined to be short-term effects that disappeared over periods of many hundreds of years.

SUMMARY AND INTERPRETATIONS

This study has shown that, on a regional scale, contemporary strain rates from seismicity are comparable with strain rates determined from modern, geodetic measurements, and with paleostrain rates determined from geologic data.

Regionally, an E-W Great Basin extension rate of 8.4 mm/a was determined from earthquake data. Locally, contemporary strain was concentrated at changes in direction of the Intermountain Seismic Belt that marks the Great Basin eastern boundary; along the western margin of the Great Basin; in central Nevada; and in some other scattered areas primarily on the region boundaries. Great Basin contemporary deformation rates in the range ~1-28 mm/a were found in this study, where rates of 20-50 mm/a were determined for active interplate subduction and transform faulting in the Pacific Northwest determined from seismicity by Hyndman and Weichert [1983] showing that Great Basin deformation rates from seismicity were, on average, from 2 to 10 times lower than plate convergence rates.

Patterns of high seismicity and deformation rate along the margins of the Great Basin show that most, and probably the deepest, brittle fracture occurs along these margins. The stress release and opening of fractures represented by this seismicity have probably allowed magma to intrude the lithosphere, and in some cases reach the surface. Figure 16, a map of surface volcanism for the last 5 ma [Smith and Luedke, 1984] and of high, seismically determined deformation rates, suggests that brittle fracture and subsequent magma intrusion has persisted along the edges of the Great Basin for at least the last few million years.

The local and regional deformation rate results, summarized above, suggest that

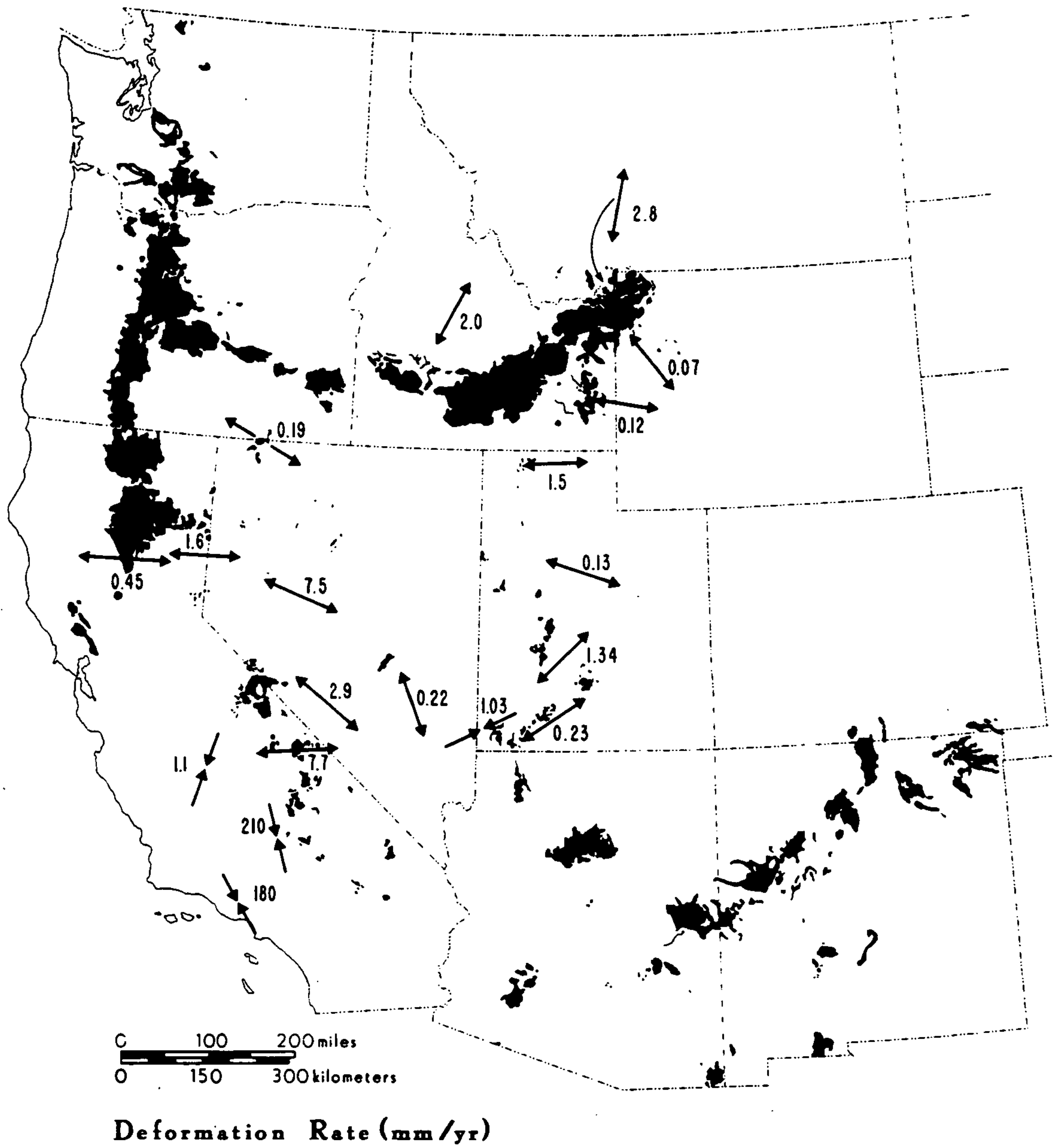

Fig. 16. Western U. S. volcanism and seismically determined deformation rates. Volcanism is from Smith and Luedke [1984] and deformation rates are in mm/a.

brittle fracture has been produced as the principal strain release, although it may ultimately be produced by creep and flow at depth through coupling in the upper-crust. It follows that most extension in the Great Basin has been expressed as brittle fracture in the upper 10 km of the crust. Thus creep in the whole of the lithosphere cannot exceed the brittle strain.

The observation that regional brittle strain release is comparable to other estimates of strain suggests that extension has been expressed consistently at depths less than 20 km. This is true on a regional level even over short time periods. Thus, contemporary mechanisms for strain release in the Great Basin must have been operating throughout the Quaternary. It follows that regional seismicity is a good indicator of future seismic activity. However, on a local scale, such as the Wasatch front, seismic quiescence reflects gaps in the seismicity that should fill in within the period of an earthquake cycle.

APPENDIX A

STRAIN DETERMINATION TEST CASE

File 1. Oregon-Nevada Border area earthquake summary catalog

yr	date	orig	time	lat-n		long-w		depth	mag	no	gap	dmn	rms
37	525	536	0.	41	30.00	119	48.00	0.	5.39	0	0	0.	0.
53	708	301	15.00	42	24.00	119	6.00	0.	3.50	0	0	0.	0.
56	110	837	24.00	41	30.00	119	6.00	0.	4.63	0	0	0.	0.
58	312	1209	16.00	42	24.00	120	0.	0.	4.63	0	0	0.	0.
58	312	1209	19.00	42	0.	119	30.00	0.	4.50	0	0	0.	0.
58	929	853	37.00	42	18.00	118	6.00	0.	4.63	0	0	0.	0.
59	1014	1434	49.00	42	12.00	118	24.00	0.	3.90	0	0	0.	0.
62	830	1335	29.00	41	48.00	118	48.00	0.	5.80	0	0	0.	0.
66	128	1800	9.10	41	36.00	118	12.00	20.00	3.20	0	0	0.	0.
68	527	553	34.00	42	12.23	119	44.93	0.	3.80	0	0	0.	0.
68	528	8	49.00	42	15.72	119	48.59	0.	3.20	0	0	0.	0.
68	528	51	3.00	42	15.35	119	46.80	0.	3.20	0	0	0.	0.
68	528	1255	44.70	42	11.88	119	48.72	0.	3.20	0	0	0.	0.
68	530	35	59.80	42	18.00	119	48.00	0.	4.60	0	0	0.	0.
68	531	306	38.00	42	5.46	119	46.79	0.	3.20	0	0	0.	0.
68	603	1327	39.70	42	12.00	119	48.00	0.	4.60	0	0	0.	0.
68	604	233	0.	42	14.64	119	46.50	0.	3.70	0	0	0.	0.
68	604	234	15.70	42	18.00	119	54.00	0.	3.20	0	0	0.	0.
68	604	238	29.00	42	18.89	119	47.15	0.	3.20	0	0	0.	0.
68	604	335	49.80	42	19.70	119	45.29	0.	3.20	0	0	0.	0.
68	604	552	32.00	42	17.28	119	49.20	0.	3.20	0	0	0.	0.
68	604	622	19.00	42	12.30	119	50.81	0.	3.20	0	0	0.	0.
68	604	1058	22.80	42	17.81	119	54.00	0.	3.20	0	0	0.	0.
68	605	451	56.80	42	18.29	119	56.81	0.	3.20	0	0	0.	0.
68	605	512	36.00	42	14.64	119	54.36	0.	3.20	0	0	0.	0.
68	605	737	45.00	42	15.60	119	54.59	0.	3.20	0	0	0.	0.
68	605	804	40.00	42	16.92	119	48.60	0.	3.30	0	0	0.	0.
68	605	820	38.00	42	17.45	119	49.91	0.	3.20	0	0	0.	0.
68	605	1408	40.00	42	18.12	119	51.59	0.	3.80	0	0	0.	0.

yr	date	orig time		lat-n		long-w		depth	mag	no	gap	dmn	rms
68	612	120	56.00	42	6.00	120	0.	0.	3.40	0	0	0.	0.
68	612	146	22.40	42	6.17	119	53.22	0.	3.20	0	0	0.	0.
68	621	2033	28.00	42	12.84	119	39.11	0.	3.20	0	0	0.	0.
68	622	939	53.50	42	11.57	119	49.43	0.	3.20	0	0	0.	0.
68	624	1103	17.30	42	17.21	119	50.34	0.	3.20	0	0	0.	0.
70	102	2052	11.10	41	57.60	118	41.90	0.	3.10	0	0	0.	0.
70	103	801	56.50	42	4.61	118	55.25	0.	3.60	0	0	0.	0.
72	113	357	33.10	41	35.58	118	38.27	0.	2.90	0	0	0.	0.
73	225	1133	57.00	41	48.59	118	28.79	0.	3.00	0	0	0.	0.
73	225	1419	45.00	41	48.59	118	28.79	0.	3.40	0	0	0.	0.
73	227	152	22.00	41	48.59	118	28.79	0.	3.70	0	0	0.	0.
73	227	418	21.00	41	48.59	118	28.79	0.	3.80	0	0	0.	0.
73	227	952	0.	41	48.59	118	28.79	0.	3.30	0	0	0.	0.
73	227	1235	38.00	41	48.59	118	28.79	0.	3.30	0	0	0.	0.
73	302	1128	42.30	41	49.86	118	32.75	5.00	3.20	0	0	0.	0.
73	302	1206	13.00	41	48.59	118	28.79	0.	3.30	0	0	0.	0.
73	302	1217	20.00	41	48.59	118	28.79	0.	3.20	0	0	0.	0.
73	302	1414	6.00	41	48.59	118	28.79	0.	4.10	0	0	0.	0.
73	303	300	3.30	41	48.59	118	27.42	5.00	3.20	0	0	0.	0.
73	303	334	51.00	41	49.20	118	40.25	5.00	3.20	0	0	0.	0.
73	303	335	51.00	41	48.59	118	28.79	0.	4.70	0	0	0.	0.
73	303	345	12.00	41	48.59	118	28.79	0.	3.60	0	0	0.	0.
73	303	807	24.00	41	48.59	118	28.79	0.	3.40	0	0	0.	0.
73	303	1004	31.00	41	48.59	118	28.79	0.	3.40	0	0	0.	0.
73	303	1852	4.30	41	50.63	118	25.13	5.00	3.20	0	0	0.	0.
73	306	1049	50.00	41	48.59	118	28.79	0.	3.00	0	0	0.	0.
73	309	330	57.00	41	48.59	118	28.79	0.	3.00	0	0	0.	0.
74	103	258	32.90	41	45.00	119	18.00	0.	3.00	0	0	0.	0.
74	426	2303	23.10	42	6.11	118	17.87	0.	2.50	0	0	0.	0.
74	724	1559	54.30	41	30.78	118	44.70	0.	2.90	0	0	0.	0.
74	1216	2141	40.70	42	9.60	119	22.68	0.	2.90	0	0	0.	0.
75	902	1448	28.60	41	58.86	118	57.47	0.	4.00	0	0	0.	0.

yr	date	orig	time	lat-n		long-w		depth	mag	no	gap	dmn	rms
78	516	2004	55.90	41	46.61	118	41.88	0.	3.10	0	0	0.	0.
80	411	642	49.90	42	12.60	119	36.77	0.	3.30	0	0	0.	0.
80	411	644	11.40	42	13.19	119	36.60	0.	3.10	0	0	0.	0.
80	411	729	47.60	42	16.70	119	34.56	0.	3.20	0	0	0.	0.
80	412	1319	26.60	42	1.62	119	36.29	0.	3.40	0	0	0.	0.
80	427	1354	34.30	41	59.27	118	56.40	0.	4.40	0	0	0.	0.
80	428	1355	34.00	41	51.90	118	54.54	5.00	4.30	0	0	0.	0.
80	428	1707	9.60	41	59.88	118	54.29	0.	4.00	0	0	0.	0.
80	428	1707	10.10	41	50.75	118	55.86	5.00	3.80	0	0	0.	0.
80	503	17	39.30	41	55.61	118	47.58	0.	4.40	0	0	0.	0.

File 2. Oregon-Nevada Border area fault plane solutions

event	location	P axis	T axis	Str	dip	rake	str	dip	rake
53 C 73	41.83 118.48			200	40	-67	350	50	-96
H2 S 680604	42.3 119.77			91	90	171	10	90	8
50 S 680430	42.17 119.92	065 35	120 13	4	80	-119	260	30	-17

File 3. Oregon-Nevada Border area synthetic fault plane solution

areal

T1	101.236938	-0.195908
P1	-169.227844	67.141098
T2	118.459373	34.957180
P2	-104.751625	46.193237
B	11.319519	22.857967

230.0	34.0
0.6	66.3

File 4. Oregon-Nevada Border area
'nstrain' input file

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nevada oregon border
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File 5. Oregon-Nevada Border area 'nstrain' output

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COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
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nevada oregon border

370525005

Fault plane solution number      1
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 2.1e+24 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor      1:
                M11=      1.9e+22  M12=     -8.3e+23  M13=       3.4e+23
                M21=     -8.3e+23  M22=      1.4e+24  M23=       1.3e+24  dyne-cm
                M31=      3.4e+23  M32=      1.3e+24  M33=      -1.4e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


530708003

Fault plane solution number      2
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.8e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor      2:
                M11=      1.6e+20  M12=     -7.1e+21  M13=       2.9e+21
                M21=     -7.1e+21  M22=      1.2e+22  M23=       1.1e+22  dyne-cm
                M31=      2.9e+21  M32=      1.1e+22  M33=      -1.2e+22
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Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


560110008

Fault plane solution number     3
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=    1. dip=  66. slip=-114. degrees
Moment Mo= 3.1e+23 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=   -89.0  vecdip=  24.0
moment tensor     3:
                M11=      2.7e+21  M12=     -1.2e+23  M13=      5.1e+22
                M21=     -1.2e+23  M22=      2.0e+23  M23=      1.9e+23  dyne-cm
                M31=      5.1e+22  M32=      1.9e+23  M33=     -2.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


580312012

Fault plane solution number     4
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=    1. dip=  66. slip=-114. degrees
Moment Mo= 3.1e+23 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=   -89.0  vecdip=  24.0
moment tensor     4:
                M11=      2.7e+21  M12=     -1.2e+23  M13=      5.1e+22
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                    M21=    -1.2e+23  M22=      2.0e+23  M23=      1.9e+23  dyne-cm
                    M31=     5.1e+22  M32=      1.9e+23  M33=     -2.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


580312012

Fault plane solution number     5
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 2.2e+23 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    5:
                    M11=     1.9e+21  M12=     -8.7e+22  M13=      3.6e+22
                    M21=    -8.7e+22  M22=      1.4e+23  M23=      1.4e+23  dyne-cm
                    M31=     3.6e+22  M32=      1.4e+23  M33=     -1.5e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


580929008

Fault plane solution number     6
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.1e+23 dyne-cm
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slipvector=(0.016,-.913,0.407)   vecaz= -89.0   vecdip= 24.0

moment tensor   6:

M11=	2.7e+21	M12=	-1.2e+23	M13=	5.1e+22	
M21=	-1.2e+23	M22=	2.0e+23	M23=	1.9e+23	dyne-cm
M31=	5.1e+22	M32=	1.9e+23	M33=	-2.1e+23	

Eigenvectors: component 1=N, 2=E, 3=V

eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0   vecdip= 17.6

eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3   vecdip= 22.9

eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9   vecdip= 60.5

591014014

Fault plane solution number   7

fault plane: strike= 230. dip= 34. slip= -46. degrees

auxilary plane: strike=   1. dip= 66. slip=-114. degrees

Moment Mo= 4.9e+22 dyne-cm

slipvector=(0.016,-.913,0.407)   vecaz= -89.0   vecdip= 24.0

moment tensor   7:

M11=	4.3e+20	M12=	-1.9e+22	M13=	8.0e+21	
M21=	-1.9e+22	M22=	3.2e+22	M23=	3.0e+22	dyne-cm
M31=	8.0e+21	M32=	3.0e+22	M33=	-3.3e+22	

Eigenvectors: component 1=N, 2=E, 3=V

eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0   vecdip= 17.6

eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3   vecdip= 22.9

eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9   vecdip= 60.5

620830013

Fault plane solution number   8

fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 6.0e+24 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 8:

M11=	5.3e+22	M12=	-2.4e+24	M13=	9.8e+23	
M21=	-2.4e+24	M22=	3.9e+24	M23=	3.7e+24	dyne-cm
M31=	9.8e+23	M32=	3.7e+24	M33=	-4.0e+24	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

660128018

Fault plane solution number 9
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 9:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

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680527005

Fault plane solution number    10
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.8e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    10:
                M11=     3.4e+20  M12=    -1.5e+22  M13=     6.2e+21
                M21=    -1.5e+22  M22=     2.5e+22  M23=     2.3e+22  dyne-cm
                M31=     6.2e+21  M32=     2.3e+22  M33=    -2.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680528000

Fault plane solution number    11
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    11:
                M11=     7.3e+19  M12=    -3.3e+21  M13=     1.4e+21
                M21=    -3.3e+21  M22=     5.5e+21  M23=     5.1e+21  dyne-cm
                M31=     1.4e+21  M32=     5.1e+21  M33=    -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
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680528000

Fault plane solution number 12
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 12:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

680528012

Fault plane solution number 13
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 13:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V

eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

680530000

Fault plane solution number   14
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 2.9e+23 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   14:

M11=	2.6e+21	M12=	-1.1e+23	M13=	4.7e+22	
M21=	-1.1e+23	M22=	1.9e+23	M23=	1.8e+23	dyne-cm
M31=	4.7e+22	M32=	1.8e+23	M33=	-1.9e+23	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

680531003

Fault plane solution number   15
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   15:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm

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                M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680603013

Fault plane solution number   16
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 2.9e+23 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    16:
                M11=      2.6e+21  M12=     -1.1e+23  M13=      4.7e+22
                M21=     -1.1e+23  M22=      1.9e+23  M23=      1.8e+23  dyne-cm
                M31=      4.7e+22  M32=      1.8e+23  M33=     -1.9e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680604002

Fault plane solution number   17
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.0e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
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moment tensor    17:
                 M11=      2.7e+20  M12=     -1.2e+22  M13=      4.9e+21
                 M21=     -1.2e+22  M22=      2.0e+22  M23=      1.8e+22  dyne-cm
                 M31=      4.9e+21  M32=      1.8e+22  M33=     -2.0e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680604002

Fault plane solution number    18
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    18:
                 M11=      7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=      5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680604002

Fault plane solution number    19
fault plane:     strike= 230. dip=  34. slip= -46. degrees
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auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    19:
                 M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680604003

Fault plane solution number   20
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    20:
                 M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680604005
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Fault plane solution number    21
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    21:
                 M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680604006

Fault plane solution number    22
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    22:
                 M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
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680604010

Fault plane solution number    23
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    23:
                 M11=       7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                 M21=      -3.3e+21  M22=      5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=       1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680605004

Fault plane solution number    24
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    24:
                 M11=       7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                 M21=      -3.3e+21  M22=      5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=       1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
```

eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

680605005

Fault plane solution number   25
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   25:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

680605007

Fault plane solution number   26
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   26:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

```
Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

680605008

```
Fault plane solution number   27
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   27:
               M11=    9.7e+19  M12=   -4.4e+21  M13=    1.8e+21
               M21=   -4.4e+21  M22=    7.2e+21  M23=    6.8e+21  dyne-cm
               M31=    1.8e+21  M32=    6.8e+21  M33=   -7.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

680605008

```
Fault plane solution number   28
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   28:
```

```
                M11=      7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                M21=     -3.3e+21  M22=      5.5e+21  M23=      5.1e+21   dyne-cm
                M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680605014

Fault plane solution number   29
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.8e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    29:
                M11=      3.4e+20  M12=     -1.5e+22  M13=      6.2e+21
                M21=     -1.5e+22  M22=      2.5e+22  M23=      2.3e+22   dyne-cm
                M31=      6.2e+21  M32=      2.3e+22  M33=     -2.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


680612001

Fault plane solution number   30
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
```

C-2

```
Moment Mo= 1.4e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    30:
                 M11=      1.2e+20  M12=     -5.5e+21  M13=      2.3e+21
                 M21=     -5.5e+21  M22=      9.2e+21  M23=      8.6e+21  dyne-cm
                 M31=      2.3e+21  M32=      8.6e+21  M33=     -9.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680612001

Fault plane solution number    31
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=    1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    31:
                 M11=      7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=      5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


680621020
```

Fault plane solution number 32
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 32:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

680622009

Fault plane solution number 33
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 33:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

```
680624011

Fault plane solution number   34
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor     34:
                  M11=     7.3e+19  M12=    -3.3e+21  M13=     1.4e+21
                  M21=    -3.3e+21  M22=     5.5e+21  M23=     5.1e+21  dyne-cm
                  M31=     1.4e+21  M32=     5.1e+21  M33=    -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


700102020

Fault plane solution number   35
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 6.5e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor     35:
                  M11=     5.7e+19  M12=    -2.6e+21  M13=     1.1e+21
                  M21=    -2.6e+21  M22=     4.3e+21  M23=     4.0e+21  dyne-cm
                  M31=     1.1e+21  M32=     4.0e+21  M33=    -4.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
```

eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

700103008

Fault plane solution number   36
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 2.3e+22 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   36:

M11=	2.0e+20	M12=	-9.1e+21	M13=	3.8e+21	
M21=	-9.1e+21	M22=	1.5e+22	M23=	1.4e+22	dyne-cm
M31=	3.8e+21	M32=	1.4e+22	M33=	-1.5e+22	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

720113003

Fault plane solution number   37
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 3.9e+21 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   37:

M11=	3.4e+19	M12=	-1.5e+21	M13=	6.4e+20	
M21=	-1.5e+21	M22=	2.6e+21	M23=	2.4e+21	dyne-cm
M31=	6.4e+20	M32=	2.4e+21	M33=	-2.6e+21	

```
Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730225011

Fault plane solution number   38
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 5.0e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   38:
                M11=     4.4e+19  M12=    -2.0e+21  M13=     8.2e+20
                M21=    -2.0e+21  M22=     3.3e+21  M23=     3.1e+21  dyne-cm
                M31=     8.2e+20  M32=     3.1e+21  M33=    -3.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730225014

Fault plane solution number   39
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.4e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   39:
                M11=     1.2e+20  M12=    -5.5e+21  M13=     2.3e+21
```

```
                M21=     -5.5e+21  M22=      9.2e+21  M23=      8.6e+21  dyne-cm
                M31=      2.3e+21  M32=      8.6e+21  M33=     -9.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730227001

Fault plane solution number   40
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.0e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   40:
                M11=      2.7e+20  M12=     -1.2e+22  M13=      4.9e+21
                M21=     -1.2e+22  M22=      2.0e+22  M23=      1.8e+22  dyne-cm
                M31=      4.9e+21  M32=      1.8e+22  M33=     -2.0e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730227004

Fault plane solution number   41
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.8e+22 dyne-cm
```

```
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    41:
                 M11=      3.4e+20  M12=     -1.5e+22  M13=      6.2e+21
                 M21=     -1.5e+22  M22=      2.5e+22  M23=      2.3e+22  dyne-cm
                 M31=      6.2e+21  M32=      2.3e+22  M33=     -2.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


730227009

Fault plane solution number    42
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=    1. dip=  66. slip=-114. degrees
Moment Mo= 1.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    42:
                 M11=      9.7e+19  M12=     -4.4e+21  M13=      1.8e+21
                 M21=     -4.4e+21  M22=      7.2e+21  M23=      6.8e+21  dyne-cm
                 M31=      1.8e+21  M32=      6.8e+21  M33=     -7.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


730227012

Fault plane solution number    43
```

fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 1.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   43:

M11=	9.7e+19	M12=	-4.4e+21	M13=	1.8e+21	
M21=	-4.4e+21	M22=	7.2e+21	M23=	6.8e+21	dyne-cm
M31=	1.8e+21	M32=	6.8e+21	M33=	-7.3e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

730302011

Fault plane solution number   44
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike=   1. dip= 66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)   vecaz= -89.0 vecdip= 24.0
moment tensor   44:

M11=	7.3e+19	M12=	-3.3e+21	M13=	1.4e+21	
M21=	-3.3e+21	M22=	5.5e+21	M23=	5.1e+21	dyne-cm
M31=	1.4e+21	M32=	5.1e+21	M33=	-5.5e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)   vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388)   vecaz.=   11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871)   vecaz.= -126.9 vecdip= 60.5

```
730302012

Fault plane solution number   45
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor   45:
                M11=      9.7e+19  M12=    -4.4e+21  M13=      1.8e+21
                M21=     -4.4e+21  M22=     7.2e+21  M23=      6.8e+21  dyne-cm
                M31=      1.8e+21  M32=     6.8e+21  M33=     -7.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730302012

Fault plane solution number   46
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor   46:
                M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

730302014

```
Fault plane solution number   47
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   47:
                M11=     7.2e+20  M12=    -3.2e+22  M13=     1.3e+22
                M21=    -3.2e+22  M22=     5.3e+22  M23=     5.0e+22  dyne-cm
                M31=     1.3e+22  M32=     5.0e+22  M33=    -5.4e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

730303003

```
Fault plane solution number   48
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   48:
                M11=     7.3e+19  M12=    -3.3e+21  M13=     1.4e+21
                M21=    -3.3e+21  M22=     5.5e+21  M23=     5.1e+21  dyne-cm
                M31=     1.4e+21  M32=     5.1e+21  M33=    -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
```

```
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303003

Fault plane solution number   49
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    49:
                 M11=      7.3e+19  M12=    -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=     5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=     5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303003

Fault plane solution number   50
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.7e+23 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    50:
                 M11=      3.3e+21  M12=    -1.5e+23  M13=      6.1e+22
                 M21=     -1.5e+23  M22=     2.4e+23  M23=      2.3e+23  dyne-cm
```

```
                 M31=      6.1e+22  M32=      2.3e+23  M33=     -2.5e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303003

Fault plane solution number   51
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 2.3e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    51:
                 M11=      2.0e+20  M12=     -9.1e+21  M13=      3.8e+21
                 M21=     -9.1e+21  M22=      1.5e+22  M23=      1.4e+22  dyne-cm
                 M31=      3.8e+21  M32=      1.4e+22  M33=     -1.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303008

Fault plane solution number   52
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.4e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
```

```
moment tensor     52:
                  M11=     1.2e+20  M12=    -5.5e+21  M13=     2.3e+21
                  M21=    -5.5e+21  M22=     9.2e+21  M23=     8.6e+21  dyne-cm
                  M31=     2.3e+21  M32=     8.6e+21  M33=    -9.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303010

Fault plane solution number   53
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.4e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor     53:
                  M11=     1.2e+20  M12=    -5.5e+21  M13=     2.3e+21
                  M21=    -5.5e+21  M22=     9.2e+21  M23=     8.6e+21  dyne-cm
                  M31=     2.3e+21  M32=     8.6e+21  M33=    -9.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


730303018

Fault plane solution number   54
fault plane:     strike= 230. dip=  34. slip= -46. degrees
```

```
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor     54:
                  M11=      7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                  M21=     -3.3e+21  M22=      5.5e+21  M23=      5.1e+21   dyne-cm
                  M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


730306010

Fault plane solution number   55
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 5.0e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor     55:
                  M11=      4.4e+19  M12=     -2.0e+21  M13=      8.2e+20
                  M21=     -2.0e+21  M22=      3.3e+21  M23=      3.1e+21   dyne-cm
                  M31=      8.2e+20  M32=      3.1e+21  M33=     -3.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


730309003
```

```
Fault plane solution number   56
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 5.0e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   56:
                M11=     4.4e+19  M12=    -2.0e+21  M13=     8.2e+20
                M21=    -2.0e+21  M22=     3.3e+21  M23=     3.1e+21  dyne-cm
                M31=     8.2e+20  M32=     3.1e+21  M33=    -3.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


740103002

Fault plane solution number   57
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 5.0e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   57:
                M11=     4.4e+19  M12=    -2.0e+21  M13=     8.2e+20
                M21=    -2.0e+21  M22=     3.3e+21  M23=     3.1e+21  dyne-cm
                M31=     8.2e+20  M32=     3.1e+21  M33=    -3.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

```
740426023

Fault plane solution number    58
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.4e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    58:
                M11=      1.2e+19  M12=     -5.5e+20  M13=      2.3e+20
                M21=     -5.5e+20  M22=      9.2e+20  M23=      8.6e+20  dyne-cm
                M31=      2.3e+20  M32=      8.6e+20  M33=     -9.3e+20

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


740724015

Fault plane solution number    59
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.9e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    59:
                M11=      3.4e+19  M12=     -1.5e+21  M13=      6.4e+20
                M21=     -1.5e+21  M22=      2.6e+21  M23=      2.4e+21  dyne-cm
                M31=      6.4e+20  M32=      2.4e+21  M33=     -2.6e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
```

```
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


741216021

Fault plane solution number   60
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 3.9e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    60:
                M11=     3.4e+19  M12=    -1.5e+21  M13=     6.4e+20
                M21=    -1.5e+21  M22=     2.6e+21  M23=     2.4e+21  dyne-cm
                M31=     6.4e+20  M32=     2.4e+21  M33=    -2.6e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


750902014

Fault plane solution number   61
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 6.3e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    61:
                M11=     5.6e+20  M12=    -2.5e+22  M13=     1.0e+22
                M21=    -2.5e+22  M22=     4.1e+22  M23=     3.9e+22  dyne-cm
                M31=     1.0e+22  M32=     3.9e+22  M33=    -4.2e+22
```

```
Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


780516020

Fault plane solution number   62
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 6.5e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    62:
                 M11=     5.7e+19  M12=    -2.6e+21  M13=      1.1e+21
                 M21=    -2.6e+21  M22=     4.3e+21  M23=      4.0e+21  dyne-cm
                 M31=     1.1e+21  M32=     4.0e+21  M33=     -4.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


800411006

Fault plane solution number   63
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.1e+22 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    63:
```

```
                 M11=     9.7e+19  M12=    -4.4e+21  M13=     1.8e+21
                 M21=    -4.4e+21  M22=     7.2e+21  M23=     6.8e+21  dyne-cm
                 M31=     1.8e+21  M32=     6.8e+21  M33=    -7.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


800411006

Fault plane solution number   64
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 6.5e+21 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor    64:
                 M11=     5.7e+19  M12=    -2.6e+21  M13=     1.1e+21
                 M21=    -2.6e+21  M22=     4.3e+21  M23=     4.0e+21  dyne-cm
                 M31=     1.1e+21  M32=     4.0e+21  M33=    -4.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


800411007

Fault plane solution number   65
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
```

```
Moment Mo= 8.3e+21 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    65:
                 M11=      7.3e+19  M12=     -3.3e+21  M13=      1.4e+21
                 M21=     -3.3e+21  M22=      5.5e+21  M23=      5.1e+21  dyne-cm
                 M31=      1.4e+21  M32=      5.1e+21  M33=     -5.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


800412013

Fault plane solution number   66
fault plane:     strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.4e+22 dyne-cm
slipvector=(0.016,-.913,0.407)     vecaz=  -89.0  vecdip=  24.0
moment tensor    66:
                 M11=      1.2e+20  M12=     -5.5e+21  M13=      2.3e+21
                 M21=     -5.5e+21  M22=      9.2e+21  M23=      8.6e+21  dyne-cm
                 M31=      2.3e+21  M32=      8.6e+21  M33=     -9.3e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)     vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)     vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)     vecaz.= -126.9  vecdip=  60.5


800427013
```

```
Fault plane solution number   67
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.7e+23 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   67:
                M11=     1.5e+21  M12=    -6.7e+22  M13=     2.8e+22
                M21=    -6.7e+22  M22=     1.1e+23  M23=     1.0e+23  dyne-cm
                M31=     2.8e+22  M32=     1.0e+23  M33=    -1.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


800428013

Fault plane solution number   68
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.3e+23 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   68:
                M11=     1.1e+21  M12=    -5.1e+22  M13=     2.1e+22
                M21=    -5.1e+22  M22=     8.6e+22  M23=     8.0e+22  dyne-cm
                M31=     2.1e+22  M32=     8.0e+22  M33=    -8.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5
```

800428017

Fault plane solution number 69
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 6.3e+22 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 69:

M11=	5.6e+20	M12=	-2.5e+22	M13=	1.0e+22	
M21=	-2.5e+22	M22=	4.1e+22	M23=	3.9e+22	dyne-cm
M31=	1.0e+22	M32=	3.9e+22	M33=	-4.2e+22	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9
eigenvector3=(-.296,-.393,0.871) vecaz.= -126.9 vecdip= 60.5

800428017

Fault plane solution number 70
fault plane: strike= 230. dip= 34. slip= -46. degrees
auxilary plane: strike= 1. dip= 66. slip=-114. degrees
Moment Mo= 3.8e+22 dyne-cm
slipvector=(0.016,-.913,0.407) vecaz= -89.0 vecdip= 24.0
moment tensor 70:

M11=	3.4e+20	M12=	-1.5e+22	M13=	6.2e+21	
M21=	-1.5e+22	M22=	2.5e+22	M23=	2.3e+22	dyne-cm
M31=	6.2e+21	M32=	2.3e+22	M33=	-2.5e+22	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302) vecaz.= 109.0 vecdip= 17.6
eigenvector2=(0.904,0.181,0.388) vecaz.= 11.3 vecdip= 22.9

```
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


800503000

Fault plane solution number   71
fault plane:    strike= 230. dip=  34. slip= -46. degrees
auxilary plane: strike=   1. dip=  66. slip=-114. degrees
Moment Mo= 1.7e+23 dyne-cm
slipvector=(0.016,-.913,0.407)    vecaz=  -89.0  vecdip=  24.0
moment tensor   71:
                M11=      1.5e+21  M12=    -6.7e+22  M13=      2.8e+22
                M21=     -6.7e+22  M22=     1.1e+23  M23=      1.0e+23  dyne-cm
                M31=      2.8e+22  M32=     1.0e+23  M33=     -1.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5



Regional moment tensor:
                M11=      1.0e+23  M12=    -4.6e+24  M13=      1.9e+24
                M21=     -4.6e+24  M22=     7.6e+24  M23=      7.1e+24  dyne-cm
                M31=      1.9e+24  M32=     7.1e+24  M33=     -7.7e+24

Eigenvalues:
sigma1=  1.2e+25  sigma2= -1.5e+18  sigma3= -1.2e+25


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
```

```
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.428, 0.359, 0.829)    vecaz= 140.vecdip=  56.
nodal plane2: strike= 230. dip=  34.
T1=(-0.195, 0.981,-0.003)    vecaz= 101.  vecdip=  -0.
B =( 0.904, 0.181, 0.388)    vecaz=  11.  vecdip=  23.
P1=(-0.382,-0.073, 0.921)    vecaz=-169.  vecdip=  67.

slipvec2=( 0.010,-0.915, 0.402)    vecaz= -89.vecdip=  24.
nodal plane1: strike=   1. dip=  66.
T2=(-0.391, 0.721, 0.573)    vecaz= 118.  vecdip=  35.
B =( 0.904, 0.181, 0.388)    vecaz=  11.  vecdip=  23.
P2=(-0.176,-0.669, 0.722)    vecaz=-105.  vecdip=  46.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 111.1x222.2x 15.0km3

The strain rates for the last  53.0 years in the directions
 of the principal stresses:
     extensional   : 8.9e-10/yr  =  8.0e-14/sec
     intermediate  :-1.2e-16/yr  = -1.0e-20/sec
     compressional:-8.9e-10/yr  = -8.0e-14/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  7.6e-10/yr =  2.4e-17/sec  Azimuth: N65W
     Minimum horizontal: -1.6e-10/yr = -5.1e-18/sec  Azimuth: N25E
     Vertical           : -6.0e-10/yr = -1.9e-17/sec
  ENTER region boundary rotation
```

```
O.
razmax
 64.6770

The maximum horizontal deformation rate =  1.9e-01 mm/yr
```

APPENDIX B

COMPUTER PROGRAMS

```
c *** program rake
c *** calculates the rakes of the slip vectors
c *** of two nodal planes of a f.p. solution
      real*4 slipaz(2),slidip(2),slivec(6),stvec(6)
      real arg
      integer*4 az(2),dip(2),rake(2)
      character*55 text
      pi=3.141592654
      rad=pi/180.
c ***prog. can be run either for whole file or
c ***individual entries. Now set for individual.  p.e.
c     open(7,file='wus',status='old',form='formatted')
c     rewind(7)
c     read(7,'(//////)')
c     do 30 k=1,109
c
c enter fps name, and two nodal plane strikes and dips
c
          write(6,*)'enter data'
          read(5,'(a5,2i3,3x,2i3)') text,az(1),dip(1),az(2),dip(2)
          write(6,'(4i6)') az(1),dip(1),az(2),dip(2)
          write(6,*)' '
c *** when the flag is = 0. the prog. runs as is and
c *** gives rakes which produce a normal-fault synthetic
c *** fault plane
c *** solution when sent to "strain.f".  If the flag
c *** is = 1., the 'rake' gives the compliments of the
c *** normal rakes, with an opposite sign. This will
c *** yield a thrust-fault f.p.s. when sent to
c *** "strain.f".
          write(6,*)'enter 1. for thrust, 0. for normal'
          write(6,*)' '
          write(6,*)'for strike-slip faults'
          write(6,*)'if the nodal plane with az. in the '
          write(6,*)'1st quadrant is closest to the north'
          write(6,*)'axis, and would be a left lateral'
          write(6,*)'fault, type 0. If it is closer to'
          write(6,*)'the east axis,(90deg) type 1.'
          write(6,*)'For right lateral faults, reverse'
          write(6,*)'0. and 1. usage'
          read(5,*)rflag
          j=1
          l=1
c
c  find trend and plunge of the slip vector
c
          do 20 i=1,2
             slipaz(i)=float(az(i))*rad-pi/2.
             slidip(i)=pi/2.-float(dip(i))*rad
             saz=slipaz(i)/rad
             sdip=slidip(i)/rad
             write(6,'("saz,sdip=",2f5.0)') saz,sdip
c
c  find components of slip vector
c
             slivec(j)=cos(slipaz(i))*cos(slidip(i))
```

```
                slivec(j+1)=tan(slipaz(i))*slivec(j)
                slivec(j+2)=tan(slidip(i))*sqrt(slivec(j)**2+slivec(j+1)
     &                **2)
                write(6,'("slivec=",3f7.3)') (slivec(m),m=j,j+2)
                if(l.eq.2) l=0
c
c  find components of nodal plane strike
c
                stvec(j)=cos(az(l+1)*rad)
                stvec(j+1)=sin(az(l+1)*rad)
                stvec(j+2)=0.
                do 40 m=1,2
                   dip(m)=ifix(dip(m))
                   az(m)=ifix(az(m))
40              continue
c
c find rake
c
                write(6,'("stvec=",3f6.3)') (stvec(m),m=j,j+2)
                arg=slivec(j)*stvec(j)+slivec(j+1)*stvec(j+1)
                if(arg.gt.1.0)arg=1.0
                if(arg.lt.-1.0)arg=-1.0
                rake(l+1)=ifix(acos(arg)/rad)
                rake(l-1)=-rake(l+1)
                if(rflag.gt.0.) rake(l+1)=180+rake(l+1)
                j=j+3
20          continue
            write(6,'(2i5)') (rake(i),i=1,2)
            open(8,file='testrake')
            write(8,'(a5,2i3,1x,i4,1x,2i3,1x,i4)') text,az(1),dip(1),
     &            rake(1),az(2),dip(2),rake(2)
30      continue
        close(8)
        stop
        end
```

```
c  moment.f
c
c  prog. to read magnitude from an e.q. file,
c  convert it to a moment via logMo=c*mag+d,
c  and write it to an input file for prog
c  'nstrain' using the summed fault plane
c  solutions available for the region.
      real mom,mag,c,d
      integer str1,str2,dip1,dip2,rake1,rake2
      character*30 title,outfil,eqfil
      integer event
      write(6,*)'ENTER: earthquake file name'
      read(5,5)eqfil
      open(2,file=eqfil,status='old',access=
     1'sequential',form='formatted',blank='zero')
      rewind 2
      write(6,*)'ENTER:c and d'
      read(5,*)c,d
      write(6,*)'ENTER: name of outfile'
      read(5,5) outfil
 5    format(a)
      open(3,file=outfil,status='new',access=
     1'sequential',form='formatted')
      write(6,*)'ENTER: title of region'
      read(5,5) title
      write(6,*)'ENTER:nodal 1 strike,dip,rake'
      read(5,*) str1,dip1,rake1
      write(6,*)'ENTER: nodal 2 strike,dip,rake'
      read(5,*) str2,dip2,rake2
      write(3,21) title
15    read(2,24,end=35) event,mag
      mom=10.**(c*mag+d)
      write(3,24) event
      write(3,22) str1,dip1,rake1
      write(3,22) str2,dip2,rake2
```

```
      write(3,23) mom
      goto 15
21    format(a30)
22    format(i4,',',i3,',',i4)
23    format(1pe8.1)
24    format(i9,36x,f5.2)
35    continue
      close(2)
      close(3)
      stop
      end
```

```
c
c *** NSTRAIN ***
c
c calculates a synthetic fault plane solution, its principal stresses
c and stress directions from a set of fault plane solutions belonging
c to a region subjected to a homogeneous stress field. Furthermore
c the strain rates and deformation rates for the region and the time
c span studied are computed.
c An output file is generated in the input format of the program fmplot2
c which plots the nodal planes and the two sets of P-and T-axes on
c the lower hemisphere.
c Aki+Richards' conventions are used:
c strike phi: azimuth of strike of fault plane in degrees
c             from north clockwise.
c dip delta:  degrees from horizontal downward
c rake lambda: degrees from horizontal line on fault plane
c              to slip vector counterclockwise.
c moment Mo in dyne*cm
c
c Structure of the data inputfile(free format):
c 1. Name of the fmplot2-Inputfile
c 2. Name of the region
c 3. Number of fault planes n
c 4. n times: title
c             strikeaz.,dip,slip of fault plane
c             strikeaz.,dip,slip of auxliary plane
c             seismic moment Mo
c 5. coefficient of internal friction
c 6. Dimensions of volume: l,w,d
c 7. Time span for strain rate calculation in years
c 8. Angle of rotation of region c.clockwise from North
c
c
c Define variables
      real mt(6,21000),smt(6),v(9),u(9),mts(6),sigma(3),Mo(21000),s(3)
```

```
      real epsi(3),phi(21000),delta(21000),lambda(21000),le,mu,slivec(3)
      real a(10,10),b(10),work(10),npaz(2),npdip(2),sdip,saz
      real strate(3),strats(3),uv(3),ev(4),eps(6),str,rrot
      real razmax,meps11,meps22,tem1,tem2,eflag,tspan
      integer ipvt(10)
      character*1 az1,az2
      character*40 name,outfil,regnam,regna

c read in the name of the output file for the synthetic focal mechanism
c and the title of the region - echo the title into the output file

      read(5,5) outfil
      read(5,5) regnam
    5 format(a40)
      write(6,11)
   11 format(//,'COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A
     1REGIONAL MOMENT TENSOR')
      write(6,12)
   12 format('*************************************************************
     1******************',/)
      write(6,13) regnam
   13 format(a40,/)
      regna=regnam
c
c read in the number of events and loop to 55 that many times
c to find the slip vector, moment tensor, and the eigenvalues
c and eigenvector of the moment tensor for each event
c
      read(5,*) numb
      do 55 i=1,numb
c
c read in fault plane solution information and echo to output
c
             read(5,5) name
             write(6,5) name
```

```
          write(6,15) i
15        format(/,'Fault plane solution number',i5)
          read(5,*) rphi,rdelta,rlambd
          write(6,20) rphi,rdelta,rlambd
20        format('fault plane:    strike=',f5.0,' dip=',f5.0,
     1' slip=',f5.0,' degrees')
          read(5,*) tphi,tdelta,tlambd
          write(6,22) tphi,tdelta,tlambd
22        format('auxilary plane: strike=',f5.0,' dip=',f5.0,
     1' slip=',f5.0,' degrees')
          read(5,*) Mo(i)
          write(6,25) Mo(i)
25        format('Moment Mo=',1pe8.1,' dyne-cm')
c
c convert degrees to radians
c
          pi=3.141592654
          rad=pi/180.
          phi(i)=rphi*rad
          delta(i)=rdelta*rad
          lambda(i)=rlambd*rad
          sphi=tphi*rad
          sdelta=tdelta*rad
c
c find strike, dip, and components of the slip vector on the fault plane
c
          slipaz=sphi-pi/2.
          slidip=pi/2.-sdelta
          slivec(1)=1./sqrt((tan(slipaz)**2+1)*(tan(slidip)**2+1))
          slivec(2)=tan(slipaz)*slivec(1)
          slivec(3)=tan(slidip)*sqrt(slivec(1)**2+slivec(2)**2)
          slipaz=slipaz/rad
          slidip=slidip/rad
          if(slipaz.gt.270..or.slipaz.lt.180.) goto 26
          slivec(1)=-slivec(1)
```

```
            slivec(2)=-slivec(2)
 26         write(6,27) (slivec(k),k=1,3),slipaz,slidip
 27         format('slipvector=(',f5.3,',',f5.3,',',f5.3,')',
   14x,'vecaz= ',f6.1,2x,'vecdip= ',f5.1)
c
c TUTORIAL SECTION B) Calculate, Sum and Diagonalize Moment Tensors
c
c  set up moment tensor - after Aki and Richards, 1980
c  uses nodal plane #1 to determine Mij
c
      mt(1,i)=-Mo(i)*(sin(delta(i))*cos(lambda(i))*sin(2*phi(i))+
     1sin(2*delta(i))*sin(lambda(i))*((sin(phi(i)))**2))
      mt(2,i)=Mo(i)*(sin(delta(i))*cos(lambda(i))*cos(2*phi(i))+0.5*
     1sin(2*delta(i))*sin(lambda(i))*sin(2*phi(i)))
      mt(4,i)=-Mo(i)*(cos(delta(i))*cos(lambda(i))*cos(phi(i))+
     1cos(2*delta(i))*sin(lambda(i))*sin(phi(i)))
      mt(3,i)=Mo(i)*(sin(delta(i))*cos(lambda(i))*sin(2*phi(i))-
     1sin(2*delta(i))*sin(lambda(i))*(cos(phi(i)))**2)
      mt(5,i)=-Mo(i)*(cos(delta(i))*cos(lambda(i))*sin(phi(i))-
     1cos(2*delta(i))*sin(lambda(i))*cos(phi(i)))
      mt(6,i)=Mo(i)*sin(2*delta(i))*sin(lambda(i))
c
c write out moment tensor for single event, i
c
            write(6,30) i
 30         format('moment tensor',i5,': ')
            write(6,35) mt(1,i),mt(2,i),mt(4,i)
 35         format(16x,'M11=',1pe12.1,2x,'M12=',1pe12.1,2x,
   1'M13=',1pe12.1)
            write(6,40) mt(2,i),mt(3,i),mt(5,i)
 40         format(16x,'M21=',1pe12.1,2x,'M22=',1pe12.1,2x,
   1'M23=',1pe12.1,'  dyne-cm')
            write(6,45) mt(4,i),mt(5,i),mt(6,i)
 45         format(16x,'M31=',1pe12.1,2x,'M32=',1pe12.1,2x,
   1'M33=',1pe12.1)
```

```
c
              iflag=0
              do 52 j=1,6
                    mts(j)=mt(j,i)/Mo(i)
   52         continue
c
c  calculate eigenvalues and eigenvectors for each moment tensor, i
c
              call eign(mts,iflag,sigma,u)
              write(6,51)
   51         format(/,'Eigenvectors: component 1=N, 2=E, 3=V')
              k=1
              m=1
   53         do 58 n=1,3
                    uv(n)=u(m)
                    m=m+1
   58         continue
              n=1
c
c  find the azimuths and dips of the three eigenvectors
c  and print azimuths, dips, and components
c
              call azdip(n,uv,vecaz,vecdip)
              write(6,54) k,u(m-3),u(m-2),u(m-1),vecaz,vecdip
   54         format('eigenvector',i1,'=(',f5.3,',',f5.3,
     1','f5.3,')',4x,'vecaz.= ',f6.1,2x,'vecdip= ',f5.1)
              k=k+1
              if(m.le.7) goto 53
              write(6,56)
   56         format(//)
   55 continue
c
c  end of loop over each event
c
c  add moment tensors vectorially for all events
```

```
c
      do 65 i=1,6
             smt(i)=0.
             k=1
   60        smt(i)=smt(i)+mt(i,k)
             if(k.eq.numb) goto 65
             k=k+1
             goto 60
   65 continue
c
c sum the scalar moments to give a scale factor
c
      SMo=0.
      do 70 k=1,numb
             SMo=SMo+Mo(k)
   70 continue
c
c write out the summed regional moment tensor
c
      write(6,75)
   75 format('Regional moment tensor:')
      write(6,80) smt(1),smt(2),smt(4)
   80 format(16x,'M11=',1pe12.1,2x,'M12=',1pe12.1,2x,
     1'M13=',1pe12.1)
      write(6,85) smt(2),smt(3),smt(5)
   85 format(16x,'M21=',1pe12.1,2x,'M22=',1pe12.1,2x,
     1'M23=',1pe12.1,'  dyne-cm')
      write(6,90) smt(4),smt(5),smt(6)
   90 format(16x,'M31=',1pe12.1,2x,'M32=',1pe12.1,2x,
     1'M33=',1pe12.1)
c
c divide out the scale factor for diagonalization
c
      do 100 j=1,6
             smt(j)=smt(j)/SMo
```

```
  100 continue
c
c calculate eigenvalues and eigenvectors for summed moment tensor
c
      iflag=0
      call eign(smt,iflag,sigma,v)
c
c multiply by the scale factor to give principal stresses
c
      do 105 i=1,3
         sigma(i)=sigma(i)*SMo
  105 continue
c
c write out the principal stresses
c
      write(6,106)
  106 format(/,'Eigenvalues:')
      write(6,110) (sigma(i),i=1,3)
  110 format('sigma1=',1pe9.1,2x,'sigma2=',1pe9.1,2x,'sigma3=',
     11pe9.1,/)
c
c END OF TUTORIAL SECTION B)
c
      write(6,51)
c
c open synthetic fault plane solution file
c
      open(7,file=outfil,status='UN',access='sequential',
     1form='formatted')
      write(7,5) regna
c
c find and print trends and plunges of the eigenvectors as before
c
      k=1
      i=1
```

```
  115 do 116 n=1,3
              uv(n)=v(i)
              i=i+1
  116 continue
      n=1
      call azdip(n,uv,vecaz,vecdip)
      write(6,54) k,v(i-3),v(i-2),v(i-1),vecaz,vecdip
      if(i-3.ne.4) goto 120
c
c define the B (intermediate) axis trend and plunge
c
      baz=vecaz
      bdip=vecdip
  120 k=k+1
      if(i.le.7) goto 115
c
c                     Generate a Synthetic Fault Plane Solution
c
c  due to the ambiguity in the fault plane, the new P-and T-axis for
c  both nodal planes are calculated according to the coefficient of
c  internal friction mu.
c  Note: nodal plane #2 is not calculated using input
c  nodal #2 data, but comes from nodal plane #1 strike,
c  dip, and rake.
c
      write(6,124)
  124 format(//,'SYNTHETIC FAULT PLANE SOLUTION:')
c
c read coeff. of friction, mu, and find alpha
c
      read(5,*) mu
      alpha=.5*atan(1./mu)
      alph=alpha/rad
      write(6,126) mu,alph
  126 format(/,'coefficient of internal friction=',f6.3,'  ==> alpha=',
```

```
     1f5.1,' degrees',/)
c
c set up a linear system matrix, 'a': each row = 1 transposed
c    principal stress axis (To), (B), or (Po)
c
      n=1
      do 119 k=1,3
             do 121 i=1,3
                    a(k,i)=v(n)
                    n=n+1
 121         continue
 119  continue
      n=3
      do 1400 j=1,6
              smt(j)=smt(j)*SMo
1400  continue
c
c set up the right-hand side of the system
c
      do 1209 l=1,2
      b(1)=cos(pi/4.)
      b(2)=0.0
      b(3)=b(1)
      if(l.eq.2) b(1)=-b(1)
c
c decompose 'a' into a triangular matrix
c
      call decomp(n,a,cond,ipvt,work)
c
c check for singularity
c
      condp1=cond+1
      if(condp1.eq.cond) write(9,1203)
1203  format(40h matrix is singular to working precision)
      condp1=cond+1
```

```
      if(condp1.eq.cond) stop
c
c solve the system and overwrite the solution, the slip-vector,
c    onto the RHS, 'b'
c
      call solve(n,a,b,ipvt)
c
c  compute trend and plunge of solution vector b, the slip-vector
c
      i=1
      call azdip(i,b,saz,sdip)
      write(6,1207) l,(b(i),i=1,3),saz,sdip
 1207 format('slipvec',i1,'=(',f6.3,',',f6.3,',',
     1f6.3,')',4x,'vecaz=',f5.0,'vecdip=',f5.0)
c
c find and print strike and dip of the conjugate nodal plane
c
      npaz(l)=saz+90.
      npdip(l)=90.-sdip
      m=2
      if(l.eq.2) m=1
      write(6,1208) m,npaz(l),npdip(l)
 1208 format('nodal plane',i1,': strike=',f5.0,' dip=',f5.0)
c
c redefine the 'a' matrix to include vectors {To}, {B}, and {Sl}
c    where {Sl}= slipvector(l)
c
      do 1212 i=1,3
              a(1,i)=v(i)
              a(2,i)=v(i+3)
              a(3,i)=b(i)
              s(i)=b(i)
 1212 continue
c
c decompose 'a' as before
```

```
c
      call decomp(3,a,cond,ipvt,work)
c
c set up RHS
c
      b(1)=cos(pi/4.-alpha)
      b(2)=0.0
      b(3)=cos(pi/2.-alpha)
      if(l.eq.2) b(3)=cos(pi/2.+alpha)
c
c check for singularity
c
      condp1=cond+1
      if(condp1.eq.cond) write(6,1203)
      condp1=cond+1
      if(condp1.eq.cond) stop
c
c solve the system to get {T1} and print it out
c
      call solve(3,a,b,ipvt)
      i=1
      call azdip(i,b,saz,sdip)
      write(6,1216) l,(b(i),i=1,3),saz,sdip
 1216 format('T',i1,'=(',f6.3,',',f6.3,',',f6.3,')',4x
     1,'vecaz=',f5.0,2x,'vecdip=',f5.0)
      write(6,1225) v(4),v(5),v(6),baz,bdip
 1225 format('B',1x,'=(',f6.3,',',f6.3,',',f6.3,')',4x
     1,'vecaz=',f5.0,2x,'vecdip=',f5.0)
      write(7,1219) l,saz,sdip
 1219 format(7x,'T',i1,1x,2f11.6)
c
c redefine the 'a' matrix to include transposed {B}, {Po}, and {S1}
c
      do 1220 i=1,3
              a(1,i)=v(i+3)
```

```
            a(2,i)=v(i+6)
            a(3,i)=s(i)
 1220 continue
c
c set up the RHS
c
      b(1)=0.0
      b(2)=cos(pi/4.-alpha)
      b(3)=cos(alpha)
c
c decompose the matrix 'a'
c
      call decomp(n,a,cond,ipvt,work)
c
c check for singularity
c
      condp1=cond+1
      if(condp1.eq.cond) write(6,1203)
      condp1=cond+1
      if(condp1.eq.cond) stop
c
c solve the system giving (P1)
c
      call solve(n,a,b,ipvt)
      i=1
      call azdip(i,b,saz,sdip)
 1222 write(6,1223) 1,(b(i),i=1,3),saz,sdip
 1223 format('P',i1,'=(',f6.3,',',f6.3,',',f6.3,')',4x
     1,'vecaz=',f5.0,2x,'vecdip=',f5.0,/)
      write(7,1224) 1,saz,sdip
 1224 format(7x,'P',i1,1x,2f11.6)
c
c restore 'a' to original composition for next iteration
c
      m=1
```

```
      do 1210 k=1,3
              do 1211 i=1,3
                      a(k,i)=v(m)
                      m=m+1
 1211         continue
 1210 continue
 1209 continue
c
c write out (B) to the focal mechanism file
c
      write(7,122) baz,bdip
  122 format(7x,'B',2x,2f11.6)
      write(7,'(''      '')')
      do 127 l=1,2
             write(7,123) npaz(l),npdip(l)
  123        format(2f6.1)
  127 continue
      close(7)
c
c
c
c compute strain rates in directions of principal stresses and horizontal
c and vertical strain rates.
c
      write(6,132)
  132 format('DETERMINATION OF THE STRAIN RATE:')
      write(6,'("**********************************")')
c
c read and echo area dimensions and find the volume
c
      read(5,*) le,w,d
      write(6,135) le,w,d
  135 format(/,'The specified volume= 'f5.1,'x',f5.1,'x',f5.1,'km3',/)
      vol=le*w*d*1e15
c
```

```
c find principal strain per unit volume assuming elastic material
c Young's modulus is 6.6e11 - not very accurate, don't use
      do 140 i=1,3
         epsi(i)=sigma(i)/(6.6e11*vol)
  140 continue
c
c read in the time span and use to find  principal strain-rates
c
      read(5,*) tspan
c
c     write(9,145) (epsi(i),i=1,3)
c 145 format(/,'epsilon11=',1pe8.1,3x,'epsilon22=',1pe8.1,3x,
c    1'epsilon33=',1pe8.1,/)
c
      do 146 i=1,3
             strate(i)=epsi(i)/tspan
             strats(i)=epsi(i)/3.15e7*tspan
  146 continue
      write(6,147) tspan
  147 format('The strain rates for the last ',f5.1,' years',
     1' in the directions',/,' of the principal stresses:')
      write(6,148) strate(1),strats(1)
      write(6,149) strate(2),strats(2)
      write(6,150) strate(3),strats(3)
  148 format(5x,'extensional  :',1pe8.1,'/yr = ',1pe8.1,'/sec')
  149 format(5x,'intermediate :',1pe8.1,'/yr = ',1pe8.1,'/sec')
  150 format(5x,'compressional:',1pe8.1,'/yr = ',1pe8.1,'/sec')
c
c TUTORIAL SECTION C)  Find Strain and Deformation Rates
c
c find strain rates from Kostrov, 1974
c
      do 151 i=1,6
         eps(i)=smt(i)/(2.*3.3e11*vol*tspan)
 151  continue
```

```
      eps33=eps(6)
      ep33=eps33/3.15e7
      call eigen(eps,eps11,eps22,ev)
      meps11=abs(eps11)
      meps22=abs(eps22)
      eflag=0.
c
c  make eps11 be the max. strain rate value of either sign
c
      if(meps11.lt.meps22)then
         tem1=eps11
         eps11=eps22
         eps22=tem1
         eflag=1.
       endif
      ep11=eps11/3.15e7
      ep22=eps22/3.15e7
c
c write out the horizontal and vertical strain rates giving
c directions in North - South terms
c
      azmax=atan(ev(2)/ev(1))/rad
      azmin=atan(ev(4)/ev(3))/rad
      if(eflag.gt.0.)then
        tem2=azmax
        azmax=azmin
        azmin=tem2
      endif
      if(azmax.lt.0.) then
      az1='W'
      azmax=abs(azmax)
      eflag=2.0
      else
      az1='E'
      endif
```

```
      if(azmin.lt.0.) then
      az2='W'
      azmin=abs(azmin)
      else
      az2='E'
      endif
      iazmax=nint(azmax)
      iazmin=nint(azmin)
      write(6,160)
160   format(/,'The horizontal and vertical strain rates:')
c     write(6,'(/,"The horizontal and vertical strain rates for the last
c         &",I3," years:")') tspan
      write(6,'(5x,"Maximum horizontal: ",1pe8.1,"/yr = ",1pe8.1,"/sec
     &Azimuth: N",i2,a1)') eps11,ep11,iazmax,az1
      write(6,'(5x,"Minumum horizontal: ",1pe8.1,"/yr = ",1pe8.1,"/sec
     &Azimuth: N",i2,a1)') eps22,ep22,iazmin,az2
      write(6,'(5x,"Vertical           : ",1pe8.1,"/yr = ",1pe8.1,"/sec
     &")') eps33,ep33
c
c calculate max deformation rate in the direction of the max strain rate
c
c enter the rotation of the rectangular region from N-S (clockwise positive)
c
      write(6,*) 'ENTER region boundary rotation'
      read(5,*) rrot
      write(6,*) rrot
      if(eflag.gt.1.0)rrot=-rrot
      razmax=azmax-rrot
      write(6,*)'razmax'
      write(6,*)razmax
c  "str" is the azimuth of the diagonal of the
c   unrotated box.  p.e.
      str=abs(atan(w/le)/rad)
      if(razmax.lt.str)then
      defrat=abs(le*1.0e6*eps11/cos(razmax*rad))
```

```
      else
      defrat=abs(w*1.0e6*eps11/cos((90.-razmax)*rad))
      endif
      write(6,'(/,"The maximum horizontal deformation rate = ",1pe8
     &.1," mm/yr")') defrat
c     close(5)
c     close(9)
  999 stop
      end
c
c END OF TUTORIAL SECTION C)
c
c *******************************************************************
c
c subroutines used
c
      subroutine eigen(e,lamd1,lamd2,ev)
c
c***  calculates eigenvalues lamd1,2 and eigenvectors ev(1),ev(2)/ev(3),ev(4)
c***  of a real symmetric 2x2 matrix
c
      real e(6),lamd1,lamd2,ev(4)
      lamd1=(e(1)+e(3)+((e(1)+e(3))*(e(1)+e(3))-4*(e(1)*e(3)-e(2)*e(2)
     &))**.5)/2.
      lamd2=(e(1)+e(3)-((e(1)+e(3))*(e(1)+e(3))-4*(e(1)*e(3)-e(2)*e(2)
     &))**.5)/2.
      ev(1)=e(2)*e(2)/((e(1)-lamd1)*(e(3)-lamd1))
      ev(2)=(lamd1*ev(1)-e(1)*ev(1))/e(2)
      ev(3)=e(2)*e(2)/((e(1)-lamd2)*(e(3)-lamd2))
      ev(4)=(lamd2*ev(3)-e(1)*ev(3))/e(2)
      return
      end
c
c ***subroutine azdip *** computes azimuth and dip of a Cartesian
c *** vector v(i),v(i+1),v(i+2)
```

```
c
      subroutine azdip(i,v,vaz,vdip)
      real vaz,vdip,v(3)
      pi=3.141592654
      rad=pi/180.
      if(v(i).eq.0.) then
     . vaz=0.
       vdip=90.
      else if(v(i).lt.0.) then
      vaz=(v(i+1)/abs(v(i+1)))*(pi-atan(abs(v(i+1))/abs(v(i))))/rad
      else if(v(i).gt.0) then
      vaz=(atan(v(i+1)/v(i)))/rad
      endif
      if(v(i).eq.0.) goto 10
      vdip=atan(v(i+2)/((v(1)*v(1)+v(2)*v(2))**.5))/rad
10    return
      end
c
c******************************************************
c eign is from the math library
      subroutine eign(r,mv,lamd,vp)
c    this subroutine solves for eigen values and eigenvectors of a
c    real symmetric matrix. eigen values are found by solving a
c    cubic equation using Cardan's formula.(see 'theory of equations'
c    pg 92,by Uspensky,1948,Mcgraw Hill Paperpacks. eigenvectors
c    are then calculated for each eigenvalue.
c        inputs ----
c
c            r(1),r(2)...r(6)  are elements r11,r12,r22,r13,r23,r33
c            of a real,symmetric ,3 x 3 matrix.
c            mv = 0 if both eigenvalues and eigenvectors are to be
c               calculated.
c            mv = 1 if only eigenvalues are computed.
c
c        outputs ----
```

```
c             lamd(1),lamd(2),lamd(3) are eigenvalues,all real in order
c              from largest to smallest(including sign). if matrix is
c              positive definite, all eigenvalues will be positive.
c             v(1)...v(3)    are eigenvector components for lamd(1).
c             v(4)...v(6)    are eigenvector components for lamd(2).
c             v(7)...v(9)    are eigenvector components for lamd(3).
c**********************************************************************
      real lamd(3)
      dimension r(6)  ,vp(9)
      det(x11,x12,x21,x22)=x11*x22-x12*x21                              eig00040
      sq3=sqrt(3.)                                                      eig00050
      r11=r(1)                                                          eig00060
      r12=r(2)                                                          eig00070
      r22=r(3)                                                          eig00080
      r13=r(4)                                                          eig00090
      r23=r(5)                                                          eig00100
      r33=r(6)                                                          eig00110
      do 11 j=1,9                                                       eig00460
 11   vp(j)=0.
c
c----see if matrix is diagonal
c
      if((r12.eq.0.).and.(r13.eq.0.).and.(r23.eq.0.)) go to 100
c
c----solve cubic equation for eigenvalues.
c
      a=-(r11+r22+r33)
      r1212=r12*r12                                                     eig00130
      r1313=r13*r13                                                     eig00140
      r2323=r23*r23                                                     eig00150
      b=r11*r22+r11*r33+r22*r33 -(r1212+r1313+r2323)                    eig00160
      c=r11*r2323+r22*r1313+r33*r1212-r11*r22*r33-2.*r12*r13*r23        eig00170
      aa=a*a                                                            eig00180
      p=b-aa/3.                                                         eig00190
      q=c-b*a/3. +aa*a/13.5                                             eig00200
```

```
      delt=4.*p*p*p+27.*q*q                                             eig00290
      amp=2.*sqrt(-p/3.)                                                eig00300
      sqd=sqrt(-delt)                                                   eig00310
      bot=-q*sqrt(27.)                                                  eig00320
      faz=(atan2(sqd,bot))/3.                                           eig00330
      csfaz=cos(faz)                                                    eig00340
      snfaz=sqrt(1.-csfaz*csfaz)                                        eig00350
      f1=amp*csfaz/2.                                                   eig00360
      f2=amp*snfaz*sq3/2.                                               eig00370
      a3=a/3.                                                           eig00380
      lamd(1)=2.*f1-a3                                                  eig00390
      lamd(2)=-f1+f2-a3                                                 eig00400
      lamd(3)=-f1-f2-a3                                                 eig00410
c
c----lamd(1).ge.lamd(2).ge.lamd(3)
c
      if(mv.eq.1) return
      if((lamd(1).eq.lamd(2)).and.(lamd(2).eq.lamd(3))) go to 87
c----- compute eigenvectors  and normalize to mag 1.
c-----if lamd(i) .eq.0.,eigen vector is set to 0.
      do 10 i=1,3
c
c---solve for v(1)/v(3) and v(2)/v(3) if v(3) is not too big.
c
      if(lamd(i).eq.0.) go to 41
      d11=r11-lamd(i)                                                   eig00520
      d22=r22-lamd(i)                                                   eig00530
      detr=det(d11,r12,r12,d22)                                         eig00540
      test=1.e-20
      ii=(i-1)*3+1
      if(abs(detr).le.test) go to 20
      v1   =(-d22*r13+r12*r23)/detr
      v2     =(r12*r13-d11*r23)/detr
c-----normalize vector to unity magnitude.
      amag=sqrt(v1*v1+v2*v2+1.)
```

```
      vp(ii)=v1/amag
      vp(ii+1)=v2/amag
      vp(ii+2)=1./amag
      go to 10
c
c----solve for v(1)/v(2) and v(3)/v(2) if v(2) is not too big.
c
 20   d33=r33-lamd(i)
      detr=det(d11,r13,r13,d33)
      if(abs(detr).le.test) go to 30
      v1=(-d33*r12+r13*r23)/detr
      v3=(r13*r12-d11*r23)/detr
      amag=sqrt(v1*v1+1.+v3*v3)
      vp(ii)=v1/amag
      vp(ii+1)=1./amag
      vp(ii+2)=v3/amag
      go to 10
c
c---solve for v(2)/v(1) and v(3)/v(1) if v(1) is not too big.
c
 30   detr= det(d22,r23,r23,d33)
      if(abs(detr).le.test) go to 40
      v2=(-d33*r12+r23*r13)/detr
      v3=(r23*r12-d22*r13)/detr
      amag=sqrt(1.+v2*v2+v3*v3)
      vp(ii)=1./amag
      vp(ii+1)=v2/amag
      vp(ii+2)=v3/amag
      go to 10
 40   write(9,60)
 60   format(' no eigenvector found'/)
 41   write(9,61)
 61   format(' zero eigenvalue'/)
 10   continue
      if(lamd(2).ne.lamd(1)) go to 85
```

```
      vp(4)=vp(2)*vp(9)-vp(3)*vp(8)
      vp(5)=vp(3)*vp(7)-vp(1)*vp(9)
      vp(6)=vp(1)*vp(8)-vp(2)*vp(7)
      return
 85   if(lamd(3).ne.lamd(2)) return
      vp(7)=vp(2)*vp(6)-vp(3)*vp(5)
      vp(8)=vp(3)*vp(4)-vp(1)*vp(6)
      vp(9)=vp(1)*vp(5)-vp(2)*vp(4)
      return
 87   vp(1)=1.
      vp(5)=1.
      vp(9)=1.
      return
  100 imin=1
      imax=1
      if(r(imin).gt.r22) imin=3
      if(r(imax).le.r22) imax=3
      if(r(imin).gt.r33) imin=6
      if(r(imax).le.r33) imax=6
      imed=10-imax-imin
      lamd(1)=r(imax)
      lamd(2)=r(imed)
      lamd(3)=r(imin)
      i1=(imax+1)/2
      i2=(imed+1)/2 +3
      i3=(imin+1)/2 +6
      vp(i1)=1.
      vp(i2)=1.
      vp(i3)=1.
      return
      end
******************************************
c decomp is from a math library
      subroutine decomp(n,a,cond,ipvt,work)
      integer n
```

```
      real a(10,10),cond,work(n)
      integer ipvt(n)
      real ek, t, anorm, ynorm, znorm
      integer nm1, i, j, k, kp1, kb, km1, m
      ipvt(n) = 1
      if (n .eq. 1) go to 80
      nm1 = n - 1
      anorm = 0.0
      do 10 j = 1, n
      t = 0.0
      do 5 i = 1, n
      t = t + abs(a(i,j))
5     continue
      if (t .gt. anorm) anorm = t
10    continue
      do 35 k = 1,nm1
      kp1= k+1
      m = k
      do 15 i = kp1,n
      if (abs(a(i,k)) .gt. abs(a(m,k))) m = i
15    continue
      ipvt(k) = m
      if (m .ne. k) ipvt(n) = -ipvt(n)
      t = a(m,k)
      a(m,k) = a(k,k)
      a(k,k) = t
      if (t .eq. 0.0) go to 35
      do 20 i = kp1,n
      a(i,k) = -a(i,k)/t
20    continue
      do 30 j = kp1,n
      t = a(m,j)
      a(m,j) = a(k,j)
      a(k,j) = t
      if (t .eq. 0.0) go to 30
```

```
      do 25 i = kp1,n
      a(i,j) = a(i,j) + a(i,k)*t
25    continue
30    continue
35    continue
      do 50 k = 1, n
      t = 0.0
      if (k .eq. 1) go to 45
      km1 = k-1
      do 40 i = 1, km1
      t = t + a(i,k)*work(i)
40    continue
45    ek = 1.0
      if (t .lt. 0.0) ek = -1.0
      if (a(k,k) .eq. 0.0) go to 90
      work(k) = -(ek + t)/a(k,k)
50    continue
      do 60 kb = 1, nm1
      k = n - kb
      t = 0.0
      kp1 = k+1
      do 55 i = kp1, n
      t = t + a(i,k)*work(k)
55    continue
      work(k) = t
      m = ipvt(k)
      if (m .eq. k) go to 60
      t = work(m)
      work(m) = work(k)
      work(k) = t
60    continue
      ynorm = 0.0
      do 65 i = 1, n
      ynorm = ynorm + abs(work(i))
65    continue
```

```
      call solve(n, a, work, ipvt)
      znorm = 0.0
      do 70 i = 1, n
      znorm = znorm + abs(work(i))
70    continue
      cond = anorm*znorm/ynorm
      if (cond .lt. 1.0) cond = 1.0
      return
80    cond = 1.0
      if (a(1,1) .ne. 0.0) return
90    cond = 1.0e+32
      return
      end
****************************************************
c solve is from a math library
      subroutine solve( n, a, b, ipvt)
      integer  n, ipvt(n)
      real a(10,10),b(n)
      integer kb, km1, nm1, kp1, i, k, m
      real t
      if (n .eq. 1) go to 50
      nm1 = n-1
      do 20 k = 1, nm1
      kp1 = k+1
      m = ipvt(k)
      t = b(m)
      b(m) = b(k)
      b(k) = t
      do 10 i = kp1, n
      b(i) = b(i) + a(i,k)*t
10    continue
20    continue
      do 40 kb = 1,nm1
      km1 = n-kb
      k = km1+1
```

```
      b(k) = b(k)/a(k,k)
      t = -b(k)
      do 30 i = 1, km1
      b(i) = b(i) + a(i,k)*t
30    continue
40    continue
50    b(1) = b(1)/a(1,1)
      return
      end
```

Generating a Synthetic Fault Plane Solution

'nstrain' is able to average fault plane solutions and construct a synthetic fault plane solution using the principal stress axes determined earlier by the program as follows. First, note the symbols for the vectors used:

T = tension axis
B = intermediate axis
P = compressional axis
S = a slip vector.

In order to find the fault plane solution, first identify the P, T and B axes (the eigenvectors referred to now as P^o T^o and B) found in 'nstrain' through diagonalization of the moment tensor. Then, for each nodal plane, find a slip vector using

$$S^i \cdot B = 0$$

$$S^i \cdot T^o = cos(45 + (i-1)(90))^o \qquad (14)$$

$$S^i \cdot P^o = cos45^o,$$

i= 1,2 (C. Renggli, unpublished data, 1983)

which can be rearranged for solution as

$$\begin{bmatrix} T^o{}_x & T^o{}_y & T^o{}_z \\ B_x & B_y & B_z \\ P^o{}_x & P^o{}_y & P^o{}_z \end{bmatrix} \begin{bmatrix} S^i{}_x \\ S^i{}_y \\ S^i{}_z \end{bmatrix} = \begin{bmatrix} cos(45 + (i-1)(90))^o \\ 0 \\ cos45^o \end{bmatrix} \quad i=1,2 \qquad (15)$$

and then solved using the math library subroutines 'decomp' and 'solve'. These subroutines use Gauss elimination to solve systems of linear equations [Forsythe et al. 1977].

Now that the slip vectors have been found, we can use a coefficient of friction, μ, to find the angle of faulting, α, needed to produce the two possible principal stress orientations associated with α and the two nodal planes. This is done using:

$$\alpha = \pm \frac{1}{2}\tan^{-1}\left[\frac{1}{\mu}\right] \tag{16}$$

and the equations

$$a)\ P^i \cdot P^o = cos(45 - \alpha); \qquad d)\ T^i \cdot T^o = cos(45 - \alpha)$$

$$b)\ P^i \cdot B = 0; \qquad e)\ T^i \cdot B = 0 \tag{17}$$

$$c)\ P^i \cdot S^i = \cos\alpha; \qquad f)\ T^i \cdot S^i = cos(90 + (-1)^i\alpha)$$

i= 1,2 (C. Renggli, unpublished data, 1983)

which can be written as

$$\begin{bmatrix} P^o{}_x & P^o{}_y & P^o{}_z \\ B_x & B_y & B_z \\ S^i{}_x & S^i{}_y & S^i{}_Z \end{bmatrix} \begin{bmatrix} P^i{}_x \\ P^i{}_y \\ P^i{}_z \end{bmatrix} = \begin{bmatrix} cos(45 - \alpha)^o \\ 0 \\ \cos\alpha \end{bmatrix} \tag{18}$$

and

$$\begin{bmatrix} T^o{}_x & T^o{}_y & T^o{}_z \\ B_x & B_y & B_z \\ S^i{}_x & S^i{}_y & S^i{}_z \end{bmatrix} \begin{bmatrix} T^i{}_x \\ T^i{}_y \\ T^i{}_z \end{bmatrix} = \begin{bmatrix} cos(45 - \alpha)^o \\ 0 \\ cos(90 + (-1)^i\alpha) \end{bmatrix} \tag{19}$$

and solved for P^i and T^i just as done for S^i previously.

In File 5), the information on the synthetic nodal planes is given along with two possible sets of P, T and B axes. Which set of axes is considered correct depends on which nodal plane is considered to be the fault plane. Note that μ is only allowed to be non-zero in the construction of the synthetic fault plane solution, not in calculations of stress and strain.

APPENDIX C

EARTHQUAKE SOURCE CITATIONS AND FAULT PLANE SOLUTION TABLE

Earthquake Source Files

This appendix is a listing of the files used to create the master earthquake summary file referred to in the main text.

In the creation of the master file, one file was chosen as the key, and all other files were compared to it. Events from other catalogs which were not found in the key file were added to the master file. When the master file was first compiled, the key file used was one entitled "PDE (USCGS - USGS)" which was contributed by Rinehart at the National Geophysical and Solar Terrestrial Data Center.

In subsequent upgradings of the master file, the Askew and Algermissen [1983] file was considered the new standard. Events were put in chronological order, duplicates were removed, and 1983 Borah Peak, Idaho events were added from UUSS files. Any two earthquakes with event times closer than 10 seconds and locations closer than 15 km were considered duplicates.

Files used:

1) University of Utah Network, Salt Lake City

   1900 - 1981 including 1983 Borah Peak, Idaho earthquake data

2) University of Nevada Network, Reno

   1900 - 1980 possible gaps from 1900 - 1970

3) National Geophysical and Solar Terrestrial Data Center - R. W. Rinehart - 4 files used

   1. 1928-1980 PDE (USCGS-USGS)
   2. 1900-1973 Oregon State University
   3. 1900-1974 Division of Mines and Geology (California)
   4. 1910-1974 University of California at Berkeley

4) California Institute of Technology Network - 7 files

1. 1932-1974 final epicenter determinations
2. 1975-1976 preliminary determinations
3. 1977 preliminary determinations
4. 1978 final determinations
5. 1979 preliminary determinations
6. 1980 very preliminary determinations
7. 1981 very preliminary determinations, as available

5) USGS Southern Basin and Range Network - Steve Harmsen and Al Rogers

Aug. 1978 - Jan. 16, 1982

6) Montana earthquake data from "Historical seismicity and earthquake hazard in Montana" by Anthony Qamar and Michael C. Stickney

July 26, 1974 - Nov. 10, 1978

7) USGS Cal Net, Menlo Park - summary data - Rob Cockerham

1969 - Nov. 30, 1981

8) University of California Network, Berkeley

Jan. 1, 1973 - June 30., 1980

9) USGS Great Basin file, Askew and Algermissen [open file report 83-86, 1983]

1900 - 1977.

Table 10. Great Basin fault plane solutions

event		time		lat	long	P		T		nodal #1			nodal #2		
						st	dip	st	dip	st	dip	rake	st	dip	rake
10	S	6908		43.0	111.4	170	75	279	10	168	40	125	31	59	63
74	S	831028	1406	43.9	113.9	127	68	27	3	138	45	-60	279	52	-115
30	S	710210		34.4	118.4	043	04	138	70	295	51	65	154	44	120
32	S	730221		34.13	119.07	196	16	073	64	260	34	54	121	64	112
31	S	520721		35.0	119.02	166	08	265	49	45	65	44	290	53	146
96	S	741014	2354	36.92	120.99	031	00	301	00	76	90	0	346	90	0
A5	C	740819		36.53	120.68	202	12	298	28	72	80	-151	338	62	-10
L2	S	620415		36.4	120.6	10	24	267	25	318	88	145	145	54	2
33	S	660628		35.92	120.42	193	14	100	13	238	70	2	147	90	160
A4	C	750803		36.46	120.35	076	55	256	35	344	10	-90	164	80	-90
A3	C	760114		36.11	120.14	208	19	326	58	96	65	61	336	35	142
A2	S	730915	0103	36.65	119.39	035	00	305	00	80	90	0	350	90	0
A9	C	750605		35.05	119.00	008	24	250	44	65	38	31	306	80	123
A8	S	730303	1814	35.24	118.55	148	54	060	10	180	50	-41	300	60	-48
A6	S	741028	0912	35.79	118.38	204	78	322	05	46	40	-138	237	50	-82
52	C			36.07	117.83			303		3	80	11	88	80	168
26	S	721221		35.92	117.80	024	00	114	00	69	90	0	159	90	0
A7	S	740102	1349	35.55	117.26	039	04	135	04	84	90	-9	174	80	0
41	S	700212		36.60	116.27	257	66	354	03	61	48	-122	284	52	-59
46	C	7305		36.09	114.77			312	21	50	30	-90	230	30	-90
47	C	7305		36.07	114.71	235	3	145	3	10	90	-176	97	90	-3
28	C	7212		36.0	114.67	043	02	134	20	180	78	163	270	78	13
6	S	671004	1020	38.5	112.1	247	39	094	47	170	86	75	275	15	164
7	C	6 907		38.5	112.2	237	58	057	40	326	85	-90	146	4	-90
48	C			38.58	112.83	126	54	285	34	203	80	-80	340	14	-92
24	S	711110	1941	37.8	113.03	250	76	160	10	345	65	-75	136	30	-116
5	S	660816	1802	37.4	114.2	239	00	150	16	290	80	12	194	80	169
45	S	711208		37.73	115.05	344	81	129	30	214	43	-99	47	48	-81
63	C	700323		37.75	116.0	267	02	174	15	220	82	174	309	84	9
20	C	6812		37.2	116.5	045	00	315	00	0	90	0	90	90	180
21	C	6812		37.20	116.5	030	70	120	00	50	50	-60	190	50	-119
43	C	7009		37.13	117.32	091	49	310	30	203	82	-110	94	22	-20
15	C	690201		38.5	117.8	033	59	260	21	153	70	-132	24	60	-43
44	S	700717		37.47	117.87	015	63	272	03	27	45	-60	163	45	-119
K6	S	321221		38.8	118.0	234	26	143	03	321	70	-42	11	74	-136
A1	S	720122	0257	37.57	118.37	016	80	264	40	0	40	-82	170	50	-96
14	C	690201		38.3	118.4	046	39	140	04	86	66	-33	191	60	-151
27	C	70-71		37.5	118.5	000	00	090	00	45	90	0	135	90	179
99	S	730918	1008	37.20	118.95	160	68	080	04	190	50	-59	328	50	-73
86	C	750505		38.61	119.73	041	00	127	00	82	90	1	352	90	180
98	C	750810		37.37	119.98	198	02	294	70	88	50	59	314	46	124
97	C	750618		37.19	120.95	032	04	138	58	272	58	49	156	48	140
88	S	740929	0126	39.96	120.73	032	05	270	82	104	40	74	306	50	104
83	C	760620		40.39	120.59	011	00	281	00	56	90	0	326	90	180
87	S	710427	0501	39.43	120.27	270	87	270	03	0	42	-90	180	48	-90
49	S	660912		39.43	120.17	358	07	258	06	44	80	0	134	90	-170
D6	S	540706		39.5	118.5			100	01	236	51	-15	336	78	-139

Table 10. cont.

event		time		lat	long	P		T		nodal #1			nodal #2		
						st	dip	st	dip	st	dip	rake	st	dip	rake
D7	S	540824		39.5	118.5	-160	62	110	01	225	51	-53	355	51	-126
D8	S	541216		39.5	118.5	208	85	304	05	246	66	-30	349	62	-152
18	C	70		39.07	118.40	124	85	304	05	27	60	-90	207	60	-89
K1	C	6812		39.1	118.1	215	60	119	4	4	56	-127	236	50	-49
16	S	541216	1107	39.2	118.1	205	40	296	02	234	57	-23	337	70	-144
19	C	70		39.20	118.00	136	85	316	05	30	45	-90	210	45	-90
40	C	6970		39.8	118.0	233	59	346	01	266	70	-55	38	50	-134
84	S	750211	1736	40.31	117.34	290	85	110	05	30	50	-90	210	30	-90
8	C	6908		40.7	112.5	307	35	134	55	220	80	89	38	7	164
66	C			40.7	112.1	105	68	260	20	177	65	-81	330	20	-114
3	S	630707	1920	39.6	111.9	220	48	106	20	350	74	-118	238	40	-26
71	C			39.7	111.9	249	48	98	38	355	85	-105	235	20	-30
67	C			40.8	111.55	142	55	310	34	225	80	-84	30	20	-162
68	C			40.5	111.4	281	34	75	53	180	80	77	320	20	50
70	S			40.3	111.4	289	40	108	50	202	85	90	22	15	133
72	S			40.49	111.36	263	67	41	17	323	64	-74	110	30	-120
73	C	7607		41.64	112.07	28	69	247	17	147	63	-104	356	30	-64
74	S	780729		41.86	112.14	246	25	61	65	154	70	88	340	20	95
69	C			40.55	111.2	281	34	75	53	180	80	77	320	20	50
UA	C			41.67	111.71	90	15	293	74	5	60	97	190	30	85
UB	C			40.78	111.56	310	25	115	64	215	70	84	20	20	140
UC	C			40.55	111.17	276	35	92	35	184	80	88	353	10	87
UD	C			40.40	111.45	299	35	122	55	207	80	90	27	10	142
UE	C			40.71	112.03	227	16	17	71	330	30	108	171	60	79
UG	C			40.51	111.34	65	89	203	67	323	64	74	110	30	119
UK	C			41.83	112.7	64	2	161	73	319	49	68	195	55	51
65	C			41.7	111.65	263	55	87	35	355	80	-92	190	25	-75
9	C	6908		41.70	111.8	067	39	247	49	338	85	90	158	4	89
2	S	620830	1335	41.8	111.8	129	76	283	13	5	32	-108	197	58	-83
J8	C	7611		41.43	112.7	64	2	160	73	319	49	68	195	55	51
17	S	340312	1505	41.8	112.9	300	50	075	30	7	80	-71	120	20	-155
64	S	750328		42.2	112.5	257	78	111	10	210	35	-78	10	35	-111
53	C	73		41.83	118.48	209	74	94	7	200	40	-67	350	50	-96
H2	S	680604		42.3	119.77	136	6	45	6	91	90	171	10	90	8
50	S	680430		42.17	119.92	065	35	120	13	4	80	-119	260	30	-17
M5	C	760412		44.3	120.8	198	13	18	77	288	32	90	108	58	90
E6	S	621018		44.2	114.9	12	27	267	27	50	50	0	140	90	140
39	S	630911	0208	44.3	114.7	275	83	009	01	287	46	-79	92	45	-100
E5	S	620926		44.6	112.5	298	19	188	45	237	74	131	130	44	83
F2	S	630106		44.9	112.1	270	11	167	49	210	66	133	98	48	136
F3	S	630224		44.8	111.9	319	27	169	62	220	70	90	40	20	157
J4	S	750208		45.88	111.33	359	11	92	12	135	74	179	45	90	15
J1	C	740716		45.73	111.39	277	2	186	27	325	70	19	38	80	153
J3	C	7505		46.0	111.45	107	15	12	16	150	68	0	60	90	21
4	C	760416		45.27	120.8	198	10	25	85	107	50	90	287	30	90
Y1	C	75		43.8	110.3	147	29	137	29	230	30	-90	50	30	-119
Y2	C	72		44.75	110.8	060	75	240	15	122	60	-90	302	30	-90
Y3	C	72		44.78	110.92	016	65	196	25	104	70	-90	286	20	-88

Table 10. cont.

event	time	lat	long	P st	P dip	T st	T dip	nodal #1 st	nodal #1 dip	nodal #1 rake	nodal #2 st	nodal #2 dip	nodal #2 rake
Y4 C	72	44.78	111.06	090	88	183	02	93	46	-88	271	44	-91
Y5 C	72	44.78	111.18	358	62	196	28	102	76	-94	303	14	-69
Y6 C	72	44.77	111.28	356	64	174	26	84	72	-89	84	18	-89
Y7 C	75	45.05	111.66	306	57	172	29	274	20	-90	94	70	-89
Y8 C	72	44.7	110.76	148	12	328	78	58	58	118	238	32	90
Y9 C	72	44.65	110.90	138	06	318	84	41	50	129	226	40	86
Y10C	72	44.62	111.02	174	16	028	74	90	60	98	252	30	105
Y11C	75	44.72	111.14	242	60	343	7	44	46	-133	224	44	-90
Y12C	72	44.8	111.43	204	82	334	08	60	40	-127	248	50	-84
Y13C	75	44.87	111.77	289	68	197	24	278	45	-90	98	45	-90
Y14C	75	44.82	111.57	239	87	70	4	162	42	-90	342	48	-90
Y15C	75	44.75	111.31	11	83	184	7	95	52	-90	275	38	-90
Y16C	75	44.68	111.68	2	65	183	25	274	20	-90	94	70	-89
Y17C	73	44.36	110.34	133	60	228	3	290	50	-131	170	50	-48
Y18S	590818 0637	44.75	111.18	012	75	192	15	102	60	-90	282	30	-90
Y19S	641021 0738	44.8	111.6	268	07	002	30	138	75	153	41	64	16
Y20S	471123 0946	44.92	111.53	266	60	88	30	357	75	-91	190	15	-77
Y21S	590819 0404	44.71	111.66	278	27	184	07	55	77	-55	318	66	-14
Y22S	590818 1526	44.84	110.68	048	62	158	10	89	60	-122	220	43	-130
DD1S	590818 0754	45.09	110.69	356	47	103	25	42	70	-46	154	48	-150
DD2S	590818 0756	45.01	110.66	040	55	130	0	70	55	-44	190	56	-135
DD3S	590818 0841	45.08	110.80	030	28	296	08	70	65	-13	167	78	-154
DD4S	590818 1103	44.94	110.76	177	01	268	40	50	64	31	305	63	151
P1 S	680530 0035	42.30	119.80			105	23	0	70	-110			
P2 S	710805 1758	36.89	115.97			117	-3	164	82	168			
P3 S	750806 0350	39.48	121.52			87	-7	0	38	-85			

APPENDIX D

STRAIN RATE RESULTS

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****

```
Oregon-Nevada Border

Regional moment tensor:
      M11=     1.0e+23  M12=    -4.6e+24  M13=     1.9e+24
      M21=    -4.6e+24  M22=     7.6e+24  M23=     7.1e+24  dyne-cm
      M31=     1.9e+24  M32=     7.1e+24  M33=    -7.7e+24

Eigenvalues:
sigma1=  1.2e+25  sigma2= -1.5e+18  sigma3= -1.2e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.310,0.902,0.302)    vecaz.=  109.0  vecdip=  17.6
eigenvector2=(0.904,0.181,0.388)    vecaz.=   11.3  vecdip=  22.9
eigenvector3=(-.296,-.393,0.871)    vecaz.= -126.9  vecdip=  60.5

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.428, 0.359, 0.829)    vecaz= 140.vecdip=  56.
nodal plane2: strike= 230. dip=  34.
T1=(-0.195, 0.981,-0.003)    vecaz= 101.  vecdip=  -0.
B =( 0.904, 0.181, 0.388)    vecaz=  11.  vecdip=  23.
P1=(-0.382,-0.073, 0.921)    vecaz=-169.  vecdip=  67.

slipvec2=( 0.010,-0.915, 0.402)    vecaz= -89.vecdip=  24.
nodal plane1: strike=   1. dip=  66.
T2=(-0.391, 0.721, 0.573)    vecaz= 118.  vecdip=  35.
B =( 0.904, 0.181, 0.388)    vecaz=  11.  vecdip=  23.
P2=(-0.176,-0.669, 0.722)    vecaz=-105.  vecdip=  46.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 111.1x222.2x 15.0km3

The strain rates for the last  53.0 years in the directions
 of the principal stresses:
     extensional   : 8.9e-10/yr =  8.0e-14/sec
     intermediate :-1.2e-16/yr = -1.0e-20/sec
     compressional:-8.9e-10/yr = -8.0e-14/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  7.6e-10/yr =  2.4e-17/sec  Azimuth: N65W
     Minimum horizontal: -1.6e-10/yr = -5.1e-18/sec  Azimuth: N25E
     Vertical           : -6.0e-10/yr = -1.9e-17/sec
  ENTER region boundary rotation
  0.
  razmax
   64.6770

The maximum horizontal deformation rate =  1.9e-01 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR

```
**********************************************
Oroville

Regional moment tensor:
      M11=      5.9e+17  M12=     -3.4e+24  M13=     -2.6e+24
      M21=     -3.4e+24  M22=      5.9e+25  M23=     -1.5e+25  dyne-cm
      M31=     -2.6e+24  M32=     -1.5e+25  M33=     -5.9e+25

Eigenvalues:
sigma1=  6.1e+25  sigma2= -1.2e+18  sigma3= -6.1e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(0.049,-.991,0.121)    vecaz.=  -87.2  vecdip=   6.9
eigenvector2=(-.998,-.043,0.055)    vecaz.= -177.5  vecdip=   3.2
eigenvector3=(0.049,0.123,0.991)    vecaz.=   68.1  vecdip=  82.4

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=( 0.070,-0.614, 0.786)    vecaz= -84.vecdip=  52.
nodal plane2: strike=   6. dip=  38.
T1=( 0.030,-0.976,-0.214)    vecaz= -88.  vecdip= -12.
B =(-0.998,-0.043, 0.055)    vecaz=-178.  vecdip=   3.
P1=( 0.063,-0.212, 0.975)    vecaz= -73.  vecdip=  77.

slipvec2=(-0.000, 0.788, 0.616)    vecaz=  90.vecdip=  38.
nodal plane1: strike= 180. dip=  52.
T2=( 0.063,-0.895, 0.442)    vecaz= -86.  vecdip=  26.
B =(-0.998,-0.043, 0.055)    vecaz=-178.  vecdip=   3.
P2=( 0.030, 0.444, 0.895)    vecaz=  86.  vecdip=  64.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 166.7x166.7x 15.0km3

The strain rates for the last  80.0 years in the directions
 of the principal stresses:
     extensional  : 2.8e-09/yr =  5.7e-13/sec
     intermediate :-5.5e-17/yr = -1.1e-20/sec
     compressional:-2.8e-09/yr = -5.7e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  2.7e-09/yr =  8.6e-17/sec  Azimuth: N87W
     Minimum horizontal: -8.7e-12/yr = -2.8e-19/sec  Azimuth: N 3E
     Vertical          : -2.7e-09/yr = -8.6e-17/sec
  ENTER region boundary rotation
  0.
  razmax
   86.7600

The maximum horizontal deformation rate =  4.5e-01 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR

```
*********************************************
Northern Cal. / Nevada border

Regional moment tensor:
      M11=    -1.3e+26  M12=    -4.0e+23  M13=    -1.8e+25
      M21=    -4.0e+23  M22=     1.3e+26  M23=    -1.5e+25  dyne-cm
      M31=    -1.8e+25  M32=    -1.5e+25  M33=    -7.9e+23

Eigenvalues:
sigma1=  1.3e+26  sigma2=  5.5e+18  sigma3= -1.3e+26

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.006,-.994,0.111)    vecaz.=  -90.3  vecdip=   6.4
eigenvector2=(-.135,0.110,0.985)    vecaz.=  140.7  vecdip=  80.0
eigenvector3=(0.991,0.009,0.135)    vecaz.=    0.5  vecdip=   7.8

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=( 0.696,-0.696, 0.174)    vecaz= -45.vecdip=  10.
nodal plane2: strike=  45. dip=  80.
T1=(-0.334,-0.941, 0.060)    vecaz=-110.  vecdip=   3.
B =(-0.135, 0.110, 0.985)    vecaz= 141.  vecdip=  80.
P1=( 0.933,-0.320, 0.164)    vecaz= -19.  vecdip=   9.

slipvec2=( 0.705, 0.709, 0.017)    vecaz=  45.vecdip=   1.
nodal plane1: strike= 135. dip=  89.
T2=( 0.322,-0.935, 0.149)    vecaz= -71.  vecdip=   9.
B =(-0.135, 0.110, 0.985)    vecaz= 141.  vecdip=  80.
P2=( 0.937, 0.337, 0.091)    vecaz=  20.  vecdip=   5.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************
The specified volume= 224.6x121.1x 15.0km3

The strain rates for the last  75.0 years in the directions
 of the principal stresses:
     extensional   : 6.6e-09/yr =  1.2e-12/sec
     intermediate  : 2.7e-16/yr =  4.8e-20/sec
     compressional:-6.6e-09/yr = -1.2e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  6.5e-09/yr =  2.1e-16/sec  Azimuth: N90W
     Minimum horizontal: -6.4e-09/yr = -2.0e-16/sec  Azimuth: N 0E
     Vertical           : -3.9e-11/yr = -1.2e-18/sec
  ENTER region boundary rotation
  -64.0000
  razmax
   25.9132

The maximum horizontal deformation rate =  1.6e+00 mm/yr
```

```
            COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                     FROM A REGIONAL MOMENT TENSOR
            *********************************************
West-Central Nevada

Regional moment tensor:
      M11=    -5.1e+26  M12=    -7.5e+26  M13=     6.1e+26
      M21=    -7.5e+26  M22=     1.1e+27  M23=     4.0e+26  dyne-cm
      M31=     6.1e+26  M32=     4.0e+26  M33=    -6.3e+26

Eigenvalues:
sigma1=  1.4e+27  sigma2=  1.3e+22  sigma3= -1.4e+27

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.335,0.939,0.084)    vecaz.=  109.6  vecdip=   4.8
eigenvector2=(0.650,0.166,0.742)    vecaz.=   14.3  vecdip=  47.9
eigenvector3=(-.682,-.303,0.665)    vecaz.= -156.1  vecdip=  41.7

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.719, 0.449, 0.530)    vecaz= 148.vecdip=  32.
nodal plane2: strike= 238. dip=  58.
T1=(-0.090, 0.986,-0.141)    vecaz=  95.  vecdip=  -8.
B =( 0.650, 0.166, 0.742)    vecaz=  14.  vecdip=  48.
P1=(-0.755, 0.025, 0.656)    vecaz= 178.  vecdip=  41.

slipvec2=(-0.246,-0.878, 0.411)    vecaz=-106.vecdip=  24.
nodal plane1: strike= -16. dip=  66.
T2=(-0.542, 0.785, 0.300)    vecaz= 125.  vecdip=  17.
B =( 0.650, 0.166, 0.742)    vecaz=  14.  vecdip=  48.
P2=(-0.533,-0.597, 0.600)    vecaz=-132.  vecdip=  37.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 236.5x254.9x 15.0km3

The strain rates for the last  75.0 years in the directions
 of the principal stresses:
     extensional   : 3.2e-08/yr  =  5.7e-12/sec
     intermediate : 3.0e-13/yr  =  5.4e-17/sec
     compressional:-3.2e-08/yr  = -5.7e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  3.2e-08/yr =  1.0e-15/sec  Azimuth: N69W
     Minimum horizontal: -1.8e-08/yr = -5.6e-16/sec  Azimuth: N21E
     Vertical           : -1.4e-08/yr = -4.4e-16/sec
  ENTER region boundary rotation
  -64.0000
  razmax
   4.81479

The maximum horizontal deformation rate =  7.5e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****
West-Central Nevada   (large magnitudes)

```
Regional moment tensor:
      M11=    -6.1e+26  M12=    -9.0e+26  M13=     7.4e+26
      M21=    -9.0e+26  M22=     1.4e+27  M23=     4.9e+26  dyne-cm
      M31=     7.4e+26  M32=     4.9e+26  M33=    -7.6e+26

Eigenvalues:
sigma1=  1.7e+27  sigma2= -5.1e+21  sigma3= -1.7e+27

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.335,0.939,0.084)    vecaz.=  109.6  vecdip=   4.8
eigenvector2=(0.650,0.166,0.742)    vecaz.=   14.3  vecdip=  47.9
eigenvector3=(-.682,-.303,0.665)    vecaz.= -156.1  vecdip=  41.7

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.719, 0.449, 0.530)    vecaz= 148.vecdip=  32.
nodal plane2: strike= 238. dip=  58.
T1=(-0.090, 0.986,-0.141)    vecaz=  95.  vecdip=  -8.
B =( 0.650, 0.166, 0.742)    vecaz=  14.  vecdip=  48.
P1=(-0.755, 0.025, 0.656)    vecaz= 178.  vecdip=  41.

slipvec2=(-0.246,-0.878, 0.411)    vecaz=-106.vecdip=  24.
nodal plane1: strike= -16. dip=  66.
T2=(-0.542, 0.785, 0.300)    vecaz= 125.  vecdip=  17.
B =( 0.650, 0.166, 0.742)    vecaz=  14.  vecdip=  48.
P2=(-0.533,-0.597, 0.600)    vecaz=-132.  vecdip=  37.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 236.5x254.9x 15.0km3

The strain rates for the last  75.0 years in the directions
 of the principal stresses:
      extensional  : 3.9e-08/yr =  6.9e-12/sec
      intermediate :-1.1e-13/yr = -2.0e-17/sec
      compressional:-3.9e-08/yr = -6.9e-12/sec

The horizontal and vertical strain rates:
      Maximum horizontal:  3.8e-08/yr =  1.2e-15/sec  Azimuth: N69W
      Minimum horizontal: -2.2e-08/yr = -6.8e-16/sec  Azimuth: N21E
      Vertical          : -1.7e-08/yr = -5.4e-16/sec
  ENTER region boundary rotation
  -64.0000
  razmax
   4.81495

The maximum horizontal deformation rate =  9.1e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****

Walker Lane

Regional moment tensor:

```
      M11=    -4.7e+24  M12=    -1.3e+26  M13=    -2.3e+24
      M21=    -1.3e+26  M22=     4.7e+24  M23=     4.1e+22  dyne-cm
      M31=    -2.3e+24  M32=     4.1e+22  M33=    -4.1e+17
```

Eigenvalues:

```
sigma1=  1.3e+26  sigma2= -1.4e+17  sigma3= -1.3e+26
```

Eigenvectors: component 1=N, 2=E, 3=V

```
eigenvector1=(-.695,0.719,0.012)    vecaz.=  134.0  vecdip=   0.7
eigenvector2=(-.000,-.017,1.000)    vecaz.=  -91.0  vecdip=  89.0
eigenvector3=(0.719,0.695,0.012)    vecaz.=   44.0  vecdip=   0.7
```

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800 ==> alpha= 25.7 degrees

```
slipvec1=( 0.017, 1.000, 0.017)    vecaz=  89.vecdip=   1.
nodal plane2: strike= 179. dip=  89.
T1=(-0.894, 0.449, 0.008)    vecaz= 153.  vecdip=   0.
B =(-0.000,-0.017, 1.000)    vecaz= -91.  vecdip=  89.
P1=( 0.449, 0.893, 0.016)    vecaz=  63.  vecdip=   1.

slipvec2=( 1.000,-0.017, 0.000)    vecaz=  -1.vecdip=   0.
nodal plane1: strike=  89. dip=  90.
T2=(-0.417, 0.909, 0.016)    vecaz= 115.  vecdip=   1.
B =(-0.000,-0.017, 1.000)    vecaz= -91.  vecdip=  89.
P2=( 0.909, 0.417, 0.008)    vecaz=  25.  vecdip=   0.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 661.4x 68.6x 15.0km3

The strain rates for the last  71.0 years in the directions
 of the principal stresses:
     extensional  : 4.2e-09/yr =  6.7e-13/sec
     intermediate :-4.3e-18/yr = -6.9e-22/sec
     compressional:-4.2e-09/yr = -6.7e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  4.2e-09/yr =  1.3e-16/sec  Azimuth: N46W
     Minimum horizontal: -4.2e-09/yr = -1.3e-16/sec  Azimuth: N44E
     Vertical          : -1.3e-17/yr = -4.1e-25/sec
  ENTER region boundary rotation
  -64.0000
  razmax
  -18.0000

The maximum horizontal deformation rate =  2.9e+00 mm/yr
```

```
           COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                  FROM A REGIONAL MOMENT TENSOR
           ***********************************************
Walker Lane     (M4+ events only)

Regional moment tensor:
      M11=    -4.4e+24  M12=    -1.3e+26  M13=    -2.2e+24
      M21=    -1.3e+26  M22=     4.4e+24  M23=     3.8e+22  dyne-cm
      M31=    -2.2e+24  M32=     3.8e+22  M33=    -3.8e+17

Eigenvalues:
sigma1=  1.3e+26  sigma2= -1.3e+17  sigma3= -1.3e+26

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.695,0.719,0.012)    vecaz.=  134.0  vecdip=   0.7
eigenvector2=(-.000,-.017,1.000)    vecaz.=  -91.0  vecdip=  89.0
eigenvector3=(0.719,0.695,0.012)    vecaz.=   44.0  vecdip=   0.7

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=( 0.017, 1.000, 0.017)    vecaz=  89.vecdip=   1.
nodal plane2: strike= 179. dip=  89.
T1=(-0.894, 0.449, 0.008)    vecaz= 153.  vecdip=   0.
B =(-0.000,-0.017, 1.000)    vecaz= -91.  vecdip=  89.
P1=( 0.449, 0.893, 0.016)    vecaz=  63.  vecdip=   1.

slipvec2=( 1.000,-0.017, 0.000)    vecaz=  -1.vecdip=   0.
nodal plane1: strike=  89. dip=  90.
T2=(-0.417, 0.909, 0.016)    vecaz= 115.  vecdip=   1.
B =(-0.000,-0.017, 1.000)    vecaz= -91.  vecdip=  89.
P2=( 0.909, 0.417, 0.008)    vecaz=  25.  vecdip=   0.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 661.4x 68.6x 15.0km3

The strain rates for the last  71.0 years in the directions
 of the principal stresses:
     extensional   : 3.9e-09/yr =  6.3e-13/sec
     intermediate :-4.0e-18/yr = -6.4e-22/sec
     compressional:-3.9e-09/yr = -6.3e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  3.9e-09/yr =  1.2e-16/sec  Azimuth: N46W
     Minimum horizontal: -3.9e-09/yr = -1.2e-16/sec  Azimuth: N44E
     Vertical          : -1.2e-17/yr = -3.8e-25/sec
  ENTER region boundary rotation
  -64.0000
  razmax
  -18.0000

The maximum horizontal deformation rate =  2.7e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****

```
Southeast Nevada

Regional moment tensor:
      M11=      1.9e+25  M12=     -1.8e+25  M13=     -2.6e+24
      M21=     -1.8e+25  M22=     -1.7e+25  M23=     -6.2e+24  dyne-cm
      M31=     -2.6e+24  M32=     -6.2e+24  M33=     -1.9e+24

Eigenvalues:
sigma1=  2.6e+25  sigma2=  2.0e+17  sigma3= -2.6e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.927,0.375,0.002)    vecaz.=  158.0  vecdip=   0.1
eigenvector2=(-.098,-.249,0.964)    vecaz.= -111.5  vecdip=  74.5
eigenvector3=(0.362,0.893,0.267)    vecaz.=   67.9  vecdip=  15.5

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.399, 0.897, 0.191)    vecaz= 114.vecdip=  11.
nodal plane2: strike= 204. dip=  79.
T1=(-0.995, 0.059,-0.086)    vecaz= 177.  vecdip=  -5.
B =(-0.098,-0.249, 0.964)    vecaz=-112.  vecdip=  74.
P1=( 0.035, 0.967, 0.253)    vecaz=  88.  vecdip=  15.

slipvec2=( 0.912, 0.366, 0.187)    vecaz=  22.vecdip=  11.
nodal plane1: strike= 112. dip=  79.
T2=(-0.755, 0.650, 0.091)    vecaz= 139.  vecdip=   5.
B =(-0.098,-0.249, 0.964)    vecaz=-112.  vecdip=  74.
P2=( 0.649, 0.718, 0.251)    vecaz=  48.  vecdip=  15.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume=  68.1x274.4x 15.0km3

The strain rates for the last  47.0 years in the directions
 of the principal stresses:
     extensional   : 3.0e-09/yr =   2.1e-13/sec
     intermediate : 2.2e-17/yr =   1.6e-21/sec
     compressional:-3.0e-09/yr = -2.1e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  3.0e-09/yr =  9.6e-17/sec  Azimuth: N22W
     Minimum horizontal: -2.8e-09/yr = -8.9e-17/sec  Azimuth: N68E
     Vertical          : -2.2e-10/yr = -6.8e-18/sec
  ENTER region boundary rotation
  0.
  razmax
   22.0621

The maximum horizontal deformation rate =  2.2e-01 mm/yr
```

```
              COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                      FROM A REGIONAL MOMENT TENSOR
*******************************************************************
Owens Valley

Regional moment tensor:
      M11=     2.8e+25  M12=      6.1e+26  M13=      3.9e+26
      M21=     6.1e+26  M22=      5.2e+27  M23=     -8.3e+26  dyne cm
      M31=     3.9e+26  M32=      8.3e+26  M33=     -5.2e+27

Eigenvalues:
sigma1=  5.3e+27  sigma2=  3.3e+21  sigma3= -5.3e+27


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.110,-.991,0.074)    vecaz.=  -96.3  vecdip=   4.2
eigenvector2=(0.990,-.103,0.091)    vecaz.=   -5.9  vecdip=   5.2
eigenvector3=(-.083,0.084,0.993)    vecaz.=  134.7  vecdip=  83.2


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.136,-0.642, 0.755)     vecaz=-102.vecdip=  49.
nodal plane2: strike= -12. dip=  41.
T1=( 0.076,-0.963,-0.259)     vecaz= -95.  vecdip= -15.
B =( 0.990,-0.103, 0.091)     vecaz=  -6.  vecdip=   5.
P1=(-0.115,-0.249, 0.962)     vecaz=-115.  vecdip=  74.

slipvec2=( 0.019, 0.760, 0.650)     vecaz=  89.vecdip=  41.
nodal plane1: strike= 179. dip=  49.
T2=(-0.131, 0.908, 0.399)     vecaz= 98.  vecdip=  21.
B =( 0.990, 0.103, 0.091)     vecaz=  -6.  vecdip=   5.
P2=(-0.042, 0.407, 0.912)     vecaz=  96.  vecdip=  64.
```

```
DETERMINATION OF THE STRAIN RATE:
********************************

The specified volume= 325.4x126.2x 15.0km3

The strain rates for the last 109.0 years in the directions
 of the principal stresses:
     extensional  : 1.2e-07/yr =  4.5e-11/sec
     intermediate : 7.3e-14/yr =  2.8e-17/sec
     compressional:-1.2e-07/yr = -4.5e-11/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  1.2e-07/yr =  3.7e-15/sec  Azimuth: N83E
     Minimum horizontal: -1.0e-09/yr = -3.2e-17/sec  Azimuth: N 7W
     Vertical          : -1.2e-07/yr = -3.7e-15/sec
  ENTER region boundary rotation
  -64.0000
  razmax
   147.274

The maximum horizontal deformation rate =  2.8e+01 mm/yr
```

```
           COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                    FROM A REGIONAL MOMENT TENSOR
           ***********************************************
Central California

Regional moment tensor:
      M11=     -2.2e+26  M12=     -1.1e+26  M13=      7.4e+25
      M21=     -1.1e+26  M22=      6.5e+25  M23=     -1.1e+26  dyne-cm
      M31=      7.4e+25  M32=     -1.1e+26  M33=      1.6e+26

Eigenvalues:
sigma1=  2.6e+26  sigma2= -2.2e+21  sigma3= -2.6e+26

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(0.251,-.575,0.778)    vecaz.=  -66.4  vecdip=  51.1
eigenvector2=(-.173,0.764,0.621)    vecaz.=  102.8  vecdip=  38.4
eigenvector3=(-.952,-.291,0.092)    vecaz.= -163.0  vecdip=   5.3

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.496,-0.612, 0.616)    vecaz=-129.vecdip=  38.
nodal plane2: strike= -39. dip=  52.
T1=( 0.552,-0.447, 0.704)    vecaz= -39.  vecdip=  45.
B =(-0.173, 0.764, 0.621)    vecaz= 103.  vecdip=  38.
P1=(-0.816,-0.465, 0.345)    vecaz=-150.  vecdip=  20.

slipvec2=(-0.851, 0.201,-0.485)    vecaz= 167.vecdip= -29.
nodal plane1: strike= 257. dip= 119.
T2=(-0.078,-0.639, 0.765)    vecaz= -97.  vecdip=  50.
B =(-0.173, 0.764, 0.621)    vecaz= 103.  vecdip=  38.
P2=(-0.982,-0.084,-0.171)    vecaz=-175.  vecdip= -10.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 302.2x194.0x 15.0km3

The strain rates for the last  80.0 years in the directions
 of the principal stresses:
     extensional   : 5.6e-09/yr =  1.1e-12/sec
     intermediate :-4.8e-14/yr  = -9.7e-18/sec
     compressional:-5.6e-09/yr  = -1.1e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -5.6e-09/yr = -1.8e-16/sec  Azimuth: N19E
     Minimum horizontal:  2.2e-09/yr =  7.0e-17/sec  Azimuth: N71W
     Vertical          :  3.4e-09/yr =  1.1e-16/sec
  ENTER region boundary rotation
  -64.0000
  razmax
   82.8439

The maximum horizontal deformation rate =  1.1e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR

```
**************************************************************************
Garlock

Regional moment tensor:
      M11=    -9.4e+27  M12=      3.6e+27  M13=      1.5e+27
      M21=     3.6e+27  M22=      4.7e+27  M23=     -6.0e+27  dyne-cm
      M31=     1.5e+27  M32=     -6.0e+27  M33=      4.7e+27

Eigenvalues:
sigma1=  1.1e+28  sigma2=  3.7e+22  sigma3= -1.1e+28

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.078,-.724,0.686)     vecaz.=  -96.1  vecdip=  43.3
eigenvector2=(0.349,0.625,0.698)     vecaz.=   60.8  vecdip=  44.3
eigenvector3=(-.934,0.294,0.204)     vecaz.=  162.5  vecdip=  11.8

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.715,-0.304, 0.629)     vecaz=-157.vecdip=  39.
nodal plane2: strike= -67. dip=  51.
T1=( 0.236, 0.780, 0.580)     vecaz= -73.  vecdip=  35.
B =( 0.349, 0.625, 0.698)     vecaz=  61.  vecdip=  44.
P1=(-0.907, 0.038, 0.420)     vecaz= 178.  vecdip=  25.

slipvec2=(-0.605, 0.720,-0.341)     vecaz= 130.vecdip= -20.
nodal plane1: strike= 220. dip= 110.
T2=(-0.383,-0.585, 0.715)     vecaz=-123.  vecdip=  46.
B =( 0.349, 0.625, 0.698)     vecaz=  61.  vecdip=  44.
P2=( 0.855, 0.517,-0.024)     vecaz= 149.  vecdip=  -1.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 174.4x223.5x 15.0km3

The strain rates for the last 124.0 years in the directions
 of the principal stresses:
     extensional  : 2.3e-07/yr =  1.1e-10/sec
     intermediate : 7.7e-13/yr =  3.8e-16/sec
     compressional:-2.3e-07/yr = -1.1e-10/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -2.1e-07/yr = -6.8e-15/sec  Azimuth: N13W
     Minimum horizontal:  1.2e-07/yr =  3.7e-15/sec  Azimuth: N77E
     Vertical          :  9.7e-08/yr =  3.1e-15/sec
   ENTER region boundary rotation
   -64.0000
   razmax
   -50.5316

The maximum horizontal deformation rate =  5.7e+01 mm/yr
```

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OF POOR QUALITY

```
            COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                    FROM A REGIONAL MOMENT TENSOR
*******************************************************************
Los Angeles

Regional moment tensor:
      M11=    -1.3e+26  M12=      7.8e+25  M13=      4.3e+25
      M21=     7.8e+25  M22=     -1.7e+25  M23=     -9.4e+25  dyne-cm
      M31=     4.3e+25  M32=     -9.4e+25  M33=      1.5e+26

Eigenvalues:
sigma1=  1.9e+26  sigma2= -9.4e+19  sigma3= -1.9e+26

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(0.026,-.402,0.915)     vecaz.=  -86.3  vecdip=  66.3
eigenvector2=(0.556,0.767,0.321)     vecaz.=   54.1  vecdip=  18.7
eigenvector3=(-.831,0.500,0.243)     vecaz.=  148.9  vecdip=  14.1

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.569, 0.070, 0.819)    vecaz= 173.vecdip=  55.
nodal plane2: strike= 263. dip=  35.
T1=(-0.299,-0.545, 0.783)    vecaz= -61.  vecdip=  52.
B =( 0.556, 0.767, 0.321)    vecaz=  54.  vecdip=  19.
P1=(-0.776, 0.339, 0.532)    vecaz= 156.  vecdip=  32.

slipvec2=(-0.606, 0.638,-0.476)    vecaz= 134.vecdip= -28.
nodal plane1: strike= 224. dip= 118.
T2=(-0.251,-0.213, 0.944)    vecaz=-140.  vecdip=  71.
B =( 0.556, 0.767, 0.321)    vecaz=  54.  vecdip=  19.
P2=(-0.793, 0.605, 0.074)    vecaz= 143.  vecdip=  -4.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 174.4x223.5x 15.0km3

The strain rates for the last  79.0 years in the directions
 of the principal stresses:
      extensional   : 6.3e-09/yr =  1.3e-12/sec
      intermediate :-3.1e-15/yr = -6.1e-19/sec
      compressional:-6.3e-09/yr = -1.3e-12/sec

The horizontal and vertical strain rates:
      Maximum horizontal: -5.6e-09/yr =  1.8e-16/sec  Azimuth: N27W
      Minimum horizontal:  7.3e-10/yr =  2.3e-17/sec  Azimuth: N63E
      Vertical           :  4.9e-09/yr =  1.6e-16/sec
   ENTER region boundary rotation
   -64.0000
   razmax
   -37.2656

The maximum horizontal deformation rate =  1.2e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR

```
**********************************************
Central Idaho

Regional moment tensor:
      M11=     2.4e+26  M12=     1.6e+26  M13=     8.8e+25
      M21=     1.6e+26  M22=     4.7e+25  M23=    -7.7e+25  dyne-cm
      M31=     8.8e+25  M32=    -7.7e+25  M33=    -2.9e+26

Eigenvalues:
sigma1=  3.3e+26  sigma2= -3.0e+20  sigma3= -3.3e+26

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(0.879,0.472,0.067)    vecaz.=   28.2  vecdip=   3.8
eigenvector2=(0.422,-.835,0.354)    vecaz.=  -63.2  vecdip=  20.7
eigenvector3=(-.223,0.283,0.933)    vecaz.=  128.3  vecdip=  68.9

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=( 0.464, 0.534, 0.707)    vecaz=  49.vecdip=  45.
nodal plane2: strike= 139. dip=  45.
T1=( 0.903, 0.352,-0.246)    vecaz=  21.  vecdip= -14.
B =( 0.422,-0.835, 0.354)    vecaz= -63.  vecdip=  21.
P1=( 0.081, 0.423, 0.903)    vecaz=  79.  vecdip=  65.

slipvec2=(-0.779,-0.134, 0.612)    vecaz=-170.vecdip=  38.
nodal plane1: strike= -80. dip=  52.
T2=( 0.756, 0.539, 0.372)    vecaz=  36.  vecdip=  22.
B =( 0.422,-0.835, 0.354)    vecaz= -63.  vecdip=  21.
P2=(-0.501, 0.110, 0.858)    vecaz= 168.  vecdip=  59.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 167.7x259.2x 15.0km3

The strain rates for the last  74.0 years in the directions
 of the principal stresses:
     extensional  : 1.0e-08/yr =  1.8e-12/sec
     intermediate :-9.5e-15/yr = -1.7e-18/sec
     compressional:-1.0e-08/yr = -1.8e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  1.0e-08/yr =  3.3e-16/sec  Azimuth: N29E
     Minimum horizontal: -1.3e-09/yr = -4.2e-17/sec  Azimuth: N61W
     Vertical          : -9.0e-09/yr = -2.9e-16/sec
  ENTER region boundary rotation
  0.
  razmax
   29.3842

The maximum horizontal deformation rate =  2.0e+00 mm/yr
```

```
            COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
                     FROM A REGIONAL MOMENT TENSOR
***************************************************************
Yellowstone/Hebgen

Regional moment tensor:
       M11=      8.8e+26  M12=      1.6e+26  M13=     -5.1e+26
       M21=      1.6e+26  M22=      3.0e+25  M23=     -1.1e+26  dyne-cm
       M31=     -5.1e+26  M32=     -1.1e+26  M33=     -9.1e+26

Eigenvalues:
sigma1=  1.0e+27  sigma2=  5.4e+20  sigma3= -1.0e+27

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.949,-.180,0.259)    vecaz.= -169.3  vecdip=  15.0
eigenvector2=(0.188,-.982,0.009)    vecaz.=  -79.1  vecdip=   0.5
eigenvector3=(0.253,0.057,0.966)    vecaz.=   12.7  vecdip=  75.0

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800  ==> alpha= 25.7 degrees

slipvec1=(-0.492,-0.087, 0.866)    vecaz=-170.vecdip=  60.
nodal plane2: strike= -80. dip=  30.
T1=(-0.979,-0.189,-0.075)     vecaz=-169.  vecdip=  -4.
B =( 0.188,-0.982, 0.009)     vecaz= -79.  vecdip=   0.
P1=(-0.076,-0.0[illegible]6, 0.997)     vecaz= 176.  vecdip=  86.

slipvec2=( 0.850, 0.168, 0.500)    vecaz=  11.vecdip=  30.
nodal plane1: strike= 101. dip=  60.
T2=(-0.812,-0.151, 0.564)     vecaz=-169.  vecdip=  34.
B =( 0.188,-0.982, 0.007)     vecaz= -79.  vecdip=   0.
P2=( 0.55.., 0.113, 0.826)     vecaz=  12.  vecdip=  56.
```

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 129.6x300.0x 15.0km3

The strain rates for the last  66.0 years in the directions
 of the principal stresses:
     extensional  : 4.1e-08/yr =  5.7e-12/sec
     intermediate : 2.1e-14/yr =  2.9e-18/sec
     compressional:-4.1e-08/yr = -5.7e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  3.6e-08/yr =  1.1e-15/sec  Azimuth: N11E
     Minimum horizontal: -3.6e-12/yr = -1.1e-19/sec  Azimuth: N79W
     Vertical          : -3.6e-08/yr = -1.1e-15/sec
  ENTER region boundary rotation
  0.
  razmax
   10.5772

The maximum horizontal deformation rate =  4.7e+00 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****

Wyoming

Regional moment tensor:

M11=	5.7e+23	M12=	-4.9e+23	M13=	-4.6e+23	
M21=	-4.9e+23	M22=	4.2e+23	M23=	4.1e+23	dyne-cm
M31=	-4.6e+23	M32=	4.1e+23	M33=	-9.9e+23	

Eigenvalues:
sigma1= 1.2e+24 sigma2= 9.8e+17 sigma3= -1.2e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.728,0.627,0.276) vecaz.= 139.3 vecdip= 16.0
eigenvector2=(0.654,0.756,0.008) vecaz.= 49.1 vecdip= 0.5
eigenvector3=(0.203,-.187,0.961) vecaz.= -42.6 vecdip= 74.0

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800 ==> alpha= 25.7 degrees

slipvec1=(-0.371, 0.312, 0.875) vecaz= 140.vecdip= 61.
nodal plane2: strike= 230. dip= 29.
T1=(-0.755, 0.654,-0.058) vecaz= 139. vecdip= -3.
B =(0.654, 0.756, 0.008) vecaz= 49. vecdip= 0.
P1=(-0.049, 0.032, 0.998) vecaz= 147. vecdip= 87.

slipvec2=(0.659,-0.575, 0.485) vecaz= -41.vecdip= 29.
nodal plane1: strike= 49. dip= 61.
T2=(-0.620, 0.530, 0.578) vecaz= 139. vecdip= 35.
B =(0.654, 0.756, 0.008) vecaz= 49. vecdip= 0.
P2=(0.433,-0.384, 0.816) vecaz= -42. vecdip= 55.

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 111.1x111.1x 15.0km3

The strain rates for the last  18.0 years in the directions
 of the principal stresses:
     extensional  : 5.3e-10/yr =  5.4e-15/sec
     intermediate : 4.5e-16/yr =  4.6e-21/sec
     compressional:-5.3e-10/yr = -5.4e-15/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  4.5e-10/yr =  1.4e-17/sec  Azimuth: N41W
     Minimum horizontal: -4.4e-14/yr = -1.4e-21/sec  Azimuth: N49E
     Vertical          : -4.5e-10/yr = -1.4e-17/sec
  ENTER region boundary rotation
  0.
  razmax
   40.5717

The maximum horizontal deformation rate =  6.6e-02 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION
FROM A REGIONAL MOMENT TENSOR
****

Soda Springs

Regional moment tensor:

M11=	-1.7e+24	M12=	-2.5e+24	M13=	-5.8e+24	
M21=	-2.5e+24	M22=	1.3e+25	M23=	3.4e+24	dyne-cm
M31=	-5.8e+24	M32=	3.4e+24	M33=	-1.2e+25	

Eigenvalues:
sigma1= 1.5e+25 sigma2= -2.9e+19 sigma3= -1.5e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.210,0.963,0.169) vecaz.= 102.3 vecdip= 9.8
eigenvector2=(-.893,-.259,0.369) vecaz.= -163.8 vecdip= 21.6
eigenvector3=(0.399,-.074,0.914) vecaz.= -10.5 vecdip= 66.1

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction= 0.800 ==> alpha= 25.7 degrees

slipvec1=(0.134, 0.629, 0.766) vecaz= 78.vecdip= 50.
nodal plane2: strike= 168. dip= 40.
T1=(-0.330, 0.933,-0.143) vecaz= 109. vecdip= -8.
B =(-0.893,-0.259, 0.369) vecaz=-164. vecdip= 22.
P1=(0.307, 0.249, 0.919) vecaz= 39. vecdip= 67.

slipvec2=(0.431,-0.733, 0.527) vecaz= -60.vecdip= 32.
nodal plane1: strike= 30. dip= 58.
T2=(-0.066, 0.884, 0.462) vecaz= 94. vecdip= 28.
B =(-0.893,-0.259, 0.369) vecaz=-164. vecdip= 22.
P2=(0.446,-0.388, 0.806) vecaz= -41. vecdip= 54.

C-3

```
DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 137.5x148.8x 15.0km3

The strain rates for the last  79.0 years in the directions
 of the principal stresses:
     extensional   : 9.1e-10/yr =  1.8e-13/sec
     intermediate :-1.8e-15/yr = -3.6e-19/sec
     compressional:-9.1e-10/yr = -1.8e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  8.7e-10/yr =  2.7e-17/sec  Azimuth: N81W
     Minimum horizontal: -1.3e-10/yr = -4.1e-18/sec  Azimuth: N 9E
     Vertical           : -7.4e-10/yr = -2.3e-17/sec
  ENTER region boundary rotation
  -63.2000
  razmax
   17.5856

The maximum horizontal deformation rate =  1.2e-01 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
****

HANSEL VALLEY REGION

```
Hansel Valley 1934

Fault plane solution number 1
fault plane:    strike=   5. dip=  80. slip= -70. degrees
auxilary plane: strike= 120. dip=  20. slip=-154. degrees
Moment Mo= 7.7e+25 dyne-cm
slipvector=( .296, .171, .940)    vecaz=   30.0  vecdip=  70.0
moment tensor 1:
                M11=    -4.3e+24  M12=     2.3e+25  M13=    -1.0e+25
                M21=     2.3e+25  M22=     2.9e+25  M23=     6.7e+25  dyne-cm
                M31=    -1.0e+25  M32=     6.7e+25  M33=    -2.5e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .170, .830, .532)    vecaz.=   78.4  vecdip=  32.1
eigenvector2=(-.941,-.023, .337)    vecaz.= -178.6  vecdip=  19.7
eigenvector3=( .292,-.558, .777)    vecaz.=  -62.4  vecdip=  51.0


Pocatello Valley 1975

Fault plane solution number 2
fault plane:    strike= 225. dip=  39. slip= -53. degrees
auxilary plane: strike=   1. dip=  60. slip=-116. degrees
Moment Mo= 1.5e+25 dyne-cm
slipvector=( .015,-.866, .500)    vecaz=  -89.0  vecdip=  30.0
moment tensor 2:
                M11=     1.8e+23  M12=    -5.9e+24  M13=     3.2e+24
                M21=    -5.9e+24  M22=     1.2e+25  M23=     6.7e+24  dyne-cm
                M31=     3.2e+24  M32=     6.7e+24  M33=    -1.2e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.324, .926, .194)    vecaz.=  109.3  vecdip=  11.2
eigenvector2=( .895, .234, .379)    vecaz.=   14.6  vecdip=  22.3
eigenvector3=(-.305,-.297, .905)    vecaz.= -135.8  vecdip=  64.8


Hansel Valley composite 1976

Fault plane solution number 3
fault plane:    strike= 195. dip=  55. slip= -50. degrees
auxilary plane: strike= 319. dip=  49. slip=-135. degrees
```

```
Moment Mo= 6.3e+22 dyne-cm
slipvector=(-.495,-.570, .656)    vecaz=  229.0  vecdip=  41.0
moment tensor 3:
                 M11=    -1.4e+22  M12=     1.7e+22  M13=     2.7e+22
                 M21=     1.7e+22  M22=     5.9e+22  M23=    -9.9e+21  dyne-cm
                 M31=     2.7e+22  M32=    -9.9e+21  M33=    -4.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.209,-.977, .038)    vecaz.= -102.1  vecdip=   2.2
eigenvector2=( .835,-.158, .527)    vecaz.=  -10.7  vecdip=  31.8
eigenvector3=(-.509, .142, .849)    vecaz.=  164.4  vecdip=  58.1


PV1c

Fault plane solution number 4
fault plane:     strike= 353. dip=  57. slip= -66. degrees
auxiliary plane: strike= 134. dip=  40. slip=-121. degrees
Moment Mo= 3.7e+23 dyne-cm
slipvector=( .462, .447, .766)    vecaz=   44.0  vecdip=  50.0
moment tensor 4:
                 M11=     3.5e+22  M12=     1.6e+23  M13=    -6.5e+22
                 M21=     1.6e+23  M22=     2.7e+23  M23=     1.5e+23  dyne-cm
                 M31=    -6.5e+22  M32=     1.5e+23  M33=    -3.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .401, .903, .157)    vecaz.=   66.1  vecdip=   9.0
eigenvector2=(-.880, .331, .341)    vecaz.=  159.4  vecdip=  19.9
eigenvector3=( .256,-.274, .927)    vecaz.=  -47.0  vecdip=  68.0


PV2e

Fault plane solution number 5
fault plane:     strike= 322. dip=  36. slip= -75. degrees
auxiliary plane: strike= 124. dip=  55. slip=-100. degrees
Moment Mo= 1.0e+25 dyne-cm
slipvector=( .679, .458, .574)    vecaz=   34.0  vecdip=  35.0
moment tensor 5:
                 M11=     5.2e+24  M12=     5.1e+24  M13=    -3.7e+24
                 M21=     5.1e+24  M22=     4.4e+24  M23=    -1.1e+24  dyne-cm
                 M31=    -3.7e+24  M32=    -1.1e+24  M33=    -9.6e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.740,-.650, .171)    vecaz.= -138.7  vecdip=   9.8
eigenvector2=( .000, .000, .000)    vecaz.=     .0  vecdip=  90.0
```

```
eigenvector3=( .229,-.005, .974)    vecaz.=   -1.2  vecdip=  76.8


n1905

Fault plane solution number 6
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor 6:
                 M11=    -4.6e+20  M12=     3.6e+22  M13=    -1.1e+22
                 M21=     3.6e+22  M22=     7.1e+22  M23=     1.1e+23  dyne-cm
                 M31=    -1.1e+22  M32=     1.1e+23  M33=    -7.1e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1909

Fault plane solution number 7
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 2.1e+25 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor 7:
                 M11=    -7.3e+22  M12=     5.6e+24  M13=    -1.8e+24
                 M21=     5.6e+24  M22=     1.1e+25  M23=     1.7e+25  dyne-cm
                 M31=    -1.8e+24  M32=     1.7e+25  M33=    -1.1e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1934a

Fault plane solution number 8
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 1.3e+25 dyne-cm
```

```
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor 8:
                    M11=    -4.4e+22  M12=     3.4e+24  M13=    -1.1e+24
                    M21=     3.4e+24  M22=     6.8e+24  M23=     1.0e+25  dyne-cm
                    M31=    -1.1e+24  M32=     1.0e+25  M33=    -6.8e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1934b

Fault plane solution number 9
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 1.0e+24 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor 9:
                    M11=    -3.5e+21  M12=     2.7e+23  M13=    -8.6e+22
                    M21=     2.7e+23  M22=     5.4e+23  M23=     8.2e+23  dyne-cm
                    M31=    -8.6e+22  M32=     8.2e+23  M33=    -5.4e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1934c

Fault plane solution number10
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 4.8e+23 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor10:
                    M11=    -1.6e+21  M12=     1.3e+23  M13=    -4.1e+22
                    M21=     1.3e+23  M22=     2.5e+23  M23=     3.8e+23  dyne-cm
                    M31=    -4.1e+22  M32=     3.8e+23  M33=    -2.5e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5
```

```
n1934d

Fault plane solution number11
fault plane:     strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=    1. dip=  73. slip= -73. degrees
Moment Mo= 3.6e+24 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor11:
                 M11=    -1.2e+22  M12=     9.5e+23  M13=    -3.1e+23
                 M21=     9.5e+23  M22=     1.9e+24  M23=     2.9e+24  dyne-cm
                 M31=    -3.1e+23  M32=     2.9e+24  M33=    -1.9e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1934e

Fault plane solution number12
fault plane:     strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=    1. dip=  73. slip= -73. degrees
Moment Mo= 3.6e+24 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor12:
                 M11=    -1.2e+22  M12=     9.5e+23  M13=    -3.1e+23
                 M21=     9.5e+23  M22=     1.9e+24  M23=     2.9e+24  dyne-cm
                 M31=    -3.1e+23  M32=     2.9e+24  M33=    -1.9e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1942

Fault plane solution number13
fault plane:     strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=    1. dip=  73. slip= -73. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
```

```
moment tensor13:
                    M11=     -4.6e+20  M12=      3.6e+22  M13=     -1.1e+22
                    M21=      3.6e+22  M22=      7.1e+22  M23=      1.1e+23  dyne-cm
                    M31=     -1.1e+22  M32=      1.1e+23  M33=     -7.1e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1973

Fault plane solution number14
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 1.1e+23 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor14:
                    M11=     -3.6e+20  M12=      2.8e+22  M13=     -8.9e+21
                    M21=      2.8e+22  M22=      5.6e+22  M23=      8.4e+22  dyne-cm
                    M31=     -8.9e+21  M32=      8.4e+22  M33=     -5.5e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


n1975

Fault plane solution number15
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 8.1e+22 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor15:
                    M11=     -2.8e+20  M12=      2.1e+22  M13=     -6.9e+21
                    M21=      2.1e+22  M22=      4.3e+22  M23=      6.5e+22  dyne-cm
                    M31=     -6.9e+21  M32=      6.5e+22  M33=     -4.3e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5
```

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n1978

Fault plane solution number16
fault plane:    strike= 135. dip=  23. slip=-133. degrees
auxilary plane: strike=   1. dip=  73. slip= -73. degrees
Moment Mo= 2.9e+23 dyne-cm
slipvector=( .017,-.956, .292)    vecaz=  -89.0  vecdip=  17.0
moment tensor16:
                M11=    -9.9e+20  M12=     7.6e+22  M13=    -2.4e+22
                M21=     7.6e+22  M22=     1.5e+23  M23=     2.3e+23  dyne-cm
                M31=    -2.4e+22  M32=     2.3e+23  M33=    -1.5e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .191, .873, .449)    vecaz.=   77.7  vecdip=  26.7
eigenvector2=(-.961, .073, .266)    vecaz.=  175.6  vecdip=  15.5
eigenvector3=( .200,-.482, .853)    vecaz.=  -67.5  vecdip=  58.5


Regional moment tensor:
                M11=     9.4e+23  M12=     3.4e+25  M13=    -1.5e+25
                M21=     3.4e+25  M22=     6.9e+25  M23=     1.1e+26  dyne-cm
                M31=    -1.5e+25  M32=     1.1e+26  M33=    -7.0e+25

Eigenvalues:
sigma1=  1.3e+26  sigma2=  3.2e+24  sigma3= -1.4e+26


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .177, .872, .456)    vecaz.=   78.5  vecdip=  27.1
eigenvector2=(-.961, .053, .273)    vecaz.=  176.9  vecdip=  15.8
eigenvector3=( .214,-.486, .847)    vecaz.=  -66.3  vecdip=  57.9

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=(  .276,  .273,  .921)    vecaz=  45.vecdip=  67.
nodal plane2: strike= 135. dip=  23.
T1=(  .096,  .984,  .149)    vecaz=  84.  vecdip=   9.
B =( -.961,  .053,  .273)    vecaz= 177.  vecdip=  16.
P1=(  .260, -.170,  .950)    vecaz= -33.  vecdip=  72.

slipvec2=(  .026, -.961,  .277)    vecaz= -88.vecdip=  16.
nodal plane1: strike=   2. dip=  74.
```

```
T2=(  .238,  .662,  .71Ø)     vecaz=  7Ø.  vecdip=  45.
B =( -.961,  .Ø53,  .273)     vecaz= 177.  vecdip=  16.
P2=(  .143, -.747,  .649)     vecaz= -79.  vecdip=  4Ø.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 125.2x 68.3x 1Ø.Økm3

The strain rates for the last  74 years in the directions of the principal stres
     extensional  : 3.2e-Ø8/yr =  5.5e-12/sec
     intermediate : 7.7e-1Ø/yr =  1.3e-13/sec
     compressional:-3.2e-Ø8/yr = -5.6e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  2.Øe-Ø8/yr =  6.3e-16/sec  Azimuth: N67E
     Minimum horizontal: -3.2e-Ø9/yr = -1.Øe-16/sec  Azimuth: N23W
     Vertical          : -1.7e-Ø8/yr = -5.3e-16/sec
 ENTER region boundary rotation
  .ØØØØØØØØØe+ØØ
 razmax
  .672963715e+Ø2

The maximum horizontal deformation rate = 1.47ØØ mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
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NORTHERN WASATCH FRONT

Brigham City composite 1976

Fault plane solution number 1
fault plane: strike= 147. dip= 63. slip=-104. degrees
auxilary plane: strike= 356. dip= 30. slip= -64. degrees
Moment Mo= 1.2e+22 dyne-cm
slipvector=(-.035,-.499, .866)   vecaz= 266.0 vecdip= 60.0
moment tensor 1:

M11=	4.4e+20	M12=	3.3e+21	M13=	-5.0e+21	
M21=	3.3e+21	M22=	9.2e+21	M23=	-5.1e+21	dyne-cm
M31=	-5.0e+21	M32=	-5.1e+21	M33=	-9.7e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.369,-.883, .290)   vecaz.= -112.7 vecdip= 16.9
eigenvector2=(-.874, .436, .216)   vecaz.= 153.5 vecdip= 12.4
eigenvector3=(.317, .174, .932)   vecaz.=   28.8 vecdip= 68.8

Fielding 1978

Fault plane solution number 2
fault plane: strike= 154. dip= 70. slip= 88. degrees
auxilary plane: strike= 340. dip= 20. slip= 95. degrees
Moment Mo= 1.3e+22 dyne-cm
slipvector=(-.117,-.321, .940)   vecaz= 250.0 vecdip= 70.0
moment tensor 2:

M11=	-1.2e+21	M12=	-3.0e+21	M13=	4.4e+21	
M21=	-3.0e+21	M22=	-6.9e+21	M23=	8.7e+21	dyne-cm
M31=	4.4e+21	M32=	8.7e+21	M33=	8.2e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(.208, .369, .906)   vecaz.=   60.7 vecdip= 64.9
eigenvector2=(-.903, .427, .033)   vecaz.= 154.7 vecdip=   1.9
eigenvector3=(-.375,-.825, .422)   vecaz.= -114.4 vecdip= 25.0

m1906

Fault plane solution number 3
fault plane: strike= 148. dip= 17. slip=-129. degrees
auxilary plane: strike=   9. dip= 77. slip= -78. degrees

```
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor 3:
                    M11=    -5.9e+21  M12=      1.5e+22  M13=    -2.3e+22
                    M21=     1.5e+22  M22=      6.5e+22  M23=     1.2e+23  dyne-cm
                    M31=    -2.3e+22  M32=      1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1909

Fault plane solution number 4
fault plane:     strike= 148. dip=  17. slip=-129. degrees
auxiliary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor 4:
                    M11=    -5.9e+21  M12=      1.5e+22  M13=    -2.3e+22
                    M21=     1.5e+22  M22=      6.5e+22  M23=     1.2e+23  dyne-cm
                    M31=    -2.3e+22  M32=      1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1913

Fault plane solution number 5
fault plane:     strike= 148. dip=  17. slip=-129. degrees
auxiliary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor 5:
                    M11=    -5.9e+21  M12=      1.5e+22  M13=    -2.3e+22
                    M21=     1.5e+22  M22=      6.5e+22  M23=     1.2e+23  dyne-cm
                    M31=    -2.3e+22  M32=      1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
```

```
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1914a

Fault plane solution number 6
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor 6:
                M11=    -5.9e+21  M12=     1.5e+22  M13=    -2.3e+22
                M21=     1.5e+22  M22=     6.5e+22  M23=     1.2e+23  dyne-cm
                M31=    -2.3e+22  M32=     1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1914b

Fault plane solution number 7
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 4.7e+24 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor 7:
                M11=    -2.0e+23  M12=     5.4e+23  M13=    -7.9e+23
                M21=     5.4e+23  M22=     2.2e+24  M23=     4.0e+24  dyne-cm
                M31=    -7.9e+23  M32=     4.0e+24  M33=    -2.0e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1915

Fault plane solution number 8
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
```

```
m1920c

Fault plane solution number11
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor11:
                   M11=    -5.9e+21  M12=     1.5e+22  M13=    -2.3e+22
                   M21=     1.5e+22  M22=     6.5e+22  M23=     1.2e+23  dyne-cm
                   M31=    -2.3e+22  M32=     1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1923

Fault plane solution number12
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor12:
                   M11=    -5.9e+21  M12=     1.5e+22  M13=    -2.3e+22
                   M21=     1.5e+22  M22=     6.5e+22  M23=     1.2e+23  dyne-cm
                   M31=    -2.3e+22  M32=     1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1946

Fault plane solution number13
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
```

```
moment tensor13:
                   M11=    -5.9e+21  M12=     1.5e+22  M13=    -2.3e+22
                   M21=     1.5e+22  M22=     6.5e+22  M23=     1.2e+23  dyne-cm
                   M31=    -2.3e+22  M32=     1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


m1950

Fault plane solution number14
fault plane:    strike= 148. dip=  17. slip=-129. degrees
auxilary plane: strike=   9. dip=  77. slip= -78. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .152,-.962, .225)    vecaz=  -81.0  vecdip=  13.0
moment tensor14:
                   M11=    -5.9e+21  M12=     1.5e+22  M13=    -2.3e+22
                   M21=     1.5e+22  M22=     6.5e+22  M23=     1.2e+23  dyne-cm
                   M31=    -2.3e+22  M32=     1.2e+23  M33=    -5.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8


Regional moment tensor:
                   M11=    -2.7e+23  M12=     7.1e+23  M13=    -1.0e+24
                   M21=     7.1e+23  M22=     2.9e+24  M23=     5.3e+24  dyne-cm
                   M31=    -1.0e+24  M32=     5.3e+24  M33=    -2.7e+24

Eigenvalues:
sigma1=  6.2e+24  sigma2= -6.5e+20  sigma3= -6.2e+24


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .011, .857, .516)    vecaz.=   89.3  vecdip=  31.0
eigenvector2=(-.978,-.099, .184)    vecaz.= -174.2  vecdip=  10.6
eigenvector3=( .208,-.506, .837)    vecaz.=  -67.6  vecdip=  56.8

SYNTHETIC FAULT PLANE SOLUTION:
```

```
coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=(  .155,  .248,  .956)    vecaz=  58.vecdip=  73.
nodal plane2: strike= 148. dip=  17.
T1=( -.059,  .976,  .209)    vecaz=  93.  vecdip=  12.
B =( -.978, -.099,  .184)    vecaz=-174.  vecdip=  11.
P1=(  .200, -.194,  .960)    vecaz= -44.  vecdip=  74.

slipvec2=(  .140, -.964,  .227)    vecaz= -82.vecdip=  13.
nodal plane1: strike=   8. dip=  77.
T2=(  .079,  .641,  .763)    vecaz=  83.  vecdip=  50.
B =( -.978, -.099,  .184)    vecaz=-174.  vecdip=  11.
P2=(  .193, -.761,  .619)    vecaz= -76.  vecdip=  38.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 167.2x 30.3x 10.0km3

The strain rates for the last  78 years in the directions of the principal stres
     extensional   : 2.4e-09/yr =  4.6e-13/sec
     intermediate :-2.5e-13/yr = -4.8e-17/sec
     compressional:-2.4e-09/yr = -4.6e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  1.2e-09/yr =  3.8e-17/sec  Azimuth: N78E
     Minimum horizontal: -1.6e-10/yr = -5.1e-18/sec  Azimuth: N12W
     Vertical          : -1.0e-09/yr = -3.3e-17/sec
 ENTER region boundary rotation
  .000000000e+00
 razmax
  .781332626e+02

The maximum horizontal deformation rate =  .0368 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR

****

EAST CACHE REGION

Cache Valley 1962 #2

Fault plane solution number 1
fault plane: strike= 197. dip= 58. slip= -84. degrees
auxilary plane: strike= 5. dip= 32. slip=-101. degrees
Moment Mo= 7.0e+24 dyne-cm
slipvector=(.046,-.528, .848) vecaz= -85.0 vecdip= 58.0
moment tensor 1:

M11=	1.9e+23	M12=	-1.2e+24	M13=	1.3e+24	
M21=	-1.2e+24	M22=	6.1e+24	M23=	-2.8e+24	dyne-cm
M31=	1.3e+24	M32=	-2.8e+24	M33=	-6.3e+24	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(.214,-.951, .222) vecaz.= -77.3 vecdip= 12.8
eigenvector2=(.967, .238, .089) vecaz.= 13.8 vecdip= 5.1
eigenvector3=(-.137, .195, .971) vecaz.= 125.0 vecdip= 76.2

Logan composite 1974-78

Fault plane solution number 2
fault plane: strike= 190. dip= 30. slip= -85. degrees
auxilary plane: strike= 5. dip= 60. slip= -93. degrees
Moment Mo= 2.6e+22 dyne-cm
slipvector=(.075,-.863, .500) vecaz= -85.0 vecdip= 30.0
moment tensor 2:

M11=	2.9e+20	M12=	-2.8e+21	M13=	-3.2e+20	
M21=	-2.8e+21	M22=	2.2e+22	M23=	1.3e+22	dyne-cm
M31=	-3.2e+20	M32=	1.3e+22	M33=	-2.2e+22	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.107, .960, .260) vecaz.= 96.3 vecdip= 15.1
eigenvector2=(.994, .099, .044) vecaz.= 5.7 vecdip= 2.5
eigenvector3=(-.016,-.263, .965) vecaz.= -93.5 vecdip= 74.7

Salt Lake City composite 1

Fault plane solution number 3
fault plane: strike= 215. dip= 70. slip= -85. degrees
auxilary plane: strike= 20. dip= 20. slip=-104. degrees

```
Moment Mo= 2.6e+22 dyne-cm
slipvector=( .117,-.321, .940)    vecaz=  -70.0  vecdip=  70.0
moment tensor 3:
                  M11=     3.5e+21  M12=     -7.1e+21  M13=      1.2e+22
                  M21=    -7.1e+21  M22=      1.3e+22  M23=     -1.6e+22  dyne-cm
                  M31=     1.2e+22  M32=     -1.6e+22  M33=     -1.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .469,-.777, .420)    vecaz.=  -58.9  vecdip=  24.8
eigenvector2=( .833, .547, .082)    vecaz.=   33.3  vecdip=   4.7
eigenvector3=(-.293, .312, .904)    vecaz.=  133.3  vecdip=  64.7


6908 thrust composite

Fault plane solution number 4
fault plane:     strike= 338. dip=  85. slip=  90. degrees
auxilary plane: strike= 158. dip=   4. slip=  89. degrees
Moment Mo= 2.6e+22 dyne-cm
slipvector=( .026, .065, .998)    vecaz=   68.0  vecdip=  86.0
moment tensor 4:
                  M11=    -6.3e+20  M12=     -1.6e+21  M13=     -9.6e+21
                  M21=    -1.6e+21  M22=     -3.9e+21  M23=     -2.4e+22  dyne-cm
                  M31=    -9.6e+21  M32=     -2.4e+22  M33=      4.5e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.241,-.596, .766)    vecaz.= -112.0  vecdip=  50.0
eigenvector2=( .912,-.410, .007)    vecaz.=  -24.2  vecdip=    .4
eigenvector3=( .287, .710, .643)    vecaz.=   68.0  vecdip=  40.0


n1959

Fault plane solution number 5
fault plane:     strike=   6. dip=  33. slip= -99. degrees
auxilary plane: strike= 197. dip=  58. slip= -84. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .248,-.811, .530)    vecaz=  107.0  vecdip=  32.0
moment tensor 5:
                  M11=     3.7e+21  M12=     -2.4e+22  M13=      2.3e+22
                  M21=    -2.4e+22  M22=      1.2e+23  M23=     -5.2e+22  dyne-cm
                  M31=     2.3e+22  M32=     -5.2e+22  M33=     -1.2e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .211,-.954, .213)    vecaz.=  -77.5  vecdip=  12.3
eigenvector2=( .969, .234, .085)    vecaz.=   13.6  vecdip=   4.9
```

```
eigenvector3=(-.131, .188, .973)    vecaz.=  124.9  vecdip=  76.8


n1960

Fault plane solution number 6
fault plane:    strike=   6. dip=  33. slip= -99. degrees
auxiliary plane: strike= 197. dip=  58. slip= -84. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .248,-.811, .530)    vecaz=  107.0  vecdip=  32.0
moment tensor 6:
                M11=     3.7e+21  M12=    -2.4e+22  M13=     2.3e+22
                M21=    -2.4e+22  M22=     1.2e+23  M23=    -5.2e+22  dyne-cm
                M31=     2.3e+22  M32=    -5.2e+22  M33=    -1.2e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .211,-.954, .213)    vecaz.=  -77.5  vecdip=  12.3
eigenvector2=( .969, .234, .085)    vecaz.=   13.6  vecdip=   4.9
eigenvector3=(-.131, .188, .973)    vecaz.=  124.9  vecdip=  76.8


n1964

Fault plane solution number 7
fault plane:    strike=   6. dip=  33. slip= -99. degrees
auxiliary plane: strike= 197. dip=  58. slip= -84. degrees
Moment Mo= 8.1e+22 dyne-cm
slipvector=( .248,-.811, .530)    vecaz=  107.0  vecdip=  32.0
moment tensor 7:
                M11=     2.2e+21  M12=    -1.4e+22  M13=     1.4e+22
                M21=    -1.4e+22  M22=     7.1e+22  M23=    -3.1e+22  dyne-cm
                M31=     1.4e+22  M32=    -3.1e+22  M33=    -7.3e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .211,-.954, .213)    vecaz.=  -77.5  vecdip=  12.3
eigenvector2=( .969, .234, .085)    vecaz.=   13.6  vecdip=   4.9
eigenvector3=(-.131, .188, .973)    vecaz.=  124.9  vecdip=  76.8


n1966

Fault plane solution number 8
fault plane:    strike=   6. dip=  33. slip= -99. degrees
auxiliary plane: strike= 197. dip=  58. slip= -84. degrees
Moment Mo= 2.9e+23 dyne-cm
```

```
slipvector=( .248,-.811, .53Ø)     vecaz=  1Ø7.Ø  vecdip=  32.Ø
moment tensor 8:
                  M11=     7.9e+21  M12=    -5.1e+22  M13=     5.Øe+22
                  M21=    -5.1e+22  M22=     2.5e+23  M23=    -1.1e+23  dyne-cm
                  M31=     5.Øe+22  M32=    -1.1e+23  M33=    -2.6e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .211,-.954, .213)    vecaz.=  -77.5  vecdip=  12.3
eigenvector2=( .969, .234, .Ø85)    vecaz.=   13.6  vecdip=   4.9
eigenvector3=(-.131, .188, .973)    vecaz.=  124.9  vecdip=  76.8


Regional moment tensor:
                  M11=     2.1e+23  M12=    -1.4e+24  M13=     1.4e+24
                  M21=    -1.4e+24  M22=     6.7e+24  M23=    -3.1e+24  dyne-cm
                  M31=     1.4e+24  M32=    -3.1e+24  M33=    -6.9e+24

Eigenvalues:
sigma1=  7.7e+24  sigma2= -1.6e+21  sigma3= -7.7e+24


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .214,-.951, .221)    vecaz.=  -77.3  vecdip=  12.8
eigenvector2=( .967, .238, .Ø87)    vecaz.=   13.8  vecdip=   5.Ø
eigenvector3=(-.136, .196, .971)    vecaz.=  124.7  vecdip=  76.2


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .8ØØ  ==> alpha= 25.7 degrees

slipvec1=(  .Ø55, -.534,  .843)    vecaz= -84.vecdip=  58.
nodal plane2: strike=   6. dip=  32.
T1=(  .247, -.963, -.112)    vecaz= -76.  vecdip=  -6.
B =(  .967,  .238,  .Ø87)    vecaz=  14.  vecdip=   5.
P1=( -.Ø57, -.13Ø,  .99Ø)    vecaz=-114.  vecdip=  82.

slipvec2=( -.247,  .811,  .53Ø)    vecaz= 1Ø7.vecdip=  32.
nodal plane1: strike= 197. dip=  58.
T2=(  .157, -.833,  .53Ø)    vecaz= -79.  vecdip=  32.
B =(  .967,  .238,  .Ø87)    vecaz=  14.  vecdip=   5.
P2=( -.199,  .5ØØ,  .843)    vecaz= 112.  vecdip=  57.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 191.8x 7Ø.4x 1Ø.Økm3
```

```
The strain rates for the last  19 years in the directions of the principal stres
     extensional  : 4.5e-09/yr =  5.2e-14/sec
     intermediate :-9.2e-13/yr = -1.1e-17/sec
     compressional:-4.5e-09/yr = -5.2e-14/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  4.1e-09/yr =  1.3e-16/sec  Azimuth: N79W
     Minimum horizontal: -3.9e-11/yr = -1.2e-18/sec  Azimuth: N11E
     Vertical          : -4.1e-09/yr = -1.3e-16/sec
 ENTER region boundary rotation
  .000000000e+00
 razmax
  .785714493e+02

The maximum horizontal deformation rate =  .2942 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR

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SOUTH SALT LAKE REGION

6808 C #8

Fault plane solution number 1
fault plane:     strike= 220. dip=  80. slip=  96. degrees
auxilary plane: strike=  38. dip=   7. slip=  88. degrees
Moment Mo= 1.0e+23 dyne-cm
slipvector=( .075,-.096, .993)    vecaz=  -52.0  vecdip=  83.0
moment tensor 1:
                M11=    -3.9e+21  M12=      1.5e+22  M13=    -6.1e+22
                M21=     1.5e+22  M22=     -3.0e+22  M23=     7.0e+22  dyne-cm
                M31=    -6.1e+22  M32=      7.0e+22  M33=     3.4e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.426, .392, .815)    vecaz.=  137.3  vecdip=  54.6
eigenvector2=( .774, .625, .103)    vecaz.=   39.0  vecdip=   5.9
eigenvector3=( .469,-.675, .570)    vecaz.=  -55.2  vecdip=  34.7


n1915

Fault plane solution number 2
fault plane:     strike= 220. dip=  80. slip=  96. degrees
auxilary plane: strike=  38. dip=   7. slip=  88. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .075,-.096, .993)    vecaz=  -52.0  vecdip=  83.0
moment tensor 2:
                M11=    -5.3e+21  M12=      2.0e+22  M13=    -8.3e+22
                M21=     2.0e+22  M22=     -4.1e+22  M23=     9.5e+22  dyne-cm
                M31=    -8.3e+22  M32=      9.5e+22  M33=     4.6e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.426, .392, .815)    vecaz.=  137.3  vecdip=  54.6
eigenvector2=( .774, .625, .103)    vecaz.=   39.0  vecdip=   5.9
eigenvector3=( .469,-.675, .570)    vecaz.=  -55.2  vecdip=  34.7


Regional moment tensor:
                M11=    -9.2e+21  M12=      3.5e+22  M13=    -1.4e+23
                M21=     3.5e+22  M22=     -7.1e+22  M23=     1.7e+23  dyne-cm
                M31=    -1.4e+23  M32=      1.7e+23  M33=     8.0e+22
```

```
Eigenvalues:
sigma1=  2.3e+23  sigma2=  1.5e+15  sigma3= -2.3e+23


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.426, .392, .815)    vecaz.=  137.3  vecdip=  54.6
eigenvector2=( .774, .625, .1ø3)    vecaz.=   39.ø  vecdip=   5.9
eigenvector3=( .469,-.675, .57ø)    vecaz.=  -55.2  vecdip=  34.7


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .8øø  ==> alpha= 25.7 degrees

slipvec1=(  .ø31, -.199,  .979)    vecaz= -81.vecdip=  78.
nodal plane2: strike=   9. dip=  12.
T1=( -.557,  .594,  .581)    vecaz= 133.  vecdip=  36.
B =(  .774,  .625,  .1ø3)    vecaz=  39.  vecdip=   6.
P1=(  .3ø2, -.5ø7,  .8ø8)    vecaz= -59.  vecdip=  54.

slipvec2=(  .633, -.754, -.174)    vecaz= -5ø.vecdip= -1ø.
nodal plane1: strike=  4ø. dip= 1øø.
T2=( -.246,  .147,  .958)    vecaz= 149.  vecdip=  73.
B =(  .774,  .625,  .1ø3)    vecaz=  39.  vecdip=   6.
P2=(  .584, -.766,  .268)    vecaz= -53.  vecdip=  16.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 227.9x 71.5x 1ø.økm3

The strain rates for the last  63 years in the directions of the principal stres
     extensional   : 3.5e-11/yr =  4.4e-15/sec
     intermediate : 2.2e-19/yr =  2.7e-23/sec
     compressional:-3.5e-11/yr = -4.4e-15/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -1.3e-11/yr = -4.1e-19/sec  Azimuth: N66W
     Minimum horizontal:  1.øe-12/yr =  3.2e-2ø/sec  Azimuth: N24E
     Vertical          :  1.2e-11/yr =  3.7e-19/sec
 ENTER region boundary rotation
  .øøøøøøøøøe+øø
 razmax
  .65592659øe+ø2

The maximum horizontal deformation rate =  .øø1ø mm/yr
```

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COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
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SOUTHERN WASATCH FRONT

Central Utah 1963

Fault plane solution number 1
fault plane:     strike= 350. dip=  74. slip=-124. degrees
auxilary plane: strike= 238. dip=  40. slip= -29. degrees
Moment Mo= 1.8e+23 dyne-cm
slipvector=( .545,-.341, .766)    vecaz=  148.0  vecdip=  50.0
moment tensor 1:
                M11=    -3.0e+22  M12=    -7.7e+22  M13=     4.9e+22
                M21=    -7.7e+22  M22=     1.1e+23  M23=     1.2e+23  dyne-cm
                M31=     4.9e+22  M32=     1.2e+23  M33=    -7.8e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.243, .897, .369)    vecaz.=  105.2  vecdip=  21.6
eigenvector2=( .843, .008, .538)    vecaz.=     .5  vecdip=  32.5
eigenvector3=(-.479,-.442, .758)    vecaz.= -137.3  vecdip=  49.3


Salt Lake City composite 2

Fault plane solution number 2
fault plane:     strike= 171. dip=  60. slip= -79. degrees
auxilary plane: strike= 330. dip=  30. slip=-108. degrees
Moment Mo= 1.3e+24 dyne-cm
slipvector=(-.250,-.433, .866)    vecaz=  240.0  vecdip=  60.0
moment tensor 2:
                M11=     9.5e+22  M12=     3.8e+23  M13=     2.3e+22
                M21=     3.8e+23  M22=     1.0e+24  M23=    -6.6e+23  dyne-cm
                M31=     2.3e+22  M32=    -6.6e+23  M33=    -1.1e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.283,-.927, .248)    vecaz.= -107.0  vecdip=  14.3
eigenvector2=( .955,-.248, .165)    vecaz.=  -14.6  vecdip=   9.5
eigenvector3=(-.092, .283, .955)    vecaz.=  108.0  vecdip=  72.7


# 71 C

Fault plane solution number 3
fault plane:     strike= 355. dip=  85. slip=-105. degrees
auxilary plane: strike= 235. dip=  20. slip= -30. degrees
```

```
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .280,-.196, .940)    vecaz=  145.0  vecdip=  70.0
moment tensor 3:
                   M11=    -5.9e+21  M12=    -3.2e+22  M13=     1.4e+22
                   M21=    -3.2e+22  M22=     2.9e+22  M23=     1.3e+23  dyne-cm
                   M31=     1.4e+22  M32=     1.3e+23  M33=    -2.3e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.116, .777, .619)    vecaz.=   98.5  vecdip=  38.2
eigenvector2=( .964,-.062, .258)    vecaz.=   -3.7  vecdip=  14.9
eigenvector3=(-.239,-.626, .742)    vecaz.= -110.8  vecdip=  47.9


n1900

Fault plane solution number 4
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 4.7e+24 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor 4:
                   M11=     1.7e+23  M12=     1.0e+24  M13=     2.7e+23
                   M21=     1.0e+24  M22=     4.2e+24  M23=    -1.5e+24  dyne-cm
                   M31=     2.7e+23  M32=    -1.5e+24  M33=    -4.4e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1910

Fault plane solution number 5
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 4.7e+24 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor 5:
                   M11=     1.7e+23  M12=     1.0e+24  M13=     2.7e+23
                   M21=     1.0e+24  M22=     4.2e+24  M23=    -1.5e+24  dyne-cm
                   M31=     2.7e+23  M32=    -1.5e+24  M33=    -4.4e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
```

eigenvector3=(-.092, .171, .981)   vecaz.= 118.2 vecdip= 78.8

n1920a

Fault plane solution number 6
fault plane: strike= 339. dip= 37. slip=-102. degrees
auxilary plane: strike= 175. dip= 54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(.071, .806, .588)   vecaz=   85.0 vecdip= 36.0
moment tensor 6:

M11=	5.0e+21	M12=	3.0e+22	M13=	7.9e+21	
M21=	3.0e+22	M22=	1.2e+23	M23=	-4.2e+22	dyne-cm
M31=	7.9e+21	M32=	-4.2e+22	M33=	-1.3e+23	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)   vecaz.= -102.5 vecdip=   8.5
eigenvector2=(.973,-.196, .125)   vecaz.= -11.4 vecdip=   7.2
eigenvector3=(-.092, .171, .981)   vecaz.= 118.2 vecdip= 78.8

n1920b

Fault plane solution number 7
fault plane: strike= 339. dip= 37. slip=-102. degrees
auxilary plane: strike= 175. dip= 54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(.071, .806, .588)   vecaz=   85.0 vecdip= 36.0
moment tensor 7:

M11=	5.0e+21	M12=	3.0e+22	M13=	7.9e+21	
M21=	3.0e+22	M22=	1.2e+23	M23=	-4.2e+22	dyne-cm
M31=	7.9e+21	M32=	-4.2e+22	M33=	-1.3e+23	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)   vecaz.= -102.5 vecdip=   8.5
eigenvector2=(.973,-.196, .125)   vecaz.= -11.4 vecdip=   7.2
eigenvector3=(-.092, .171, .981)   vecaz.= 118.2 vecdip= 78.8

n1920c

Fault plane solution number 8
fault plane: strike= 339. dip= 37. slip=-102. degrees
auxilary plane: strike= 175. dip= 54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm

```
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor 8:
                        M11=     5.0e+21  M12=     3.0e+22  M13=     7.9e+21
                        M21=     3.0e+22  M22=     1.2e+23  M23=    -4.2e+22  dyne-cm
                        M31=     7.9e+21  M32=    -4.2e+22  M33=    -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1938

Fault plane solution number 9
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor 9:
                        M11=     5.0e+21  M12=     3.0e+22  M13=     7.9e+21
                        M21=     3.0e+22  M22=     1.2e+23  M23=    -4.2e+22  dyne-cm
                        M31=     7.9e+21  M32=    -4.2e+22  M33=    -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1943a

Fault plane solution number10
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor10:
                        M11=     2.9e+22  M12=     1.8e+23  M13=     4.6e+22
                        M21=     1.8e+23  M22=     7.2e+23  M23=    -2.5e+23  dyne-cm
                        M31=     4.6e+22  M32=    -2.5e+23  M33=    -7.5e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8
```

```
n1943b

Fault plane solution number11
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxiliary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor11:
                M11=      5.0e+21  M12=      3.0e+22  M13=      7.9e+21
                M21=      3.0e+22  M22=      1.2e+23  M23=     -4.2e+22  dyne-cm
                M31=      7.9e+21  M32=     -4.2e+22  M33=     -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1952

Fault plane solution number12
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxiliary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor12:
                M11=      5.0e+21  M12=      3.0e+22  M13=      7.9e+21
                M21=      3.0e+22  M22=      1.2e+23  M23=     -4.2e+22  dyne-cm
                M31=      7.9e+21  M32=     -4.2e+22  M33=     -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1955

Fault plane solution number13
fault plane:    strike= 339. dip=  37. slip=-102. degrees
auxiliary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
```

```
moment tensor13:
                 M11=     5.0e+21  M12=     3.0e+22  M13=     7.9e+21
                 M21=     3.0e+22  M22=     1.2e+23  M23=    -4.2e+22  dyne-cm
                 M31=     7.9e+21  M32=    -4.2e+22  M33=    -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1958a

Fault plane solution number14
fault plane:     strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor14:
                 M11=     5.0e+21  M12=     3.0e+22  M13=     7.9e+21
                 M21=     3.0e+22  M22=     1.2e+23  M23=    -4.2e+22  dyne-cm
                 M31=     7.9e+21  M32=    -4.2e+22  M33=    -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8


n1958b

Fault plane solution number15
fault plane:     strike= 339. dip=  37. slip=-102. degrees
auxilary plane: strike= 175. dip=  54. slip= -80. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .071, .806, .588)    vecaz=   85.0  vecdip=  36.0
moment tensor15:
                 M11=     5.0e+21  M12=     3.0e+22  M13=     7.9e+21
                 M21=     3.0e+22  M22=     1.2e+23  M23=    -4.2e+22  dyne-cm
                 M31=     7.9e+21  M32=    -4.2e+22  M33=    -1.3e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.213,-.966, .148)    vecaz.= -102.5  vecdip=   8.5
eigenvector2=( .973,-.196, .125)    vecaz.=  -11.4  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.2  vecdip=  78.8
```

```
Regional moment tensor:
                M11=      4.8e+23  M12=      2.8e+24  M13=      7.5e+23
                M21=      2.8e+24  M22=      1.1e+25  M23=     -4.0e+24  dyne-cm
                M31=      7.5e+23  M32=     -4.0e+24  M33=     -1.2e+25

Eigenvalues:
sigma1=  1.3e+25  sigma2=  1.9e+22  sigma3= -1.3e+25


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.212,-.966, .149)    vecaz.= -102.4  vecdip=   8.6
eigenvector2=( .973,-.194, .126)    vecaz.=  -11.3  vecdip=   7.2
eigenvector3=(-.092, .171, .981)    vecaz.=  118.3  vecdip=  78.8


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=( -.215, -.562,  .799)    vecaz=-111.vecdip=  53.
nodal plane2: strike= -21. dip=  37.
T1=( -.170, -.968, -.184)    vecaz=-100.  vecdip= -11.
B =(  .973, -.194,  .126)    vecaz= -11.  vecdip=   7.
P1=( -.157, -.158,  .975)    vecaz=-135.  vecdip=  77.

slipvec2=(  .085,  .804,  .588)    vecaz=  84.vecdip=  36.
nodal plane1: strike= 174. dip=  54.
T2=( -.231, -.855,  .465)    vecaz=-105.  vecdip=  28.
B =(  .973, -.194,  .126)    vecaz= -11.  vecdip=   7.
P2=( -.017,  .481,  .876)    vecaz=  92.  vecdip=  61.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 185.9x 30.3x 10.0km3

The strain rates for the last  78 years in the directions of the principal stres
     extensional   : 4.4e-09/yr =  8.4e-13/sec
     intermediate  : 6.4e-12/yr =  1.2e-15/sec
     compressional:-4.4e-09/yr = -8.4e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  4.2e-09/yr =  1.3e-16/sec  Azimuth: N76E
     Minimum horizontal: -6.6e-11/yr = -2.1e-18/sec  Azimuth: N14W
     Vertical          : -4.1e-09/yr = -1.3e-16/sec
 ENTER region boundary rotation
```

```
 .000000000e+00
razmax
 .764970627e+02

The maximum horizontal deformation rate =  .1301 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
****

PROVO REGION

Heber City composite 1972

Fault plane solution number 1
fault plane: strike= 323. dip= 64. slip= -74. degrees
auxilary plane: strike= 110. dip= 30. slip=-120. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(.470, .171, .866)   vecaz=   20.0 vecdip= 60.0
moment tensor 1:

M11=	6.9e+22	M12=	5.8e+22	M13=	3.5e+22	
M21=	5.8e+22	M22=	3.3e+22	M23=	7.4e+22	dyne-cm
M31=	3.5e+22	M32=	7.4e+22	M33=	-1.0e+23	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(.717, .628, .301)   vecaz.=   41.2 vecdip= 17.5
eigenvector2=(-.695, .675, .248)   vecaz.= 135.8 vecdip= 14.3
eigenvector3=(-.048,-.387, .921)   vecaz.= -97.0 vecdip= 67.1

Heber City thrust composite 1a #68

Fault plane solution number 2
fault plane: strike= 184. dip= 80. slip= 92. degrees
auxilary plane: strike= 353. dip= 10. slip= 79. degrees
Moment Mo= 1.8e+22 dyne-cm
slipvector=(-.021,-.172, .985)   vecaz= 263.0 vecdip= 80.0
moment tensor 2:

M11=	5.6e+19	M12=	-1.8e+20	M13=	-1.3e+21	
M21=	-1.8e+20	M22=	-6.2e+21	M23=	1.7e+22	dyne-cm
M31=	-1.3e+21	M32=	1.7e+22	M33=	6.2e+21	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.065, .571, .819)   vecaz.=   96.5 vecdip= 55.0
eigenvector2=(.997, .064, .034)   vecaz.=   3.7 vecdip=   2.0
eigenvector3=(.033,-.819, .573)   vecaz.= -87.7 vecdip= 35.0

Heber City thrust composite 1b #69

Fault plane solution number 3
fault plane: strike= 184. dip= 80. slip= 92. degrees
auxilary plane: strike= 353. dip= 10. slip= 79. degrees

```
Moment Mo= 1.8e+22 dyne-cm
slipvector=(-.021,-.172, .985)    vecaz=  263.0  vecdip=  80.0
moment tensor 3:
                 M11=     5.6e+19  M12=     -1.8e+20  M13=     -1.3e+21
                 M21=    -1.8e+20  M22=     -6.2e+21  M23=      1.7e+22  dyne-cm
                 M31=    -1.3e+21  M32=      1.7e+22  M33=      6.2e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.065, .571, .819)    vecaz.=   96.5  vecdip=  55.0
eigenvector2=( .997, .064, .034)    vecaz.=    3.7  vecdip=   2.0
eigenvector3=( .033,-.819, .573)    vecaz.=  -87.7  vecdip=  35.0


Heber City reversed composite 2

Fault plane solution number 4
fault plane:    strike= 207. dip=  80. slip=  90. degrees
auxilary plane: strike=  27. dip=  10. slip=  90. degrees
Moment Mo= 1.8e+22 dyne-cm
slipvector=( .079,-.155, .985)    vecaz=  -63.0  vecdip=  80.0
moment tensor 4:
                 M11=    -1.3e+21  M12=      2.5e+21  M13=     -7.7e+21
                 M21=     2.5e+21  M22=     -4.9e+21  M23=      1.5e+22  dyne-cm
                 M31=    -7.7e+21  M32=      1.5e+22  M33=      6.2e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.260, .511, .819)    vecaz.=  117.0  vecdip=  55.0
eigenvector2=( .077, .952, .296)    vecaz.=   85.4  vecdip=  17.2
eigenvector3=( .372,-.730, .574)    vecaz.=  -63.0  vecdip=  35.0


n1915

Fault plane solution number 5
fault plane:    strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor 5:
                 M11=    -3.1e+23  M12=     -3.5e+23  M13=     -1.7e+23
                 M21=    -3.5e+23  M22=     -9.3e+22  M23=     -5.8e+23  dyne-cm
                 M31=    -1.7e+23  M32=     -5.8e+23  M33=      4.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
```

```
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


n1916

Fault plane solution number 6
fault plane:     strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor 6:
                M11=    -5.3e+22  M12=    -6.0e+22  M13=    -3.0e+22
                M21=    -6.0e+22  M22=    -1.6e+22  M23=    -9.9e+22  dyne-cm
                M31=    -3.0e+22  M32=    -9.9e+22  M33=     6.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


n1950

Fault plane solution number 7
fault plane:     strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor 7:
                M11=    -5.3e+22  M12=    -6.0e+22  M13=    -3.0e+22
                M21=    -6.0e+22  M22=    -1.6e+22  M23=    -9.9e+22  dyne-cm
                M31=    -3.0e+22  M32=    -9.9e+22  M33=     6.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


n1951

Fault plane solution number 8
fault plane:     strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 1.4e+23 dyne-cm
```

```
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor 8:
              M11=    -5.3e+22  M12=    -6.0e+22  M13=    -3.0e+22
              M21=    -6.0e+22  M22=    -1.6e+22  M23=    -9.9e+22  dyne-cm
              M31=    -3.0e+22  M32=    -9.9e+22  M33=     6.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


n1953

Fault plane solution number 9
fault plane:    strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor 9:
              M11=    -5.3e+22  M12=    -6.0e+22  M13=    -3.0e+22
              M21=    -6.0e+22  M22=    -1.6e+22  M23=    -9.9e+22  dyne-cm
              M31=    -3.0e+22  M32=    -9.9e+22  M33=     6.9e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


n1958

Fault plane solution number10
fault plane:    strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor10:
              M11=    -3.1e+23  M12=    -3.5e+23  M13=    -1.7e+23
              M21=    -3.5e+23  M22=    -9.3e+22  M23=    -5.8e+23  dyne-cm
              M31=    -1.7e+23  M32=    -5.8e+23  M33=     4.1e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3
```

```
n1963

Fault plane solution number11
fault plane:    strike=  98. dip=  29. slip=  37. degrees
auxilary plane: strike= 335. dip=  73. slip= 114. degrees
Moment Mo= 6.3e+22 dyne-cm
slipvector=(-.404,-.867, .292)    vecaz=  245.0  vecdip=  17.0
moment tensor11:
                     M11=     -2.5e+22  M12=     -2.8e+22  M13=     -1.4e+22
                     M21=     -2.8e+22  M22=     -7.4e+21  M23=     -4.6e+22  dyne-cm
                     M31=     -1.4e+22  M32=     -4.6e+22  M33=      3.2e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.0  vecdip=  55.6
eigenvector2=(-.775, .499, .387)    vecaz.=  147.3  vecdip=  22.8
eigenvector3=( .629, .659, .412)    vecaz.=   46.3  vecdip=  24.3


Regional moment tensor:
                     M11=     -7.9e+23  M12=     -9.1e+23  M13=     -4.5e+23
                     M21=     -9.1e+23  M22=     -2.4e+23  M23=     -1.5e+24  dyne-cm
                     M31=     -4.5e+23  M32=     -1.5e+24  M33=      1.0e+24

Eigenvalues:
sigma1=  2.0e+24  sigma2=  1.8e+22  sigma3= -2.0e+24


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .049,-.563, .825)    vecaz.=  -85.1  vecdip=  55.6
eigenvector2=(-.775, .500, .386)    vecaz.=  147.2  vecdip=  22.7
eigenvector3=( .630, .658, .412)    vecaz.=   46.3  vecdip=  24.3

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=(  .480,  .068,  .875)    vecaz=   8.vecdip=  61.
nodal plane2: strike=  98. dip=  29.
T1=( -.163, -.749,  .642)    vecaz=-102.  vecdip=  40.
B =( -.775,  .500,  .386)    vecaz= 147.  vecdip=  23.
P1=(  .610,  .435,  .662)    vecaz=  35.  vecdip=  41.

slipvec2=(  .411,  .863, -.292)    vecaz=  65.vecdip= -17.
```

```
nodal plane1: strike= 155. dip= 107.
T2=(  .254, -.313,  .915)    vecaz= -51.  vecdip=  66.
B =( -.775,  .500,  .386)    vecaz= 147.  vecdip=  23.
P2=(  .578,  .808,  .116)    vecaz=  54.  vecdip=   7.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 103.8x 71.5x 10.0km3

The strain rates for the last  63 years in the directions of the principal stres
     extensional  : 6.6e-10/yr =  8.3e-14/sec
     intermediate : 5.8e-12/yr =  7.3e-16/sec
     compressional:-6.6e-10/yr = -8.3e-14/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -4.8e-10/yr = -1.5e-17/sec  Azimuth: N37E
     Minimum horizontal:  1.4e-10/yr =  4.5e-18/sec  Azimuth: N53W
     Vertical          :  3.4e-10/yr =  1.1e-17/sec
 ENTER region boundary rotation
  .0000000000e+00
 razmax
  .365128403e+02

The maximum horizontal deformation rate =  .0572 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR

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**************************************************************************************

CENTRAL UTAH REGION

 6 S

Fault plane solution number 1
fault plane:     strike= 170. dip=  86. slip= 105. degrees
auxilary plane: strike= 275. dip=  15. slip=  16. degrees
Moment Mo= 1.3e+24 dyne-cm
slipvector=(-.258,-.023, .966)    vecaz=  185.0  vecdip=  75.0
moment tensor 1:
                M11=    -1.2e+23  M12=    -3.5e+23  M13=      2.0e+23
                M21=    -3.5e+23  M22=    -5.6e+22  M23=      1.2e+24  dyne-cm
                M31=     2.0e+23  M32=     1.2e+24  M33=      1.8e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.066, .680, .731)    vecaz.=   95.5  vecdip=  46.9
eigenvector2=( .948,-.186, .258)    vecaz.=  -11.1  vecdip=  15.0
eigenvector3=(-.311,-.710, .632)    vecaz.= -113.7  vecdip=  39.2


48 C

Fault plane solution number 2
fault plane:     strike= 203. dip=  80. slip= -80. degrees
auxilary plane: strike= 340. dip=  14. slip=-132. degrees
Moment Mo= 3.0e+22 dyne-cm
slipvector=(-.083,-.227, .970)    vecaz=  250.0  vecdip=  76.0
moment tensor 2:
                M11=    -2.1e+21  M12=    -6.9e+19  M13=      1.1e+22
                M21=    -6.9e+19  M22=     1.2e+22  M23=     -2.5e+22  dyne-cm
                M31=     1.1e+22  M32=    -2.5e+22  M33=     -9.9e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .206,-.800, .563)    vecaz.=  -75.5  vecdip=  34.3
eigenvector2=( .918, .357, .171)    vecaz.=   21.2  vecdip=   9.8
eigenvector3=(-.338, .482, .809)    vecaz.=  125.0  vecdip=  54.0


n1901

Fault plane solution number 3
fault plane:     strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
```

```
Moment Mo= 1.3e+26 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 3:
                  M11=    -2.0e+25  M12=     3.3e+25  M13=     3.2e+25
                  M21=     3.3e+25  M22=     3.5e+24  M23=    -1.2e+26  dyne-cm
                  M31=     3.2e+25  M32=    -1.2e+26  M33=     1.6e+25

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1902

Fault plane solution number 4
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 4:
                  M11=    -2.1e+22  M12=     3.5e+22  M13=     3.4e+22
                  M21=     3.5e+22  M22=     3.7e+21  M23=    -1.2e+23  dyne-cm
                  M31=     3.4e+22  M32=    -1.2e+23  M33=     1.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1910a

Fault plane solution number 5
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 5:
                  M11=    -1.2e+23  M12=     2.1e+23  M13=     2.0e+23
                  M21=     2.1e+23  M22=     2.2e+22  M23=    -7.3e+23  dyne-cm
                  M31=     2.0e+23  M32=    -7.3e+23  M33=     1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
```

```
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n19100b

Fault plane solution number 6
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 6:
                M11=    -1.2e+23  M12=     2.1e+23  M13=     2.0e+23
                M21=     2.1e+23  M22=     2.2e+22  M23=    -7.3e+23  dyne-cm
                M31=     2.0e+23  M32=    -7.3e+23  M33=     1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1921a

Fault plane solution number 7
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 7:
                M11=    -2.1e+22  M12=     3.5e+22  M13=     3.4e+22
                M21=     3.5e+22  M22=     3.7e+21  M23=    -1.2e+23  dyne-cm
                M31=     3.4e+22  M32=    -1.2e+23  M33=     1.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1921b

Fault plane solution number 8
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 1.4e+23 dyne-cm
```

```
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 8:
                 M11=    -2.1e+22  M12=     3.5e+22  M13=     3.4e+22
                 M21=     3.5e+22  M22=     3.7e+21  M23=    -1.2e+23  dyne-cm
                 M31=     3.4e+22  M32=    -1.2e+23  M33=     1.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1921c

Fault plane solution number 9
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 2.1e+25 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor 9:
                 M11=    -3.3e+24  M12=     5.5e+24  M13=     5.4e+24
                 M21=     5.5e+24  M22=     5.9e+23  M23=    -2.0e+25  dyne-cm
                 M31=     5.4e+24  M32=    -2.0e+25  M33=     2.7e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1921d

Fault plane solution number10
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 4.7e+24 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor10:
                 M11=    -7.3e+23  M12=     1.2e+24  M13=     1.2e+24
                 M21=     1.2e+24  M22=     1.3e+23  M23=    -4.3e+24  dyne-cm
                 M31=     1.2e+24  M32=    -4.3e+24  M33=     6.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2
```

n1921e

Fault plane solution number11
fault plane: strike= 273. dip= 16. slip= 166. degrees
auxilary plane: strike= 349. dip= 94. slip= 75. degrees
Moment Mo= 2.1e+25 dyne-cm
slipvector=(-.190,-.979,-.070) vecaz= 259.0 vecdip= -4.0
moment tensor11:

M11=	-3.3e+24	M12=	5.5e+24	M13=	5.4e+24	
M21=	5.5e+24	M22=	5.9e+23	M23=	-2.0e+25	dyne-cm
M31=	5.4e+24	M32=	-2.0e+25	M33=	2.7e+24	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(.005,-.687, .727) vecaz.= -89.5 vecdip= 46.6
eigenvector2=(.919, .290, .267) vecaz.= 17.5 vecdip= 15.5
eigenvector3=(-.395, .666, .633) vecaz.= 120.6 vecdip= 39.2

n1921f

Fault plane solution number12
fault plane: strike= 273. dip= 16. slip= 166. degrees
auxilary plane: strike= 349. dip= 94. slip= 75. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.190,-.979,-.070) vecaz= 259.0 vecdip= -4.0
moment tensor12:

M11=	-2.1e+22	M12=	3.5e+22	M13=	3.4e+22	
M21=	3.5e+22	M22=	3.7e+21	M23=	-1.2e+23	dyne-cm
M31=	3.4e+22	M32=	-1.2e+23	M33=	1.7e+22	

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(.005,-.687, .727) vecaz.= -89.5 vecdip= 46.6
eigenvector2=(.919, .290, .267) vecaz.= 17.5 vecdip= 15.5
eigenvector3=(-.395, .666, .633) vecaz.= 120.6 vecdip= 39.2

n1943

Fault plane solution number13
fault plane: strike= 273. dip= 16. slip= 166. degrees
auxilary plane: strike= 349. dip= 94. slip= 75. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=(-.190,-.979,-.070) vecaz= 259.0 vecdip= -4.0

```
moment tensor13:
                 M11=    -2.1e+22  M12=     3.5e+22  M13=     3.4e+22
                 M21=     3.5e+22  M22=     3.7e+21  M23=    -1.2e+23  dyne-cm
                 M31=     3.4e+22  M32=    -1.2e+23  M33=     1.7e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1959

Fault plane solution number14
fault plane:     strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor14:
                 M11=    -1.2e+23  M12=     2.1e+23  M13=     2.0e+23
                 M21=     2.1e+23  M22=     2.2e+22  M23=    -7.3e+23  dyne-cm
                 M31=     2.0e+23  M32=    -7.3e+23  M33=     1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1972a

Fault plane solution number15
fault plane:     strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 1.7e+23 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor15:
                 M11=    -2.7e+22  M12=     4.5e+22  M13=     4.4e+22
                 M21=     4.5e+22  M22=     4.8e+21  M23=    -1.6e+23  dyne-cm
                 M31=     4.4e+22  M32=    -1.6e+23  M33=     2.2e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2
```

```
n1972b

Fault plane solution number16
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 6.3e+22 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor16:
                M11=    -9.8e+21  M12=     1.6e+22  M13=     1.6e+22
                M21=     1.6e+22  M22=     1.7e+21  M23=    -5.8e+22  dyne-cm
                M31=     1.6e+22  M32=    -5.8e+22  M33=     8.1e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


n1982

Fault plane solution number17
fault plane:    strike= 273. dip=  16. slip= 166. degrees
auxilary plane: strike= 349. dip=  94. slip=  75. degrees
Moment Mo= 6.3e+22 dyne-cm
slipvector=(-.190,-.979,-.070)    vecaz=  259.0  vecdip=  -4.0
moment tensor17:
                M11=    -9.8e+21  M12=     1.6e+22  M13=     1.6e+22
                M21=     1.6e+22  M22=     1.7e+21  M23=    -5.8e+22  dyne-cm
                M31=     1.6e+22  M32=    -5.8e+22  M33=     8.1e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .005,-.687, .727)    vecaz.=  -89.5  vecdip=  46.6
eigenvector2=( .919, .290, .267)    vecaz.=   17.5  vecdip=  15.5
eigenvector3=(-.395, .666, .633)    vecaz.=  120.6  vecdip=  39.2


Regional moment tensor:
                M11=    -2.8e+25  M12=     4.6e+25  M13=     4.5e+25
                M21=     4.6e+25  M22=     4.8e+24  M23=    -1.6e+26  dyne-cm
                M31=     4.5e+25  M32=    -1.6e+26  M33=     2.3e+25

Eigenvalues:
sigma1=  1.8e+26   sigma2=  8.3e+21   sigma3= -1.8e+26
```

```
Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .008,-.686, .728)    vecaz.=  -89.4  vecdip=  46.7
eigenvector2=( .918, .294, .267)    vecaz.=   17.7  vecdip=  15.5
eigenvector3=(-.397, .666, .632)    vecaz.=  120.8  vecdip=  39.2


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=( -.275, -.014,  .961)    vecaz=-177.vecdip=  74.
nodal plane2: strike= -87. dip=  16.
T1=(  .139, -.868,  .477)    vecaz= -81.  vecdip=  29.
B =(  .918,  .294,  .267)    vecaz=  18.  vecdip=  15.
P1=( -.372,  .401,  .837)    vecaz= 133.  vecdip=  57.

slipvec2=( -.286,  .956, -.068)    vecaz= 107.vecdip=  -4.
nodal plane1: strike= 197. dip=  94.
T2=( -.124, -.427,  .896)    vecaz=-106.  vecdip=  64.
B =(  .918,  .294,  .267)    vecaz=  18.  vecdip=  15.
P2=( -.377,  .855,  .355)    vecaz= 114.  vecdip=  21.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume= 135.9x101.8x 10.0km3

The strain rates for the last  81 years in the directions of the principal stres
     extensional  : 2.4e-08/yr =  4.9e-12/sec
     intermediate : 1.1e-12/yr =  2.3e-16/sec
     compressional:-2.4e-08/yr = -4.9e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -8.1e-09/yr = -2.6e-16/sec  Azimuth: N35W
     Minimum horizontal:  5.0e-09/yr =  1.6e-16/sec  Azimuth: N55E
     Vertical          :  3.1e-09/yr =  9.8e-17/sec
 ENTER region boundary rotation
  .0000000000e+00
 razmax
  .351692390e+02

The maximum horizontal deformation rate = 1.3428 mm/yr
```

COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
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*****************************************************************************

SOUTHERN UTAH REGION

24 S

Fault plane solution number 1
fault plane:     strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 3.0e+22 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 1:
                M11=     4.9e+21  M12=     1.1e+22  M13=     1.6e+21
                M21=     1.1e+22  M22=     1.7e+22  M23=     1.9e+22  dyne-cm
                M31=     1.6e+21  M32=     1.9e+22  M33=    -2.2e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1933

Fault plane solution number 2
fault plane:     strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 2:
                M11=     1.3e+23  M12=     3.1e+23  M13=     4.4e+22
                M21=     3.1e+23  M22=     4.6e+23  M23=     5.0e+23  dyne-cm
                M31=     4.4e+22  M32=     5.0e+23  M33=    -5.9e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1936

Fault plane solution number 3
fault plane:     strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
```

```
Moment Mo= 3.7e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 3:
                      M11=     6.2e+22  M12=     1.4e+23  M13=     2.0e+22
                      M21=     1.4e+23  M22=     2.1e+23  M23=     2.3e+23  dyne-cm
                      M31=     2.0e+22  M32=     2.3e+23  M33=    -2.8e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1937

Fault plane solution number 4
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 4:
                      M11=     2.3e+22  M12=     5.2e+22  M13=     7.4e+21
                      M21=     5.2e+22  M22=     7.7e+22  M23=     8.5e+22  dyne-cm
                      M31=     7.4e+21  M32=     8.5e+22  M33=    -1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1942a

Fault plane solution number 5
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 5:
                      M11=     1.3e+23  M12=     3.1e+23  M13=     4.4e+22
                      M21=     3.1e+23  M22=     4.6e+23  M23=     5.0e+23  dyne-cm
                      M31=     4.4e+22  M32=     5.0e+23  M33=    -5.9e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
```

```
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1942b

Fault plane solution number 6
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 6:
                M11=     2.3e+22  M12=     5.2e+22  M13=     7.4e+21
                M21=     5.2e+22  M22=     7.7e+22  M23=     8.5e+22  dyne-cm
                M31=     7.4e+21  M32=     8.5e+22  M33=    -1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1942c

Fault plane solution number 7
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 7:
                M11=     1.3e+23  M12=     3.1e+23  M13=     4.4e+22
                M21=     3.1e+23  M22=     4.6e+23  M23=     5.0e+23  dyne-cm
                M31=     4.4e+22  M32=     5.0e+23  M33=    -5.9e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1943

Fault plane solution number 8
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 1.4e+23 dyne-cm
```

```
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 8:
                 M11=     2.3e+22  M12=     5.2e+22  M13=     7.4e+21
                 M21=     5.2e+22  M22=     7.7e+22  M23=     8.5e+22  dyne-cm
                 M31=     7.4e+21  M32=     8.5e+22  M33=    -1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1953

Fault plane solution number 9
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor 9:
                 M11=     2.3e+22  M12=     5.2e+22  M13=     7.4e+21
                 M21=     5.2e+22  M22=     7.7e+22  M23=     8.5e+22  dyne-cm
                 M31=     7.4e+21  M32=     8.5e+22  M33=    -1.0e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1959a

Fault plane solution number10
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor10:
                 M11=     1.3e+23  M12=     3.1e+23  M13=     4.4e+22
                 M21=     3.1e+23  M22=     4.6e+23  M23=     5.0e+23  dyne-cm
                 M31=     4.4e+22  M32=     5.0e+23  M33=    -5.9e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6
```

```
n1959b

Fault plane solution number11
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 2.8e+24 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor11:
                M11=     4.7e+23  M12=     1.1e+24  M13=     1.6e+23
                M21=     1.1e+24  M22=     1.6e+24  M23=     1.8e+24  dyne-cm
                M31=     1.6e+23  M32=     1.8e+24  M33=    -2.1e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1966

Fault plane solution number12
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 8.1e+22 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
moment tensor12:
                M11=     1.4e+22  M12=     3.2e+22  M13=     4.5e+21
                M21=     3.2e+22  M22=     4.7e+22  M23=     5.1e+22  dyne-cm
                M31=     4.5e+21  M32=     5.1e+22  M33=    -6.0e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


n1981

Fault plane solution number13
fault plane:    strike= 345. dip=  65. slip= -75. degrees
auxilary plane: strike= 136. dip=  30. slip=-116. degrees
Moment Mo= 2.3e+23 dyne-cm
slipvector=( .347, .360, .866)    vecaz=   46.0  vecdip=  60.0
```

```
moment tensor13:
                     M11=     3.9e+22  M12=     9.0e+22  M13=      1.3e+22
                     M21=     9.0e+22  M22=     1.3e+23  M23=      1.5e+23  dyne-cm
                     M31=     1.3e+22  M32=     1.5e+23  M33=     -1.7e+23

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6


Regional moment tensor:
                     M11=     1.2e+24  M12=     2.8e+24  M13=      4.0e+23
                     M21=     2.8e+24  M22=     4.2e+24  M23=      4.6e+24  dyne-cm
                     M31=     4.0e+23  M32=     4.6e+24  M33=     -5.4e+24

Eigenvalues:
sigma1=  7.3e+24  sigma2= -7.2e+16  sigma3= -7.3e+24


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=( .417, .850, .320)    vecaz.=   63.9  vecdip=  18.7
eigenvector2=(-.905, .356, .235)    vecaz.=  158.5  vecdip=  13.6
eigenvector3=( .086,-.388, .918)    vecaz.=  -77.5  vecdip=  66.6

SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=(  .356,  .327,  .875)    vecaz=  43.vecdip=  61.
nodal plane2: strike= 133. dip=  29.
T1=(  .365,  .931, -.002)    vecaz=  69.  vecdip=    .
B =( -.905,  .356,  .235)    vecaz= 159.  vecdip=  14.
P1=(  .219, -.084,  .972)    vecaz= -21.  vecdip=  76.

slipvec2=( -.235, -.875,  .423)    vecaz=-105.vecdip=  25.
nodal plane1: strike= -15. dip=  65.
T2=(  .422,  .674,  .606)    vecaz=  58.  vecdip=  37.
B =( -.905,  .356,  .235)    vecaz= 159.  vecdip=  14.
P2=( -.057, -.647,  .760)    vecaz= -95.  vecdip=  49.

DETERMINATION OF THE STRAIN RATE:
*********************************

The specified volume=  94.4x138.6x 10.0km3
```

```
The strain rates for the last  48 years in the directions of the principal stres
     extensional  : 1.7e-09/yr =  1.3e-13/sec
     intermediate :-1.7e-17/yr = -1.3e-21/sec
     compressional:-1.7e-09/yr = -1.3e-13/sec

The horizontal and vertical strain rates:
     Maximum horizontal:  1.4e-09/yr =  4.5e-17/sec  Azimuth: N59E
     Minimum horizontal: -1.2e-10/yr = -3.8e-18/sec  Azimuth: N31W
     Vertical          : -1.3e-09/yr = -4.1e-17/sec
 ENTER region boundary rotation
  .0000000000e+00
 razmax
  .5881219100e+02

The maximum horizontal deformation rate =  .2290 mm/yr
```

```
COMPUTATION OF A SYNTHETIC FAULT PLANE SOLUTION FROM A REGIONAL MOMENT TENSOR
******************************************************************************

UTAH-NEVADA BORDER REGION

 5 S

Fault plane solution number 1
fault plane:     strike= 290. dip=  80. slip=  12. degrees
auxiliary plane: strike= 194. dip=  80. slip= 169. degrees
Moment Mo= 2.3e+25 dyne-cm
slipvector=( .238,-.956, .174)    vecaz=  104.0  vecdip=  10.0
moment tensor 1:
                M11=     1.3e+25  M12=    -1.8e+25  M13=    -5.7e+24
                M21=    -1.8e+25  M22=    -1.5e+25  M23=     2.2e+24  dyne-cm
                M31=    -5.7e+24  M32=     2.2e+24  M33=     1.7e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


n1902a

Fault plane solution number 2
fault plane:     strike= 290. dip=  80. slip=  12. degrees
auxiliary plane: strike= 194. dip=  80. slip= 169. degrees
Moment Mo= 2.1e+25 dyne-cm
slipvector=( .238,-.956, .174)    vecaz=  104.0  vecdip=  10.0
moment tensor 2:
                M11=     1.2e+25  M12=    -1.6e+25  M13=    -5.2e+24
                M21=    -1.6e+25  M22=    -1.3e+25  M23=     2.0e+24  dyne-cm
                M31=    -5.2e+24  M32=     2.0e+24  M33=     1.5e+24

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


n1902b

Fault plane solution number 3
fault plane:     strike= 290. dip=  80. slip=  12. degrees
auxiliary plane: strike= 194. dip=  80. slip= 169. degrees
```

```
Moment Mo= 7.9e+23 dyne-cm
slipvector=( .238,-.956, .174)    vecaz=  104.0  vecdip=  10.0
moment tensor 3:
                    M11=      4.4e+23  M12=     -6.0e+23  M13=     -1.9e+23
                    M21=     -6.0e+23  M22=     -5.0e+23  M23=      7.4e+22  dyne-cm
                    M31=     -1.9e+23  M32=      7.4e+22  M33=      5.6e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


n1914

Fault plane solution number 4
fault plane:    strike= 290. dip=  80. slip=  12. degrees
auxilary plane: strike= 194. dip=  80. slip= 169. degrees
Moment Mo= 1.4e+23 dyne-cm
slipvector=( .238,-.956, .174)    vecaz=  104.0  vecdip=  10.0
moment tensor 4:
                    M11=      7.5e+22  M12=     -1.0e+23  M13=     -3.3e+22
                    M21=     -1.0e+23  M22=     -8.5e+22  M23=      1.3e+22  dyne-cm
                    M31=     -3.3e+22  M32=      1.3e+22  M33=      9.6e+21

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


n1966

Fault plane solution number 5
fault plane:    strike= 290. dip=  80. slip=  12. degrees
auxilary plane: strike= 194. dip=  80. slip= 169. degrees
Moment Mo= 3.7e+23 dyne-cm
slipvector=( .238,-.956, .174)    vecaz=  104.0  vecdip=  10.0
moment tensor 5:
                    M11=      2.1e+23  M12=     -2.8e+23  M13=     -9.0e+22
                    M21=     -2.8e+23  M22=     -2.3e+23  M23=      3.5e+22  dyne-cm
                    M31=     -9.0e+22  M32=      3.5e+22  M33=      2.6e+22

Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
```

```
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


Regional moment tensor:
                  M11=     2.6e+25  M12=    -3.5e+25  M13=    -1.1e+25
                  M21=    -3.5e+25  M22=    -2.9e+25  M23=     4.3e+24  dyne-cm
                  M31=    -1.1e+25  M32=     4.3e+24  M33=     3.3e+24

Eigenvalues:
sigma1=  4.6e+25  sigma2= -1.0e+18  sigma3= -4.6e+25


Eigenvectors: component 1=N, 2=E, 3=V
eigenvector1=(-.867, .421, .268)    vecaz.=  154.1  vecdip=  15.5
eigenvector2=( .231,-.137, .963)    vecaz.=  -30.8  vecdip=  74.4
eigenvector3=( .442, .897, .022)    vecaz.=   63.8  vecdip=   1.3


SYNTHETIC FAULT PLANE SOLUTION:

coefficient of internal friction=  .800  ==> alpha= 25.7 degrees

slipvec1=( -.301,  .932,  .205)    vecaz= 108.vecdip=  12.
nodal plane2: strike= 198. dip=  78.
T1=( -.964,  .100,  .245)    vecaz= 174.  vecdip=  14.
B =(  .231, -.137,  .963)    vecaz= -31.  vecdip=  74.
P1=(  .130,  .985,  .109)    vecaz=  82.  vecdip=   6.

slipvec2=(  .925,  .337, -.174)    vecaz=  20.vecdip= -10.
nodal plane1: strike= 110. dip= 100.
T2=( -.672,  .694,  .260)    vecaz= 134.  vecdip=  15.
B =(  .231, -.137,  .963)    vecaz= -31.  vecdip=  74.
P2=(  .704,  .707, -.068)    vecaz=  45.  vecdip=  -4.

DETERMINATION OF THE STRAIN RATE:
***********************************

The specified volume=  94.4x 65.0x 10.0km3

The strain rates for the last  80 years in the directions of the principal stres
     extensional  : 1.4e-08/yr =  2.9e-12/sec
     intermediate :-3.2e-16/yr = -6.5e-20/sec
     compressional:-1.4e-08/yr = -2.9e-12/sec

The horizontal and vertical strain rates:
     Maximum horizontal: -1.4e-08/yr = -4.5e-16/sec  Azimuth: N64E
     Minimum horizontal:  1.3e-08/yr =  4.2e-16/sec  Azimuth: N26W
```

```
    Vertical          :  1.0e-09/yr =  3.2e-17/sec
ENTER region boundary rotation
 .0000000000e+00
razmax
 .6394300809e+02

The maximum horizontal deformation rate = 1.0291 mm/yr
```

APPENDIX E

EARTHQUAKE RECURRENCE RATES

The main earthquake catalog, by study area, was used to determine a- and b-values from the equation

$$\log(N) = a - bM \qquad (20)$$ (20)

where N is the number of earthquakes of magnitude M or greater occurring within the time period examined. The b-values were determined using the maximum likelihood estimate method discussed by Aki [1965] with confidence limits set at 95%:

$$b = \frac{\log_{10}e}{\overline{M} - M_o} \qquad (21)$$ (21)

where $\overline{M}$ = mean magnitude of the events considered, M_o = the minimum magnitude considered, and the error can be determined using

$$\frac{1 - d_\varepsilon / \sqrt{n}}{\sum_{i=1}^{i=n} M_i / \; n - M_o} \leq b' \leq \frac{1 + d_\varepsilon / \sqrt{n}}{\sum_{i=1}^{i=n} M_i / \; n - M_o} \qquad (22)$$ (22)

where $b' = \frac{b}{\log_{10}e}$, d_ε = 1.96 ((+ -d_ε are confidence limits used by Aki [1965] to develop equation (22)) and n is the number of events considered [Aki, 1965]. Typically, the minimum magnitude used was M_L 3.0, although occasionally, when the sampling completeness differed, larger or smaller minimum magnitudes were used. Results are shown in Figures 17-22.

a- and b- values were determined using the entire data set from 1900 to 1981. Consequently, the results are biased by variable network coverage early in the century. The lack of recorded small events probably accounts for the low b-values determined for the Utah region (~5.0 in this study, compared to ~0.75-1.2 from Arabasz et al. [1980])

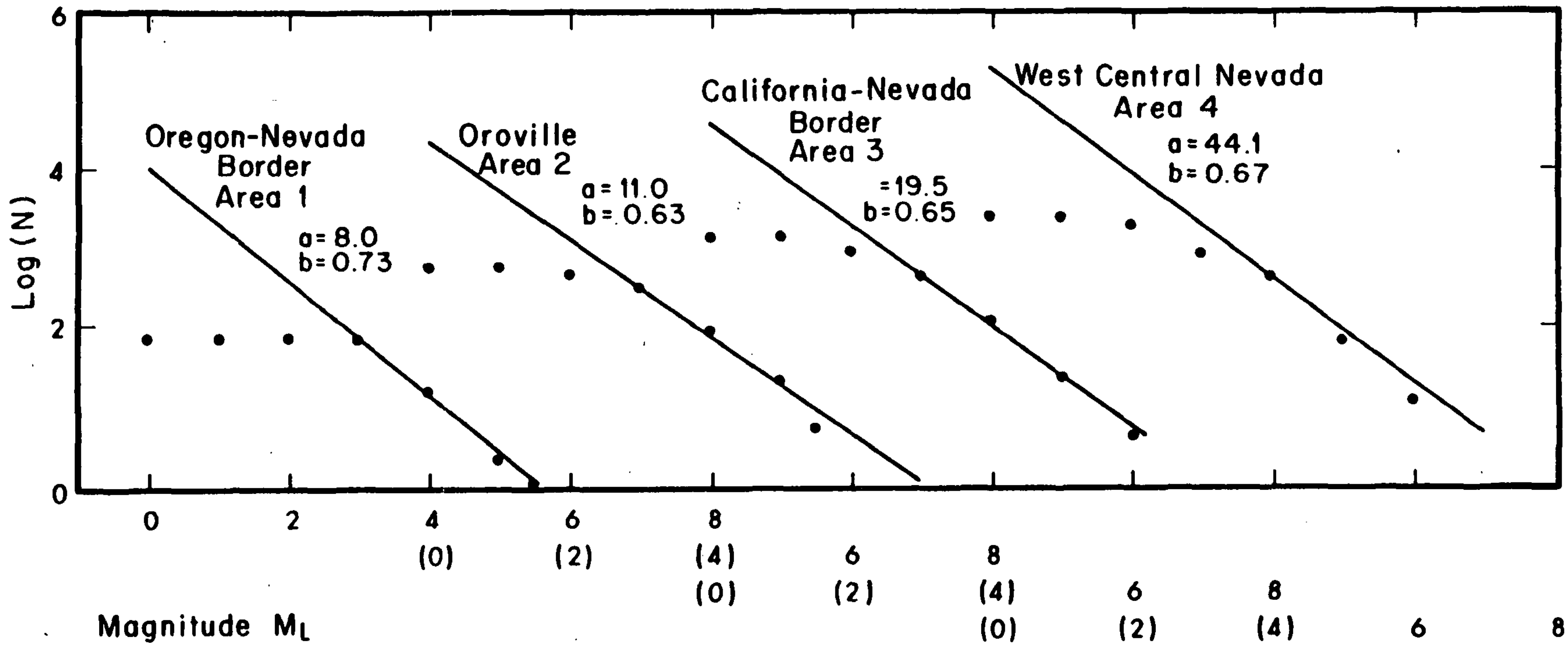

Figure 17. Area 1-4 a- and b-value graphs.

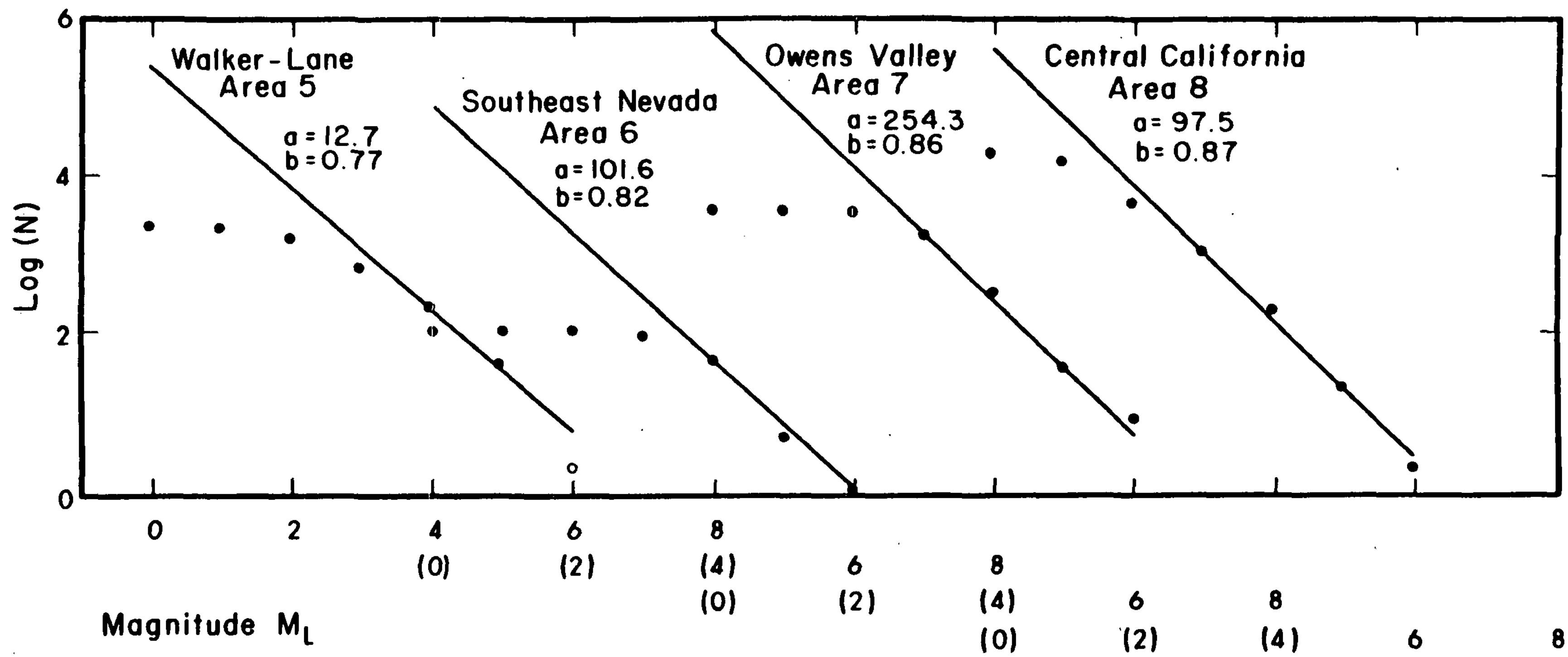

Figure 18. Area 5-8 a- and b-value graphs.

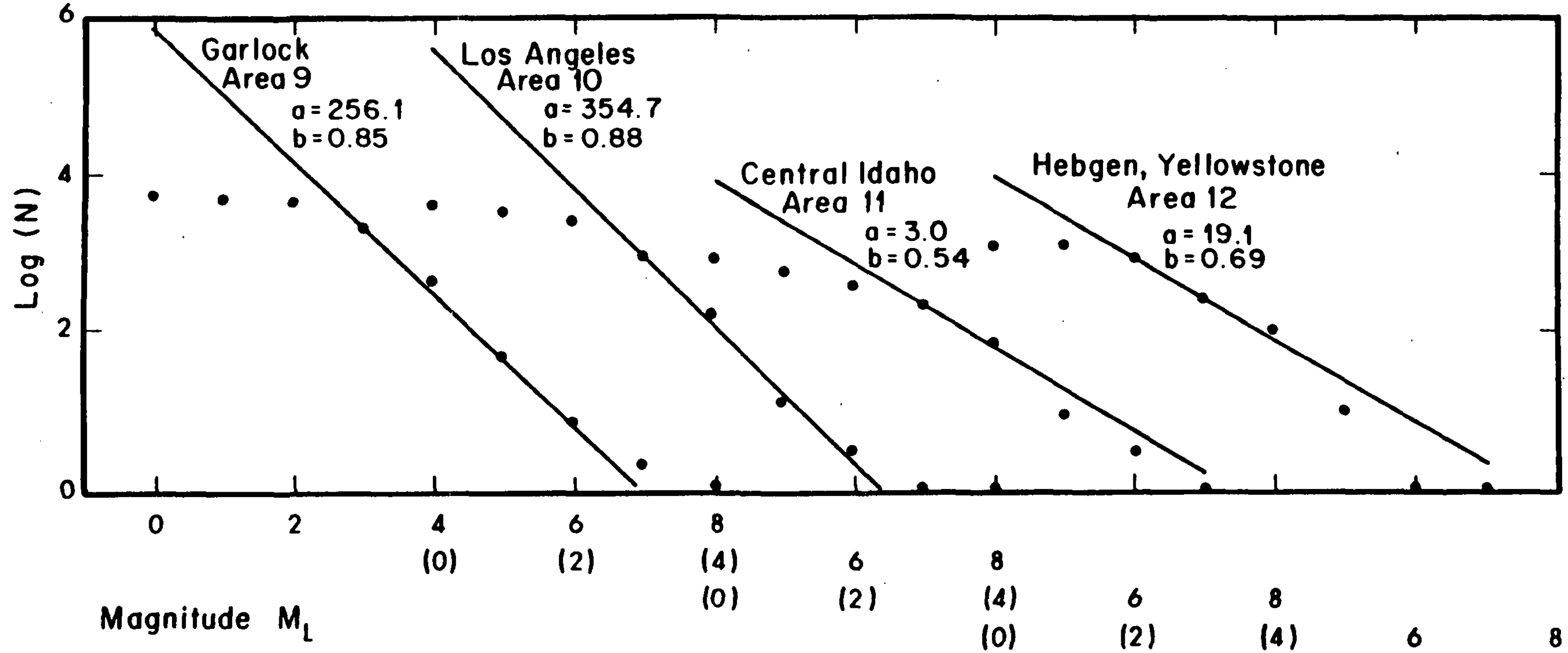

Figure 19. Area 9-12 a- and b-value graphs.

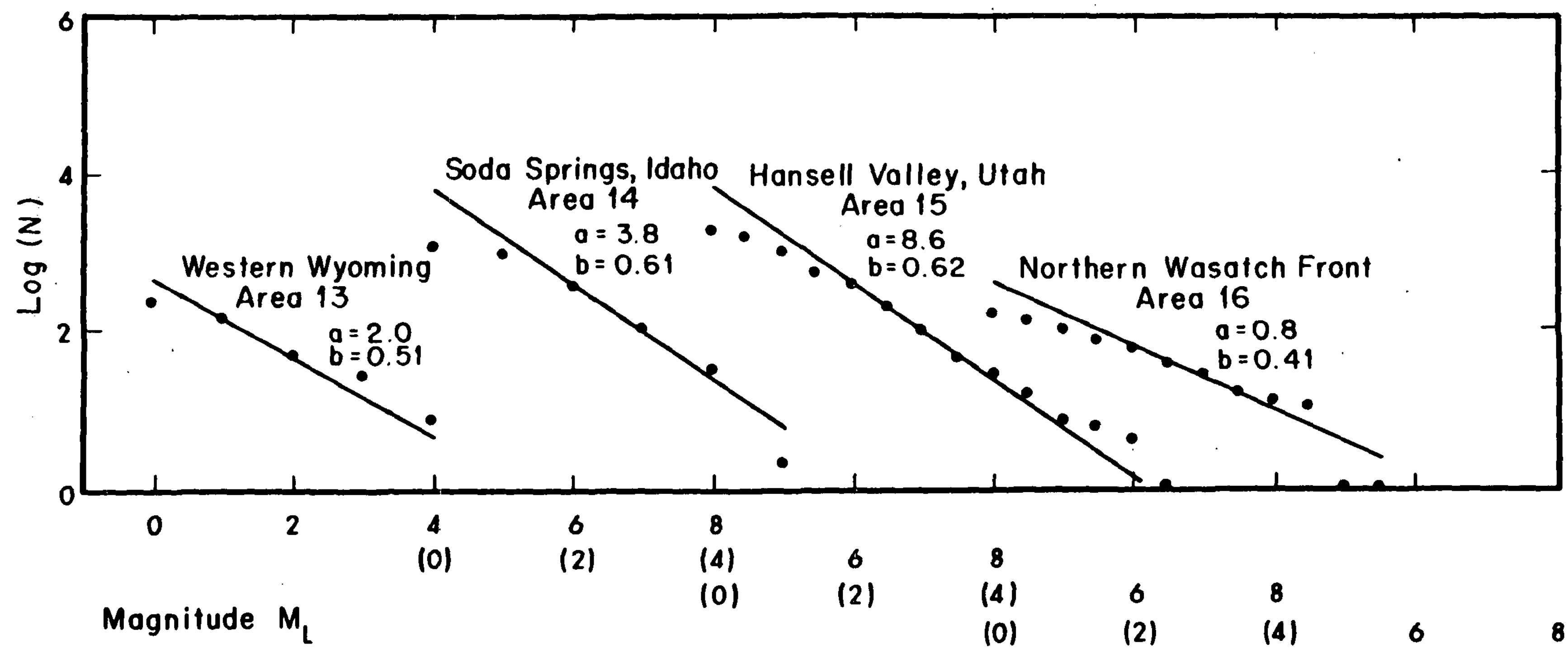

Figure 20. Area 13-16 a- and b-value graphs.

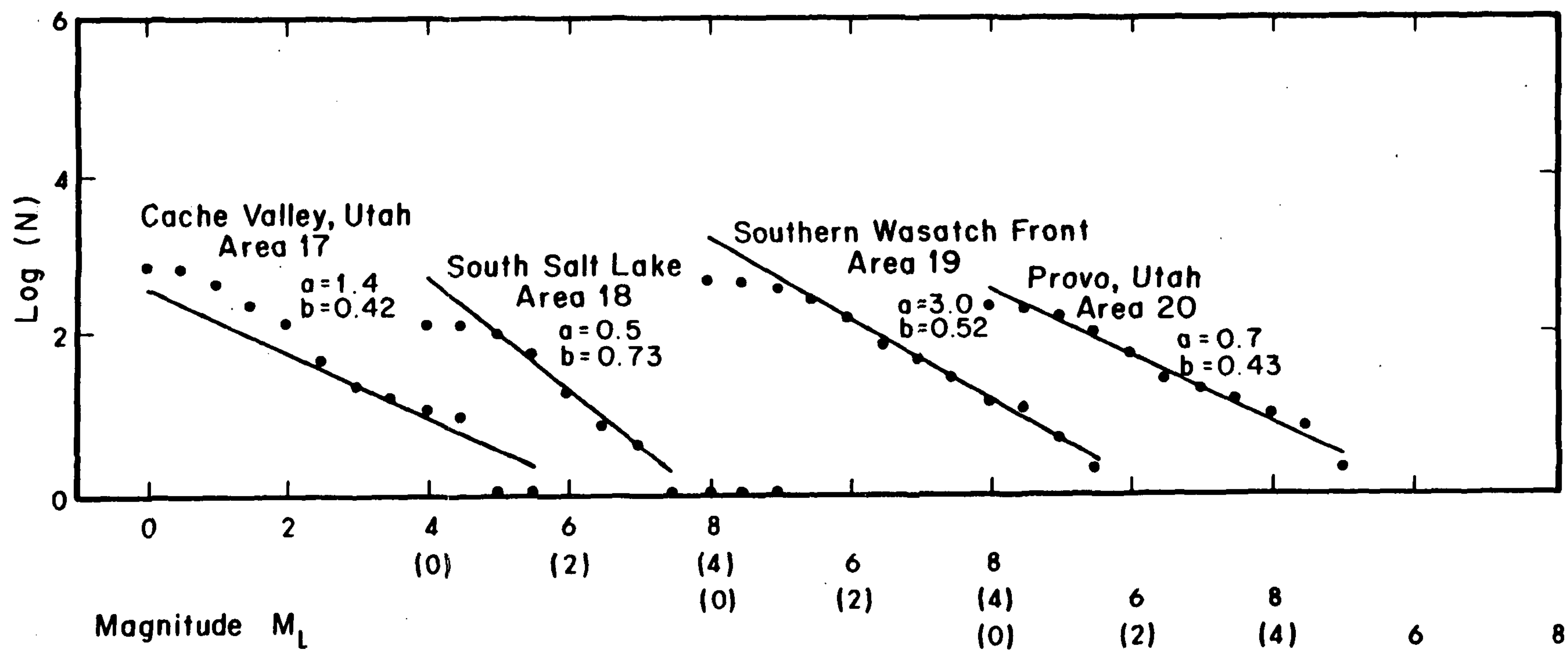

Figure 21. Area 17-20 a- and b-value graphs.

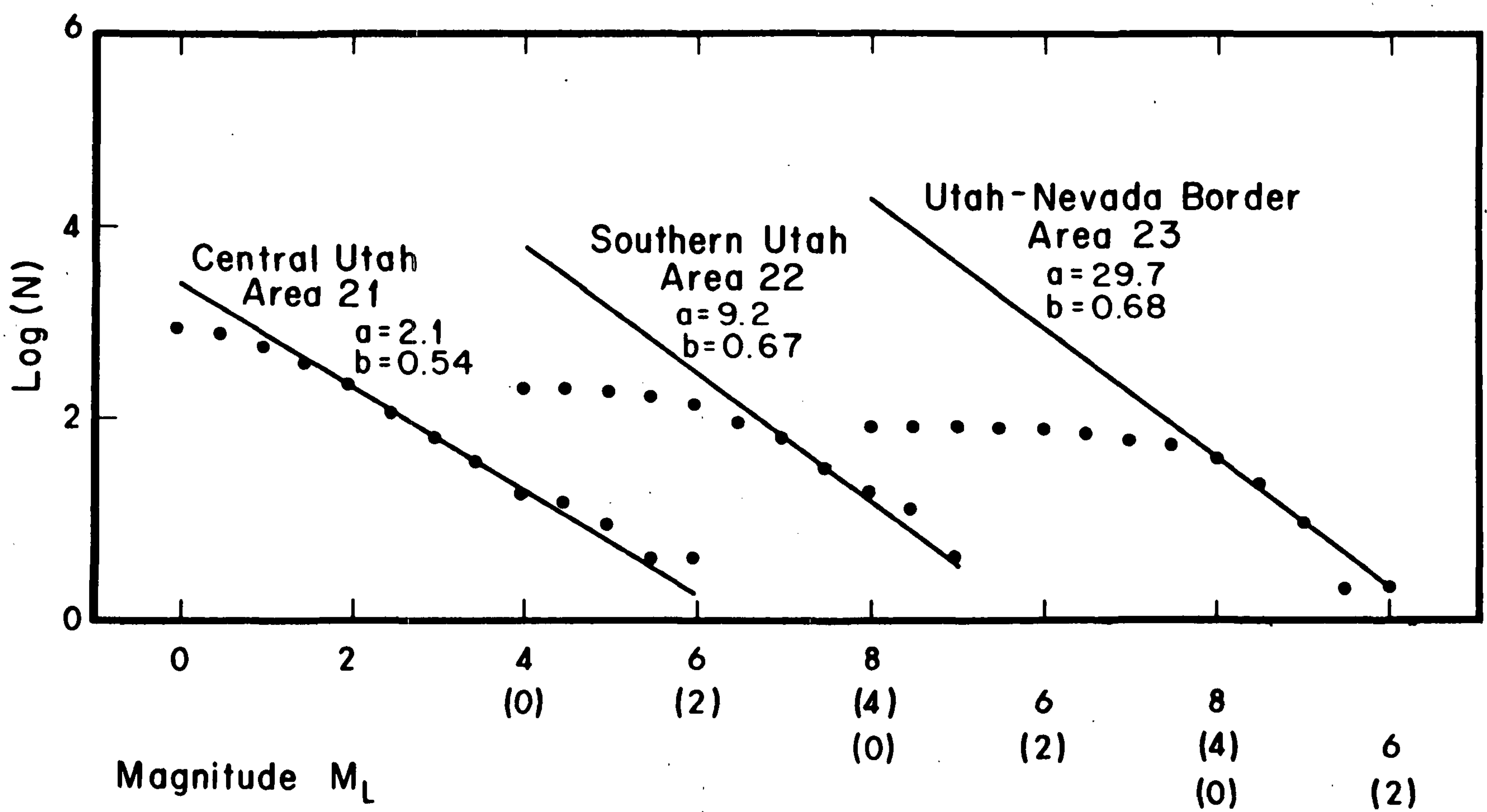

Figure 22. Area 21-23 a- and b-value graphs.

APPENDIX F

LITHOSPHERE DEFORMATION MODEL

Finite Element Modeling

Strain rates obtained from the earthquake data along with measured vertical strain rates [Brown, et al, 1980] were used to constrain two-dimensional, viscoelastic, finite element modeling of the Great Basin. The finite element program used ('nrift'), by Lynch [1983], considers the lithosphere of the earth to be symmetric with respect to the axis of a rift. It also assumes that structure is fixed perpendicular to the rift axis (assuming a plane-strain, two-dimensional configuration). The model is symmetric about the center of the Great Basin along an east - west cross-section of the lithosphere loaded perpendicular to the rift axis (Figure 23).

The program allows the lithosphere to deform under a given stress field according to the viscosities which develop in materials with different properties. Thus, the input rock types may deform brittley, plasticly, elastically, or according to some intermediate flow law depending on the temperature, stress field, and material properties.

'Nrift' allowed for model evolution through time by recalculating stresses, strains, and deformation style for each time step using the previous time step results as an initial model. The size of the time step was calculated by 'nrift' from the viscosity term to provide the maximum step size which would produce numerically stable results [Lynch, 1983].

Limiting Assumptions

Simplifying assumptions are made in 'nrift' which limit the reliability of the program's results. These are 1) bilateral symmetry of the rift modeled, 2) two-dimensional, plane-strain stress-strain laws, 3) far-field loading of the right hand edge of a model crust, and 4) deformation only by simple stretching, i.e no thermal doming, addition of mantle

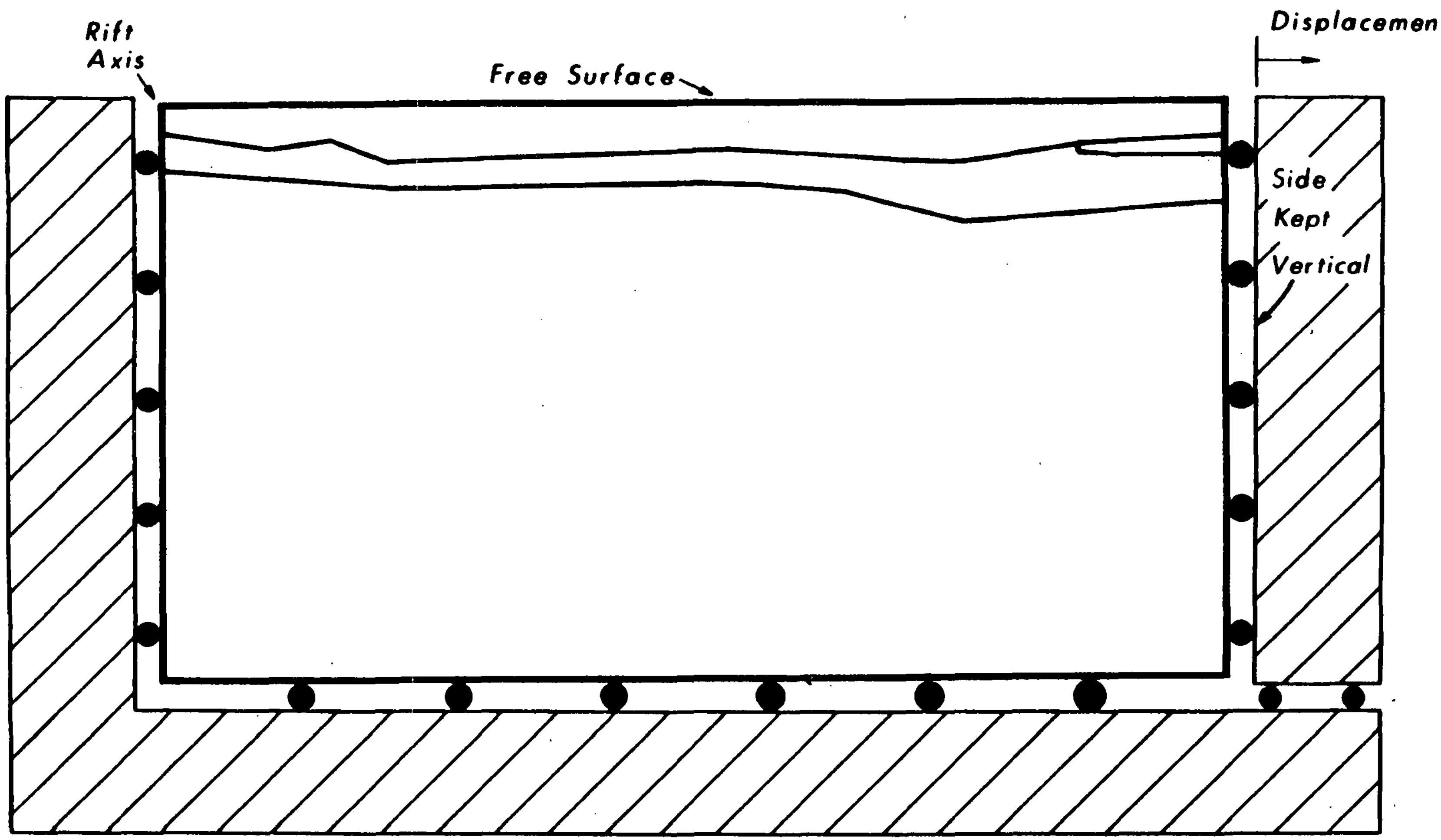

Fig. 23. Diagram showing boundary assumptions used to model the right (east) half of an E-W symmetric Great Basin lithosphere. The load is applied to the east edge, which is maintained vertical throughout modeling.

material, etc.

The most appropriate of these assumptions is bilateral symmetry perpendicular to the rift axis. As noted in the section on regional geology and geophysics, the Great Basin does display remarkable east-west symmetry. However, this symmetry is not exact and so 'nrift' imposes some artificial symmetry on the Great Basin model.

Another simplification which can be quite confidently applied is the plane-strain case. 'Nrift' models a one meter thick, east-west cross-section of the crust. Since one meter is very much less than the north - south length of the Great Basin, plane-strain stress-strain laws are a valid assumption.

The third simplifying condition addressed above cannot be applied with as much confidence as were the first two. This third assumption is that the crust is loaded along a right hand edge that is so far from the rift that spurious effects are minimal. This is a fair assumption when using 'nrift' to model narrow rift zones. In those cases, the right hand edge can be 2-3 times the rift radius away from the rift. Unfortunately, the extreme width of the Great Basin made it necessary to decrease this distance. Numerical stability in 'nrift' requires the model to be only 2-2.5 times as wide as it is thick [Lynch, 1984]. This means that for rifts as wide as the Great Basin, it is impractical to put the right hand edge of the crust more than about one tenth of a rift radius away from the rift itself. The result is edge effect contamination of the model. The loaded edge must be maintained as a vertical edge throughout the modeling. Also, the lowest point on this edge must be fixed for the finite element equations to have a unique solution. Consequently, unreasonably high stress is concentrated along the edge changing deformation styles (less ductile), and increasing displacement rates.

The fourth assumption is that of the simple stretching model. Lachenbruch and Sass [1978] pointed out that this mode of deformation is inefficient from a thermal standpoint. Unfortunately, there is no provision in 'nrift' for any addition of material once modeling has begun. Consequently, neither magma intrusion, mantle convection, nor crustal underplating can be modeled using this program.

Model Parameters

The model tested in this study, shown in Figure 24, came from a lithospheric cross-section of the western United States from Continental Transects Profile C-2 by Blake, et al.(unpublished data, 1985). Material properties for the rocks were taken from Smith and Bruhn [1984] and from Turcotte and Schubert [1982]. Heat flow and heat generation used to determine temperature depth profiles were taken from Lachenbruch and Sass [1978] and Turcotte and Schubert [1982]. The model used is presented along with the temperature-depth profile and a diagram of rock properties in Figure 25.

Results of Finite Element Modeling

Figure 26a shows the the results of the model after 660 years of lateral crustal stretching. The vertical displacements have been grossly exaggerated to make them visible. Figure 26b is a graph of surface horizontal deformation rate versus horizontal distance. Using these two figures, meaningful effects and model assumption artifacts can be segregated to some degree.

The largest deformation rates were found in the center and toward the left edge of the model and are connected by a dotted line in Figure 26b. These deformation rates are considered to be products of localized, upper crust doming in the model. This local folding is associated with the simple stretching assumption and hence has been omitted from the solid line in Figure 26b which represents true model results.

The crust in these areas of high deformation has fallen rather rapidly due to crustal stretching and subsequent "necking down" of the mantle. Any mantle upwarps under the crust acted as pivots over which the crust draped. Directly over these pivots, the upper crust exhibited its most pronounced deformation. Between the folds, upper crustal extension droped to zero. Mantle upwelling and the possible addition of material to the crust

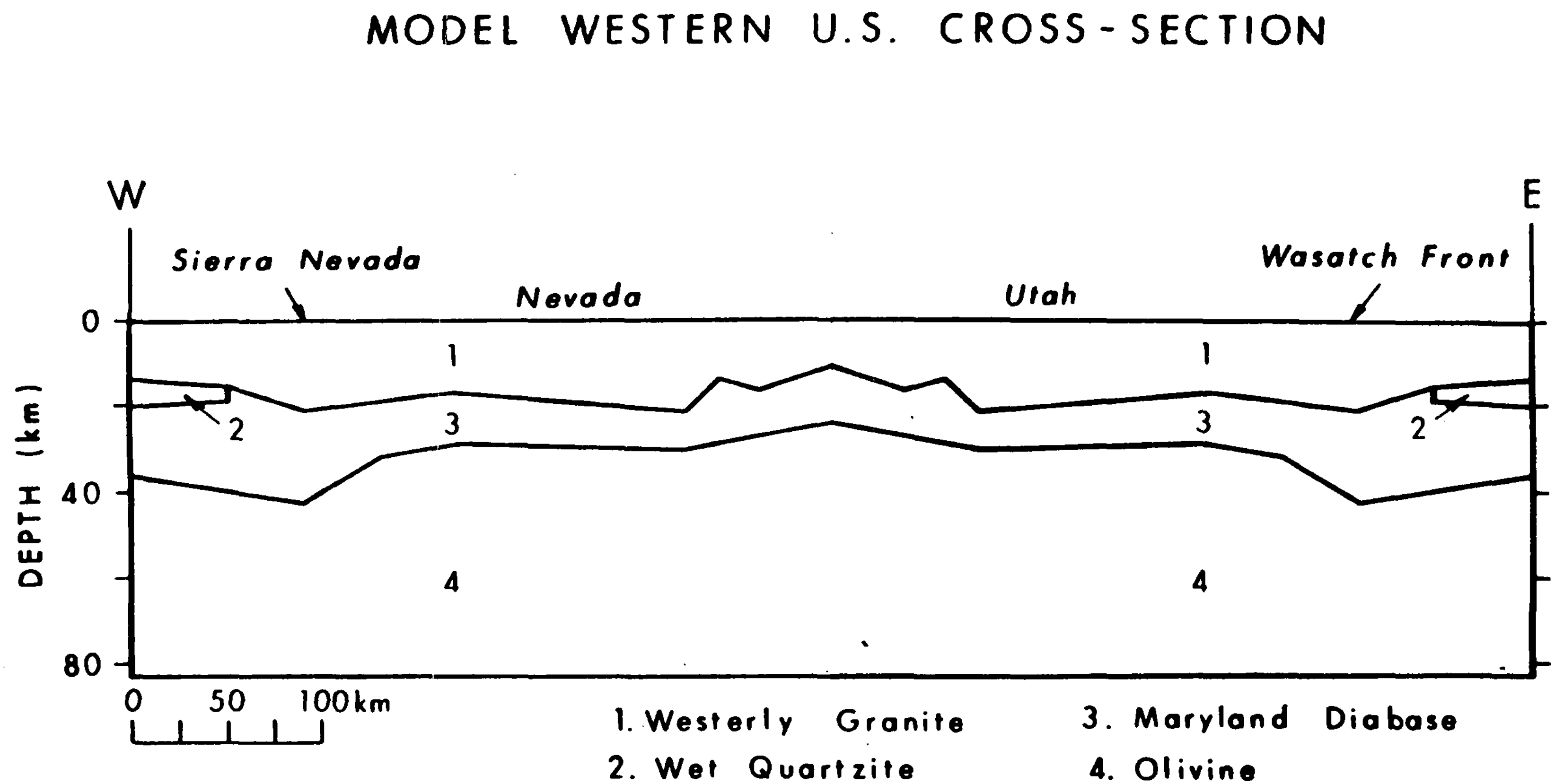

Fig. 24. E-W symmetric, simplified Great Basin lithospheric model.

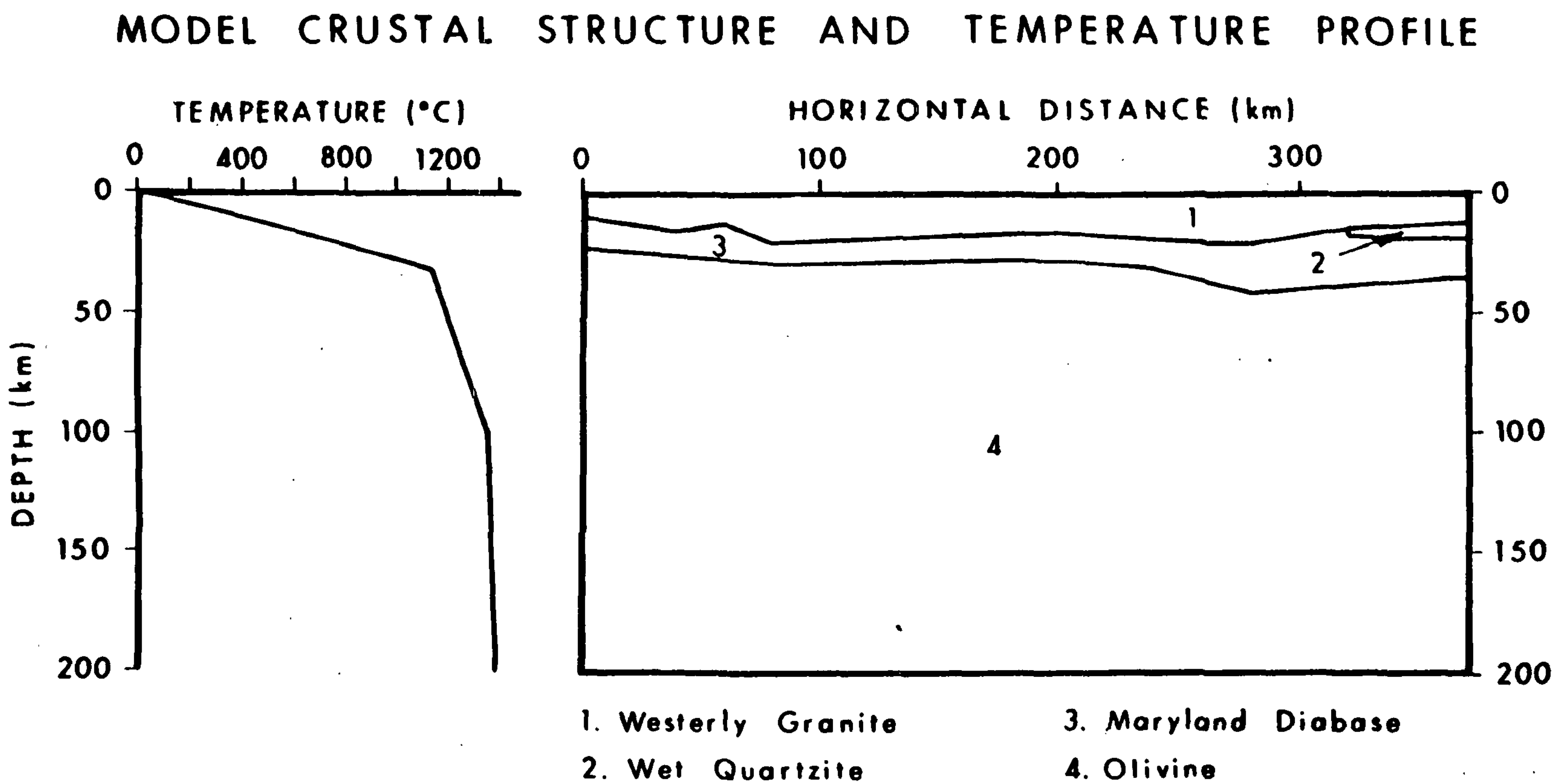

Fig. 25. Model material and temperature depth assumptions.

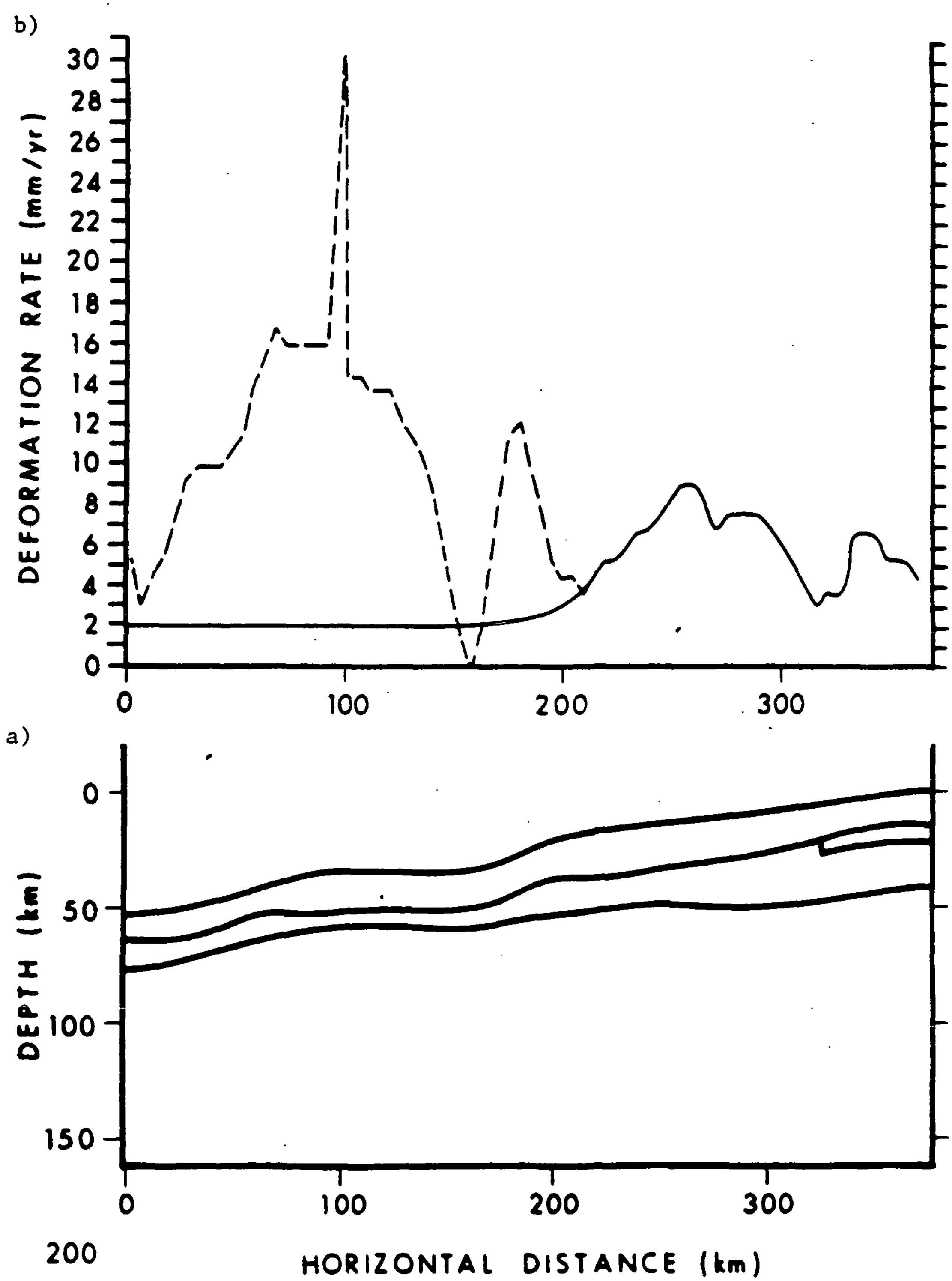

Fig. 26. Modeling results showing a) relative magnitudes of vertical deformation and b) surface horizontal deformation rates per element versus distance across the Great Basin. The dashed line refers to results assumed to be model artifacts.

here would have counteracted this vertical drop and thus eliminated the folding of the crust described above. Brown et al. [1980] have shown through leveling studies that the central Great Basin crust has indeed been uplifted not down-dropped in the past 60 years.

Another area of high deformation rate is found on the extreme right hand margin of the model. This zone of deformation is probably a loaded edge effect. To accommodate both a deviatoric stress and gravity induced stresses, the right edge must be maintained in a vertical position and no vertical motion can be allowed (otherwise the model would extend at the base and slump at the top - something like a melting butter cube). Still, it is not clear how edge effects are expressed in the model, so this deformation high was left in the solid line curve in Figure 26b.

The most significant feature left in the solid line graph of Figure 26b is a band of high deformation about 100 km wide located at the east side of the graph. This zone of high deformation rate compares very well with the location of the diffuse band of seismicity and deformation which marks the borders of the Great Basin and could be caused by lithospheric thinning occurring at the margins of the Great Basin where the depth to the "olivine" mantle rocks increases from ~30 km to ~40 km.

The type of deformation is another important factor to be considered. Figure 27 maps the deformational styles found throughout the model crust. Note that significant brittle deformation is only found at depth beneath the zone of high deformation corresponding to the Great Basin margin seismicity belts. This corresponds to locations of large earthquakes and major faults (such as the Wasatch fault) located within these belts.

Figure 27 also shows that deformation style changes from brittle to ductile with depth within a given material and then commonly goes through this cycle again when a new material is encountered. This effect is predicted in Smith and Bruhn [1984] and helps explain depths of earthquake nucleation as discussed earlier in this work.

Note that edge effects can be seen in Figure 27 as a 20 km wide zone of mostly elastic deformation located on the right edge of the model.

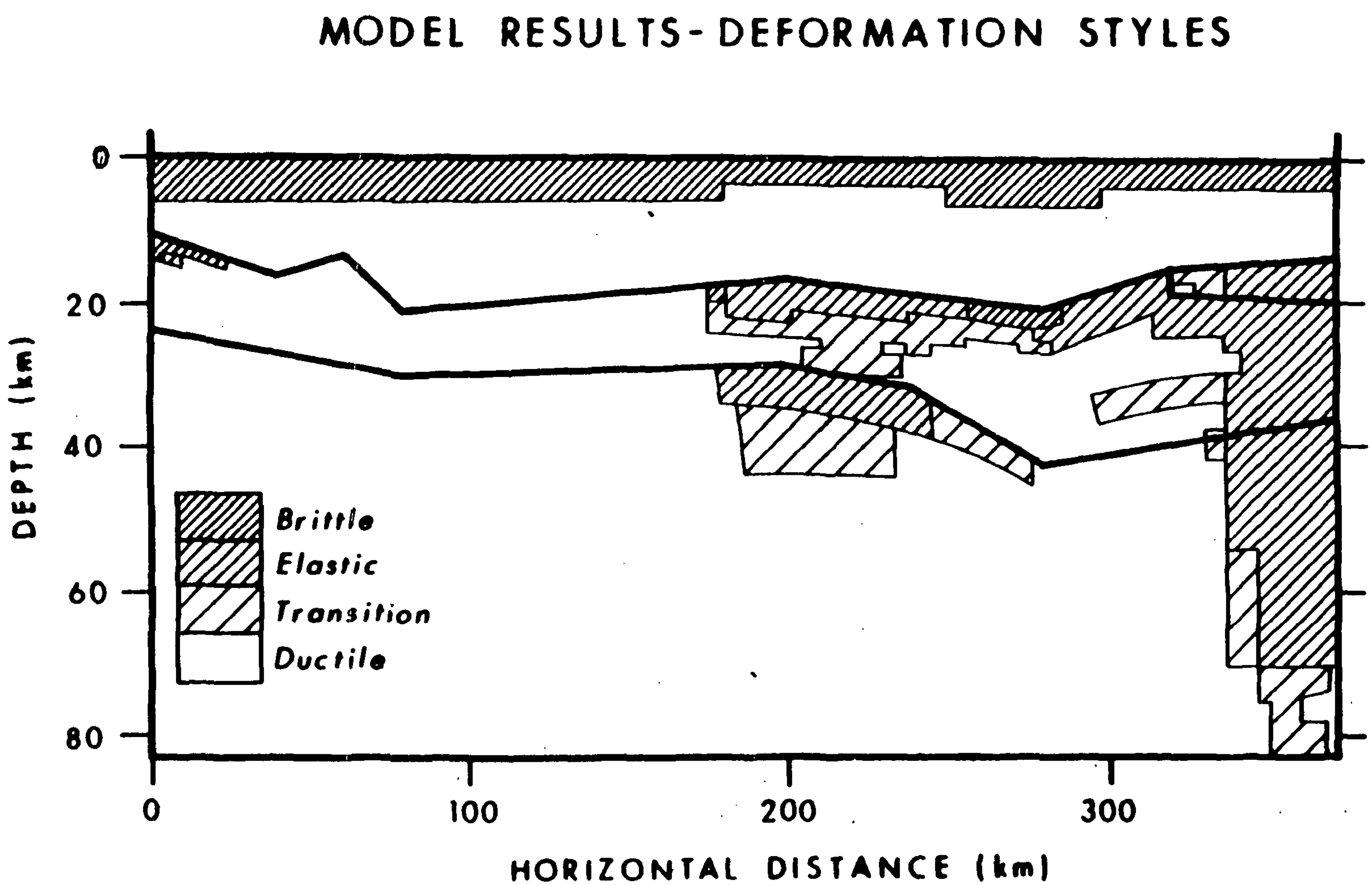

Fig. 27. Modeling results showing deformational style throughout the lithosphere.

The general conclusion derived from this modeling experiment is that the crustal model stretching employed [Figure 23] accounted well for the surface horizontal deformation trends and the changes in deformation style associated with the Great Basin.

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